EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR RESEARCH & INNOVATION

Innovation Union and European Research Area
Research infrastructure

GRANT AGREEMENT

NUMBER — 653477 — ASTERICS

This **Agreement** ('the Agreement') is **between** the following parties:

on the one part,

*the **European Union** ('the EU'), represented by the European Commission ('the Commission')*[1],

represented for the purposes of signature of this Agreement by Head of Unit, DIRECTORATE-GENERAL FOR RESEARCH & INNOVATION, Innovation Union and European Research Area , Administration and finance, Pascale CID,

and

on the other part,

1. 'the coordinator':

STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY (ASTRON) NL6, 41166026, established in Oude Hoogeveensedijk 4, DWINGELOO 7991PD, Netherlands, NL003447741B01, represented for the purposes of signing the Agreement by General Director, Michael GARRETT

and the following other beneficiaries, if they sign their 'Accession Form' (see Annex 3 and Article 56):

2. **CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)**, 180089013, established in Rue Michel -Ange 3, PARIS 75794, France, FR40180089013,

3. **ISTITUTO NAZIONALE DI ASTROFISICA (INAF)**, 97220210583, established in Viale del Parco Mellini 84, ROMA 00136, Italy, IT06895721006,

4. **THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE (UCAM)** GB12, established in The Old Schools, Trinity Lane, CAMBRIDGE CB2 1TN, United Kingdom, GB823847609,

5. **JOINT INSTITUTE FOR V.L.B.I. IN EUROPE (J.I.V.E.) (JIVE)** NL6, 41020054, established in OUDE HOOGEVEENSEDIJK 4, DWINGELOO 7991 PD, Netherlands, na,

6. **INSTITUTO NACIONAL DE TECNICA AEROESPACIAL ESTEBAN TERRADAS (INTA)**, established in CR TORREJON AJALVIR KM 4 2, TORREJON DE ARDOZ MADRID 28850, Spain, ESQ2822003F,

7. **THE UNIVERSITY OF EDINBURGH (UEDIN)**, SC005336, established in OLD COLLEGE, SOUTH BRIDGE, EDINBURGH EH8 9YL, United Kingdom, GB592950700,

8. **RUPRECHT-KARLS-UNIVERSITAET HEIDELBERG (UHEI)**, established in SEMINARSTRASSE 2, HEIDELBERG 69117, Germany, DE811225433,

9. **THE OPEN UNIVERSITY (OU)**, RC000391, established in WALTON HALL, MILTON KEYNES MK7 6AA, United Kingdom, GB650748918,

1 Text in *italics* shows the options of the Model Grant Agreement that are applicable to this Agreement.

10. **FRIEDRICH-ALEXANDER-UNIVERSITAT ERLANGEN NURNBERG (FAU)**, none, established in SCHLOSSPLATZ 4, ERLANGEN 91054, Germany, DE132507686,

11. **STICHTING VU-VUMC (VU/VUmc)** NL6, 53815211, established in DE BOELELAAN 1105, AMSTERDAM 1081 HV, Netherlands, NL851029279B01,

12. **COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA)** EPIC, 775685019, established in RUE LEBLANC 25, PARIS 15 75015, France, FR43775685019,

13. **UNIVERSITEIT VAN AMSTERDAM (UVA)**, 34370207, established in SPUI 21, AMSTERDAM 1012WX, Netherlands, NL003240782B01,

14. **UNIVERSIDAD DE GRANADA (UGR)**, established in CUESTA DEL HOSPICIO SN, GRANADA 18071, Spain, ESQ1818002F,

15. **STICHTING VOOR FUNDAMENTEEL ONDERZOEK DER MATERIE - FOM (FOM)** NL6, 41150068, established in Van Vollenhovenlaan 659, UTRECHT 3527 JP, Netherlands, NL002882243B01,

16. **INSTITUT D'ESTUDIS ESPACIALS DE CATALUNYA FUNDACION (IEEC)** ES3, 976, established in GRAN CAPITA 2-4 OESPATX 201, BARCELONA 08034, Spain, ESG61051710,

17. **INSTITUTO DE FISICA DE ALTAS ENERGIAS (IFAE)**, DOGC 1476 DEL 5/8/91 , established in CAMPUS DE BELLATERRA - UNIVERSIDAD AUTONOMA DE BARCELONA, CERDANYOLA DEL VALLES 08193, Spain, ESQ5856257J ,

18. **UNIVERSIDAD COMPLUTENSE DE MADRID (UCM)**, established in AVENIDA DE SENECA 2, MADRID 28040, Spain, ESQ2818014I,

19. **ISTITUTO NAZIONALE DI FISICA NUCLEARE (INFN)**, 976596, established in Via Enrico Fermi 40, FRASCATI 00044, Italy, IT04430461006,

20. **SCIENCE AND TECHNOLOGY FACILITIES COUNCIL (STFC)**, RC000747, established in Polaris House North Star Avenue, SWINDON SN2 1SZ, United Kingdom, GB618367325,

21. **STIFTUNG DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY (DESY)** DE2, 922.16-35, established in NOTKESTRASSE 85, HAMBURG 22607, Germany, DE118714904,

22. **SURFnet bv (SURFnet)** BV, 30090777, established in MOREELSEPARK 48, UTRECHT 3511 EP, Netherlands, NL008960173B01,

Unless otherwise specified, references to ‘beneficiary’ or ‘beneficiaries’ include the coordinator.

The parties referred to above have agreed to enter into the Agreement under the terms and conditions below.

By signing the Agreement or the Accession Form, the beneficiaries accept the grant and agree to implement it under their own responsibility and in accordance with the Agreement, with all the obligations and conditions it sets out.

The Agreement is composed of:

Terms and Conditions

Annex 1 Description of the action

Annex 2 Estimated budget for the action

Annex 3 Accession Forms

Annex 4 Model for the financial statements

Annex 5 Model for the certificate on the financial statements

Annex 6 Model for the certificate on the methodology

TERMS AND CONDITIONS

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CHAPTER 1 GENERAL

ARTICLE 1 — SUBJECT OF THE AGREEMENT

This Agreement sets out the rights and obligations and the terms and conditions applicable to the grant awarded to the beneficiaries for implementing the action set out in Chapter 2.

CHAPTER 2 ACTION

ARTICLE 2 — ACTION TO BE IMPLEMENTED

The grant is awarded for the action entitled '***Astronomy ESFRI and Research Infrastructure Cluster — ASTERICS***' **('action')**, as described in Annex 1.

ARTICLE 3 — DURATION AND STARTING DATE OF THE ACTION

The duration of the action will be ***48*** **months** as of *the first day of the month following the date the Agreement enters into force (see Article 58)* ('**starting date of the action**').

ARTICLE 4 — ESTIMATED BUDGET AND BUDGET TRANSFERS

4.1 Estimated budget

The '**estimated budget**' for the action is set out in Annex 2.

It contains the estimated eligible costs and the forms of costs, broken down by beneficiary *(and linked third party)* and budget category (see Articles 5, 6*, and 14*).

4.2 Budget transfers

The estimated budget breakdown indicated in Annex 2 may be adjusted by transfers of amounts between beneficiaries or between budget categories (or both). This does not require an amendment according to Article 55, if the action is implemented as described in Annex 1.

However, the beneficiaries may not add costs relating to subcontracts not provided for in Annex 1, unless such additional subcontracts are approved by an amendment or in accordance with Article 13.

CHAPTER 3 GRANT

ARTICLE 5 — GRANT AMOUNT, FORM OF GRANT, REIMBURSEMENT RATES AND FORMS OF COSTS

5.1 Maximum grant amount

The '**maximum grant amount**' is **EUR 14,991,194.00** (fourteen million nine hundred and ninety one thousand one hundred and ninety four EURO).

5.2 Form of grant, reimbursement rates and forms of costs

The grant reimburses ***100% of the action's eligible costs*** (see Article 6) ('**reimbursement of eligible costs grant**') (see Annex 2).

The estimated eligible costs of the action are EUR **14,991,194.00** (fourteen million nine hundred and ninety one thousand one hundred and ninety four EURO).

Eligible costs (see Article 6) must be declared under the following forms ('**forms of costs**'):

(a) for **direct personnel costs**:

- as actually incurred costs ('**actual costs**') or
- on the basis of an amount per unit calculated by the beneficiary in accordance with its usual cost accounting practices ('**unit costs**').

Personnel **costs for SME owners** or **beneficiaries that are natural persons** not receiving a salary (see Article 6.2, Points A.4 and A.5) must be declared on the basis of the amount per unit set out in Annex 2 (**unit costs**);

(b) for **direct costs for subcontracting**: as actually incurred costs (**actual costs**);

(c) for **direct costs of providing financial support to third parties**: *not applicable;*

(d) for **other direct costs**: as actually incurred costs (**actual costs**);

(e) for **indirect costs**: on the basis of a flat-rate applied as set out in Article 6.2, Point E ('**flat-rate costs**');

(f) ***specific cost category(ies):*** *not applicable.*

5.3 Final grant amount — Calculation

The '**final grant amount**' depends on the actual extent to which the action is implemented in accordance with the Agreement's terms and conditions.

This amount is calculated by the *Commission* — when the payment of the balance is made (see Article 21.4) — in the following steps:

Step 1 – Application of the reimbursement rates to the eligible costs

Step 2 – Limit to the maximum grant amount

Step 3 – Reduction due to the no-profit rule

Step 4 – Reduction due to improper implementation or breach of other obligations

5.3.1 Step 1 — Application of the reimbursement rates to the eligible costs

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries *and linked third parties* (see Article 20) and approved by the *Commission* (see Article 21).

5.3.2 Step 2 — Limit to the maximum grant amount

If the amount obtained following Step 1 is higher than the maximum grant amount set out in Article 5.1, it will be limited to the latter.

5.3.3 Step 3 — Reduction due to the no-profit rule

The grant must not produce a profit.

'**Profit**' means the surplus of the amount obtained following Steps 1 and 2 plus the action's total receipts, over the action's total eligible costs.

The '**action's total eligible costs**' are the consolidated total eligible costs approved by the *Commission*.

The '**action's total receipts**' are the consolidated total receipts generated during its duration (see Article 3).

The following are considered **receipts**:

(a) income generated by the action; if the income is generated from selling equipment or other assets purchased under the Agreement, the receipt is up to the amount declared as eligible under the Agreement;

(b) financial contributions given by third parties to the beneficiary *or to a linked third party* specifically to be used for the action, and

(c) in-kind contributions provided by third parties free of charge and specifically to be used for the action, if they have been declared as eligible costs.

The following are however not considered receipts:

(a) income generated by exploiting the action's results (see Article 28);

(b) financial contributions by third parties, if they may be used to cover costs other than the eligible costs (see Article 6);

(c) financial contributions by third parties with no obligation to repay any amount unused at the end of the period set out in Article 3.

If there is a profit, it will be deducted from the amount obtained following Steps 1 and 2.

5.3.4 Step 4 — Reduction due to improper implementation or breach of other obligations — Reduced grant amount — Calculation

If the grant is reduced (see Article 43), the *Commission* will calculate the reduced grant amount by deducting the amount of the reduction (calculated in proportion to the improper implementation of the action or to the seriousness of the breach of obligations in accordance with Article 43.2) from the maximum grant amount set out in Article 5.1.

The final grant amount will be the lower of the following two:

- the amount obtained following Steps 1 to 3 or

- the reduced grant amount following Step 4.

5.4 Revised final grant amount — Calculation

If — after the payment of the balance (in particular, after checks, reviews, audits or investigations; see Article 22) — the *Commission* rejects costs (see Article 42) or reduces the grant (see Article 43), it will calculate the '**revised final grant amount**' for the beneficiary concerned by the findings.

This amount is calculated by the *Commission* on the basis of the findings, as follows:

- in case of **rejection of costs**: by applying the reimbursement rate to the revised eligible costs approved by the *Commission* for the beneficiary concerned;

- in case of **reduction of the grant**: by calculating the concerned beneficiary's share in the grant amount reduced in proportion to its improper implementation of the action or to the seriousness of its breach of obligations (see Article 43.2).

In case of **rejection of costs and reduction of the grant**, the revised final grant amount for the beneficiary concerned will be the lower of the two amounts above.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE COSTS

6.1 General conditions for costs to be eligible

'**Eligible costs**' are costs that meet the following criteria:

(a) for **actual costs**:

(i) they must be actually incurred by the beneficiary;

(ii) they must be incurred in the period set out in Article 3, with the exception of costs relating to the submission of the periodic report for the last reporting period and the final report (see Article 20);

(iii) they must be indicated in the estimated budget set out in Annex 2;

(iv) they must be incurred in connection with the action as described in Annex 1 and necessary for its implementation;

(v) they must be identifiable and verifiable, in particular recorded in the beneficiary's accounts in accordance with the accounting standards applicable in the country where the beneficiary is established and with the beneficiary's usual cost accounting practices;

(vi) they must comply with the applicable national law on taxes, labour and social security, and

(vii) they must be reasonable, justified and must comply with the principle of sound financial management, in particular regarding economy and efficiency;

(b) for **unit costs**:

(i) they must be calculated as follows:

{amounts per unit set out in Annex 2 or calculated by the beneficiary in accordance with its usual cost accounting practices (see Article 6.2, Point A)

multiplied by

the number of actual units};

(ii) the number of actual units must comply with the following conditions:

- the units must be actually used or produced in the period set out in Article 3;
- the units must be necessary for implementing the action or produced by it, and
- the number of units must be identifiable and verifiable, in particular supported by records and documentation (see Article 18);

(c) for **flat-rate costs**:

(i) they must be calculated by applying the flat-rate set out in Annex 2, and

(ii) the costs (actual costs or unit costs) to which the flat-rate is applied must comply with the conditions for eligibility set out in this Article.

6.2 Specific conditions for costs to be eligible

Costs are eligible if they comply with the general conditions (see above) and the specific conditions set out below for each of the following budget categories:

A. direct personnel costs;
B. direct costs of subcontracting;
C. *not applicable;*
D. other direct costs;
E. indirect costs;
F. *not applicable.*

'Direct costs' are costs that are directly linked to the action implementation and can therefore be attributed to it directly. They must not include any indirect costs (see Point E below).

'Indirect costs' are costs that are not directly linked to the action implementation and therefore cannot be attributed directly to it.

A. Direct personnel costs

Types of eligible personnel costs

A.1 **Personnel costs** are eligible, if they are related to personnel working for the beneficiary under an employment contract (or equivalent appointing act) and assigned to the action ('**costs for employees (or equivalent)**'). They must be limited to salaries (including during parental leave), social security contributions, taxes and other costs included in the **remuneration**, if they arise from national law or the employment contract (or equivalent appointing act).

Beneficiaries that are non-profit legal entities[2] may also declare as personnel costs **additional remuneration** for personnel assigned to the action (including payments on the basis of supplementary contracts regardless of their nature), if:

(a) it is part of the beneficiary's usual remuneration practices and is paid in a consistent manner whenever the same kind of work or expertise is required;

(b) the criteria used to calculate the supplementary payments are objective and generally applied by the beneficiary, regardless of the source of funding used.

Additional remuneration for personnel assigned to the action is eligible up to the following amount:

(a) if the person works full time and exclusively on the action during the full year: up to EUR 8 000;

(b) if the person works exclusively on the action but not full-time or not for the full year: up to the corresponding pro-rata amount of EUR 8 000, or

(c) if the person does not work exclusively on the action: up to a pro-rata amount calculated as follows:

{{EUR 8 000

divided by

the number of annual productive hours (see below)},

multiplied by

the number of hours that the person has worked on the action during the year}.

A.2 The **costs for natural persons working under a direct contract** with the beneficiary other than an employment contract are eligible personnel costs, if:

(a) the person works under the beneficiary's instructions and, unless otherwise agreed with the beneficiary, on the beneficiary's premises;

(b) the result of the work carried out belongs to the beneficiary, and

(c) the costs are not significantly different from those for personnel performing similar tasks under an employment contract with the beneficiary.

A.3 The **costs of personnel seconded by a third party against payment** are eligible personnel costs, if the conditions in Article 11.1 are met.

[2] For the definition, see Article 2.1(14) of the Rules for Participation Regulation No 1290/2013: '**non-profit legal entity**' means a legal entity which by its legal form is non-profit-making or which has a legal or statutory obligation not to distribute profits to its shareholders or individual members.

A.4 **Costs of owners** of beneficiaries that are small and medium-sized enterprises ('**SME owners**') who are working on the action and who do not receive a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2 multiplied by the number of actual hours worked on the action.

A.5 **Costs of 'beneficiaries that are natural persons'** not receiving a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2 multiplied by the number of actual hours worked on the action.

Calculation

Personnel costs must be calculated by the beneficiaries as follows:

{{hourly rate

multiplied by

the number of actual hours worked on the action},

plus

for non-profit legal entities: additional remuneration to personnel assigned to the action under the conditions set out above (Point A.1)}.

The number of actual hours declared for a person must be identifiable and verifiable (see Article 18).

The total number of hours declared in EU or Euratom grants, for a person for a year, cannot be higher than the annual productive hours used for the calculations of the hourly rate. Therefore, the maximum number of hours that can be declared for the grant is:

{the number of annual productive hours for the year (see below)

minus

total number of hours declared by the beneficiary for that person in that year for other EU or Euratom grants}.

The '**hourly rate**' is one of the following:

(a) for personnel costs declared as **actual costs:** the hourly rate is the amount calculated as follows:

{actual annual personnel costs (excluding additional remuneration) for the person

divided by

number of annual productive hours}.

The beneficiaries must use the annual personnel costs and the number of annual productive hours for each financial year covered by the reporting period. If a financial year is not closed at the end of the reporting period, the beneficiaries must use the hourly rate of the last closed financial year available.

For the 'number of annual productive hours', the beneficiaries may choose one of the following:

(i) 'fixed number of hours': 1 720 hours for persons working full time (or corresponding pro-rata for persons not working full time);

(ii) 'individual annual productive hours': the total number of hours worked by the person in the year for the beneficiary, calculated as follows:

{annual workable hours of the person (according to the employment contract, applicable collective labour agreement or national law)

plus

overtime worked

minus

absences (such as sick leave and special leave)}.

'Annual workable hours' means the period during which the personnel must be working, at the employer's disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation.

If the contract (or applicable collective labour agreement or national working time legislation) does not allow to determine the annual workable hours, this option cannot be used;

(iii) 'standard annual productive hours': the 'standard number of annual hours' generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the 'standard annual workable hours'.

If there is no applicable reference for the standard annual workable hours, this option cannot be used.

For all options, the actual time spent on **parental leave** by a person assigned to the action may be deducted from the number of annual productive hours;

(b) for personnel costs declared on the basis of **unit costs**: the hourly rate is one of the following:

(i) for SME owners or beneficiaries that are natural persons: the hourly rate set out in Annex 2 (see Points A.4 and A.5 above), or

(ii) for personnel costs declared on the basis of the beneficiary's usual cost accounting practices: the hourly rate calculated by the beneficiary in accordance with its usual cost accounting practices, if:

- the cost accounting practices used are applied in a consistent manner, based on objective criteria, regardless of the source of funding;

- the hourly rate is calculated using the actual personnel costs recorded in the beneficiary's accounts, excluding any ineligible cost or costs included in other budget categories.

The actual personnel costs may be adjusted by the beneficiary on the basis of budgeted or estimated elements. Those elements must be relevant for calculating

the personnel costs, reasonable and correspond to objective and verifiable information;

and

- the hourly rate is calculated using the number of annual productive hours (see above).

B. Direct costs of subcontracting (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if the conditions in Article 13.1.1 are met.

C. Direct costs of providing financial support to third parties *not applicable.*

D. Other direct costs

D.1 **Travel costs and related subsistence allowances** (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if they are in line with the beneficiary's usual practices on travel.

D.2 *The **depreciation costs of equipment, infrastructure or other assets** (new or second-hand) as recorded in the beneficiary's accounts are eligible, if they were purchased in accordance with Article 10.1.1 and written off in accordance with international accounting standards and the beneficiary's usual accounting practices.*

*The **costs of renting or leasing** equipment, infrastructure or other assets (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are also eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets and do not include any financing fees.*

*The costs of equipment, infrastructure or other assets **contributed in-kind against payment** are eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets, do not include any financing fees and if the conditions in Article 11.1 are met.*

The only portion of the costs that will be taken into account is that which corresponds to the duration of the action and rate of actual use for the purposes of the action.

D.3 **Costs of other goods and services** (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible, if they are:

(a) purchased specifically for the action and in accordance with Article 10.1.1 or

(b) contributed in kind against payment and in accordance with Article 11.1.

Such goods and services include, for instance, consumables and supplies, dissemination (including open access), protection of results, certificates on the financial statements (if they are required by the Agreement), certificates on the methodology, translations and publications.

D.4 **Capitalised and operating costs of 'large research infrastructure'**[3]*: Not applicable*

E. Indirect costs

Indirect costs are eligible if they are declared on the basis of the flat-rate of 25% of the eligible direct costs (see Article 5.2 and Points A to D above), from which are excluded:

(a) costs of subcontracting and

(b) costs of in-kind contributions provided by third parties which are not used on the beneficiary's premises;

(c) *not applicable;*

(d) *not applicable.*

Beneficiaries receiving an operating grant[5] financed by the EU or Euratom budget cannot declare indirect costs for the period covered by the operating grant.

F. *Specific cost category(ies)*

Not applicable

6.3 Conditions for costs of linked third parties to be eligible

Costs incurred by linked third parties are eligible if they fulfil — mutatis mutandis — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 14.1.1.

6.4 Conditions for in-kind contributions provided by third parties free of charge to be eligible

In-kind contributions provided free of charge are eligible direct costs (for the beneficiary *or linked third party*), if the costs incurred by the third party fulfil — *mutatis mutandis* — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 12.1.

6.5 Ineligible costs

'**Ineligible costs**' are:

(a) costs that do not comply with the conditions set out above (Article 6.1 to 6.4), in particular:

(i) costs related to return on capital;

[3] '**Large research infrastructure**' means research infrastructure of a total value of at least EUR 20 million, for a beneficiary, calculated as the sum of historical asset values of each individual research infrastructure of that beneficiary, as they appear in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure.

[5] For the definition, see Article 121(1)(b) of Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 218, 26.10.2012, p.1) ('**Financial Regulation No 966/2012**'): '**operating grant**' means direct financial contribution, by way of donation, from the budget in order to finance the functioning of a body which pursues an aim of general EU interest or has an objective forming part of and supporting an EU policy.

(ii) debt and debt service charges;

(iii) provisions for future losses or debts;

(iv) interest owed;

(v) doubtful debts;

(vi) currency exchange losses;

(vii) bank costs charged by the beneficiary's bank for transfers from the *Commission*;

(viii) excessive or reckless expenditure;

(ix) deductible VAT;

(x) costs incurred during suspension of the implementation of the action (see Article 49);

(b) costs declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU or Euratom budget and grants awarded by bodies other than the *Commission* for the purpose of implementing the EU or Euratom budget); in particular, indirect costs if the beneficiary is already receiving an operating grant financed by the EU or Euratom budget in the same period.

6.6 Consequences of declaration of ineligible costs

Declared costs that are ineligible will be rejected (see Article 42).

This may also lead to any of the other measures described in Chapter 6.

CHAPTER 4 RIGHTS AND OBLIGATIONS OF THE PARTIES

SECTION 1 RIGHTS AND OBLIGATIONS RELATED TO IMPLEMENTING THE ACTION

ARTICLE 7 — GENERAL OBLIGATION TO PROPERLY IMPLEMENT THE ACTION

7.1 General obligation to properly implement the action

The beneficiaries must implement the action as described in Annex 1 and in compliance with the provisions of the Agreement and all legal obligations under applicable EU, international and national law.

7.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 8 — RESOURCES TO IMPLEMENT THE ACTION — THIRD PARTIES INVOLVED IN THE ACTION

The beneficiaries must have the appropriate resources to implement the action.

If it is necessary to implement the action, the beneficiaries may:

- purchase goods, works and services (see Article 10);
- use in-kind contributions provided by third parties against payment (see Article 11);
- use in-kind contributions provided by third parties free of charge (see Article 12);
- call upon subcontractors to implement action tasks described in Annex 1 (see Article 13);
- call upon linked third parties to implement action tasks described in Annex 1 (see Article 14).

In these cases, the beneficiaries retain sole responsibility towards the *Commission* and the other beneficiaries for implementing the action.

ARTICLE 9 — IMPLEMENTATION OF ACTION TASKS BY BENEFICIARIES NOT RECEIVING EU FUNDING

Not applicable

ARTICLE 10 — PURCHASE OF GOODS, WORKS OR SERVICES

10.1 Rules for purchasing goods, works or services

10.1.1 If necessary to implement the action, the beneficiaries may purchase goods, works or services.

The beneficiaries must make such purchases ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their contractors.

10.1.2 Beneficiaries that are 'contracting authorities' within the meaning of Directive 2004/18/EC[6] or 'contracting entities' within the meaning of Directive 2004/17/EC[7] must comply with the applicable national law on public procurement.

[6] Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public work contracts, public supply contracts and public service contracts (OJ L 134, 30.04.2004, p. 114).

[7] Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors (OJ L 134, 30.04.2004, p. 1).

10.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 10.1.1, the costs related to the contract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).

If a beneficiary breaches any of its obligations under Article 10.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 11 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES AGAINST PAYMENT

11.1 Rules for the use of in-kind contributions against payment

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties against payment.

The beneficiaries may declare costs related to the payment of in-kind contributions as eligible (see Article 6.1 and 6.2), up to the third parties' costs for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services.

The third parties and their contributions must be set out in Annex 1. The *Commission* may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

11.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs related to the payment of the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 12 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES FREE OF CHARGE

12.1 Rules for the use of in-kind contributions free of charge

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties free of charge.

The beneficiaries may declare costs incurred by the third parties for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services as eligible in accordance with Article 6.4.

The third parties and their contributions must be set out in Annex 1. The *Commission* may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and

- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

12.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs incurred by the third parties related to the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 13 — IMPLEMENTATION OF ACTION TASKS BY SUBCONTRACTORS

13.1 Rules for subcontracting action tasks

13.1.1 If necessary to implement the action, the beneficiaries may award subcontracts covering the implementation of certain action tasks described in Annex 1.

Subcontracting may cover only a limited part of the action.

The beneficiaries must award the subcontracts ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The tasks to be implemented and the estimated cost for each subcontract must be set out in Annex 1 and the total estimated costs of subcontracting per beneficiary must be set out in Annex 2. The *Commission* may however approve subcontracts not set out in Annex 1 and 2 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and

- they do not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their subcontractors.

13.1.2 The beneficiaries must ensure that their obligations under Articles 35, 36, 38 and 46 also apply to the subcontractors.

Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC or ‘contracting entities’ within the meaning of Directive 2004/17/EC must comply with the applicable national law on public procurement.

13.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 13.1.1, the costs related to the subcontract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).

If a beneficiary breaches any of its obligations under Article 13.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 14 — IMPLEMENTATION OF ACTION TASKS BY LINKED THIRD PARTIES

14.1 Rules for calling upon linked third parties to implement part of the action

*14.1.1 The following **affiliated entities**[9] and **third parties with a legal link to a beneficiary**[10] (‘**linked third parties**’) may implement the action tasks attributed to them in Annex 1:*

- *OBSERVATOIRE DE PARIS (OBSPARIS), affiliated or linked to CNRS*
- *UNIVERSITE DE STRASBOURG (UNISTRA), affiliated or linked to CNRS*
- *GTD SISTEMAS DE INFORMACION SA (GTD), affiliated or linked to IEEC*

The linked third parties may declare as eligible the costs they incur for implementing the action tasks in accordance with Article 6.3.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their linked third parties.

14.1.2 The beneficiaries must ensure that their obligations under Articles 18, 20, 35, 36 and 38 also apply to their linked third parties.

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[9] For the definition, see Article 2.1(2) of the Rules for Participation Regulation No 1290/2013: '**affiliated entity**' means any legal entity that is:
- under the direct or indirect control of a participant, or
- under the same direct or indirect control as the participant, or
- directly or indirectly controlling a participant.

‘Control’ may take any of the following forms:
(a) the direct or indirect holding of more than 50% of the nominal value of the issued share capital in the legal entity concerned, or of a majority of the voting rights of the shareholders or associates of that entity;
(b) the direct or indirect holding, in fact or in law, of decision-making powers in the legal entity concerned.

However the following relationships between legal entities shall not in themselves be deemed to constitute controlling relationships:
(a) the same public investment corporation, institutional investor or venture-capital company has a direct or indirect holding of more than 50% of the nominal value of the issued share capital or a majority of voting rights of the shareholders or associates;
(b) the legal entities concerned are owned or supervised by the same public body.

[10] ‘**Third party with a legal link to a beneficiary**’ is any legal entity which has a legal link to the beneficiary implying collaboration that is not limited to the action.

14.2 Consequences of non-compliance

If any obligation under Article 14.1.1 is breached, the costs of the linked third party will be ineligible (see Article 6) and will be rejected (see Article 42).

If any obligation under Article 14.1.2 is breached, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 15 — FINANCIAL SUPPORT TO THIRD PARTIES

15.1 Rules for providing financial support to third parties

Not applicable

15.2 Financial support in the form of prizes

Not applicable

15.3 Consequences of non-compliance

Not applicable

ARTICLE 16 — PROVISION OF TRANS-NATIONAL OR VIRTUAL ACCESS TO RESEARCH INFRASTRUCTURE

16.1 Rules for providing trans-national access to research infrastructure

Not applicable

16.2 Rules for providing virtual access to research infrastructure

Not applicable

16.3 Consequences of non-compliance

Not applicable

SECTION 2 RIGHTS AND OBLIGATIONS RELATED TO THE GRANT ADMINISTRATION

ARTICLE 17 — GENERAL OBLIGATION TO INFORM

17.1 General obligation to provide information upon request

The beneficiaries must provide — during implementation of the action or afterwards and in accordance with Article 41.2 — any information requested in order to verify eligibility of the costs, proper implementation of the action and compliance with any other obligation under the Agreement.

17.2 Obligation to keep information up to date and to inform about events and circumstances likely to affect the Agreement

Each beneficiary must keep information stored in the 'Beneficiary Register' (via the electronic exchange system; see Article 52) up to date, in particular, its name, address, legal representatives, legal form and organisation type.

Each beneficiary must immediately inform the coordinator — which must immediately inform the *Commission* and the other beneficiaries — of any of the following:

(a) **events** which are likely to affect significantly or delay the implementation of the action or the EU's financial interests, in particular:

(i) changes in its legal, financial, technical, organisational or ownership situation *or those of its linked third parties and*

(ii) changes in the name, address, legal form, organisation type of its linked third parties;

(b) **circumstances** affecting:

(i) the decision to award the grant or

(ii) compliance with requirements under the Agreement.

17.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 18 — KEEPING RECORDS — SUPPORTING DOCUMENTATION

18.1 Obligation to keep records and other supporting documentation

The beneficiaries must — for a period of *five* years after the payment of the balance — keep records and other supporting documentation in order to prove the proper implementation of the action and the costs they declare as eligible.

They must make them available upon request (see Article 17) or in the context of checks, reviews, audits or investigations (see Article 22).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Articles 22), the beneficiaries must keep the records and other supporting documentation until the end of these procedures.

The beneficiaries must keep the original documents. Digital and digitalised documents are considered originals if they are authorised by the applicable national law. The *Commission* may accept non-original documents if it considers that they offer a comparable level of assurance.

18.1.1 Records and other supporting documentation on the scientific and technical implementation

The beneficiaries must keep records and other supporting documentation on scientific and technical implementation of the action in line with the accepted standards in the respective field.

18.1.2 Records and other documentation to support the costs declared

The beneficiaries must keep the records and documentation supporting the costs declared, in particular the following:

(a) for **actual costs**: adequate records and other supporting documentation to prove the costs declared, such as contracts, subcontracts, invoices and accounting records. In addition, the beneficiaries' usual cost accounting practices and internal control procedures must enable direct reconciliation between the amounts declared, the amounts recorded in their accounts and the amounts stated in the supporting documentation;

(b) for **unit costs**: adequate records and other supporting documentation to prove the number of units declared. Beneficiaries do not need to identify the actual eligible costs covered or to keep or provide supporting documentation (such as accounting statements) to prove the amount per unit.

In addition, **for direct personnel costs declared as unit costs calculated in accordance with the beneficiary's usual cost accounting practices**, the beneficiaries must keep adequate records and documentation to prove that the cost accounting practices used comply with the conditions set out in Article 6.2, Point A.

The beneficiaries *and linked third parties* may submit to the Commission, for approval, a certificate (drawn up in accordance with Annex 6) stating that their usual cost accounting practices comply with these conditions ('**certificate on the methodology**'). If the certificate is approved, costs declared in line with this methodology will not be challenged subsequently, unless the beneficiaries have concealed information for the purpose of the approval.

(c) for **flat-rate costs**: adequate records and other supporting documentation to prove the eligibility of the costs to which the flat-rate is applied. The beneficiaries do not need to identify the costs covered or provide supporting documentation (such as accounting statements) to prove the amount declared at a flat-rate.

In addition, for **personnel costs** (declared as actual costs or on the basis of unit costs), the beneficiaries must keep **time records** for the number of hours declared. The time records must be in writing and approved by the persons working on the action and their supervisors, at least monthly. In the absence of reliable time records of the hours worked on the action, the *Commission* may accept alternative evidence supporting the number of hours declared, if it considers that it offers an adequate level of assurance.

As an exception, for **persons working exclusively on the action**, there is no need to keep time records, if the beneficiary signs a **declaration** confirming that the persons concerned have worked exclusively on the action.

For costs declared by linked third parties (see Article 14), it is the beneficiary that must keep the originals of the financial statements and the certificates on the financial statements of the linked third parties.

18.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, costs insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 42), and the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 19 — SUBMISSION OF DELIVERABLES

19.1 Obligation to submit deliverables

The coordinator must submit the '**deliverables**' identified in Annex 1, in accordance with the timing and conditions set out in it.

19.2 Consequences of non-compliance

If the coordinator breaches any of its obligations under this Article, the *Commission* may apply any of the measures described in Chapter 6.

ARTICLE 20 — REPORTING — PAYMENT REQUESTS

20.1 Obligation to submit reports

The coordinator must submit to the *Commission* (see Article 52) the technical and financial reports set out in this Article. These reports include the requests for payment and must be drawn up using the forms and templates provided in the electronic exchange system (see Article 52).

20.2 Reporting periods

The action is divided into the following '**reporting periods**':
- RP1: from month 1 to month 18
- *RP2: from month 19 to month 36*
- *RP3: from month 37 to month 48*

20.3 Periodic reports — Requests for interim payments

The coordinator must submit a periodic report within 60 days following the end of each reporting period.

The **periodic report** must include the following:

(a) a '**periodic technical report**' containing:

(i) an **explanation of the work carried out** by the beneficiaries;

(ii) an **overview of the progress** towards the objectives of the action, including milestones and deliverables identified in Annex 1.

This report must include explanations justifying the differences between work expected to be carried out in accordance with Annex 1 and that actually carried out.

The report must also detail the exploitation and dissemination of the results and — if required in Annex 1 — an updated '**plan for the exploitation and dissemination of the results**';

(iii) a **summary** for publication by the *Commission*;

(iv) the answers to the '**questionnaire**', covering issues related to the action implementation and the economic and societal impact, notably in the context of the Horizon 2020 key performance indicators and the Horizon 2020 monitoring requirements;

(b) a '**periodic financial report**' containing:

(i) an '**individual financial statement**' (see Annex 4) from each beneficiary *and from each linked third party*, for the reporting period concerned.

The individual financial statement must detail the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) for each budget category (see Annex 2).

The beneficiaries *and linked third parties* must declare all eligible costs, even if — for actual costs, unit costs and flat-rate costs — they exceed the amounts indicated in the estimated budget (see Annex 2). Amounts which are not declared in the individual financial statement will not be taken into account by the *Commission*.

If an individual financial statement is not submitted for a reporting period, it may be included in the periodic financial report for the next reporting period.

The individual financial statements of the last reporting period must also detail the **receipts of the action** (see Article 5.3.3).

Each beneficiary *and each linked third party* must **certify** that:

- the information provided is full, reliable and true;
- the costs declared are eligible (see Article 6);
- the costs can be substantiated by adequate records and supporting documentation (see Article 18) that will be produced upon request (see Article 17) or in the context of checks, reviews, audits and investigations (see Article 22), and
- for the last reporting period: that all the receipts have been declared (see Article 5.3.3);

(ii) an **explanation of the use of resources** and the information on subcontracting (see Article 13) and in-kind contributions provided by third parties (see Articles 11 and

12) from each beneficiary *and from each linked third party*, for the reporting period concerned;

(iii) *not applicable;*

(iv) a '**periodic summary financial statement**' (see Annex 4), created automatically by the electronic exchange system, consolidating the individual financial statements for the reporting period concerned and including — except for the last reporting period — the **request for interim payment**.

20.4 Final report — Request for payment of the balance

In addition to the periodic report for the last reporting period, the coordinator must submit the final report within 60 days following the end of the last reporting period.

The **final report** must include the following:

(a) a '**final technical report**' with a **summary** for publication containing:

(i) an overview of the results and their exploitation and dissemination;

(ii) the conclusions on the action, and

(iii) the socio-economic impact of the action;

(b) a '**final financial report**' containing:

(i) a '**final summary financial statement**' (see Annex 4), created automatically by the electronic exchange system, consolidating the individual financial statements for all reporting periods and including the **request for payment of the balance** and

(ii) a '**certificate on the financial statements**' (drawn up in accordance with Annex 5) for each beneficiary *and for each linked third party*, if it requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 5.2 and Article 6.2, Point A).

20.5 Information on cumulative expenditure incurred

Not applicable

20.6 Currency for financial statements and conversion into euro

Financial statements must be drafted in euro.

Beneficiaries *and linked third parties* with accounting established in a currency other than the euro must convert the costs recorded in their accounts into euro, at the average of the daily exchange rates published in the C series of the *Official Journal of the European Union*, calculated over the corresponding reporting period.

If no daily euro exchange rate is published in the *Official Journal of the European Union* for the currency in question, they must be converted at the average of the monthly accounting rates published on the Commission's website, calculated over the corresponding reporting period.

Beneficiaries *and linked third parties* with accounting established in euro must convert costs incurred in another currency into euro according to their usual accounting practices.

20.7 Language of reports

All reports (technical and financial reports, including financial statements) must be submitted in the language of the Agreement.

20.8 Consequences of non-compliance — Suspension of the payment deadline — Termination

If the reports submitted do not comply with this Article, the *Commission* may suspend the payment deadline (see Article 47) and apply any of the other measures described in Chapter 6.

If the coordinator breaches its obligation to submit the reports and if it fails to comply with this obligation within 30 days following a written reminder sent by the *Commission*, the Agreement may be terminated (see Article 50).

ARTICLE 21 — PAYMENTS AND PAYMENT ARRANGEMENTS

21.1 Payments to be made

The following payments will be made to the coordinator:

- one **pre-financing payment**;
- one or more **interim payments**, on the basis of the request(s) for interim payment (see Article 20), and
- one **payment of the balance**, on the basis of the request for payment of the balance (see Article 20).

21.2 Pre-financing payment — Amount — Amount retained for the Guarantee Fund

The aim of the pre-financing is to provide the beneficiaries with a float.

It remains the property of the *EU* until the payment of the balance.

The amount of the pre-financing payment will be EUR **5,621,697.94** (five million six hundred and twenty one thousand six hundred and ninety seven EURO and ninety four eurocents).

The *Commission* will — except if Article 48 applies — make the pre-financing payment to the coordinator within 30 days either from the entry into force of the Agreement (see Article 58) or from 10 days before the starting date of the action (see Article 3), whichever is the latest.

An amount of EUR **749,559.70** (seven hundred and forty nine thousand five hundred and fifty nine EURO and seventy eurocents), corresponding to 5% of the maximum grant amount (see Article 5.1),

is retained by the *Commission* from the pre-financing payment and transferred into the '**Guarantee Fund**'.

21.3 Interim payments — Amount — Calculation

Interim payments reimburse the eligible costs incurred for the implementation of the action during the corresponding reporting periods.

The *Commission* will pay to the coordinator the amount due as interim payment within 90 days from receiving the periodic report (see Article 20.3), except if Articles 47 or 48 apply.

Payment is subject to the approval of the periodic report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as interim payment** is calculated by the *Commission* in the following steps:

Step 1 – Application of the reimbursement rates

Step 2 – Limit to 90% of the maximum grant amount

21.3.1 Step 1 — Application of the reimbursement rates

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs ; see Article 6) declared by the beneficiaries *and the linked third parties* (see Article 20) and approved by the *Commission* (see above) for the concerned reporting period.

21.3.2 Step 2 — Limit to 90% of the maximum grant amount

The total amount of pre-financing and interim payments must not exceed 90% of the maximum grant amount set out in Article 5.1. The maximum amount for the interim payment will be calculated as follows:

{90% of the maximum grant amount (see Article 5.1)

minus

{pre-financing and previous interim payments}}.

21.4 Payment of the balance — Amount — Calculation — Release of the amount retained for the Guarantee Fund

The payment of the balance reimburses the remaining part of the eligible costs incurred by the beneficiaries for the implementation of the action.

If the total amount of earlier payments is greater than the final grant amount (see Article 5.3), the payment of the balance takes the form of a recovery (see Article 44).

If the total amount of earlier payments is lower than the final grant amount, the *Commission* will pay the balance within 90 days from receiving the final report (see Article 20.4), except if Articles 47 or 48 apply.

Payment is subject to the approval of the final report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as the balance** is calculated by the *Commission* by deducting the total amount of pre-financing and interim payments (if any) already made, from the final grant amount determined in accordance with Article 5.3:

{final grant amount (see Article 5.3)

minus

{pre-financing and interim payments (if any) made}}.

At the payment of the balance, the amount retained for the Guarantee Fund (see above) will be released and:

- if the balance is positive: the amount released will be paid in full to the coordinator together with the amount due as the balance;

- if the balance is negative (payment of the balance taking the form of recovery): it will be deducted from the amount released (see Article 44.1.2). If the resulting amount:

    - is positive, it will be paid to the coordinator

    - is negative, it will be recovered.

The amount to be paid may however be offset — without the beneficiary's consent — against any other amount owed by the beneficiary to the Commission or an executive agency (under the EU or Euratom budget), up to the maximum EU contribution indicated, for that beneficiary, in the estimated budget (see Annex 2).

21.5 Notification of amounts due

When making payments, the *Commission* will formally notify to the coordinator the amount due, specifying whether it concerns an interim payment or the payment of the balance.

For the payment of the balance, the notification will also specify the final grant amount.

In the case of reduction of the grant or recovery of undue amounts, the notification will be preceded by the contradictory procedure set out in Articles 43 and 44.

21.6 Currency for payments

The *Commission* will make all payments in euro.

21.7 Payments to the coordinator — Distribution to the beneficiaries

Payments will be made to the coordinator.

Payments to the coordinator will discharge the *Commission* from its payment obligation.

The coordinator must distribute the payments between the beneficiaries without unjustified delay.

Pre-financing may however be distributed only:

(a) if the minimum number of beneficiaries set out in the call for proposals has acceded to the Agreement (see Article 56) and

(b) to beneficiaries that have acceded to the Agreement (see Article 56).

21.8 Bank account for payments

All payments will be made to the following bank account:

Name of bank: ABN AMRO BANK N.V.
Address of branch: 10, GUSTAV MAHLERLAAN AMSTERDAM, Netherlands
Full name of the account holder: ASTRON
Full account number (including bank codes):
IBAN code: NL82ABNA0642388180

21.9 Costs of payment transfers

The cost of the payment transfers is borne as follows:

- the *Commission* bears the cost of transfers charged by its bank;
- the beneficiary bears the cost of transfers charged by its bank;
- the party causing a repetition of a transfer bears all costs of the repeated transfer.

21.10 Date of payment

Payments by the *Commission* are considered to have been carried out on the date when they are debited to its account.

21.11 Consequences of non-compliance

21.11.1 If the *Commission* does not pay within the payment deadlines (see above), the beneficiaries are entitled to **late-payment interest** at the rate applied by the European Central Bank (ECB) for its main refinancing operations in euros ('reference rate'), plus three and a half points. The reference rate is the rate in force on the first day of the month in which the payment deadline expires, as published in the C series of the *Official Journal of the European Union*.

If the late-payment interest is lower than or equal to EUR 200, it will be paid to the coordinator only upon request submitted within two months of receiving the late payment.

Late-payment interest is not due if all beneficiaries are EU Member States (including regional and local government authorities or other public bodies acting on behalf of a Member State for the purpose of this Agreement).

Suspension of the payment deadline or payments (see Articles 47 and 48) will not be considered as late payment.

Late-payment interest covers the period running from the day following the due date for payment (see above), up to and including the date of payment.

Late-payment interest is not considered for the purposes of calculating the final grant amount.

21.11.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or the participation of the coordinator may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 22 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

22.1 Checks, reviews and audits by the Commission

22.1.1 Right to carry out checks

The Commission will — during the implementation of the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing deliverables and reports.

For this purpose the Commission may be assisted by external persons or bodies.

The Commission may also request additional information in accordance with Article 17. The Commission may request beneficiaries to provide such information to it directly.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

22.1.2 Right to carry out reviews

The Commission may — during the implementation of the action or afterwards — carry out reviews on the proper implementation of the action (including assessment of deliverables and reports), compliance with the obligations under the Agreement and continued scientific or technological relevance of the action.

Reviews may be started **up to two years after the payment of the balance**. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the review is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The Commission may carry out reviews directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted (including information on the use of resources). The Commission may request beneficiaries to provide such information to it directly.

The coordinator or beneficiary concerned may be requested to participate in meetings, including with external experts.

For **on-the-spot** reviews, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the review findings, a '**review report**' will be drawn up.

The Commission will formally notify the review report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations ('**contradictory review procedure**').

Reviews (including review reports) are in the language of the Agreement.

22.1.3 Right to carry out audits

The Commission may — during the implementation of the action or afterwards — carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Audits may be started **up to two years after the payment of the balance**. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the audit is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The Commission may carry out audits directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data) to verify compliance with the Agreement. The Commission may request beneficiaries to provide such information to it directly.

For **on-the-spot** audits, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the audit findings, a '**draft audit report**' will be drawn up.

The Commission will formally notify the draft audit report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations ('**contradictory audit procedure**'). This period may be extended by the Commission in justified cases.

The '**final audit report**' will take into account observations by the coordinator or beneficiary concerned. The report will be formally notified to it.

Audits (including audit reports) are in the language of the Agreement.

The Commission may also access the beneficiaries' statutory records for the periodical assessment of unit costs or flat-rate amounts.

22.2 Investigations by the European Anti-Fraud Office (OLAF)

Under Regulations No 883/2013[15] and No 2185/96[16] (and in accordance with their provisions and procedures) the European Anti-Fraud Office (OLAF) may — at any moment during implementation of the action or afterwards — carry out investigations, including on-the-spot checks and inspections, to establish whether there has been fraud, corruption or any other illegal activity affecting the financial interests of the EU.

22.3 Checks and audits by the European Court of Auditors (ECA)

Under Article 287 of the Treaty on the Functioning of the European Union (TFEU) and Article 161 of the Financial Regulation No 966/2012[17], the European Court of Auditors (ECA) may — at any moment during implementation of the action or afterwards — carry out audits.

The ECA has the right of access for the purpose of checks and audits.

22.4 Checks, reviews, audits and investigations for international organisations

Not applicable

22.5 Consequences of findings in checks, reviews, audits and investigations — Extension of findings

22.5.1 Findings in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to the rejection of ineligible costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44) or to any of the other measures described in Chapter 6.

Rejection of costs or reduction of the grant after the payment of the balance will lead to a revised final grant amount (see Article 5.4).

Findings in checks, reviews, audits or investigations may lead to a request for amendment for the modification of Annex 1 (see Article 55).

Checks, reviews, audits or investigations that find systemic or recurrent errors, irregularities, fraud or breach of obligations may also lead to consequences in other EU or Euratom grants awarded under similar conditions ('**extension of findings from this grant to other grants**').

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[15] Regulation (EU, Euratom) No 883/2013 of the European Parliament and of the Council of 11 September 2013 concerning investigations conducted by the European Anti-Fraud Office (OLAF) and repealing Regulation (EC) No 1073/1999 of the European Parliament and of the Council and Council Regulation (Euratom) No 1074/1999 (OJ L 248, 18.09.2013, p. 1).

[16] Council Regulation (Euratom, EC) No 2185/1996 of 11 November 1996 concerning on-the-spot checks and inspections carried out by the Commission in order to protect the European Communities' financial interests against fraud and other irregularities (OJ L 292, 15.11.1996, p. 2).

[17] Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 ('**Financial Regulation No 966/2012**') (OJ L 298, 26.10.2012, p. 1).

Moreover, findings arising from an OLAF investigation may lead to criminal prosecution under national law.

22.5.2 Findings in other grants

The Commission may extend findings from other grants to this grant ('**extension of findings from other grants to this grant**'), if:

(a) the beneficiary concerned is found, in other EU or Euratom grants awarded under similar conditions, to have committed systemic or recurrent errors, irregularities, fraud or breach of obligations that have a material impact on this grant and

(b) those findings are formally notified to the beneficiary concerned — together with the list of grants affected by the findings — no later than two years after the payment of the balance of this grant.

The extension of findings may lead to the rejection of costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44), suspension of payments (see Article 48), suspension of the action implementation (see Article 49) or termination (see Article 50).

22.5.3 Procedure

The Commission will formally notify the beneficiary concerned the systemic or recurrent errors and its intention to extend these audit findings, together with the list of grants affected.

22.5.3.1 If the findings concern **eligibility of costs**: the formal notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings;

(b) the request to submit **revised financial statements** for all grants affected;

(c) the **correction rate for extrapolation** established by the Commission on the basis of the systemic or recurrent errors, to calculate the amounts to be rejected if the beneficiary concerned:

(i) considers that the submission of revised financial statements is not possible or practicable or

(ii) does not submit revised financial statements.

The beneficiary concerned has 90 days from receiving notification to submit observations, revised financial statements or to propose a duly substantiated **alternative correction method**. This period may be extended by the Commission in justified cases.

The amounts to be rejected will be determined on the basis of the revised financial statements, subject to their approval.

If the Commission does not receive any observations or revised financial statements, does not accept the observations or the proposed alternative correction method or does not approve the revised financial statements, it will formally notify the beneficiary concerned the application of the initially notified correction rate for extrapolation.

If the Commission accepts the alternative correction method proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative correction method.

22.5.3.2 If the findings concern **improper implementation** or a **breach of another obligation**: the formal notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings and

(b) the flat-rate the Commission intends to apply according to the principle of proportionality.

The beneficiary concerned has 90 days from receiving notification to submit observations or to propose a duly substantiated alternative flat-rate.

If the Commission does not receive any observations or does not accept the observations or the proposed alternative flat-rate, it will formally notify the beneficiary concerned the application of the initially notified flat-rate.

If the Commission accepts the alternative flat-rate proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative flat-rate.

22.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, any insufficiently substantiated costs will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 23 — EVALUATION OF THE IMPACT OF THE ACTION

23.1 Right to evaluate the impact of the action

The Commission may carry out interim and final evaluations of the impact of the action measured against the objective of the *EU* programme.

Evaluations may be started during implementation of the action and up to *five* years after the payment of the balance. The evaluation is considered to start on the date of the formal notification to the coordinator or beneficiaries.

The Commission may make these evaluations directly (using its own staff) or indirectly (using external bodies or persons it has authorised to do so).

The coordinator or beneficiaries must provide any information relevant to evaluate the impact of the action, including information in electronic format.

23.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the *Commission* may apply the measures described in Chapter 6.

SECTION 3 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND AND RESULTS

SUBSECTION 1 GENERAL

ARTICLE 23a — MANAGEMENT OF INTELLECTUAL PROPERTY

23a.1 Obligation to take measures to implement the Commission Recommendation on the management of intellectual property in knowledge transfer activities

Beneficiaries that are universities or other public research organisations must take measures to implement the principles set out in Points 1 and 2 of the Code of Practice annexed to the Commission Recommendation on the management of intellectual property in knowledge transfer activities[18].

This does not change the obligations set out in Subsections 2 and 3 of this Section.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

23a.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the *Commission* may apply any of the measures described in Chapter 6.

SUBSECTION 2 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND

ARTICLE 24 — AGREEMENT ON BACKGROUND

24.1 Agreement on background

The beneficiaries must identify and agree (in writing) on the background for the action ('**agreement on background**').

'**Background**' means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that:

(a) is held by the beneficiaries before they acceded to the Agreement, and

(b) is needed to implement the action or exploit the results.

24.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

[18] Commission Recommendation C (2008) 1329 of 10.4.2008 on the management of intellectual property in knowledge transfer activities and the Code of Practice for universities and other public research institutions attached to this recommendation.

ARTICLE 25 — ACCESS RIGHTS TO BACKGROUND

25.1 Exercise of access rights — Waiving of access rights — No sub-licensing

To exercise access rights, this must first be requested in writing ('**request for access**').

'**Access rights**' means rights to use results or background under the terms and conditions laid down in this Agreement.

Waivers of access rights are not valid unless in writing.

Unless agreed otherwise, access rights do not include the right to sub-license.

25.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to background needed to implement their own tasks under the action, unless the beneficiary that holds the background has — before acceding to the Agreement —:

(a) informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel), or

(b) agreed with the other beneficiaries that access would not be on a royalty-free basis.

25.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other access — under fair and reasonable conditions — to background needed for exploiting their own results, unless the beneficiary that holds the background has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel).

'**Fair and reasonable conditions**' means appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.4 Access rights for affiliated entities

Unless otherwise agreed in the consortium agreement, access to background must also be given — under fair and reasonable conditions (see above; Article 25.3) and unless it is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel) — to affiliated entities[19] established in an EU Member State or '**associated country**' [20], if this is needed to exploit the results generated by the beneficiaries to which they are affiliated.

[19] For the definition, see 'affiliated entity' footnote (Article 14.1).

Unless agreed otherwise (see above; Article 25.1), the affiliated entity concerned must make the request directly to the beneficiary that holds the background.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.5 Access rights for third parties

Not applicable

25.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SUBSECTION 3 RIGHTS AND OBLIGATIONS RELATED TO RESULTS

ARTICLE 26 — OWNERSHIP OF RESULTS

26.1 Ownership by the beneficiary that generates the results

Results are owned by the beneficiary that generates them.

'**Results**' means any (tangible or intangible) output of the action such as data, knowledge or information — whatever its form or nature, whether it can be protected or not — that is generated in the action, as well as any rights attached to it, including intellectual property rights.

26.2 Joint ownership by several beneficiaries

Two or more beneficiaries own results jointly if:

(a) they have jointly generated them and

(b) it is not possible to:

(i) establish the respective contribution of each beneficiary, or

(ii) separate them for the purpose of applying for, obtaining or maintaining their protection (see Article 27).

The joint owners must agree (in writing) on the allocation and terms of exercise of their joint ownership ('**joint ownership agreement**'), to ensure compliance with their obligations under this Agreement.

[20] For the definition, see Article 2.1(3) of the Rules for Participation Regulation No 1290/2013: '**associated country**' means a third country which is party to an international agreement with the Union, as identified in *Article 7 of Horizon 2020 Framework Programme Regulation No 1291/2013. Article 7 sets out the conditions for association of non-EU countries to Horizon 2020.*

Unless otherwise agreed in the joint ownership agreement, each joint owner may grant non-exclusive licences to third parties to exploit jointly-owned results (without any right to sub-license), if the other joint owners are given:

(a) at least 45 days advance notice and

(b) fair and reasonable compensation.

Once the results have been generated, joint owners may agree (in writing) to apply another regime than joint ownership (such as, for instance, transfer to a single owner (see Article 30) with access rights for the others).

26.3 Rights of third parties (including personnel)

If third parties (including personnel) may claim rights to the results, the beneficiary concerned must ensure that it complies with its obligations under the Agreement.

If a third party generates results, the beneficiary concerned must obtain all necessary rights (transfer, licences or other) from the third party, in order to be able to respect its obligations as if those results were generated by the beneficiary itself.

If obtaining the rights is impossible, the beneficiary must refrain from using the third party to generate the results.

26.4 *EU* ownership, to protect results

26.4.1 *The EU* may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to disseminate its results without protecting them, except in any of the following cases:

(a) the lack of protection is because protecting the results is not possible, reasonable or justified (given the circumstances);

(b) the lack of protection is because there is a lack of potential for commercial or industrial exploitation, or

(c) the beneficiary intends to transfer the results to another beneficiary or third party established in an EU Member State or associated country, which will protect them.

Before the results are disseminated and unless any of the cases above under Points (a), (b) or (c) applies, the beneficiary must formally notify the *Commission* and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the *Commission* decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

No dissemination relating to these results may before the end of this period or, if the *Commission* takes a positive decision, until it has taken the necessary steps to protect the results.

26.4.2 *The EU* may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to stop protecting them or not to seek an extension of protection, except in any of the following cases:

(a) the protection is stopped because of a lack of potential for commercial or industrial exploitation;

(b) an extension would not be justified given the circumstances.

A beneficiary that intends to stop protecting results or not seek an extension must — unless any of the cases above under Points (a) or (b) applies — formally notify the *Commission* at least 60 days before the protection lapses or its extension is no longer possible and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the *Commission* decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

26.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to the any of the other measures described in Chapter 6.

ARTICLE 27 — PROTECTION OF RESULTS — VISIBILITY OF EU FUNDING

27.1 Obligation to protect the results

Each beneficiary must examine the possibility of protecting its results and must adequately protect them — for an appropriate period and with appropriate territorial coverage — if:

(a) the results can reasonably be expected to be commercially or industrially exploited and

(b) protecting them is possible, reasonable and justified (given the circumstances).

When deciding on protection, the beneficiary must consider its own legitimate interests and the legitimate interests (especially commercial) of the other beneficiaries.

27.2 *EU* ownership, to protect the results

If a beneficiary intends not to protect its results, to stop protecting them or not seek an extension of protection, *The EU* may — under certain conditions (see Article 26.4) — assume ownership to ensure their (continued) protection.

27.3 Information on EU funding

Applications for protection of results (including patent applications) filed by or on behalf of a beneficiary must — unless the *Commission* requests or agrees otherwise or unless it is impossible — include the following:

> "The project leading to this application has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 653477".

27.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 28 — EXPLOITATION OF RESULTS

28.1 Obligation to exploit the results

Each beneficiary must — up to four years after the period set out in Article 3 — take measures aiming to ensure '**exploitation**' of its results (either directly or indirectly, in particular through transfer or licensing; see Article 30) by:

(a) using them in further research activities (outside the action);

(b) developing, creating or marketing a product or process;

(c) creating and providing a service, or

(d) using them in standardisation activities.

This does not change the security obligations in Article 37, which still apply.

28.2 Results that could contribute to European or international standards — Information on EU funding

If results could reasonably be expected to contribute to European or international standards, the beneficiary concerned must — up to four years after the period set out in Article 3 — inform the Commission.

If results are incorporated in a standard, the beneficiary concerned must — unless the *Commission* requests or agrees otherwise or unless it is impossible — ask the standardisation body to include the following statement in (information related to) the standard:

> "Results incorporated in this standard received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 653477".

28.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced in accordance with Article 43.

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 29 — DISSEMINATION OF RESULTS — OPEN ACCESS — VISIBILITY OF EU FUNDING

29.1 Obligation to disseminate results

Unless it goes against their legitimate interests, each beneficiary must — as soon as possible — '**disseminate**' its results by disclosing them to the public by appropriate means (other than those

resulting from protecting or exploiting the results), including in scientific publications (in any medium).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

A beneficiary that intends to disseminate its results must give advance notice to the other beneficiaries of — unless agreed otherwise — at least 45 days, together with sufficient information on the results it will disseminate.

Any other beneficiary may object within — unless agreed otherwise — 30 days of receiving notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the dissemination may not take place unless appropriate steps are taken to safeguard these legitimate interests.

If a beneficiary intends not to protect its results, it may — under certain conditions (see Article 26.4.1) — need to formally notify the *Commission* before dissemination takes place.

29.2 Open access to scientific publications

Each beneficiary must ensure open access (free of charge online access for any user) to all peer-reviewed scientific publications relating to its results.

In particular, it must:

(a) as soon as possible and at the latest on publication, deposit a machine-readable electronic copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific publications;

Moreover, the beneficiary must aim to deposit at the same time the research data needed to validate the results presented in the deposited scientific publications.

(b) ensure open access to the deposited publication — via the repository — at the latest:

(i) on publication, if an electronic version is available for free via the publisher, or

(ii) within six months of publication (twelve months for publications in the social sciences and humanities) in any other case.

(c) ensure open access — via the repository — to the bibliographic metadata that identify the deposited publication.

The bibliographic metadata must be in a standard format and must include all of the following:

- the terms *"European Union (EU)" and "Horizon 2020"*;

- the name of the action, acronym and grant number;

- the publication date, and length of embargo period if applicable, and

- a persistent identifier.

29.3 Open access to research data

Not applicable

29.4 Information on EU funding — Obligation and right to use the EU emblem

Unless the *Commission* requests or agrees otherwise or unless it is impossible, any dissemination of results (in any form, including electronic) must:

(a) display the EU emblem and

(b) include the following text:

> "This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 653477".

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the *Commission*.

This does not however give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

29.5 Disclaimer excluding *Commission* responsibility

Any dissemination of results must indicate that it reflects only the author's view and that the *Commission* is not responsible for any use that may be made of the information it contains.

29.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 30 — TRANSFER AND LICENSING OF RESULTS

30.1 Transfer of ownership

Each beneficiary may transfer ownership of its results.

It must however ensure that its obligations under Articles 26.2, 26.4, 27, 28, 29, 30 and 31 also apply to the new owner and that this owner has the obligation to pass them on in any subsequent transfer.

This does not change the security obligations in Article 37, which still apply.

Unless agreed otherwise (in writing) for specifically-identified third parties or unless impossible under applicable EU and national laws on mergers and acquisitions, a beneficiary that intends to transfer ownership of results must give at least 45 days advance notice (or less if agreed in writing) to the other beneficiaries that still have (or still may request) access rights to the results. This notification must include sufficient information on the new owner to enable any beneficiary concerned to assess the effects on its access rights.

Unless agreed otherwise (in writing) for specifically-identified third parties, any other beneficiary may object within 30 days of receiving notification (or less if agreed in writing), if it can show that the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

30.2 Granting licenses

Each beneficiary may grant licences to its results (or otherwise give the right to exploit them), if:

(a) this does not impede the rights under Article 31 and

(b) *not applicable.*

In addition to Points (a) and (b), exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights (see Article 31.1).

This does not change the dissemination obligations in Article 29 or security obligations in Article 37, which still apply.

30.3 *Commission* right to object to transfers or licensing

Not applicable

30.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 31 — ACCESS RIGHTS TO RESULTS

31.1 Exercise of access rights — Waiving of access rights — No sub-licensing

The conditions set out in Article 25.1 apply.

The obligations set out in this Article do not change the security obligations in Article 37, which still apply.

31.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

31.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other — under fair and reasonable conditions (see Article 25.3) — access to results needed for exploiting their own results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.4 Access rights of affiliated entities

Unless agreed otherwise in the consortium agreement, access to results must also be given — under fair and reasonable conditions (Article 25.3) — to affiliated entities established in an EU Member State or associated country, if this is needed for those entities to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 31.1), the affiliated entity concerned must make any such request directly to the beneficiary that owns the results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.5 Access rights for the EU institutions, bodies, offices or agencies and EU Member States

The beneficiaries must give access to their results — on a royalty-free basis — to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes.

Such access rights are limited to non-commercial and non-competitive use.

This does not change the right to use any material, document or information received from the beneficiaries for communication and publicising activities (see Article 38.2).

31.6 Access rights for third parties

Not applicable

31.7 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SECTION 4 OTHER RIGHTS AND OBLIGATIONS

ARTICLE 32 — RECRUITMENT AND WORKING CONDITIONS FOR RESEARCHERS

32.1 Obligation to take measures to implement the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers

The beneficiaries must take all measures to implement the principles set out in the Commission Recommendation on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers[22], in particular regarding:

- working conditions;
- transparent recruitment processes based on merit, and
- career development.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

32.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the *Commission* may apply any of the measures described in Chapter 6.

ARTICLE 33 — GENDER EQUALITY

33.1 Obligation to aim for gender equality

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action. They must aim, to the extent possible, for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial level.

33.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the *Commission* may apply any of the measures described in Chapter 6.

ARTICLE 34 — ETHICS

34.1 Obligation to comply with ethical principles

The beneficiaries must carry out the action in compliance with:

(a) ethical principles (including the highest standards of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity[23] — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct) and

[22] Commission recommendation (EC) No 251/2005 of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers (OJ L 75, 22.03.2005, p. 67).

[23] The European Code of Conduct for Research Integrity of ALLEA (All European Academies) and ESF (European Science Foundation) of March 2011.
http://www.esf.org/fileadmin/Public_documents/Publications/Code_Conduct_ResearchIntegrity.pdf

(b) applicable international, EU and national law.

Funding will not be granted for activities carried out outside the EU if they are prohibited in all Member States.

The beneficiaries must ensure that the activities under the action have an exclusive focus on civil applications.

The beneficiaries must ensure that the activities under the action do not:

(a) aim at human cloning for reproductive purposes;

(b) intend to modify the genetic heritage of human beings which could make such changes heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed), or

(c) intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

34.2 Activities raising ethical issues

Activities raising ethical issues must comply with the '**ethics requirements**' set out in Annex 1.

Before the beginning of an activity raising an ethical issue, the coordinator must submit (see Article 52) to the *Commission* copy of:

(a) any ethics committee opinion required under national law and

(b) any notification or authorisation for activities raising ethical issues required under national law.

If these documents are not in English, the coordinator must also submit an English summary of the submitted opinions, notifications and authorisations (containing, if available, the conclusions of the committee or authority concerned).

If these documents are specifically requested for the action, the request must contain an explicit reference to the action title. The coordinator must submit a declaration by each beneficiary concerned that all the submitted documents cover the action tasks.

34.3 Activities involving human embryos or human embryonic stem cells

Activities involving research on human embryos or human embryonic stem cells may be carried out only if:

- they are set out in Annex 1 or
- the coordinator has obtained explicit approval (in writing) from the *Commission* (see Article 52).

34.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 35 — CONFLICT OF INTERESTS

35.1 Obligation to avoid a conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the action is compromised for reasons involving economic interest, political or national affinity, family or emotional ties or any other shared interest ('**conflict of interests**').

They must formally notify to the *Commission* without delay any situation constituting or likely to lead to a conflict of interests and immediately take all the necessary steps to rectify this situation.

The *Commission* may verify that the measures taken are appropriate and may require additional measures to be taken by a specified deadline.

35.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 36 — CONFIDENTIALITY

36.1 General obligation to maintain confidentiality

During implementation of the action and for four years after the period set out in Article 3, the parties must keep confidential any data, documents or other material (in any form) that is identified as confidential at the time it is disclosed ('**confidential information**').

If a beneficiary requests, the *Commission* may agree to keep such information confidential for an additional period beyond the initial four years.

If information has been identified as confidential only orally, it will be considered to be confidential only if this is confirmed in writing within 15 days of the oral disclosure.

Unless otherwise agreed between the parties, they may use confidential information only to implement the Agreement.

The beneficiaries may disclose confidential information to their personnel or third parties involved in the action only if they:

(a) need to know to implement the Agreement and

(b) are bound by an obligation of confidentiality.

This does not change the security obligations in Article 37, which still apply.

The *Commission* may disclose confidential information to its staff, other EU institutions and bodies or third parties, if:

(a) this is necessary to implement the Agreement or safeguard the EU's financial interests and

(b) the recipients of the information are bound by an obligation of confidentiality.

Under the conditions set out in Article 4 of the Rules for Participation Regulation No 1290/2013[24], the Commission must moreover make available information on the results to other EU institutions, bodies, offices or agencies as well as Member States or associated countries.

The confidentiality obligations no longer apply if:

(a) the disclosing party agrees to release the other party;

(b) the information was already known by the recipient or is given to him without obligation of confidentiality by a third party that was not bound by any obligation of confidentiality;

(c) the recipient proves that the information was developed without the use of confidential information;

(d) the information becomes generally and publicly available, without breaching any confidentiality obligation, or

(e) the disclosure of the information is required by EU or national law.

36.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 37 — SECURITY-RELATED OBLIGATIONS

37.1 Results with a security recommendation

Not applicable

37.2 Classified results

Not applicable

37.3 Activities involving dual-use goods or dangerous materials and substances

Not applicable

37.4 Consequences of non-compliance

Not applicable

[24] Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" (OJ L 347, 20.12.2013 p.81).

ARTICLE 38 — PROMOTING THE ACTION — VISIBILITY OF EU FUNDING

38.1 Communication activities by beneficiaries

38.1.1 Obligation to promote the action and its results

The beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public) in a strategic and effective manner.

This does not change the dissemination obligations in Article 29, the confidentiality obligations in Article 36 or the security obligations in Article 37, all of which still apply.

Before engaging in a communication activity expected to have a major media impact, the beneficiaries must inform the *Commission* (see Article 52).

38.1.2 Information on EU funding — Obligation and right to use the EU emblem

Unless the *Commission* requests or agrees otherwise or unless it is impossible, any communication activity related to the action (including in electronic form, via social media, etc.) and any infrastructure, equipment and major results funded by the grant must:

(a) display the EU emblem and

(b) include the following text:

> For communication activities: "This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 653477".
>
> For infrastructure, equipment and major results: "This *[infrastructure][equipment][insert type of result]* is part of a project that has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 653477".

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the *Commission*.

This does not, however, give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

38.1.3 Disclaimer excluding the *Commission* responsibility

Any communication activity related to the action must indicate that it reflects only the author's view and that the *Commission* is not responsible for any use that may be made of the information it contains.

38.2 Communication activities by the *Commission*

38.2.1 Right to use beneficiaries' materials, documents or information

The *Commission* may use, for its communication and publicising activities, information relating to the action, documents notably summaries for publication and public deliverables as well as any other

material, such as pictures or audio-visual material that it receives from any beneficiary (including in electronic form).

This does not change the confidentiality obligations in Article 36 and the security obligations in Article 37, all of which still apply.

However, if the *Commission's* use of these materials, documents or information would risk compromising legitimate interests, the beneficiary concerned may request the *Commission* not to use it (see Article 52).

The right to use a beneficiary's materials, documents and information includes:

(a) **use for its own purposes** (in particular, making them available to persons working for the *Commission* or any other EU institution, body, office or agency or body or institutions in EU Member States; and copying or reproducing them in whole or in part, in unlimited numbers);

(b) **distribution to the public** (in particular, publication as hard copies and in electronic or digital format, publication on the internet, as a downloadable or non-downloadable file, broadcasting by any channel, public display or presentation, communicating through press information services, or inclusion in widely accessible databases or indexes);

(c) **editing or redrafting** for communication and publicising activities (including shortening, summarising, inserting other elements (such as meta-data, legends, other graphic, visual, audio or text elements), extracting parts (e.g. audio or video files), dividing into parts, use in a compilation);

(d) **translation**;

(e) giving **access in response to individual requests** under Regulation No 1049/2001[25], without the right to reproduce or exploit;

(f) **storage** in paper, electronic or other form;

(g) **archiving**, in line with applicable document-management rules, and

(h) the right to authorise **third parties** to act on its behalf or sub-license the modes of use set out in Points (b),(c),(d) and (f) to third parties if needed for the communication and publicising activities of the *Commission*.

If the right of use is subject to rights of a third party (including personnel of the beneficiary), the beneficiary must ensure that it complies with its obligations under this Agreement (in particular, by obtaining the necessary approval from the third parties concerned).

Where applicable (and if provided by the beneficiaries), the *Commission* will insert the following information:

> "© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the *European Union (EU)* under conditions."

[25] Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents, OJ L 145, 31.5.2001, p. 43.

38.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 39 — PROCESSING OF PERSONAL DATA

39.1 Processing of personal data by the Commission

Any personal data under the Agreement will be processed by the Commission under Regulation No 45/2001[26] and according to the 'notifications of the processing operations' to the Data Protection Officer (DPO) of the Commission (publicly accessible in the DPO register).

Such data will be processed by the '**data controller**' of the Commission for the purposes of implementing, managing and monitoring the Agreement or protecting the financial interests of the EU or Euratom (including checks, reviews, audits and investigations; see Article 22).

The persons whose personal data are processed have the right to access and correct their own personal data. For this purpose, they must send any queries about the processing of their personal data to the data controller, via the contact point indicated in the 'service specific privacy statement(s) (SSPS)' that are published on the Commission websites.

They also have the right to have recourse at any time to the European Data Protection Supervisor (EDPS).

39.2 Processing of personal data by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with applicable EU and national law on data protection (including authorisations or notification requirements).

The beneficiaries may grant their personnel access only to data that is strictly necessary for implementing, managing and monitoring the Agreement.

The beneficiaries must inform the personnel whose personal data are collected and processed by the Commission . For this purpose, they must provide them with the service specific privacy statement (SSPS) (see above), before transmitting their data to the Commission .

39.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 39.2, the *Commission* may apply any of the measures described in Chapter 6.

[26] Regulation (EC) No 45/2001 of the European Parliament and of the Council of 18 December 2000 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data (OJ L 8, 12.01.2001, p. 1).

ARTICLE 40 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE *COMMISSION*

The beneficiaries may not assign any of their claims for payment against the *Commission* to any third party, except if approved by the *Commission* on the basis of a reasoned, written request by the coordinator (on behalf of the beneficiary concerned).

If the *Commission* has not accepted the assignment or the terms of it are not observed, the assignment will have no effect on it.

In no circumstances will an assignment release the beneficiaries from their obligations towards the *Commission*.

CHAPTER 5 DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES

ARTICLE 41 — DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES

41.1 Roles and responsibilities towards the *Commission*

The beneficiaries have full responsibility for implementing the action and complying with the Agreement.

The beneficiaries are jointly and severally liable for the **technical implementation** of the action as described in Annex 1. If a beneficiary fails to implement its part of the action, the other beneficiaries become responsible for implementing this part (without being entitled to any additional EU funding for doing so), unless the *Commission* expressly relieves them of this obligation.

The **financial responsibility** of each beneficiary is governed by Articles 44, 45 and 46.

41.2 Internal division of roles and responsibilities

The internal roles and responsibilities of the beneficiaries are divided as follows:

(a) Each **beneficiary** must:

(i) keep information stored in the 'Beneficiary Register' (via the electronic exchange system) up to date (see Article 17);

(ii) inform the coordinator immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 17);

(iii) submit to the coordinator in good time:

- individual financial statements for itself *and its linked third parties* and, if required, certificates on the financial statements (see Article 20);
- the data needed to draw up the technical reports (see Article 20);
- ethics committee opinions and notifications or authorisations for activities raising ethical issues (see Article 34);

- any other documents or information required by the Commission under the Agreement, unless the Agreement requires the beneficiary to submit this information directly to the Commission.

(b) The **coordinator** must:

(i) monitor that the action is implemented properly (see Article 7);

(ii) act as the intermediary for all communications between the beneficiaries and the *Commission* (in particular, providing the *Commission* with the information described in Article 17), unless the Agreement specifies otherwise;

(iii) request and review any documents or information required by the *Commission* and verify their completeness and correctness before passing them on to the *Commission*;

(iv) submit the deliverables and reports to the *Commission* (see Articles 19 and 20);

(v) ensure that all payments are made to the other beneficiaries without unjustified delay (see Article 21);

(vi) inform the *Commission* of the amounts paid to each beneficiary, when required under the Agreement (see Articles 44 and 50) or requested by the *Commission*.

The coordinator may not delegate the above-mentioned tasks to any other beneficiary or subcontract them to any third party.

41.3 Internal arrangements between beneficiaries — Consortium agreement

*The beneficiaries must have internal arrangements regarding their operation and co-ordination to ensure that the action is implemented properly. These internal arrangements must be set out in a written '**consortium agreement**' between the beneficiaries, which may cover:*

- *internal organisation of the consortium;*
- *management of access to the electronic exchange system;*
- *distribution of EU funding;*
- *additional rules on rights and obligations related to background and results (including whether access rights remain or not, if a beneficiary is in breach of its obligations) (see Section 3 of Chapter 4);*
- *settlement of internal disputes;*
- *liability, indemnification and confidentiality arrangements between the beneficiaries.*

The consortium agreement must not contain any provision contrary to the Agreement.

41.4 Relationship with complementary beneficiaries — Collaboration agreement

Not applicable

41.5 Relationship with partners of a joint action — Coordination agreement

Not applicable

CHAPTER 6 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — PENALTIES — DAMAGES — SUSPENSION — TERMINATION — FORCE MAJEURE

SECTION 1 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — PENALTIES

ARTICLE 42 — REJECTION OF INELIGIBLE COSTS

42.1 Conditions

42.1.1 The *Commission* will — at the time of an **interim payment, at the payment of the balance** or **afterwards** — reject any costs which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 22).

42.1.2 The rejection may also be based on the **extension of findings from other grants to this grant**, under the conditions set out in Article 22.5.2.

42.2 Ineligible costs to be rejected — Calculation — Procedure

Ineligible costs will be rejected in full.

If the *Commission* rejects costs **without reduction of the grant** (see Article 43) or **recovery of undue amounts** (see Article 44), it will formally notify the coordinator or beneficiary concerned the rejection of costs, the amounts and the reasons why (if applicable, together with the notification of amounts due; see Article 21.5). The coordinator or beneficiary concerned may — within 30 days of receiving notification — formally notify the *Commission* of its disagreement and the reasons why.

If the *Commission* rejects costs **with reduction of the grant** or **recovery of undue amounts** , it will formally notify the rejection in the '**pre-information letter**' on reduction or recovery set out in Articles 43 and 44.

42.3 Effects

If the *Commission* rejects costs at the time of an **interim payment** or **the payment of the balance**, it will deduct them from the total eligible costs declared, for the action, in the periodic or final summary financial statement (see Articles 20.3 and 20.4). It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the *Commission* — **after an interim payment but before the payment of the balance** — rejects costs declared in a periodic summary financial statement, it will deduct them from the total eligible costs declared, for the action, in the next periodic summary financial statement or in the final summary

financial statement. It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the *Commission* rejects costs **after the payment of the balance**, it will deduct the amount rejected from the total eligible costs declared, by the beneficiary, in the final summary financial statement. It will then calculate the revised final grant amount as set out in Article 5.4.

ARTICLE 43 — REDUCTION OF THE GRANT

43.1 Conditions

43.1.1 The *Commission* may — **at the payment of the balance** or **afterwards** — reduce the maximum grant amount (see Article 5.1), if the action has not been implemented properly as described in Annex 1 or another obligation under the Agreement has been breached.

43.1.2 The *Commission* may also reduce the maximum grant amount on the basis of the **extension of findings from other grants to this grant**, under the conditions set out in Article 22.5.2.

43.2 Amount to be reduced — Calculation — Procedure

The amount of the reduction will be proportionate to the improper implementation of the action or to the seriousness of the breach.

Before reduction of the grant, the *Commission* will formally notify a '**pre-information letter**' to the coordinator or beneficiary concerned:

- informing it of its intention to reduce the grant, the amount it intends to reduce and the reasons why and

- inviting it to submit observations within 30 days of receiving notification

If the *Commission* does not receive any observations or decides to pursue reduction despite the observations it has received, it will formally notify **confirmation** of the reduction (if applicable, together with the notification of amounts due; see Article 21).

43.3 Effects

If the *Commission* reduces the grant at the time of **the payment of the balance**, it will calculate the reduced grant amount for the action and then determine the amount due as payment of the balance (see Articles 5.3.4 and 21.4).

If the *Commission* reduces the grant **after the payment of the balance**, it will calculate the revised final grant amount for the beneficiary concerned (see Article 5.4). If the revised final grant amount for the beneficiary concerned is lower than its share of the final grant amount, the *Commission* will recover the difference (see Article 44).

ARTICLE 44 — RECOVERY OF UNDUE AMOUNTS

44.1 Amount to be recovered — Calculation — Procedure

The *Commission* will — after **termination of the participation of a beneficiary, at the payment of the balance** or **afterwards** — claim back any amount that was paid but is not due under the Agreement.

Each beneficiary's financial responsibility in case of recovery is limited to its own debt *(including undue amounts paid by the Commission for costs declared by its linked third parties)*, except for the amount retained for the Guarantee Fund (see Article 21.4).

44.1.1 Recovery after termination of a beneficiary's participation

If recovery takes place after termination of a beneficiary's participation (including the coordinator), the *Commission* will claim back the undue amount from the beneficiary concerned, by formally notifying it a debit note (see Article 50.2 and 50.3). This note will specify the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Commission will **recover** the amount:

(a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Commission* may offset before the payment date specified in the debit note;

(b) *Not applicable;*

(c) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial regulation No 966/2012.

If payment is not made by the date specified in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC[27] applies.

44.1.2 Recovery at payment of the balance

[27] Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC (OJ L 319, 05.12.2007, p. 1).

If the payment of the balance takes the form of a recovery (see Article 21.4), the *Commission* will formally notify a '**pre-information letter**' to the coordinator:

- informing it of its intention to recover, the amount due as the balance and the reasons why;
- specifying that it intends to deduct the amount to be recovered from the amount retained for the Guarantee Fund;
- requesting the coordinator to submit a report on the distribution of payments to the beneficiaries within 30 days of receiving notification, and
- inviting the coordinator to submit observations within 30 days of receiving notification.

If no observations are submitted or the *Commission* decides to pursue recovery despite the observations it has received, it will **confirm recovery** (together with the notification of amounts due; see Article 21.5) and:

- pay the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is positive** or
- formally notify to the coordinator a **debit note** for the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is negative**. This note will also specify the terms and the date for payment.

If the coordinator does not repay the *Commission* by the date in the debit note and has not submitted the report on the distribution of payments: the Commission will **recover** the amount set out in the debit note from the coordinator (see below).

If the coordinator does not repay the *Commission* by the date in the debit note, but has submitted the report on the distribution of payments: the *Commission* will:

(a) identify the beneficiaries for which the amount calculated as follows is negative:

{{{{beneficiary's costs declared in the final summary financial statement and approved by the *Commission* multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned

plus

its linked third parties' costs declared in the final summary financial statement and approved by the Commission multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned}

divided by

the EU contribution for the action calculated according to Article 5.3.1}

multiplied by

the final grant amount (see Article 5.3)},

minus

{pre-financing and interim payments received by the beneficiary}}.

(b) formally notify to each beneficiary identified according to point (a) a **debit note** specifying the terms and date for payment. The amount of the debit note is calculated as follows:

{{amount calculated according to point (a) for the beneficiary concerned

divided by

the sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)}

multiplied by

the amount set out in the debit note formally notified to the coordinator}.

If payment is not made by the date specified in the debit note, the *Commission* will **recover** the amount:

(a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Commission* may offset before the payment date specified in the debit note;

(b) by **drawing on the Guarantee Fund**. The Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

(i) *not applicable;*

(ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

44.1.3 Recovery of amounts after payment of the balance

If, for a beneficiary, the revised final grant amount (see Article 5.4) is lower than its share of the final grant amount, it must repay the difference to the *Commission*.

The beneficiary's share of the final grant amount is calculated as follows:

{{{beneficiary's costs declared in the final summary financial statement and approved by the *Commission* multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned

plus

its linked third parties' costs declared in the final summary financial statement and approved by the Commission multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned}

divided by

the EU contribution for the action calculated according to Article 5.3.1}

multiplied by

the final grant amount (see Article 5.3)}.

If the coordinator has not distributed amounts received (see Article 21.7), the *Commission* will also recover these amounts.

The *Commission* will formally notify a **pre-information letter** to the beneficiary concerned:

- informing it of its intention to recover, the due amount and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If no observations are submitted or the *Commission* decides to pursue recovery despite the observations it has received, it will **confirm** the amount to be recovered and formally notify to the beneficiary concerned a **debit note**. This note will also specify the terms and the date for payment.

If payment is not made by the date specified in the debit note, the *Commission* will **recover** the amount:

(a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Commission* may offset before the payment date specified in the debit note;

(b) by **drawing on the Guarantee Fund**. The Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

(i) *not applicable;*

(ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the

date for payment in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

ARTICLE 45 — ADMINISTRATIVE AND FINANCIAL PENALTIES

45.1 Conditions

Under Articles 109 and 131(4) of the Financial Regulation No 966/2012, the *Commission* may impose **administrative** and **financial penalties** if a beneficiary:

(a) has committed substantial errors, irregularities or fraud or is in serious breach of its obligations under the Agreement or

(b) has made false declarations about information required under the Agreement or for the submission of the proposal (or has not supplied such information).

Each beneficiary is responsible for paying the financial penalties imposed on it.

Under Article 109(3) of the Financial Regulation No 966/2012, the Commission may — under certain conditions and limits — publish decisions imposing administrative or financial penalties.

45.2 Duration — Amount of penalty — Calculation

Administrative penalties exclude the beneficiary from all contracts and grants financed from the EU or Euratom budget for a maximum of five years from the date the infringement is established by the *Commission*.

If the beneficiary commits another infringement within five years of the date the first infringement is established, the *Commission* may extend the exclusion period up to 10 years.

Financial penalties will be between 2% and 10% of the maximum EU contribution indicated, for the beneficiary concerned, in the estimated budget (see Annex 2).

If the beneficiary commits another infringement within five years of the date the first infringement is established, the *Commission* may increase the rate of financial penalties to between 4% and 20%.

45.3 Procedure

Before applying a penalty, the *Commission* will formally notify the beneficiary concerned:

- informing it of its intention to impose a penalty, its duration or amount and the reasons why and
- inviting it to submit observations within 30 days.

If the *Commission* does not receive any observations or decides to impose the penalty despite of observations it has received, it will formally notify **confirmation** of the penalty to the beneficiary

concerned and — in case of financial penalties — deduct the penalty from the payment of the balance or formally notify a **debit note**, specifying the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Commission may **recover** the amount:

(a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Commission* may offset before the payment date specified in the debit note;

(b) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

SECTION 2 LIABILITY FOR DAMAGES

ARTICLE 46 — LIABILITY FOR DAMAGES

46.1 Liability of the *Commission*

The *Commission* cannot be held liable for any damage caused to the beneficiaries or to third parties as a consequence of implementing the Agreement, including for gross negligence.

The *Commission* cannot be held liable for any damage caused by any of the beneficiaries or third parties involved in the action, as a consequence of implementing the Agreement.

46.2 Liability of the beneficiaries

46.2.1 Conditions

Except in case of force majeure (see Article 51), the beneficiaries must compensate the *Commission* for any damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement.

Each beneficiary is responsible for paying the damages claimed from it.

46.2.2 Amount of damages - Calculation

The amount the *Commission* can claim from a beneficiary will correspond to the damage caused by that beneficiary.

46.2.3 Procedure

Before claiming damages, the *Commission* will formally notify the beneficiary concerned:

- informing it of its intention to claim damages, the amount and the reasons why and
- inviting it to submit observations within 30 days.

If the *Commission* does not receive any observations or decides to claim damages despite the observations it has received, it will formally notify **confirmation** of the claim for damages and a **debit note**, specifying the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Commission may **recover** the amount:

(a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the *Commission* may offset before the payment date specified in the debit note;

(b) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

SECTION 3 SUSPENSION AND TERMINATION

ARTICLE 47 — SUSPENSION OF PAYMENT DEADLINE

47.1 Conditions

The *Commission* may — at any moment — suspend the payment deadline (see Article 21.2 to 21.4) if a request for payment (see Article 20) cannot be approved because:

(a) it does not comply with the provisions of the Agreement (see Article 20);

(b) the technical reports or financial reports have not been submitted or are not complete or additional information is needed, or

(c) there is doubt about the eligibility of the costs declared in the financial statements and additional checks, reviews, audits or investigations are necessary.

47.2 Procedure

The *Commission* will formally notify the coordinator of the suspension and the reasons why.

The suspension will **take effect** the day notification is sent by the *Commission* (see Article 52).

If the conditions for suspending the payment deadline are no longer met, the suspension will be **lifted** — and the remaining period will resume.

If the suspension exceeds two months, the coordinator may request the *Commission* if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the technical or financial reports (see Article 20) and the revised report or statement is not submitted or was submitted but is also rejected, the *Commission* may also terminate the Agreement or the participation of the beneficiary (see Article 50.3.1(l)).

ARTICLE 48 — SUSPENSION OF PAYMENTS

48.1 Conditions

The *Commission* may — at any moment — suspend, in whole or in part, the pre-financing payment and interim payments for one or more beneficiaries or the payment of the balance for all beneficiaries, if a beneficiary:

(a) has committed or is suspected of having committed substantial errors, irregularities, fraud or serious breach of obligations in the award procedure or under this Agreement or

(b) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2).

48.2 Procedure

Before suspending payments, the *Commission* will formally notify the coordinator:

- informing it of its intention to suspend payments and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the *Commission* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the suspension procedure is not continued.

The suspension will **take effect** the day the confirmation notification is sent by the *Commission*.

If the conditions for resuming payments are met, the suspension will be **lifted**. The *Commission* will formally notify the coordinator.

During the suspension, the periodic report(s) (see Article 20.3) must not contain any individual financial statements from the beneficiary concerned *and its linked third parties*. When the *Commission* resumes payments, the coordinator may include them in the next periodic report.

The beneficiaries may suspend implementation of the action (see Article 49.1) or terminate the Agreement or the participation of the beneficiary concerned (see Article 50.1 and 50.2).

ARTICLE 49 — SUSPENSION OF THE ACTION IMPLEMENTATION

49.1 Suspension of the action implementation, by the beneficiaries

49.1.1 Conditions

The beneficiaries may suspend implementation of the action or any part of it, if exceptional circumstances — in particular *force majeure* (see Article 51) — make implementation impossible or excessively difficult.

49.1.2 Procedure

The coordinator must immediately formally notify to the *Commission* the suspension (see Article 52), stating:

- the reasons why and
- the expected date of resumption.

The suspension will **take effect** the day this notification is received by the *Commission*.

Once circumstances allow for implementation to resume, the coordinator must immediately formally notify the *Commission* and request an **amendment** of the Agreement to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement or the participation of a beneficiary has been terminated (see Article 50).

The suspension will be **lifted** with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension of the action implementation are not eligible (see Article 6).

49.2 Suspension of the action implementation, by the *Commission*

49.2.1 Conditions

The *Commission* may suspend implementation of the action or any part of it:

(a) if a beneficiary has committed or is suspected of having committed substantial errors, irregularities, fraud or serious breach of obligations in the award procedure or under this Agreement;

(b) if a beneficiary has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2), or

(c) if the action is suspected of having lost its scientific or technological relevance.

49.2.2 Procedure

Before suspending implementation of the action, the *Commission* will formally notify the coordinator:

- informing it of its intention to suspend the implementation and the reasons why and

- inviting it to submit observations within 30 days of receiving notification.

If the *Commission* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the procedure is not continued.

The suspension will **take effect** five days after confirmation notification is received by the coordinator (or on a later date specified in the notification).

It will be **lifted** if the conditions for resuming implementation of the action are met.

The coordinator will be formally notified of the lifting and the Agreement will be **amended** to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement has already been terminated (see Article 50).

The suspension will be lifted with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension are not eligible (see Article 6).

The beneficiaries may not claim damages due to suspension by the *Commission* (see Article 46).

Suspension of the action implementation does not affect the *Commission's* right to terminate the Agreement or participation of a beneficiary (see Article 50), reduce the grant or recover amounts unduly paid (see Articles 43 and 44).

ARTICLE 50 — TERMINATION OF THE AGREEMENT OR OF THE PARTICIPATION OF ONE OR MORE BENEFICIARIES

50.1 Termination of the Agreement by the beneficiaries

50.1.1 Conditions and procedure

The beneficiaries may terminate the Agreement.

The coordinator must formally notify termination to the *Commission* (see Article 52), stating:

- the reasons why and

- the date the termination will take effect. This date must be after the notification.

If no reasons are given or if the *Commission* considers the reasons do not justify termination, the Agreement will be considered to have been '**terminated improperly**'.

The termination will **take effect** on the day specified in the notification.

50.1.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a periodic report (for the open reporting period until termination; see Article 20.3) and

(ii) the final report (see Article 20.4).

If the *Commission* does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The *Commission* will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Improper termination may lead to a reduction of the grant (see Article 43).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

50.2 Termination of the participation of one or more beneficiaries, by the beneficiaries

50.2.1 Conditions and procedure

The participation of one or more beneficiaries may be terminated by the coordinator, on request of the beneficiary concerned or on behalf of the other beneficiaries.

The coordinator must formally notify termination to the *Commission* (see Article 52) and inform the beneficiary concerned.

If the coordinator's participation is terminated without its agreement, the formal notification must be done by another beneficiary (acting on behalf of the other beneficiaries).

The notification must include:

- the reasons why;

- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing);

- the date the termination takes effect. This date must be after the notification, and

- a request for amendment (see Article 55), with a proposal for reallocation of the tasks and the estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination takes effect after the period set out in Article 3, no request for amendment must be included unless the beneficiary concerned is the coordinator. In this case, the request for amendment must propose a new coordinator.

If this information is not given or if the *Commission* considers that the reasons do not justify termination, the participation will be considered to have been **terminated improperly**.

The termination will **take effect** on the day specified in the notification.

50.2.2 Effects

The coordinator must — within 30 days from when termination takes effect — submit:

(i) a report on the distribution of payments to the beneficiary concerned and

(ii) if termination takes effect during the period set out in Article 3, a '**termination report**' from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Articles 20.3 and 20.4).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the *Commission*, (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the *Commission*, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The *Commission* will **calculate** — on the basis of the periodic reports, the termination report and the report on the distribution of payments — if the (pre-financing and interim) payments received by the beneficiary concerned exceed the beneficiary's EU contribution (calculated by applying the reimbursement rate(s) to the eligible costs declared by the beneficiary *and its linked third parties* and approved by the *Commission*). Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

- If the payments received **exceed the amounts due**:

  - if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The *Commission* will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the *Commission* will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- in all other cases (in particular if termination takes effect after the period set out in Article 3), the *Commission* will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Commission* the amount due and the *Commission* will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:

  - termination is after an interim payment and

  - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

  In this case, the *Commission* will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Commission* the amount due. The *Commission* will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

• If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the *Commission* does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the *Commission* does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that

- the beneficiary concerned must not repay any amount to the coordinator.

Improper termination may lead to a reduction of the grant (see Article 43) or termination of the Agreement (see Article 50).

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

50.3 Termination of the Agreement or the participation of one or more beneficiaries, by the *Commission*

50.3.1 Conditions

The *Commission* may terminate the Agreement or the participation of one or more beneficiaries, if:

(a) one or more beneficiaries do not accede to the Agreement (see Article 56);

(b) a change to their legal, financial, technical, organisational or ownership situation *(or those of its linked third parties)* is likely to substantially affect or delay the implementation of the action or calls into question the decision to award the grant;

(c) following termination of participation for one or more beneficiaries (see above), the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants (see Article 55);

(d) implementation of the action is prevented by force majeure (see Article 51) or suspended by the coordinator (see Article 49.1) and either:

(i) resumption is impossible, or

(ii) the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants;

(e) a beneficiary is declared bankrupt, being wound up, having its affairs administered by the courts, has entered into an arrangement with creditors, has suspended business activities, or is subject to any other similar proceedings or procedures under national law;

(f) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has been found guilty of professional misconduct, proven by any means;

(g) a beneficiary does not comply with the applicable national law on taxes and social security;

(h) the action has lost scientific or technological relevance;

(i) *not applicable;*

(j) *not applicable;*

(k) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed fraud, corruption, or is involved in a criminal organisation, money laundering or any other illegal activity affecting the EU's financial interests;

(l) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has — in the award procedure or under the Agreement — committed:

(i) substantial errors, irregularities, fraud or

(ii) serious breach of obligations, including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles;

(m) a beneficiary has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant ('**extension of findings from other grants to this grant**').

50.3.2 Procedure

Before terminating the Agreement or participation of one or more beneficiaries, the *Commission* will formally notify the coordinator:

- informing it of its intention to terminate and the reasons why and

- inviting it, within 30 days of receiving notification, to submit observations and — in case of Point (l.ii) above — to inform the *Commission* of the measures to ensure compliance with the obligations under the Agreement.

If the *Commission* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify to the coordinator **confirmation** of the termination and the date it will take effect. Otherwise, it will formally notify that the procedure is not continued.

The termination will **take effect**:

- for terminations under Points (b), (c), (e), (g), (h), (j), and (l.ii) above: on the day specified in the notification of the confirmation (see above);

- for terminations under Points (a), (d), (f), (i), (k), (l.i) and (m) above: on the day after the notification of the confirmation is received by the coordinator.

50.3.3 Effects

(a) for **termination of the Agreement**:

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a periodic report (for the last open reporting period until termination; see Article 20.3) and

(ii) a final report (see Article 20.4).

If the Agreement is terminated for breach of the obligation to submit the reports (see Articles 20.8 and 50.3.1(l)), the coordinator may not submit any reports after termination.

If the *Commission* does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The *Commission* will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

This does not affect the *Commission's* right to reduce the grant (see Article 43) or to impose administrative and financial penalties (Article 45).

The beneficiaries may not claim damages due to termination by the *Commission* (see Article 46).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

(b) for **termination of the participation of one or more beneficiaries**:

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a report on the distribution of payments to the beneficiary concerned;

(ii) a request for amendment (see Article 55), with a proposal for reallocation of the tasks and estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination is notified after the period set out in Article 3, no request for amendment must be submitted unless the beneficiary concerned is the coordinator. In this case the request for amendment must propose a new coordinator, and

(iii) if termination takes effect during the period set out in Article 3, a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Article 20).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the *Commission* (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the *Commission*, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The *Commission* will **calculate** — on the basis of the periodic reports, the termination report and the report on the distribution of payments — if the (pre-financing and interim) payments received by the beneficiary concerned exceed the beneficiary's EU contribution (calculated by applying the reimbursement rate(s) to the eligible costs declared by the beneficiary *and its linked third parties* and approved by the *Commission*). Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

- If the payments received **exceed the amounts due**:

  - if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The *Commission* will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the *Commission* will draw upon the Guarantee Fund to pay the coordinator and then notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

  - in all other cases, in particular if termination takes effect after the period set out in Article 3, the *Commission* will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Commission* the amount due and the *Commission* will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- if the beneficiary concerned is the former coordinator, it must repay the new coordinator the amount unduly received, unless:

  - termination takes effect after an interim payment and

  - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7)

  In this case, the *Commission* will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Commission* the amount due. The *Commission* will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

• If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the *Commission* does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the *Commission* does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned, and that

- the beneficiary concerned must not repay any amount to the coordinator.

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

SECTION 4 FORCE MAJEURE

ARTICLE 51 — FORCE MAJEURE

'Force majeure' means any situation or event that:

- prevents either party from fulfilling their obligations under the Agreement,

- was unforeseeable, exceptional situation and beyond the parties' control,

- was not due to error or negligence on their part (or on the part of third parties involved in the action), and

- proves to be inevitable in spite of exercising all due diligence.

The following cannot be invoked as force majeure:

- any default of a service, defect in equipment or material or delays in making them available, unless they stem directly from a relevant case of force majeure,

- labour disputes or strikes, or
- financial difficulties.

Any situation constituting force majeure must be formally notified to the other party without delay, stating the nature, likely duration and foreseeable effects.

The parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible.

The party prevented by force majeure from fulfilling its obligations under the Agreement cannot be considered in breach of them.

CHAPTER 7 FINAL PROVISIONS

ARTICLE 52 — COMMUNICATION BETWEEN THE PARTIES

52.1 Form and means of communication

Communication under the Agreement (information, requests, submissions, 'formal notifications', etc.) must:

- be made in writing and
- bear the number of the Agreement.

Until the payment of the balance: all communication must be made through the electronic exchange system and using the forms and templates provided there.

After the payment of the balance: formal notifications must be made by registered post with proof of delivery ('formal notification on paper').

Communications in the electronic exchange system must be made by persons authorised according to the 'Terms and Conditions of Use of the electronic exchange system'. For naming the authorised persons, each beneficiary must have designated — before the signature of this Agreement — a 'Legal Entity Appointed Representative (LEAR)'. The role and tasks of the LEAR are stipulated in his/her appointment letter (see Terms and Conditions of Use of the electronic exchange system).

If the electronic exchange system is temporarily unavailable, instructions will be given on the Commission websites.

52.2 Date of communication

Communications are considered to have been made when they are sent by the sending party (i.e. on the date and time they are sent through the electronic exchange system).

Formal notifications through the **electronic** exchange system are considered to have been made when they are received by the receiving party (i.e. on the date and time of acceptance by the receiving party, as indicated by the time stamp). A formal notification that has not been accepted within 10 days after sending is considered to have been accepted.

Formal notifications **on paper** sent by **registered post** with proof of delivery (only after the payment of the balance) are considered to have been made on either:

- the delivery date registered by the postal service or
- the deadline for collection at the post office.

If the electronic exchange system is temporarily unavailable, the sending party cannot be considered in breach of its obligation to send a communication within a specified deadline.

52.3 Addresses for communication

The **electronic** exchange system must be accessed via the following URL:

https://ec.europa.eu/research/participants/portal/desktop/en/projects/

The *Commission* will formally notify the coordinator and beneficiaries in advance any changes to this URL.

Formal notifications on paper (only after the payment of the balance) addressed **to the *Commission*** must be sent to the following address:

European Commission
DIRECTORATE-GENERAL FOR RESEARCH & INNOVATION
Research infrastructure
ORBN 4/108
B-1049 Brussels Belgium

Formal notifications on paper (only after the payment of the balance) addressed **to the beneficiaries** must be sent to their legal address as specified in the 'Beneficiary Register'.

ARTICLE 53 — INTERPRETATION OF THE AGREEMENT

53.1 Precedence of the Terms and Conditions over the Annexes

The provisions in the Terms and Conditions of the Agreement take precedence over its Annexes.

Annex 2 takes precedence over Annex 1.

53.2 Privileges and immunities

Not applicable

ARTICLE 54 — CALCULATION OF PERIODS, DATES AND DEADLINES

In accordance with Regulation No 1182/71[28], periods expressed in days, months or years are calculated from the moment the triggering event occurs.

The day during which that event occurs is not considered as falling within the period.

[28] Regulation (EEC, Euratom) No 1182/71 of the Council of 3 June 1971 determining the rules applicable to periods, dates and time-limits (OJ L 124, 8.6.1971, p. 1).

ARTICLE 55 — AMENDMENTS TO THE AGREEMENT

55.1 Conditions

The Agreement may be amended, unless the amendment entails changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

Amendments may be requested by any of the parties.

55.2 Procedure

The party requesting an amendment must submit a request for amendment signed in the electronic exchange system (see Article 52).

The coordinator submits and receives requests for amendment on behalf of the beneficiaries (see Annex 3).

If a change of coordinator is requested without its agreement, the submission must be done by another beneficiary (acting on behalf of the other beneficiaries).

The request for amendment must include:

- the reasons why;
- the appropriate supporting documents;
- for a change of coordinator without its agreement: the opinion of the coordinator (or proof that this opinion has been requested in writing).

The *Commission* may request additional information.

If the party receiving the request agrees, it must sign the amendment in the electronic exchange system within 45 days of receiving notification (or any additional information the *Commission* has requested). If it does not agree, it must formally notify its disagreement within the same deadline. The deadline may be extended, if necessary for the assessment of the request. If no notification is received within the deadline, the request is considered to have been rejected

An amendment **enters into force** on the day of the signature of the receiving party.

An amendment **takes effect** on the date agreed by the parties or, in the absence of such an agreement, on the date on which the amendment enters into force.

ARTICLE 56 — ACCESSION TO THE AGREEMENT

56.1 Accession of the beneficiaries mentioned in the Preamble

The other beneficiaries must accede to the Agreement by signing the Accession Form (see Annex 3) in the electronic exchange system (see Article 52) within 30 days after its entry into force (see Article 58).

They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 58).

If a beneficiary does not accede to the Agreement within the above deadline, the coordinator must — within 30 days — request an amendment to make any changes necessary to ensure proper implementation of the action. This does not affect the *Commission's* right to terminate the Agreement (see Article 50).

56.2 Addition of new beneficiaries

In justified cases, the beneficiaries may request the addition of a new beneficiary.

For this purpose, the coordinator must submit a request for amendment in accordance with Article 55. It must include an Accession Form (see Annex 3) signed by the new beneficiary in the electronic exchange system (see Article 52).

New beneficiaries must assume the rights and obligations under the Agreement with effect from the date of their accession specified in the Accession Form (see Annex 3).

ARTICLE 57 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

57.1 Applicable law

The Agreement is governed by the applicable EU law, supplemented if necessary by the law of Belgium.

57.2 Dispute settlement

If a dispute concerning the interpretation, application or validity of the Agreement cannot be settled amicably, the General Court — or, on appeal, the Court of Justice of the European Union — has sole jurisdiction. Such actions must be brought under Article 272 of the Treaty on the Functioning of the EU (TFEU).

If a dispute concerns administrative or financial penalties, offsetting or an enforceable decision under Article 299 TFEU (see Articles 44, 45 and 46), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice of the European Union — under Article 263 TFEU.

ARTICLE 58 — ENTRY INTO FORCE OF THE AGREEMENT

The Agreement will enter into force on the day of signature by the *Commission* or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

Michael GARRETT with ECAS id ngarremi signed in the Participant Portal on 24/03/2015 at 14:15:06 (transaction id SigId-3656-mmjPztRBmX4Mt5Z03wzpLazq5MiYFgwkp7UZkUvdQrOzXnH1GuaJFELh4Ud8sIB1cLMocVXQ4YuIW3vxnB6zNgm-PHslUMVSXYCTEhexgy3OjC-zqbZ3DanmlkJvAVcjhg4ztiF1aaxLBSq5lbXnzrNtB7e). Timestamp by third party at
Tue Mar 24 14:15:11 CET 2015

For the *Commission*

Pascale CID with ECAS id cidlupa signed in the Participant Portal on 22/04/2015 at 17:22:15 (transaction id SigId-6062-sxmrBaA6Sh1Bzx8nWYNHp4nzsq2zJNV1KlHNKxw2jHWxame0Pl06FtUZWwP2yztbwzqmXL1l2uelx0lDcdQNmnzm-Jj71zxYb8yrsWziRzxU0uBm-9iRzipIXPuCE1v8GeInBUFesHVZNjsAJoPLLZoT3Xzkm). Timestamp by third party at
Wed Apr 22 18:22:20 CEST 2015

EUROPEAN COMMISSION

DIRECTORATE-GENERAL FOR RESEARCH & INNOVATION

Research infrastructure

ANNEX 1 (part A)

Research and Innovation action

NUMBER — 653477 — ASTERICS

Table of Contents

1.1. The project summary

Project Number [1]	653477	Project Acronym [2]	ASTERICS

One form per project

General information	
Project title [3]	Astronomy ESFRI and Research Infrastructure Cluster
Starting date [4]	The first day of the month after the signature by the Commission
Duration in months [5]	48
Call (part) identifier [6]	H2020-INFRADEV-1-2014-1
Topic	INFRADEV-4-2014-2015 Implementation and operation of cross-cutting services and solutions for clusters of ESFRI and other relevant research infrastructure initiatives
Fixed EC Keywords	NATURAL SCIENCES
Free keywords	ESFRI, Astronomy, Astroparticle Physics, SKA, CTA, KM3NeT, Big Data, Science 2.0, Virtual Observatory, Citizen Science.

Abstract [7]

ASTERICS (Astronomy ESFRI & Research Infrastructure Cluster) aims to address the cross-cutting synergies and common challenges shared by the various Astronomy ESFRI facilities (SKA, CTA, KM3Net & E-ELT). It brings together for the first time, the astronomy, astrophysics and particle astrophysics communities, in addition to other related research infrastructures. The major objectives of ASTERICS are to support and accelerate the implementation of the ESFRI telescopes, to enhance their performance beyond the current state-of-the-art, and to see them interoperate as an integrated, multi-wavelength and multi-messenger facility. An important focal point is the management, processing and scientific exploitation of the huge datasets the ESFRI facilities will generate. ASTERICS will seek solutions to these problems outside of the traditional channels by directly engaging and collaborating with industry and specialised SMEs. The various ESFRI pathfinders and precursors will present the perfect proving ground for new methodologies and prototype systems. In addition, ASTERICS will enable astronomers from across the member states to have broad access to the reduced data products of the ESFRI telescopes via a seamless interface to the Virtual Observatory framework. This will massively increase the scientific impact of the telescopes, and greatly encourage use (and re-use) of the data in new and novel ways, typically not foreseen in the original proposals. By demonstrating cross-facility synchronicity, and by harmonising various policy aspects, ASTERICS will realise a distributed and interoperable approach that ushers in a new multi-messenger era for astronomy. Through an active dissemination programme, including direct engagement with all relevant stakeholders, and via the development of citizen scientist mass participation experiments, ASTERICS has the ambition to be a flagship for the scientific, industrial and societal impact ESFRI projects can deliver.

1.2. List of Beneficiaries

Project Number [1]	653477	Project Acronym [2]	ASTERICS

List of Beneficiaries

No	Name	Short name	Country	Project entry month[8]	Project exit month
1	STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY	ASTRON	Netherlands	1	48
2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	CNRS	France	1	48
3	ISTITUTO NAZIONALE DI ASTROFISICA	INAF	Italy	1	48
4	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE	UCAM	United Kingdom	1	48
5	JOINT INSTITUTE FOR V.L.B.I. IN EUROPE (J.I.V.E.)	JIVE	Netherlands	1	48
6	INSTITUTO NACIONAL DE TECNICA AEROESPACIAL ESTEBAN TERRADAS	INTA	Spain	1	48
7	THE UNIVERSITY OF EDINBURGH	UEDIN	United Kingdom	1	48
8	RUPRECHT-KARLS-UNIVERSITAET HEIDELBERG	UHEI	Germany	1	48
9	THE OPEN UNIVERSITY	OU	United Kingdom	1	48
10	FRIEDRICH-ALEXANDER-UNIVERSITAT ERLANGEN NURNBERG	FAU	Germany	1	48
11	STICHTING VU-VUMC	VU/VUmc	Netherlands	1	48
12	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	France	1	48
13	UNIVERSITEIT VAN AMSTERDAM	UVA	Netherlands	1	48
14	UNIVERSIDAD DE GRANADA	UGR	Spain	1	48
15	STICHTING VOOR FUNDAMENTEEL ONDERZOEK DER MATERIE - FOM	FOM	Netherlands	1	48
16	INSTITUT D'ESTUDIS ESPACIALS DE CATALUNYA FUNDACION	IEEC	Spain	1	48
17	INSTITUTO DE FISICA DE ALTAS ENERGIAS	IFAE	Spain	1	48
18	UNIVERSIDAD COMPLUTENSE DE MADRID	UCM	Spain	1	48
19	ISTITUTO NAZIONALE DI FISICA NUCLEARE	INFN	Italy	1	48
20	SCIENCE AND TECHNOLOGY FACILITIES COUNCIL	STFC	United Kingdom	1	48
21	STIFTUNG DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY	DESY	Germany	1	48
22	SURFnet bv	SURFnet	Netherlands	1	48

1.3. Workplan Tables - Detailed implementation

1.3.1. WT1 List of work packages

WP Number [9]	WP Title	Lead beneficiary [10]	Person-months [11]	Start month [12]	End month [13]
WP1	Management	1 - ASTRON	88.00	1	48
WP2	Dissemination, Engagement and Citizen Science (DECS)	9 - OU	53.00	1	48
WP3	OBELICS (OBservatory E-environments LInked by common ChallengeS)	2 - CNRS	752.00	1	48
WP4	DADI (Data Access, Discovery and Interoperability)	2 - CNRS	476.00	1	48
WP5	CLEOPATRA: Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts	5 - JIVE	332.00	1	48
		Total	1,701.00		

1.3.2. WT2 list of deliverables

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D1.1	Exploitation plan	WP1	1 - ASTRON	Report	Public	5
D1.2	Collaboration plan	WP1	1 - ASTRON	Report	Public	5
D1.3	Exploitation plan update	WP1	1 - ASTRON	Report	Public	23
D1.4	Collaboration plan update	WP1	1 - ASTRON	Report	Public	23
D1.5	Integration Activity	WP1	1 - ASTRON	Other	Public	44
D2.1	ASTERICS project website live	WP2	9 - OU	Websites, patents filling, etc.	Public	3
D2.2	ASTERICS project brochure publication	WP2	9 - OU	Report	Public	12
D2.3	Educational resources for first MPE	WP2	9 - OU	Websites, patents filling, etc.	Public	23
D2.4	first online MPE	WP2	9 - OU	Websites, patents filling, etc.	Public	23
D2.5	Public and stakeholder engagement via video resources	WP2	9 - OU	Websites, patents filling, etc.	Public	29
D2.6	Open-access publications from first MPE	WP2	9 - OU	Report	Public	32
D2.7	Educational resources for MPE	WP2	9 - OU	Websites, patents filling, etc.	Public	35
D2.8	online MPE	WP2	9 - OU	Websites, patents filling, etc.	Public	35
D2.9	Open-access publications from MPE	WP2	9 - OU	Report	Public	46
D3.1	Detailed WP3 Project plan	WP3	2 - CNRS	Report	Public	4
D3.2	First main thematic training event	WP3	2 - CNRS	Other	Public	12

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D3.3	Analysis Report on Standards and Libraries	WP3	18 - UCM	Report	Public	12
D3.4	Software Libraries (initial)	WP3	4 - UCAM	Other	Public	12
D3.5	Analysis Report on Resource Requirements	WP3	2 - CNRS	Report	Public	18
D3.6	First WP3 general workshop	WP3	2 - CNRS	Other	Public	18
D3.7	Second main thematic training event	WP3	2 - CNRS	Other	Public	24
D3.8	Technology Benchmark Report (D-GEX, mid-term)	WP3	1 - ASTRON	Report	Public	24
D3.9	Technology Benchmark Reports (D-INT, mid-term)	WP3	1 - ASTRON	Report	Public	24
D3.10	Technology Benchmark Report (D-ANA, mid-term)	WP3	4 - UCAM	Report	Public	24
D3.11	Second WP3 general workshop	WP3	2 - CNRS	Other	Public	30
D3.12	Third main thematic training event	WP3	2 - CNRS	Other	Public	36
D3.13	Analysis Report on Frameworks and Architectures	WP3	3 - INAF	Report	Public	36
D3.14	Repository of Services (D-INT)	WP3	2 - CNRS	Other	Public	36
D3.15	Repository of Services (D-ANA)	WP3	3 - INAF	Other	Public	36
D3.16	Third WP3 general workshop	WP3	2 - CNRS	Other	Public	42
D3.17	Final integral WP3 Report	WP3	2 - CNRS	Report	Public	48
D3.18	Technology Benchmark Report (D-GEX, final)	WP3	1 - ASTRON	Report	Public	48
D3.19	Technology Benchmark Reports (D-INT, final)	WP3	1 - ASTRON	Report	Public	48
D3.20	Software Libraries	WP3	4 - UCAM	Other	Public	48

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D4.1	First ASTERICS DADI Technology Forum	WP4	2 - CNRS	Other	Public	5
D4.2	First ASTERICS European School	WP4	6 - INTA	Other	Public	7
D4.3	First ESFRI Forum & Training event	WP4	3 - INAF	Other	Public	7
D4.4	Second ASTERICS DADI Technology Forum	WP4	7 - UEDIN	Other	Public	11
D4.5	Second ASTERICS European School	WP4	2 - CNRS	Other	Public	19
D4.6	First “European Data Provider Forum & Training event”	WP4	8 - UHEI	Other	Public	19
D4.7	Third ASTERICS DADI Technology Forum	WP4	2 - CNRS	Other	Public	23
D4.8	Repository of WP4 products (mid-term delivery)	WP4	2 - CNRS	Other	Public	24
D4.9	Third ASTERICS European School	WP4	6 - INTA	Other	Public	31
D4.10	Second ESFRI Forum & Training event	WP4	3 - INAF	Other	Public	32
D4.11	Fourth ASTERICS DADI Technology Forum	WP4	7 - UEDIN	Other	Public	35
D4.12	Fourth ASTERICS European School	WP4	2 - CNRS	Other	Public	43
D4.13	Second European Data Provider Forum & Training event	WP4	8 - UHEI	Other	Public	45
D4.14	Fifth ASTERICS DADI Technology Forum	WP4	2 - CNRS	Other	Public	47
D4.15	Repository of WP4 products (final delivery)	WP4	2 - CNRS	Other	Public	48
D5.1	General design rules for implementation in existing optical networks	WP5	22 - SURFnet	Report	Public	14

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D5.2	Multi-messenger alert handling design document	WP5	1 - ASTRON	Report	Public	18
D5.3	Qualification of WRE components under (harsh) realistic conditions	WP5	21 - DESY	Report	Public	24
D5.4	Hardware for maser-level time & frequency distribution in optical transport networks	WP5	11 - VU/VUmc	Demonstrator	Public	26
D5.5	Data streaming software client	WP5	5 - JIVE	Other	Public	28
D5.6	Tools and methods for delay calibration before installation and in situ.	WP5	15 - FOM	Report	Public	30
D5.7	Time transfer in SURFnet/ LOFAR network & general design rules for network implementation	WP5	11 - VU/VUmc	Report	Public	32
D5.8	Summary of workshop in alerting mechanisms with outside partners	WP5	13 - UVA	Report	Public	32
D5.9	Report on scheduling algorithms and standard interfaces for cross-facility scheduling	WP5	20 - STFC	Report	Public	36
D5.10	Software components multi-messenger event handling	WP5	1 - ASTRON	Report	Public	40
D5.11	Scientific study synergies of transient event observing	WP5	13 - UVA	Report	Public	42
D5.12	Multi-facility scheduling simulation and performance analysis software	WP5	16 - IEEC	Demonstrator	Public	42
D5.13	Pilot multi-messenger event handling	WP5	2 - CNRS	Demonstrator	Public	46
D5.14	Demonstration of VLBI synchronization	WP5	5 - JIVE	Report	Public	48

Deliverable Number [14]	Deliverable Title	WP number [9]	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
	via existing SURFnet/ LOFAR network					
D5.15	Advanced algorithms and WRE upgrade to 10 Gb/s capacity	WP5	14 - UGR	Demonstrator	Public	48

1.3.3. WT3 Work package descriptions

Work package number [9]	WP1	**Lead beneficiary** [10]	1 - ASTRON
Work package title	Management		
Start month	1	**End month**	48

Objectives

This work package will establish the ASTERICS Management Support Team (AMST), and will thus guarantee the smooth execution of all financial, administrative and reporting elements of the project. It will also permit the AMST (see also section 3.2) to exercise central control and oversight of the scientific and technical progress of the project, as measured by the successful receipt of deliverables and secured milestones. A high-level Policy Forum (involving the ESFRI projects and other large astronomy research infrastructures) will also be established in order to coordinate and agree new models for joint time allocation, observing and data access/sharing, in addition to other more general policy matters of common interest. The culmination of ASTERICS will be a grand Integrating Event which show-case the results of the project and their relevance to the ESFRI telescopes and all other relevant stakeholders.

Description of work and role of partners

WP1 - Management [Months: 1-48]
ASTRON, CNRS
The work is conducted by the AMST which includes the ASTERICS Coordinator, the Project Manager, Project Scientist, Financial Controller and Administrator.

Task 1.1: Project Governance
Effort (PM)
ASTRON 4

Establish the appropriate governance structure for the project, as laid down in the Consortium Agreement, including (but not limited to) the appointment of the ASTERICS General Assembly (AGA), ASTERICS Executive Board (AEB), ASTERICS Management Support Team (AMST) and ASTERICS External Advisory Board (AEAB).
Organise, prepare and minute meetings of the AGA, AEB, AMST and AEAB.
Oversee the implementation of the decisions of the AGA, AEB, and advice of the AEAB.
Update and maintain the Consortium Agreement.

Task 1.2: Project Coordination
Effort (PM)
ASTRON 12
CNRS-INSU 4

Develop a close-knit network of intra-project communication channels between all WPs, the AMST and the AEB.
Ensure close cooperation with the various astronomical ESFRI projects, and direct engagement with senior figures in their central organisations.
Foster cooperation with all relevant organisations, including other EC projects (e.g. ASTRONET, APPEC, RadioNet, OPTICON, Europlanet, SOLARNET etc), industrial stakeholders, other research infrastructures, national funding agencies, etc.
Visibly promote ASTERICS to the global, European and national communities by attending relevant meetings (e.g. IAU General Assembly, EWASS, Big Data gatherings with industry and SMEs) and making high quality presentations.
Establish and run a vibrant Policy Forum for the ESFRI and other related astronomy facilities, in order to coordinate joint actions (e.g. interoperability, commensal observations etc.) and discuss general policy matters of common and general interest.
A grand Integrating Event will be held to show-case the final results of the ASTERICS project and engage with all relevant stakeholders.

Task 1.3: Project Management
Effort (PM)
ASTRON 68

Distribute EC funding to the partners based on the Horizon 2020 rules and the Consortium Agreement.
Maintain a broad overview of the ASTERICS project in terms of overall staff effort, including subcontractors.
Implement appropriate and transparent reporting structures within and between the various WPs.
Monitor milestones and deliverables, chasing any outstanding actions/deadlines.
Prepare, compile and generate all relevant project reports (including financial data) for all major external and internal stakeholders (e.g. the EC, AGA, AEB etc).
Generate an Exploitation plan – a dedicated plan will be generated to ensure the early identification of both high-impact ASTERICS technologies, IPR foreground or patent restrictions, and appropriate (industrial) target sectors. Exploitation events will be organised during major conferences and corporate events, in order to engage with potential industrial interests, backed up with printed materials, and conceptual demos. Actions to ensure the long-term and sustainable exploitation of the project beyond its formal contract duration will be identified and executed. This will include the Data Management Plan that addresses all aspects of ASTERICS dissemination activities.
Generate a Collaboration plan – a central plank of our strategy will be to seek links and interactions with other projects (including other EC-funded projects), industries, research organisations etc. in order to broaden our knowledge base and to find opportunities to show-case our results/products.
Establish, maintain and update the:
o central risk register, incl. entries for contingency and risk mitigation,
o Intellectual Property (IP) register,
o list of all publications, open source software contributions and other ASTERICS products,
o global registry of ASTERICS partners, third parties, subcontractors, industry contacts and SMEs
These registers will be stored on the project website and open to at least the project partners. An overview of important changes and issues in these will be presented in the periodic reports.

Participation per Partner

Partner number and short name	WP1 effort
1 - ASTRON	84.00
2 - CNRS	4.00
Total	88.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D1.1	Exploitation plan	1 - ASTRON	Report	Public	5
D1.2	Collaboration plan	1 - ASTRON	Report	Public	5
D1.3	Exploitation plan update	1 - ASTRON	Report	Public	23
D1.4	Collaboration plan update	1 - ASTRON	Report	Public	23
D1.5	Integration Activity	1 - ASTRON	Other	Public	44

Description of deliverables

Exploitation and Collaboration plan and updates Integration Activity Event

D1.1 : Exploitation plan [5]

Exploitation plan

D1.2 : Collaboration plan [5]

Collaboration plan

D1.3 : Exploitation plan update [23]

Exploitation plan update

D1.4 : Collaboration plan update [23]

Collaboration plan update

D1.5 : Integration Activity [44]

The culmination of ASTERICS will be a grand Integrating Event which show-case the results of the project and their relevance to the ESFRI telescopes and all other relevant stakeholders.

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	Project Kick-Off meeting	1 - ASTRON	1	Website
MS3	1st AGA meeting Governance entities (e.g. AEB, AEAB) and AMST fully appointed	1 - ASTRON	3	Minutes of the meeting
MS4	1st ASTERICS Policy Forum group meeting	1 - ASTRON	6	Website + minutes of the meeting
MS6	1st AEAB evaluation + Acceptance of annual reports	1 - ASTRON	12	Review of Deliverables of M1 - M12
MS13	Mid-Term Review + AEAB evaluation + Acceptance of annual reports	1 - ASTRON	24	Review of Deliverables of M13 - M24 Mid-Term project review report
MS25	AEAB evaluation + Acceptance of annual reports	1 - ASTRON	38	Review of Deliverables of M25 – M36
MS29	AEAB evaluation + Acceptance of annual reports + Final project review (incl. lessons learned)	1 - ASTRON	48	Review of Deliverables of M37 – M48 final project review report

Work package number [9]	WP2	Lead beneficiary [10]	9 - OU
Work package title	Dissemination, Engagement and Citizen Science (DECS)		
Start month	1	End month	48

Objectives

The Objective of WP2 (DECS) is to promote ASTERICS and the ESFRI astronomy facilities it aims to serve. In particular, it aims to and open-up the ESFRI facilities to all relevant stakeholders and the widest possible audience, including the paying public:
Production of high quality branding and promotional outreach materials. More ambitiously, DECS also embraces ASTERICS' adoption of the principles of Science 2.0.
Create web-based interfaces that will open-up the astronomy related ESFRI facilities to the general public via a harmonised suite of Citizen Science mass participation experiments (MPEs) and online video material.
Attract young people to science by networking the ESFRI facilities via citizen science initiatives such as these, and through coordinating open educational resources.
Internal dissemination of ASTERICS results and the promotion and engagement of the project within the community and beyond.

Description of work and role of partners

WP2 - Dissemination, Engagement and Citizen Science (DECS) [Months: 1-48]
OU, ASTRON, INAF
The partners have selected Dr. Stephen Serjeant (OU) as the leader of WP2. He will dedicate approximately 10% of his working time to the project.

Figure 4 (See Part B): ASTERICS realises Mass participation Experiments (MPEs) with Citizen Scientists.

Task 2.1: DECS Production
Effort (PM)
OU 5

Oversee the production process for online audio, video, image and text products (acting as "executive producer" for media products).
Manage the academic relationship with external production companies, artists and designers. Assume responsibility for signing off on the various production stages.
Commission the creation of sixty-second animations, modelled on the "Sixty Second Adventures in Astronomy" series (using an independent video production company), highlighting the science of an ESFRI facility and inviting the viewer to participate in a related mass participation experiment (D2.5, D2.6, D2.9).

Task 2.2: Adapt Mass Participation Experiment Infrastructure
Effort (PM)
OU/Oxford UK 12

Design and build a common mass participation experiment (MPE) infrastructure, adapting resources from Oxford University's existing IVOA (International Virtua Observatory Alliance) compliant Galaxy Zoo infrastructure and creating new resources, including tools for cross-calibration of MPE participant responses, plus the associated hosting and design interfaces (D2.3, D2.7).

Task 2.3 Mass Participation Experiment Operation
Effort (PM)
OU 24

Test and verify interfaces with the IVOA.
Investigate the citizen science goals that are most compelling for astronomy ESFRI facilities via two international workshops, also including the participation of prominent citizen scientists.
Adapt and produce simulated data for testing of MPE and training of citizen scientists where appropriate; collate/ produce related data sets / pathfinder data sets for beta testing and early operation of MPEs;
Manage operation of four mass participation experiments for SKA, CTA, KM3Net, E-ELT (D2.4, D2.8).

Design of the so-called “learning journey” leading participants to further educational resources; creation of new educational resources, assessment strategy and writing; creation of video / image / text resources (cognisant of future adaptation and translation for non-English-speaking communities); citizen science product generation and data management.

Task 2.4 Translation and testing
Effort (PM)
INAF 12

Co-ordinate translation and adaption of resources for different national communities.
Create compilation of existing online resources related to MPE. Translate and adapt existing online resources.
Testing of mass participation experiments in face-to-face classroom settings.

Task 2.5 Internal dissemination and project outreach
Effort (PM)
ASTRON 12

Generate standard branding and outreach materials for the ASTERICS project (including a booth to be used for events and exhibitions)
Create a project website and portal for internal coordination, and internal and external dissemination of ASTERICS results (D2.1).
Create brochures for informed communities and public-facing websites for ASTERICS activities (D2.2).
Attend high-level events and meetings where ASTERICS results can be show-cased to external stakeholders, including industrial and commercial concerns.

Participation per Partner

Partner number and short name	WP2 effort
1 - ASTRON	12.00
3 - INAF	12.00
9 - OU	29.00
Total	53.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D2.1	ASTERICS project website live	9 - OU	Websites, patents filling, etc.	Public	3
D2.2	ASTERICS project brochure publication	9 - OU	Report	Public	12
D2.3	Educational resources for first MPE	9 - OU	Websites, patents filling, etc.	Public	23
D2.4	first online MPE	9 - OU	Websites, patents filling, etc.	Public	23

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D2.5	Public and stakeholder engagement via video resources	9 - OU	Websites, patents filling, etc.	Public	29
D2.6	Open-access publications from first MPE	9 - OU	Report	Public	32
D2.7	Educational resources for MPE	9 - OU	Websites, patents filling, etc.	Public	35
D2.8	online MPE	9 - OU	Websites, patents filling, etc.	Public	35
D2.9	Open-access publications from MPE	9 - OU	Report	Public	46

Description of deliverables

Dissemination and outreach through website and brochures Input, output and organisation of Mass Participation Experiments

D2.1 : ASTERICS project website live [3]

ASTERICS project website live

D2.2 : ASTERICS project brochure publication [12]

Brochures for informed communities for ASTERICS activities

D2.3 : Educational resources for first MPE [23]

Resources available for common mass participation experiment (MPE) infrastructure, adapted from Oxford University's existing IVOA (International Virtual Observatory Alliance) compliant Galaxy Zoo infrastructure and new resources, including tools for cross-calibration of MPE participant responses, plus the associated hosting and design interfaces.

D2.4 : first online MPE [23]

Online Mass participation experiments

D2.5 : Public and stakeholder engagement via video resources [29]

Sixty-second animations, modelled on the "Sixty Second Adventures in Astronomy" series (using an independent video production company), highlighting the science of an ESFRI facility and inviting the viewer to participate in a related mass participation experiment.

D2.6 : Open-access publications from first MPE [32]

Open-access publications from Mass participation experiments

D2.7 : Educational resources for MPE [35]

Resources available for common mass participation experiment (MPE) infrastructure, adapted from Oxford University's existing IVOA (International Virtual Observatory Alliance) compliant Galaxy Zoo infrastructure and new resources, including tools for cross-calibration of MPE participant responses, plus the associated hosting and design interfaces.

D2.8 : online MPE [35]

Online Mass participation experiments

D2.9 : Open-access publications from MPE [46]
Open-access publications from Mass participation experiments

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification

Work package number [9]	WP3	Lead beneficiary [10]	2 - CNRS
Work package title	OBELICS (OBservatory E-environments LInked by common ChallengeS)		
Start month	1	End month	48

Objectives

Enable interoperability and software re-use for the data generation, integration and analysis of the ASTERICS ESFRI and pathfinder facilities. An essential ingredient is the creation of an open innovation environment for establishing open standards and software libraries for multiwavelength/multi-messenger data. Furthermore, development of common solutions for streaming data processing and extremely large databases is required. Study of advanced analysis algorithms and software frameworks for data processing and quality control is the third focus area. The specific objectives are:
Train researchers and data scientists in the ASTERICS ESFRI and pathfinder projects to apply state-of-the-art parallel software programming techniques, to adopt big-data software frameworks, to benefit from new processor architectures and e-science infrastructures. This will create a community of experts that can contribute across facilities and domains.
Maximise software re-use and co-development of technology for the robust and flexible handling of the huge data streams generated by the ASTERICS ESFRI and pathfinder facilities. This involves the definition of open standards and design patterns, and the development of software libraries in an open innovation environment.
Adapt and optimise extremely large database systems to fulfil the requirements of the ASTERICS ESFRI projects. This requires the development of use cases, prototypes and benchmarks to demonstrate scalability and deployment on distributed non-homogeneous resources. Cooperation with the ESFRI pathfinders, computing centres, e-infrastructure providers and industry will be organised and managed to fulfil this objective.
Study and demonstrate data integration across ASTERICS ESFRI and pathfinder projects using data mining tools and statistical analysis techniques on Petascale data sets. This will require adaptable and evolving workflow management systems, to allow deployment on existing and future e-science infrastructures.

All tasks are built upon the state-of-the-art in ICT, in cooperation with major European einfrastructures and are conceived to minimise fragmentation. Communications and links with other communities and e-science service providers are considered in order to contribute to the effectiveness of the proposed objectives.

Description of work and role of partners

WP3 - OBELICS (OBservatory E-environments LInked by common ChallengeS) [Months: 1-48]
CNRS, ASTRON, INAF, UCAM, JIVE, FAU, CEA, IFAE, UCM, INFN
OBELICS (OBservatory E-environments LInked by common ChallengeS)

The partners have selected Dr. Giovanni Lamanna (CNRS-LAPP) as scientific coordinator of WP3. He will dedicate approximately 20% of his working time to the project. The leadership of tasks is shared between CNRS-LAPP, ASTRON, UCAM, INAF and UCM. All the ESFRI facilities (CTA, SKA, KM3NeT), and other major international projects or pathfinders, namely EUCLID, LSST, VIRGO/EGO, LOFAR, e-VLBI, HESS, MAGIC and ANTARES take part in all tasks and share responsibilities for task deliverables. The E-ELT (ESO) will be involved in particular in the development of open standards and common software libraries (task 3.2).
The work in WP3 is organised in four tasks. All tasks have well-defined connections with DADI (WP4), either through the definition of standards (task 3.2), making available of meta-data (task 3.3) or direct interfacing with VO libraries (task 3.4). The interface with WP4 is managed through a special subtask of task 4.3 led by INAF.

Figure 5 (See part B): ASTERICS delivers a repository of services and Data Technology solutions for the ESFRI projects.

Task 3.1 MAUD: MAnagement, User engagement and data Dissemination
Effort (PM)
LAPP 44

As WP3 represents a major effort in its own right, this first task is devoted to the detailed day-today management of the work package, aiming to guarantee the federated character of all activities
among ASTERICS ESFRI projects, and organising the three technical tasks in a coherent and well regulated manner. OBELICS is the cornerstone of the ASTERICS project and it also aims to guarantee the best interface with major e-infrastructures in Europe, as expected from the work programme of the INFRADEV4 call.

The task 3.1 addresses the following topics:
1. Defining and monitoring the planning, compiling progress reports and organising regular meetings.
- 3 annual WP3 general workshops (M18, M30, M42).
- 3 main thematic training events: (a) software parallelisation and big-data frameworks; (b) new computing technology; (c) archive and metadata-data-base systems. Where possible we invite communities and disciplines larger than those covered by ASTERICS.
2. Overall data dissemination, communication and exposure of the results to the target communities (in cooperation with WP1 & 2). Foster co-located periodical meetings and promote the ASTERICS-ESFRI users engagement in larger forums: e.g. new HEP-software foundation; e-infrastructures initiatives such as EGI; data-infrastructures initiatives such as EUDAT and RDA.
3. Managing and assuring coherent and cooperative interfaces with major computing/data centers (some already committing in a sustainable way to the support of the ASTERICS-ESFRI projects individually), providing test-bench platforms for the developments foreseen in all tasks (e.g. service agreements), as well as with transversal international e-initiatives, e.g. RDA and EGI, and with international collaborations of data and computing resource providers, e.g. PRACE, EU-T0 and similar consortia.
4. ASTERICS aims to deliver a broad range of innovative software libraries and services to the facilities. The prioritisation of these software components and the specification of their requirements can only be made in the course of the project – arranging appropriate subcontractors at this stage is premature. For a selection of the components, the generation is optimally executed in co-development with industry. Therefore, the consortium will organise industrial engagement for (precompetitive) co-development with industry via an internal call for sub-contracting technical works. WP3.1 manages this process in the same way as has been successfully organised for the FP7 CTA Preparatory Phase project. After the completion of this call, the consortium agreement and annex 1 will be adapted to incorporate any new subcontractors. A preliminary innovation plan of investments foresees some possible paths such as:
a) “Professional software co-developments” with intellectual property of the delivered products transferred entirely to ASTERICS partners.
b) Co-development of database software frameworks where private companies have already achieved a superior level of competence or are willing to follow-up the ESFRI use cases for cooperative work. An example is the case of applying web-technologies such Hadoop generally used on text files to astronomical data formats such as FITS and/or FITSwrapped data packets.
c) Consulting contracts to support technological survey (e.g. on workload management on distributed data centres; engineering of on-line data streaming processing/ground segments).
d) Exploring a few co-funded PhD scholarships with major private companies (e.g. CUDA for GPU programming) around astronomical data analysis use cases.
e) Sub-contracting to SMEs some computing benchmark prototypes, combining low-cost processors such as ARM and GPUs, integrating both on-line data streaming efficiency and data processing acceleration.

Task 3.2 D-GEX: Data GEneration and information eXtraction (UCM +INAF)
Effort (PM)
INAF 24
UCM 16
ASTRON 24
UCAM 24
CPPM 18
LAPP 6
IFAE 10
INFN 12

In this area of the data flow, there are common challenges to create more robust hardware and software solutions for the handling of ever increasing data streams, and to ensure interoperability between a variety of different data-sources. OBELICS will promote sustained cross-fertilisation via a three-step process: a) share studies and seek synergies, b) foster evaluation and adoption of innovative solutions, c) sharing common prototype frameworks and standards.
Following this approach, D-GEX will be concerned with:
1. Surveying the real-time streaming data architectures applied and envisaged for the ESFRI and pathfinder facilities, to establish best practices and agree on common software frameworks or common software modules, extending e.g. LOFAR, ASKAP, HESS, MAGIC, ANTARES and ALMA frameworks.
2. Developing new and common data models and high performance formats for data streaming, compatible with interoperability standards beyond the existing FITS, ROOT and HDF5 leading to common standards.

3. Developing prototype libraries that allow robust and optimised handling of secondary data streams and meta-data (environmental and engineering data, temporary local archive, device control software and observation scheduling), ensuring long-term & shared maintenance of the proposed products.
4. Benchmarking low-power computer platforms (including Multicore, MIC, Microservers, GPU, FPGA, ARM) and software technologies/methods for data-driven scalable parallel programming. This subtask will also follow a three-step approach, and will last the full ASTERICS project duration, since it will evolve by monitoring the continuous evolution of the technologies and could be also inspired by progress made in other scientific domains. The expected measurable value is the up-take of these new computing and information technologies by the ESFRI facilities and there platforms.

Task 3.3 D-INT: Data systems INTegration
Effort (PM)
LAPP 72
ASTRON 48
INAF 48
UCAM 48
UCM 8
IFAE 14
FAU 36
INFN 6

The major common challenge addressed in this task is scaling-up existing databases and storage architectures beyond the Peta-scale level, while allowing for more complex queries addressing both primary sensor data and secondary data-streams. This task will involve:
1. Collecting use cases from existing facilities (in particular LOFAR) that place extreme requirements on the databases and the e-infrastructures on which they are deployed, and develop these into benchmarks for future facilities and technologies (in particular the Extremely Large Data Base “XLDB” initiative) aiming for full interoperability. This will allow the ESFRI and related pathfinder facilities to optimally engage with providers of e-infrastructures.
2. Developing of prototype benchmarks for testing within a larger multidisciplinary context (in particular the XLDB initiative) aiming for interoperability. The current investigation and prototypes of some partners are around the Qserv solutions or new generation DBs such as Cassandra or MongoDB. These will be used as examples and compared to the use cases of other projects.
3. Developing a portfolio of open services for data integration, based on existing Data Management System services like FLUME, RUCIO and Hadoop but extending these with optimised software modules to support e.g. VO-integration (in collaboration with WP4), and data interoperability between primary and secondary data-streams. Some services are already well known and applied, therefore a minimal repository can be made available in the first year. The repository will continuously be filled with new results of common work.
4. Extending software frameworks for data catalogues and query solutions to maximise data integration. This requires the reduction of latency for high data rates and the integration of multi-parameter Instrument Response Functions. Benchmarking and verification will be done through real pathfinder data, as well as Monte Carlo simulations. The complete software will be made available through the service repository.

Task 3.4 D-ANA: Data ANAlysis/interpretation
Effort (PM)
INAF 36
UCAM 60
LAPP 30
IAP 36
APC 24
CPPM 6
CEA 36
ASTRON 24
JIVE 24
INFN 18

In this area of the data flow, there is a common challenge to assess the quality of Petascale data sets and execute automatic analysis to reduce their size. This task is therefore concerned with:
1. Developing a collection of statistically robust and domain independent open source software libraries for data analysis and data mining on Peta-scale datasets. This will enable a sustained community-based effort towards excellent

exploitation of all data generated by the ESFRI and pathfinder facilities. The initial set of libraries developed within this task are in particular:
- Statistically robust approaches (Bayesian and likelihood analyses) to advance crossmatching between catalogues and transients detected via different instruments
- Domain independent image analysis for simultaneous feature classification and extraction in multi-dimensional/ multi-resolution data where the data are from multiple instruments.
- Effective likelihood reconstruction methods and new graphical processing approaches (mainly for event-based and signal-based projects but not exclusively) optimised for new computing technologies and maximum efficiency.

2. Establishing a common set of workflow architectures for the orchestration of compute intensive analysis of Peta-scale datasets on distributed computing infrastructures. This involves providing use cases and technical requirements, designing and testing of workflow engines on distributed compute-intensive systems, and improving existing authorisation, authentication and accounting protocols (e.g. eduGAIN services). In this respect, the cooperation with projects supported by the European Commission through the call EINFRA-7-2014, "Provision of core services across e-infrastructures" aimed to produce a global authorisation and authentication infrastructure is foreseen. Dedicated working meetings in the first stage of the project (M6) will be organized between the OBELICS partners and e-infrastructures providers, identifying the services to be adopted, explored or further developed through a shared approach.
All activities in this task will liaise and be complementary with WP4 (DADI), interfacing the respective activities will allow that the data, managed through the mechanisms identified and built by WP3, are archived, accessed, discovered and interoperated through the mechanisms defined by WP4.

UCM intends to subcontract technical assistance related to its participation in Tasks 3.2 D-GEX and 3.3 D-INT. The budget of the contract would amount to about one third of the direct personnel UCM budget, 40k Euro. The contract would last one year. It would cover:
• Assistance on software technologies used for Data access and distribution in astronomical observatories.
• Report on existing technologies and lessons learnt from previous observatories.
• Modelling and prototyping of the metadata and systems needed to locate the data, interpret it, and integrate this knowledge in the analysis chains.

We seek a partner with experience in services to Astronomical projects or observatories, who can work in close contact with the UCM team providing the software engineering expertise to complement our scientific experience. The selection will be done based on characteristics of the service offered, experience on similar projects and economic conditions.

Participation per Partner

Partner number and short name	WP3 effort
1 - ASTRON	96.00
2 - CNRS	236.00
3 - INAF	108.00
4 - UCAM	132.00
5 - JIVE	24.00
10 - FAU	36.00
12 - CEA	36.00
17 - IFAE	24.00
18 - UCM	24.00
19 - INFN	36.00
Total	752.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D3.1	Detailed WP3 Project plan	2 - CNRS	Report	Public	4
D3.2	First main thematic training event	2 - CNRS	Other	Public	12
D3.3	Analysis Report on Standards and Libraries	18 - UCM	Report	Public	12
D3.4	Software Libraries (initial)	4 - UCAM	Other	Public	12
D3.5	Analysis Report on Resource Requirements	2 - CNRS	Report	Public	18
D3.6	First WP3 general workshop	2 - CNRS	Other	Public	18
D3.7	Second main thematic training event	2 - CNRS	Other	Public	24
D3.8	Technology Benchmark Report (D-GEX, mid-term)	1 - ASTRON	Report	Public	24
D3.9	Technology Benchmark Reports (D-INT, mid-term)	1 - ASTRON	Report	Public	24
D3.10	Technology Benchmark Report (D-ANA, mid-term)	4 - UCAM	Report	Public	24
D3.11	Second WP3 general workshop	2 - CNRS	Other	Public	30
D3.12	Third main thematic training event	2 - CNRS	Other	Public	36
D3.13	Analysis Report on Frameworks and Architectures	3 - INAF	Report	Public	36
D3.14	Repository of Services (D-INT)	2 - CNRS	Other	Public	36
D3.15	Repository of Services (D-ANA)	3 - INAF	Other	Public	36
D3.16	Third WP3 general workshop	2 - CNRS	Other	Public	42

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D3.17	Final integral WP3 Report	2 - CNRS	Report	Public	48
D3.18	Technology Benchmark Report (D-GEX, final)	1 - ASTRON	Report	Public	48
D3.19	Technology Benchmark Reports (D-INT, final)	1 - ASTRON	Report	Public	48
D3.20	Software Libraries	4 - UCAM	Other	Public	48

Description of deliverables

User engagement forums and training events Analysis Reports, Technology Benchmarking, Software Libraries , and Service Repositories

D3.1 : Detailed WP3 Project plan [4]
Detailed WP3 Project plan

D3.2 : First main thematic training event [12]
First main thematic training event

D3.3 : Analysis Report on Standards and Libraries [12]
Analysis Report on Standards and Libraries

D3.4 : Software Libraries (initial) [12]
Software Libraries (initial)

D3.5 : Analysis Report on Resource Requirements [18]
Analysis Report on Resource Requirements

D3.6 : First WP3 general workshop [18]
First WP3 general workshop

D3.7 : Second main thematic training event [24]
Second main thematic training event

D3.8 : Technology Benchmark Report (D-GEX, mid-term) [24]
Technology Benchmark Report (D-GEX, mid-term)

D3.9 : Technology Benchmark Reports (D-INT, mid-term) [24]
Technology Benchmark Reports (D-INT, mid-term)

D3.10 : Technology Benchmark Report (D-ANA, mid-term) [24]
Technology Benchmark Report (D-ANA, mid-term)

D3.11 : Second WP3 general workshop [30]
Second WP3 general workshop

D3.12 : Third main thematic training event [36]
Third main thematic training event

D3.13 : Analysis Report on Frameworks and Architectures [36]
Analysis Report on Frameworks and Architectures

D3.14 : Repository of Services (D-INT) [36]

Repository of Services (D-INT)

D3.15 : Repository of Services (D-ANA) [36]
Repository of Services (D-ANA)

D3.16 : Third WP3 general workshop [42]
Third WP3 general workshop

D3.17 : Final integral WP3 Report [48]
Final integral WP3 Report

D3.18 : Technology Benchmark Report (D-GEX, final) [48]
Technology Benchmark Report (D-GEX, final)

D3.19 : Technology Benchmark Reports (D-INT, final) [48]
Technology Benchmark Reports (D-INT, final)

D3.20 : Software Libraries [48]
Software Libraries

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS10	Initial Analysis	2 - CNRS	18	Review D3.3, D3.4, D3.5
MS14	Mid-term Benchmarks	2 - CNRS	24	Review D3,7, D3.8, D3.9
MS22	Final Analysis	2 - CNRS	36	Review D3.11; D3.12, D3.13 available
MS30	Final Benchmarks	2 - CNRS	48	Review D3.15, D3.16, D3.17

Work package number [9]	WP4	Lead beneficiary [10]	2 - CNRS
Work package title	DADI (Data Access, Discovery and Interoperability)		
Start month	1	End month	48

Objectives

Make the ESFRI and pathfinder project data available for discovery and usage by the whole astronomical community, interoperable in a homogeneous international framework, and accessible with a set of common tools. More specifically:
Train and support ESFRI project staff in the usage and implementation of the VO framework and tools, and make them active participants in the development of the VO framework definition and updates, thus contributing to relevance and sustainability of the framework.
Train and support the wider astronomical community in scientific use of the framework, in particular for pathfinder data, and gather their requirements and feedback.
Adapt the VO framework and tools to the ESFRI project needs, and make sure European astronomers remain lead actors in the IVOA, influencing it in the interest of the European infrastructures and the European scientific community.

Description of work and role of partners

WP4 - DADI (Data Access, Discovery and Interoperability) [Months: 1-48]
CNRS, ASTRON, INAF, INTA, UEDIN, UHEI
DADI (Data Access, Discovery and Interoperability)

The partners have selected Dr. Francoise Genova (CNRS/OAS) as the leader of WP4. She will dedicate approximately 20% of her working time to the project. The leadership of the various tasks is shared between CNRS OAS, INAF, INTA, UEDIN and UHEI which participate in all tasks, as well as SKA (represented in WP4 by ASTRON), CTA (represented by CNRS/LUTH), EGO (represented by CNRS/APC) and KM3Net (represented by CNRS/CPPM) and the related pathfinders. As associate partners in ASTERICS, ESO will also be invited to participate in these activities and provide the E-ELT requirements.
An annual report on WP4 activities will include feedback and requirements on standards and tools from the ESFRI projects and the scientific community, progress in the test implementation at the pathfinders and ESFRI projects, description of and links to the training material, description of ASTERICS staff activities in the IVOA, and description and links to the products (data publication tools & libraries, standards and data access tools) (These reports will be included in the project's periodic report). WP4 products (data publication tools and software, standards & access tools, training material etc.) will be made available in the product repository as produced by the project (mid-term D4.8, final D4.15)

Figure 6 (See part B): The ESFRI projects integrated in the VO Framework offers users uniform access.

Task 4.1 - Support to astronomy ESFRI facilities, their pathfinders and other infrastructures of pan-European interest for implementation of their data in the VO framework
Effort (PM)
INAF 36
UHEI 36
APC 15
CPPM 8
OAS 14
UNISTRA 4
LUTH 3
OBSPAR 23
UEDIN 15
ASTRON 26
INTA 15

Networking and training:
o Annual Forum and Training event to network, share lessons learnt, discuss requirements and provide training on how to implement data in the VO. Years 1 and 3: 'ESFRI Forum and Training event' gathering ESFRI facility staff and VO developers (3 persons/WP4 participant) – D4.3 & D4.10. Years 2 and 4: 'European Data Provider Forum and Training

event' open to other data providers but still focused on ESFRI projects – D4.6 & D4.13. These are the same kind of meeting including other European Data Providers, in particular from infrastructures of pan-European interest, with a Call for participation open to the whole European astronomical community. A similar participation is expected from WP4 partners, with additionally ~20 participants from other data providers.
o Provision of on-line tutorials and training material (D4.8, D4.15).
Direct support to implementation of ESFRI facility data in the VO framework, local training of technical and scientific staff (helpdesk, registry, software libraries and repository, visits of experienced staff from VO teams),
Gathering ESFRI project requirements and feedback from all activities as an input to Task 4.3.

Task 4.2 - Support to the astronomical community
Effort (PM)
INTA 36
OAS 32
UNISTRA 4
APC 7
CPPM 2
INAF 13
LUTH 3
OBSPAR 7
UEDIN 15
ASTRON 10
UHEI 10

Provision of training (European, regional and national schools)
o 1 European school/year (D4.2, D4.5, D4.9, D4.12). The schools (~50 participants) are aimed at scientists, in particular at the PhD and post-doctoral level, with a Call for participation open to the whole European astronomical community. They have handson format with regularly updated tutorials, including support of participant's science project. Tutors will be VO specialists, access tool developers and ESFRI facility related staff.
o Provision of on-line science tutorials (D4.8, D4.15),
o Collaboration with science projects to enable them to use the data framework.
o Gathering scientific requirements and feedback from all activities as an input to Task 4.3

Task 4.3 - Updates of the VO framework from feedback and requirements
Effort (PM)
OAS 32
UNISTRA 4
UEDIN 36
INAF 17
CPPM 2
APC 4
LUTH 1
UHEI 20
OBSPAR 5
ASTRON 6
INTA 15

Identification of priorities based on ESFRI, pathfinder and scientific needs (incremental process with inputs from Tasks 4.1 and 4.2):
o Identification of priorities by the AEAB – ASTERICS External Advisory Board,
o Initial priorities: multi-dimensional data (including polarisation), time domain, provenance, adapt VO tools to new observables.
Update or definition of standards:
o Participation in IVOA meetings (8 Milestones, 2 participants/WP4 partner to each event, to present progress and results and discuss priorities),
o ASTERICS DADI Technology Forum. The Forums enable technology discussion involving the framework developers and ESFRI project staff, to develop technical collaboration and exchange good practice - establishing a European strategy for IVOA and RDA activities. 2 events in year 1, then 1/year, ~28 participants (D4.1, D4.4, D4.7, D4.11, D4.14)
o Technical work in IVOA Working Groups and Interest Groups driven by the priorities.

Updates of the data-publication tools, software libraries and VO-enabled access tools: technical work on priorities. (Repository of products D4.8, D4.15)
Liaison with RDA and other initiatives dealing with interoperability (the bi-yearly RDA plenaries constitute 8 meetings, with participation expected from the VO and ESFRI teams).
Liaison with OBELICS (WP3) led by INAF.

Participation per Partner

Partner number and short name	WP4 effort
1 - ASTRON	42.00
2 - CNRS	123.00
OBSPARIS	35.00
UNISTRA	12.00
3 - INAF	66.00
6 - INTA	66.00
7 - UEDIN	66.00
8 - UHEI	66.00
Total	476.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D4.1	First ASTERICS DADI Technology Forum	2 - CNRS	Other	Public	5
D4.2	First ASTERICS European School	6 - INTA	Other	Public	7
D4.3	First ESFRI Forum & Training event	3 - INAF	Other	Public	7
D4.4	Second ASTERICS DADI Technology Forum	7 - UEDIN	Other	Public	11
D4.5	Second ASTERICS European School	2 - CNRS	Other	Public	19
D4.6	First “European Data Provider Forum & Training event”	8 - UHEI	Other	Public	19
D4.7	Third ASTERICS DADI Technology Forum	2 - CNRS	Other	Public	23

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D4.8	Repository of WP4 products (mid-term delivery)	2 - CNRS	Other	Public	24
D4.9	Third ASTERICS European School	6 - INTA	Other	Public	31
D4.10	Second ESFRI Forum & Training event	3 - INAF	Other	Public	32
D4.11	Fourth ASTERICS DADI Technology Forum	7 - UEDIN	Other	Public	35
D4.12	Fourth ASTERICS European School	2 - CNRS	Other	Public	43
D4.13	Second European Data Provider Forum & Training event	8 - UHEI	Other	Public	45
D4.14	Fifth ASTERICS DADI Technology Forum	2 - CNRS	Other	Public	47
D4.15	Repository of WP4 products (final delivery)	2 - CNRS	Other	Public	48

Description of deliverables

Forums, Schools, and Training Events Repository of WP4 products

D4.1 : First ASTERICS DADI Technology Forum [5]
First ASTERICS DADI Technology Forum (Sept 2015)

D4.2 : First ASTERICS European School [7]
First ASTERICS European School (November 2015)

D4.3 : First ESFRI Forum & Training event [7]
First ESFRI Forum & Training event (November 2015)

D4.4 : Second ASTERICS DADI Technology Forum [11]
Second ASTERICS DADI Technology Forum (May 2016)

D4.5 : Second ASTERICS European School [19]
Second ASTERICS European School (November 2016)

D4.6 : First “European Data Provider Forum & Training event” [19]
First “European Data Provider Forum & Training event” (November 2016)

D4.7 : Third ASTERICS DADI Technology Forum [23]
Third ASTERICS DADI Technology Forum (March 2017)

D4.8 : Repository of WP4 products (mid-term delivery) [24]
Repository of WP4 products (mid-term delivery)

D4.9 : Third ASTERICS European School [31]

Third ASTERICS European School (November 2017)

D4.10 : Second ESFRI Forum & Training event [32]

Second ESFRI Forum & Training event (December 2017)

D4.11 : Fourth ASTERICS DADI Technology Forum [35]

Fourth ASTERICS DADI Technology Forum (March 2018)

D4.12 : Fourth ASTERICS European School [43]

Fourth ASTERICS European School (November 2018)

D4.13 : Second European Data Provider Forum & Training event [45]

Second European Data Provider Forum & Training event (January 2019)

D4.14 : Fifth ASTERICS DADI Technology Forum [47]

Fifth ASTERICS DADI Technology Forum (March 2019)

D4.15 : Repository of WP4 products (final delivery) [48]

Repository of WP4 products (final delivery)

Schedule of relevant Milestones

Milestone number [18]	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS2	Presentation of progress and results and discussion of priorities at IVOA (1)	2 - CNRS	2	Meeting website – ASTERICS participation
MS5	Progress and priorities at IVOA (2)	2 - CNRS	6	Meeting website – ASTERICS participation
MS7	Progress and priorities at IVOA (3)	2 - CNRS	13	Meeting website – ASTERICS participation
MS11	Progress and priorities at IVOA (4)	2 - CNRS	18	Meeting website – ASTERICS participation
MS16	Progress and priorities at IVOA (5)	2 - CNRS	25	Meeting website – ASTERICS participation
MS20	Progress and priorities at IVOA (6)	2 - CNRS	30	Meeting website – ASTERICS participation
MS24	Progress and priorities at IVOA (7)	2 - CNRS	37	Meeting website – ASTERICS participation
MS27	Progress and priorities at IVOA (8)	2 - CNRS	42	Meeting website – ASTERICS participation

Work package number [9]	WP5	Lead beneficiary [10]	5 - JIVE
Work package title	CLEOPATRA: Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts		
Start month	1	End month	48

Objectives

The partners in ASTERICS share an ambition to use modern communication methods, such as fast broadband connectivity, to improve the scientific capabilities of their research infrastructures. The research activities aim specifically at synergetic observing modes, and fast and reliable access to large data streams. These aspects are covered in the work package CLEOPATRA (Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts).
Develop technology for the enabling of long-haul and many-element time and frequency distribution over fibre connections. This has the potential to increase the efficiency and affordability of all radio astronomy facilities (SKA, LOFAR, VLBI). Such developments are also highly relevant for astroparticle facilities (CTA, KM3NET) and can enable novel realtime multi messenger observations.
Develop methods for relaying alerts, which will signal transient event detections between the facilities and enable joint observing programmes. The focus will not just be on interchange formats but on scientific strategies and methods for joint observing.
Further development of existing data streaming software, building on the success of previous e-VLBI projects, and providing tools for robust and efficient data dissemination for all facilities in the user domain, including ESO facilities such as ALMA and the E-ELT.
Foster the development of advanced scheduling algorithms, using AI approaches for optimal usage of the ESFRI facilities. The proposed tasks reflect a consistent set of enhancements of the facilities based on developments in connectivity and data transport.

Description of work and role of partners

WP5 - CLEOPATRA: Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts [Months: 1-48]
JIVE, ASTRON, CNRS, VU/VUmc, UVA, UGR, FOM, IEEC , STFC, DESY, SURFnet
CLEOPATRA: Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts

Figure 7 (See part B): CLEOPATRA delivers solutions for shared challenges of ESFRI facilities.

Task 5.1. Synchronization.
Effort (PM)
VU 36
ASTRON 12
JIVE 24
UGR 36
FOM 30
DESY 18
SURFnet 8

The partners have selected Prof. Huib Jan van Langevelde (JIVE) as leader of WP5. He will dedicate approximately 20% of his working time to the project. Radio interferometers and other distributed astronomy facilities depend critically on the distribution of a common clock and frequency standard. For the highest observing frequencies and longest baselines this can demand frequency stabilities of ~ 10-13 at one second averaging, and timing uncertainties < 1 nanosecond (ns). We propose to enable time and frequency transfer on optical fibre networks through White Rabbit Ethernet (WRE). WRE is already deployed for physics detectors, in order to overcome the need for expensive atomic or maser clocks and extensive calibration procedures. This technology provides a highly standardised alternative to the intricate and custom-built timing solutions used in previous neutrino telescopes and radio telescope arrays. In addition to this intra-experiment application, the technology can interconnect facilities into coherent networks. WRE will also enable highly synchronised real-time observations of the same astronomical objects by widely separated instruments, providing a unique "multi-messenger" view of astrophysical phenomena, using lowand high-energy photons as well as neutrinos simultaneously.

Looking beyond these exciting scientific applications, the technology could be used to back-up or augment, timing and navigation through the Global Navigation Satellite Systems (such as GPS and Galileo), enabling e.g. centimetre-level positioning for indoor navigation and autonomous vehicles using hybrid opticalwireless networks.

This task will be implemented as an R&D project to:
upgrade WRE to generic technology for deployment on long-haul telecom networks,
increase its frequency stability by three orders of magnitude in order to achieve the hydrogen maser level stability required by the SKA and other (commercial) applications
develop new calibration and characterisation tools for WRE equipment, providing a faithful and accurate timing source to the many element detector arrays of the CTA and KM3NeT.

For long-haul synchronisation, a critical issue is developing (design rules for) bi-directional light paths (needed for sub-ns timing) in existing and operational fibre-optic telecommunication networks which could be preferred over leasing dedicated fibres (D5.1). Upgrading the stability of off-the-shelf WRE to maser-level performance (enabling simple fibre-optic distribution of the signal of a single maser to many users) will take the development of state-of-the-art clean-up filters based on cost-effective yet high-quality oscillators, and predictive control schemes based on fuzzy logic or Costas control loops (deliverable D5.4). These efforts should enable the signal distribution of a single maser, with sub-ns accuracy, through an existing optical transport network (D5.7). A VLBI field trial (using radio telescopes at Westerbork and Dwingeloo) is foreseen using a 2×125 km fibre link traversing parts of the SURFnet and LOFAR networks, and running fully parallel to live data traffic (D5.14). Robust WRE hardware and interfaces need to be developed that can operate in the harsh (desert or deep underwater) conditions to be encountered at the ESFRI sites (D5.3). New tools and methods must be established in order to calibrate hundreds of WRE nodes prior to installation, and for in situ calibration and quality assurance of the WRE network synchronisation system in the field (D5.6). The current version of WRE therefore needs to be upgraded to a version with such robustness and added functionality, suited for all RIs, and with advanced algorithms for time stamping and monitoring. Also, all RIs consist of nodes transmitting over 1 Gbps of data each. It is therefore mandatory to extend 1 Gbps WRE to 10 Gbps data transport capability (D5.15). These tasks will be accomplished by UGR, FOM (Nikhef), and DESY.

Task 5.2 Multi messenger methods.
Effort (PM)
ASTRON 24
CNRS-APC 24
JIVE 24
UVA 24

The detection of astrophysical transients has become very important in astronomy and many efforts have started to enable follow-up observations at other wavelengths within hours or even minutes of a transient detection. A common interest of the ASTERICS partners is to port these practices to multi-messenger astronomy and implement them for the large-scale RIs (including the E-ELT) of the future. The exchange of the event messages can be implemented through VOEvents, defined by the Virtual Observatory community. However, for joint programmes this effort must be enhanced to include the exchange of instrument status information and to define and implement handshake protocols to allow predictable and reliable handling of follow-up, or joint, observations. Because future observatories may create up to millions of alerts per night (e.g. LSST), a critical focus area will be on tools that can distil the most promising triggers for a specific facility. This implies a major effort dealing with the receiving system, authorisation, prioritisation and identity methodology.
This task will aim to develop standards for the generation, dissemination, distribution, and reaction to multi-messenger events. This will take the form of a design document, leading to software being implemented for one or two facilities (LOFAR & EGO). A demonstration is to be set up in which e.g. radio facilities follow-up an event generated by a gravitational wave detector. Part of the project is to investigate potential scientific synergies for implementing methods for automated follow-up observations. A workshop will be organised in order to give outside parties (from small optical telescopes to space programmes) the chance to connect to these developments.

Task 5.3. Post-detection data streaming.
Effort (PM)
JIVE 24

In the context of e-VLBI, some data streaming methods have been developed (e.g. via the ECfunded FP6 EXPReS & FP7 NEXPReS projects) that successfully adapted several protocols for optimal connectivity and implemented data selection based on available bandwidth. Across a number of ESFRI partners in ASTERICS there are similar data-flow control needs, mostly when disseminating the results from the facility to the users or data archives. After making an

inventory of these needs, we propose to produce a user client that robustly and intelligently helps users and operators make decisions on how much data they choose to transport, automatically adopts the appropriate transfer protocol and manages their expectations on the time to completion. This task is relevant to all the ASTERICS ESFRI facilities, in addition to many other major telescopes e.g. ALMA.

Task 5.4, Scheduling of large astronomical infrastructures.
Effort (PM)
IEEC 24
STFC 24
GTD 24

A common issue for some of the new and operational facilities in the ASTERICS consortium is the scheduling of complex, many-element detector arrays. Highly efficient planning and decisionmaking procedures in such large astronomical facilities by human intervention has become largely unaffordable and also inefficient. Although all observatories have their specific design considerations, it is envisioned that these schemes can benefit from common and modern Artificial Intelligence (AI) techniques that optimise the scientific procedures. A joint programme will research how the SKA and CTA could maximise their science return with AI scheduling solutions. The programme will also incorporate multi-frequency, multi-messenger astrophysics at the scheduling level, providing a framework to coordinate and schedule multiple facilities. Research on standardisation will permit schemes where mutual constraints can also be taken into account. This will be of interest to existing facilities too (LOFAR, ESO / ALMA), as well as the E-ELT. This effort builds on an existing effort of the CTA, and the project will research the impact of SKA and CTA cross-facility coordination.

Participation per Partner

Partner number and short name	WP5 effort
1 - ASTRON	36.00
2 - CNRS	24.00
5 - JIVE	72.00
11 - VU/VUmc	36.00
13 - UVA	24.00
14 - UGR	36.00
15 - FOM	30.00
16 - IEEC	24.00
GTD	12.00
20 - STFC	12.00
21 - DESY	18.00
22 - SURFnet	8.00
Total	332.00

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D5.1	General design rules for implementation	22 - SURFnet	Report	Public	14

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
	in existing optical networks				
D5.2	Multi-messenger alert handling design document	1 - ASTRON	Report	Public	18
D5.3	Qualification of WRE components under (harsh) realistic conditions	21 - DESY	Report	Public	24
D5.4	Hardware for maser-level time & frequency distribution in optical transport networks	11 - VU/VUmc	Demonstrator	Public	26
D5.5	Data streaming software client	5 - JIVE	Other	Public	28
D5.6	Tools and methods for delay calibration before installation and in situ.	15 - FOM	Report	Public	30
D5.7	Time transfer in SURFnet/ LOFAR network & general design rules for network implementation	11 - VU/VUmc	Report	Public	32
D5.8	Summary of workshop in alerting mechanisms with outside partners	13 - UVA	Report	Public	32
D5.9	Report on scheduling algorithms and standard interfaces for cross-facility scheduling	20 - STFC	Report	Public	36
D5.10	Software components multi-messenger event handling	1 - ASTRON	Report	Public	40
D5.11	Scientific study synergies of transient event observing	13 - UVA	Report	Public	42

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D5.12	Multi-facility scheduling simulation and performance analysis software	16 - IEEC	Demonstrator	Public	42
D5.13	Pilot multi-messenger event handling	2 - CNRS	Demonstrator	Public	46
D5.14	Demonstration of VLBI synchronization via existing SURFnet/ LOFAR network	5 - JIVE	Report	Public	48
D5.15	Advanced algorithms and WRE upgrade to 10 Gb/s capacity	14 - UGR	Demonstrator	Public	48

Description of deliverables

Multiple technical steps in the developement of WP5 products

D5.1 : General design rules for implementation in existing optical networks [14]
General design rules for implementation in existing optical networks

D5.2 : Multi-messenger alert handling design document [18]
Multi-messenger alert handling design document

D5.3 : Qualification of WRE components under (harsh) realistic conditions [24]
Qualification of WRE components under (harsh) realistic conditions

D5.4 : Hardware for maser-level time & frequency distribution in optical transport networks [26]
Hardware for maser-level time & frequency distribution in optical transport networks

D5.5 : Data streaming software client [28]
Data streaming software client

D5.6 : Tools and methods for delay calibration before installation and in situ. [30]
Tools and methods for delay calibration before installation and in situ.

D5.7 : Time transfer in SURFnet/LOFAR network & general design rules for network implementation [32]
Time transfer in SURFnet/LOFAR network & general design rules for network implementation

D5.8 : Summary of workshop in alerting mechanisms with outside partners [32]
Summary of workshop in alerting mechanisms with outside partners

D5.9 : Report on scheduling algorithms and standard interfaces for cross-facility scheduling [36]
Report on scheduling algorithms and standard interfaces for cross-facility scheduling

D5.10 : Software components multi-messenger event handling [40]
Software components multi-messenger event handling

D5.11 : Scientific study synergies of transient event observing [42]
Scientific study synergies of transient event observing

D5.12 : Multi-facility scheduling simulation and performance analysis software [42]

Multi-facility scheduling simulation and performance analysis software

D5.13 : Pilot multi-messenger event handling [46]

Pilot multi-messenger event handling

D5.14 : Demonstration of VLBI synchronization via existing SURFnet/LOFAR network [48]

Demonstration of VLBI synchronization via existing SURFnet/LOFAR network

D5.15 : Advanced algorithms and WRE upgrade to 10 Gb/s capacity [48]

Advanced algorithms and WRE upgrade to 10 Gb/s capacity

Schedule of relevant Milestones

Milestone number [18]	**Milestone title**	**Lead beneficiary**	**Due Date (in months)**	**Means of verification**
MS8	Design rules/ simulations tool	5 - JIVE	14	Results of simulation tool
MS9	Prototype software	5 - JIVE	14	Prototype
MS12	Multi Messenger Design	5 - JIVE	20	Agreed design
MS15	WRE functionality guaranteed for equipment in harsh conditions	5 - JIVE	24	Results of climate chamber tests
MS17	Hardware for maser-level time & frequency distribution in optical transport networks demonstrated	5 - JIVE	26	Prototype
MS18	Delivery software client	5 - JIVE	28	Software tool available
MS19	In situ verification of WRE sub-ns timing uncertainty	5 - JIVE	30	Results of calibration & test campaign
MS21	Interoperability with live networks demonstrated	5 - JIVE	32	Laboratory test (SURFsara DAS network)
MS23	Define algorithms	5 - JIVE	36	Report
MS26	Simulation software	5 - JIVE	42	Software running
MS28	Multi Messenger Pilot	5 - JIVE	46	Pilot execution
MS31	VLBI with fibre-optic synchronisation demonstrated	5 - JIVE	48	Results of field trial
MS32	WRE equipment with 10 Gb/s capacity, advanced algorithms and common interface	5 - JIVE	48	Prototype

1.3.4. WT4 List of milestones

Milestone number [18]	Milestone title	WP number [9]	Lead beneficiary	Due Date (in months) [17]	Means of verification
MS1	Project Kick-Off meeting	WP1	1 - ASTRON	1	Website
MS2	Presentation of progress and results and discussion of priorities at IVOA (1)	WP4	2 - CNRS	2	Meeting website – ASTERICS participation
MS3	1st AGA meeting Governance entities (e.g. AEB, AEAB) and AMST fully appointed	WP1	1 - ASTRON	3	Minutes of the meeting
MS4	1st ASTERICS Policy Forum group meeting	WP1	1 - ASTRON	6	Website + minutes of the meeting
MS5	Progress and priorities at IVOA (2)	WP4	2 - CNRS	6	Meeting website – ASTERICS participation
MS6	1st AEAB evaluation + Acceptance of annual reports	WP1	1 - ASTRON	12	Review of Deliverables of M1 - M12
MS7	Progress and priorities at IVOA (3)	WP4	2 - CNRS	13	Meeting website – ASTERICS participation
MS8	Design rules/ simulations tool	WP5	5 - JIVE	14	Results of simulation tool
MS9	Prototype software	WP5	5 - JIVE	14	Prototype
MS10	Initial Analysis	WP3	2 - CNRS	18	Review D3.3, D3.4, D3.5
MS11	Progress and priorities at IVOA (4)	WP4	2 - CNRS	18	Meeting website – ASTERICS participation
MS12	Multi Messenger Design	WP5	5 - JIVE	20	Agreed design
MS13	Mid-Term Review + AEAB evaluation + Acceptance of annual reports	WP1	1 - ASTRON	24	Review of Deliverables of M13 - M24 Mid-Term project review report
MS14	Mid-term Benchmarks	WP3	2 - CNRS	24	Review D3,7, D3.8, D3.9
MS15	WRE functionality guaranteed for	WP5	5 - JIVE	24	Results of climate chamber tests

Milestone number [18]	Milestone title	WP number [9]	Lead beneficiary	Due Date (in months) [17]	Means of verification
	equipment in harsh conditions				
MS16	Progress and priorities at IVOA (5)	WP4	2 - CNRS	25	Meeting website – ASTERICS participation
MS17	Hardware for maser-level time & frequency distribution in optical transport networks demonstrated	WP5	5 - JIVE	26	Prototype
MS18	Delivery software client	WP5	5 - JIVE	28	Software tool available
MS19	In situ verification of WRE sub-ns timing uncertainty	WP5	5 - JIVE	30	Results of calibration & test campaign
MS20	Progress and priorities at IVOA (6)	WP4	2 - CNRS	30	Meeting website – ASTERICS participation
MS21	Interoperability with live networks demonstrated	WP5	5 - JIVE	32	Laboratory test (SURFsara DAS network)
MS22	Final Analysis	WP3	2 - CNRS	36	Review D3.11; D3.12, D3.13 available
MS23	Define algorithms	WP5	5 - JIVE	36	Report
MS24	Progress and priorities at IVOA (7)	WP4	2 - CNRS	37	Meeting website – ASTERICS participation
MS25	AEAB evaluation + Acceptance of annual reports	WP1	1 - ASTRON	38	Review of Deliverables of M25 – M36
MS26	Simulation software	WP5	5 - JIVE	42	Software running
MS27	Progress and priorities at IVOA (8)	WP4	2 - CNRS	42	Meeting website – ASTERICS participation
MS28	Multi Messenger Pilot	WP5	5 - JIVE	46	Pilot execution
MS29	AEAB evaluation + Acceptance of annual reports + Final project review (incl. lessons learned)	WP1	1 - ASTRON	48	Review of Deliverables of M37 – M48 final project review report
MS30	Final Benchmarks	WP3	2 - CNRS	48	Review D3.15, D3.16, D3.17

Milestone number [18]	Milestone title	WP number [9]	Lead beneficiary	Due Date (in months) [17]	Means of verification
MS31	VLBI with fibre-optic synchronisation demonstrated	WP5	5 - JIVE	48	Results of field trial
MS32	WRE equipment with 10 Gb/s capacity, advanced algorithms and common interface	WP5	5 - JIVE	48	Prototype

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
R1	Project governance does not work	WP1	The partners forming the consortium (see section 3.3) have extensive experience in working on EC funded projects and understand the requirements they demand, also with respect to reporting and financial administration.
R2	Project coordinator does not work	WP1	Governance structure in place to monitor and act.
R3	Project management does not work	WP1	Project coordinator and Governance structure in place to monitor and act.
R4	MPE Infrastructure not ready	WP2	MPE Infrastructure will be built based on existing infrastructure, so no critical design components. Content progress will be monitored.
R5	No participants for MPE Operation	WP2	Participation will be beneficial for ESFRI facilities participating in the project, so there will be enough pressure to participate.
R6	Dissemination and outreach does not reach far enough	WP2	ASTRON (lead) has a good record on outreach and dissemination and has an interest in making the project well known to everyone.
R7	Lack of ICT infrastructures and skills in computing	WP3	Direct involvement of major Computing Centres owned by ASTERICS partners and supporting the ESFRI projects is formally defined through D3.1. This would minimize the risk and allow to look for international “relay-mode” cooperation among centres, e.g. EU-T0 collaboration framework will support the WP3 management and to guarantee the execution of the project plan.
R8	Activities diverging from the cooperative	WP3	All proposed tasks are selected on the basis of common prior interest with

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
	framework and lack of cross-fertilization		at least two or more ESFRI projects standing to benefit. Funded human resources are allocated exclusively for federated efforts. Mid-term deliverables will help to gather interest and cooperation from more partners and allow monitoring that the path followed path is consistent with the expected objectives. The AEB together with the AMST will monitor this closely.
R9	Scale of WP3 leads to fragmentation of effort and disengagement from the main project. Limited coherence with similar efforts and developments in other domains	WP3	Task MAUD will bring sufficient management resources to ensure OBELICS does not diverge - data dissemination through co-located thematic but multi-disciplinary events; cooperation of well-established and transversal ICT and e-initiatives etc.
R10	VO framework does not meet the needs of the ESFRI infrastructures.	WP4	ASTERICS is designed to collect requirements and feedback from ESFRI projects on implementation of the VO framework (Task 4.1). ASTERICS partners have significant experience with implementation of the framework, and will use the requirements and feedback to make any necessary customisations. ASTERICS partners hold leadership roles in IVOA and will integrate priorities and requirements for the updates of the framework into the IVOA process.
R11	Pathfinder/ESFRI projects do not implement the VO framework	WP4	ASTERICS is designed to provide support from experienced VO teams (Task 4.1): direct support, helpdesk, and the provision of data publication software libraries. Global emphasis on Science 2.0 principle will force European scale

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
			projects to comply with VO goals.
R12	The data framework does not meet the needs of the scientific community	WP4	ASTERICS Task 4.2 uses training combined with the gathering of requirements and feedback to ensure the relevance of VO tools and framework. High-level guidance is provided by the AEAB.
R13	Divergence of priorities between ASTERICS and IVOA	WP4	ASTERICS partners include leading actors in the IVOA, and Task 4.3 will ensure representation of European priorities within IVOA.
R14	Wavelength-stabilized OSC-band transmitters not commercially available (D5.1.1)	WP5	In-house design of transmitters is possible.
R15	Impact of environmental site factors on timing precision underestimated (D5.1.5)	WP5	Partners have realistic lab simulators that can recreate these conditions. Combine lab tests with actual field test campaign at CTA site
R16	Divergent scientific and operational requirements and goals	WP5	Invoke task coordination meetings and identify primary objectives early on.
R17	No budgeted operational/ investment cost for pilot	WP5	Review impact at design milestone
R18	CTA and SKA scheduling software applications are not ready to integrate both projects in the simulation	WP5	Involve CTA and SKA development teams from the beginning to discuss the maturity of the software and jointly define the base requirements to build the simulation infrastructure.

1.3.6. WT6 Summary of project effort in person-months

	WP1	WP2	WP3	WP4	WP5	Total Person/Months per Participant
1 - ASTRON	84	12	96	42	36	270
2 - CNRS	4	0	236	123	24	387
· OBSPARIS	0	0	0	35	0	35
· UNISTRA	0	0	0	12	0	12
3 - INAF	0	12	108	66	0	186
4 - UCAM	0	0	132	0	0	132
5 - JIVE	0	0	24	0	72	96
6 - INTA	0	0	0	66	0	66
7 - UEDIN	0	0	0	66	0	66
8 - UHEI	0	0	0	66	0	66
9 - OU	0	29	0	0	0	29
10 - FAU	0	0	36	0	0	36
11 - VU/VUmc	0	0	0	0	36	36
12 - CEA	0	0	36	0	0	36
13 - UVA	0	0	0	0	24	24
14 - UGR	0	0	0	0	36	36
15 - FOM	0	0	0	0	30	30
16 - IEEC	0	0	0	0	24	24
· GTD	0	0	0	0	12	12
17 - IFAE	0	0	24	0	0	24
18 - UCM	0	0	24	0	0	24
19 - INFN	0	0	36	0	0	36
20 - STFC	0	0	0	0	12	12
21 - DESY	0	0	0	0	18	18

	WP1	WP2	WP3	WP4	WP5	Total Person/Months per Participant
22 - SURFnet	0	0	0	0	8	8
Total Person/Months	88	53	752	476	332	1701

1.3.7. WT7 Tentative schedule of project reviews

Review number [19]	Tentative timing	Planned venue of review	Comments, if any
RV1	24	Brussels	

1.4. Ethics Requirements

No ethics requirements indicated

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

R	Document, report
DEM	Demonstrator, pilot, prototype
DEC	Websites, patent fillings, videos, etc.
OTHER	

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

PU	Public

CO Confidential, only for members of the consortium (including the Commission Services)
CI Classified, as referred to in Commission Decision 2001/844/EC

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number:MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

VA if virtual access,
TA-uc if trans-national access with access costs declared on the basis of unit cost,
TA-ac if trans-national access with access costs declared as actual costs, and
TA-cb if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.

History of Changes after proposal submission on 2 September 2014

date	location of change	change
17/03/2015	4.2.18	Removed PM from description of subcontracting for UCM.
17/03/2015	Table 3.4b (18)	UCM Total cost corrected, it still included the subcontracting cost that was removed from this table.
17/03/2015	Table 4.1.2.d	Université de Paris Pierre et Marie Curie has no person/months and will not claim any costs in the ASTERICS project.
17/03/2015	Table 4.1.2.e	Paris-Diderot University has no person/months and will not claim any costs in the ASTERICS project.
17/03/2015	Table 4.1.2.g	Université de Savoie has no person/months and will not claim any costs in the ASTERICS project.
17/03/2015	Table 4.1.2.h	University of Aix-Marseille has no person/months and will not claim any costs in the ASTERICS project.
09/03/2015	Table 4.2.9	Corrected OU table Linked third party to Article 11
09/03/2015	Table 3.1a.2,	Removed Oxford University as linked third party
09/03/2015	Table 3.4b (9),	Cost for in-kind contribution of Oxford University
04/03/2015	Table 3.4b (all), Section 3.4	Added breakdown and justification of travel cost
04/03/2015	Table 4.2.9	Corrected OU table subcontracted to Linked third party
04/03/2015	Table 3.4b (2),	corrected travel budget € 7000 from CNRS to INFN
04/03/2015	Table 3.1a.4, Task 4.1	corrected typo, OAS 18 → 14 PM
04/03/2015	Table 3.1a.1, Task 1.3	added: These registers (*mentioned in Task 1.3*) will be stored on the project website and open to at least the project partners. An overview of important changes and issues in these will be presented in the periodic reports.
04/03/2015	Table 3.1a.1, Task 1.3	Added Exploitation plan (D1.1, D1.3), Collaboration plan (D1.2, D1.4) to Task 1.3 and Deliverables conform description in impact section
04/03/2015	Table 3.1c	Removed periodic reports from Deliverable table. Added Exploitation plan and Collaboration plan as Deliverables.
04/03/2015	Table 3.1a.3, Table 3.1c	Correction: Changed description of Deliverables 3.2, 3.6, 3.10 (old numbering) and added three missing Deliverables to reflect earlier changes to Task 3.1.1.

03/03/2015	Table 3.4b (5)	Corrected typo in total cost Jive. Audit cost was listed but not included in the total in this table. It was included in Annex 2.
03/03/2015	Table 4.2.2 →(copy) 4.1.2.e	Description of Université de Strasbourg (UNISTRA) copied to the description of the main party CNRS-OAS
03/03/2015	Table 4.2.2 →(copy) 4.1.2.e	Description of Observatoire de Paris edited and copied to the description of the main party CNRS-LUTH
03/03/2015	Table 4.1.2.e	Paris-Diderot University has no person/months in the project.
03/03/2015	Table 4.1.2.g	Université de Savoie has no person/months in the project.
03/03/2015	Table 4.1.2.h	University of Aix-Marseille has no person/months in the project.
03/03/2015	Table 3.4b (18)	UCM subcontracting cost removed from this table.
03/03/2015	section 3.4 → 4.2.18	Moved description of subcontracting for UCM from section 3.4 to section 4.2.18 and small edits to the moved text.
03/03/2015	4.2.2	Copied description of subcontracting plans for CNRS from table 3.1a.3, Task 3.1(4) to section 4.2.2.
25/02/2015	page 11 and 34	Changed wording around “associate partner”, since this does not exist as legal term in H2020
25/02/2015	appendices 1,2	Moved from section 3 to end of document
18/02/2015	Table 3.1a.3 and section 3.4	added UCM subcontracting description (12 lines)
18/02/2015	Table 3.4b (end)	added table with UCM subcontracting costs
16/02/2015	WP4 Milestones Table 3.2a	The WP4 Milestones are linked to IVOA (International Virtual Observatory Alliance) Meetings, which are scheduled by an external organisation, normally in the months May and October. During the proposal preparation the start month of the project was not known, so the relative months were estimated incorrectly. This has been corrected now. Effectively, most of the dates were moved one months earlier in the project.
16/02/2015	WP4 Deliverables Table 3.1a.4 and Table 3.1c	The DADI Technology Forums were scheduled with respect to the IVOA Interops. The Schools and Training events were scheduled for fixed months (November) during the proposal preparation. Since the start month of the project was not known the relative months were estimated incorrectly. This has been corrected now. Effectively, most of the dates were moved two months later in the project. The product Deliverables dates were not moved.
15/02/2015	Table 3.1a.1	Corrected D1.4 from M40 to M44 to be consistent with Table 3.1c.
15/02/2015	Table 3.4a	Corrected CNRS and INFN effort for WP3. The numbers did not correspond to the numbers in Table 3.1a.3

Table of Contents

1. EXCELLENCE

This proposal – ASTERICS[1] (*Ast*ronomy *E*SFRI & *R*esearch *I*nfrastructure *C*luster) addresses the Horizon 2020 Work Programme, and the INFRADEV-4-2014/2015 Call – "Implementation and operation of cross-cutting services and solutions for clusters of ESFRI and other relevant research infrastructure initiatives". ASTERICS brings together, for the very first time, the astronomy, astrophysics and astroparticle physics facilities encompassed within the ESFRI roadmap. These include: the Square Kilometre Array (SKA), the Cherenkov Telescope Array (CTA), KM3NeT (km^3 Neutrino Telescope) and the European Extremely Large Telescope (E-ELT). Letters of support from the ESFRI projects and the astronomy and particle physics networks are presented in Appendix 1 of this document.

ASTERICS also engages with *aspiring* ESFRI projects (*e.g.* the Einstein Telescope, ET under the umbrella of the European Gravitational Observatory, EGO), and several other world-class research infrastructures (including the Joint Institute for VLBI in Europe, JIVE, currently in the final stages of evolving its legal status to an ERIC). The European Virtual Observatory (EURO-VO) is also a major contributor to this venture.

[1] A list of handy acronyms is provided at the end of the proposal.

The recent comprehensive assessment of the various ESFRI projects has noted the rapid progress already made by projects such as the E-ELT, and further prioritised a subset of the projects (12 of the 36), for support in the implementation phase. This subset includes both the SKA and CTA (for further details see http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri). This is further confirmation that these projects are pushing the boundaries of scientific excellence, are strategically relevant for Europe, and are ripe for investment by both the member states and the EC.

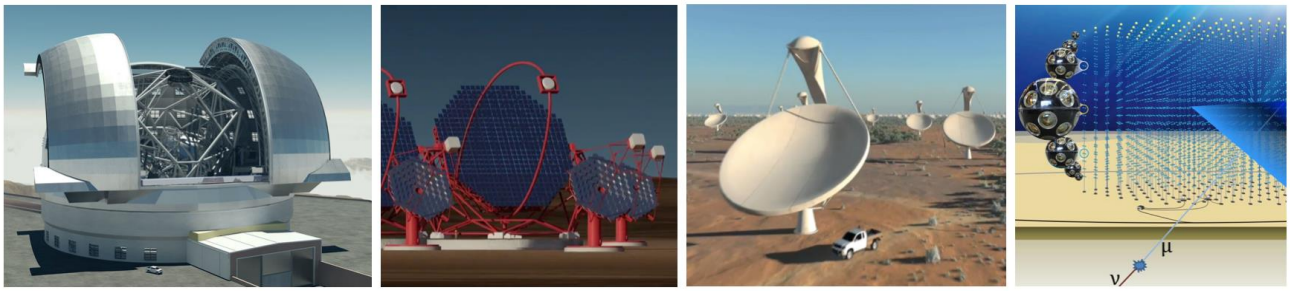


Figure 1: The astronomy and astro-particle facilities that form the focus of the ASTERICS project and are included in the ESFRI Roadmap (from left to right): E-ELT, CTA, SKA and KM3NeT.

Individually, the science case for each of the ESFRI facilities (see Figure 1) championed by ASTERICS is quite simply outstanding, and they represent the main (ground-based) priorities of the European astronomy and astroparticle physics communities - see, for example, the ASTRONET and APPEC (ASPERA) roadmaps:

http://www.astronet-eu.org/FP6/astronet/www.astronet-eu.org/IMG/pdf/Astronet-Book.pdf

http://www.appec.org/images/Documents/Roadmaps/2011_ASPERA_roadmap_german.pdf

Together, the astronomy related ESFRI projects and their pathfinders will open new windows on the universe, significantly extending our observational capabilities across the electromagnetic spectrum, in addition to neutrino detectors, high-energy particle showers and gravitational waves. The respective 'messengers'; photons, neutrinos, cosmic-rays and gravitational waves are detected and measured in very different ways but their combination enables a wider view. Multi-messenger astronomy, combined with the time sampling and large statistical samples provides an unprecedented chance to open unexplored regions of a combined observational parameter space. The astronomy ESFRI infrastructures will provide the observing tools for these messengers, their coordination and interoperability brings the efficiency of common solutions, and the great potential for discovery.

1.1 Objectives

The chief objective of ASTERICS is to establish a single collaborative cluster of next generation ESFRI telescope facilities in the area of astronomy, astrophysics and astroparticle physics. The goal of the project is to jointly embark on a 4 year programme of work that advances the ESFRI projects towards their full implementation - identifying, addressing and solving key challenges of common interest, adopting cross-cutting solutions with mutual and wide-ranging benefit to all concerned. Letters of support from the ESFRI projects and the astronomy and astroparticle physics networks are presented in appendix 1 of this document.

As the ESFRI projects settle on mature technology choices for their detailed design and upcoming construction phase, ASTERICS continues the process of identifying areas of rapid technology development, where the adoption of a complementary and synergetic approach across the projects can lead to significant added value in their operational phase. Perhaps, not surprisingly, the general management, curation, interchange and scientific exploitation of data has rapidly emerged

as a major challenge that is common to all the astronomy related ESFRI telescope facilities. Moreover, as the ESFRI projects sharply focus on their own design requirements, ASTERICS looks towards enabling interoperability between the facilities, minimising fragmentation, encouraging cross-fertilisation, developing joint multi-wavelength/multi-messenger capabilities, and opening-up the next generation of observatories to discovery and usage (and indeed re-usage) by the entire astronomical community.

A key goal is to Engage with society at large – embracing the principles of *Science 2.0*, developing popular citizen science applications and deploying an ambitious programme for public and stakeholder engagement. ASTERICS aims to achieve its objectives in a spirit of "open innovation" via a close collaboration with the ESFRI projects, other research organisations, major industrial players, and local specialised SMEs.

Educating, training and interacting with ESFRI facility staff, industry and the wider user community is an essential objective of the project, in order to define requirements, and ensure wide and rapid up-take of ASTERICS' results and deliverables.

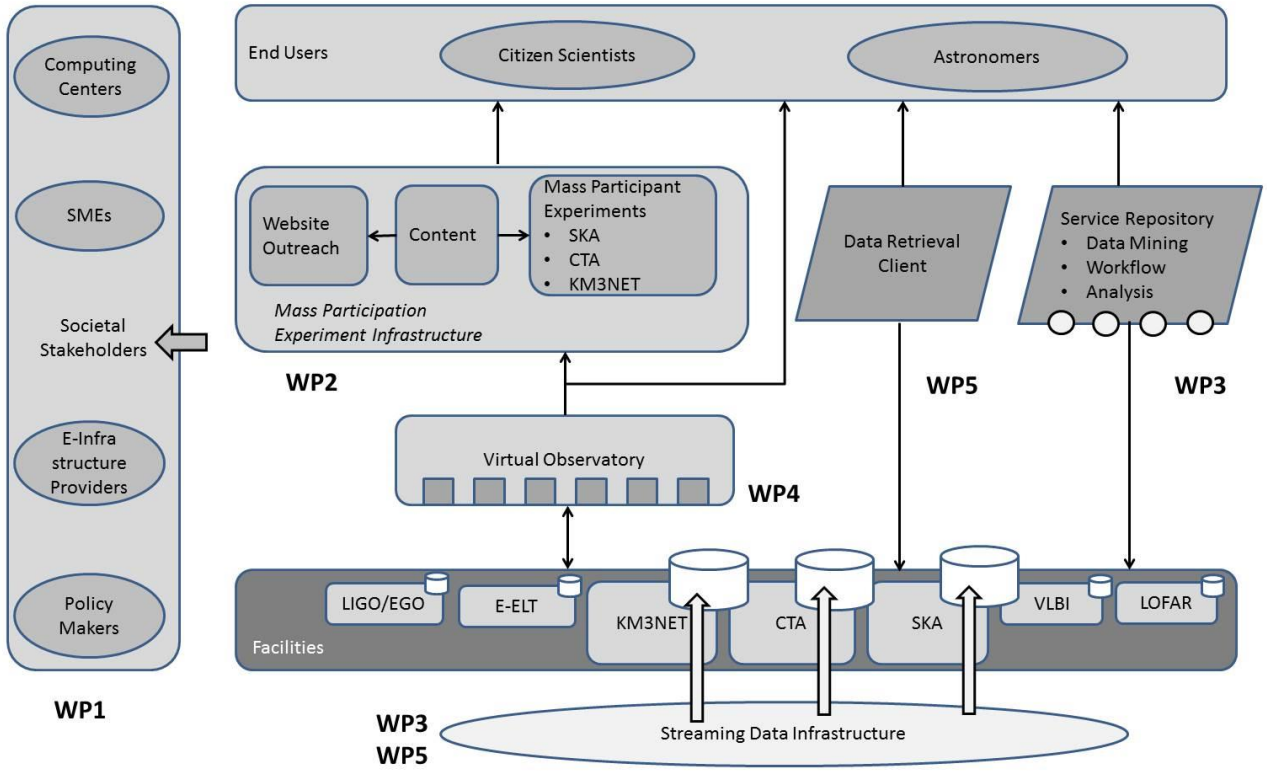


Figure 2: Overview of the ASTERICS project.

Specific objectives of ASTERICS are to:

- Maximise software re-use and technology co-development for the robust, scalable and flexible handling and exploitation of the huge data streams and distributed petascale database systems associated with the ESFRI facilities - identifying best practice, defining open standards, design patterns and benchmarks, generating prototypes, constructing use-cases, and optimising frameworks and software libraries in an open innovation environment.
- Investigate and demonstrate data integration across the ESFRI facilities, using data mining tools and statistical (e.g. Bayesian) analysis techniques, introducing adaptable and evolving

work management systems that will permit deployment on existing and future e-science infrastructures.

- Coordinate and harmonise the joint and efficient scheduling, operation and interoperability of the ESFRI facilities (and indeed other ground and space based telescopes) via a high-level policy forum and through technical developments such as innovative time synchronisation that enable multi-messenger astronomy via a rapid exchange and evaluation of VOEvent messages alerts, taking into account all necessary book-keeping logistics such as interchange formats, authorisation, prioritisation and identity methodology.
- Adapt the VO framework and tools to the ESFRI project needs, gathering requirements from the community and making the data interoperable in a homogeneous environment, enabling discovery and re-usage by the entire astronomical community and accessibility via a set of common tools and standards.
- Disseminate the results of ASTERICS to as wide an audience as possible, via the production of high quality outreach materials and direct engagement with all relevant stakeholders. Open-up the ESFRI facilities to the general public via a suite of Citizen Scientist Mass Participation Experiments (MPEs) that will capture the interest of the general public, especially the next generation of future engineers and scientists.
- Train and educate the community in the usage and implementation of the ASTERICS products (*e.g.* the VO framework and tools), and make ESFRI staff active participants in the use of new cross-domain Big Data software solutions, processor architectures and citizen science applications. Build capacity in the field, to train and develop the next generation of scientists and engineers that will be the future users of the ESFRI astronomy facilities.

ASTERICS is an ambitious project but the goals are clear and attainable. The ultimate measure of its success is how often the project results and products are incorporated into the ESFRI observatories. On timescales similar to the duration of the project (4 years), success can also be measured via implementation on the ESFRI pathfinder telescopes – the latter provide existing platforms on which ASTERICS technologies can be tested and proven. The incorporation of other related projects (*e.g.* EUCLID) provides further testing opportunities, and additionally addresses the demand to realise the potential offered by combining astrophysics and cosmology together. The ASTERICS partners can also call upon significant additional resources in terms of access to major computing data centres, e-infrastructures and other ICT providers. Wide-spread experience and long-term participation in transversal European ICT and e-Science initiatives also provides assurance of the capacity of the project. These factors, plus the complementary backgrounds of radio astronomers, high-energy astrophysicists and particle astrophysicists, together with the associated expertise they share in software development, high performance computing, advanced research networks, data analysis and discovery, makes the goals of the project realistic and attainable.

1.2 Relation to the work programme

ASTERICS is a response to the Horizon 2020 work programme INFRADEV-4-2014/2015. The proposal presented here outlines a range of activities that aim to achieve the implementation and operation of a cluster of ESFRI facilities (and other related research infrastructures) associated with a specific thematic area - astronomy, astrophysics and astroparticle physics. In line with the requirements of the Call, the activities of ASTERICS are centred on the relevant ESFRI projects (SKA, CTA, KM3NeT, E-ELT). The main goal is to contribute to the construction and operation of the ESFRI projects by addressing a set of synergetic challenges where the impact can be maximised – typically the focus of ASTERICS is in key areas where rapid and sustained advances offer the possibility to adopt common approaches that can greatly expand upon the base capacity

and discovery potential of the various instruments. This generic, collective approach reduces the risk of fragmentation, and promises impressive economies of scale, and a more efficient and innovative use of finite resources in the field. The ASTERICS work programme and the various work packages (WP) therein, specifically aims to develop synergies and coordination in the domain of data management and data systems of the ESFRI projects, exploring standards, prototyping and deploying advanced data services, and adopting new technologies via industrial partnerships (*e.g.* WP3 – OBELICS). Engaging with industrial partners and specialised SMEs is a fundamental tenet of the ASTERICS approach.

By establishing a thematic cluster of complementary ESFRI facilities, ASTERICS has the opportunity to demonstrate that the whole is greater than the sum of its parts. As the ESFRI projects focus on their own immediate concerns, ASTERICS can ensure that their interoperability is not neglected. There is a tremendous opportunity here, to open-up a new era of providing a unique "multi-messenger" view of astrophysical phenomena, using low- and high-energy photons, as well as neutrinos and gravitational waves simultaneously. Realising this goal requires a concerted effort at both the policy and operational level. In this regard, WP1's Policy Forum will coordinate and agree new models for joint time allocation, observing and data access/sharing, while WP5 – CLEOPATRA (see section 3.1 for a full description of the work packages) will develop the real-time logistical platform and key synchronisation technologies that will enable a true multi-messenger (and transient) approach to be developed. Training users to take advantage of all aspects of the ASTERICS programme is embedded across the various WPs.

All these efforts will lead to a significant increase in the productivity of the facilities and the researchers they serve. In particular, the astronomy related ESFRI projects will generate rich and complex multi-dimensional data sets, and the scientific exploitation of this unique combination of astronomy 'Big Data' requires a common data infrastructure for data discovery, access and interoperability. The Virtual Observatory (VO) has been incredibly successful in integrating distributed infrastructures into one single virtual astronomy facility - the diversity of the various multi-messenger ESFRI facilities represent the obvious next step forwards. By ensuring that the ESFRI telescope products are openly accessible via the VO framework (WP4 – DADI), ASTERICS will facilitate the interoperability and re-use of these data, making them accessible to the full European and indeed international communities. This will support new and novel approaches to data exploitation, and provides a natural repository where reduced, open data products (*e.g*. survey legacy data) can be reliably maintained and curated. As in many other key areas, training and educating the next generation of facility staff and users will be essential in securing the success of this and many other aspects of the ASTERICS programme.

Extending the concept of open access and open innovation to their logical next steps, ASTERICS also places significant emphasis (see WP2 - DECS) in public engagement, dissemination of research outcomes and industrial partnerships. These activities increase the potential for innovation, including social innovation, and open-up the ESFRI facilities to the widest possible audience, thus maximising their full (potential) exploitation.

We believe that this comprehensive programme of activities, represents an excellent fit to the intended scope of the INFRADEV-4 Call, and indeed to the wider goals of Horizon 2020.

1.3 Concept and approach

In preparing for this Call, the ASTERICS partners formally agreed and adopted two guiding principles in arriving at a final concept for the programme of work:

- the work package tasks must be built around the astronomy related ESFRI projects with a sharp focus on advancing and contributing to their design, construction and implementation,

- work package activities and their deliverables should be of high impact and broadly relevant to as wide a range of the astronomy related ESFRI projects as possible, addressing common technical challenges and collective issues such as harmonisation, interoperability, exchange and cross-facility multi-wavelength/multi-messenger integration.

In developing the ASTERICS work programme, we consciously discriminated between the merits of the proposed activities by giving higher weight to those tasks that encompassed actions relevant to both the SKA and CTA. We did this on the basis of:

(i) the recent independent assessment report of the ESFRI facilities (see http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri) in which the SKA and CTA emerge with high priority, and
(ii) on the observation based on the same report, that the E-ELT under the auspices of ESO is already making significant, independent progress towards implementation.

The ASTERIC work programme therefore represents the synthesis of a series of brain-storming sessions (see Figure 3) and engagements in which a multitude of activities were proposed, and tried and tested against the above principles. ASTERICS therefore represents one of the first opportunities for the astronomy, astrophysics and particle astrophysics communities to come together in a single collective scientific and technical endeavour. As a result, a cornerstone of the ASTERICS strategy has been to engage with all the relevant stakeholders (see also section 3.3) and the communities at large. Throughout 2014, presentations of the ASTERICS concept were made to participants of the APPEC H2020 workshop, to the SKA Organisation Board and to the ASTRONET executive Board. An invited talk was delivered at the EWASS (European Week of Astronomy and Space Science) in Geneva, and ASTERICS was also represented at the ASTRONET discussion forum in which an open exchange with the community was also possible. ASPERA and APPEC in the last four years have organised international workshops, debates (also producing a conclusive white paper) about the data and computing challenges in all current and future projects in particle astrophysics. ASTERICS is also the final result of such a successful long-term cooperative initiative.

With this inclusive, engaging and open approach, we believe that the ASTERICS partners have arrived at a concept that is relevant to the implementation of the astronomy related ESFRI facilities, and that is supported and endorsed by the main players of the multi-disciplinary astronomy and astroparticle physics communities. We believe that the end result is a coherent programme of work that is consistent with the goals of the Call. We note that *letters of support* from the most important stakeholders (including the leading representatives of the ESFRI projects) are presented in Appendix 1 of this document.

Perhaps, not surprisingly, the general management, curation, comparison and scientific exploitation of data rapidly emerged as a major challenge that is common to all the astronomy related ESFRI telescope facilities. Instinctively, ASTERICS subdivides this “data challenge” into two major work packages (WP3 – OBELICS and WP4 – DADI – see section 3), rather than adopting a single, monolithic approach. In particular, we have drawn a line between on one side raw data generated, processed, reduced and archived by the telescopes, and on the other side, the exploitation of the data, including its combination from various multi-instrument, multi-wavelength and multi-messenger sources. WP5 (CLEOPATRA) also addresses some common data challenges (e.g. user access to data via optimised data transfer techniques originally developed for e-VLBI) but also includes other connectivity challenges that are of key importance to many of the ESFRI facilities both individually and collectively.

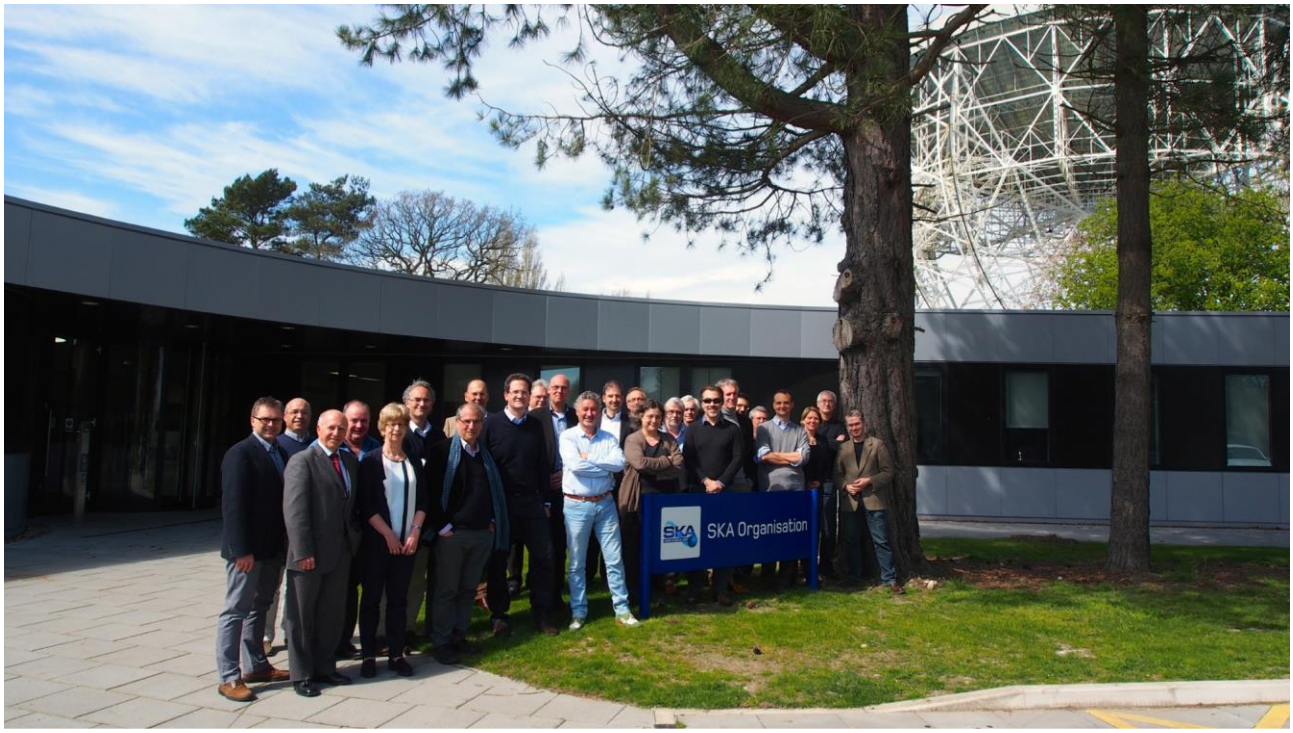


Figure 3: ASTERICS brings together the astronomy ESFRI facilities together for the first time - establishing a major collaboration between multi-wavelength and multi-messenger next generation telescopes. Face-to-face meetings were held in Amsterdam, at the Astroparticle and Cosmology (APC) laboratory in Paris and the SKA HQ at Jodrell Bank.

An important part of ASTERICS plan is to make as much use as possible of the ESFRI pathfinder telescopes. These pathfinders and precursors are significant instruments in their own right, and provide real use cases that can lead the way toward construction and operation of the ESFRI projects themselves. Working together as a cluster of projects provides the ideal environment for creating and testing solutions for a common data infrastructure on already available data. The pathfinders for the astronomy ESFRI projects are LOFAR and VLBI for the SKA; HESS and MAGIC for the CTA; IceCube and ANTARES for KM3Net, and VLT instruments for the e-ELT. EGO is also a participant within ASTERICS with gravitational waves being taken as an important additional representative of multi-messenger astronomy.

The WPs within ASTERICS implicitly employ the same systems engineering philosophy embedded within the individual ESFRI projects themselves. This is essential in order to ensure that the products of ASTERICS can be seamlessly adopted by all the facilities. The main elements of this approach require a project cycle that accommodates preliminary study, analysis and requirements definition; followed by design, development, integration, testing, implementation, maintenance, evaluation and improvement. The products of ASTERICS are designed to be either (i) deployed largely independently of the detailed design of the ESFRI facilities (*e.g.* WP2 – DECS and WP4 – DADI) or (ii) standalone products that are “good to go” or can be launched as applications (WP3 – OBELICS and WP5 - CLEOPATRA).

ASTERICS makes a conscious choice to make a major investment in the training and education of both users and ESFRI (including pathfinder) facility staff (in particular WP2-3-4), again in order to ensure the requirements are properly understood, the products are appropriate and the uptake of ASTERICS deliverables is easy and operationally seamless. The training events are also excellent occasions to gather feedback on the project priorities, activities and products. Capacity building, and the training of a new generation of scientists and engineers that will go on to fully exploit the ESFRI facilities is also a implicit goal of these activities. In addition, ASTERICS roundly embraces the principles of *Science 2.0* (see section 2.2a and http://ec.europa.eu/research/consultations/science-2.0/background.pdf), in particular, we believe passionately in the need to open-up public access to publicly funded research (WP2 - DECS).

Developing an ambitious outreach programme in which the development of citizen science applications for the various ESFRI facilities will open them up to the widest possible audience, thus maximising their full (potential) exploitation.

Trans-disciplinary considerations

Much of the technology development associated with ASTERICS will have its origins from outside the field. Over the last decade, astronomy and astroparticle physics have been able to take great advantage of the huge investments being made in the ICT industry, and the resulting advances in high-speed data transport, digital processing, high performance computing and storage capacity. This has led to the establishment of a new, next generation set of facilities, the ESFRI telescopes being the latest and most innovative examples. Astronomy is not only an early adapter of the latest ICT developments but it is also pushing the envelope of the current and projected state-of-the-art. ASTERICS work packages such as OBELICS (WP3) will make their own contribution to some of today's biggest trans-disciplinary topics – Big Data being a prime example. This will involve close engagement with industry and e-infrastructures such as large computing centres, research network providers and e-science facilities. Links with other scientific communities facing similar challenges will also be made – a natural partner in this regard is the High Energy Physics (HEP) community. Future HEP experiments require the same performance improvement expected from new processor architectures coming from parallelism (many cores, vector instructions etc.) and major improvements in software performance. ASTERICS will organise co-located workshops and training initiatives with the recently proposed "HEP software foundation" - the extension of this HEP initiative to a larger community has already been discussed during the kick-off meeting at CERN. ASTERICS could bring significant momentum to these efforts, in particular for the co-development and dissemination of new software frameworks and parallel programming standards. White Rabbit Ethernet (WRE) is another CERN based project that ASTERICS will extend in order to transfer time and frequency standards across distributed networks. While this is bound to have application in other disciplines, the HEP community that originally developed WRE can also stand to benefit. Experience with the FITS file format (see also section 2.1) suggests that standard astronomical file formats can also serve many other communities too. WP3-DADI's participation in the RDA also serves important trans-disciplinary goals.

Organising transversal training initiatives with broad participation from other fields is a recognised project goal. The rise of the Data Scientist in the era of Big Data raises another area where ASTERICS can contribute to human capital development – creating the kind of scientists and engineers that have a skill-set that is highly sought after in the market place.

National and international innovation activities linked with ASTERICS

The ASTERICS WPs stand to benefit from innovations associated with various national and international research activities.

In the case of WP2 (DECS), The Open University's Wolfson Open Science Laboratory (the portal for the WP2 Science 2.0 activities) is already a successful platform for citizen science experiments, and is an area of active pedagogic and learning research. WP2 DECS will also make use of the Zooniverse project (through a third party, Oxford University) which itself is a highly successful and scientifically productive international crowdsourcing resource. To date, Galaxy Zoo has generated 44 papers, Planet Hunters 8 papers, and there are nearly 20 published papers from several other Zooniverse.org scientific crowdsourcing projects. Some of these are also highly relevant to ASTERICS *e.g.* Spacewarps and Radio Galaxy Zoo. It should also be noted that the Zooniverse is already IVOA-compliant (see WP4 - DADI).

The partners of WP3 (OBELICS) are major contributors to the innovation of distributed computing infrastructures and new computing architectures, *e.g.* federated computing infrastructures in the WLCG and EGEE/EGI initiatives, as well as national integrated supercomputing facilities (i.e. HPC centres, PRACE, DiRAC etc). Initiatives such as these will certainly contribute to WP3 OBELICS activities, together with the expertise attained via previous EC FP5-7 initiatives in the field of

astronomical image data processing, support facilities and services for data management: e.g. the TERAPIX data centre, as well as other supported European projects *e.g.* ASTRO_WISE, OPTICON & RadioNet. The active participation of OBELICS in key open-source software solutions for data management or data format standards is a central pillars of the WP's approach e.g. the iRODS (Integrated Rule-Oriented Data System). The FITS (Flexible Image Transport System), the most commonly used digital file format in astronomy, is one more historical example of astronomical research and innovation activities feeding into the ASTERICS programme. The astronomy related ESFRI projects will construct their archive systems based on the OASIS standards. Open source software projects providing solutions for authentication, authorization and trustworthy exchange of information (e.g. Shibboleth and OpenLDAP, the eduGAIN service etc.) will also be used by OBELICS. The outcomes of the ASTRON-IBM public private initiative – DOME – a centre for Exascale Computing will also provide a direct flow of expertise and knowledge into the ASTERICS project.

The activities of WP4 (DADI) build on the previous EC FP5-7 projects (e.g. EuroVO-DCA, EuroVO-AIDA, EuroVO-ICE & CoSADIE all led by CNRS/OAS), and will make use of the VO framework defined by the IVOA (International Virtual Observatory Alliance). Representatives of DADI will also participate in the IVOA Working Groups, in order to perform the work necessary to implement ESFRI needs within the framework. More generally, the Research Data Alliance (RDA) builds the social and technical bridges that enable open data sharing across disciplinary borders. The way the generic framework defined by the RDA will interface with the disciplinary IVOA one has to be assessed. WP4-DADI will follow closely the output of the Research Data Alliance (RDA), implementing the building blocks proposed by the RDA whenever relevant. It will also participate in the RDA activities to ensure the ESFRI requirements are properly accounted for. ESO expresses in their letter of support (Appendix 1 of this document) the wish to be associated to ASTERICS, to remain appraised of the activities of ASTERICS, without being a full partner. The fact that they want to be closely related to the project ensures convergence with the other major European ground facilities under their responsibility.

WP5 (CLEOPATRA) builds partly on the results generated from the highly successful EC FP6 EXPReS and FP7 NEXPReS e-VLBI projects (also led by JIVE). Similarly, the goal of enabling long-haul and many-element time and frequency distribution over fibre connections, which has the potential to increase the efficiency and affordability of all radio astronomy facilities of relevance to the SKA, CTA and KM3Net will make significant use of the advances already made via the White Rabbit Ethernet (WRE) project. The Dutch STW (Stichting voor de Technische Wetenschappen) funded project "Super-GPS" which attempts to transfer atomic clock signals across fibre networks and is led by the VU (also an ASTERICS partner) is also likely to be highly relevant. The work on transient detection is also based on the previous VOEvent development within the IVOA and NEXPReS – in the latter effort response mechanisms for heterogeneous telescope arrays have been pioneered. The experience obtained with dedicated transport protocols in (N)EXPReS also feeds into the work in WP5 task 3, where a data transfer client is envisioned that can make effective use of end-to-end connectivity protocols. Finally, task 4 of CLEOPATRA takes advantage of many years of experience in space technology to use clever software solutions for complex scheduling problems.

The ASTERICS partners are sufficiently well embedded in these external projects, that the use and re-use of these resources is not expected to be an issue.

Overall approach and methodology

ASTERICS brings significant added value to the national investments now being made in the astronomy related ESFRI projects. The strong synergy between the ESFRI facilities and the ASTERICS team, avoids investments being made in areas that are already addressed elsewhere. Indeed, it should be clear that we do not aim to directly develop essential hardware elements that are on the critical path (*e.g.* parabolic dishes, mirrors, network infrastructure, data correlators etc.) – the ESFRI projects have clearly signaled that mission critical elements must lie within their direct

span of control. In particular, projects nearing the construction phase (*e.g.* the SKA and CTA) must now adopt mature solutions with the highest technical readiness levels. What ASTERICS does is to focus on the most challenging areas where there is already evidence of on-going and rapid technical innovation (*e.g.* evolving domains in areas such as data handling, processing, science harvesting, citizen science etc.), and where innovative paths forward can greatly enhance the effective capacity, impact and scientific return of the ESFRI facilities in their operational phase. Focusing on areas that are most easily absorbed by the ESFRI facilities (*e.g.* software related developments) is greatly aided by the ability of the ASTERICS partners to deploy their prototype systems on the various pathfinder telescopes (*e.g.* LOFAR, e-VLBI, HESS, MAGIC, IceCube and ANTARES *etc.*). Not only are these pathfinders the perfect proving ground for ASTERICS, the resulting enhancements to these instruments also increases their global competitiveness, and further develops and trains the European community to capitalise on the future opportunity that the ESFRI facilities also represent.

Sex and gender analysis

The ASTERICS project will develop new methods, techniques and technologies that will advance the implementation and exploitation of the astronomy ESFRI facilities. These facilities are being constructed in order to service the needs of the international community in its *entirety*, and it is therefore absolutely essential that the project embraces and promotes the principles of gender equality, racial and religious tolerance, and diversity (in the broadest possible sense). Given that in Europe, women are known to be significantly under-represented in the fields of both physical sciences and engineering (especially at the most senior levels), the ASTERICS partners will adopt the latest best practice in terms of staff recruitment, career development, mentoring and promotion - guaranteeing equal-opportunity to all staff regardless of gender, race, ethnic origin, physical handicap, sexual orientation or religion. In addition, WP2 DECS (Dissemination, Engagement & Citizen Science) will ensure that a very positive image is promoted of female participation in the project via appropriate outreach and dissemination materials.

The relationship between gender (and other related diversity issues), and the impact and success of a technically based astronomical project such as ASTERICS (and indeed the related ESFRI facilities) has (to our knowledge) rarely been considered. It is an important but complex topic to explore and feedback arising from the various training schools (*e.g.* WP4) will pay specific attention to these points. The lack of sex-disaggregated data in terms of even basic demographic information also hinders progress. Within ASTERICS we propose to implement a simple system of sex & gender analysis that permits us to monitor key aspects of the project's characteristics and performance. Wherever feasible, we will record sex-disaggregated data in order to measure aspects of the project's form in terms of inequalities between male and female staff, tracking their respective roles and responsibilities within the project, access to and control of resources, and involvement in the high-level decision making process. The various WPs will be responsible for recording these data, and the ASTERICS Management Support Team (AMST) will collate the results centrally, with the results formally reported in the annual reports.

1.4 Ambition

The astronomy related ESFRI facilities are set to radically change the way we perceive the universe and our place within it. The ambition of ASTERICS is to support and accelerate the implementation of these instruments, to enhance their performance beyond the current state-of-the-art, and to see them interoperate as an integrated, multi-wavelength and multi-messenger facility.

In every stage of the data flow, the ESFRI telescopes, and their pathfinders face major challenges – from scheduling the observations to mining the data. To place things in some perspective, the

SKA, for example, is capable of generating Exabyte scale archives on a daily basis i.e. generating about 10 times the current global Internet traffic. There is therefore an urgent need for a highly automated approach, requiring robust real-time processing platforms (and associated software libraries), and optimised handling of secondary data streams and meta-data (including, for example, environmental information). Distributed facilities have to be managed, by means of an integration of wide-area networks, Exascale data storage systems and distributed processing resources. The scientific drive towards combining and aligning data from different facilities online in order to comprehensively study multi-messenger and transient events requires interoperability between hybrid data streams with unprecedented time synchronization across locations distributed across the planet.

The astronomy and astroparticle physics communities jointly share these data challenges, and ASTERICS plans to address these by identifying and addressing common issues, by encouraging cross-fertilization and common innovative software and hardware solutions, and by ensuring data-interoperability between the facilities. ASTERICS brings together the major players that are critical contributors to the current design effort on the SKA, CTA and KM3NeT. While the ESFRI projects focus on the here and now, ASTERICS continues the essential effort to research and adopt the latest technologies and novel methodologies. ASTERICS foresees petascale datasets being reduced via intelligent processing pipelines that are orchestrated via advanced workflow management systems. These will be active not only in the first rounds of calibration but also for the initial analysis, directing scientists to areas of interest and generating high-level science results online. Emerging databases will reside on hybrid distributed e-infrastructures and will have to be configured and extended to allow the optimal ingestion of huge data volumes. ASTERICS will address these issues generating new algorithms that are statistically robust and employ advanced cognitive imaging techniques. Direct engagement with industrial partners and specialised SMEs will take advantage of the huge investments being made in key areas such as Big Data analytics.

By seizing on the latest developments in ICT and related fields, ASTERICS can greatly enhance the performance and scientific impact of the ESFRI facilities. Initial operations of these telescopes are likely to be limited by the amount of streaming data they can routinely handle from initial acquisition through to post-processing and archiving. The speed at which the reduced data products can be reliably processed acts as a natural throttle on the total data throughput *e.g.* in the case of the SKA it is unreasonable to consider that the raw data product can be stored for more than a few weeks. As the final design of the projects become fixed, the ongoing research studies by ASTERICS will be essential in order to evolve the facilities towards adopting higher performance systems and methodologies as they become available. The role of deploying these new systems on the pathfinders will be essential in proving their value and in facilitating the mechanics of adoption.

The VO framework is a key element in successfully clustering the ESFRI projects. The basic building blocks of seamless access to the data are already operational, and ASTERICS will ensure that the framework fits the ESFRI project and science needs. ASTERICS brings to the table two facilities from opposite ends of the electromagnetic spectrum (the SKA and CTA) and the first generation of neutrino and gravitational wave observatories (KM3NeT and EGO). By closely interfacing with the ESFRI projects and their pathfinders, integrating these new kind of facilities within the VO is a challenge but a manageable one. With the ESFRI facilities integrated into the VO framework, astronomers will be able to discover, access, use, and compare data from the ESFRI pathfinders, and later the ESFRI projects themselves, combining it with data from other ground- and space based observatories as well as from theoretical model collections. Access via the VO will greatly increase the usage of ESFRI archival data in novel and unexpected ways, often not foreseen in the original proposals. With most of the ESFRI facilities likely to provide access on the basis of national contributions, interfacing the telescopes with the VO is the best way to ensure both maximal re-use of data and broad access to astronomers from across Europe. ASTERICS will therefore greatly expand the impact of the ESFRI facilities beyond the richest member states and create a truly Europe-wide community.

The close and direct involvement of ESFRI project and pathfinder staff is essential in realising the major ASTERICS ambitions. In the area of data handling, the key ASTERICS partners and individual researchers are almost seamlessly integrated with the ESFRI projects. As one might expect, the exploitation of ESFRI data via the VO connects more naturally with the already operating pathfinder telescopes. The need to also engage with ESFRI project staff and train and educate users is an important consideration that is addressed across the project, including public and stakeholder engagement.

An exciting part of the ASTERICS work programme is to embrace the principles of Science 2.0 and to open up the project and the ESFRI faciliies not only to the hard-core scientific community but to all possible stakeholders, including industry, SMEs and the general public. The citizen science Mass Participation Experiments (MPEs) will truly engage with society at large, and give the paying public a real and tangible connection with the ESFRI projects. Initiatives like Galaxy Zoo have also demonstrated that MPEs can also expand the discovery potential of the data – in astronomy, perhaps the best example is the discovery of “Hanny’s Voorwerp” by a Dutch school teacher. This has led to a completely new understanding of the timescales involved in the lifecycle of active galaxies. The MPEs that we wish to develop under the ASTERICS project can have even greater impact – the way in which these new approaches interface and energise the research capacity of completely new telescopes such as KM3NeT and the EGO is completely unknown territory.

Innovation potential

Astronomy has a fantastic track record in developing new and innovative applications that eventually pervade society – the development of WiFi (specifically the IEEE 802.11 standard operating on and linking together billions of devices and computers around the globe) is probably the best-known (recent) example. Little surprise then, that companies with global impact such as IBM, SGI, Intel, AMD, CISCO, ALTERA, Xilinx, Amazon and Raytheon) are already directly involved in the Design Phase of the SKA and CTA. With these already existing close collaborations with industry and commerce in place, ASTERICS has a natural conduit in which new knowledge and new innovations can be shared.

Exploring new approaches, consolidating standards, combining hardware, software and middleware for the on-line big data streaming challenge ASTERICS addresses, naturally translates in substantial innovation potential. Many software products currently being generated via the huge investment now being made in Big Data are also relevant to ASTERICS. One example that is of elevated interest is the further development of the open source Hadoop software system. Most applications of the system are so far related to processing and mining of unstructured data, such as sources of social media. ASTERICS requires the handling of much larger but structured data sets that will push the scalability requirements further along. The enhancements required by ASTERICS will lead to new innovative uses of such software – IBM is already excited about the possibilities after initial studies from the DOME project suggest advantageous to both sides. Initiatives such as this can have a massive impact not only in other scientific fields but also the industrial and commercial sector.

A similar situation also exists for the successful application of novel computing technology within ASTERICS *e.g.* ARM or GPU processors, and zetascale database systems. Furthermore, the requirement within ASTERICS to distribute accurate timing on fibre telecom networks is also likely to lead to serious innovation spread in systems that would greatly benefit from GPS independent data. In today’s networked world, tight synchronisation of clocks is a silent driving force behind modern technologies such as: 4G mobile Internet, global financial transactions, and synchronisation of electric power plants for reliable energy supply to millions of people and businesses. Unfortunately, effects such as deliberate GPS jamming can severely limit the reliability of these developments. A similar demand also exists in other areas of innovation such as robotics, traffic management and vehicle automation (including precision drone applications). ASTERICS aims to deliver a network-based solution to time and frequency synchronisation which will not only be highly beneficial to the ESFRI telescopes (especially those distributed across wide geographical

areas) but can perhaps have an even great societal impact in these other applications. Related to this, the efficient data transport methodologies also required by ASTERICS can have application on the internet where current protocols requiring 100% data integrity are extremely conservative in their download performance settings – possible applications can be any standard video, image and audio data.

The grand expectations of "open science" fully include innovation, as powerfully summarised by the G8 Science Ministers in their Statement in June 2013[2]. As a pioneer of open and transparent access to data, astronomy (largely via the VO) has played its part as a highly visible and successful exemplar that has been adopted by many other fields. Federating the ESFRI data products supports democratisation of the field and greatly broadens the talent pool in astronomy. Mass participation experiments (MPEs) such as those supported by ASTERICS already have a successful track record of fostering innovation – the Galaxy Zoo forum has been a scientific gold mine and the contribution and depth of interest shown by the volunteers is nothing short of extraordinary with citizen scientists often becoming *bona fide* research collaborators. The Galaxy Zoo idea has now been extended to other fields, including the humanities, biology, climate change and nature (*e.g. snapshot Serengeti).* By encouraging young people into science, ASTERICS will both directly and indirectly foster innovation in science and technology via the next generation of school children and university students.

2. IMPACT

2.1 Expected impact

The ASTERICS work programme is unashamedly built around the astronomy related ESFRI projects. It is specifically designed to identify and solve the common problems that they share, and address the general challenges that they face. The focus is to deliver added value to the instruments – especially in areas where rapid technology developments require late adoption in the project design life cycles. ASTERICS will make a significant contribution to the final design of the telescopes and their implementation but it will also continue to advance the R&D effort that is required to maintain the instruments at the state-of-the-art as they enter their fully operational phase.

A generic approach to the Data Challenge faced by the ESFRI telescopes will lead to the integrated development of common services, open standards, data management solutions, ready-to-go software products, innovative and multi-use algorithms and advanced applications. The products generated by ASTERICS will be made openly and directly available to the ESFRI projects, and will be tried and tested on their respective pathfinders and precursors. The pathfinders are substantial instruments in their own right, and enhancements to their operations via ASTERICS will therefore enhance the development of European research infrastructures in the broadest sense.

A major scientific goal of the project is to kick-start the political process of ensuring routine interoperability between the ESFRI projects. In addition, advances to be made in data communication protocols, together with enhanced time distribution methods will provide nanosecond accuracy for all the ESFRI detectors and instruments, irrespective of the astrophysical messenger they are built for. These technical developments will permit synergetic joint observing programmes between the ESFRI facilities and/or their pathfinders. While the telescopes all boast exceptional individual science cases, the impact of combining these forces together is likely to be

[2] https://www.gov.uk/government/news/g8-science-ministers-statement

substantial. It is difficult to quantify what the scientific impact might be numerically but the promise of an integrated multi-wavelength/multi-messenger distributed facility must be capable of generating profound scientific results, and very likely Nobel Prize winning research.

By making the ESFRI telescope data products available to all scientists through the Virtual Observatory (VO) framework, the number of scientists that will have open access to the data is set to grow by at least an order of magnitude. The VO will also provide the tools by which the data can be manipulated, combined, compared and fully exploited. By curating the data products under the VO umbrella, the longevity of the data is also ensured, and inevitably the users' trust in the data's reliability and robustness also improves. Because the VO makes these data available to everybody with Internet access, the ESFRI facilities can also represent a major research opportunity for scientists from poorer (non-contributing) member states who may not be eligible for guaranteed access to the telescopes. This will lead to a much more open and broader scientific return, boosting the efficiency and productivity of the entire community, and addressing research that lies well beyond the scope envisaged in the original observing proposals.

By embracing solutions that can be adopted across all the facilities, a natural economy of scale is realised that encompasses not only the ESFRI facilities themselves but also the related pathfinder facilities. We expect that in areas of key importance, for example those associated with the data challenge, the resources saved apply not only to the construction phase but more importantly to operations. Since a focus of the research is also in identifying low-power solutions to data intensive processes - savings of up to 30% in the operating costs of the facilities is not unrealistic.

It is important to also consider that this economy of scale is also typically accompanied by enhanced performance, so that the scientific capacity of the telescopes will also benefit. The re-use of data represents another important and perhaps unexpected economy of scale. By re-using data via the VO framework, parts of the sky need not be re-observed, and with the expected operating costs of the largest ESFRI facilities ~ 10k€ per hour, this represents a substantial saving of resources and observing time.

Innovation capacity & integration of new knowledge

The major objectives of the H2020 Framework are Excellent Science, Competitive Industries and a Better Society. ASTERICS boosts Excellent Science directly via the ESFRI facilities having a strengthening effect on the European scientific community. As discussed elsewhere in the proposal, ASTERICS acts as a substantial multiplier, in terms of the facilities capacity, performance, scientific output and return on investment. New scientific challenges that require the kind of interoperable multi-messenger/multi-wavelength facilities ASTERICS aims for, can transform the astronomical landscape, creating new and interlinked neutrino and gravitational wave observatories, dependent on other electromagnetic counterparts to help elucidate the nature of these phenomena. Advances in fundamental physics can be expected, leading to long-term innovations that can only be guessed at. ASTERICS stands ready to open-up this new frontier to scientists across the member states, reinforcing Europe's competitiveness to attract and retain the very best scientists in the world.

ASTERICS also supports Competitive Industries in Europe, as an early adopter and indeed developer of the technologies and methodologies required to deal with a real-time data challenge that is extreme in terms of all major Big Data characteristics – Volume, Velocity, Variety and Veracity – the 3 (or 4) Vs. Similarly, ASTERICS also aims to advance the state-of-the-art in areas such as precision location positioning, wide area network synchronisation and high-speed data transfer.

These challenges are not specific to the ESFRI facilities - innovation in almost all societal challenges in Europe rely on similar solutions in the same domains. And while there are other areas in which technological advance will bring profound changes to the way we live (*e.g.* nanotechnology), the avalanche of data generated by sensor networks, communication devices,

control systems, social media, retail services… the list is almost endless… is generating a new kind of global industry in which data analytics, visualization and predictive modeling are essential features. Ten years from now, large facets of our society will be entirely based on data, and the ability to process, interpret and extract value from this data will form the foundation of some of the largest and most competitive industries around the world. These societal challenges have a common denominator in the growing dependencies of implementing real-time solutions across widely distributed geographical areas. The extreme requirements of the ESFRI facilities in this regard, means that they and ASTERICS must be early adopters and developers of this new technology - advances made here can be adopted by many other disciplines.

Other sectors in which ASTERICS can contribute, include (but are not limited to) financial systems, energy efficiency, healthcare and smart cities. For example, our financial systems have progressed towards a globally interconnected and interdependent system in which unanticipated financial events in one part of the world, can lead to global financial instability in another. Financial markets operate on infrastructures in which low latency (~ microsecond level) is crucial, and time-sensitive algorithms are being used for high frequency trading. ASTERICS encounters similar, though rather more demanding problems of synchronisation across large telescope arrays and in delivering interoperability between the facilities themselves. In addition to being highly relevant to the sectors mentioned earlier, advanced research in this area is also fundamental to the deployment and operations of wide-area sensor networks, a specific example being smart city developments. In addition, the goal of ASTERICS to distribute atomic time across long-distance fibre networks can also be used to back-up or augment, timing and navigation through the Global Navigation Satellite Systems (such as GPS and Galileo), enabling centimetre-level positioning for indoor navigation and autonomous automobiles (plus other traffic applications) using hybrid optical-wireless networks. The full impact of these technologies is difficult to fully assess but they already appear to be of interest to many industrial concerns *e.g.* KPN in the Netherlands.

The solutions ASTERICS will apply to these and other problems, including the generation of open source services and software libraries, can also be directly applicable to many other developing sectors of the European and global economies where comparable challenges exist. A further related example is the emerging European energy market in which energy is traded on a real time basis, and where consumers and prosumers (consumers that also produce energy using renewable sources) operate independently. In order to operate a stable grid without congestion requires a real time market. Key technologies are precision timing, synchronisation over wide area grids and large distributed data flows and Big Data analysis. The advanced scheduling systems also envisaged as part of the ASTERICS programme, also have relevance to robotic systems operating in dynamic real-world environments and in space. The research activities on scheduling are also aligned with the roadmaps defined by the EU (LEIT-ICT and Space work programmes) and the European Space Agency (ESA's Technology Transfer Programme) that are promoting the use of robotic technologies in space and its further transference to industry for societal applications. The industrial collaboration foreseen in ASTERICS (*e.g.* WP5) ensures the exploitation of telescope network scheduling research activities in other space science projects and their transference from space to societal applications such as advanced manufacturing and smart factories. Finally, like astronomy, the healthcare sector shows an exponential growth in data, mostly due to digital imaging. Real time analytics for clinical decision support are using extremely large data sets and cloud based analytics. The imaging challenges of the ESFRI facilities and the healthcare sector are quite comparable, for instance producing billion pixel Fourier images in real time. The recent adoption of the astronomical multi-dimensional FITS file format by many other entities (*e.g.* the latest is the Vatican library which will use the FITS standard to archive its books and manuscripts), suggests that new file format standards being researched via ASTERICS can have application well beyond the domain of the ESFRI facilities. Moreover, the software libraries and services that ASTERICS will develop are expected to be directly transferrable to many different sectors with healthcare being again a likely beneficiary.

Social impact

ASTERICS places significant value on engaging the paying public with the astronomical facilities their taxes have helped to realise. Mass Participation Experiments (MPEs) have already played an important role in democratising research (see section 2.2 and "Science 2.0"), demonstrating that a large fraction of the public is interested and willing to contribute. In the past few years, citizen science has increased the numbers of active participants in astronomy research by much more than an order of magnitude (*e.g.* 100,000 participants in Galaxy Zoo and 5.2 million participants in SETI@Home). This can be compared to the ~10,000 members of the IAU. These developments offer mutual benefits for both the citizen scientists and the facilities involved. ASTERICS wishes to build on these successes but to also match them to excellent educational resources, encouraging the participants to take their interest further, and monitoring their educational progress to quantify the impact. The Longitudinal Study of American Youth (www.lsay.org) has clearly shown that even a small exposure to science education dramatically changes a person's lifelong civic scientific literacy. This is of key importance for European competitiveness, given the widely recognised economic need to attract young people (and especially females) into a science education. ASTERICS is deliberately designed to generate environmental and socially important impact through its mass participation experiments, by attracting young people to science and through coordinating/providing open educational resources for citizen science participants to advance their interests still further. ASTERICS aims to attract an already science-inclined public to a more formal science education. A further impact of ASTERICS is in harmonising citizen science practice across the ESFRI facilities, spreading good practice and avoiding parallel development of divergent solutions in open research data access for the general public. Our programme is in tune with the times - we are anxious to get started and see large-scale facilities such as the ESFRI telescopes really connecting with the paying public, creating and enthusing a new generation of scientists and engineers.

Barriers and Obstacles

The ASTERICS project foresees some barriers to success but believes these to be modest. Some minor barriers may hinder or delay progress, especially in the start-up period as the consortium gels together. One of the objectives of ASTERICS is to bring together the astronomy and the astroparticle physics communities. The project will powerfully contribute to the convergence between the "observatory" culture of astronomy and the more "experimental" culture of astroparticle physics. ASTERICS can facilitate the transition currently being made by the next generation of neutrino and gravitational wave observatories (KM3NeT and EGO), exchanging best practice and forging a common culture and integration between both communities. Nevertheless, cultural differences are also known to be difficult to overcome - some of the differences are linked to organisation embedding or distinct funding schemes that cannot be easily changed. However, our experience in preparing this proposal, suggests that the challenges *can* be overcome.

Another aspect that requires some consideration is to note that the ASTERICS ESFRI projects are in somewhat different stages in terms of their design and construction phase. Some projects adopt a centralized approach to design and development, while others take a remarkably distributed approach. The effective deployment of the knowledge and research that ASTERICS will generate, depends on some factors that are outside of the projects' control *e.g.* the speed at which the ESFRI projects themselves make in terms of fixing their final design, acquiring funds and beginning construction. The SKA and CTA, forming the main focus of most of the ASTERICS WPs, aim to begin construction in 2016 - a delay of 1-2 years might not be unexpected and indeed might actually favour the up-take of ASTERICS products within the projects. By developing the latter on the various pathfinders however, ASTERICS aims to deliver "good-to-go" products that the ESFRI projects can easily digest. Nevertheless, more substantial ESFRI project delays could have an adverse effect on ASTERICS' ability to deliver, given the finite duration of the project – again the role of installing ASTERICS technologies on the already operational pathfinder projects helps to mitigate against such a scenario. Barriers for adoption of ASTERICS solutions (services, design patterns, synchronisation solutions etc.) in the operational pathfinder facilities could in principle

arise but we believe that the solutions will be so attractive and beneficial that the up-take will be rapid – the ASTERICS partners are also deeply embedded in the management of the pathfinder projects.

Framework conditions on Third Party involvement in Horizon 2020 have changed from the earlier programmes - our expectation is that this is a good thing, and only reduces the obstacles for ASTERICS.

2.2 Measures to maximise impact

a) Dissemination and exploitation of results

The dissemination and exploitation of the results that will undoubtedly flow from ASTERICS, calls for an innovative and progressive approach. More specifically, ASTERICS embraces the main principles of *Science 2.0* (see http://ec.europa.eu/research/consultations/science-2.0/background.pdf), in particular, opening up public access to publicly funded research (see also WP2). Science 2.0 is currently gaining traction in the globally networked research community, and is currently the topic of a consultation process running via the EC's Horizon 2020 programme. As an early-adopter of this new approach, ASTERICS can be in the forefront of best-practice, disseminating its results to the widest possible audience, thus maximising their full (potential) exploitation.

The ASTERICS project embraces the Science 2.0 initiative and its main drivers. Specifically we aim to ensure:

- open access to both ASTERICS publications, code and associated data, including early access to and open annotation of ASTERICS' research results, open research collaboration (open innovation) with other partners (universities, industry, business, SMEs, general public etc.) that extend beyond the ASTERICS consortium, and in particular a strong engagement with Citizen Science,
- development of new and novel techniques in a uniquely data intensive environment with the explicit goal of further advancing those that may represent viable solutions to societal challenges,
- preservation, curation and re-use of ASTERICS data wherever possible,
- adoption of "alternative metrics" that measure the wider impact and quality of the ASTERICS research output, in addition to the traditional (publication/press based) criteria.

ASTERICS' chief audience in terms of dissemination and exploitation will include (a) the scientific and technical community, academia, private industry, other public research centres, SMEs and policy makers, EC H2020 *etc.* and (b) the general public, including the media, schools, students, and citizen scientists. WP2-DECS addresses the needs of both groups but the other WPs (see section 3.1) have a significant contribution to make in this area, in particular with respect to their respective training programmes.

ASTERICS draft communication, dissemination and exploitation plan

- Logo creation (see front cover for an example) and communication templates (*e.g.* standard document templates for deliverables, reports, presentations etc.), brochures, flyers, exhibition stand.
- Comprehensive review of target audience, (measurable) goals, communication partners, channels and tools.
- Web portal: this will be the face of the project, *the* entry port for ALL partners, stakeholders and general public. It will have rich functionality with components maintained and distributed across the project.
- It will feature both "push and pull" marketing strategies:
  - links to the ASTERICS Facebook, Twitter & Linkedin accounts,
  - "boosting" specific Facebook posts, and targeted specific audiences based on appropriate demographics,
  - popular features such as event calendar, news, public resources area.
- ASTERICS will produce high quality video products (via WP2-DECS) made available via the portal and through a dedicated YouTube Channel.
- News from the ASTERICS project will regularly be submitted to the Newsletter of the European Astronomical Society (EAS), the DOME Newsletter and other appropriate outlets including prestigious technical magazines.
- Publication in scientific and technical peer-reviewed journals, conference proceedings, monographs etc.
- ASTERICS project exhibition stand and booth, present at high-level meetings and key events, with cheese and wine meet and greet opportunities, and prototype demos.
- Exploitation plan – a dedicated plan will be generated to ensure the early identification of both high-impact ASTERICS technologies, IPR foreground or patent restrictions, and appropriate (industrial) target sectors. Exploitation events will be organised during major conferences and corporate events, in order to engage with potential industrial interests, backed up with printed materials, and conceptual demos. Actions to ensure the long-term and sustainable exploitation of the project beyond its formal contract duration will be identified and executed.
- Collaboration plan – a central plank of our strategy will be to seek links and interactions with other projects (including other EC-funded projects), industries, research organisations etc. in order to broaden our knowledge base and to find opportunities to show-case our results/products.

A priority within the ASTERICS communication and dissemination plan (see draft in text box above) is to provide extra attention to engaging with the general public. In WP2-DECS, we aim to develop and support an ambitious programme of Mass Participation Experiments (MPEs) associated with the ASTERICS ESFRI facilities. We also wish to give ASTERICS and the science and technology behind it a "human face". Our public communication strategy will therefore emphasise the role of individual scientists and highlight their personalities via profile pages – attention to broad cultural and gender issues will be taken up, and diversity will be positively promoted wherever possible in our outreach materials.

Social media will be a useful tool in getting the ASTERICS message home – this permits our approach to be active as well as passive – this "push and pull" communications strategy will permit us to broadcast our results to tailor made audiences – Facebook is particularly useful in this regard with the ability to "boost" particular posts to particular types of users.

A plan for the communication, dissemination and exploitation of ASTERICS will be an early deliverable of the project.

WP2 has the overall lead on all matters of dissemination, engagement and citizen science (DECS). Within ASTERICS, the Project Scientist will take the lead in establishing and executing the standard project dissemination strategy (material design, distribution, communication, press releases, web-portal *etc.*), supported by other members of the AMST, including the coordinator (the latter has particular interest in such activities). Meetings and teleconferences between the AMST and WP2 leader will be regularly scheduled. The Coordinator, the Project Scientist and the various WP leaders/individual researchers will be active in presenting the work of ASTERICS to all the stakeholders at high-level conferences and events. The results of ASTERICS will not only be of great relevance for Astronomy but also for many other industrial and commercial stakeholders. A major aim will be to go out on the road and demonstrate ASTERICS project results to potential industrial partners and commercial interests. This will requires a broad dissemination of the results, and on several levels. Annual attendance at major scientific (*e.g.* IAU General Assembly) and business events (*e.g.* Big Data Innovation Summit) will occur, together with more numerous regional/local events (*e.g.* presentations at local technical schools, SMEs *etc.*). The latter will be largely bottom-up driven, via the initiative of the various WP leaders.

The exploitation of ASTERICS' products is an important strand in the project's overall success oriented strategy. Naturally, the products of ASTERICS will have a direct and very positive impact on the implementation of the astronomy related ESFRI facilities. Ensuring that the project delivers above and beyond this will be a key goal. At the level of each WP we will:

- Identify further internal research that should continue within the ASTERICS partnership or the ESFRI facilities or some other collaboration (post-contract research).
- Reach out to industrial and commercial partners in collaborative research initiatives that build on ASTERICS internal research that may be relevant to companies in terms of developing new and original innovative products, associated services, standardisation and/ or potential licensing agreements.
- Openly entertaining possible joint ventures with commercial entities, pre-existing holding companies associated with the ASTERICS partners or creating new spin-off companies in order to most effectively bring to the market place technologies resulting from the project.

Each work package within ASTERICS has a strong component of training – the aim is to attract and educate young scientists in using the newly developed tools and methodologies. The training includes workshops, schools, online tutorials and collaboration with other science projects. Such programmes are essential in order to ensure that the results of ASTERICS will proliferate beyond the project partners, and can help ensure a long-term legacy for the project that will endure long beyond the formal contractual period.

Measures to achieve impact

ASTERICS will undertake a very broad but well-focused range of measures in order to ensure the effective dissemination, communication and exploitation of key results. We have identified actions that we believe are most appropriate for the communities that we wish to directly engage with. The web portal is a key tool to bring ASTERICS to the attention of the main stakeholders. By delivering rich functionality here, together with high quality materials (incl. posters, brochures *etc.*), we can be sure that the results of ASTERICS are presented in the best possible light. By splitting the portal into various channels, we can optimise our message for each section of the community.

Our measures will be active as well as passive – in particular our "push and pull" communications strategy will also permit us to directly engage with specific target audiences. Our attendance at major events and high-level meetings will bring ASTERICS face-to-face with other academic, industrial and commercial entities. This will permit us to demonstrate at first hand the cross-fertilisation between astronomy and industry – in particular, our plan is to highlight the technologies we are developing to currently manage, store, process, transmit and interpret complex, Big Data products. Our presence at specialised conferences on a global but also local/regional scale will lead to a fruitful exchange of ideas across different fields. The latter will also give ASTERICS staff

an opportunity to reach SMEs and to attract young technicians and scientists, active in other areas. An important selection criterion for investing in, and attending these events, will be the participation of relevant stakeholders, and in particular prospective industrial and commercial collaborators.

ASTERICS places a lot of emphasis on the need to train the next generation of scientists and engineers. Training events within the various Work Packages (and in particular WPs 2-4), will ensure a good dissemination of the knowledge and results generated within ASTERICS. While the astronomical community is a primary target here, we are also ensuring that industrial partners are also involved. The training events aimed at the scientific community will be open to astronomers from all EU member states, and contribute to sustaining an integrated European astronomical community.

ASTERICS's mass participation experiments will maximise impact (a) by using existing Zooniverse infrastructure (b) by crowd-sourcing the themes (a proven Zooniverse technique for maximising science impact), (c) by exploiting potential for promotion through in-house links to makor broadcasters (e.g. the BBC), (d) by 'learning journey' analytics to monitor and tailor the learning impact.

Management of the research data generated

The various ASTERICS work-packages will not produce or own original scientific (astronomical) data. ASTERICS will however, generate software and simulated data products that will be available under open license, for example, via the GNU General Public License. This will make the routines and associated data readily available to any interested party. The ESFRI pathfinders are expected to generate data as part of ASTERICS' prototyping and testing activities but these data will remain under the ownership of the respective pathfinder facilities, and hence subject to their rules and regulations regarding public access and re-use. Typically, such data enters the public domain after a 12-month proprietary period. Astronomical data is usually provided in FITS (Flexible Image Transport System) format – originally developed for astronomy and now maintained under the auspices of the IAU (International Astronomical Union).

ASTERICS will make liberal use of the VO framework standards – enabling data to be discoverable through an OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting) registry, and to be interoperable with the other astronomy on-line resources. WRE (White Rabbit Ethernet – see WP5) is becoming a de-facto standard for time stamp transfer and synchronisation. The latter is governed under the CERN Open Hardware Licence and it will adhere to existing standards for formatting the time information that is to be transferred. ASTERICS will make wide use of a selection of familiar connectivity standards (TCP, UDP, UDT), and these will also be employed in a single interface for intensive data transfer sessions. In order to establish precision timing and synchronisation across the ESFRI facilities it will be necessary to develop a uniform time stamp format for data streams with nanosecond precision. A natural choice may be the TAI64 (Temps Atomique International 64 bit) timestamp, which is used to denote International Atomic Time (IAT) with high precision.

ASTERICS embraces the principles of Science 2.0, and will make strenuous efforts to ensure that all of its products are openly available to all (see also earlier in section 2.2a). We intend to establish a long-term repository that will collect together all the various project data products *e.g.* software routines and tools, simulated data, reports and publications, tutorials, presentations *etc.* The repository will reside at ASTRON (with a standard backup and recovery service) but we will also investigate the various merits of public repository services *e.g.* CERN and OpenAIRE's (see www.openaire.eu) ZENODO (www.zenodo.org). Using a repository such as this, can ensure that the products of ASTERICS are readily available and preserved on timescales that are much longer than the formal project duration. In terms of the reduced data products generated by the ESFRI facilities themselves, it should be noted that the CDS (Centre de Donnees astronomiques de Strasbourg) repository operated by CNRS-OAS was recently awarded the "Data Seal of Approval" (http://www.datasealofapproval.org/en), which certifies it as a sustainable data repository.

Knowledge Management and Open Access

Within ASTERICS the responsibility for Knowledge Management (KM) will lie within the ASTERICS Executive Board (AEB) - chiefly the Coordinator and WP leaders, and the ASTERICS Management Support Team (AMST). The creation of new knowledge will be high on the ASTERICS agenda, and the expectations of top project management will be visibly high. A significant fraction of the WP leaders time and effort will be spent identifying, capturing and assessing the value of new knowledge generated by the project. Standard tools such as “invention scanning” will be implemented within the WPs in order to encourage direct engagement with ASTERICS researchers, thus extracting knowledge that can be catalogued within an inventory and regularly reviewed and assessed. A KM culture based on reporting, monitoring, supporting and training will pervade the project and will be cultivated at the highest level. The need to retain knowledge over the course of ASTERICS and beyond will also be a key goal of the KM strategy.

A firm basis for these ambitions will be the ASTERICS Consortium and IP agreement – the latter will be a particularly important tool in ensuring that new knowledge and the rights of innovation be appropriately shared, protected and secured across the project. Given the academic nature of most of the partners, information exchange will happen in an open atmosphere, but there may be areas in which management of knowledge capital will be important. For this a flexible implementation of Intellectual Property Rights (IPR) will be necessary. This formal process of ownership and for use and sharing of intellectual property will be defined in the ASTERICS Consortium Agreement. In general, developments within the project will be viewed as shared products, equally available to all project partners. Nonetheless, the agreement will provide adequate and effective protection of knowledge that is likely to be of industrial or commercial application. This is clearly required for the developments of technological processes but also for special design and characterisation procedures developed in the partners’ laboratories. IPR will be a standing agenda item at the team meetings and followed by the AMST throughout the projects duration.

Consistent with the requirements of the Horizon 2020 programme and the adopted Science 2.0 drivers, all ASTERICS publications will be in the public domain. So far as possible, this will be “green” open access with full-text publications indexed and available via the web portal. The web portal will also permit open annotation of individual ASTERICS products – permitting comments on articles to be made. Associations to other links and to other relevant information can also be archived there. So far as possible, we will use ArXiv.org as a global repository of ASTERICS publications – as the standard server for all astronomy, computing, maths and physics papers, we expect at least 80% of ASTERICS publications to be openly available there. For papers with content that falls outside of these domains, papers will be placed in the public domain by publishing in open access journals or by directly procuring “gold” open access rights.

The integration of ESFRI facility data in a single data framework through the VO is also an excellent example of the ASTERICS commitment to “open science”. Such an inclusive approach leads to significant benefits for scientific productivity, novel science and RoI (return on investment).

b) Communication activities

ASTERICS will have a strong “online” presence, with a public web portal that will target all potential stakeholders and present the full scope of the project and its key objectives and results. This will be implemented via WP2 – DECS.

Additionally, we will specifically focus on four major channels of communication, each targeting a different key audience:

1) A public web featuring the astronomy related ESFRI facilities, featuring promotional animations, and targeting the general public.

2) Cross-platform delivery of videos on dedicated YouTube channels and iTunes, again targeting the general public with a specific focus on the young adult science-inclined public.
3) A public technical web for ASTERICS and related ESFRI facilities, industrial/commercial/research centre based collaborators, providing links to open-access peer-reviewed publications, data and software products, targeting the technical specialist communities.
4) Mass participation experiments (MPEs) and educational resources, targeting the science-inclined public.
5) Promotional colour brochures describing ASTERICS and the ESFRI facilities, targeting the informed decision-making communities.

The public website and the MPEs are aimed specifically at engaging with the public - driving societal engagement in the ESFRI facilities. The MPEs provide open access to research data to a much wider community than the technical specialist user base of each facility. Our objective in providing mass participation experiments (MPE) is to create interfaces to enable the use of astronomy ESFRI facilities for education and public services, and to attract the public (particularly young people) to science by networking facilities via citizen science and through the provision of open educational resources for citizen science participants to develop their interests still further. By targeting the science-inclined public and stimulating their interest to take science further, we greatly increase the size of the community using the data from ESFRI facilities, and we generate economic impact through scientific and technical training. These outcomes have quantitative metrics described below. Public and societal engagement will further be monitored through the online forums associated with the public MPEs (see below).

In addition, to having a public web portal, the same infrastructure will also host an internal area reserved for project staff. This area will serve as the ASTERICS-internal information archive and will be password-protected. Here, all information related to the implementation of the work description will be made available, such as: meeting minutes, reports, agenda, and the data and software archive. There will be a web-based mailing list for ASTERICS partners-only, for discussions and rapid information exchange.

Monitoring impact of communication activities

In addition to employing traditional performance metrics (publications, citations, journal, press-release stats etc), ASTERICS will also measure its performance via “alternative metrics” – this is particularly relevant to the projects’ communication activities. Following also the Science 2.0 agenda, we will also place significant emphasis on “reputation” based metrics that will monitor other key indicators such as data and publication access, instances of data re-use, social media impact (page likes, tags, re-tweets, followers etc), the use of project blogs and the uptake on the open annotation of the projects publications and products. Some of this can be recorded directly via the web portal but we will also make use of tools that are available via enterprises such as *altmetric.com* and *impactstory.org.* In this way, we hope to provide a more holistic view of ASTERICS’ full impact.

For the more complex Citizen Scientist projects (see WP2), methodologies for monitoring “click-through rates” and sign-ups for further study will be adopted from pre-existing projects. WP2-DECS partners already have a wealth of experience in using such indicators as a metric of success. This methodology is known as a “learning journey”, tracking a participant’s progress from participation in an MPE, to informal learning, to formal learning. Web traffic can be monitored in real-time to track people’s learning journeys and these figures can be presented in the ASTERICS annual reports. This methodology was originally developed for monitoring the educational effectiveness of prime-time television and radio broadcasting, co-produced by the lead participant of WP2. Similar “click-through” monitoring will also be applied to the promotional videos and to the ASTERICS public-facing website. In this way, it will be possible to quantifiably demonstrate the impact where the ESFRI facilities have stimulated educational interest. Experience of the WP2 partners in Galaxy Zoo, demonstrate that monitoring the usage of mass participation experiment (MPE) forums

provides an indication of the uptake of further participant study, a key measurement of the performance of our MPE, in addition to quantitative learning journey metrics.

3. Implementation

3.1 Work plan — Work packages, deliverables and milestones

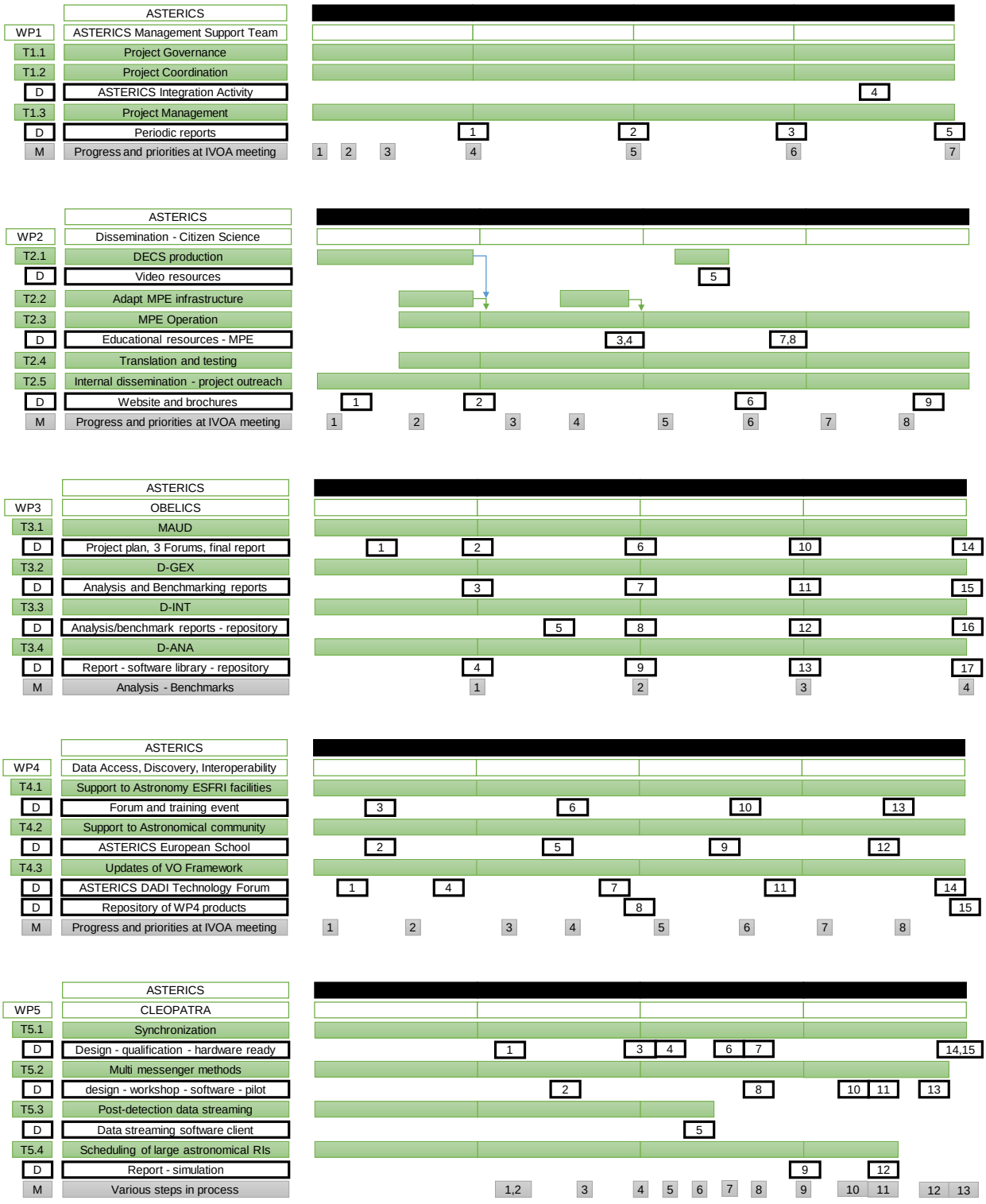
Overall structure of the Work plan

ASTERICS is split into 5 main work packages (WP 1-5). The first WP deals with the governance and management of the project, and its structure is discussed in section 3.2. The ASTERICS MST (Management Support Team) will play a crucial role in terms of maintaining oversight of the project and the various WPs, aided by the coordinator and WP leaders. WP1 also supports the establishment of a Policy Forum in which the ESFRI facilities, together with other major astronomy research infrastructures will harmonise the joint and efficient scheduling, operation and interoperability of the various multi-wavelength and multi-messenger telescopes. The remaining WPs represent the main technical content of the project. They include:

WP2: Dissemination, Engagement and Citizen Science (DECS) – it is increasingly important that the results from major projects such as ASTERICS, and the engagement with the various project stakeholders and potential collaborators (including the general public) is adequately addressed. We have therefore consciously chosen to create a separate WP in which the issues of dissemination, engagement and citizen science can be appropriately prioritised. WP2 will be continuously in step with the progress being made by the other WPs across the project, and will seek opportunities to circulate information on the relevance of our results and the overall success of our programme. It will also spearhead its own technical programme, aiming to fully engage the ESFRI facilities with all relevant stakeholders, including the general public. In the latter case an ambitious programme of public engagement and education via citizen science mass participation experiments is foreseen.

WP3 & 4 have a strong and interrelated focus on delivering common solutions, standards and analysis to the management and exploitation of large volume and high velocity data streams. Key goals include interoperability between facilities such as the SKA, CTA, EGO, KM3Net etc. with the realisation that astronomy in the next decade will not only be multi-wavelength but also multi-messenger. Enormous exascale data streams will have to be successfully managed (*WP3* – OBELICS (*Observatory E-environments Linked by common ChallengeS*) and an almost industrial-scale approach to scientific discovery (*WP4 - Data Access, Discovery & Interoperability* or DADI) will be required in order to fully exploit data from many different sources, including the new ESFRI astronomy facilities. By utilising the existing VO framework, WP4 opens-up the data products of the ESFRI facilities to scientists across *all* member states. The ESFRI projects will generate a rich variety of “Big Data” whose scientific exploitation and combination requires a common approach for optimum infrastructure deployment, efficient data transfer, data management, archive, access, interoperability, discovery, exploitation, curation and re-use. It is in this specific area of the Data Challenge where the maximum synergy between the various ESFRI telescopes naturally arises. Both WP3 and WP4 also entail significant training opportunities for external stakeholders, in order to ensure that telescope staff and users are fully engaged with the ASTERICS programme.

WP5: Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts (CLEOPATRA) – is a coherent collection of common challenges related to connectivity, synchronisation, scheduling and last but not least, cross-facility coordination – the latter being especially crucial in terms of response to (multi-messenger) transient alerts. Like WP4, this WP is partly building on the success of earlier projects, including the WRE (White Rabbit Ethernet) and the EC DG-EXPReS/NEXPRES projects.



Timing of the WPs

The timing of the Work Packages and their components is visualised in the charts above. The bars represent tasks, the open boxes deliverables (text and numbers) and the filled boxes at the bottom of each WP represent the Milestones (text and numbers).

Detailed Work Package Descriptions

ASTERICS WP2 – Dissemination, Engagement and Citizen Science

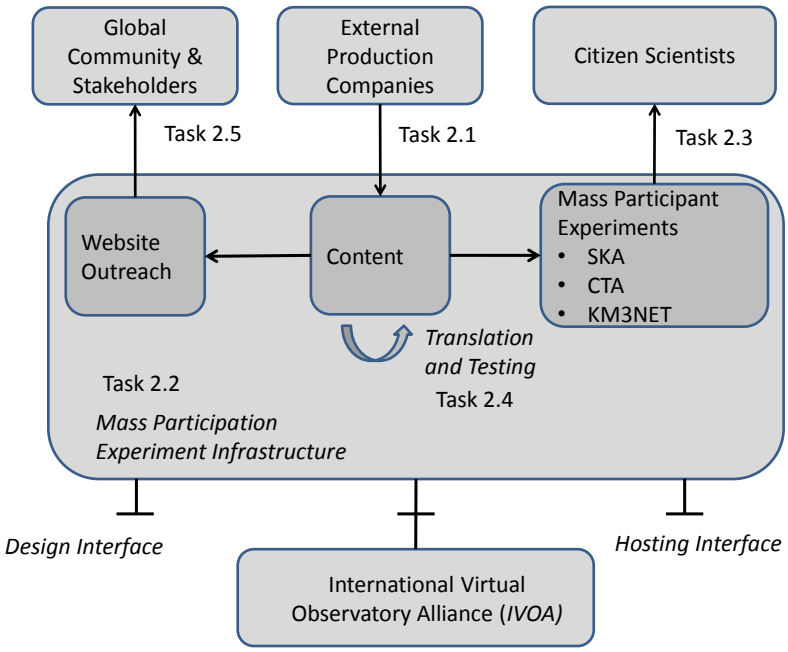


Figure 4: ASTERICS realises Mass participation Experiments (MPEs) with Citizen Scientists.

ASTERICS WP3: OBELICS (OBservatory E-environments LInked by common ChallengeS)

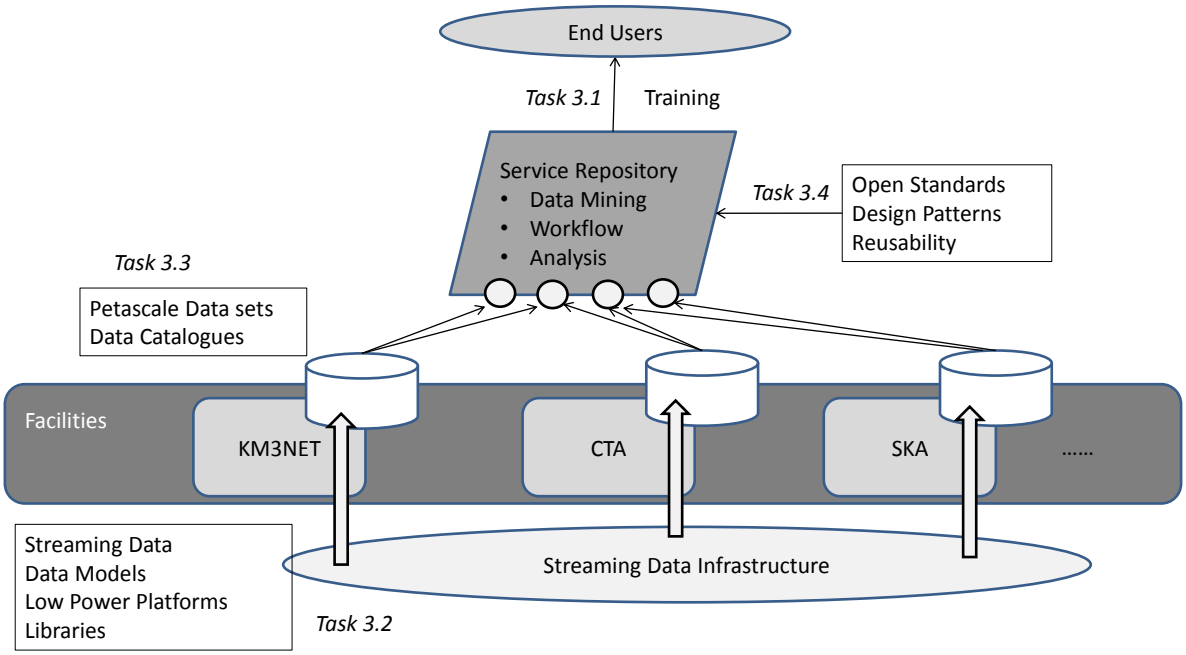


Figure 5: ASTERICS delivers a repository of services and Data Technology solutions for the ESFRI projects.

ASTERICS WP4: DADI (Data Access, Discovery and Interoperability)

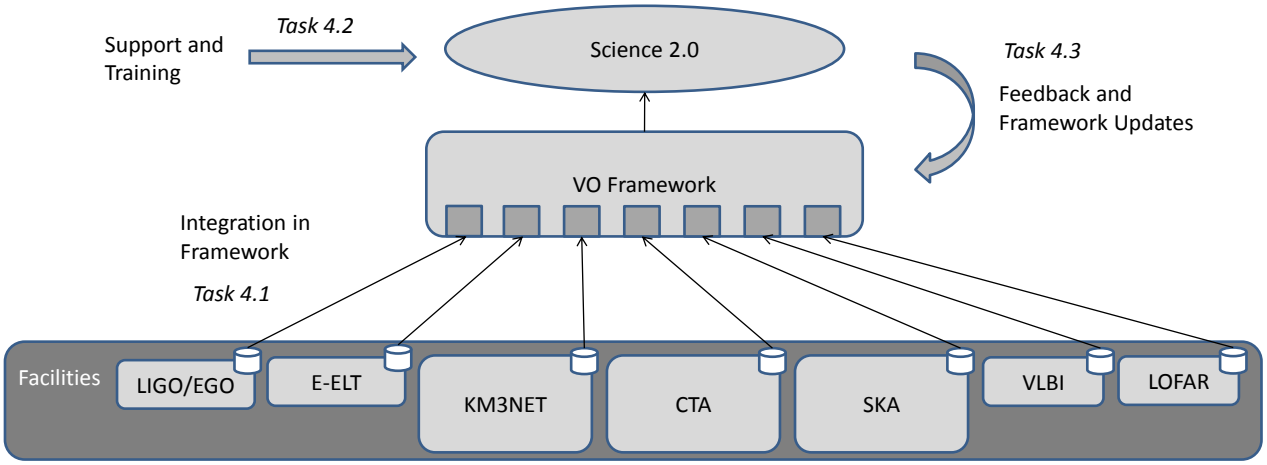


Figure 6: The ESFRI projects integrated in the VO Framework offers users uniform access.

ASTERICS WP5: CLEOPATRA: Connecting Locations of ESFRI Observatories and Partners in Astronomy for Timing and Real-time Alerts

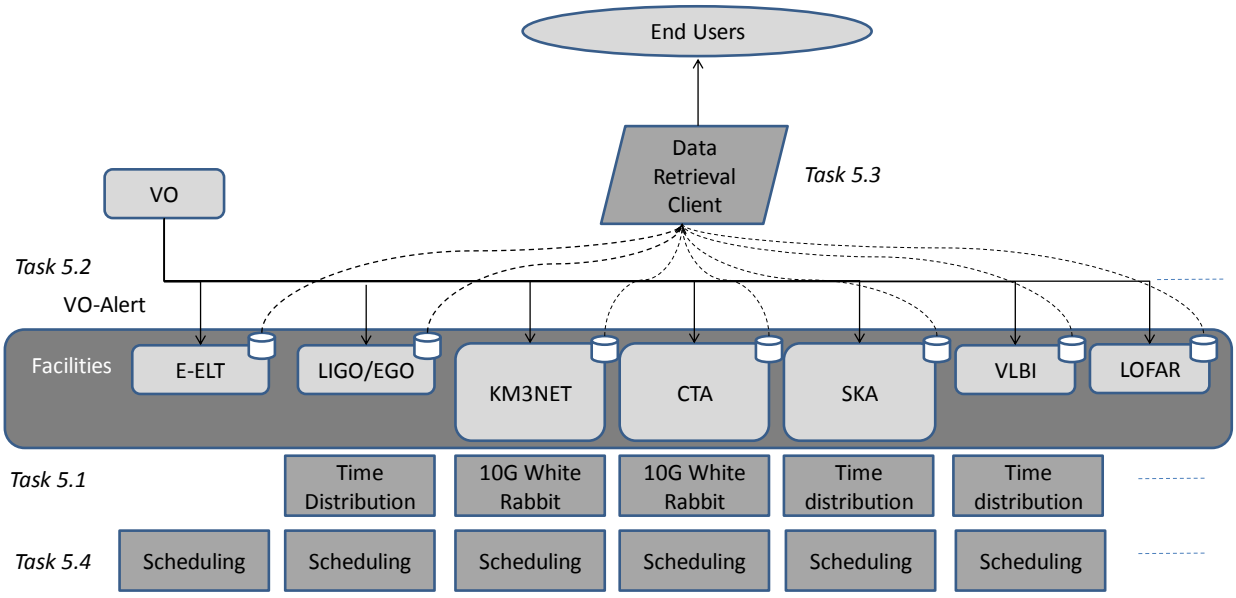


Figure 7: CLEOPATRA delivers solutions for shared challenges of ESFRI facilities.

Graphical representation of the WP components

Figure 8 shows the WPs and the manner in which they interact. By design, ASTERICS has attempted to reduce any interdependencies between the WPs to a minimum. This simplifies the management of the project and reduces the risk overall. WP1 naturally has oversight of the entire project with WP2 also taking responsibility for global dissemination of the ASTERICS results, together with support from the other technical work packages. There exists a direct interaction between WP3 and 4 in the area of overlap between the VO framework developments (WP4 - DADI) and the definition of standards, availability of meta-data and VO library interfaces (WP3 - OBELICS). ASTERICS culminates with a grand "Integration Event" (D1.4) in which the project will formalise its results, technologies and final deliverables. The event will be open to the full community and all other relevant stakeholders, in particular industrial and commercial concerns.

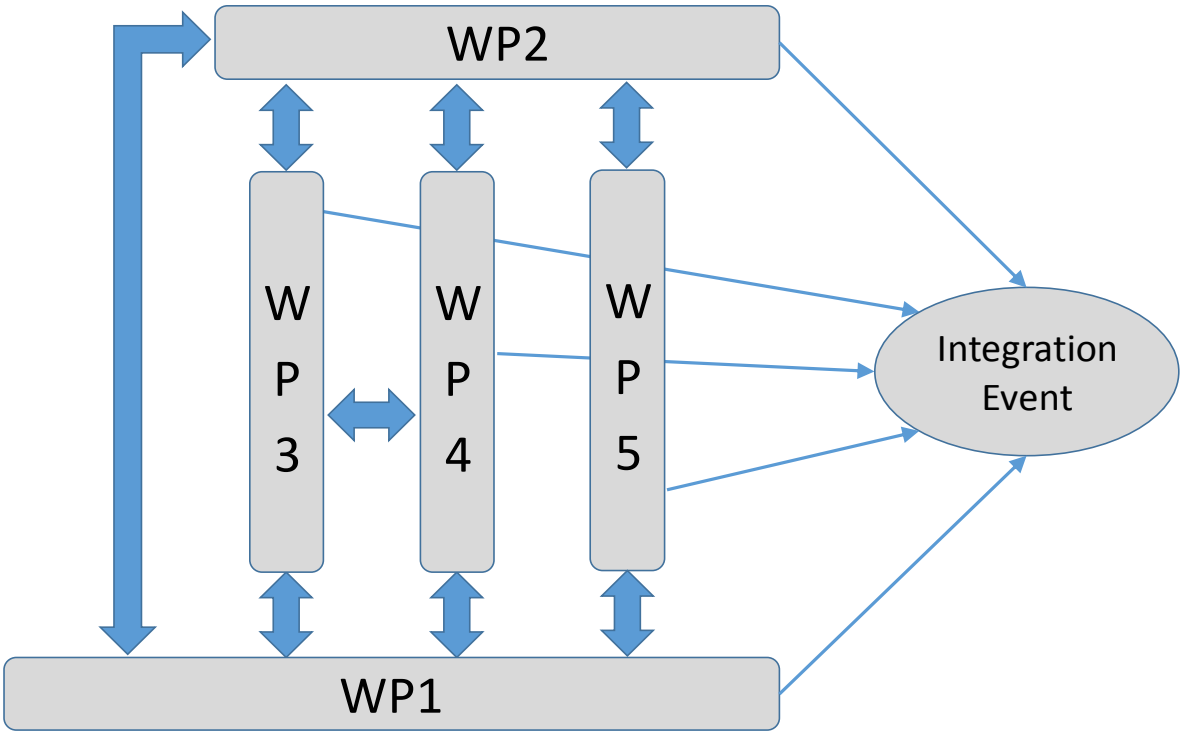


Figure 8: Graphical representation of the ASTERICS WP components.

3.2 Management structure and procedures

Innovation management

ASTERICS is active in areas of science and technology that are advancing rapidly, so there is a need to adopt the latest concepts and technologies as they become available. This situation is not new or unexpected, and many of the ASTERICS partners have proven themselves adept at recognising the latest advances, and deploying them in short order. Some prime examples where this approach has worked well is in the development of pathfinders for the ESFRI facilities. Innovation management is part and parcel of how ambitious ideas have been developed and matured into successful projects – LOFAR is just one example of a transformational new telescope developed in Europe that has greatly benefited from this logical form of approach.

Preventing heavy, up-front investments in poor innovations or in aging technology and correctly assessing the associated risks is also a familiar dilemma. The ASTERICS collaboration represents a group of complementary partners in which “open innovation” (and Science 2.0, see section 2.2a) has and can work well, sharing the risks but also the rewards. In addition, we recognise that ASTERICS will not have all the answers (this is particularly the case with WP3), and we cannot afford to rely entirely on our own internal research. As a result, we wish to engage as much as possible with other interested partners, in particular industrial partners and commercial entities with which we can share ideas and paths to market. Within WP3, we explicit make provision to contract industry for various services, including technical surveys, access to DB products and benchmarking exercises. Innovation management and open innovation with therefore be at the core of the ASTERICS project.

Risk management

ASTERICS is a project involving state-of-the-art research, and the level of risk across the various

WPs is not insignificant. By design, the WPs have been developed so that any inter-dependencies are limited, and especially limited in terms of overall risk to the project. So far as possible, the same approach has been applied to the various tasks within a WP but here the cross-dependence is naturally much higher. To proactively mitigate the risks associated with ASTERICS, and to make them fully visible on a central platform, the ASTERICS Management Support Team (AMST) will establish a project-based *risk register* (risk database). The risk register will be "owned" by the ASTERICS Project Manager, and be updated on a regular basis. Input to the risk management register will be established at all levels within the project, with WP leaders naturally playing a major role. The risk register will appear as a standing agenda item on the monthly meetings of the AEB. The register will identify the nature of the risk, and evaluate its likelihood, and impact. The latter will be differentiated between impact at task, WP and total project level. Contingency planning and risk mitigation will also be included as essential components of the register. Annual reviews of the status of the risk register, including any outstanding concerns will be presented to the ASTERICS General Assembly (AGA) for discussion and resolution.

Table 3.2 presents the main critical risks identified at this stage of the project, together with the mitigating actions.

Table 3.2b: Critical risks for implementation
This table is now in Part A.

ASTERICS Organisational structure

The organisational structure and decision-making process of ASTERICS will largely follow the main principles of the DESCA (Development of a Simplified Consortium Agreement) initiative (see www.desca-2020.eu for details) but with some minor tweaks and modification. Specifically, ASTERICS will recognise five main governance entities: (i) a General Assembly, (ii) an Executive Board, (iii) a Coordinator, (iv) a Management Support Team and (v) an External Advisory Board. Figure 9 shows the basic ASTERICS governance structure, and how these entities interact with each other and various other external stakeholders.

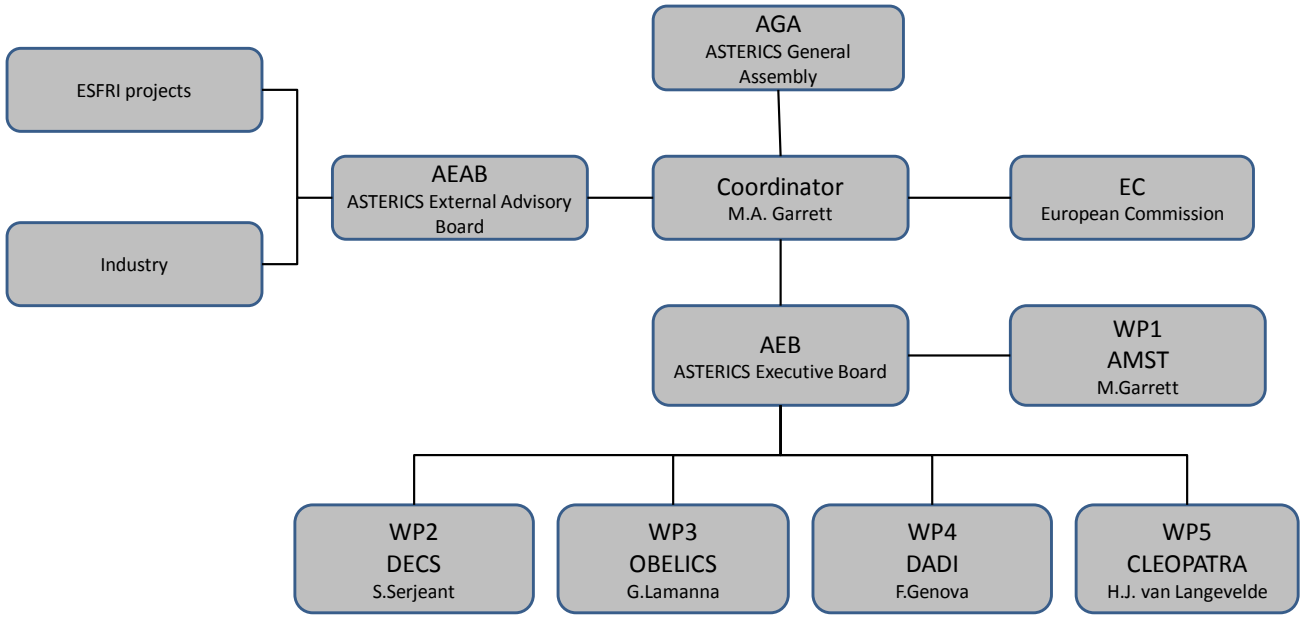


Figure 9: The overall governance and organisation of the ASTERICS project.

ASTERICS General Assembly (AGA)

The ASTERICS General Assembly (hereafter AGA) will be the ultimate decision making body of the consortium, with each of the full partners (see list of participants page 1) able to appoint one assembly member. The AGA will typically meet face-to-face at least once per year – additional meetings (should they be required) will be held via video conference. Quorum will be achieved when 2/3 of the AGA members are present or represented by a proxy.

The AGA will elect from its membership a chairperson who will serve for a renewable term of two years. We note that on this specific point, the Governance of ASTERICS differs from the DESCA model in which the coordinator is suggested to be the chair. Our experience in previous large EC projects suggests that having an independent chair of the AGA empowers that body to act as a proper sparring partner with the coordinator and Executive Board.

In keeping with the fundamental spirit of good collaboration, decisions will be made wherever possible, on the basis of consensus. In the event that consensus cannot be achieved, motions will be approved with a majority of 2/3 of the votes cast. Other non-voting guests (e.g. the Executive Board) will be invited to AGA meetings by the chair.

ASTERICS Executive Board (AEB)

The ASTERICS Executive Board (hereafter AEB) is a supervisory body for the execution of the Project. The AEB shall report to and be accountable to the AGA. In particular, the AEB will be responsible for the proper execution and implementation of the decisions of the AGA. It will also assess and monitor the progress of the project in terms of compliance with the original (or modified) planning, and advise the AGA on actions required to remedy potential deviations from the schedule of deliverables and milestones. AEB meetings will occur regularly (roughly once per month) and will be chaired by the coordinator. The Executive Board will be invited to open sessions of the AGA meeting. The AEB membership will be proposed by the project coordinator, and approved by the AGA. The AEB is expected to consist of the coordinator and the Work Package (WP) leaders.

The role of the WP leaders is to:

- ensure that the agreed work programme is followed and that the dates of milestones and deliverables are adhered to,
- monitor, manage and report on all relevant WP resources and performance indicators,
- provide quarterly financial reports, half-yearly progress reports and a comprehensive annual report to the AMST, including financial statements, all in a timely fashion.

ASTERICS Coordinator

The ASTERICS Coordinator will be a member of the AGA and chair the AEB. The coordinator will act as an intermediary between the ASTERICS partners and the EC, and shall perform all tasks assigned to it as described in the Grant Agreement and Consortium Agreement.

The partners have selected Prof. Michael A. Garrett, General & Scientific Director of ASTRON (the Netherlands Institute for Radio Astronomy), as the ASTERICS coordinator. The coordinator will dedicate approximately 20% of his working time to the project. This effort will be financed by ASTRON.

The tasks of the coordinator (see also the DESCA documentation) will include:

- Monitoring the compliance of the partners with respect to the obligations they have assumed as ASTERICS partners,
- Maintaining and making available the address list of the ASTERICS project partners and other relevant contact persons,
- Collecting, verifying and reviewing the various submitted reports, other ASTERICS deliverables (including financial statements, related certifications and other relevant documents) to the EC,
- Transmitting ASTERICS documents and information to all relevant parties, including internal participants (e.g. WP leaders) and external stakeholders,
- Administering the financial contribution of the EC and fulfilling the financial tasks described in the Grant Agreement and the Consortium Agreement.
- Providing, upon request, the ASTERICS partners with official copies or originals of documents that are in the sole possession of the Coordinator when such copies or originals are necessary for the partners to present claims.

ASTERICS Management Support Team (AMST)

The Management Support Team (AMST) will be proposed by the Coordinator and formally appointed by the Executive Board. The ASTERICS AMST will assist and facilitate the work of the Coordinator and the Executive Board. In particular, it will execute the decisions made by the AGA, and support the day-to-day and overall management of the ASTERICS project. On behalf of the coordinator, the AMST will collect and provide all necessary information from and to the partners (i.e. minutes of meetings, scientific and financial reports etc). However, the responsibility for providing these scientific and financial reports on the envisaged time schedule lies with the project partners. The AMST will be composed of a Project Manager (0.75 FTE/yr), Project Scientist (0.75 FTE/yr) a Financial Assistant (0.3 FTE/yr) and an administrative assistant (0.2 FTE/yr). The ASTERICS coordinator and the AMST will be in daily contact with each other – formal meetings (with minutes) will be scheduled on a monthly basis.

Collectively, the responsibilities of the AMST will include:

- supporting the coordinator in all aspects of the projects management and execution,
- implementing strategic decisions and recommendations made by the AGA and AEB,
- monitoring progress of the various ASTERICS WPs against the milestones and deliverables agreed by the Board,
- commissioning and receiving progress and financial reports from all ASTERICS activities.
- reporting to the AGA and AEB on a regular basis on all relevant developments,
- commissioning and receiving plans for next stage (annual implementation plan) of the ASTERICS programme,
- submitting approved reports to the ASTERICS coordinator for submission to the EC.
- managing the ASTERICS budget, including reconciliation of annually audited accounts.
- maintaining all financial, administrative and statistical records for review by the Board.
- supporting the promotion of ASTERICS at international fora.
- provision of secretarial support for the AGA and AEB.

ASTERICS External Advisory Board (AEAB)

An ASTERICS External Advisory Board (AEEAB) will be established in order to provide independent advice to the ASTERICS coordinator, and to conduct an independent assessment of the progress being made by the project. The AEAB will be composed of independent experts, closely associated with the ESFRI projects, other related Research Infrastructures and Industry – this will ensure optimal alignment of the work in ASTERICS with the needs of the ESFRI facilities. Members will be proposed by the coordinator but formally approved by the AGA. The AEAB will appoint a chairperson from within its membership. The AEAB will meet face-to-face at least once per year and will provide a written report on their findings. The report will be received by the coordinator, who will also distribute it to the AGA. The coordinator will send a written response to the AEAB chair with a copy to the AGA. The chair of the AEAB (and potentially other members) will be invited to participate in AGA meetings. Reports of the AEAB (and the response of the coordinator) can be useful input to the mid-term and final evaluation of the project.

A list of the ASTERICS project milestones is shown on Table 3.2.

Table 3.2a: List of milestones
This table is now in Part A.

Appropriate organisation for the scale of the project

Our experience in managing and executing previous large multi-partner (EC) projects is that the governance model described above is appropriate for a project with the complexity and scale of ASTERICS. The AGA is the ultimate decision making body of the consortium, and has total oversight of the project as a whole. The AEB runs the Work Packages, ensuring that they deliver on schedule and within budget, and reports to the AGA on an annual basis. The Work package leaders report to the coordinator via the AEB on a monthly basis. The AMST supports the coordinator and the AEB on all day-to-day matters, enabling them to focus on the technical content, managing and monitoring the WP effort on the basis of a result oriented approach. The Coordinator will be fully immersed in all aspects of the project, and operate within and between the different governance entities – he is independently advised by the AEAB and reports to the AGA and EC.

We are confident we understand the governance structure well, and how to properly implement and execute it. The ASTERICS partners are familiar with this type of construct, and have previously demonstrated their ability to deliver and to make it work. The partners forming the consortium (see section 3.3) have extensive experience in working on EC funded projects and understand the requirements they demand, also with respect to the reporting and financial administration aspects. Our conclusion is that by adopting the standard DESCA model, we are well prepared to tackle the type of problems that always arise in projects that are distributed across many partners. The coordinator of ASTERICS, his management team and the WP leaders have significant experience in working in this kind of environment, and making it successful. We're confident that while ASTERICS is a large and complicated project, the organisational structure can cope with these pressures and deliver on its promises.

Transnational access

No pilot trans-national access programme is foreseen at this stage of the ASTERICS project.

3.3 Consortium as a whole

The ASTERICS partnership was formed through the course of 2014 with face-to-face meetings organised at Jodrell Bank, Paris and Amsterdam. The consortium building process saw the invitation of the relevant stakeholders to all of these meetings, including (i) high-level representatives of the ESFRI projects, (ii) the major institutes and organisations contributing to the final design of the ESFRI telescopes and instruments, (iii) senior figures from the related ERA-NET projects and funding agencies (e.g. ASTRONET & APPEC), (iv) the EC Integrating Activities (e.g. RadioNet, OPTICON, EUROPLANET, SOLARNET), (v) "aspiring" ESFRI projects (e.g. EGO), (vi) research infrastructures of pan-European interest such as JIVE (currently on the path towards becoming astronomy's first ERIC), and the relevant ESFRI pathfinders (e.g. LOFAR, VLT, HESS, ANTARES, VIRGO).

The process of developing the ASTERICS work programme led to a natural distillation of the final list of consortium partners presented in Figure 10. As one would expect, the consortium includes some of the major players in European astronomy and astroparticle physics – those entities that are contributing heavily to the final designs of the ESFRI projects are particularly well represented. As a result, the partners have experience in applying systems and software engineering for their own facilities but also in a community setting for the ESFRI facilities. Essentially all the partners have been previously involved in large European projects (including the relevant ESFRI Design Studies and Preparatory Phase projects). In this regard they are familiar with the expectations of consortium membership having fulfilled consortium management roles, PI roles, project scientist roles and system engineering roles.

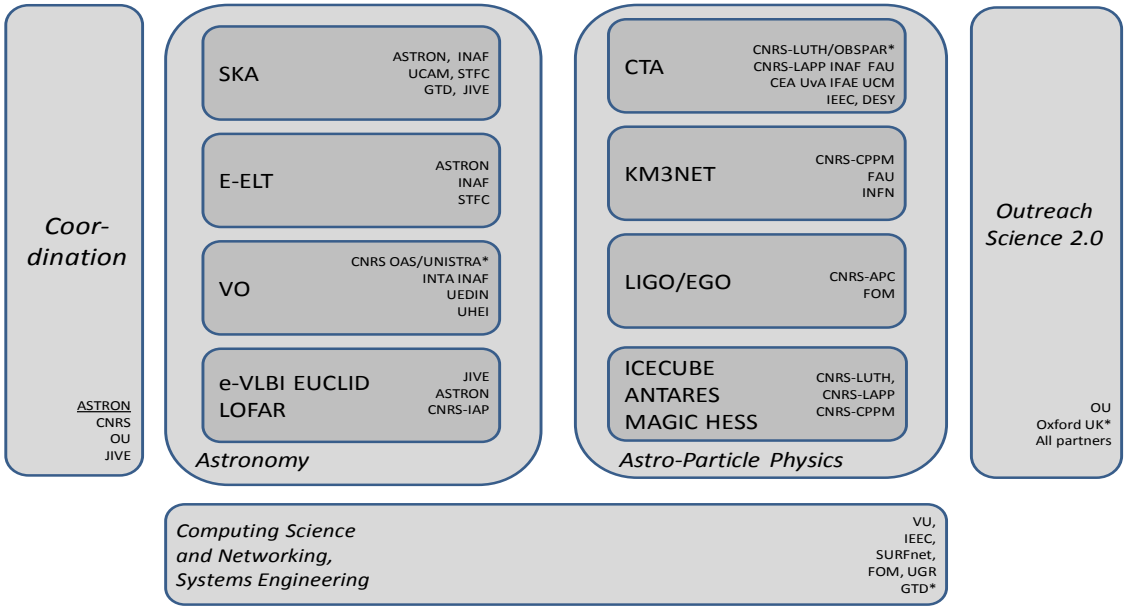


Figure 10: The ASTERICS partners (including third parties) and how they relate to the ESFRI projects, and their pathfinders.*

The legal entities representing the ESFRI project organisations (e.g. ESO, the SKA Organisation etc.) prefer to contribute to the project as associated members. The ESFRI projects are therefore not formally partners in the consortium but they will participate via appointments to the ASTERICS External Advisory Board (AEAB), and they will also receive invitations to the ASTERICS General Assembly (AGA). For further information, please see the letters of support provided by the ESFRI projects (see appendix 1 of this document).

The consortium partners bring a wealth of expertise and experience to the project. All the main European ESFRI pathfinders are involved, and several of the partners operate and exploit state-of-the art astronomical observatories (e.g. ASTRON, CNRS IAP, INAF, STFC) or are involved in major particle physics instruments (e.g. FOM). In terms of outreach, dissemination and citizen science, almost all the partners have strong individual programmes, and the OU/Oxford have established multiple outreach platforms, including mass participation experiments that serve millions of citizen scientists around the world. This is a solid basis on which ASTERICS can firmly build.

Similarly, the partners have a broad and complementary technical expertise in areas that include: Big Data and Exascale technologies (e.g. ASTRON via the public-private DOME collaboration with IBM), broadband networking technology for timing, distribution and synchronization (e.g. VU, SURFnet, JIVE), the Virtual Observatory (CNRS OAS, INAF, INTA, UEDIN & UHEI), and control and scheduling software (various including IEEC & GTD).

In short, the ASTERICS consortium consists of internationally leading organisations with complementary and overlapping expertise, spread both within and across the partners. The consortium includes many entities that have previously worked together but it should be noted that new collaborations are also being formed for the first time. We believe the latter development is long overdue, and we look forward to embracing new partners and new ideas – ASTERICS represents an unprecedented opportunity to bring together the related fields of astronomy and astroparticle physics on the European scale. In summary, this consortium has all the skills, and all the competencies required to coordinate the activities, and deliver on the major goals and objectives described in the proposal.

Industrial & Commercial involvement

In a number of critical technologies astronomy is pushing the boundary of the current and indeed projected state-of-the-art that is of great interest to industry and has the possibility of stimulating many new commercial applications. As detailed elsewhere ASTERICS can make substantial contributions to important sectors that include most generically: Big Data, mobile communications and navigation, sensor networks and data transport – for details of the technologies involved see sections 1.4 - innovation and section 2.1 – innovation capacity.

The number of industrial partners involved in the ASTERICS ESFRI projects is impressive. For the SKA alone, 35 major industrial companies are contributing to the design phase – ranging from Altera to Xilinx. Some of the ASTERICS partners also have well established cooperation with private-public consortia, such as DOME at ASTRON, or the Helix Nebula initiative of CERN, EMBL and ESA – pioneering a unique partnership between big science and big business in Europe, and charting the course towards the sustainable provision of cloud computing - the Science Cloud.

Within ASTERICS we have chosen to largely engage with commercial partners in the context of the ESFRI projects themselves, and the ASTERICS partners own substantial network of industrial and commercial contacts. WP3 - OBELICS will however subcontract to industrial partners in terms of its aim to deliver a broad range of innovative software libraries and services to the ESFRI facilities. The prioritisation of these software components and the specification of their requirements can only be made in the course of the project – arranging appropriate sub-contractors at this stage is premature. For some of the components, the development is optimally executed in co-development with industry. Therefore, the consortium will organise industrial engagement for (precompetitive) co-development with industry via an internal call for sub-contracting various technical works. WP3.1 manages this process in the same way as has been successfully organised for the FP7 CTA Preparatory Phase project. After the completion of this call, the consortium agreement and annex 1 will be amended to incorporate any new subcontractors (see WP task 3.1 point 4 for more details).

To ensure that industrial and commercial partners have sufficient input to the ASTERICS project, several industrial representatives will be asked to serve on the AEAB (ASTERICS External Advisory Board).

Other countries

All the ASTERICS partners are entities based in the Member States of the EU, and are therefore eligible for EC funding.

3.4 Resources to be committed

Tables 3.4a and 3.4 b summarise the staff resources to be committed to the project and other direct costs.

Table 3.4a: Summary of staff effort
This table is now in Part A.

Table 3.4b: 'Other direct cost' items (travel, equipment, other goods and services, access costs)

1 ASTRON	Cost (€)	Justification
Travel	173460	Attending forums, conferences, events and meetings WP: 1 — # trips: 68 — budget: 50000 WP: 2 — # trips: 10 — budget: 8000 WP: 3 — # trips: 40 — budget: 56000 WP: 4 — # trips: 58 — budget: 53700 WP: 5 — # trips: 12 — budget: 5760
Equipment	10000	Exhibition stand
Other goods and services	140000	Organising costs forums, events, meetings, dissemination materials
Total	323460	

2 CNRS	Cost (€)	Justification
Travel	405660	Attending technical forums, schools, training and other visits. (incl. guests) WP: 1 — # trips: 40 — budget: 40000 WP: 3 — # trips: 98 — budget: 140000 WP: 4 — # trips: 262 — budget: 224700 WP: 5 — # trips: 2 — budget: 960
Equipment	0	
Other goods and services	258000	Costs for 3 training courses, 3 workshops, communications and audit costs
Total	663660	

3 INAF	Cost (€)	Justification
Travel	143200	Attending DADI techno forums, schools, trainings and other visits WP | # trips | budget 3 | 45 | 63000 4 | 92 | 80200
Equipment	0	
Other goods and services	13000	Audit costs and other small expenses
Total	156200	

5 JIVE	Cost (€)	Justification
Travel	25520	Attending forums, conferences, events and meetings WP | # trips | budget 3 | 10 | 14000 5 | 24 | 11520
Equipment	80000	White Rabbit Ethernet hardware connection
Other goods and services	7500	Audit costs
Total	113020	

6 INTA	Cost (€)	Justification
Travel	137200	Attending DADI techno forums, schools, trainings and other visits, plus support to school attendants WP | # trips | budget 4 | 176 | 137200
Equipment	0	
Other goods and services	13500	Audit costs and other small expenses
Total	150700	

7 UEDIN	Cost (€)	Justification
Travel	80200	Attending DADI techno forums, schools, trainings and other visits WP | # trips | budget 4 | 92 | 80200
Equipment	0	
Other goods and services	10500	Audit costs and other small expenses
Total	90700	

8 UHEI	Cost (€)	Justification
Travel	80200	attending DADI techno forums, schools, trainings and other visits WP | # trips | budget 4 | 92 | 80200
Equipment	0	
Other goods and services	10500	Audit costs and other small expenses
Total	90700	

9 OU	Cost (€)	Justification
Travel	41330	Attending and organizing dissemination events (guests) WP | # trips | budget 2 | 30 | 41330
Equipment	0	
Other goods and services	53728	Brochures, materials, 5 videos and other small expenses
	72139	Cost for in-kind contribution of Oxford University
Total	167197	

15 FOM	Cost (€)	Justification
Travel	1920	Travel WP | # trips | budget 5 | 4 | 1920
Equipment	80000	White Rabbit Ethernet hardware connection
Other goods and services	0	
Total	81920	

18 UCM	Cost (€)	Justification
Travel	14000	Attending forums, conferences, events and meetings WP | # trips | budget 3 | 10 | 14000
Equipment	0	
Other goods and services	0	
Total	14000	

Justification of travel

WP1
ASTRON: Coordinator, project manager, project scientist, each 5 visits per year to event, meeting, or other partner, other officer 3 visits per year, total 68 trips
CNRS: 4 visits per year of project manager to visit event, meeting, or other partner + travel to policy forums for external people.

WP2
ASTRON: 10 trips for dissemination events/meetings
OU: 30 trips: 15 persons to attend two Workshops

WP3
Based on past experience:

a) 1k€ for 2-3 day meeting in Europe
b) 2 k€ for a <10 days working meeting
c) 2 k€ for a week conference, or other longer or combined event (workshop, training)

Average participation of funded personnel per year is about 3 topical working meetings, 1 long meeting and 1 conference or other longer or combined event = 3 x a + b + c = 3 + 2 + 2 = 7 k€/y

WP4
The work package consists of the following partners

- 5 VO = CNRS/OAS+UNISTRA, INAF, INTA, UEDIN, UHEI
- 4 ESFRI = ASTRON (SKA), CNRS: [LUTH + OP (CTA), APC (EGO), CPPM (KM3Net)]

There are many meetings organised in the WP, all involving several persons per partner:

meeting name	# meetings/ project	persons/ partner	total persons/ meeting		total trips/ project	
DADI Techno forums	5	4 VO, 2 ESFRI	28		140	
Schools	4	tutors (2 VO, 1 ESFRI)	14	50	56	200
		others from partners	15		60	
		external	21		84	
Forum & training event	2	3 VO, 3 ESFRI	27		54	
Data Provider Forum	2	3 VO, 3 ESFRI	27		54	
		(+ 20 others on their own funds)			0	
Specific visits	4	2 / partner	18		72	
IVOA Europe	4	2 VO, 2 ESFRI	18		72	
IVOA International	4	2 VO, 2 ESFRI	18		72	
RDA Europe	4	2 VO, 1 ESFRI	14		56	
RDA International	4	2 VO, 1 ESFRI	14		56	
Total					**776**	

Cost estimate: European trips at € 750, International trips at € 1600

WP5
Average cost per trip is set to €480, as many trips are within the Netherlands (6/11 partners). Trips will be short (1-2 days) for topical meetings. Number of trips related to effort of partner.

4. MEMBERS OF THE CONSORTIUM

4.1 Participants (applicants)

4.1.1 ASTRON

ASTRON is the Netherlands Institute for Radio Astronomy. Its mission is to make discoveries in radio astronomy happen, via the development of novel and innovative technologies, the operation of world class radio astronomy facilities, and the pursuit of fundamental astronomical research. ASTRON hosts both JIVE (Joint Institute for VLBI in Europe), the NOVA Optical/IR Group and DOME (the ASTRON & IBM Center for Exascale Technology). ASTRON designed, built and now operates the International LOFAR Telescope (a recognized Pathfinder for the SKA). ASTRON plays a major role in the various consortia contributing to the current SKA Design Phase. It leads both the SKA Low Frequency Aperture Array and the SKA Mid Frequency Aperture Array work packages. In addition, ASTRON plays a prominent role in the Science Data Processor (SDP) work package and also several others.

ASTRON hosts the NOVA Optical Infrared group. The group develops optical instrumentation for the European Southern Observatory in Chile and the Isaac Newton Group of telescopes on La Palma. In the course of 25 years a wide range of instruments has been built, but in general the emphasis has been on spectrographs, on the infrared wavelength range and consequently on cryogenic instruments. The group plays an important role in the development of the Extreme Large Telescope (E-ELT), with a substantial participation in 4 of the 7 E-ELT instruments.

ASTRON Staff

Michael Garrett (m) is the General & Scientific Director of ASTRON, and the Professor of Radio Astronomy Techniques at the University of Leiden. He is a member of the SKA Board of Directors and previously served as chair of the SKA Science & Engineering Committee (SSEC). Garrett has published over 100 refereed papers and maintains an interest in very deep, high resolution and wide-field observations of faint radio sources. For the last 7 years he has taught the Radio Astronomy Masters course in Leiden. Currently, he also serves on a number of different boards including JIVE, the ILT and RadioNet. He has a long history of successfully proposing and managing various EC funded projects, including RadioNet and EXPReS. He is an active astronomer with an interest in the application of Big Data and Cognitive computing to the field of astronomy in general, and radio astronomy in particular.

Marco de Vos (m) is Managing Director of ASTRON and Professor of Sensor Technology at the Hanze University, Institute of Engineering and Technology. He was one of the founding fathers of LOFAR and was responsible for the project execution. Marco is member of the SKA Scientific and Engineering Advisory Committee (SEAC) and the ESO Science and Technology committee (STC). He is one of the Principal Investigators of the Amsterdam ASTRON Radio Transients Facility and Analysis Centre (AARTFAAC) and leads the RadioNet3 JRA Hilado project. He is coordinator of the Radionet Hilado project. Marco de Vos is member of the Steering Board of the DOME Exascale Project and the ASTRON & IBM Centre for Exascale Technology which is one of his

initiatives. He is eScience Integrator for Astronomy for the Netherlands eScience Centre.

Michael Wise (m) is a senior staff astronomer at ASTRON, the Netherlands Institute for Radio Astronomy, and Project Scientist for the International LOFAR Telescope. His research interests include cluster of galaxies, AGN feedback, and the formation and evolution of large-scale structure. He has worked extensively at a variety of wavelengths including X-ray, optical, infra-red, and radio. In addition to scientific research, he has over 20 years of experience supporting the construction and operation of large-scale astronomical facilities. He has served as a member of the Chandra HETG instrument team, staff scientist with the Chandra X-ray Science Center, contributed to the design of the CIAO scientific analysis software system, and led the development and commissioning effort for the LOFAR telescope. Along with basic astronomy research, his interests include a variety of topics in data-intensive astronomy including high performance computing, streaming processing, large-scale data storage and management, high performance formats and data access layers, and active computational archival data centers.

Gert Kruithof (m) is head of Research and Development at Astron. He is responsible for all research and development projects related to LOFAR, Westerbork and Square Kilometer Array including the joint research programme DOME with IBM on Exascale technology. In SKA, he is chairman of the Board of one of the consortia, the Low Frequency Aperture Array. He is a physicist from origin and obtained a PhD in Applied Physics from the University of Groningen. He has conducted industrial research at KPN on Network Technology and Software Mass Customization at the University of Groningen. As a senior business consultant for TNO, he advised multi-national organisations on board level on IT management.

Rob van der Meer (m) is Program Officer European Collaboration at ASTRON. He is a (astro)physicist from origin and in the last seven years worked on EC projects in Astroparticle Physics (ASPERA I and II) for APPEC, finding synergies, similarities and common challenges between funding bodies of astroparticle physics research in Europe and on distributed e-infrastructures in EGI-InSPIRE for EGI, working on stakeholder management, project administration and organization and contact person for the EC Project officer during negotiation and start-up of the project.

ASTRON Publications

1. Haarlem M. van, Wise M., Gunst A.W. et al. (2013). *LOFAR: The LOw-Frequency Array*. Astronomy & Astrophysics, Vol. 556, id.A2, EDP Sciences, DOI: 10.1051/0004-6361/201220873

2. Vos M. de, Gunst A.W., Nijboer R. (2009). *The LOFAR Telescope: System Architecture and Signal Processing.* Proceedings of the IEEE, Vol. 97, Issue: 8, pp 1431-1437

3. Broekema P.C., Boonstra A.J., Engbersen T. et al. (2012). *Dome: Towards the ASTRON & IBM Center for ExaScale Technology.* Proceedings AstroHPC'12, Delft, The Netherlands

4. Wise M.W., Alexov A., Folk M., Pierfederici F., Anderson K., Bähren L. (2011). *Towards HDF5: Encapsulation of Large and/or Complex Astronomical Data*. Astronomical Data Analysis Software and Systems XX, ASP Conference Proceedings Vol. 442, p 663

5. Anderson K., Alexov A., Bähren L., Grießmeier J.-M., Wise M.W., and Renting G.A. (2011). *LOFAR and HDF5: Toward a New Radio Data Standard*. Astronomical Data Analysis Software and Systems XX, ASP Conference Proceedings Vol. 442, p 53

ASTRON Projects

ASTRON is leading the pre-construction phase of two SKA Element consortia.: the Low Frequency Array Element construction expected to start in 2018 in Australia and the Mid Frequency Array Element that is planned in South Africa. Next to leading these consortia ASTRON is participating in other SKA element consortia.

LOFAR (http://www.astron.nl/radio-observatory/radio-observatory) is the Low Frequency Array in the low frequency range for radio astronomy (10-240 MHz). LOFAR is an interferometric array using dipole antennas stations distributed throughout the Netherlands, the UK, France, Sweden and Poland. LOFAR was designed and built by ASTRON and is one of the SKA pathfinders.

The DOME (http://www.dome-exascale.nl/) project is a collaboration between ASTRON and IBM that carries out fundamental research in technologies needed to develop the Square Kilometre Array. The main research areas are green computing, data & streaming and nano-photonics.

ASTRON has a leading role in the development of the mid infrared instrument METIS for E-ELT. The prime management (principal investigator, project management, system engineering, project scientist) is shared between Leiden and the ASTRON group. The core technical development team will be the NOVA team at ASTRON. The full integration and final test phase will be in the Netherlands and most likely at ASTRON, needing several technical disciplines like optics, mechanics, electronics, systems and software and project management. Besides METIS other technical development for 3 other E-ELT instruments will be done by the NOVA-ASTRON group within different time frames of each other, covering a period from now (METIS is running) up to 2030.

ASTRON main tasks in project

Profile: representing SKA, E-ELT, LOFAR
Main tasks:

- Consortium lead,
- Lead of: WP1, Tasks 2.5 3.3, 5.2
- Participation: Tasks 3.2, 3.4, 4.1, 4.2, 4.3 5.1

4.1.2 Centre national de la recherche scientifique (CNRS)

The Centre National de la Recherche Scientifique (National Centre for Scientific Research) is a government-funded research organization, under the administrative authority of France's Ministry of Research.
CNRS's annual budget represents a quarter of French public spending on civilian research. As the largest fundamental research organization in Europe, CNRS carried out research in almost all fields of knowledge, through its eight research institutes : Mathematics (INSMI), Physics (INP), Chemistry (INC); Biological Sciences (INSB); Humanities and Social Sciences (INSHS); Ecology and Environment (INEE); Engineering and Systems (INSIS); Information Sciences (INS2I); and its two national institutes: the National Institute of Earth Sciences and Astronomy (INSU); and the National Institute of Nuclear and Particle Physics (IN2P3).

Its own laboratories as well as those it maintains jointly with universities, other research organizations, or industry are located throughout France, but also overseas with international joint laboratories located in several countries. Measured by the amount of human and material resources it commits to scientific research or by the great range of disciplines in which its scientists carry on their work, the CNRS is clearly the hub of research activity in France. It is also an important breeding ground for scientific and technological innovation.

The two institutes of the CNRS concerned with the ASTERICS project and working together are IN2P3 (National Institute of Nuclear and Particle Physics) and INSU (National Institute of Science of the Universe). The researchers and engineers are deployed in mixed research units, UMR (usually laboratories) where they work together with researcher lecturers employed by the University system.

4.1.2.a CNRS INSU (National Institute for Earth Sciences and Astronomy)

The (INSU) aims to design, promote and coordinate national and international research in the fields of astronomy and of solid Earth, ocean, atmospheric and space sciences. Working with other partner organizations and universities, INSU carries out prospective scientific studies in order to identify emerging research areas that require priority support. As part of the joint programs that it coordinates, the Institute funds research projects and sets up national and international facilities. INSU also helps to structure national research in its own field, in particular by managing the network of Observatoires des Sciences de l'Univers (Earth Science and Astronomy Observatories - OSU). INSU sets up information systems for the archiving, provision and exploitation of collected scientific data. INSU coordinates strategic planning for European astronomy and collaborates in the development of European observation networks. The Institute sets up and/or participates in international programs. It manages large facilities together with European and international agencies, and designs instruments within the international consortiums that it often leads.

CNRS INSU Staff

Denis Mourard has been the Deputy Director for Astronomy and Astrophysics at CNRS-INSU since 2012 and the coordinator of ASTRONET. He is also the Vice-President of the IAU Commission on Interferometry. Denis Mourard will lead the community forum proposed in WP1 and will be the CNRS scientific contact for ASTERICS.

Elisabeth KOHLER leads the Europe office of INSU for more than 15 years. She has been involved in many European contracts (Astronet, Europlanet, Eramin, Opticon) and will be the CNRS administrative contact for ASTERICS.

CNRS INSU Projects

CNRS-INSU has been coordinating ASTRONET since 2006. This ERA-NET funded by the EC (2006-2010 and 2011-2014) is aiming to establish a strategic planning mechanism for all of European astronomy for the next 5-25 years. It covers scientific topics from the Sun and Solar System to the limits of the observable Universe and research tools from the radio domain to gamma-rays and particles, on the ground as well as in space; but also theory and computing, outreach, training and recruitment of the vital human resources. And, importantly, ASTRONET aims to engage all astronomical communities and relevant funding agencies on the new map of Europe.

CNRS INSU main tasks in project

Profile: CNRS INSU coordinates ASTRONET
Main tasks: Participation in Task 1.2

4.1.2.b CNRS IN2P3 (National institute of nuclear and particle physics)

Founded in 1971, the aim of the National institute of nuclear and particle physics (IN2P3) of the CNRS is to promote and unify research activities in the fields of nuclear physics, particle and astroparticle physics. It coordinates programmes within these fields on behalf of the CNRS and universities, in partnership with CEA. The goal of this research is to explore the physics of elementary particles, their fundamental interactions and the manner in which they assemble into atomic nuclei, to study the properties of these nuclei and to explore the connections between the infinitely small and the infinitely large. Whilst these main themes represent the core of the discipline, IN2P3 also has several additional vocations: enabling other scientific domains to benefit from its competencies and solving certain problems posed by society, and accompanying universities in contributing to youngsters' training. IN2P3 is also responsible for running several major national facilities including particle accelerators. It also supports several international facilities (e.g. CERN, EGO/VIRGO,...). As the experiments require significant investments in terms of

financing and personnel, from the outset the Institute took the structure of a limited number of large laboratories and Infrastructures or technological platforms in order to facilitate the pooling and optimization of its resources and competencies. IN2P3 also shares with the CNRS/INSU Institute for Astrophysics the support to some projects in Astrophysics and Cosmology. CNRS, together with CEA-IRFU, fund almost all national e-Infrastructures for these domains. The CC-IN2P3 (Centre de Calcul de l'IN2P3), the National Computing Centre of the IN2P3 Institute provides data archive and computing resources for many of astroparticle physics experiments: AMS, ANTARES, H.E.S.S., VIRGO, Fermi. It supports the future major projects such as CTA, EUCLID and LSST. It provide computing resources also to research projects in other fields such as biology and life science, humanity and social science.

4.1.2.c CNRS OAS (Observatoire Astronomique de Strasbourg)

The Observatoire Astronomique de Strasbourg (Strasbourg Astronomical Observatory) is a Joint Research Unit (UMR7550) of the CNRS and of the Université de Strasbourg (UNISTRA). It hosts the *Centre de Données astronomiques de Strasbourg* (Strasbourg astronomical Data Centre CDS, http://cdsweb.unistra.fr/). Since its creation in 1972, the CDS has been providing reference services which are widely used by the world-wide astronomical community with more than 1 million queries/day in average in 2013. The CDS is labelled as a Research Infrastructure in the national Research Infrastructure Roadmap.

Université de Strasbourg (UNISTRA)

The **University of Strasbourg** (UNISTRA) is one of the largest universities in France, with over 43000 students and over 4000 researchers. The University also offers access to 25 modern languages, multinational diplomas, jointly supervised doctorates, upholding renowned international postgraduate schools and student exchange agreements. The scale of research activity at Strasbourg is substantial, involving a European Doctoral College, 10 doctoral schools and 79 research units. The University of Strasbourg (UNISTRA) is one of the largest universities in France, with over 43000 students and over 4000 researchers. Thanks to the worldwide reputation of its research teams, the University of Strasbourg emerges among Europe's foremost research universities and is a founding member of the League of the European Research Universities.

CNRS OAS Staff

Francoise Genova (f) has been the director of the CDS since 1995. She led the data center transition to the internet era, and has been one of the key persons in the International Virtual Observatory Alliance from the start of the VO project around 2000. Since 2006, she has been leading the four projects supported by the European Commission in support to the development of the European Virtual Observatory on behalf of the CNRS. She has been leading the national project which supports the development of the VO in France, *Action Spécifique Observatoires Virtuels France*, since its creation in 2004. She is a member of the IVOA Executive Board, representing the French VO and Euro-VO, and she chaired the Board in 2006-2007. She is a member of the RDA – Europe projects and of the RDA Technical Advisory Board.

Mark Allen (m) is a CNRS research scientist at the Observatoire Astronomique de Strasbourg. He has 12 years experience implementing e-Science projects in Astronomy within the CDS and EC funded European Virtual Observatory (Euro-VO) projects. He is the chair of the IVOA Committee for Science Priorities and has served as the IVOA Applications Working Group chair and IVOA Executive Secretary. As Euro-VO project scientist he has engaged and coordinated astronomical data centers, software developers and scientists in the development and use of the Virtual Observatory framework including support to the astronomy community via leading schools and workshops at the national and European levels. He also served as a member of the Astronet Infrastructure Roadmap (Panel D - *Theory, computing facilities and networks, Virtual Observatory*). His astronomical interests include active galactic nuclei and comparison of theoretical plasma models to multi-wavelength observations.

CNRS OAS Publications, Products and Services

1. CDS develops three services widely used by the international astronomical community: SIMBAD, the reference database for the nomenclature and bibliography of astronomical objects, VizieR, the reference service for astronomical catalogues and tables published in academic journals, and the Aladin interactive sky atlas, the VO portal for images.

2. Genova F. (2012). *The Astronomical Virtual Observatory: Lessons Learned, Looking Forward*. Proceedings of Astronomical Data Analysis Software and Systems XXI, ASP Conference Series, Vol. 461, p 247

3. Allen M.G., Depretz M., Zuther J., Arviset C., Tedds J.A., Genova F. (2009). *Census of European Astronomy Data Centres*. Deliverable (D5) of the EuroVO Data Centre Alliance Project, http://cds.u-strasbg.fr/twikiDCA/bin/view/EuroVODCA/DCACensusQuestionnaires

4. Allen M.G., Ochsenbein F., Derriere S., Boch T., Fernique P., Landais G. (2014). *Extracting Photometry Measurements from VizieR Catalogs*. Proceedings of Astronomical Data Analysis Software and Systems XXIII, ASP Conference Series, Vol. 485, p.219

5. Françoise Genova, the CDS Director, was a member of the High Level Expert Group on Scientific Data set up by the European Commission in 2010, which produced the influential report “Riding the Wave – How Europe can gain from the rising tide of scientific data” (2010).

CNRS OAS Projects

Since 2006 CDS has been the coordinator, on behalf of the CNRS, of all the projects funded by the European Commission to support the implementation of European Virtual Observatory (one FP6 and 3 FP7 projects): the *Euro-VO Data Centre Alliance* Collaboration Action (EuroVO-DCA - Project RI031675, Communication Network Development framework, 2006-2008), the *Euro-VO Astronomical Infrastructure for Data Access* FP7 Integrated Infrastructure Initiative (EuroVO-AIDA - Project 212104, Call INFRA-2007-1.2.1 – Scientific Digital Repositories, 2008-2010), and two Coordination and Support Actions, *Euro-VO International Cooperation Empowerment* (EuroVO-ICE, Project 261541, Call INFRA-2010-3.3, http://www.eurovo-ice.eu, 2010-2012) and *Collaborative and Sustainable Data Infrastructure for Europe* (CoSADIE, Call INFRA-2012-3.3 Research Infrastructures, project 312559, http://www.cosadie.eu, 2012-2015).

Several CDS staff members lead IVOA Working Groups: Pierre Fernique (chair of the Application Working Group), François Bonnarel (chair of the Data Access Layer WG), André Schaaff (chair of the Grid & Web Services WG). Mireille Louys (associated researcher to CDS, ICUBE laboratory, UNISTRA) is the co-chair of the Semantics Working Group. Thomas Boch and Sébastien Derriere are also key participants in the development of Applications and Semantics IVOA Recommendations.

CDS is a partner, on behalf of CNRS, of the Research Data Alliance – Europe project (Formerly iCORDI – International Collaboration on Research Data Infrastructure, Coordination and Support Action, Project 312424, Call FP7-INFRASTRUCTURES-2012-1, 2012-2015) and of RDA Europe 2 (Coordination and Support Action, Project 632756, Call FP7-INFRASTRUCTURES-2013-2).

CNRS OAS main tasks in project

Profile: CNRS OAS represents the Virtual Observatory and CDS.
Main tasks:

- Lead of: WP4, Tasks 4.2, 4.3
- Participation: Tasks 4.1

4.1.2.d CNRS IAP (Institut d'Astrophysique de Paris)

IAP (Institut d'Astrophysique de Paris) was created in 1938. It is currently a joint CNRS and Université de Paris Pierre et Marie Curie (UMPC) laboratory (Université de Paris Pierre et Marie Curie has no person/months and will not claim any costs in the ASTERICS project). About 130 people are working at IAP of which 75 are staff researchers, post-docs or PhD students. The primary scientific mission of IAP is to carry out research in astrophysics (planet formation, exoplanets, stellar astrophysics, evolution of galaxies, cosmology and gravitation). IAP is a leading institute in theoretical cosmology, gravitation, numerical cosmology, observational cosmology and cosmological surveys, and in data processing. IAP hosts the Planck Data Center, the TERAPIX data center (TERAPIX has led the production and release of many wide field visible of near infrared surveys : CFHTLS, CFHTLenS, ESO/UltraVISTA, ESO/VVDS, ESO/VIPERS, Subaru/COSMOS, CFHT/NGVS, CFHT/WIRCam), and is responsible for the software development and the data processing of the visible wide field instrument VIS of the Euclid mission. IAP has therefore a very long and solid experience in software and pipeline developement and in data management in image processing and wide field cosmological surveys. IAP hosts the PI (Euclid Consortium Lead) and its support office of the Euclid space mission on dark energy which is a priority of the institute for the decade to come. About 35 IAP scientists and engineers are presently involved in Euclid.

CNRS IAP Staff

Yannick Mellier (m) is a senior staff astronomer at IAP. He is the director of the TERAPIX data center and the scientific lead of the Euclid Consortium (1250 persons). He was the PI of the Canada-France-Hawaii Legacy Survey (CFHTLS) and is currently leading Euclid team at IAP and the national Euclid-France organization. Mellier is a specialist of observational cosmology and gravitational lensing and worked in a variety of related-topic like strong and weak lensing modeling of galaxy and cluster of galaxies, cosmic shear analysis, galaxy clustering and large scale structure of the universe, cosmological surveys, dark matter and dark energy, image processing, intensive data processing, large scale data management. He was one of the discoverer of the gravitational arcs and led the team who first mesured cosmological weak lensing. Mellier has published more than 200 refereed papers. He also served in many advisory bodies at ESA and ESO and is currently member of the Science Definition Team of the NASA WFIRST mission.

CNRS IAP Publications, Products and Services

1. Fu L., et al. (2014). *CFHTLenS: cosmological constraints from a combination of cosmic shear two-point and three-point correlations*. MNRAS 441, 2725

2. Laureijs R., Hoar J., Buenadicha G., Mellier Y., Pasian F., Dabin C., Sauvage M. and the Euclid Collaboration (2014). *The Euclid Mission: Cosmology Data Processing and Much More*. ASPC 485, 495

3. Amendola et al. (2013). *Cosmology and Fundamental Physics with the Euclid Satellite*. LRR 16, 6

4. Cropper M., Hoekstra H., Kitching T., Massey R., Amiaux J., Miller L., Mellier Y. et al.(2013). *Defining a weak lensing experiment in space*. MNRAS 431, 3103

5. McCracken H.J. et al. (2013). *UltraVISTA : A VISTA Public Survey of the Distant Universe*. Msngr 154, 29

CNRS IAP Projects

IAP represents Euclid: the ESA M-Class space mission of the *Cosmic Vision* program. Euclid aims at understanding why the expansion of the Universe is accelerating and the very nature of dark energy and gravity. Euclid will explore the imprint of dark energy on the expansion rate and the growth rate of cosmic structure in the Universe. The satellite will observe 12 billions galaxies over 15,000 square-degree of the sky and will measure the shape and photometric redshift of 2 billion galaxies and the spectroscopic redshifts of 30 millions of them. Together with the ground-based visible data, the survey comprises about 100 Pbytes of data that will be processed and analysed by the Euclid Consortium (http://www.euclid-ec.org). The Euclid Consortium is composed of 1250 scientists and engineers spread over 15 European countries and in the US, in more than 120 laboratories.

TERAPIX : is a French national data center created in 1998. Its servicing mission consists in developing and running image processing software and pipeline optimized for panoramic cameras and wide field imaging visible and near infrared surveys. TERAPIX is in operation since 1998. More than 100 individual-PI or Consortium-survey projects have been processed and released by TERAPIX, mostly from the CFHT MegaCam and WIRCam and the ESO/VISTA/VIRCAM wide field cameras. The TERAPIX data center is hosted by IAP but is an independent cluster, separated of the IAP computing facilities. It comprises a cluster of 30 nodes, 1 Pbytes of disk space which works 24h/day.

PLANCK: The Institut d'Astrophysique de Paris is a key player in ESA Planck Mission. The Planck team at IAP consists of about 20 scientists and engineers. Francois Bouchet, co-PI of one of HFI instrument, leads the Planck group at IAP. The group is both involved in the scientific exploitation of the cosmic microwave background (CMB), and on the low level data processing of the HFI data.

IAP scientists had key contributions on the foreground cleaning of the microwave sky, the estimation of the CMB power spectra and their statistical properties, the full sky measurement of the gravitational lensing effect induced by the large scale structures on the temperature anisotropies of the CMB, and on the measurement of the primordial non-gaussian features in the CMB.

IAP is leading the processing of the HFI data from the raw time ordered data to the microwave sky maps. Francois Bouchet is the DPC manager of the HFI consortium in charge of organising the work of the labs involved in the HFI processing pipeline, of operating the pipeline and of producting the data releases. The management, production and distribution of those releases are performed by IAP. IAP had also a key role in the end-to-end HFI simulations, the pointing reconstruction, the glitch detection and removal, the noise level estimation, the correction for different systematics, the beam determination and beam error estimate and propagation on the science products.

The main computer cluster used for the development and the operation of the data processing and simulation pipelines is hosted at IAP. IAP engineers have built all of the infrastructure code and database needed for the data and data flow management and logging. This infrastructure has been used by all the labs involved in the HFI data processing, and it has been deployed on IAP and on three other massive clusters in France, UK and the US.

CNRS IAP main tasks in project

Profile: IAP represents EUCLID.
Participation: Tasks 3.4

4.1.2.e CNRS LUTH (Laboratoire Univers et Theories)

LUTH (Laboratoire Univers et Theories) is a department of the Paris Observatory, and a joint research unit (UMR 8102) in partnership with the CNRS and the Paris-Diderot University (Paris-Diderot University has no person/months and will not claim any costs in the ASTERICS project). With more than 60 researchers its principal activity is analytical or numerical simulation of astronomical systems in an interdisciplinary framework. LUTH is composed of 4 groups working mainly on cosmology, gravitation, high-energy astrophysics and laboratory physics. LUTH is also involved in the definition of standards and formats for the International Virtual Observatory Alliance for theory (VO-theory) and for the characterization of Cherenkov data. LUTH is strongly involved in high energy Cherenkov astrophysics, through its direct participation to the High Energy Stereoscopic System (H.E.S.S.) experiment and strong involvement in CTA, the next generation of Cherenkov array (science definition, data management, simulations, telescope development). LUTH is involved in porting CTA complex data to the Virtual Observatory.

Observatoire de Paris

The **Observatoire de Paris** will appear as CNRS third party through their Joint Research Unit UMR 8102 Laboratoire de l'Univers et de ses Théories (LUTH), which represents CTA in WP4.

Observatoire de Paris (http://www.obspm.fr) is the largest astronomy center in France and one of the most important in the world. It represents itself one third of astronomy in France. It depends on the Ministry of Higher Education and Research as it has the status of an independent University. It covers about all the fields of Astronomy/Astrophysics, up to Physics and Mathematics, and also

History of Sciences. It gathers about a thousand people.

Observatoire de Paris hosts six departments (GEPI, LESIA, LERMA, LUTH, SYRTE, LERMA), one scientific Unit (Nançay Radio Astronomy Station) and one Institute (IMCCE), which provides and publishes ephemerides of solar system bodies. All of these entities are Joint Research Units with CNRS and some are associated with other Paris Universities. They are spread over three locations : Paris, Meudon and Nançay (Research Center in Radioastronomy).
Observatoire de Paris benefits from important technical and administrative services, such as the most important astronomy Library in France and a very performant computing Department. Moreover, Paris Observatory develops training activities (pre and post doc level) with the UFE "Teaching and Training Unit" and it is responsible for the "Ecole Doctorale Astronomie et Astrophysique d'Ile de France".

Observatoire de Paris also has a Contracts Department (SRCV), with a European Projects Office. It participated to 37 FP7 european projects, such as FP7-SPACE Collaborative projects, FP7-ERC grants management, FP7-Marie Curie Actions, FP7-Infrastrucutres or FP7-JRPs (EURAMET grants). Observatoire de Paris was coordinator of 12 of these projects.

Observatoire de Paris through VO-Paris Data Centre (VOPDC) develops activities for disseminating and accessing astronomical and physical data in the Virtual Observatory context since more than ten years. In this frame several engineers and researchers have contribution to the activities of the International Virtual Observatory Alliance (IVOA) and the International Planetary Data Alliance (IPDA). Several leading activities of VOPDC are performed at the international level , in particular in the domain of atomic and molecular physics, simulation and modeling in astrophysics, heliophysics and planetology. VOPDC is, or has been, a coordinator or a participant to several European projects. VOPDC is located at Paris Observatory and has been implemented there as a federative activity. All the Paris Observatory scientific departments (LUTH, LERMA, LESIA, GEPI, SYRTE, IMCCE, USN) and the computing department (DIO) give a contribution to VOPDC. The centre, as a regional centre officially recognized by CNRS/INSU as an expertise centre, is also open to partnership with other laboratories from Ile-de-France region. Thus, VOPDC contibutes to the Paris Observatory system for high level services for data access and dissemination in astronomy.

CNRS LUTH Staff

Catherine Boisson (f) is the head of the high energy physics group of LUTH. She has a large experience in observation and modelling of galactic and extragalactic sources across the electromagnetic spectrum from radio to TeV energies. Her research interest is now mainly centered on the understanding of the structure and the fundamental source of energy of active nuclei of galaxies. Her more recent work consists in the leptonic and hadronic modelling of AGN detected in the TeV range. She is an active member of the H.E.S.S and CTA collaborations since the beginning. She is currently coordinating the definition of standards and formats for the next generation of Cherenkov array, CTA, with the current Cherenkov experiments (H.E.S.S., MAGIC and VERITAS) as test benches, to ensure compatibility with the Virtual Observatory tools. She is also coordinating the CTA Science User Group.

CNRS LUTH Publications, Products and Services

1. The H.E.S.S. High level Data base is currently being integrated in the VO Paris Data Center, see http://vo-web.obspm.fr/database.php

2. Boisson C., Data from the Cherenkov Telescope Array, in section “Input from Data Provider” - COSADIE Forum (2013) http://g-vo.org/cosadie-dcforum/program.php

3. Le Petit F., Boisson C. et al.(2012). VO-Paris Data Centre (VO-PDC), ASPC 461, 399

4. Cerruti M., Boisson C., Zech A. (2013). Constraining the parameter space of the one-zone synchrotron-self-Compton model for GeV-TeV detected BL Lacertae objects, A&A 588, 47

5. Acharya B.S. et al. (2013). Introducing the CTA concept, APh 43, 3

CNRS LUTH Projects

Co-I of the H.E.S.S. international collaboration (2000-) – data analysis, AGN modelling, AGN high level data base –.
H.E.S.S. is one of the leading observatories studying *very high energy* (VHE) gamma-ray astrophysics. H.E.S.S. is made of five telescopes located in Namibia and operated by the collaboration of more than 170 scientists, from 32 scientific institutions and 12 different countries. To date, the H.E.S.S. Collaboration has published over 100 articles in high-impact scientific journals, including the top-ranked ‘Nature’ and ‘Science’ journals.
H.E.S.S. was awarded in 2006 the Descartes Prize of the European Commission - the highest recognition for collaborative research - and in 2010 the prestigious Rossi Prize of the American Astronomical Society. In a survey in 2006, H.E.S.S. was ranked the 10th most influential observatory worldwide, joining the ranks with the Hubble Space Telescope or the telescopes of the European Southern Observatory ESO in Chile.

LUTH is Member of the Cherenkov Telescope Array consortium (2008-) : Design study phase and now Preparatory Phase –chair of the Science User Group, responsible for the data exposure to the Virtual Observatory – partially funded by FP7 INFRA-2010-2.2.10 / 262053.

CNRS LUTH main tasks in project

Profile: CNRS LUTH represents CTA and HESS.
Main tasks: Participation in Tasks 4.1, 4.2, 4.3

4.1.2.f CNRS APC (AstroParticule et Cosmologie)

APC (AstroParticule et Cosmologie, UMR 7164) laboratory is one of the largest research units on the campus of University of Paris Diderot. APC hosts 75 permanent researchers, and over 60 engineers, technicians and administrative staff. APC is organized in three research groups working on cosmology and gravitation, high-energy astrophysics and neutrinos and two transversal groups working on theoretical physics and data science & computational astrophysics (DaSCA). APC brings together experts from various areas of astroparticle physics and hence provides an environment that naturally fosters the development of multi-messenger astronomy.
Gravitational wave (GW) physics is one of the major research topics of APC, thanks to its involvement in both the ground-based Virgo experiment (and its successors, such as the Einstein Telescope) and the space-based mission eLISA.

CNRS APC Staff

Eric Chassande-Mottin (m) has been recently appointed head of the DaSCA group. He is an active member of the Virgo Collaboration since 2000. Currently, he is the co-chair of the GW burst search group which is one of the four science groups of the LIGO Virgo joint collaboration. He was co-lead of the committee in charge of establishing collaboration agreements between the LIGO and Virgo experiments and the astronomy community for the follow-up of GW alerts in association with the future science runs.

CNRS APC Publications, Products and Services

1. Ando S. et al. (2013). *Multimessenger astronomy with gravitational waves and high-energy neutrinos*. Rev. Mod. Phys., Vol. 85, n 4pp. 1401-1420.

2. Adrian-Martinez S. et al. (2013). *A First Search for coincident Gravitational Waves and High Energy Neutrinos using LIGO, Virgo and ANTARES data from 2007*. JCAP, Vol. 06, p. 008.

3. Chassande-Mottin E. (2012). *Data analysis challenges in transient gravitational wave astronomy*. In: AIP Conf. Proceedings: Acoustic and Radio EeV Neutrino Detection Activities. ARENA'12, p. 252. Erlangen (Germany), ArXiv:1210.7173.

4. Abadie J., et al. (2012). *Implementation and testing of the first prompt search for electromagnetic counterparts to gravitational wave transients*. Astronomy & Astrophysics, Vol. 539, p. A124.

5. Chassande-Mottin E., Hendry M., Sutton P., Marka S. (2011). *Multimessenger astronomy with the Einstein Telescope*. General Relativity and Gravitation, Vol. 43, pp. 437-464.

CNRS APC Projects

APC represents Virgo/EGO. Joint searches of gravitational waves and high-energy neutrinos (combining observations from LIGO/Virgo and ANTARES taken during 2007-2010). First electromagnetic follow-up program of GW events observed by LIGO/Virgo during 2009-2010 (contribution to the generation/transmission of alerts, collaboration with a network of robotic telescopes, analysis of astronomical follow-up images). Co-responsability for the future GW-EM program for advanced LIGO and Virgo.

CNRS APC main tasks in project

Profile: CNRS APC represents EGO and LIGO
Main tasks: Participation in Tasks 4.1, 4.2, 4.3, 5.2

4.1.2.g CNRS LAPP (Laboratoire d'Annecy-le-Vieux de Physique des Particules)

LAPP (Laboratoire d'Annecy-le-Vieux de Physique des Particules) is a combined CNRS and Université de Savoie unit (Université de Savoie has no person/months and will not claim any costs in the ASTERICS project). Close to 150 people are working at LAPP: researchers, professors, engineers and support staff, students and visiting scientists. The laboratory is very actively involved in several large international collaborations working on accelerators (ATLAS and LHCb on the LHC at CERN, BaBar at SLAC in California, OPERA in Gran Sasso) and astroparticle experiments (Virgo, AMS, H.E.S.S. and CTA). Involved in many R&D and construction programs for large research infrastructures, the laboratory's skills cover a large scope of domains involving innovative technologies in micro-electronics, complex mechanical structure design and optimization, grid computing and scientific software developments. The location of LAPP, 50km from CERN, and the presence of the theory laboratory LAPTh in the same premises, makes the LAPP campus a very attractive research place for scientists contributing to particle and astroparticle physics. LAPP hosts the MUST -mid-range data storage and computing center - widely open to Grid infrastructure supporting research and academic projects.

CNRS LAPP Staff

Giovanni Lamanna (m) is a physicist, Director of Research, CNRS. He is author/co-author of more than 200 scientific publications, proceeding of conferences, technical reports. He leads the high energy Gamma-ray Astrophysics research team at the LAPP participating to the H.E.S.S. and CTA collaborations. Some of his areas of research are fundamental and applied physics, experimental research instrumentation and data processing. He coordinates the Data Management project of the CTA international consortium. He has been cooperating during the last years with APPEC (the Astroparticle Physics European Consortium) on issues concerning optimal and efficient large-scale data analysis and management in Astroparticle. In 2013 Giovanni Lamanna became computing, e-science and e-infrastructure policy manager at IN2P3 institute; IN2P3 through its reference large computing centre (CC-IN2P3) and some other national distributed centers, provides e-infrastructures and

know-how in data archive and processing to international research collaboration and scientists worldwide.

CNRS LAPP Publications, Products and Services

1. Aguilar M. et al. *(*2002). *The Alpha Magnetic Spectrometer (AMS) on the International Space Station. I: Results from the test flight on the space shuttle*. AMS Collaboration*,* Phys.Rept. 366: pp 331-405

2. Dubois F., Lamanna G., Jacholkowska A. (2009). *A multivariate analysis approach for the imaging atmospheric Cherenkov telescopes system H.E.S.S.*. Astroparticle Physics, Vol. 32, Issue 2, ISSN 0927-6505

3. H.E.S.S. collaboration, ASTRON (2012). *Probing the extent of the non-thermal emission from the Vela X region at TeV energies with H.E.S.S.*. Astrophys. 548 A38

4. Di Mauro M., Donato F., Lamanna G., Sanchez D.A, and Serpico P.D. (2014). *Diffuse γ-Ray Emission from Unresolved BL Lac Objects*. apj 786, 129

5. The CTA consortium (2011). *Design concepts for the Cherenkov Telescope Array CTA.* Experimental Astronomy 32: pp 193-316

CNRS LAPP Projects

Co-I of the H.E.S.S. international collaboration (2005-) – data analysis, dark matter search, galactic sources and cosmic-ray astrophysics. G. Lamanna with his team participated to the construction of the camera of the 5th Cherenkov telescope of the H.E.S.S. experiment.

LAPP represents CTA. Giovanni Lamanna has been since 2009 the coordinator of the Data Management project within the CTA-FP7-Preparatory Phase and for the CTA international consortium. He is the coordinator of the international EGI «CTACG – *CTA Computing Grid »* project, federating about twenty centers in about ten countries, aiming at the application of Grid distributed computing resources for managing and analysing Monte Carlo simulated data for the CTA consortium. G. Lamanna is committed in the construction of the Large Size Telescopes of CTA.

Co-author of the multi-wavelength astro-particle research work program proposed within the project « ENIGMASS » in response of the French government call LABEX «*Laboratoire d'Excellence – Investissements d'avenir*»,..

G. Lamanna coordinates the EU-T0 consortium aiming at establishing a European Tier 0 data-management and computing center in support of research infrastructures and research communities from multiple disciplines.

CNRS LAPP main tasks in project

Profile: CNRS LAPP represents CTA and HESS
Main tasks:

- Lead of: WP3, Tasks 3.1, 3.3
- Participation: Tasks 3.2, 3.4

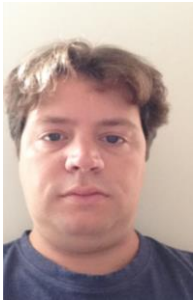
4.1.2.h CNRS CPPM (Center for Particle Physics of Marseille*)*

CPPM (Center for Particle Physics of Marseille) is a mixed research laboratory (UMR6550) supported by the CNRS/IN2P3 and the University of Aix-Marseille (University of Aix-Marseille has no person/months and will not claim any costs in the ASTERICS project). The principal activity of the laboratory is fundamental research in *particle physics*, *astroparticles physics* and in *observational cosmology.* The CPPM is the host laboratory for the ANTARES neutrino telescope and is also responsible for one of the sites of the KM3NeT neutrino telescope.

CNRS CPPM Staff

Paschal Coyle (m) is a Director of Research, CNRS, at the CPPM. He has worked on particle physics experiments at the SLAC (SLD) and CERN (WA69, ALEPH) accelerators. Since 2000 he has been involved in the ANTARES deep-sea neutrino telescope and during 2008-2014 was the SpokesPerson of the Collaboration. Coyle represented the IN2P3 during the Design Study and Preparatory Phases of the KM3NeT project and was a key contributor in proposing and managing these projects. He is currently the Deputy SpokesPerson of the KM3NeT Collaboration. He has published over 350 papers related to particle physics and neutrino astronomy.

Jurgen Brunner (m) is a CNRS research engineer at the CPPM. He has worked on the Protvino neutrino experiment and was responsible for the online software of the CHORUS neutrinos oscillations experiment at CERN. He has also worked on the IceCube neutrino telescope. Brunner has been the offline software coordinator of the ANTARES telescope and has been responsible for its data processing at the IN2P3 data center for many years. He is currently the Technical Coordinator of the ANTARES telescope. He has published over 100 papers related to neutrino physics.



Damien Dornic (m) is a Charge de research, CNRS, at the CPPM. He has worked on the Pierre Auger experiment studying high-energy cosmic rays and on the ANTARES/KM3NeT telescopes studying high-energy neutrinos. Dornic is the coordinator of the multi-messenger astronomy group of the ANTARES Collaboration. He initiated the target of opportunity system of ANTARES based on sending real-time neutrino alerts to a network of rapid robotic optical telescopes. Dornic is also the coordinator of the astroparticle section of the LabEX for the South of France Universities (OCEVU).

CNRS CPPM Publications, Products and Services

1. Brunner J., Coyle P., Dornic D., et al. (2011). *ANTARES: the first undersea neutrino telescope*. Nucl.Instrum.Meth. A656 pp.11-38, 10.1016/j.nima.2011.06.103

2. Brunner J., Coyle P., Dornic D., et al. (2014). *Searches for Point-like and extended neutrino sources close to the Galactic Centre using the ANTARES neutrino Telescope*. Astrophys.J. Vol. 786, L5, DOI: 10.1088/2041-8205/786/1/L5

3. Brunner J., Coyle P., Dornic D., et al. (2012). *The ANTARES Telescope Neutrino Alert System*, Astropart.Phys. Vol. 35, pp 530-536, DOI: 10.1016/j.astropartphys.2011.11.011

4. Brunner J., Coyle P., Dornic D., et al. (2010). *KM3NeT: The technical design report for a deep-sea research infrastructure in the Mediterranean Sea Incorporating a very large volume neutrino telescope*. KM3NeT website

5. Brunner J., Coyle P., Dornic D., et al. (2013). *Detection Potential of the KM3NeT Detector for High-Energy Neutrinos from the Fermi Bubbles.* Astropart. Phys. Vol. 42, pp 7-14 DOI: 10.1016/j.astropartphys.2012.11.010

CNRS CPPM Projects

CPPM represents KM3NET via the pathfinder ANTARES (http://antares.in2p3.fr). This is a deep-sea neutrino telescope located at a depth of 2500 m and 42 km off the coast of the South of France. It comprises a three dimensional array of 900 phototubes which detect the Cherenkov light induced by the interaction of high energy neutrinos (>10 GeV) in the vicinity of the instrumented volume (450m*250m*250m). ANTARES has pioneered the deep-sea technique for neutrino astronomy and is a pathfinder for KM3NeT. The CPPM initiated the ANTARES project and is the host laboratory for the telescope.

CNRS CPPM main tasks in project

Profile: CNRS CPPM represents KM3NET and ANTARES
Main tasks: Participation: Tasks 3.2, 3.4, 4.1, 4.2, 4.3

4.1.3 Istituto Nazionale di Astrofisica (INAF)

INAF is a governmental research organization with 19 research centers geographically distributed over the national territory, plus the “Galileo” observing facility located in La Palma, Canary Islands. INAF promotes, realizes and coordinates, also within programs of the European Union and international organisms, research activities in many astronomical fields, such as optical/infrared astronomy, radio astronomy, X and γ ray astronomy, particle astrophysics and cosmic physics, both in collaboration with Universities and with other public and private, national and international agencies. INAF is a major partner of the astrophysics related ESFRI projects (CTA, SKA and E-ELT), having actively participated in their definition since the initial phases; it has furthermore important participations in several other world class projects, both ground-based (e.g. ALMA, LBT, MAGIC) and space-borne (e.g. Planck, Gaia, Euclid). INAF is also active in the field of infrastructures for research, and in particular distributed computing technologies (deployment of infrastructure and integration of domain specific applications, leadership of the A&A Heavy Users Community in the FP7 EGI-Inspire project), distributed archives of astronomical data (both from ground-based and space-borne facilities) and the astronomical Virtual Observatory (Euro-VO and IVOA). Participation in the ESFRI projects allows INAF to focus on their real needs in terms of infrastructure, and the experience from previous and current projects increases the feasibility of the planned facilities.

INAF Staff

Fabio Pasian (m) is a senior INAF Full Astronomer, author/co-author of over 500 papers and technical reports. Senior Archive Scientist for the Hubble Space Telescope at ST-ECF/ESO (1989-1992), leader of the archiving system for the TNG Italian national telescope (1992-1998), Data Processing Manager for the LFI instrument of the ESA Planck mission (1997-2005), director of the INAF Information Systems Unit (2004-2011). He has done consultant activities for ESA and ESO in the field of information systems and data processing and archiving. Since 2009 he is the Manager of the Scientific Ground Segment of the Consortium for the ESA Euclid mission. Member of the Organising Committee of Commission no. 5 (Documentation and Astronomical Data) of the International Astronomical Union, he leads the Italian Virtual Observatory initiative VObs.it and is a member of the International Virtual Observatory Alliance Executive Committee, which he has chaired between November 2008 and May 2010. In ASTERICS he is the main contact point for INAF, coordinates INAF participation in WP4, and is involved in WP3 activities.

Lucio Angelo Antonelli (m) is a senior INAF Research Astronomer, author/co-author of about 450 papers, proceeding of conferences, circulars and technical reports; project Scientist of the ASI Science Data Center (2005-present), INAF representative in the MAGIC collaboration (2012-present), member of the Executive Board of the MAGIC collaboration (2014). He joined the CTA Project and in particular the Data Management activity since 2006. Since 2009 he is responsible for the CTA Archive Work Package. Since 2009 he is also responsible for the Data Handling and Archiving of ASTRI, the INAF Flagship Project for the realization of an end-to-end prototype of the CTA Small Size Telescope and a mini-array of SSTs. In ASTERICS he coordinates the INAF participation in WP3.

Massimo Ramella (m) is a senior Associate Astronomer at the INAF Astronomical Observatory of Trieste. His scientific interests are observational extragalactic astronomy, identification and properties of groups and clusters of galaxies, measures of the Large Scale Structure of the universe, and e-Science. He was visiting scientist at the Harvard-Smithsonian Center for Astrophysics between 1981 and 1993, and at ESO in 1998. He is author of over 150 papers reported in the ADS, with over 2600 citations (excluding self-citations). He has led the outreach and education packages in the EU/FP7 projects EuroVO-AIDA, EuroVO-ICE and CoSADIE, and since 2012 he is the Chair of the International Virtual Observatory Alliance (IVOA) Interest Group on Education. In ASTERICS he coordinates the INAF participation in WP2.

INAF Publications, Products and Services

1. Pasian F., Brescia M., Longo G. (2012). *Astronomical Images and Data Mining in the International Virtual Observatory Context*. Science - Image in Action. Zavidovique B. & Lo Bosco G. eds., World Scientific Publishing, pp 230-240

2. Pasian F., Hoar J., Sauvage M., Dabin C., Poncet M., Mansutti O. (2012). *Science ground segment for the ESA Euclid Mission*. Software and Cyberinfrastructure for Astronomy II. Proceedings of the SPIE, Vol. 8451, 12 pp

3. Ramella M., Iafrate G., De Marco M.. Molinaro M., Knapic C., Smareglia R., Cepparo F. (2014). *VO for Education: Archive Prototype. Astronomical Data Analysis Software and Systems XXIII.* N. Manset & P. Forshay eds. Astronomical Society of the Pacific, pp. 317-320

4. Antonelli L. A., Lombardi S., Lucarelli F. et al. (2014). *ASTRI SST-2M Data Handling and Archiving System*, SPIE Conf. Series, in press

5. Bulgarelli A., Fioretti V., Contreras J.L., Antonelli L.A., Lamanna G. et al. (2014). *The Real-Time Analysis of the Cherenkov Telescope Array Observatory*. SPIE Conf. Series, in press

INAF Projects

Cherenkov Telescope Array: INAF has started the participation in the CTA project since the very beginning in 2006. The INAF contribution to this project spans on a wide number of activities from the realization of a prototype of the small size telescope to the participation to the data analysis and archiving chain. As a path-finder for CTA, the ASTRI Project is in charge of the implementation of an end-to-end prototype of a Small Size Telescope (SST) for the CTA in a dual-mirror configuration (SST-2M) and, subsequently, of a mini-array comprising seven SST-2M telescopes.

Euclid: INAF has a relevant participation in Euclid, the space mission of the ESA Cosmic Vision program aiming at understanding the nature of dark energy and gravity. Within the Euclid Consortium, INAF staff is in charge of coordinating several Science Working Groups, and has responsibilities in the development of the two instruments; it is furthermore responsible for several data processing steps of the Euclid pipeline, and for the overall coordination of the Science Ground Segment.

Virtual Observatory (VObs) initiatives: INAF participates in initiatives aimed at giving access to the open, highly diverse, highly distributed data holdings of astronomy as a founding member of the world-wide International Virtual Observatory Alliance (IVOA) and of the European Virtual Observatory initiative (Euro-VO). INAF has played an active role in a number of related projects funded by the EU Framework Programmes: VO-TECH, EuroVO-DCA, EuroVO-AIDA, EuroVO-ICE and CoSADIE. INAF staff has also specific responsibilities within IVOA: Massimo Ramella chairs the Interest Group on Education, Marco Molinaro is the Vice-Chair of the Data Access Layer Working Group and Giulia Iafrate is about to become the IVOA Documentation Coordinator.

Grid and Distributed Computing projects: INAF has played an active role in a number of projects dedicated to distributed computing infrastructures, both in Italy (Grid.it, DRACO) and at European level (all funded by EU/FP7): EGEE-II (unfunded partner), EGEE-III, EGI-Inspire. In particular, EGI-Inspire is a collaborative effort involving more than 50 institutions in over 40 countries to establish a sustainable European Grid Infrastructure (EGI) and to join together the new Distributed Computing Infrastructures (DCIs) such as clouds, supercomputing networks and desktop grids, for the benefit of user communities within the European Research Area. INAF represents and supports the astronomical community, providing some operational Grid nodes as well.

ER-flow is a project funded by FP7 and aims at building a European Research Community to promote workflow sharing and to investigate interoperability of the scientific data in workflow sharing. The project disseminates the coarse-grained workflow interoperability based on the SHIWA Simulation Platform. It targets major research communities that use workflows to run their experiments on a regular basis. In the project INAF is a major developer and represents and provides support to the astronomical community.

INAF main tasks in project

Profile: INAF represents CTA, EUCLID, Virtual Observatory and SKA
Main tasks:

- LEAD: Tasks 2.4, 3.2, 3.4, 4.1
- Participation: Tasks 3.3, 4.2, 4.3

4.1.4 University of Cambridge (UCAM)

The University of Cambridge hosts one of the most important centers of physics research in Europe, especially in the field of astronomy. Astronomy research is carried out in the Battcock Centre for Astrophysics in the Cavendish Laboratory (Department of Physics), in the Institute of Astronomy and theoretical research in astronomy is also done at the Department of Applied Mathematics and Theoretical Physics. There is also a cross-departmental venture, the Kavli Institute for Cosmology in Cambridge, in which all three groups participate and which provides an environment for close collaboration between the three groups in areas of common interest. The Astrophysics Group at the Battcock Centre has about 40 research staff, 25 research students and 10 support staff. The Institute of Astronomy has about 60 research staff, 50 research students and 30 support staff. Cambridge has a wide ranging astrophysical research programme and a long-established excellence in radio astronomy.
The University of Cambridge also has a High Performance Computing Service which is an internationally leading university-based HPC group. It specializes in development and deployment of commodity based HPC solutions with excellent power/performance characteristics, e.g. the recently deployed Wilkes cluster. Cambridge has strong interactions with a large number of computing industry partners, including NVidia (Cambridge is a CUDA center of Excellence) DELL and Intel.

UCAM Staff

Paul Alexander is Professor of Radio Astronomy, the head of Astrophysics and Director of the Battcock Centre for Experimental Astrophysics in the Cavendish Laboratory. He has over 150 publications and currently holds grants directly supporting 17 postdoctoral staff. He is the lead of the SKA Science Data Processor consortium. He has a long record of contribution to the SKA and in addition to his role in the SKA SDP work he is also the UK SKA Science Director of the SKA Organization. His astrophysical research is in the areas of galaxy evolution, design of radio interferometers and the analysis of interferometric observations.

Bojan Nikolic is a Senior Research Associate at the University of Cambridge in the Astrophysics Group. He is the Project Engineer and Architect of the SKA Science Data Processor element. In this role he has the responsibility for technical aspects of the work of the consortium (an international team of about 50 people). Previous to that, Bojan Nikolic worked on atmospheric phase correction for ALMA (the largest current ground-based astronomy project) during which he designed, implemented and delivered the software currently used for phase correction of all ALMA data. He was also involved in aspects of hardware production, and in overall commissioning efforts of the observatory. Previously to that he was a Research Associate at the National Radio Astronomy Observatory and a Senior Software Engineer and Quantitative Analyst at Deutsche Bank in London. Bojan's software for processing of astronomical data (in particular the wvrgcal ALMA calibration package and the OOF data analysis package) is in regular use at radio-astronomy institutes around the world.

Gerry Gilmore FRS is Professor of Experimental Philosophy in the Institute of Astronomy, UK PI for Gaia, supporting some 30 FTE staff in Cambridge and across the UK, holds an ERC Advanced Grant, is PI of the EC FP7 Opticon I3 coordination activity in optical-infrared astronomy, and is Co-PI of the 400-member Gaia-ESO Survey, ESO's largest VLT Public Spectroscopic Survey. His scientific interests are in galaxy formation, galactic chemical evolution, and dark matter, as studied in the nearby universe. He has over 650 scientific publications with over 25000 citations.

Richard McMahon is Professor of Astronomy in the Institute of Astronomy and has over 25 years of experience in design and data management of wide field astronomical surveys from the radio to the X-rays. He is PI of the VISTA Hemisphere Survey, the largest public survey with the VISTA telescope (allocated 60 nights per year over 7 years starting in 2010). He is also a leading member of the 525 night Dark Energy Survey which is a 5 year project survey which started in 2013. He has over 500 scientific publications with over 25000 citations. His scientific interests are in galaxy formation and supermassive black hole formation and evolution, as studied at the highest redshifts feasible.

Nicholas Walton is a research fellow at the Institute of Astronomy. He is a member of the ESA Gaia Science Team, coordinator of the ESF GREAT Research Network Programme and EC FP7 GREAT Initial Training Network. He leads the development of the Exoplanet Analysis System for the ESA PLATO mission. He is Technical coordinator of the EC FP7 Virtual Atomic and Molecular Data Centre. He has been actively involved in the development of the Virtual Observatory both as Euro-VO Technology Centre Project Scientist and secretary of the International Virtual Observatory Alliance. His research focuses on the studies of both the nearby universe, and supernovae as cosmological probes.

UCAM Publications

1. Gilmore G. et al (2012). *The Gaia-ESO Public Spectroscopic Survey*, ESO Messenger.

2. Kordopatis G., Gilmore G. et al (2013). *The Radial Velocity Experiment (RAVE): Fourth Data Release.* AJ

3. Nikolic B. et al. (2014). *SKA Science Data Processing*. Presentation at AASTCS 2: Exascale Radio Astronomy Conference, Monterey, CA, USA

4. Alexander, Bregman and Faulkner (2010). *SKA Data Flow and Processing*. Wide-Field Astronomy and Technology for the SKA. http://www.skads-eu.org/PDF/limelette2_v1.1.pdf, p 119

5. Venemans B.P. et al. (2013) *Discovery of Three z > 6.5 Quasars in the VISTA Kilo-Degree Infrared Galaxy (VIKING) Survey*. ApJ

UCAM Projects

UCAM is active with projects related to almost any major astronomy instrument today and actively involved in the HPC and Big Data aspects of these instruments. Some examples:

University of Cambridge is leading the consortium for the design of the SKA Science Data Processor (SDP): the SDP-Consortium will deliver the design of the software and computing element of the SKA.
Cambridge has had a strong track record in delivery to the SKA project including leading the first costed system design as part of SKADS, development of the "Design and Costing tool", significant contributions to the site selection process, the SKALA antenna design and co-leadership of the Software and Computing CoDR and is also a major contributor to the design of the SKA low-frequency aperture array (work led by ASTRON).

Cambridge has a strong track record in astronomical software: the delivery of end-to-end software for all telescopes at our observatory; it hosts the level-3 Planck data analysis center as well as the Cambridge Astronomical Survey unit which is currently developing pipelines for VISTA and other wide area sky-survey projects.

Cambridge hosts the (DPCI) photometric processing center for the ESA Gaia Cornerstone mission, processing all data from Gaia's camera, the largest flown in space. DPCI also has sole responsibility for real-time discoveries from Gaia photometry, to be published through http://gaia.ac.uk. In addition, dynamical modelling of the Petabyte-scale Gaia data are a core specification and test data set for next-generation HPC developments in the UK, to be hosted in Cambridge.

Cambridge has had a leading role in the development of the Astrophysical Virtual Observatory, hosting the UK project scientist.
Development of calibration and analysis tools for ALMA observatory in Chile.
There is a substantial and strong research programme in the development of Bayesian data analysis techniques applied to astronomy and cosmology.

EU FP7 RadioNET/HILADO project (better user interfaces for astronomical data reduction packages)

UCAM main tasks in project

Profile: UCAM represents SKA
Main tasks:

- LEAD: Tasks 3.4
- Participation: Tasks 3.2, 3.3

4.1.5 Joint Institute for VLBI in Europe (JIVE)

The Joint Institute for VLBI in Europe (JIVE) is the central node of the European VLBI Network (EVN, http://www.evlbi.org/), a distributed array of radio telescopes, in and outside of Europe, offering astronomers the highest resolution view of radio sources. Besides user and telescope services, JIVE excels in research and development to innovate VLBI and related radio astronomy techniques. With the help of the EC through the EXPReS and NEXPReS projects, the institute pioneered e-VLBI by connecting the telescopes with wide-band fibers and enabling real-time results. The VLBI application to observe spacecraft and determine their precise position in the planetary system is also advocated by JIVE. In relation to the development of the SKA, there is considerable overlap between the digital program at JIVE and the requirements of the SKA; JIVE has initiated the development of the UniBoard platform, which is a low-power solution for future beam forming and correlation applications. JIVE is actively involved in a number of SKA work consortia. Additionally, the JIVE scientists are dedicated to innovating observational strategies for radio astronomy and are very active in the SKA definition process, particularly in defining its possible interfaces to VLBI. It is expected that in 2014 JIV-ERIC (a European Research Infrastructure Consortium) will be established as the new legal entity for all these activities.

JIVE Staff

Huib van Langevelde (m) is the director of JIVE and professor in Galactic radio astronomy at Sterrewacht Leiden. He was the coordinator of EXPReS and recently NEXPReS, which scored excellent at its final review of 2013. Within various RadioNet programmes he was the leader of user software initiatives, resulting in the widely used ParselTongue processing interface. His astronomical research focuses on molecular astrophysics, in particular on using stellar masers to measure distances, evolutionary stages and magnetic fields of young stars. He is involved in the ERC-funded BlackHoleCam project to image the black hole at the Galactic Centre. As JIVE director, he is a member of the EVN and RadioNet board, as well as the global and European ALMA advisory committees. He has initiated the transformation of JIVE into an ERIC, aligning the ambitions to foster VLBI among the JIVE partners.

Arpad Szomoru (m) is the head of R&D at JIVE. He has an impressive track record in implementing EC and nationally funded research activities. In the RadioNet context he supervised both the UniBoard and UniBoard^2 projects, overseeing the hardware definition and software production for this processing board. In the EXPReS and NEXPReS projects he was ultimately responsible for almost all technical aspects, starting with retrofitting the legacy correlator for real-time use. His team established all the connections to the remote telescopes and optimized the transport protocols. The software correlator (SFXC), which was developed in this context is currently the workhorse for EVN operations and it offers astronomers unique observing capabilities. He is a member of the GEANT advisory committee and has won a special Internet2 recognition for his work on e-VLBI.

JIVE Publications

1. Szomoru A., Langevelde H.J. van, Verkouter H., Kettenis M., Kramer B., Olnon F., Anderson J., Reynolds C., Paragi Z., Garrett M.A. (2006). *VLBI in transition.* SPIE proceedings 6267, 129

2. Langevelde H.J. van (2013). *The future of VLBI.* Proceedings of RTS2012, ArXiv 1301.1060

3. Szomoru, A. (2009). *e-EVN progress*. Proceedings of the 8th International e-VLBI, Workshop, 22-26, Madrid, Spain, PoS(EXPReS09)023

4. Kettenis M., Keimpema A., Small D., Marchal D. (2009). *e-VLBI with the SFXC correlator*. Proceedings of the 8th International e-VLBI Workshop, PoS (EXPReS09) 45

5. Szomoru A. (2010). *The UniBoard*. Proceedings of the 10th European VLBI Network Symposium and EVN Users Meeting, Manchester, UK, PoS (10th EVN Symposium) 098

JIVE projects

NEXPReS (http://www.nexpres.eu/) was the project to enhance the operational practices and scientific capabilities after EXPReS (http://www.expres-eu.org/) in which e-VLBI was introduced as an operational facility. Both were close collaborations between radio astronomical research institutes and research network providers.

Within the RadioNet collaboration (http://www.radionet-eu.org/) JIVE took on management responsibilities for the overall network programme, the EVN Trans National Access, the UniBoard^2 project, as well as some of the communication programmes with peers, the public and policy makers.

JIVE is also a member of EuroPlaNet (http://www.europlanet-eu.org/) and related initiatives. The technique of measuring the accurate position of spacecraft is planned to be used in current and future space missions.

JIVE main tasks in project

Profile: JIVE represents VLBI and SKA
Main tasks:

- LEAD: WP5, Tasks 5.3
- Participation: Tasks 3.4, 5.1, 5.2

4.1.6 Instituto Nacional de Tecnica Aeroespacial (INTA)

INTA (National Institute for Aerospace Technology) is the Spanish Public Research Organization specialized in aerospace research and technology development. Its main responsibilities are the acquisition, maintenance and continuous improvement of all those technologies that can be applied to the aerospace field; to perform all types of tests to check, approve and certify materials, components equipment items, subsystems and systems that have an aerospace application; to provide technical assessment and services to official bodies and agencies, and also to industrial or technological companies; and to act as a technological center for the Ministry of Defence.

INTA leads the Spanish Virtual Observatory (SVO) project, an initiative funded since 2004 by the Ministry of Economy and Competitiveness to enhance the participation of the Spanish institutes in the VO framework through technical (VO compliance of astronomical archives, implementation of theoretical services) and scientific (VO science cases) developments, provision of added-value services (data mining and VO tools) and organization of meetings to explore ways of collaboration and exploit synergies among teams. INTA hosts at *Centro de Astrobiología* the most important Spanish Astronomical Data Centre which, among others, provides Virtual Observatory compliant access to the Gran Telescopio CANARIAS (GTC) and Calar Alto archives. GTC is the largest optical-infrared telescope in the world whereas Calar Alto is the largest observatory in continental Europe.

INTA Staff

Enrique Solano (m) received his astronomy PhD from Universidad Complutense de Madrid in 1994. In 1995 he took up a position as IUE Resident Astronomer until the end of the project (February 1998). In September 1998 he started to work at INTA for the ESA-INTA INES Transfer Programme at the end of which (June 2000) INTA took full responsibility for the INES Archive. Since January 2002, he has been leading the INTA Astronomical Data Centre. He is the Principal Investigator of the Spanish Virtual Observatory project (funded since 2004) and has been responsible for the Spanish VO initiatives both at regional, national and international level. He is a member of the IVOA Executive Committee and has been the Spanish representative in the Board of the EuroVO-DCA, EuroVO-AIDA and EuroVO-CoSADIE projects. He is also co-author of a significant number of VO-science refereed papers.

INTA Publications, Products and Services

1. Sarro L.M., Bouy H., Berihuete A., Bertin E., Moraux E., Bouvier J., Cuillandre J.-C., Barrado D., Solano E. (2014). *Cluster membership probabilities from proper motions and multi-wavelength photometric catalogues. I. Method and application to the Pleiades cluster*. Astronomy & Astrophysics, Vol. 563, p. 45

2. Suárez J.C., García Hernández A., Moya A., Rodrigo C., Solano E., Garrido R., Rodón J. R. (2014). *Measuring mean densities of δ Scuti stars with asteroseismology. Theoretical properties of large separations using TOUCAN*. Astronomy & Astrophysics, Vol. 563, p 7.

3. 2013A&A...556A.144L López Martí B., Jiménez-Esteban F., Bayo A., Barrado D., Solano E., Bouy H., Rodrigo C. (2013). *Proper motions of young stars in Chamaeleon. II. New*

kinematical candidate members of Chamaeleon I and II. Astronomy & Astrophysics, Vol. 556, p 144

4. Solano E., Gutiérrez R., Alacid J.M., Jiménez-Esteban F., Velasco Trasmonte A. (2012). The Gran Telescopio Canarias and Calar Alto Virtual Observatory compliant archives, SPIE, 8448.

5. Services: The CAB Scientific Data Centre (http://svo.cab.inta-csic.es)

INTA Projects

GENIUS. Gaia European Network for Improved data User Services
European Commission. Seventh Framework Programme. SPACE
Start Date: November 2013
End Date: May 2016

Astronomical Resource Cross-matching for High Energy Studies (ARCHES).
European Commission. Seventh Framework Programme. SPACE.2012.2.1-01
Start Date: January 2013
End Date: July 2015

CoSADIE. Collaborative and Sustainable Astronomical Data Infrastructure for Europe
European Commission. Seventh Framework Programme.
Start Date: September 2012
End Date: February 2015

The Spanish Virtual Observatory
Spanish Ministry of Economy and Competitiveness
Start Date: January 2012
End Date: December 2014

EuroVO Astronomical Infrastructure for Data Access (EuroVO-AIDA).
European Commissión. Seventh Framework Programme. Infra-2007-1.2.1. / 212104
Start Date: February 2008
End Date: July 2010.

INTA main tasks in project

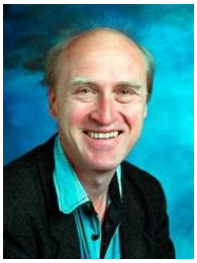
Profile: INTA represents the Virtual Observatory
Main tasks:

- LEAD: Tasks 4.2
- Participation: Tasks 4.1, 4.3

4.1.7 University of Edinburgh (UEDIN)

UEDIN is a major European University. It hosts a leading Astronomy research center at the Royal Observatory, with the University's Institute for Astronomy (IfA) on the same site as the UK Astronomy Technology Centre, owned by the Science and Technologies Facilities Council (STFC). The IfA, as well as conducting front rank research in cosmology, active galaxies, galactic structure, and star and planet formation, operates the Wide Field Astronomy Unit (WFAU) which provides state of the art science archives for some of the world's largest astronomical databases, such as SuperCosmos, UKIDSS, VISTA, and soon GAIA and Euclid, with plans to operate the UK Data Access Centre for LSST. As well as this astronomical expertise, Edinburgh is world renowned for both theoretical and applied computer science, having hosted the UK's National e-Science Centre (NeSC), the Digital Curation Centre (DCC), and several successive national supercomputing facilities through the Edinburgh Parallel Computing Centre (EPCC).

UEDIN Staff



Andy Lawrence (m) is Regius Professor of Astronomy at the University of Edinburgh. His research interests are in the nature and structure of active galactic nuclei, observational cosmology, and survey astronomy. He is Principal Investigator of the UKIRT Infrared Deep Sky Survey (UKIDSS) project, leading a consortium of 130 astronomers across Europe. He is a leader of the worldwide VO initiative, and has been a participant in a sequence of EU Euro-VO projects, and in particular has chaired the IVOA Executive, and has been leader or coordinator of the UK AstroGrid project, the EU VOTECH project, and the Edinburgh Wide Field Astronomy Unit. Currently he leads a project (ASTROTROP) which aims to re-purpose VO software for tropical forest monitoring.

Keith Noddle (m) is Technical Lead for the Edinburgh Wide Field Astronomy Unit, and has many years of experience both in the commercial and academic IT sectors. He has been involved in a sequence of Euro-VO EU projects, and was Project Manager for AstroGrid. Currently he is playing a key role in the development of the Euclid data archive system.

Bob Mann (m) is the Director of the Wide Field Astronomy Unit at the University of Edinburgh. His research interests are in observational cosmology, clusters of galaxies, and the application of information technology to astronomy. He is the Project Lead for the consortium which is currently proposing to STFC a UK involvement in LSST, and is leading the development of a proposed UK Data Access Centre.

Clive Davenhall is the Grant Manager for the Wide Field Astronomy Unit. His interests are in astronomical surveys and archives, digital preservation and curation, and the history of astronomy.

UEDIN Publications, Products and Services

1. Lawrence et al. (2007). *The UKIRT Infrared Deep Sky Survey* (UKIDSS). MNRAS 379, 1599

2. Roseboom, Lawrence et al. (2013). *IR-derived covering factors for a large sample of quasars* from WISE-UKIDSS-SDSS. MNRAS 429, 1494.

3. Hambly et al. incl. Man. Lawrence (2008). *The WFCAM Science Archive*. MNRAS 384, 637.

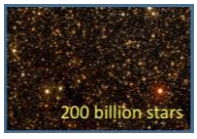
4. Lawrence (2009). *Drowning in Data: VO to the rescue*. In Dot.Astronomy: Networked Astronomy and the New Media. Ed RJ Simpson, D.Ward-Thompson, arXiv:0905.2020.

5. The WFCAM Science Archive http://surveys.roe.ac.uk/wsa/
   a) The VISTA Science Archive http://horus.roe.ac.uk/vsa/

UEDIN Projects

Virtual Observatory: UEDIN are partners in the current EU-funded Euro-VO project CoSADIE, as they were in the precursor projects such as EuroVO-AIDA, VOTECH, and Astrophysical Virtual Observatory AVO. UEDIN were the lead organization for VOTECH, and for the UK VO project AstroGrid. UEDIN are active members of the International Virtual Observatory Alliance and play key roles in many of the working groups as well as leading some of them.

Astronomical Surveys and advanced archive interfaces: Edinburgh scientists are leaders of or closely involved in many major survey projects, such as UKIDSS, VISTA, Gaia, and PanSTARRS, will play a major role in Euclid, and are leading a UK proposal for involvement in LSST. The Wide Field Astronomy Unit is responsible for providing the user interface for several of these surveys, and is currently developing advanced data access services .



Interdisciplinary projects: UEDIN has a long history of collaboration between astronomy, informatics, and IT companies, and is currently researching the opportunities for re-purposing VO technologies within the Earth Observation and Forest Monitoring disciplines, through the ASTROTROP project. UEDIN is also developing VO service for Gaia within the GENIUS project, which also has interdisciplinary aspects.

UEDIN main tasks in project

Profile: UEDIN represents EUCLID, LSST and the Virtual Observatory
Main tasks:

- LEAD: Tasks 4.3
- Participation: Tasks 4.1, 4.2

4.1.8 Ruprecht-Karls-Universität Heidelberg (UHEI)

UHEI is the oldest University in Germany. It is a member of the League of European Research Universities (LERU) which comprises 22 of the strongest research places in Europe. Heidelberg's Fakultät für Physik und Astronomie produces the largest number of physics PhDs among all German universities. The German partner institute is the Zentrum für Astronomie der Universität Heidelberg (ZAH). ZAH consists of the Astronomisches Rechen-Institut (ARI), the Institut für Theoretische Astrophysik (ITA) and the Landessternwarte Königstuhl (LSW). It was founded in 2005 and now constitutes the largest astronomy group at a German University. ZAH scientists participate at major astronomical projects like LBT (Large Binocular Telescope) or Gaia (ESA Cornerstone Mission). Recently, Heidelberg astronomy was awarded a "Sonderforschungsbereich" (Special Research Grant) about "The Milky Way System" by the German Science Foundation (DFG).

The Astronomisches Rechen-Institut (ARI) is representing the Virtual Observatory part of the German astronomical community, GAVO (German Astrophysical Virtual Observatory, website: www.g-vo.org). Support was renewed earlier this year by the German Ministry for Education and Research (BMBF) with a new three year funding period which started on July 1, 2014. The ZAH is the Principal Investigator Institute of GAVO, the other major partner is the Leibniz Institut for Astrophysics in Potsdam (AIP). The activities of ARI at ZAH are based on a long tradition for archiving and compiling astronomical literature and astronomical catalogues.

UHEI Staff

Joachim Wambsganss (m) is a professor at Heidelberg University and director of the Astronomisches Rechen-Institut (ARI). Since 2005, he has also been the director of the Zentrum für Astronomie der Universität Heidelberg (ZAH). His research interests range from searching for extrasolar planets, studying galaxy clusters and quasars to cosmological implications of gravitational lensing. He is the Principal Investigator of the GAVO program, which is supported by the German Government, and a member of the IVOA Executive Board.

Markus Demleitner (m) is associate astronomer and software engineer at Heidelberg University and the senior scientist of the GAVO team. Since he joined ARI in 2007, he has been working on data publication and developing software supporting it. He is an active member of the IVOA working groups (WG) on Registry, Data Access Layer, Application, and Data Modeling. Since 2014, he is the Chair of the Registry WG. He is the primary author of the data center software package DaCHS, and he is co-author on many VO standards (VOTable, VOUnits, TAPRegExt, Datalink, and several others).

UHEI Publications, Products and Services

1. Demleitner M., Harrison P., Molinaro M., Greene G., Dower T., Perdikeas M.; Editor: Demleitner M. (2014). *IVOA Registry Relational Schema*. IVOA Proposed Recommendation, (http://www.ivoa.net/documents/RegTAP/20140227/index.html).

2. Demleitner M., Derriere S., Gray N., Louys M., Ochsenbein F.; Editors: Derriere S. and Gray N. (2014). *Units in the VO*. IVOA Recommendation, (http://www.ivoa.net/documents/VOUnits/20140523/index.html).

3. Husemann B., Demleitner M. et al. (2013). *CALIFA, the Calar Alto Legacy Integral Field Area survey. II. First public data release*. Astronomy & Astrophysics, Vol. 549, p 87, services at ivo://org.gavo.dc/califa/q/s (on http://dc.g-vo.org)

4. Data Center Helper Suite DaCHS, http://soft.g-vo.org/dachs

5. SPLAT VO-enabled spectral analysis tool http://www.g-vo.org/pmwiki/About/SPLAT

UHEI Projects

GAVO is the German member organization of the IVOA. Since 2005, it has been publishing data (e.g., the Millennium simulation, the CALIFA IFU survey, or the PPMXL all-sky catalog) to the VO. One of GAVO's major data centers is run at ARI with data holdings of the order of 15 TB in about 100 services and data collections. GAVO also develops tools for VO access (e.g., SPLAT, tapsh) as well as for running VO-enabled, integrated services (e.g., DaCHS). GAVO participates in many standardization efforts on the international level.

GAVO has been a partner in EuroVO-AIDA and EuroVO-CoSADIE. In CoSADIE, UHEI leads the Data Centre Working Group.

M. Demleitner chairs the IVOA Registry Working Group.

UHEI main tasks in project

Profile: UHEI represents the Virtual Observatory
Main tasks:

- LEAD: Tasks 4.1
- Participation: Tasks 4.2, 4.3

4.1.9 Open University (OU)

The Open University is a world leader in modern distance learning, the pioneer of teaching and learning methods that enable people to achieve their career and life goals studying at times and places to suit them. The OU is the largest academic institution in the UK, in terms of student numbers. It has more than 240000 students, close to 7000 tutors, more than 1100 full-time academic staff and more than 3500 support staff. It teaches more astronomy undergraduates than the rest of the UK higher education sector combined, and has more than double the number of students in total than the combined US Ivy League. The OU has 15 curriculum partnerships established in 23 countries.

The OU is founder of the FutureLearn consortium, the first UK-led provider of massive open online courses. FutureLearn is wholly owned by the Open University and features a diverse course list from 29 internationally-renowned institutions. The OU's partners in FutureLearn include the BBC, Microsoft, Skype, Harper Collins, Bigpoint, Endemol, BSkyB, NBC, Paul Smith, Jasper Conran, and GOV.UK, as well as 29 universities worldwide.

The Science Faculty at the OU has created eSTEeM, a cross-departmental center for Science Technology Engineering and Mathematics (STEM) to promote innovation, scholarship and research in teaching, learning and engagement in the STEM education area. One of its many strands of activity is the Open Science Laboratory (OSL), an online laboratory for practical science teaching. OSL actively incorporates citizen science: a distributed way of gathering data, where non-professionals collect or process data as part of a scientific enquiry. The laboratory will provide online access to data from real physical instruments and equipment - not only to OU students but to students across the globe. The OU is a partner in the South East Physics Network, SEPNET, a consortium of nine UK universities. The SEPNET programme includes outreach activities designed to increase student interest and enrolment in physics and employer engagement initiatives.

The OU is also an important research university. In the UK's last Research Assessment Exercise, the Open University was ranked in the top third of UK higher education institutions. The Department of Physical Sciences (DPS) is the largest of the three academic departments within the OU Science Faculty, with about 150 staff and postgraduate students; it is also part of the University's Research Centre for Physical and Environmental Sciences (CEPSAR), the largest of five Research Centres central to the OU's research strategy.

DPS has a strong stake in complementary science undertaken with space missions. Members of DPS have been involved with instrumentation for all the major ESA planetary missions to date, as well participating in many missions from other agencies. Much present work focuses on the on-going and imminent missions such as Rosetta (Ptolemy instrument PI), Cassini-Huygens (Surface Science Package PI), and ExoMars (lead or joint lead for UV-Vis spectrometer, Advanced Environmental Package, Entry and Descent Landing System). As well as in situ instrumentation, recent sample return missions such as the NASA Stardust and Genesis missions have provided an invaluable link between the meteorite samples and distant objects that do not arrive on the surface of the Earth, at least in a readily identifiable form. DPS also houses the Centre for Electronic Imaging (CEI), a collaboration between The Open University and e2v technologies plc., who provide sponsorship contributing towards PhD studentships and research positions. The CEI is dedicated to the research and

development of advanced technologies for electronic image sensing and provides knowledge exchange between the UK technology industry and academia. The main focus of the CEI's work relates to the development of imaging sensors for space applications, with expertise in X-ray spectroscopy and the study of the effects of radiation damage. The CEI are involved in detector development for many current and future missions, such as Gaia, Euclid, IXO/Athena, Chandrayaan-1 & 2, UKube-1. Astronomers at the OU have leading roles in many major international projects and facilities, including SuperWASP, JCMT Legacy Surveys, LOFAR, and Herschel. We use many international facilities, from ground-based observatories (e.g. ALMA, ESO) to space telescopes (e.g. AKARI, Herschel, HST, Spitzer, STEREO), and are involved in the planning and preparation for future international missions (e.g. SPICA, FIRI, PLATO, EChO, Athena, Euclid). The Astronomy Discipline is a member of the UK SALT Consortium, which owns a 5% share in the 10m Southern African Large Telescope.

OU Staff

Stephen Serjeant (m) is a Reader in Cosmology and head of the Astronomy Discipline at the OU. He is the author of the CUP textbook Observational Cosmology (2010), reviewing essentially all of extragalactic observational astronomy at an advanced undergraduate level, and is a co-author of two entry-level Open University textbooks, Earth and Space (2007) and Galaxies, Stars and Planets (2012). His research focuses on multi-wavelength studies of galaxy evolution and strong gravitational lensing. He is a Fellow of the Institute of Physics, a Chartered Physicist, a Fellow of the Higher Education Academy (the UK's professional recognition of higher education teaching excellence) and a Fellow of the Royal Astronomical Society. Serjeant co-won the 2004 Daiwa Adrian Prize for his Anglo-Japanese scientific collaborations. He has published over 160 refereed publications with a Hirsch index of 51. He is the lead Science consultant on the BBC1 series Bang Goes The Theory and has consulted on BBC2 Stargazing Live and BBC4 Light and Dark. With Norton, Chambers and others, Serjeant contributed to the Sixty Second Adventures in Astronomy series of online cartoons, which have had 200000+ views to date. Serjeant will oversee the OU contribution to the project and liaise with other partners, as well as authoring material for the MOOC.

Nigel Mason (m) is Professor of Physics at the Open University. He is a keen promoter of physics and public understanding of science having held senior positions in both the Institute of Physics and the British Association of Science. His research investigates the manipulation and control of the reactivity of molecules using electrons and photons with applications to atmospheric physics; astrochemistry, plasma physics and radiation chemistry. He is a leader of several international research networks involving more than 100 research groups in Europe, Australia and India. He has a long-term commitment to engaging the general public with science, through for example the British Association for the Advancement of Science and the Institute of Physics (where he is currently a Council member) and he was the inaugural Director of the Milton Keynes Science Festival. He was appointed an OBE for his services to science. As incoming PI of EuroPLANET, Mason will act as the liaison with other EuroPLANET partners in the production and dissemination of the educational resources produced in this proposal.

OU Publications

1. 60 Second Adventures in Astronomy (YouTube, iTunes, OpenLearn), voiced by David Mitchell. This series of twelve 60 second animations examines different scientific concepts from the big bang to relativity, from black holes to dark matter.

2. Moons of the Solar System (YouTube): online videos.

3. Moons (FutureLearn MOOC): https://www.futurelearn.com/courses/moons

4. Serjeant S. (2010). *Observational Cosmology*. CUP, ISBN 978-0-521-15715-5

5. Clark S., Green S., Serjeant S. (2012*). Galaxies Stars and Planets*. Open University, ISBN 978-1-7800-7334-7

OU Projects

The Open University has been successfully producing and disseminating educational material through broadcasting for more than 40 years via a unique partnership with the British Broadcasting Corporation (BBC). The reach of the OU/BBC partnership is enormous: 267.8 million TV viewers and radio listeners were reached by OU/BBC programming in 2013 alone. OU broadcasts have received many national and international awards.

Audience sizes quoted where available.

- BBC2 Stargazing Live 2013. Typical audience 3.8 million.
- Light and Dark. BBC4, 2013. Average audience 0.51 million.
- Bang Goes The Theory, series 1-7. BBC1, typical audience 3-4 million.
- Life, BBC1, 2010. Typical audience 4 million.
- The virtual revolution. BBC2, 2010. Typical audience 1.1 million.
- The Story of Maths. BBC4, 2010. Typical audience 0.2 million.

OU operates 4 online learning platforms. The OU's public facing website OpenLearn has the world's largest collection of open educational resources, all available to download free. The site has won multiple awards: University Design Consortium USA 2010 Innovation Award; Times Higher Leadership & Management Awards - ICT Initiative of the Year Award; e.learning age - winner of best use of social media; The Commonwealth of Learning - Award of Excellence for Distance Education Materials; IMS Global Learning Consortium Learning Impact Awards - platinum award; and many other accolades. The OU also has channels on iTunes University and YouTube (see below). The OU was the first university in Europe to reach more than one million subscriptions through the iTunes app, and over 50m international downloads.

- OU iTunes University channel (2013 1.7 million unique visitors, 8.7 million downloads, many products frequently featuring in the global iTunes University top ten downloads). Women in Science (iTunes): celebrating the 100th anniversary of International Women's Day (March 8th, 2011), this online series was a global number one on iTunes University

- OU YouTube channel (2013 2.1 million unique visitors, 5.1 million video views)

- OpenLearn (2013 5.2 million unique browser visits)

- FutureLearn (450000 enrolments since 2013 launch)

Initial Training Networks, FP7 and Infrastructure projects:

- EPIC
- LASSIE
- PIMMS
- MEMSTICK
- HERMITAGE,
- EUROPLANET-RI
- e-infrastructure VAMDC
- SUP@VAMDC.

OU main tasks in project

Profile: OU organises the Dissemination, Engagement and Citizen Science.
Main tasks: LEAD: WP2 Tasks 2.1 2.2, 2.3

4.1.10 Friedrich-Alexander Universität Erlangen Nürnberg (FAU)

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) is one of the largest universities in Germany. With its five faculties, FAU offers an almost unique scope of subjects ranging from the Humanities to Law and Economics as well as Sciences, Medicine and Engineering. The close collaboration between the single disciplines is reflected by the University's Mission Statement "Advance through Networks". FAU thus offers perfect conditions for interdisciplinary research and learning to students and scientists alike.

Moreover, over the last decades, the University has established its reputation as a top-ranking institution in cutting-edge research. It is firmly anchored in a close network of interdisciplinary co-operations. These include partners from industry, specialized non-university research center and a number of leading international universities.

In 2007, the Erlangen Centre for Astroparticle Physics (ECAP) was founded as a focus research center of the University of Erlangen-Nuremberg. ECAP encompasses the working groups of eleven professors with over hundred scientists. An electronics and a mechanics workshop with more than twenty engineers and technicians support the research. ECAP has rapidly developed to become the largest astroparticle site of all German universities, with major involvements in several experiments in the focus of the ASTERICS proposal.

The Erlangen Centre for Astroparticle Physics combines expertise in the fields of neutrino, TeV gamma, X-ray and optical astronomy as well as development of novel detectors. It is a major player in: neutrino astronomy, with strong participations in ANTARES, IceCube, KM3NeT and acoustic detection; gamma-ray astronomy with a major participation in H.E.S.S. and the future CTA project; X-ray astronomy (in particular the satellite experiments eROSITA and XEUS). The scientists at ECAP have long-standing, leading expertise in construction and operation of large-scale experiments and in their scientific exploitation (data analysis and interpretation).

FAU Staff

Uli Katz (m) is a chair in experimental physics (astroparticle physics) and member of the senate at the University of Erlangen. He worked in the field of neutrino physics and particle physics – in the ZEUS collaboration, where he coordinated different physics groups. Currently his main activity is on high-energy neutrino and gamma astronomy. He is physics and software coordinator of the KM3NeT collaboration and member of this project's management team. In addition he is member of CTA, H.E.S.S. and IceCube.
Uli Katz acts as referee for diverse journals; as advisor for the German BMBF, MPG and Alexander-von-Humboldt-Foundation; and international organizations as NWO (NL), FWO (BE), GIF (IL), Croatea (HR) and the EU Marie-Curie-programme. He is member of the APPEC peer review committee and ASPERA scientific advisory committee. He coordinated the EU-funded KM3NeT design study (FP6).

Gisela Anton (f) is a chair in experimental physics (particle and astroparticle physics) at the University of Erlangen. She worked in field of hadron (nucleon) physics and is currently active in neutrino astronomy and detector development in astroparticle and medical physics.
She is member of advisory boards of DFG and BMBF, of the supervisory board of the Karlsruhe research center (KIT) and the physics research committee of DESY. For many years she was head of the institute board of the ANTARES project.

Kay Graf (m) is senior staff researcher at ECAP and steering committee member of the KM3NeT collaboration. He coordinates the KM3NeT working group for computing and software that handles the data challenge and data processing tasks for this experiment. He also leads the high-performance computing group of the ECAP that coordinates and implements the local data processing and analysis of all the ECAP projects.

FAU Publications, Products and Services

1. Bagley P. et al., KM3NeT Collaboration (2010). *KM3NeT Technical Design Report*. ISBN 978-90-6488-033-9. http://www.km3net.org

2. Adrián-Martínez S. et al., KM3NeT Collaboration (2013). *Detection potential of the KM3NeT detector for high-energy neutrinos from the Fermi bubbles*. Astroparticle Physics, 14, 7-14. http://dx.doi.org/10.1016/j.astropartphys.2012.11.010

3. Adrián-Martínez S. et al., ANTARES Collaboration (2013). *Search for muon neutrinos from gamma-ray bursts with the ANTARES neutrino telescope using 2008 to 2011 data*. Astronomy & Astrophysics 559, A9. http://dx.doi.org/10.1051/0004-6361/201322169

4. Aartsen M.G. et al., IceCube Collaboration (2013). *Evidence for High-Energy Extraterrestrial Neutrinos at the IceCube Detector.*
Science, 342, 6161. http://dx.doi.org/10.1126/science.124285

FAU Projects

CTA – http://portal.cta-observatory.org – is a large infrastructure for very high energy gamma-ray astronomical research. It is part of the ESFRI roadmap. FAU is a major partner in technical development for the mirrors and camera system of the telescopes used in CTA.

IceCube – http://icecube.wisc.edu – is a next generation neutrino telescope, located below the South Pole ice-cap. FAU is active in data analysis and technical development for the proposed IceCube updates (PINGU, MICA).

KM3NeT – http://km3net.org – is a future distributed multi-cubic-kilometre neutrino telescope in the deep Mediterranean Sea. It will be the first network of neutrino telescopes streaming the data to a common distant data center. Real-time multi-messenger observation is one of the objectives. FAU is co-ordinating the physics and software activities of the KM3NeT project.

FAU main tasks in project

Profile: FAU represents CTA, KM3NET and ICECUBE
Main tasks: Participation: Tasks 3.3

4.1.11 VU University (VU)

The Dutch VU University is one of Amsterdam's two universities. Ranking between 101 and 150 in the 2013 Shanghai Ranking, VU University provides high-quality academic education to approximately 23,000 students. The Department of Physics & Astronomy at VU is home to the Atomic and Laser Physics (ALF) group, headed by Prof. Wim Ubachs. The VU campus furthermore harbors the LaserLaB institute, in which the ALF group participates. At LaserLaB, the ALF group performs research towards the development of new, state-of-the-art lasers, precision measurements of atoms and molecules using lasers, optical metrology, and distribution of very precise time and frequency signals through fiber-optic networks. In collaboration with Dutch partners such as SURFnet (national research and education network), VSL (Dutch metrology institute), and various academic institutions, VU University has been the driving force behind the first successful field trials of extremely accurate clock synchronization through installed underground fiber links in the Netherlands.

VU Staff

Jeroen Koelemeij (m) is the leader of one of the research teams within the ALF group at VU, and initiator and principal investigator of the project 'SuperGPS through optical networks'. After obtaining his PhD from VU University in 2004, he worked in various laboratories in Europe and the USA. Among other things, he contributed to the second aluminum-ion optical clock in the group of David J. Wineland at NIST Boulder (USA), which was the world's most accurate clock between 2010 and 2014. After his return to VU University in 2008, he set up a new research line aimed at highly accurate time and frequency distribution through fiber-optic telecommunication networks. He is the initiator and key coordinator of a fast-growing public-private research consortium in the Netherlands, pursuing the vision of a future telecommunication network which will provide not only high-capacity data connectivity, but also extremely accurate timing, positioning and navigation to scientific, industrial, governmental, commercial and civilian users. Since establishing such an infrastructure will take high-tech industrial-commercial activities, Jeroen Koelemeij co-founded in 2014 a spin-off company (OPNT B.V.) in order to accommodate such activities.

VU Publications, Products and Services

1. Sotiropoulos N., Okonkwo C.M., Nuijts R., Waardt H. de, and Koelemeij J.C.J. (2013). *Delivering 10 Gb/s optical data with picosecond timing uncertainty over 75 km distance*. Optics Express 21(26), 32643-32654

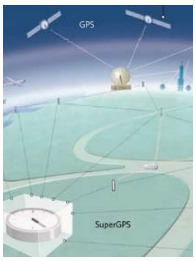
2. Chou C.-W., Hume D.B., Koelemeij J.C.J., Wineland D.J., and Rosenband T. (2010). *Frequency comparison of two high-accuracy Al^+ optical clocks*. Physical Review Letters 104, 070802.

3. Tour C. van, Pinkert T.J., Sotiropoulos N., Eikema K.S.E., and Koelemeij J.C.J. (in preparation). *Performance comparison of actively compensated fiber links for ultrastable optical frequency transfer using semiconductor and erbium-doped-fiber optical amplifiers.*

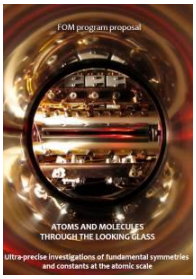
4. Pinkert T.J., Böll O., Jansen G.S.M., Willmann L., Smets R., Dijck E.A., Groeneveld B., Jungmann K., Bosveld F., Ubachs W., Eikema K.S.E., and Koelemeij J.C.J. (in preparation).

Simple optical frequency transfer over carrier-grade dense-wavelength-division-multiplexing fibre-optic networks and effects of soil temperature.

VU Projects



The project 'SuperGPS through optical networks' started at VU in 2010, in collaboration with SURFnet and the nuclear accelerator facility KVI in Groningen, the Netherlands. Since then, the consortium joined forces with more Dutch institutes, including VSL Delft, Eindhoven University of Technology, and Nikhef Amsterdam. More recently, the SuperGPS project has teamed up with Delft University of Technology and telecom network operator Royal KPN N.V., in order to add extremely accurate wireless positioning to the portfolio of SuperGPS applications. The project received substantial funding from the Dutch Technology Foundation, STW.



VU is partner within the program "Broken Mirrors and Drifting Constants", funded by the Dutch Foundation for Fundamental Research on Matter, FOM. Research within the program is conducted in collaboration with partner KVI Groningen. For the purpose of very accurate optical frequency distribution between high-precision measurement setups at VU and KVI, the two labs are connected by a 2×317-km-long fiber-optic link, which is part of the SURFnet fiber-optic network.

VU main tasks in project

Profile: VU brings unique expertise on optical networking technology.
Main tasks: LEAD: Tasks 5.1

4.1.12 Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)

CEA is a national scientific and engineering agency playing a major role in energy, information technology and health, with a strong emphasis on fundamental research. The institute participating to this project, Irfu (Institute of research into the fundamental laws of the Universe) belongs to the Direction des Sciences de la Matière (DSM) of the CEA. Irfu is located at the CEA Saclay centre. It comprises nuclear and particle physicists, and astrophysicists, together with a strong technical support. Scientists participating to this project belong to the astrophysics division of Irfu, a laboratory involved in several high energy astrophysics and cosmology projects (CTA, Hess, Fermi, SVOM, Euclid, SKA, XMM-Newton).

CEA Staff

Thierry Stolarczik (m) is the CTA group leader at the CEA astrophysics division, and was the coordinator of the site infrastructure work package in the CTA preparatory phase. He was formerly Science leader of the KM3NeT CEA group and co-coordinated the "Production preparation of telescope components" and "Strategic issues and international networking" work packages of the KM3NeT-Preparatory Phase (2008-2012). He also led the CEA Antares group between 2005 and 2012, a period including the construction and early analysis phases. In the earlier years he was in charge of the Antares software Framework and coordinated algorithm developments. He got experienced to large data volume treatment and databases during his participation to the NOMAD experiment at CERN (1993-2000).

Karl Kosack (m) is a staff physicist in the astrophysics department of IRFU, specializing in science topics and analysis techniques related to very-high-energy (VHE) gamma-ray astronomy. He is the leader of the CTA data reduction pipelines subproject. He is also an active member of the HESS collaboration, where he serves as the secretary of the Observation Committee, a member of the publication board, and was formerly the Analysis and Calibration working-group leader. In addition to a focus on galactic science at high energies, he has over 14 years of experience in the development of software and hardware for the Whipple 10m, VERITAS, and HESS, and now CTA ground-based atmospheric Cherenkov telescopes.

Marc Sauvage (m) Marc Sauvage (m) is an astrophysicist whose research focuses on the properties of the interstellar medium observed in the Milky Way or in distant galaxies. Observational data for this research come mainly from space experiments operating in the infrared, and he has been heavily involved in the two flagship infrared instruments developed at CEA, i.e. ISOCAM camera for ISO satellite, and PACS on board Herschel. In the course of these developments he has gathered extensive expertise associated with the development and management of large ground segments for space missions. This has led to his current involvement in the Euclid mission, where he is the ground segment scientist, in charge of overseeing the development of data processing systems that will have to face the challenging task of extracting cosmological parameters of an all-sky visible and near-infrared imaging and spectroscopic survey.

CEA Publications, Products and Services

1. Adrián-Martínez S. (2014). *Searches for Point-like and extended neutrino sources close to the Galactic Centre using the ANTARES neutrino Telescope - ANTARES Collaboration*. The Astrophysical Journal Letters, 786:L5

2. A first search for coincident gravitational waves and high energy neutrinos using LIGO, Virgo and ANTARES data from 2007 Antares collaboration JCAP06(2013)008

3. Aharonian, F., et al. (2008) *Exploring a SNR/molecular cloud association* within HESS J1745-303, (HESS Collaboration), Astronomy & Astrophysics, 483, p509

4. Aharonian, F., et al. (2008) *HESS very-high-energy gamma-ray sources without identified counterparts*, Astronomy & Astrophysics, 477, 353.

5. F. Pasian et al. (2014) *Development plans for the Euclid Science Ground Segment*, ASP conference series, vol. 485, p505

CEA Projects

CEA, through Irfu, is a key member of the CTA consortium. The particle physics division is leading the NectarCam camera project intended to equip the medium size telescopes. It is also involved in the development of new generation of mirrors for the CTA telescopes. The astrophysics division has been involved in the telescope array infrastructure definition and the CTA site selection process, and is leading the data pipeline developments in the consortium.

CEA is a long-time member of the HESS collaboration, the most successful Atmospheric Cherenkov Telescope array currently in operation. Irfu staff have had a strong involvement in HESS data analysis, scientific output, and have made major contributions to both software and hardware development for the project.

CEA and more precisely its institute for research into the fundamental laws of the Universe (CEA/DSM/Irfu) is a major partner of the Euclid project. At Irfu we will build the complete focal plane of the visible instrument (VIS) that is tasked with the extragalactic survey for weak-lensing signals. Focusing on the astrophysics division, we will have a significant role in the data processing activities. First through the position of ground segment scientist we participate in the important choices for the implementation of the data processing systems. Second as lead for the development of high-level science products, we play a critical role in defining and implementing the algorithms that will process the Euclid shear and position catalogs to reconstruct the dark matter density distribution and its evolution over time. We also have a significant role in the group that is in charge of building shear measurements algorithms, focusing on exploiting the knowledge we will gain from the VIS instrument construction and calibration.

CEA main tasks in project

Profile: CEA represents EUCLID and CTA
Main tasks: Participation: Tasks 3.4

4.1.13 University of Amsterdam (UvA)

The Anton Pannekoek Institute for Astronomy (API, http://www.astro.uva.nl/) of the University of Amsterdam (UvA) is located in the Amsterdam Science Park, amidst the majority of the university's scientific departments and also with close contact to other national research institutes like the national computing facility SURFsara (www.surfsara.nl) and the national sub-atomic physics institute Nikhef (www.nikhef.nl). The API is part of the Netherlands Research School for Astronomy (NOVA), and conducts research and teaching in astronomy at the highest level worldwide. Its particular expertises are in exoplanetary and stellar astrophysics, and in the extreme astrophysics of neutron stars and black holes, and astroparticle physics.

For the latter in particular, API has recently obtained funding to start a new research focus area at the UvA together with the institutes of high-energy physics and theoretical: GRAPPA (GRavitation AstroParticle Physics Amsterdam, www.grappa-uva.nl). As an inter-disciplinary center of excellence, GRAPPA has grown since 2011 into a research group of six new faculty members (of which Berge is one) and around 25 postdocs and PhD students. The group focusses on the most basic questions at the interface of physics and astronomy with a unique combination of topics and talents: What is the nature of gravity and the fabric of space-time? What is dark matter made of, and where does it come from? How and where are the most extreme forms of matter created?

UvA Staff

David Berge is a lecturer at the UvA and a scientist active in astroparticle physics. He is a member of the ATLAS experiment at CERN's LHC (http://atlas.ch) and the current and future very-high-energy gamma-ray telescope projects (H.E.S.S. and CTA, respectively). He is leading the Dutch CTA activities involving five faculty members and their respective groups spread over three Dutch universities. Berge publishes on his very-high-energy gamma-ray research, pursued within the H.E.S.S. telescope collaboration, in international peer reviewed journals like Nature and Science. With the H.E.S.S. telescopes going into operation about ten years ago, the field of gamma-ray astronomy at the highest accessible energies entered a new era leaping forward from only a few known sources of such gamma rays in the whole sky to by now more than 150 sources. Berge was responsible for one of the main scientific achievements of H.E.S.S., the first ever resolved image of an astronomical object in gamma rays (see publication 1 below).
At the moment, Berge is a member of the H.E.S.S. and CTA group leader boards, and for the Netherlands he is an observer of the resource board of CTA, which is the body of funding agencies of the future observatory. He is holding two instrumentation grants as PI at the moment to contribute to CTA (worth 645 k€ and 1.2 M€, respectively). He is a co-organizer of a number of international workshops and conferences in the field of astroparticle physics (see http://uva.nl/profile/d.berge for more details).

UvA Publications, Products and Services

1. The H.E.S.S. collaboration (lead D.Berge) (2004). *High energy particle acceleration in the shell of a supernova remnant*. Nature, Vol. 432, http://arxiv.org/abs/astro-ph/0411533

2. The H.E.S.S. collaboration (co-lead D.Berge) (2006). *Discovery of very-high-energy gamma-rays from the Galactic Centre ridge*. Nature, Vol. 439, http://arxiv.org/abs/astro-ph/0603021

3. Berge D., Funk S., Hinton J. (2007). *Background modeling in very-high-energy gamma-ray astronomy*. Astron. Astrophys., Vol. 466, http://arxiv.org/abs/astro-ph/0610959

4. Pareschi G., Berge D. et al. for the CTA consortium (2013). *The dual-mirror Small Size Telescope for the Cherenkov Telescope Array*. Proceedings 33rd International Cosmic Ray Conference Rio de Janeiro, http://arxiv.org/abs/1307.4962

5. Daniel M.K., White R.J., Berge D. et al. for the CTA consortium (2013). *A Compact High Energy Camera for the Cherenkov Telescope Array*. Proceedings 33rd International Cosmic Ray Conference Rio de Janeiro. http://arxiv.org/abs/1307.2807

UvA Projects

UvA is a member of the CTA consortium (http://cta-observatory.org). The UvA gamma-ray group comprises four faculty members and six postdoctoral researchers and PhD students. The UvA CTA contributions are focused on the small-size telescopes of CTA and on the CTA trigger and timing system.

UvA is a member of the H.E.S.S. telescope project (http://www.mpi-hd.mpg.de/hfm/HESS/HESS.shtml), the leading very-high-energy gamma-ray facility currently in operation. The UvA H.E.S.S. group contributes to the currently ongoing H.E.S.S. camera upgrade and to the science exploitation of the five H.E.S.S. telescopes.

UvA is closely cooperating with ASTRON, and as such heavily contributing to and involved in LOFAR and SKA.

UVA main tasks in project

Profile: UVA represents CTA, LOFAR and HESS
Main tasks: Participation: Tasks 5.2

4.1.14 Universidad de Granada (UGR)

UGR is one of the largest universities in Europe (with approximately 60.000 students) and a relevant research institution, ranked between 301-400 in the Shangai ranking 2013. Particularly, the School of Informatics is the best academic institution in Spain according to the Taiwan Ranking 2013 (NTU Ranking 2013), and is ranked in the position 267 in the world (according to its scientific publications and other research indicators).

The Computer Architecture and Technology group (Departamento de Arquitectura y Tecnología de Computadores, ATC) has participated in many EU Framework projects, (more than 8 projects from V to VII framework, flagships and embedded platform specific calls). Furthermore, ATC participates in large projects such as SKA (SADT group, mainly working on Synchronization and Timing activities) and other international research initiatives related with LINAC particle accelerators. Concretely, it participated in the original development of White Rabbit switches, as partner of a national research project, in collaboration with Seven Solutions and other institutions such as CERN or GSI. Currently UGR collaborates with this initiative providing developments related with management and application software, control and evolution towards 10G technology.
The group has a strong expertise in FPGA circuits development, firmware and embedded systems with more than 20 years of expertise on the field. Furthermore the group participates actively in the evaluation and further development of White Rabbit technology in collaboration with an open and wide international community.

UGR Staff

Javier Diaz Alonso is a senior researcher with more than 60 scientific papers in journals and conferences (mainly in FPGA circuits and embedded systems developments). He is also the Principal Investigator (PI) at the University of Granada at SKA (Spanish coordinator of the SADT activities). He has been PI in regional and also EU projects, such as RECOMP (ARTEMIS-100202), as well as in four R&D projects in collaboration with technology based companies as Cibernos or Seven Solutions. He has participated in more than 5 EU research projects in FP5, FP6 and FP7. At the University of Granada, he teaches technology related subjects such as Safety-Critical Systems, Integrated Electronics Systems for Telecommunications, Hardware implementation of algorithms and on-chip computer vision. His interests include timing and synchronization technologies, high performance computing architectures, embedded systems and real-time processing.

Eduardo Ros, is Full Professor at the Department of Computer Architecture and Technology with more than 60 research papers in Scientific journals. He has participated as IP (from the University of Granada) in 7 EU grants in FP5, FP6, FP7 and H2020. He has participated also as IP in 3 National Projects, besides some collaborative project with industrial partners such as Telefonica I+D, Anafocus, etc. He is also part of HIPEAC initiative (European Network of Excellence on High Performance and Embedded Architecture and Compilation). At the University of Granada, his teaching is focused on Technology subjects, such as Technology and Organization of Computers (TOC), and has supervised more than 12 PhDs, mainly in real-time processing, FPGA processing

architectures and hardware development. His interests include timing and synchronization technologies, real-time processing and on-chip computing architectures.

José Luis Gutiérrez received his BSc. degree in Computer Engineering from University of Granada, Granada, Spain, in 2006. He received his MSc. degree in 2009. He is currently a researcher in the Department of Computer Architecture and Technology at the University of Granada with more than 5 scientific papers in journals and conferences mainly in embedded systems engineering. He has participated in several FP7 international projects, such as RECOMP (ARTEMIS-100202) and SKA, and national R&D projects, such as ACELTEC, with both academic and industrial partners. In addition, he has also participated in Open Source developments as the White Rabbit project. His research interests are in the areas of safety-critical systems, real-time operating systems, timing and synchronization technologies and embedded systems.

UGR Publications, Products and Services

1. Jiménez López M., Gutiérrez J.L., Díaz J. (2014). *A White-Rabbit Network Interface Card for Synchronized Sensor Networks*. IEEE SENSORS, in press

2. Rodriguez-Gomez R., Fernandez-Sanchez E., Diaz J. and Ros E. (2012). *FPGA implementation for real-time background subtraction based on Horprasert model.* Sensors, Vol. 12, pp 585-611

3. Pauwels K., Tomasi M., Díaz J., Ros E., Hulle M.M. van (2011). *A Comparison of FPGA and GPU for Real-Time Phase-based Optical Flow, Stereo, and Local Image Features.* IEEE Trans. on Computers

4. Anguita M., Díaz J., Ros E. and Fernández-Baldomero J. (2009). *Optimization Strategies for High-performance Computing of Optical-flow in General-purpose Processors*. IEEE Trans. On Circuits and Systems for Video Technology, 19 (10), pp. 1475-1488

5. Díaz J., Ros E., Rotter A. and Muehlenberg M. (2008). *Lane change Decision Aid system based on motion driven vehicle tracking*. IEEE Transactions on Vehicular Technology, Vol. 57, Issue 5, pp 2736 - 2746

UGR Projects

Square Kilometre Array SKA (http://www.skatelescope.org/) is an international effort to build the world's largest radio telescope, with a square kilometre (one million square metres) of collecting area. UGR participates in the Signal and Data Transport group (SaDT) with activities related with time transfer based on optical fibre links.

The EMC2 project (http://www.emc2-project.eu/) is an ARTEMIS Joint Undertaking project in the Innovation Pilot Programme 'Computing platforms for embedded systems' (AIPP5). EMC² finds solutions for dynamic adaptability in open systems, provides handling of mixed criticality applications under real-time conditions, scalability and utmost flexibility, full scale deployment and management of integrated tool chains, through the entire lifecycle. The objective of EMC² is to establish Multi-Core technology in all relevant Embedded Systems domains. EMC² is a project of 99 partners of embedded industry and research from 19 European countries with an effort of about 800 person years and a total

budget of about 100 million Euro. UGR participates by providing deterministic solutions for Time transfer over optical fibres.

The RECOMP project (http://www.recomp-project.eu) formed a joint European task force contributing to the European Standard Reference Technology Platform for enabling cost-efficient certification and re-certification of safety-critical systems and mixed-criticality systems, i.e. systems containing safety-critical and non-safety-critical components. The aim was to establish methods, tools and platforms for enabling cost-efficient (re-)certification of safety-critical and mixed-criticality systems. Applications addressed are automotive, aerospace, industrial control systems, and lifts and transportation systems. UGR contributed to research infrastructures with the expertise gained on this project to provide high reliable solutions capable to offer very high availability services.

UGR main tasks in project

Profile: UGR represents the SKA
Main tasks: Participation: Tasks 5.1

4.1.15 Stichting Fundamenteel Onderzoek der Materie (FOM)

In the Netherlands, FOM is the funding agency for physics. Nikhef is the Netherlands national institute for subatomic physics, coordinating and leading the Dutch experimental activities in the fields of accelerator-based particle physics and astroparticle physics. Nikhef is a partnership between FOM and four universities: Radboud University Nijmegen, University of Amsterdam, Utrecht University and VU University Amsterdam. The research at Nikhef relies on the development of innovative technologies. It has expertise in designing and building detectors for subatomic experiments, development of simulation, reconstruction and physics analysis software and GRID technologies for large data processing. The knowledge and technology transfer to third parties, i.e., industry, civil society and general public, is an integral part of Nikhef mission. The knowledge and return of experience at Nikhef of applying White Rabbit technologies for timing over Ethernet in the KM3NeT neutrino telescope is very relevant for the task of Nikhef in this proposal to develop methods and tools for accurate (long haul) time synchronization, which would allow for real time multi-messenger observation.

FOM Staff

Aart Heijboer received his PhD at the University of Amsterdam in 2004 for his research in neutrino astronomy with the ANTARES telescope. In the years following, he worked as research associate at FNAL (Chicago, USA) in the CDF experiment where he was (a.o.) the co-convenor of the CDF B-physics Analysis Group. In 2007, he was awarded a CERN Research Fellowship and joined the ATLAS experiment at CERN. In 2008, he was awarded the prestigious Dutch NWO Vidi Grant (600 k€/5 years) with the proposal '*Exploring the Cosmos with Neutrinos*'. In 2009, he returned to Nikhef as FOM research physicist. Since 2013, he is the leader of the ANTARES and KM3NeT research programme of Nikhef, supervising a group of about 15 people. Relevant for this proposal is his supervision of engineers that have developed the sub-nanosecond timing system for the KM3NeT telescope using White Rabbit technologies.

Maarten de Jong is senior FOM research physicist at Nikhef and professor at Leiden University. He was responsible for the data acquisition system of the ANTARES telescope and during the KM3NeT Design Study leader of the work package 'Information Technology'. Since 2013, he is the Spokesperson of the KM3NeT Collaboration for the implementation of the first phase of KM3NeT and chair of the executive management team. The international KM3NeT Collaboration has about 300 members.

FOM Publications, Products and Services

Publications relative for the task of FOM in this proposal:

1. Adrián-Martínez S. et al (2014). *Searches for Point-like and Extended Neutrino Sources Close to the Galactic Center Using the ANTARES Neutrino Telescope*. The Astrophysical Journal Letters, 786:L5

2. Adrián-Martínez S. et al. (2013). *Detection potential of the KM3NeT detector for high-energy neutrinos from the Fermi bubbles*. Astroparticle Physics 42 7–14

3. Jansweijer P. et al. (2013). *White Rabbit: Sub-nanosecond timing over Ethernet*. Nucl. Instrum. Meth A725 187-190

4. Adrián-Martínez S. et al. (2013). *A first search for coincident gravitational waves and high energy neutrinos using LIGO, Virgo and ANTARES data from 2007*. JCAP 06 - 006

5. Kooijman P. ed. (2010). *KM3NeT Technical Design Report for a Deep-Sea Research Infrastructure in the Mediterranean Sea Incorporating a Very Large Volume Neutrino Telescope*. ISBN 978-90-6388-033-9

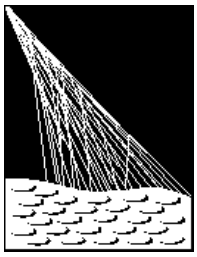
FOM Projects

ANTARES – operational neutrino telescope. Pre-cursor for KM3NeT, located at a depth of 2.5 km in the Mediterranean. The design of the DAQ system and the major reconstruction software package of ANTARES was the responsibility of FOM. The ANTARES Collaboration signed several MoUs with other observatories for exchange of on-line alerts to allow for multi-messenger observations.

KM3NeT – future distributed multi-cubic-kilometre neutrino telescope at the south coasts of Europe in the deep Mediterranean Sea. It will be the first network of neutrino telescopes streaming the data to a common distant data center. FOM is responsible for the design of the optical module, the readout electronics and the optical data transmission network. (Real time) multi-messenger observation is one of the objectives of KM3NeT.

VIRGO – Interferometer for detection of Gravitational Waves located near Pisa, Italy. Scientific collaboration between VIRGO, LIGO and ANTARES is formalized in a MoU to allow for multi-messenger observation.

AUGER – Operational Pierre Auger Observatory for observation of cosmic rays. The sky view of the observatory is similar to that of ANTARES/KM3NeT and offers the keen possibility of multi-messenger observation.



FOM main tasks in project

Profile: FOM represents the KM3NET, ANTARES and VIRGO
Main tasks: Participation: Tasks 5.1

4.1.16 Institute for Space Studies of Catalonia (IEEC)

IEEC is a private non-profit foundation devoted to research on space science and technology and its applications since 1996. IEEC participates in different European networks and consortia (i.e., ASTRONET, APPEC, KOPERNIKUS, E-GEM), and in various space missions (p.e., GAIA, LISA Pathfinder, Euclid, Fermi, Paris-IoD, PAZ or CHEOPS). Also relevant is the role played in ground instrumentation projects, which includes the construction of CTA, robotic telescopes (TJO, SQT), the CARMENES instrument (CAHA, Spain), or the Dark Energy Survey (DES) instrument for the 4-m CTIO telescope (Chile).
The expertise in telescope and observatory control software and, in particular, AI-based scheduling applications for telescope time management and robotic operation is being applied to some of the aforementioned projects. Experienced scientific and engineering staff at IEEC work together for the development of suitable technological solutions. The IEEC is leading the task for the development of the Central Scheduler for CTA in the Array Control and Data Acquisition work package.

IEEC Staff

Josep Colomé (m) has a Ph.D. in Astrophysics from the University of Barcelona (Spain). He is involved in research activities since 2001, when he joined IEEC, and he obtained a permanent position in 2007. He has participated in several technological projects mainly devoted to the development of control software for the operation of astronomical instrumentation and telescopes. He has carried out systems engineering and project management activities in different Space missions (LISA Pathfinder and EChO ESA-M3 candidate) and in ground-based instrumentation projects. He is the task leader at Consortium level to develop the scheduler for CTA since 2012. He is also the manager at IEEC for international cooperation in the EC-H2020 programme framework.

Diego F. Torres (m) is ICREA Professor of Astrophysics, and Head, Department of Astrophysics of IEEC-CSIC. He has published about 200 papers on high energy astrophysics and edited 5 books. He is Editor-in-Chief of the Journal of High Energy Astrophysics (Elsevier), and director of the workshop setting Sant Cugat Forum on Astrophysics. He has received several scientific awards (among them, the Friedrich Wilhelm Bessel Award of the Humboldt Foundation in 2012, and the Shakti Duggal Award on Cosmic Ray Physics of the International Union of Pure and Applied Physics in 2007) and published about 100 additional papers. He participates in CTA committees, including the Collaboration Board.

Emma de Oña Wilhelmi (f) is Ramon y Cajal tenure-track fellow in IEEC-CSIC. She has been part of the HEGRA, H.E.S.S. and MAGIC collaboration, having different responsibilities in each of them. She was coordinator of the H.E.S.S. group for pulsars, pulsar wind nebulae and supernova remnants and currently coordinator of galactic physics in the MAGIC collaboration and group leader at IEEC-CSIC. She also serves as deputy physics coordinator, coordinator of pulsar and pulsar wind nebula and galactic coordinator for key projects within CTA. De Ona Wilhelmi has published more than 100 refereed papers and maintains an interest in high- and very-high-energy gamma-rays with a strong multi-wavelength support.

Jordi Campreciós (m) is a senior software engineer at IEEC with more than 6 years participating in software development projects. He is part of the Scheduler team in the CTA consortium since 2011, contributing to the array simulator and scheduling test platform.

Álvaro García (m) has a Ph.D. in Artificial Intelligence (2012) from University Ramon Llull (Spain). He carries out applied research of top-rated Artificial Intelligence and Machine Learning techniques in planning and scheduling of observatory operations based on his expertise in optimization techniques using EA and MOEA algorithms. He is involved in space science research, where IEEC is leading the development of planning and scheduling software tools (p.e., CARMENES, EChO). He contributes to the CTA scheduling test platform.

IEEC Publications, Products and Services

1. García-Piquer Á. et al. (2014). *Artificial Intelligence for the EChO Mission Planning Tool*. Experimental Astronomy (in press)

2. Colomé J. et al. (2014). *Artificial intelligence for the CTA Observatory scheduler*. Proceedings of SPIE (in press)

3. Fuessling M. et al. (2014). *Towards a global software architecture for operating and controlling the Cherenkov Telescope Array*. Proceedings of SPIE (in press)

4. García-Piquer Á. et al. (2014). *CARMENES instrument control system and operational scheduler*. Proceedings of SPIE (in press)

5. Colomé J. et al. (2012). *Research on Schedulers for Astronomical Observatories*. Proceedings of SPIE, Vol. 8448, DOI:10.1117/12.926899

IEEC Projects

IEEC contributes to CTA at a scientific and technological level. Scheduler activities have been granted by the Spanish ministry with different projects: *CTA Preparatory Phase* devoted to the scheduler development (budget to IEEC: 50 KEUR for 1 yr), *Scheduler for CTA (initial demonstrator)* in collaboration with GTD S.I. industrial partner (budget: 170 KEUR for 2.5 yr).

IEEC develops a prototype of the EChO (http://echo-spacemission.com/) Long-term Mission Planner and the operative version of the CARMENES (http://carmenes.caha.es) instrument control system and scheduler: *EChO mission and preparation of the mission ground-segment and the scheduler application* (budget: 195 KEUR for 1 yr); *CARMENES science research and instrument development* (budget: 230 KEUR for 3 yr).

IEEC main tasks in project

Profile: IEEC represents the CTA
Main tasks: Lead: Tasks 5.4

4.1.17 Instituto De Fisica De Altas Energias (IFAE)

IFAE conducts experimental and theoretical research at the frontier of fundamental physics, namely in Particle Physics, Astrophysics and Cosmology. IFAE also works at the cutting edge of detector technology, applying its know-how to Medical Imaging and other applied research fields. It maintains a fruitful collaboration with its spinoff company, X-Ray Imatek. In 2012, IFAE was granted the Severo Ochoa award, given by the Spanish government to a few leading national research centers. IFAE Experimental Division comprises 65 persons, including staff researchers, postdocs, engineers and students. The Gamma-ray Astronomy group at IFAE has played a leading role in the field, having constructed and operated some of the critical parts of the MAGIC telescopes. Since 2008, in collaboration with the Port d'Informació Cientifica (PIC), IFAE has constructed, maintained and run the MAGIC Data Center.

IFAE Staff

Javier Rico (m) is the Principal Investigator of the MAGIC research group at IFAE. Since 2008, he has coordinated the design, construction, maintenance and operation of the MAGIC Data Center, in charge of the systematic transfer, storage, calibration and processing of MAGIC data (about 300 TByte per year). He is member of the CTA Data Model Working Group, as responsible for the design and development of the Instrument Response Model. Along with fundamental Physics research with gamma rays, his interests include the standardization and public release of data formats and analysis tools in Gamma-ray Cherenkov Astronomy.

IFAE Publications, Products and Services

1. Reichardt I., Rico J. et al. (2009). *The MAGIC Data Center*. Proc. of the 31st International Cosmic Ray Conference. arXiv:0907.0968

2. Moralejo A. et al. (2009). *MARS, the MAGIC Analysis and Reconstruction Software*. Proc. of the 31st International Cosmic Ray Conference. arXiv:0907.0943

3. Firpo R., Delfino M., Neissner C., Reichardt I., Rico J., Tallada P. and Tonello N. (2011). *The MAGIC data processing pipeline*. Proc. of the International Conference on Computing in High Energy and Nuclear Physics. J. Phys. Conf. Ser. 331, 032040. DOI: 10.1088/1742-6596/331/3/032040

4. Bernlöhr K. et al. (2013). *Monte Carlo design studies for the Cherenkov Telescope Array.* Astropart. Phys. *43,* 171-188. DOI: 10.1016/j.astropartphys.2012.10.002

5. Acharya B.S. et al. (The CTA Consortium) (2013). *Introducing the CTA concept.* Astropart. Phys., 43, 3-18. DOI: 10.1016/j.astropartphys.2013.01.007

IFAE Projects

MAGIC (https://magic.mpp.mpg.de/) is a system of two Cherenkov telescopes located at the Observatorio del Roque de los Muchachos, in the Canary island of La Palma (Spain), for the observation of gamma rays in the energy range between 50 GeV and 30 TeV. IFAE constructed the photo-multiplier camera of the first MAGIC telescope in 2005, and main parts of the readout for the second one in 2008. IFAE hosts and operates the MAGIC Data Center since 2008. (http://magic.pic.es)

Within CTA, IFAE is contributing with the construction and partial validation of a prototype of the Large Sized Telescopes (LST) undercarriage; the coordination of the LST camera prototyping; the trigger system; development of data models and analysis software, and application to Monte Carlo simulations to evaluate the physics performance of CTA. Besides these tasks, IFAE is leading the efforts in support of Tenerife or La Palma, a location of the CTA northern site.

IFAE main tasks in project

Profile: UGR represents the CTA
Main tasks: Participation: Tasks 3.2, 3.3

4.1.18 Universidad Complutense de Madrid (UCM)

UCM stands for Universidad Complutense de Madrid. It is the largest university in Spain, with more than 75,000 students. The High Energy Physics Group signing this project belongs to the Faculty of Physics, which itself is the largest Faculty of Physics in Spain, grouping around 400 teachers and technical staff. The group pioneered the Spanish research activity in the field of Astroparticle Physics, contributing to the construction and exploitation of the HEGRA experiment since 1985, the first European Very High Energy Astrophysics observatory. Nowadays the group is still fully devoted to Astroparticle Physics being active in MAGIC, CTA and The Pierre Auger Observatory. It comprises 10 staff over a total of 20 members. Inside MAGIC the group is centered in Dark Matter searches, AGN and pulsar physics and it is responsible for the onsite analysis and the timing system of the observatory. The group also participates actively in CTA. It is in close contact with members of the enterprise ISDEFE, which carry out their work in the ESA Science Center close to Madrid. Members of the group teach actively in the degree of Physics at UCM, the Masters in Astrophysics, Theoretical Physics and Biomedical Physics, as well as in other science related degrees.

UCM Staff

José Luis Contreras (m) is the Principal Investigator of the CTA project at UCM. He is presently the coordinator of the Data Model sub-working package of CTA. He is author/co-author of more than 250 refereed papers in Particle and Astroparticle Physics, having been a member of DELPHI, HEGRA, MAGIC and CTA collaborations. Associate professor at UCM his research interests orbit around the experimental techniques for the detection and the analysis of Astroparticle Physics data, as well as the application of these technologies to Medical Physics. J.L. Contreras co-coordinates Task2 of WP3.

UCM Publications, Products and Services

1. Bulgarelli A., Fioretti V., Contreras J.L., Lamanna G. et al. (2014). *The Real-Time Analysis of the Cherenkov Telescope Array Observatory*. SPIE Conf. Series, in press Sol H. et al. including Contreras J.L. et al. for The CTA Collaboration. *Active Galactic Nuclei under the scrutiny of CTA*. APPhys 43 215-240

2. Hassan T., Mirabal N., Contreras J.L. and Oya I. (2013). *Gamma-ray active galactic nucleus type through machine-learning algorithms.* MNRAS 428 220-225

3. Ponz D., Contreras J.L., Ibarra A., Calle I. de la, Puerto I. (2010). *CTA: the Project and the Challenges.* Proceedings of the XX Astronomical Data Analysis Software and Systems (ADASS) Boston, USA

4. Vázquez, Calle I. de la, Contreras J.L., Ibarra A., Tapiador D. (2007). *Migration of Montecarlo simulation of High Energy Atmospheric showers to GRID infrastructure*. J. Phys.: Conf. Ser. 219

UCM Projects

MAGIC (https://magic.mpp.mpg.de/), the Major Atmospheric Gamma-ray Imaging Cherenkov Telescope is a Very High Energy Observatory located in Spain, in one of the Canary Islands, La Palma. Composed of two 17 m diameter Cherenkov Telescope it covers the energy range from 30 GeV to some TeVs with High Sensitivity. UCM is responsible for the Onsite Analysis of MAGIC data. It runs automatically each night at the observatory site, providing all physically meaningful data around noon. Most of the physics analyses of MAGIC are based on this data.

Inside CTA the group coordinates the Data Model sub-working package and is involved in the design of the Large Size Telescopes and the Physics program.

UCM main tasks in project

Profile: UGR represents CTA and MAGIC
Main tasks:

- Lead: Task 3.2
- Participation: Tasks 3.3

4.1.19 Istituto Nazionale Di Fisica Nucleare (INFN)

The National Institute for Nuclear Physics (INFN) is the Italian research agency dedicated to the study of the fundamental constituents of matter and the laws that govern them, under the supervision of the Ministry of Education, Universities and Research (MIUR). It conducts theoretical and experimental research in the fields of subnuclear, nuclear and astroparticle physics. Today the INFN employs some 5,000 scientists whose work is recognized internationally not only for their contribution to various European laboratories, but also to numerous research centers worldwide. Concerning astroparticles, INFN has a wide range of activities, including direct involvements in AUGER, MAGIC, AMS, Fermi, VIRGO, CTA, KM3NeT. INFN designed and operated the detectors for the NEMO underwater neutrino telescopes and participates in Antares and KM3NeT. INFN has directly contributed to the development of modern supercomputers and to distributed computing infrastructures, in particular, within the IGI and EGI frameworks. INFN runs a Tier-1 facility for LHC data analysis at CNAF and is a partner of other large-scale computing initiatives.

INFN Staff

Cristiano Bozza (m) - Asst. Professor at Department of Physics of the University of Salerno/Gruppo Collegato INFN. He has a vast experience in data flow, processing and storage, from close interaction with DAQ hardware to high-level processing and distribution on Wide Area Networks. He developed SySal, the automatic readout system for emulsion films that was used by Italian nuclear emulsion laboratories in the CHORUS experiment and later evolved into the ESS (European Scanning System) used by all European laboratories of the OPERA experiment and also in Japan at Tokyo Earthquake Research Institute. Bozza has specific experience on real-time high-speed processing. In the OPERA experiment, as Database Coordinator, Bozza designed and set up the distributed database system built of geographically distant relational databases, estimated to reach 100 TB of fully relational data. Bozza designed and operated DAQ control systems and custom cluster computing software, both for CPU-based servers and for GPU-based servers. He developed a Distributed Computing Infrastructure used in several European laboratories. He has experience in GPU programming for track reconstruction. He has also developed Web Application servers providing high performance data distribution services, ubiquitously accessible and compatible with GRID access. One such server is used by the KM3NeT Collaboration, of which Bozza is a database developer and administrator.

Agnese Martini (f) - Technologist at the Laboratori Nazionali di Frascati - Istituto Nazionale di Fisica Nucleare. She has a vast experience in system management of different operating systems. Since 2006 she has given her contribution for the approval (May 2011) of the ATLAS GRID TIER2 in Frascati. She has also expertise in real-time software. Her knowledge involves also the microprocessor technology. In the last years she has developed an oceanographic instrument, (PORFIDO) based on the RFID technology. She also participates in the development of the slow control console interface of KM3NeT-Capopassero Towers.

Rosa Coniglione (f) - Research staff member at Laboratori Nazionali del Sud (INFN). From 1990 to 2000 she worked in the field of nuclear physics and in particular in the study of the reaction mechanisms induced by heavy ions at intermediate energy. Coniglione has been the coordinator of the High Energy Physics working group in KM3NeT since 2012. In the NEMO and KM3NeT collaborations she has conducted the simulation work for the scientific validation and for optimization of the detector layout by means of Monte Carlo codes that describe physics processes and detector response.

INFN Publications, Products and Services

1. The KM3NeT Collaboration. *KM3NeT Technical Design Report* http://www.km3net.org/TDR/TDRKM3NeT.pdf (ISBN 978-90-6488-033-9)

2. Bozza, C., Albert A. for the KM3NeT Collaboration (2013). *The relational database system of KM3NeT*. VLVnt, http://agenda.albanova.se/materialDisplay.py?contribId=331&sessionId=263&materialId=slides&confId=3930

3. Coniglione R. for the Km3NeT Collaboration (2013). *KM3NeT and Fermi bubbles: Some predictions*. NIMA 725 49-51

4. Sapienza P., Trovato A., Coniglione R. for the KM3NeT Collaboration (2013). *KM3NeT sensitivity and discovery potential for galactic point-like sources.* NIMA 725 45-48

5. Adrián-Martínez S. et al. (KM3NeT Collaboration) (2013). *Detection potential of the KM3NeT detector for high-energy neutrinos from the Fermi bubbles*. Astrop. Phys. 42 7-14

INFN Projects

KM3NeT (http://www.km3net.org) is a Collaboration with the goal of constructing and operating a network of neutrino telescopes in the Mediterranean Sea. Unlike IceCube, KM3NeT has a favorable position for observing the galactic center. INFN paved the way in past years for the development of the facility, by the NEMO underwater telescopes and participating in the realization, operation and data analysis of the Antares experiment. INFN hosts one of the KM3NeT shore stations at Capopassero.

INFN hosts and runs one of the Tier-1 of LHC GRID at CNAF, which is also one of the major computing centers in Europe. It currently manages more than 10000 cores and has the technology and resources for permanent storage and archival of about 12 PB. INFN also runs several Tier-2 centers in Italy with smaller computing and storage capability.

INFN main tasks in project

Profile: INFN represents KM3NET
Main tasks: Participation: Tasks 3.2, 3.3 3.4

4.1.20 The UK Astronomy Technology Centre (STFC)

The UK Astronomy Technology Centre is part of the STFC and is the UK's National center for the design and production of world leading astronomical telescopes, instruments and systems. It has delivered hardware and software to space missions (e.g. Herschel and JWST) and the telescopes of the European Southern Observatory (Chile), the Isaac Newton Group of Telescopes (La Palma), Gemini (Chile/Hawaii) and the UK Infrared Telescope (Hawaii), the James Clerk Maxwell Telescope (Hawaii) and the ALMA telescopes (Chile). It is currently engaged in the pre-construction phase of the Square Kilometre Array (SKA) Project working on the systems engineering for the Central Signal Processor and is leading the work on the Observation Management software for the Telescope Manager. To meet the needs of these customers the STFC employs a staff with specialist expertise including: systems engineering and project management; software engineering; infrared/sub-mm optical design; cryogenics and low-temperature engineering; mechanism design and analysis; stiff structures with low vibration.

STFC Staff

Alan Bridger: Ph.D. in Astrophysics from University of St. Andrews, with over 20 years experience of observation management software for the UKIRT 4m telescope and ALMA, and over 8 years working in the operational environment at UKIRT. He has led the development team for the ALMA Proposal and Observation Preparation System for the past 14 years and currently leading the Observation Management team in the SKA Telescope Manager consortium.

Stewart Williams has a Ph.D. in Astrophysics (2003) from UMIST, Manchester; over 9 years experience developing software for ALMA, contributing to the archive, observing preparation and data pipeline subsystems, with specific experience in creating user-facing observation preparation systems for interferometers. Has many years of experience participating in a large project with a remote distributed team environment. Currently part of the Observation Management team in the SKA Telescope Manager consortium.

STFC Publications, Products and Services

1. Bridger A. et al. (2004). *Proposal and Observing Preparation for ALMA in Optimizing Scientific Return for Astronomy through Information Technologies*. Proc. Of SPIE, Vol. 5493, p 392, eds. Quinn P.J. & Bridger A.

2. Bridger A. et al. (2008). *The ALMA Observing Tool in Advanced Software and Control for Astronomy II.* Proc. of SPIE, 7019-27, eds. Bridger A. & Radziwill N.

3. Bridger A. et al. (2012). *The ALMA OT in Early Science: supporting multiple customers, in Software and Cyberinfrastructure for Astronomy II*. Proc. of SPIE, 8451-45, eds. Radziwill N. & Chiozzi G.

STFC Projects

The STFC is leading the Observation Management within the SKA Telescope Manager Consortium. It is also participating in the Central Signal Processing Consortium for the SKA.

The STFC is leading the design and development of the ALMA Observing Tool, under contract from the European Southern Observatory. It is also playing a key role in the ALMA Pipeline development.

The STFC is the European PI Institute for the MIRI Instrument on board the James Webb Space Telescope. In addition to leading the design and production of this instrument it is working on the processing pipeline algorithms for MIRI.

STFC main tasks in project

Profile: STFC represents the SKA
Main tasks: Participation: Tasks 5.4

4.1.21 Stiftung Deutsches Elektronen-Synchrotron DESY

DESY ("Stiftung Deutsches Elektronen-Synchrotron DESY") is one of the world's leading centers for the investigation of the structure of matter. DESY develops, operates, and uses accelerators and detectors for photon science and particle physics. DESY is involved in large-scale astroparticle physics projects, that study the high energy non-thermal universe in gamma-rays and neutrinos - like ground based Cherenkov telescopes H.E.S.S, MAGIC, VERITAS, and the IceCube neutrino telescope (and its predecessor AMANDA). DESY is playing a key role in planning and constructing the Cherenkov Telescope Array CTA, the next generation high-energy gamma-ray observatory.
As a member of the Helmholtz Association in Germany, DESY is a non-profit research organization supported by public funds.

DESY Staff

Ralf Wischnewski (m) is senior researcher at DESY with a long record in managing astroparticle physics experiments from their early design phase through construction, commissioning and routine operation - being active in astroparticle physics since the late 80ies. Wischnewski was active in bringing experimental neutrino astronomy to reality with the world's first two high energy neutrino telescopes (Baikal/Siberia and AMANDA /SouthPole; responsible e.g. for data acquisition and precision-time calibration), and was involved in IceCube construction. He joined the Pamela satellite project (cosmic ray antimatter experiment) for 2002/2003 and was responsible for system integration (INFN Italy). Since 2012, Wischnewski is PI of a Helmholtz Project that applies new technologies for gamma-ray and cosmic-ray detection at the Siberian Tunka-facility. There, the non-imaging gamma-ray telescope HiSCORE operates on his initiative a prototype field application of the WhiteRabbit sub-nsec timing technology. Working for the CTA project since 2009, he is involved in developing a modern clock distribution and time stamping system for the array of CTA telescopes.

DESY Publications, Products and Services

1. Actis M. et al. (CTA Consortium) (2011). *Design concepts for the Cherenkov Telescope Array CTA: An advanced facility for ground-based high-energy gamma-ray astronomy*. arXiv:1008.370, 10.1007/s10686-011-9247-0, Exper.Astron.32 193-316

2. Andres E. et al. (AMANDA Collaboration) (2001). *Observation of high-energy neutrinos using Cherenkov detectors embedded deep in Antarctic ice*. Nature 410 441

3. Achterberg A. et al. (IceCube Collaboratio) (2006). *First Year Performance of The IceCube Neutrino Telescope.* Astropart.Phys. 26 155-173

4. Brueckner M. and Wischnewski R. (2013). *A White Rabbit setup for sub-nsec synchronization, timestamping and time calibration in large scale astroparticle physics experiments.* Proceed. 33rd ICRC, Rio de Janeiro, paper 1146

DESY Projects

CTA (http://astro.desy.de/gamma_astronomy/cta, http://www.cta-observatory.org) is a key project to construct and operate the next generation ground based high-energy gamma-ray observatory. Sensitivity and energy range of CTA will supersede that of previous gamma telescopes by an order of magnitude. DESY is a key player in the CTA-consortium; it is leading the MST-telescope construction (Mid-Size Telescopes) – the first MST prototype being located in Berlin, and is leading the CTA array control effort (ACTL). DESY is one of the candidate sites to host the CTA-headquarter.
DESY is actively working on a White Rabbit based CTA-wide clock and time-stamping system.

IceCube (http://astro.desy.de/neutrino_astronomy/icecube/) is a cutting-edge next generation neutrino telescope, located below the South Pole ice-cap. With 5160 optical sensors distributed over a cubic kilometer of ice, IceCube is the biggest particle detector world-wide. It is about 20-times larger than its predecessor AMANDA, which established high-energy neutrino astronomy at the SouthPole in the late 1990ies. DESY played a key role in project design, production of optical sensors and electronics, as well as precision calibration for both projects (nsec-precision timing being the key technology to catch rare neutrino signatures in the presence of a 7 orders larger background).

DESY main tasks in project

Profile: DESY represents the CTA and IceCube.
Main tasks: Participation: Tasks 5.1

4.1.22 SURFnet

SURFnet is the Dutch National Research and Education Network (NREN). SURFnet ensures that researchers, instructors, and students can work together simply and effectively with the aid of ICT. It therefore promotes, develops, innovates and operates an advanced, trusted, and connecting ICT infrastructure that facilitates optimum use of the possibilities offered by ICT. In this way, SURFnet is working to create a connected world in which simple and reliable tools are available to ensure universal connectivity and access. This makes SURFnet the ICT motor for innovation in higher education and research in the Netherlands. SURFnet operates about 12,000 km of fiber and over 300 nodes with IP, Ethernet and Photonic network services.

SURFnet is a non-profit subsidiary of SURF, in which Dutch universities, universities for applied sciences and research centers collaborate nationally and internationally on innovate ICT facilities. Other subsidiaries of the SURF organization are SURFsara, SURFshare, and SURFmarket.

SURFnet Staff

Erik Huizer (m) is CTO at SURFnet, the Dutch national educational and research network. Until May 2012 he was managing director for Information Society at the Netherlands Organization for Applied Scientific Research (TNO), directing a research group of 400 people. He is also part-time professor Internet Applications at University of Utrecht and a member of the Dutch Topteam for Creative Industries. Erik Huizer was inducted into the Internet Hall of Fame in April 2014. From December 1991 till April 1995 he was Area Director for the Applications area of the Internet Engineering Task Force (IETF) and as such a member of the Internet Engineering Steering Group (IESG). From 1995-2002 he was a member of the Internet Architecture Board. From 1999 till 2002 he was chairman of the Internet Research Task Force (IRTF). He served on the ISOC Board of Trustees from 2002 till 2007. Erik is a strategist with substantial board level experience in ICT, Internet, media, digital culture and broadcast. He has a focus on new business and new opportunities. He has an extensive national and international network and experience with large international projects. His focus is on developing and building partnerships and developing and using new ICT-technologies.

Rob Smets (m) is Prime Optical Transport and Photonic Network Architect at SURFnet. At SURFnet he is responsible for bringing innovation into the network and secure proper operation of SURFnet's national photonic and transport national network and its three cross-border fibers. He received a M.Sc. from the Eindhoven University of Technology in Theoretical Electromagnetics and in 1999 a Ph.D. on semi-conductor optical-amplifier enabled all-optical high-speed signal processing also from the Eindhoven University of Technology. From 1999 to 2007 he worked for Alcatel-Lucent in Hilversum and Antwerp where he held different positions ranging from Research Scientist to Technical Presales Expert. Between 2008 and 2013 he worked for TNO, the Netherlands Organization for Applied Scientific Research (TNO) specializing in Network Architecture and Network Operations in support of a diverse set of network operating organizations. During his career Rob has participated in European projects of different framework such as ACTS, FP6, FP7, and Celtic. He has authored and co-authored more than 30 papers and has eight patents filed.

SURFnet Publications, Products and Services

1. Lund R. and Smets R., White Paper – Alien Wave Services in the NREN Community
2. *The operational challenges of taking foreign waves into production* (2013). GEANT Document Code: GN3-13-164
3. *SURFnet Annual Report 2013, What SURFnet realized in 2013*. http://www.surf.nl/binaries/content/assets/surf/en/knowledgebase/2014/jaarverslag_surfnet_2013_en.pdf
4. Beshir A., Nuijts R., Malhotra R., and Kuipers F., *Survivable Impairment-Aware Traffic Grooming,* Proceedings 16th NOC 2011, Newcastle-Upon-Tyne pp 208 – 211

SURFnet Projects

SURFnet7

SURFnet7 is the new SURFnet network operational as of 2014. This network abandons SDH and relies fully on packet transport and offers unprecedented performance of L2 lightpath services and L3 IP traffic. In addition the network supports alien waves by default.

Amsterdam-London CBF is the newest Light-system and transport system. In collaboration with NORDUnet, SURFnet has deployed this ca. 500 km Cross Border Fiber between Amsterdam and London featuring Raman amplification on a > 200km submarine link. The CBF supports Alien wavelength transmission and is to contribute in a larger network of CBFs between London, Hamburg, Geneva, Paris, and Copenhagen.

RoN-Atomic Clock TFT: In SURFnet's Research on Networks program institutions contribute to SURFnet's innovating capabilities by performing high-risk research. This project has demonstrated first capabilities of deploying a novel scheme to transport time and frequency information with unprecedented accuracy and resolution. The project has been finished in July 2014 proofing feasibility.

NLight (Netherlight) is SURFnet's open exchange platform for any institution and organization for any service supporting the lower layers of the OSI model. On a regular basis the interconnecting functionality and performance is improved. An example of a recent successful project is the first 100G transatlantic connection between four open exchange points. http://www.surf.nl/en/services-and-products/netherlight/best-practices/first-transatlantic-100-gbit-s-connection/index.html

SURFnet main tasks in project

Profile: SURFnet has unique expertise on networking technology
Main tasks: Participation: Tasks 5.1

4.2. Third parties involved in the project (including use of third party resources)

4.2.1 ASTRON

No third parties involved

4.2.2 CNRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)?	Y

ASTERICS aims to deliver a broad range of innovative software libraries and services to the facilities. The prioritisation of these software components and the specification of their requirements can only be made in the course of the project – arranging appropriate sub-contractors at this stage is premature. For a selection of the components, the generation is optimally executed in co-development with industry. Therefore, the consortium will organise industrial engagement for (precompetitive) co-development with industry via an internal call for sub-contracting technical works. WP3.1 manages this process in the same way as has been successfully organised for the FP7 CTA Preparatory Phase project. After the completion of this call, the consortium agreement and annex 1 will be adapted to incorporate any new subcontractors. A preliminary innovation plan of investments foresees some possible paths such as:

a) "Professional software co-developments" with intellectual property of the delivered products transferred entirely to ASTERICS partners.

b) Co-development of database software frameworks where private companies have already achieved a superior level of competence or are willing to follow-up the ESFRI use cases for cooperative work. An example is the case of applying web-technologies such Hadoop generally used on text files to astronomical data formats such as FITS and/or FITS-wrapped data packets.

c) Consulting contracts to support technological survey (e.g. on workload management on distributed data centres; engineering of on-line data streaming processing/ground segments).

d) Exploring a few co-funded PhD scholarships with major private companies (e.g. CUDA for GPU programming) around astronomical data analysis use cases.

e) Sub-contracting to SMEs some computing benchmark prototypes, combining low-cost processors such as ARM and GPUs, integrating both on-line data streaming efficiency and data processing acceleration.

Does the participant envisage that part of its work is performed by linked third parties[3]?	Y

The **University of Strasbourg** (UNISTRA) is one of the largest universities in France, with over 43000 students and over 4000 researchers. The University also offers access to 25 modern languages, multinational diplomas, jointly supervised doctorates, upholding renowned international postgraduate schools and student exchange agreements. The scale of research activity at Strasbourg is substantial, involving a European Doctoral College, 10 doctoral schools and 79 research units. The University of Strasbourg (UNISTRA) is one of the largest universities

[3] A third party that is an affiliated entity or has a legal link to a participant implying a collaboration not limited to the action. (Article 14 of the Model Grant Agreement).

in France, with over 43000 students and over 4000 researchers. Thanks to the worldwide reputation of its research teams, the University of Strasbourg emerges among Europe's foremost research universities and is a founding member of the League of the European Research Universities.

The **Observatoire de Paris** will appear as CNRS third party through their Joint Research Unit UMR 8102 Laboratoire de l'Univers et de ses Théories, which represents CTA in WP4.
Observatoire de Paris (http://www.obspm.fr) is the largest astronomy center in France and one of the most important in the world. It represents itself one third of astronomy in France. It depends on the Ministry of Higher Education and Research as it has the status of an independent University. It covers about all the fields of Astronomy/Astrophysics, up to Physics and Mathematics, and also History of Sciences. It gathers about a thousand people.

Observatoire de Paris hosts six departments (GEPI, LESIA, LERMA, LUTH, SYRTE, LERMA), one scientific Unit (Nançay Radio Astronomy Station) and one Institute (IMCCE), which provides and publishes ephemerides of solar system bodies. All of these entities are Joint Research Units with CNRS and some are associated with other Paris Universities. They are spread over three locations : Paris, Meudon and Nançay (Research Center in Radioastronomy).
Observatoire de Paris benefits from important technical and administrative services, such as the most important astronomy Library in France and a very performant computing Department. Moreover, Paris Observatory develops training activities (pre and post doc level) with the UFE "Teaching and Training Unit" and it is responsible for the "Ecole Doctorale Astronomie et Astrophysique d'Ile de France".

Observatoire de Paris also has a Contracts Department (SRCV), with a European Projects Office. It participated to 37 FP7 european projects, such as FP7-SPACE Collaborative projects, FP7-ERC grants management, FP7-Marie Curie Actions, FP7-Infrastrucutres or FP7-JRPs (EURAMET grants). Observatoire de Paris was coordinator of 12 of these projects.

Observatoire de Paris through VO-Paris Data Centre (VOPDC) develops activities for disseminating and accessing astronomical and physical data in the Virtual Observatory context since more than ten years. In this frame several engineers and researchers have contribution to the activities of the International Virtual Observatory Alliance (IVOA) and the International Planetary Data Alliance (IPDA). Several leading activities of VOPDC are performed at the international level , in particular in the domain of atomic and molecular physics, simulation and modeling in astrophysics, heliophysics and planetology. VOPDC is, or has been, a coordinator or a participant to several European projects. VOPDC is located at Paris Observatory and has been implemented there as a federative activity. All the Paris Observatory scientific departments (LUTH, LERMA, LESIA, GEPI, SYRTE, IMCCE, USN) and the computing department (DIO) give a contribution to VOPDC. The centre, as a regional centre officially recognized by CNRS/INSU as an expertise centre, is also open to partnership with other laboratories from Ile-de-France region. Thus, VOPDC contibutes to the Paris Observatory system for high level services for data access and dissemination in astronomy.

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)?	N

4.2.3 INAF

No third parties involved

4.2.4 UCAM

No third parties involved

4.2.5 JIVE

No third parties involved

4.2.6 INTA

No third parties involved

4.2.7 UEDIN

No third parties involved

4.2.8 UHEI

No third parties involved

4.2.9 OU

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)?	N
Does the participant envisage that part of its work is performed by linked third parties[4]?	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)?	Y
Article 11: We will use the Mass Participation platform being developed by the Galaxy Zoo team at Oxford University. Some of the PDRA-level staffing to develop, maintain and interpret the mass participation experiments will be hosted at Oxford, funded through the Open University.	
Article 12: Mass participation platform technology, adapted for the ASTERICS mass participation experiments.	

4.2.10 FAU

No third parties involved

[4] A third party that is an affiliated entity or has a legal link to a participant implying a collaboration not limited to the action. (Article 14 of the Model Grant Agreement).

4.2.11 VU

No third parties involved

4.2.12 CEA

No third parties involved

4.2.13 UvA

No third parties involved

4.2.14 UGR

No third parties involved

4.2.15 FOM

No third parties involved

4.2.16 IEEC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)?	N
Does the participant envisage that part of its work is performed by linked third parties[5]?	Y
GTD Sistemas de Información SAU is a SME company established in Barcelona, Spain. With over 25 years' experience working alongside major contractors in the aeronautical and space sectors, gtd has unique know-how in delivering embedded systems and software components for civil and military aircraft and spacecraft programs. GTD develops global solutions for the space sector – ground control systems, space transportation onboard software (including ATV) and operational tasks outsourcing at the European Spaceport in French Guiana. GTD is specialized in developing Ground & On-Board Systems for Spacecraft platforms. That includes: the engineering of Ground Segment Systems for Launchers and Spacecrafts; the industrialization process for the designed solutions; the engineering of on-board software, including methods, tools and standards for the design, development and verification; the independent verification and validation of the critical software; the engineering of new electronic systems and avionics architecture dedicated to space segment. gtd staff in the Space Direction is now about 100 people located in Spain, France, Germany and French Guyana. GTD has participated and is participating in several R&D European Framework Programmes projects. GTD is involved in the development of the scheduler for CTA and is a Full Member in the Telescope Manager work package for the Square Kilometer Array. Therefore, gtd holds the necessary expertise to collaborate with IEEC in the ASTERICS proposal. In particular, they will	

[5] A third party that is an affiliated entity or has a legal link to a participant implying a collaboration not limited to the action. (Article 14 of the Model Grant Agreement).

participate in the research on algorithms for scheduling telescope networks and in the development of the software prototype to simulate and evaluate the benefits of cross-facility scheduling. GTD has been working jointly with IEEC on several projects since 2010. This fruitful partnership motivated the signature of an institutional collaboration agreement in 2012 that will be the framework for the work to be carried out in the ASTERICS proposal.

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)?	N

4.2.17 IFAE

No third parties involved

4.2.18 UCM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)?	Y

UCM intends to subcontract technical assistance related to its participation in Tasks 3.2 D-GEX and 3.3 D-INT.
The budget of the contract would amount to about 40k Euro. The work to be subcontracted will be mostly concentrated in task 3.2D-INT, for the tasks of Data Access and distribution, but not exclusively. We also search for consultancy and software engineering support. The contract could last approximately one year.

The contract would cover :

- Assistance on software technologies used for Data access and distribution in astronomical observatories.
- Report on existing technologies and lessons learnt from previous observatories.
- Modelling and prototyping of the metadata and systems needed to locate the data, interpret it and integrate this knowledge in the analysis chains.

We seek a partner with experience in services to Astronomical projects or observatories, who can provide the software engineering expertise to complement our scientific experience. The selection will be done based on characteristics of the service offered, experience on similar projects and economic conditions.

Does the participant envisage that part of its work is performed by linked third parties[6]?	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)?	N

[6] A third party that is an affiliated entity or has a legal link to a participant implying a collaboration not limited to the action. (Article 14 of the Model Grant Agreement).

4.2.19 INFN

No third parties involved

4.2.20 STFC

No third parties involved

4.2.21 DESY

No third parties involved

4.2.22 SURFnet

No third parties involved

5. Ethics and Security

5.1 Ethics

There are no ethical issues associated with the ASTERICS project or its programme of activities.

5.2 Security

There are no security issues associated with the ASTERICS project or its programme of activities. More specifically:

- activities or results raising security issues: No
- 'EU-classified information' as background or results: No

Appendix 1: Letters of support

In this appendix we present letters of support from the four ESFRI facilities associated with the ASTERICS proposal and the two major ERA-NETs (European Research Area Network). They are presented in the following order:

- Letter of Support from Prof. Philip Diamond, Director General of the Square Kilometre Array (SKA) Office.
- Letter of Support from Prof. Werner Hoffman and Manel Martinez, Spokesperson and co-spokesperson of the Cherenkov Array Telescope (CTA) consortium.
- Letter of Support from Prof. Maarten de Jong, Spokesperson KM3NeT.
- Letter of Support from Prof. Tim de Zeeuw, Director General of the European Southern Observatory (ESO).
- Letter of Support from Dr. Ronald Stark, chair of ASTRONET Board.
- Letter of Support from Prof. Stavros Katsanevas, chair of the Astroparticle Physics European Consortium (APPEC).

SKA Organisation
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Cheshire, SK11 9DL.
UK

t: +44 (0)161 306 9600
e: enquiries@skatelescope.org
w: www.skatelescope.org

18th August 2014

To whom it may concern,

ASTERICS: H2020 Call INFRADEV-4

I am writing in my capacity as Director-General of the SKA to indicate my strong support for the ASTERICS proposal.

ASTERICS is an innovative response to the INFRADEV-4 call and is designed to develop several strands of work that will maximise the impact of a cluster of ESFRI-recognised facilities. I have observed, from the sidelines, the development of the work-packages and have been impressed at the focus on selecting those aspects that will have benefit across much of astronomy.

WP3 (OBELICS) and WP4 (DADI) are aimed at addressing two things: first the data challenges that face modern astronomy projects, specifically looking at the early development of techniques for the future that might be adopted by several facilities; then secondly, at continuing the invaluable work done through previous Virtual Observatory-related projects to ensure that the VO framework is adopted by the ESFRI projects (constrained budgets inevitably mean that projects focus on the need to deliver, with refinements such as VO coming later) and that the facilities are fully interoperative.

The latter point is an essential precursor to maximise the science that will be enabled by WP5 (CLEOPATRA). This work-package is aimed at developing the methods to enable different facilities to respond immediately to real-time alerts, for example when a supernova explosion is detected via neutrino emission, to ensure that optical, IR and radio telescopes are immediately notified and that automatic procedures slew those telescopes to the position of the supernova. This is very timely since modern telescopes will enable real-time viewing of much of the sky at all times.

Finally, I find WP2 (DPECS) to be an immensely exciting work-package. Citizen Science has taken off over the last few years, with astronomy leading the way. The implementation work proposed in ASTERICS has the potential to take this to a new level for multiple facilities, to deliver exciting new science and to provide a major and highly visible public outreach activity.

The management team for ASTERICS is experienced and competent, as evidenced by the smooth manner in which they brought together this excellent proposal.

The planned activities will have a major and positive effect on the SKA, which is the primary, but not only, driver for my interest and support. The work being planned will provide significant added value to the science that will be undertaken with the SKA and will dramatically speed up our ability to work together with other facilities.

Sincerely,

Company Number: 07881918
Company Limited by Guarantee
Registered in England & Wales

Mailing address:

Prof. Werner Hofmann

CTA Project Office

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Prof. Michael A. Garrett
General Director & Scientific Director ASTRON
Netherlands Institute for Radio Astronomy
Postbus 2, 7990 AA Dwingeloo, The Netherlands.
Phone (office): +31 521 595126 [1];
Phone (PA): +31 521595119 [2];
e-mail: garrett@astron.nl

Dear Mike,

As Spokespersons of the CTA Project, we are writing to express our strong support of the ASTERICS proposal, responding to the INFRADEV-4 call regarding clusters of ESFRI facilities.

The work packages proposed within ASTERICS all cover topics which are of significant relevance for the further evolution of CTA, and for which a large degree of synergy is expected with the other ESFRI projects involved. In particular, work packages WP3 – on Observatory E-Environments, WP4 – on Data Access, Discovery and Interoperability, and WP5 – on Connecting ESFRI Observatories and
Partners in Astronomy for Timing and Real-time Alerts – address areas that are crucial for the optimal exploitation of CTA. These work packages nicely complement the topics of project organization and telescope prototyping, that were in the focus of the CTA Preparatory Phase. Also the coordinated approach towards Dissemination, Public Engagement and Citizen Science (WP2) is definitely of interest for us.

We would like to thank you for your engagement and effort in coordinating and assembling this excellent proposal, which we trust will be successful, given that it addresses key synergies of ESFRI facilities in our field. We look forward to future cooperation and to the common exploitation of the new facilities!

Sincerely

Werner Hofmann
CTA Spokesperson

Manel Martinez
CTA Co-Spokesperson

KM3NeT
Opens a new window on our universe

19 August 2014, Amsterdam

Dear Sir/Madam,

This letter is to support the ASTERICS proposal which is a response to the EC's Horizon 2020 Call INFRADEV-4, clusters of ESFRI facilities. This proposal is a joint venture which includes KM3NeT. The KM3NeT Research Infrastructure consists of a cabled network of deep-sea neutrino telescopes in the Mediterranean Sea. The main objective of KM3NeT is the discovery and subsequent observation of high-energy neutrino sources in the Universe.

Following a critical review by the Assessment Expert Group in February 2013, KM3NeT has made significant progress towards its implementation. The project is organized in a single collaboration with a central management and a common data analysis and repository centre. The funding agencies (or funding authorities) involved have installed the Resources Review Board (RRB) which oversees the project. The RRB is advised by an international Scientific and Technical Advisory Committee (STAC). A Memorandum of Understanding for the first phase, covering the total available budget of about 31 M€, has been *pro forma* signed by the RRB (formal signature in progress) and a Letter of Intent for the next phase(s) has been reviewed by the STAC and discussed with the RRB. A decision on the evolution of KM3NeT is expected by 2016.

The ASTERICS proposal will provide for a common and sustainable platform for the interoperability of cosmic observatories. After the discovery of high-energy neutrinos from the cosmos in 2013 (awarded by the British magazine Physics World as Breakthrough of the year), the cooperative observation of the cosmos by multi-messengers –as envisaged by this proposal– is right and timely.

Sincerely yours,

Prof.dr. M. de Jong
Spokesperson KM3NeT,
Nikhef and Leiden University

European Organisation for Astronomical Research in the Southern Hemisphere

Director General

Garching, 21 August 2014
ODG101-14/isk

Professor Michael A. Garrett
General Director & Scientific Director ASTRON
Netherlands Institute for Radio Astronomy
Postbus 2
NL-7990 AA Dwingeloo

Horizon 2020 Proposal "Astronomy ESFRI and Research Infrastructure Cluster"

Dear Professor Garrett,

The European Organisation for Astronomical Research in the Southern Hemisphere, ESO, is a key provider of astronomical infrastructure with the VLT, VISTA, VST and ALMA and is also currently constructing the E-ELT, a major ESFRI facility. ESO recognizes the strategic importance to exploit synergies to ensure harmonization and interoperability between various ESFRI facilities and would like to be an associate partner to the project "Astronomy ESFRI and Research Infrastructure Cluster" (ASTERICS). As such, ESO will remain appraised of the activities of ASTERICS but would not participate directly in the work.

Having initiated the E-ELT Construction Phase, and with the Organisation under considerable financial pressure, ESO needs to concentrate its efforts on the core priorities. Further full participation in ASTERICS at this stage would commit resources that would reduce ESO's flexibility in ways that cannot be sustained. Thus, ESO has reluctantly concluded that it will not be able to participate as a full partner.

ESO considers data handling, access, interoperability and dissemination as essential to serve the global astronomy data network. This requires that the international community continue to develop a sustainable framework.

ESO thus supports the "Astronomy ESFRI and Research Infrastructure Cluster" proposal in response to the EC's Horizon 2020 Call INFRADEV-4 – clusters of ESFRI facilities.

Best wishes,

Tim de Zeeuw

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Dr. Ronald Stark
Netherlands Organisation for Scientific Research
P.O. Box 93138
NL 2509 AC Den Haag

Prof. Mike Garrett
PO Box 2
7990 AA Dwingeloo
The Netherlands

August 26, 2014

Subject: Letter of support for ASTERICS proposal in response of Horizon 2020 Call INFRADEV-4 - clusters of ESFRI facilities

Dear Prof. Garrett,

In my capacity as chair of the Board of the ERA-NET ASTRONET, I am writing to express the support of ASTRONET for the ASTERICS proposal as a response to the EC's Horizon 2020 Call INFRADEV-4 - clusters of ESFRI facilities, currently being prepared by ASTRON on behalf of a consortium of European institutions.

European astronomy has engaged in a process of establishing coherent, long-term and sustainable strategic planning and coordination on an unprecedented scale, involving all relevant national and international players and considering all aspects of the total research enterprise. The aim of ASTRONET is to establish a strategic planning mechanism for all of European astronomy. So far, ASTRONET has successfully united essentially all European funding agencies for astronomy in this enterprise. Its Science Vision (2007, update released in 2013) and Infrastructure Roadmap (2008, update ready in the fall 2014) have defined the way toward a successful European Research Area Network in astronomy, and ASTRONET is now moving towards the realisation of the recommendations in these documents.

The ASTERICS proposal and its common activities reflect the spirit of ASTRONET, and will deliver a very important contribution to the implementation of the ASTRONET Infrastructure Roadmap, on which ESFRI projects such as the E-ELT, SKA and CTA appear prominently. Among other things, ASTERICS will set up a forum that ensures that the new generation of large facilities will appropriately engage with each other at a high level.

The ASTRONET Roadmap strongly supports the development of the Virtual and several specific recommendations were made. These are further addressed in the ASTRONET Task 4.4 (Virtual Observatory and Astrophysical Software Laboratory). I am pleased to note that one of the ASTERICS work packages will focus on topic specifically and will strive to align the framework of the Virtual Observatory to ESFRI project needs.

Should the ASTERICS proposal be approved, it will be an invaluable instrument to enable the further progress of the ESFRI projects it unites, addressing strategic objectives such as the big data challenge, engaging the public, interfacing various research infrastructures into the Virtual Observatory and connecting the different facilities to enhance combined science capabilities.

With this background, it is my pleasure to endorse the submission of this proposal as a critical tool in achieving our collective aims. I look forward to having further discussions with you and the other participants on how ASTRONET can contribute, in the event of favourable assessment of the proposal, and would be pleased to provide any other supporting information to the assessors that might be helpful.

Sincerely,

Ronald Stark
Chair, ASTRONET Board

Astroparticle Physics European Consortium

Mailing address:
APPEC Chairman
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Telephone: +33 01 57 27 61 69
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Prof. Mike Garrett
PO Box 2
7990 AA Dwingeloo
The Netherlands

CC: J. Seed, T. Berghoefer,

Paris, 27 August 2014

Letter of support for ASTERICS proposal in response of Horizon 2020 Call INFRADEV---4

Dear Prof. Garrett,

In my capacity as chair of the Board of the Astroparticle Physics European Consortium (APPEC), (www.appec.org) in which the main European agencies funding Astroparticle Physics are represented, I am writing you to express APPEC's support for the ASTERICS proposal. APPEC was the outcome and the sustainable continuation of the EU funded ERANET ASPERA.

The need: to develop multi-messenger and multi-wavelength studies; to coordinate the observation strategies of several large Astrophysics, Astroparticle Physics, and Cosmology infrastructures e.g. through the efficient distribution of alerts; to facilitate data access; to encourage the development of common and new computing technologies and algorithms as demanded e.g. by new computing infrastructures, are all themes which have been at the centre of APPEC's attention and which are the subject of the ASTERICS proposal.

Furthermore, through ASPERA, APPEC has established a research infrastructures roadmap in 2011, which is now under review to arrive at a coherent timeline for the funding of its priorities, taking into account realistic budgetary constraints. Several of APPEC's high-priority projects, such as the ESFRI recognized high-energy photon Cherenkov Telescope Array (CTA) and the KM3NeT underwater neutrino observatory, and projects like the EGO/VIRGO gravitational-wave antenna, the AUGER high-energy cosmic-ray observatory and the dark-energy survey LSST, are already participating in the ASTERICS program or will hopefully be involved in the future. A rich and complementary space-based program with e.g. EUCLID, ATHENA, eLISA and SVOM as main missions is under construction or in development and also here we expect synergies with the ASTERICS program regarding common operation characteristics and inter-accessibility of data with ground-based research infrastructures.

It is therefore our pleasure to endorse the submission of the ASTERICS proposal, which includes many astroparticle physics infrastructures and follows the spirit of coordination, both European and global, we as APPEC have always been advocating. If desirable, we gladly provide any other further information to the reviewers Following a favourable assessment of the proposal, we look forward to participate in the planned coordination forum foreseen in the proposal.

Sincerely,

Stavros Katsanevas
APPEC Chairman

www.appec.org

Appendix 2: List of acronyms

AEAB	ASTERICS External Advisory Board
AEB	ASTERICS Executive Board
AGA	ASTERICS General Assembly
ALMA	Atacama Large Millimeter/submillimeter Array
AMST	ASTERICS Management Support Team
ANTARES	Astronomy with a Neutrino Telescope and Abyss environmental Research
APC	AstroParticule et Cosmologie
APPEC	AstroParticle Physics European Consortium
ASPERA	Astroparticle Physics European Research Area
ASTERICS	Astronomy ESFRI & Research Infrastructure Cluster
ASTRON	Netherlands Institute for Radio Astronomy
ASTRONET	An ERA-NET of European funding agencies for long-term planning in astronomy
Astro-WISE	Astronomical Wide-field Imaging System for Europe
CEA	Commissariat à l'Energie Atomique et aux Energies Alternatives
CLEOPATRA	Connect Locations of ESFRI Obs. & Partners in Astronomy for Timing & RT Alerts
CNRS	Centre National de la Recherche Scientifique
CPPM	Centre de Physique des Particules de Marseille
CTA	Cherenkov Telescope Array
CUDA	Compute Unified Device Architecture
DADI	Data Access, Discovery and Interoperability (WP4)
D-ANA	Data Analysis/interpretation
DECS	Dissemination, Engagement and Citizen Science
DESCA	Development of a Simplified Consortium Agreement
DESY	Deutsches Elektronen-Synchrotron
D-GEX	Data Generation and information Extraction
D-GIA	Data Generation, Integration & Analysis
D-INT	Data systems Integration
DiRAC	Distributed infrastructure with Remote Agent Control
DOME	ASTRON IBM Center for Exascale Computing
EAS	European Astronomical Society
E-ELT	European Extremely Large Telescope
EGEE	Enabling Grids for E-science
EGI	European Grid Infastructure
EGO	European Gravitational Observatory
ERA-NET	European Research Area Network
ERIC	European Research Infrastructure Consortium
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Southern Observatory
Euclid	ESA medium class astronomy and astrophysics space Mission
EUDAT	European Collaborative Data Infrastructure
EU-T0	Data Research and Innovation Hub (European Tier 0)
EURO-VO	European Virtual Observatory
e-VLBI	Electronic VLBI (see VLBI)
EXPReS	Express Production Real-time e-VLBI Service
FAU	Friedrich-Alexander Universität Erlangen Nürnberg
FITS	Flexible Image Transport System
FOM	Stichting Fundamenteel Onderzoek der Materie
GTD	GTD Systems & Software Engineering
HDF	Hierarchical Data Format
HESS	High Energy Stereoscopic System
IAP	Institut d'Astrophysique de Paris
IAU	International Astronomical Union
IceCube	South Pole neutrino observatory

IEEC	Institut d'Estudis Espacials de Catalunya (Institute for Space Studies of Catalonia)
IFAE	Instituto de Fisica de Altas Energias
INAF	Instituto Nazionale di AstroFisica
INFN	Instituto Nazionale di Fisica Nucleare
INTA	Instituto Nacional de Tecnica Aeroespacial
iRODS	Integrated Rule-Oriented Data System
IVOA	International Virtual Observatory Alliance
JIVE	Joint Institute for VLBI in Europe
KM	Knowledge Management
KM3-NeT	KM^3 Neutrino Telescope
LAPP	Laboratoire d'Annecy-le-Vieux de Physique des Particules
LEIT	Leadership in Enabling & Industrial Technologies
LIGO	Laser Interferometer Gravitational-wave Observatory
LOFAR	Low Frequency Array
LSST	Large Synoptic Survey Telescope
LUTH	Laboratoire de l'Univers et de ses Théories
MAGIC	Major Atmospheric Gamma-ray Imaging Cherenkov telescopes
MAUD	Management, User engagement and data Dissemination
MPE	Mass Participation Experiments
NEXPReS	Novel Explorations Pushing Robust e-VLBI Services
NIKHEF	Nationaal Instituut voor Kernfysica en Hoge-EnergieFysica
OAI-PMH	Open Archives Initiative Protocol for Metadata Harvesting
OAS	Observatoire Astronomique de Strasbourg
OASIS	Optically Adaptive System for Imaging Spectroscopy
OBELICS	Observatory E-environments Linked by Common Challenges
OBSPAR	Observatoire de Paris
OpenLDAP	Open Lightweight Directory Access Protocol
OU	Open University
PRACE	Partnership for Advanced Computing in Europe
PM	Person Month
RDA	Research Data Alliance
RI	Research Infrastructure
ROOT	Object-oriented program amd library developed by CERN
S&T	Science and Technology
SKA	Square Kilometre Array
STFC	Science & Technology Facilities Council
STW	Stichting voor de Technische Wetenschappen
SURFnet	subsidiary of Samenwerkende Universitaire Reken Faciliteiten
TERAPIX	Traitement Élémentaire, Réduction et Analyse des Pixels
UCAM	University of Cambridge
UCM	Universidad Complutense de Madrid
UEDIN	University of Edinburgh
UGR	Universidad de Granada
UHEI	Ruprecht-Karls-Universität Heidelberg
UNISTRA	Université de Strasbourg
UvA	Universiteit van Amsterdam (University of Amsterdam)
VERITAS	Very Energetic Radiation Imaging Telescope Array System
VIRGO	Interferometer for detection of Gravitational Waves
VLBI	Very Long Baseline Interferometry
VLT	Very Large Telescope
VO	Virtual Observatory
VU	Vrije Universiteit (Free University of Amsterdam)
WRE	White Rabbit Ethernet

Associated with document Ref. Ares(2015)1271239 - 23/03/2015

ESTIMATED BUDGET FOR THE ACTION (page 1 of 3)

	Estimated eligible[1] costs (per budget category)									EU contribution			Additional information		
	A. Direct personnel costs				B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs	E. Indirect costs[2]	F. Special unit costs	Total costs	Reimbursement rate %	Maximum EU contribution[3]	Maximum grant amount[4]	Information for indirect costs	Information for auditors	Other information:
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons [A.6 Personnel for providing access to research infrastructure]		A.4 SME owners without salary A.5 Beneficiaries that are natural persons without salary				D.1 Travel D.2 Equipment D.3 Other goods and services D.4 Costs of large research infrastructure		F. 1 "Costs for providing trans-national access to research infrastructure" **					Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving EU funding
Form of costs[6]	Actual	Unit[7]	Unit[8]		Actual	Actual	Actual	Flat-rate[9]	Unit[11]							
								25%								
	(a)	Total (b)	No hours	Total (c)	(d)	(e)	(f)	(g)=0,25x ((a)+(b)+ (c)+(f) +[(h1)+(h2)]- (m))	Total (h1)	(i)= (a)+(b)+(c)+ (d)+(e)+(f)+ (g)+(h1)+(h2)+(h3)	(j)	(k)	(l)	(m)	Yes/No	
1. ASTRON	1792904.00	0.00			0.00	0.00	323460.00	529091.00	0.00	2645455.00	100.00	2645455.00	2645455.00	0.00	No	
2. CNRS	2113500.00	0.00			300000.00	0.00	663660.00	694290.00	0.00	3771450.00	100.00	3771450.00	3771450.00	0.00	No	
- OBSPARIS[14]	160000.00	0.00			0.00	0.00	0.00	40000.00	0.00	200000.00	100.00	200000.00	200000.00	0.00	No	
- UNISTRA[14]	60000.00	0.00			0.00	0.00	0.00	15000.00	0.00	75000.00	100.00	75000.00	75000.00	0.00	No	
Total beneficiary 2	2333500.00	0.00			300000.00	0.00	663660.00	749290.00	0.00	4046450.00		4046450.00	4046450.00	0.00		
3. INAF	1011232.00	0.00			0.00	0.00	156200.00	291858.00	0.00	1459290.00	100.00	1459290.00	1459290.00	0.00	No	
4. UCAM	760000.00	0.00			0.00	0.00	87000.00	211750.00	0.00	1058750.00	100.00	1058750.00	1058750.00	0.00	No	
5. JIVE	528000.00	0.00			0.00	0.00	113020.00	160255.00	0.00	801275.00	100.00	801275.00	801275.00	0.00	No	
6. INTA	412500.00	0.00			0.00	0.00	150700.00	140800.00	0.00	704000.00	100.00	704000.00	704000.00	0.00	No	
7. UEDIN	412500.00	0.00			0.00	0.00	90700.00	125800.00	0.00	629000.00	100.00	629000.00	629000.00	0.00	No	
8. UHEI	412500.00	0.00			0.00	0.00	90700.00	125800.00	0.00	629000.00	100.00	629000.00	629000.00	0.00	No	
9. OU	155340.00	0.00			0.00	0.00	167197.00	62599.50	0.00	385136.50	100.00	385136.50	385136.50	72139.00	No	
10. FAU	240000.00	0.00			0.00	0.00	21000.00	65250.00	0.00	326250.00	100.00	326250.00	326250.00	0.00	No	
11. VU/VUmc	213000.00	0.00			0.00	0.00	2880.00	53970.00	0.00	269850.00	100.00	269850.00	269850.00	0.00	No	
12. CEA	0.00	180000.00			0.00	0.00	21000.00	50250.00	0.00	251250.00	100.00	251250.00	251250.00	0.00	No	
13. UVA	0.00	125932.00			0.00	0.00	960.00	31723.00	0.00	158615.00	100.00	158615.00	158615.00	0.00	No	
14. UGR	150000.00	0.00			0.00	0.00	2880.00	38220.00	0.00	191100.00	100.00	191100.00	191100.00	0.00	No	
15. FOM	175000.00	0.00			0.00	0.00	81920.00	64230.00	0.00	321150.00	100.00	321150.00	321150.00	0.00	No	
16. IEEC	79000.00	0.00			0.00	0.00	960.00	19990.00	0.00	99950.00	100.00	99950.00	99950.00	0.00	No	
- GTD[14]	75000.00	0.00	0.00	0.00	0.00	0.00	960.00	18990.00		94950.00	100.00	94950.00	94950.00	0.00	No	
Total beneficiary 16	154000.00	0.00	0.00	0.00	0.00	0.00	1920.00	38980.00	0.00	194900.00		194900.00	194900.00	0.00		
17. IFAE	120000.00	0.00			0.00	0.00	14000.00	33500.00	0.00	167500.00	100.00	167500.00	167500.00	0.00	No	
18. UCM	88000.00	0.00			40000.00	0.00	14000.00	25500.00	0.00	167500.00	100.00	167500.00	167500.00	0.00	No	
19. INFN	180000.00	0.00			0.00	0.00	21000.00	50250.00	0.00	251250.00	100.00	251250.00	251250.00	0.00	No	
20. STFC	90938.00	0.00			0.00	0.00	960.00	22974.50	0.00	114872.50	100.00	114872.50	114872.50	0.00	No	
21. DESY	108000.00	0.00			0.00	0.00	960.00	27240.00	0.00	136200.00	100.00	136200.00	136200.00	0.00	No	

ESTIMATED BUDGET FOR THE ACTION (page 2 of 3)

	Estimated eligible[1] costs (per budget category)										EU contribution			Additional information		
	A. Direct personnel costs				B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs	E. Indirect costs[2]	F. Special unit costs	Total costs	Reimbursement rate %	Maximum EU contribution[3]	Maximum grant amount[4]	Information for indirect costs	Information for auditors	Other information:
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons [A.6 Personnel for providing access to research infrastructure]		A.4 SME owners without salary A.5 Beneficiaries that are natural persons without salary				D.1 Travel D.2 Equipment D.3 Other goods and services D.4 Costs of large research infrastructure		F. 1 "Costs for providing trans-national access to research infrastructure" **					Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving EU funding
Form of costs[6]	Actual	Unit[7]	Unit[8]		Actual	Actual	Actual	Flat-rate[9]	Unit[11]							
								25%								
	(a)	Total (b)	No hours	Total (c)	(d)	(e)	(f)	(g)=0,25x ((a)+(b)+ (c)+(f) +[(h1)+(h2)]- (m))	Total (h1)	(i)= (a)+(b)+(c)+ (d)+(e)+(f)+ (g)+(h1)+(h2)+(h3)	(j)	(k)	(l)	(m)	Yes/No	
22. SURFnet	64960.00	0.00	0.00	0.00	0.00	0.00	960.00	16480.00	0.00	82400.00	100.00	82400.00	82400.00	0.00	No	
Total consortium	9402374.00	305932.00		0.00	340000.00	0.00	2027077.00	2915811.00	0.00	14991194.00		14991194.00	14991194.00	72139.00		0.00

ESTIMATED BUDGET FOR THE ACTION (page 3 of 3)

(1) See Article 6 for the eligibility conditions
(2) The indirect costs covered by the operating grant (received under any EU or Euratom funding programme; see Article 6.5.(b)) are ineligible under the GA. Therefore, a beneficiary that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant (see Article 6.2.E).
(3) This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission/Agency decided to grant for the action) (see Article 5.1).
(4) The 'maximum grant amount' is the maximum grant amount decided by the Commission/Agency. It normally corresponds to the requested grant, but may be lower.
(5) Depending on its type, this specific cost category will or will not cover indirect costs. Specific unit costs that include indirect costs are: costs for energy efficiency measures in buildings, access costs for providing trans-national access to research infrastructure and costs for clinical studies.
(6) See Article 5 for the forms of costs
(7) Unit : hours worked on the action; costs per unit (hourly rate) : calculated according to beneficiary's usual accounting practice
(8) See Annex 2a 'Additional information on the estimated budget' for the details (costs per hour (hourly rate)).
(9) Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs
(10) See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit).
(11) See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit, estimated number of units, etc)
(12) Only specific unit costs that do not include indirect costs
(13) See Article 9 for beneficiaries not receiving EU funding
(14) Only for linked third parties that receive EU funding

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS), 180089013, established in Rue Michel -Ange 3, PARIS 75794, France, FR40180089013, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘2’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Hélène NAFTALSKI with ECAS id nnaftahe signed in the Participant Portal on 22/05/2015 at 09:38:35 (transaction id SigId-325-hEFBmAPRzidHjne29HDVDt2OklZImX4xXxtXZ7t3ZzVNMollKh1LPwqzkZ5lZeyW8Ay39YTwx8ExvzzsMxiWWzkm-Jj71zxYb8yrdi8QXtrbBAm-qvuTYlALbbxzX9jeLGSjLDs07iY2h3KdsRm6LzqNpiG0). Timestamp by third party at
Fri May 22 10:38:55 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ISTITUTO NAZIONALE DI ASTROFISICA (INAF), 97220210583, established in Viale del Parco Mellini 84, ROMA 00136, Italy, IT06895721006, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘3’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

stefano BORGANI with ECAS id nborgast signed in the Participant Portal on 22/04/2015 at 20:22:20 (transaction id SigId-6159-FjZ9J0ZzsCub92ANNPDmCHlBRSATKDGtzk7NMwD2Xal0eBtcwozccOKPzoR6QSN4GzHeVQTTvzGCc7ajDMUmpaIW-Jj71zxYb8yrsWziRzxU0uBm-jSJpW4KcQUWo5lmfD6Zx71Di1ohw3oiUUPSoPKVEVIG). Timestamp by third party at
Wed Apr 22 21:22:25 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE (UCAM) GB12, established in The Old Schools, Trinity Lane, CAMBRIDGE CB2 1TN, United Kingdom, GB823847609, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘4’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Renata P. SCHAEFFER with ECAS id nschaert signed in the Participant Portal on 28/04/2015 at 12:05:18 (transaction id SigId-15274-Lzdne2tSODNNL50nNIqrNAhBMihzchu5Jp3Nuyzki1QqHIhzvew7S6L94KArFzfib4DZNzp0meLpjTxi0pkCwuPW-Jj71zxYb8yrsWziRzxU0uBm-hRDvvq7ZdXCzU3fxA7xp8tjmzZyWOrvnxp5Ffwl6ikom). Timestamp by third party at
Tue Apr 28 13:05:24 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

JOINT INSTITUTE FOR V.L.B.I. IN EUROPE (J.I.V.E.) (JIVE) NL6, 41020054, established in OUDE HOOGEVEENSEDIJK 4, DWINGELOO 7991 PD, Netherlands, na, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘5’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Huib VAN LANGEVELDE with ECAS id nvanlahu signed in the Participant Portal on 23/04/2015 at 11:07:16 (transaction id SigId-7299-r1KtsB3e8RbJkjRRtliUM3cd0pzSqaBZ6QzqozgnvzU3rqlxprVEBzrM0gXfsIOP1KsWhFv9uWXQNrZqluyLUil-Jj71zxYb8yrsWziRzxU0uBm-heQ3o8Qjm0zozSNyzY6ZilA57psCbmJQGkOokCEpLpn4). Timestamp by third party at Thu Apr 23 12:07:21 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTITUTO NACIONAL DE TECNICA AEROESPACIAL ESTEBAN TERRADAS (INTA), established in CR TORREJON AJALVIR KM 4 2, TORREJON DE ARDOZ MADRID 28850, Spain, ESQ2822003F, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘6’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Jose Maria SALOM with ECAS id nsalojse signed in the Participant Portal on 23/04/2015 at 10:47:50 (transaction id SigId-7205-BlGV9OQLXXtdNyyUkVezWsu3zmxwO0h0TnxdanFoNv8f7QAPIuvYy1dVOgvM8N1hCzUG2S8xdPzwErYiLcdFzsP-Jj71zxYb8yrsWziRzxU0uBm-aqxDbhR3gMIh80hXMYW4p3NgKgjzsFJE6ZXr9sFW9RC). Timestamp by third party at Thu Apr 23 11:47:59 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

THE UNIVERSITY OF EDINBURGH (UEDIN), SC005336, established in OLD COLLEGE, SOUTH BRIDGE, EDINBURGH EH8 9YL, United Kingdom, GB592950700, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘7’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Angela Noble with ECAS id nnoblean signed in the Participant Portal on 29/04/2015 at 10:59:03 (transaction id SigId-17534-Big1EcvuUYF2lCKa9ZAyC2IzLlO8dOpAPBVKM5ceabjmY59ldzN96HkSvq6gmzUAP2PZmSBRPVYySwXcN3SzyXK-Jj71zxYb8yrsWziRzxU0uBm-SH1uHqX1nou2SAseGxZkezbbzLktknjMdktZ5gTeDzl4). Timestamp by third party at Wed Apr 29 11:59:13 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

RUPRECHT-KARLS-UNIVERSITAET HEIDELBERG (UHEI), established in SEMINARSTRASSE 2, HEIDELBERG 69117, Germany, DE811225433, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary ('8')

in Grant Agreement No 653477 ('the Agreement')

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union ('the EU'), represented by the European Commission ('the Commission'),*

for the action entitled 'Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Norbert HUBER with ECAS id nhubernt signed in the Participant Portal on 23/04/2015 at 10:26:47 (transaction id SigId-7096-MefQ3GzuXBIuarALN9glczvBYE15ouTF3x8EbcwvurVzYF0daqFAuaHC8WTZ9FndRzHuA8eWG97eKzwXzQulyzYG-Jj71zxYb8yrsWziRzxU0uBm-u0XzbsWyPswK7xR3DNq5f1y9hlAFRtKxqzG3ZNrHtkTG). Timestamp by third party at
Thu Apr 23 11:26:52 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

THE OPEN UNIVERSITY (OU), RC000391, established in WALTON HALL, MILTON KEYNES MK7 6AA, United Kingdom, GB650748918, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘9’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Gemma MALDAR with ECAS id nmaldgmm signed in the Participant Portal on 27/04/2015 at 12:21:00 (transaction id SigId-132-SOGDNZK2sBY8f5EwD6MT8332uLNSFkSoSIuTsEAQH9dVcXdtSh8Hf4V OdTEqVOkuJgLzuKnAIAXMcm4hrV5Lou-PHslUMVSXYCActVGZGu4ya-3pG1MAcWRn1pTCKOwLeY4QBjJg8aGR3ZfZeULVOoT8e). Timestamp by third party at Mon Apr 27 13:21:05 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

FRIEDRICH-ALEXANDER-UNIVERSITAT ERLANGEN NURNBERG (FAU), none, established in SCHLOSSPLATZ 4, ERLANGEN 91054, Germany, DE132507686, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘10’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ulrike HOFFMANN with ECAS id nhofulri signed in the Participant Portal on 23/04/2015 at 11:00:32 (transaction id SigId-7268-uA9zsAa7ZvruukvPF8O2yeXbIZ1o0zy4LQCQzaSb727go3hQoOK8qGuzHUzamNdXQ60GLDR25H4mcu20ZE90zdC0-Jj71zxYb8yrsWziRzxU0uBm-J43rxRSEweLooUHmyG3dohY3vbgS9GtmjrqXb7yBJ0S). Timestamp by third party at
Thu Apr 23 12:00:38 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STICHTING VU-VUMC (VU/VUmc) NL6, 53815211, established in DE BOELELAAN 1105, AMSTERDAM 1081 HV, Netherlands, NL851029279B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘11’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Yvonne KOPS with ECAS id nkopsyon signed in the Participant Portal on 29/04/2015 at 08:18:41 (transaction id SigId-16851-dF0B01lHWrHqv5pNWJrzQvuaQ2MywqzXfQnswdw7Eq0G3uwvcCvAzbeDdtO8DqzbxRHDP4nw19d6q3puWfpUUlO-Jj71zxYb8yrsWziRzxU0uBm-32YFrUzyE03W2UpAPqVQCQzOzrzU58D81MfsAu3U2nc5). Timestamp by third party at Wed Apr 29 09:18:50 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA) EPIC, 775685019, established in RUE LEBLANC 25, PARIS 15 75015, France, FR43775685019, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘12’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Gaelle DECROIX with ECAS id ndecroga signed in the Participant Portal on 29/04/2015 at 08:01:19 (transaction id SigId-16795-V3UQJDq5nzzzhPNkvzuTM18xFZ6FI4liacNRCtdzxPPT2jynaAK2Ltc9vEZvAQsWJ9UbYbJGzG2kyOzc274Ls39K-Jj71zxYb8yrsWziRzxU0uBm-JMlKzYkg9X1fRCsGzkgfTziJnBTdt75g0lyTqYpCAHPK). Timestamp by third party at Wed Apr 29 09:01:31 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITEIT VAN AMSTERDAM (UVA), 34370207, established in SPUI 21, AMSTERDAM 1012WX, Netherlands, NL003240782B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘13’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Rudi RUST with ECAS id nrustrud signed in the Participant Portal on 07/05/2015 at 13:51:40 (transaction id SigId-2576-cyktwAOqIgU4B1hpZTU4Sn7uXlvAQ4zfwrJQfizIydvV78L7M1nVACKN TIKIxIUg4GxKujw5gzkzIXQi4wXBCKm-Jj71zxYb8yrdSFDAzJE3WI-G1zzIEvZaGQblytzVq7iP3WzoKTKuszN7xtPgWGHBHELm).
Timestamp by third party at
Thu May 07 14:51:52 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSIDAD DE GRANADA (UGR), established in CUESTA DEL HOSPICIO SN, GRANADA 18071, Spain, ESQ1818002F, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘14’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

María de los Dolores SUÁREZ ORTEGA with ECAS id nsuamria signed in the Participant Portal on 23/04/2015 at 08:35:49 (transaction id SigId-6499-HxNvJ50kSfK4yKOqd2gLPD5Lsr4nHHAT6mzoi4hzbUjufupVN5duVkzntmtwXyXBGX0zq43zmBBBAATzoUWQosdm-Jj71zxYb8yrsWziRzxU0uBm-Pwyd7oQ6hzMMHzvXamhqP2kU7GFznLcByK4nzvzVlwcHG). Timestamp by third party at
Thu Apr 23 09:35:54 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STICHTING VOOR FUNDAMENTEEL ONDERZOEK DER MATERIE - FOM (FOM) NL6, 41150068, established in Van Vollenhovenlaan 659, UTRECHT 3527 JP, Netherlands, NL002882243B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘15’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Arjen VAN RIJN with ECAS id nvanriar signed in the Participant Portal on 23/04/2015 at 11:44:21 (transaction id SigId-7462-s1M5Lbm8zpqQARbOf1TechAsxW3nDdjMgmtPXyjIQpFNH29hU9KMxlhzJPJaYZNVqhSyIVufToAU1Lf2HYv7xy-Jj71zxYb8yrsWziRzxU0uBm-G4JNPiGbzk59oRmy7HgCtKJDHUi1GcKzY6kNT1KvPrSG).
Timestamp by third party at
Thu Apr 23 12:44:25 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTITUT D'ESTUDIS ESPACIALS DE CATALUNYA FUNDACION (IEEC) ES3, 976, established in GRAN CAPITA 2-4 OESPATX 201, BARCELONA 08034, Spain, ESG61051710, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘16’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Jordi ISERN with ECAS id nisernji signed in the Participant Portal on 23/04/2015 at 09:13:30 (transaction id SigId-6674-09DzbzgrrMzIZzKifW3fkG0iywznojnRrkCDRRFKeuaP5GMBvFaKgY9V3XnHzGHZgtjZhlPFvQveECPcHPTiT1rm-Jj71zxYb8yrsWziRzxU0uBm-6XSb1X2HJhzNhqKJCYfgImmKDymoM2MzVf4F3zIauOqu).
Timestamp by third party at
Thu Apr 23 10:13:34 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTITUTO DE FISICA DE ALTAS ENERGIAS (IFAE), DOGC 1476 DEL 5/8/91 , established in CAMPUS DE BELLATERRA - UNIVERSIDAD AUTONOMA DE BARCELONA, CERDANYOLA DEL VALLES 08193, Spain, ESQ5856257J , ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘17’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ramon MIQUEL with ECAS id nmiquera signed in the Participant Portal on 23/04/2015 at 11:42:38 (transaction id SigId-7453-ukbwzzu9AlJCf3gHkWRpf2ZlbTSLcOdfBgoNnCdwTVlNpa1Q8zkbDzXO96pcxxpAhjhHYQbzYIgnpPbCgw1pZAw-Jj71zxYb8yrsWziRzxU0uBm-0Ww2PMCs5cLDzYItTVuV7B3s2Nhy82wcvLztKG6ffSd0). Timestamp by third party at Thu Apr 23 12:42:45 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSIDAD COMPLUTENSE DE MADRID (UCM), established in AVENIDA DE SENECA 2, MADRID 28040, Spain, ESQ2818014I, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘18’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Francisco TIRADO FERNANDEZ with ECAS id ntirafra signed in the Participant Portal on 23/04/2015 at 12:54:37 (transaction id SigId-7746-Jd98ezbohKVPAMKkFvm7BjMAqGznFuNM3V8Rva3U2zLF0ROmaCFi7Oa5l6TVM39NiMcRFLpN9AGZNPBzJFOcwMW-Jj71zxYb8yrsWziRzxU0uBm-zXWgfTnXjk0ChGETFlzywDOPBsl46VgiPjg8q5uzParm). Timestamp by third party at
Thu Apr 23 13:54:41 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ISTITUTO NAZIONALE DI FISICA NUCLEARE (INFN), 976596, established in Via Enrico Fermi 40, FRASCATI 00044, Italy, IT04430461006, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘19’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Giovanni LA RANA with ECAS id nranagio signed in the Participant Portal on 23/04/2015 at 10:42:46 (transaction id SigId-7180-giCtqvD6zYHkFusEG75CyfQ2PjuqysAghgUQs4zimdJu9IVuYV04FC63ijqclj4xMcvyWVyEGeFezvgKCMIYQZm-Jj71zxYb8yrsWziRzxU0uBm-zsYRmo4RCBAqbB59NA3qxizUR1QTI5p8a5ovouzIanWy). Timestamp by third party at Thu Apr 23 11:42:55 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SCIENCE AND TECHNOLOGY FACILITIES COUNCIL (STFC), RC000747, established in Polaris House North Star Avenue, SWINDON SN2 1SZ, United Kingdom, GB618367325, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘20’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Shelley DECKER with ECAS id ndeckesh signed in the Participant Portal on 23/04/2015 at 11:00:41 (transaction id SigId-7272-wu0E7SazPV2sfiL2lZpgN3jNOY2VVg1svVOj49cYzP0REnZkzIYfRED daf2lRcAaC1zr4ryp5MVECsKXrzxtAbK-Jj71zxYb8yrsWziRzxU0uBm-K7XmzT37ZpXXkFFyaT3EQDDaCe3P9tzzTgv5EmnTC13q). Timestamp by third party at Thu Apr 23 12:02:46 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STIFTUNG DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY (DESY) DE2, 922.16-35, established in NOTKESTRASSE 85, HAMBURG 22607, Germany, DE118714904, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘21’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ute KRELL with ECAS id nkrellut signed in the Participant Portal on 30/04/2015 at 08:30:04 (transaction id SigId-19142-D9dZkliakQkEBF4XOMnmsOs5GkzqMvemgKaMmiLSC9BaY2x5GzqOSsDIc1RvU67GZFQ9gPJ2yccgvsVK8m3Si0-Jj71zxYb8yrsWziRzxU0uBm-3PLs6bTcchYWVUU5TZuwsBMR2UZLgsTgR5Mj8XAda1C). Timestamp by third party at Thu Apr 30 09:30:16 CEST 2015

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SURFnet bv (SURFnet) BV, 30090777, established in MOREELSEPARK 48, UTRECHT 3511 EP, Netherlands, NL008960173B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary (‘22’)

in Grant Agreement No 653477 (‘the Agreement’)

between STICHTING ASTRON, NETHERLANDS INSTITUTE FOR RADIO ASTRONOMY **and** *the European Union (‘the EU’), represented by the European Commission ('the Commission'),*

for the action entitled ‘Astronomy ESFRI and Research Infrastructure Cluster (ASTERICS)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement the grant in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Erik HUIZER with ECAS id nhuizeer signed in the Participant Portal on 28/04/2015 at 21:44:14 (transaction id SigId-16594-MK0ElWHC4MbsFXEzPT5auwAfzVtY6DL1YSfzOkA2KqpL7gWcuCq2lJEPF9HzvYDiyYAekt0k3SPUuHp4V8SkZPm-Jj71zxYb8yrsWziRzxU0uBm-ztVBcKlrzzK7sGbAnaxgVGFMpEGuETOD12zyBQ3ixfvL). Timestamp by third party at
Tue Apr 28 22:44:19 CEST 2015

ⓘ print format A4 landscape

MODEL ANNEX 4 FOR H2020 GENERAL MGA — MULTI

FINANCIAL STATEMENT FOR *[BENEFICIARY [name]/ LINKED THIRD PARTY [name]]* FOR REPORTING PERIOD [reporting period]

	Eligible[1] costs (per budget category)											Receipts	EU contribution			Additional information
	A. Direct personnel costs				B. Direct costs of subcontracting	*[C. Direct costs of fin. support]*	D. Other direct costs		E. Indirect costs[2]	*[F. Costs of …]*		Total costs	Receipts	Reimbursement rate %	Maximum EU contribution[3]	Requested EU contribution	Information for indirect costs :
	A.1 Employees (or equivalent) A.2 Natural persons under direct contract A.3 Seconded persons *[A.6 Personnel for providing access to research infrastructure]*		A.4 SME owners without salary A.5 Beneficiaries that are natural persons without salary				D.1 Travel D.2 Equipment D.3 Other goods and services	*[D.4 Costs of large research infrastructure]*		*[F.1 Costs of …]*			Receipts of the action, to be reported in the last reporting period, according to Article 5.3.3				Costs of in-kind contributions not used on premises
Form of costs[4]	Actual	Unit	Unit		Actual	Actual	Actual	Actual	Flat-rate[5] 25%	Unit	Unit						
	a	Total b	No hours	Total c	d	*[e]*	f	*[g]*	h=0,25 x (a+b+ c+f+*[g]* + *[i1]*[6] +*[i2]*[6] - o)	No units	Total *[i1]*	Total *[i2]*	j = a+b+c+d+*[e]* +f +*[g]* +h+*[i1]* +*[i2]*	k	l	m	n	o
[short name beneficiary/linked third party]																	

The beneficiary/linked third party hereby confirms that:
The information provided is complete, reliable and true.
The costs declared are eligible (see Article 6).
The costs can be substantiated by adequate records and supporting documentation that will be produced upon request or in the context of checks, reviews, audits and investigations (see Articles 17, 18 and 22).
For the last reporting period: that all the receipts have been declared (see Article 5.3.3).

ⓘ Please declare all eligible costs, even if they exceed the amounts indicated in the estimated budget (see Annex 2). Only amounts that were declared in your individual financial statements can be taken into account lateron, in order to replace other costs that are found to be ineligible.

[1] See Article 6 for the eligibility conditions

[2] The indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.2.E). If you have received an operating grant during this reporting period, you cannot claim any indirect costs.

[3] This is the *theoretical* amount of EU contribution that the system calculates automatically (by multiplying the reimbursement rate by the total costs declared). The amount you request (in the column 'requested EU contribution') may have to be less (e.g. if you and the other beneficiaries are above budget, if the 90% limit (see Article 21) is reached, etc).

[4] See Article 5 for the form of costs

[5] Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs (see Article 6.2.E)

[6] Only specific unit costs that do not include indirect costs

ANNEX 5

MODEL FOR THE CERTIFICATE ON THE FINANCIAL STATEMENTS

- **For options [*in italics in square brackets*]: choose the applicable option. Options not chosen should be deleted.**
- **For fields in [grey in square brackets]: enter the appropriate data**

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Terms of Reference for an Independent Report of Factual Findings on costs declared under a Grant Agreement financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the '**Terms of Reference (ToR)**' under which

[OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')]

agrees to engage

[**insert legal name of the auditor**] ('the Auditor')

to produce an independent report of factual findings ('the Report') concerning the Financial Statement(s)[1] drawn up by the *[Beneficiary] [Linked Third Party]* for the Horizon 2020 grant agreement [insert number of the grant agreement, title of the action, acronym and duration from/to] ('the Agreement'), and

to issue a Certificate on the Financial Statements' ('CFS') referred to in Article 20.4 of the Agreement based on the compulsory reporting template stipulated by the Commission.

The Agreement has been concluded under the Horizon 2020 Research and Innovation Framework Programme (H2020) between the Beneficiary and *[OPTION 1: the European Union, represented by the European Commission ('the Commission')][OPTION 2: the European Atomic Energy Community (Euratom,) represented by the European Commission ('the Commission')][OPTION 3: the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] ('the Agency'), under the powers delegated by the European Commission ('the Commission').]*

[1] By which costs under the Agreement are declared (see template 'Model Financial Statements' in Annex 4 to the Grant Agreement).

The *[Commission] [Agency]* is mentioned as a signatory of the Agreement with the Beneficiary only. The *[European Union][Euratom][Agency]* is not a party to this engagement.

1.1 Subject of the engagement

The coordinator must submit to the *[Commission][Agency]* the final report within 60 days following the end of the last reporting period which should include, amongst other documents, a CFS for each beneficiary and for each linked third party that requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 20.4 of the Agreement). The CFS must cover all reporting periods of the beneficiary or linked third party indicated above.

The Beneficiary must submit to the coordinator the CFS for itself and for its linked third party(ies), if the CFS must be included in the final report according to Article 20.4 of the Agreement..

The CFS is composed of two separate documents:

- The Terms of Reference ('the ToR') to be signed by the *[Beneficiary] [Linked Third Party]* and the Auditor;
- The Auditor's Independent Report of Factual Findings ('the Report') to be issued on the Auditor's letterhead, dated, stamped and signed by the Auditor (or the competent public officer) which includes the agreed-upon procedures ('the Procedures') to be performed by the Auditor, and the standard factual findings ('the Findings') to be confirmed by the Auditor.

If the CFS must be included in the final report according to Article 20.4 of the Agreement, the request for payment of the balance relating to the Agreement cannot be made without the CFS. However, the payment for reimbursement of costs covered by the CFS does not preclude the *[Commission,][Agency,]* the European Anti-Fraud Office and the European Court of Auditors from carrying out checks, reviews, audits and investigations in accordance with Article 22 of the Agreement.

1.2 Responsibilities

The *[Beneficiary] [Linked Third Party]:*

- must draw up the Financial Statement(s) for the action financed by the Agreement in compliance with the obligations under the Agreement. The Financial Statement(s) must be drawn up according to the *[Beneficiary's] [Linked Third Party's]* accounting and book-keeping system and the underlying accounts and records;
- must send the Financial Statement(s) to the Auditor;
- is responsible and liable for the accuracy of the Financial Statement(s);
- is responsible for the completeness and accuracy of the information provided to enable the Auditor to carry out the Procedures. It must provide the Auditor with a written representation letter supporting these statements. The written representation letter must state the period covered by the statements and must be dated;
- accepts that the Auditor cannot carry out the Procedures unless it is given full access to the *[Beneficiary's] [Linked Third Party's]* staff and accounting as well as any other relevant records and documentation.

The Auditor:

- *[Option 1 by default:* is qualified to carry out statutory audits of accounting documents in accordance with Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts, amending Council Directives 78/660/EEC and 83/349/EEC and repealing Council Directive 84/253/EEC or similar national regulations*]*.
- *[Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer:* is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary*].*
- *[Option 3 if the Beneficiary or Linked Third Party is an international organisation:* is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation*].*

The Auditor:

- must be independent from the Beneficiary *[and the Linked Third Party]*, in particular, it must not have been involved in preparing the *[Beneficiary's] [Linked Third Party's]* Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with this ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the *[Beneficiary] [Linked Third Party]*.

The Commission sets out the Procedures to be carried out by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement, the Auditor does not provide an audit opinion or a statement of assurance.

1.3 Applicable Standards

The Auditor must comply with these Terms of Reference and with[2]:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the *[Commission][Agency]* requires that the Auditor also complies with the Code's independence requirements.

The Auditor's Report must state that there is no conflict of interests in establishing this Report between the Auditor and the Beneficiary *[and the Linked Third Party]*, and must specify - if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7).

Under Article 22 of the Agreement, the [*Commission*] [*Agency*], the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are declared from [*the European Union*] [*Euratom*] budget. This includes work related to this engagement. The Auditor must provide access to all working papers (e.g. recalculation of hourly rates, verification of the time declared for the action) related to this assignment if the *[Commission] [Agency]*, the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by *[*dd Month yyyy*]*.

[2] Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services ('ISRS') 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.

1.6 Other terms

[*The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor's fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.*]

[legal name of the Auditor]	[legal name of the *[Beneficiary][Linked Third Party]*]
[name & function of authorised representative]	[name & function of authorised representative]
[dd Month yyyy]	[dd Month yyyy]
Signature of the Auditor	Signature of the *[Beneficiary][Linked Third Party]*

Independent Report of Factual Findings on costs declared under Horizon 2020 Research and Innovation Framework Programme

(To be printed on the Auditor's letterhead)

To

[name of contact person(s)], [Position]

[[*Beneficiary's*] [*Linked Third Party's*] name]

[Address]

[dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with *[OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')],*

we

[name of the auditor] ('the Auditor'),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],

have carried out the procedures agreed with you regarding the costs declared in the Financial Statement(s)[3] of the *[Beneficiary] [Linked Third Party]* concerning the grant agreement

[insert grant agreement reference: number, title of the action and acronym] ('the Agreement'),

with a total cost declared of

[total amount] EUR,

and a total of actual costs and 'direct personnel costs declared as unit costs calculated in accordance with the [*Beneficiary's*] [*Linked Third Party's*] usual cost accounting practices' declared of

[sum of total actual costs and total direct personnel costs declared as unit costs calculated in accordance with the *[Beneficiary's] [Linked Third Party's]* usual cost accounting practices] EUR

and **hereby provide our Independent Report of Factual Findings ('the Report')** using the compulsory report format agreed with you.

The Report

Our engagement was carried out in accordance with the terms of reference ('the ToR') appended to this Report. The Report includes the agreed-upon procedures ('the Procedures') carried out and the standard factual findings ('the Findings') examined.

The Procedures were carried out solely to assist the [*Commission*] [*Agency*] in evaluating whether the [*Beneficiary's*] [*Linked Third Party's*] costs in the accompanying Financial Statement(s) were declared in accordance with the Agreement. The *[Commission] [Agency]* draws its own conclusions from the Report and any additional information it may require.

[3] By which the Beneficiary declares costs under the Agreement (see template 'Model Financial Statement' in Annex 4 to the Agreement).

The scope of the Procedures was defined by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence. Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, the Auditor does not give a statement of assurance on the Financial Statements.

Had the Auditor carried out additional procedures or an audit of the *[Beneficiary's] [Linked Third Party's]* Financial Statements in accordance with International Standards on Auditing or International Standards on Review Engagements, other matters might have come to its attention and would have been included in the Report.

Not applicable Findings

We examined the Financial Statement(s) stated above and considered the following Findings not applicable:

Explanation (to be removed from the Report):

*If a Finding was not applicable, it must be marked as '**N.A.**' ('Not applicable') in the corresponding row on the right-hand column of the table and means that the Finding did not have to be corroborated by the Auditor and the related Procedure(s) did not have to be carried out.*

The reasons of the non-application of a certain Finding must be obvious i.e.

i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable;

ii) if the condition set to apply certain Procedure(s) are not met the related Finding(s) and those Procedure(s) are not applicable. For instance, for 'beneficiaries with accounts established in a currency other than euro' the Procedure and Finding related to 'beneficiaries with accounts established in euro' are not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.

List here all Findings considered not applicable for the present engagement and explain the reasons of the non-applicability.

….

Exceptions

Apart from the exceptions listed below, the *[Beneficiary] [Linked Third Party]* provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and evaluate the Findings.

Explanation (to be removed from the Report):

- *If the Auditor was not able to successfully complete a procedure requested, it must be marked as '**E**' ('Exception') in the corresponding row on the right-hand column of the table. The reason such as the inability to reconcile key information or the unavailability of data that prevents the Auditor from carrying out the Procedure must be indicated below.*
- *If the Auditor cannot corroborate a standard finding after having carried out the corresponding procedure, it must also be marked as '**E**' ('Exception') and, where possible, the reasons why the Finding was not fulfilled and its possible impact must be explained here below.*

List here any exceptions and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, include the corresponding amount.

….

Example (to be removed from the Report):

1. *The Beneficiary was unable to substantiate the Finding number 1 on … because ….*
2. *Finding number 30 was not fulfilled because the methodology used by the Beneficiary to calculate unit costs was different from the one approved by the Commission. The differences were as follows: …*
3. *After carrying out the agreed procedures to confirm the Finding number 31, the Auditor found a difference of _____ EUR. The difference can be explained by …*

Further Remarks

In addition to reporting on the results of the specific procedures carried out, the Auditor would like to make the following general remarks:

Example (to be removed from the Report):

1. *Regarding Finding number 8 the conditions for additional remuneration were considered as fulfilled because …*
2. *In order to be able to confirm the Finding number 15 we carried out the following additional procedures: ….*

Use of this Report

This Report may be used only for the purpose described in the above objective. It was prepared solely for the confidential use of the *[Beneficiary] [Linked Third Party]* and the [*Commission*] [*Agency*], and only to be submitted to the [*Commission*] [*Agency*] in connection with the requirements set out in Article 20.4 of the Agreement. The Report may not be used by the *[Beneficiary] [Linked Third Party]* or by the [*Commission*] [*Agency*] for any other purpose, nor may it

be distributed to any other parties. The [*Commission*] [*Agency*] may only disclose the Report to authorised parties, in particular to the European Anti-Fraud Office (OLAF) and the European Court of Auditors.

This Report relates only to the Financial Statement(s) submitted to the *[Commission] [Agency]* by the *[Beneficiary] [Linked Third Party]* for the Agreement. Therefore, it does not extend to any other of the [*Beneficiary's*] [*Linked Third Party's*] Financial Statement(s).

There was no conflict of interest[4] between the Auditor and the Beneficiary *[and Linked Third Party]* in establishing this Report. The total fee paid to the Auditor for providing the Report was EUR _____ (including EUR_____ of deductible VAT).

We look forward to discussing our Report with you and would be pleased to provide any further information or assistance.

[legal name of the Auditor]

[name and function of an authorised representative]

[dd Month yyyy]

Signature of the Auditor

[4] A conflict of interest arises when the Auditor's objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:
- was involved in the preparation of the Financial Statements;
- stands to benefit directly should the certificate be accepted;
- has a close relationship with any person representing the beneficiary;
- is a director, trustee or partner of the beneficiary; or
- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.

Agreed-upon procedures to be performed and standard factual findings to be confirmed by the Auditor

The European Commission reserves the right to i) provide the auditor with additional guidance regarding the procedures to be followed or the facts to be ascertained and the way in which to present them (this may include sample coverage and findings) or to ii) change the procedures, by notifying the Beneficiary in writing. The procedures carried out by the auditor to confirm the standard factual finding are listed in the table below.

If this certificate relates to a Linked Third Party, any reference here below to 'the Beneficiary' is to be considered as a reference to 'the Linked Third Party'.

The 'result' column has three different options: 'C', 'E' and 'N.A.':

- 'C' stands for 'confirmed' and means that the auditor can confirm the 'standard factual finding' and, therefore, there is no exception to be reported.
- 'E' stands for 'exception' and means that the Auditor carried out the procedures but cannot confirm the 'standard factual finding', or that the Auditor was not able to carry out a specific procedure (e.g. because it was impossible to reconcile key information or data were unavailable),
- 'N.A.' stands for 'not applicable' and means that the Finding did not have to be examined by the Auditor and the related Procedure(s) did not have to be carried out. The reasons of the non-application of a certain Finding must be obvious i.e. i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable; ii) if the condition set to apply certain Procedure(s) are not met then the related Finding(s) and Procedure(s) are not applicable. For instance, for 'beneficiaries with accounts established in a currency other than the euro' the Procedure related to 'beneficiaries with accounts established in euro' is not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
A	**ACTUAL PERSONNEL COSTS AND UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICE**		

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	The Auditor draws a sample of persons whose costs were declared in the Financial Statement(s) to carry out the procedures indicated in the consecutive points of this section A. (*The sample should be selected randomly so that it is representative. Full coverage is required if there are fewer than 10 people (including employees, natural persons working under a direct contract and personnel seconded by a third party), otherwise the sample should have a minimum of 10 people, or 10% of the total, whichever number is the highest)* The Auditor sampled _____ people out of the total of _____ people.		
A.1	**PERSONNEL COSTS** <u>For the persons included in the sample and working under an employment contract or equivalent act (general procedures for individual actual personnel costs and personnel costs declared as unit costs)</u> To confirm standard factual findings 1-5 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary: ○ a list of the persons included in the sample indicating the period(s) during which they worked for the action, their position (classification or category) and type of contract; ○ the payslips of the employees included in the sample; ○ reconciliation of the personnel costs declared in the Financial Statement(s) with the accounting system (project accounting and general ledger) and payroll system; ○ information concerning the employment status and employment conditions of personnel included in the sample, in particular their employment contracts or equivalent;	1) The employees were i) directly hired by the Beneficiary in accordance with its national legislation, ii) under the Beneficiary's sole technical supervision and responsibility and iii) remunerated in accordance with the Beneficiary's usual practices.	
		2) Personnel costs were recorded in the Beneficiary's accounts/payroll system.	
		3) Costs were adequately supported and reconciled with the accounts and payroll	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ the Beneficiary's usual policy regarding payroll matters (e.g. salary policy, overtime policy, variable pay); ○ applicable national law on taxes, labour and social security and ○ any other document that supports the personnel costs declared. The Auditor also verified the eligibility of all components of the retribution (see Article 6 GA) and recalculated the personnel costs for employees included in the sample.	records.	
		4) Personnel costs did not contain any ineligible elements.	
		5) There were no discrepancies between the personnel costs charged to the action and the costs recalculated by the Auditor.	
	Further procedures if 'additional remuneration' is paid To confirm standard factual findings 6-9 listed in the next column, the Auditor: ○ reviewed relevant documents provided by the Beneficiary (legal form, legal/statutory obligations, the Beneficiary's usual policy on additional remuneration, criteria used for its calculation…); ○ recalculated the amount of additional remuneration eligible for the action based on the supporting documents received (full-time or part-time work, exclusive or non-exclusive dedication to the action, etc.) to arrive at the applicable FTE/year and pro-rata rate (see data collected in the course of carrying out the procedures under A.2 'Productive hours' and A.4 'Time recording system').	6) The Beneficiary paying "additional remuneration" was a non-profit legal entity.	
		7) The amount of additional remuneration paid corresponded to the Beneficiary's usual remuneration practices and was consistently paid whenever the same kind of work or expertise was required.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	IF ANY PART OF THE REMUNERATION PAID TO THE EMPLOYEE IS NOT MANDATORY ACCORDING TO THE NATIONAL LAW OR THE EMPLOYMENT CONTRACT ("ADDITIONAL REMUNERATION") AND IS ELIGIBLE UNDER THE PROVISIONS OF ARTICLE 6.2.A.1, THIS CAN BE CHARGED AS ELIGIBLE COST TO THE ACTION UP TO THE FOLLOWING AMOUNT: *(A) IF THE PERSON WORKS FULL TIME AND EXCLUSIVELY ON THE ACTION DURING THE FULL YEAR: UP TO EUR 8 000/YEAR;* *(B) IF THE PERSON WORKS EXCLUSIVELY ON THE ACTION BUT NOT FULL-TIME OR NOT FOR THE FULL YEAR: UP TO THE CORRESPONDING PRO-RATA AMOUNT OF EUR 8 000, OR* *(C) IF THE PERSON DOES NOT WORK EXCLUSIVELY ON THE ACTION: UP TO A PRO-RATA AMOUNT CALCULATED IN ACCORDANCE TO ARTICLE 6.2.A.1.*	8) The criteria used to calculate the additional remuneration were objective and generally applied by the Beneficiary regardless of the source of funding used.	
		9) The amount of additional remuneration included in the personnel costs charged to the action was capped at EUR 8,000 per FTE/year (up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).	
	Additional procedures in case "unit costs calculated by the Beneficiary in accordance with its usual cost accounting practices" is applied: Apart from carrying out the procedures indicated above to confirm standard factual findings 1-5 and, if applicable, also 6-9, the Auditor carried out following procedures to confirm standard factual findings 10-13 listed in the next column:	10) The personnel costs included in the Financial Statement were calculated in accordance with the Beneficiary's usual cost accounting practice. This methodology was consistently used in all H2020 actions.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ obtained a description of the Beneficiary's usual cost accounting practice to calculate unit costs;. ○ reviewed whether the Beneficiary's usual cost accounting practice was applied for the Financial Statements subject of the present CFS; ○ verified the employees included in the sample were charged under the correct category (in accordance with the criteria used by the Beneficiary to establish personnel categories) by reviewing the contract/HR-record or analytical accounting records; ○ verified that there is no difference between the total amount of personnel costs used in calculating the cost per unit and the total amount of personnel costs recorded in the statutory accounts; ○ verified whether actual personnel costs were adjusted on the basis of budgeted or estimated elements and, if so, verified whether those elements used are actually relevant for the calculation, objective and supported by documents.	11) The employees were charged under the correct category.	
		12) Total personnel costs used in calculating the unit costs were consistent with the expenses recorded in the statutory accounts.	
		13) Any estimated or budgeted element used by the Beneficiary in its unit-cost calculation were relevant for calculating personnel costs and corresponded to objective and verifiable information.	
	<u>For natural persons included in the sample and working with the Beneficiary under a direct contract other than an employment contract, such as consultants (no subcontractors).</u> To confirm standard factual findings 14-18 listed in the next column the Auditor reviewed following information/documents provided by the Beneficiary: ○ the contracts, especially the cost, contract duration, work description, place of work, ownership of the results and reporting obligations to the Beneficiary;	14) The natural persons reported to the Beneficiary (worked under the Beneficiary's instructions).	
		15) They worked on the Beneficiary's premises (unless otherwise agreed with the Beneficiary).	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ the employment conditions of staff in the same category to compare costs and; ○ any other document that supports the costs declared and its registration (e.g. invoices, accounting records, etc.).	16) The results of work carried out belong to the Beneficiary.	
		17) Their costs were not significantly different from those for staff who performed similar tasks under an employment contract with the Beneficiary.	
		18) The costs were supported by audit evidence and registered in the accounts.	
	<u>For personnel seconded by a third party and included in the sample (not subcontractors)</u> To confirm standard factual findings 19-22 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary: ○ their secondment contract(s) notably regarding costs, duration, work description, place of work and ownership of the results; ○ if there is reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution against payment): any documentation that supports the costs declared (e.g. contract, invoice, bank payment, and proof of registration in its accounting/payroll, etc.) and reconciliation of the Financial Statement(s) with the accounting system (project accounting and general ledger) as well as any proof that the amount invoiced by the third party did not include any profit;	19) Seconded personnel reported to the Beneficiary and worked on the Beneficiary's premises (unless otherwise agreed with the Beneficiary).	
		20) The results of work carried out belong to the Beneficiary.	
		If personnel is seconded against payment: 21) The costs declared were supported with documentation and recorded in the	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ if there is no reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution free of charge): a proof of the actual cost borne by the Third Party for the resource made available free of charge to the Beneficiary such as a statement of costs incurred by the Third Party and proof of the registration in the Third Party's accounting/payroll; ○ any other document that supports the costs declared (e.g. invoices, etc.).	Beneficiary's accounts. The third party did not include any profit.	
		If personnel is seconded free of charge: 22) The costs declared did not exceed the third party's cost as recorded in the accounts of the third party and were supported with documentation.	
A.2	**PRODUCTIVE HOURS** To confirm standard factual findings 23-28 listed in the next column, the Auditor reviewed relevant documents, especially national legislation, labour agreements and contracts and time records of the persons included in the sample, to verify that: ○ the annual productive hours applied were calculated in accordance with one of the methods described below, ○ the full-time equivalent (FTEs) ratios for employees not working full-time were correctly calculated.	23) The Beneficiary applied method [*choose one option and delete the others*] [**A**: 1720 hours] [**B**: the 'total number of hours worked'] [**C**: 'annual productive hours' used correspond to usual accounting practices]	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	If the Beneficiary applied method B, the auditor verified that the correctness in which the total number of hours worked was calculated and that the contracts specified the annual workable hours. If the Beneficiary applied method C, the auditor verified that the 'annual productive hours' applied when calculating the hourly rate were equivalent to at least 90 % of the 'standard annual workable hours'. The Auditor can only do this if the calculation of the standard annual workable hours can be supported by records, such as national legislation, labour agreements, and contracts. *BENEFICIARY'S PRODUCTIVE HOURS' FOR PERSONS WORKING FULL TIME SHALL BE ONE OF THE FOLLOWING METHODS:* ***A.*** *1720 ANNUAL PRODUCTIVE HOURS (PRO-RATA FOR PERSONS NOT WORKING FULL-TIME)* ***B.*** *THE TOTAL NUMBER OF HOURS WORKED BY THE PERSON FOR THE BENEFICIARY IN THE YEAR (THIS METHOD IS ALSO REFERRED TO AS 'TOTAL NUMBER OF HOURS WORKED' IN THE NEXT COLUMN). THE CALCULATION OF THE TOTAL NUMBER OF HOURS WORKED WAS DONE AS FOLLOWS: ANNUAL WORKABLE HOURS OF THE PERSON ACCORDING TO THE EMPLOYMENT CONTRACT, APPLICABLE LABOUR AGREEMENT OR NATIONAL LAW PLUS OVERTIME WORKED MINUS ABSENCES (SUCH AS SICK LEAVE OR SPECIAL LEAVE).*	24) Productive hours were calculated annually.	
		25) For employees not working full-time the full-time equivalent (FTE) ratio was correctly applied.	
		If the Beneficiary applied method B. 26) The calculation of the number of 'annual workable hours', overtime and absences was verifiable based on the documents provided by the Beneficiary.	
		If the Beneficiary applied method C. 27) The calculation of the number of 'standard annual workable hours' was verifiable based on the documents provided by the Beneficiary.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	C. THE STANDARD NUMBER OF ANNUAL HOURS GENERALLY APPLIED BY THE BENEFICIARY FOR ITS PERSONNEL IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES (THIS METHOD IS ALSO REFERRED TO AS 'TOTAL ANNUAL PRODUCTIVE HOURS' IN THE NEXT COLUMN). THIS NUMBER MUST BE AT LEAST 90% OF THE STANDARD ANNUAL WORKABLE HOURS. *'ANNUAL WORKABLE HOURS' MEANS THE PERIOD DURING WHICH THE PERSONNEL MUST BE WORKING, AT THE EMPLOYER'S DISPOSAL AND CARRYING OUT HIS/HER ACTIVITY OR DUTIES UNDER THE EMPLOYMENT CONTRACT, APPLICABLE COLLECTIVE LABOUR AGREEMENT OR NATIONAL WORKING TIME LEGISLATION.*	28) The 'annual productive hours' used for calculating the hourly rate were consistent with the usual cost accounting practices of the Beneficiary and were equivalent to at least 90 % of the 'annual workable hours'.	
A.3	**HOURLY PERSONNEL RATES** <u>I) For unit costs calculated in accordance to the Beneficiary's usual cost accounting practice (unit costs):</u> If the Beneficiary has a "Certificate on Methodology to calculate unit costs " (CoMUC) approved by the Commission, the Beneficiary provides the Auditor with a description of the approved methodology and the Commission's letter of acceptance. The Auditor verified that the Beneficiary has indeed used the methodology approved. If so, no further verification is necessary. If the Beneficiary does not have a "Certificate on Methodology" (CoMUC) approved by the	29) The Beneficiary applied [*choose one option and delete the other*]: [Option I: "Unit costs (hourly rates) were calculated in accordance with the Beneficiary's usual cost accounting practices"] [Option II: Individual hourly rates were applied]	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	Commission, or if the methodology approved was not applied, then the Auditor: o reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates; o recalculated the unit costs (hourly rates) of staff included in the sample following the results of the procedures carried out in A.1 and A.2. II) For individual hourly rates: The Auditor: o reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates; o recalculated the hourly rates of staff included in the sample following the results of the procedures carried out in A.1 and A.2. *"UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES":* *IT IS CALCULATED BY DIVIDING THE TOTAL AMOUNT OF PERSONNEL COSTS OF THE CATEGORY TO WHICH THE EMPLOYEE BELONGS VERIFIED IN LINE WITH PROCEDURE A.1 BY THE NUMBER OF FTE AND THE ANNUAL TOTAL PRODUCTIVE HOURS OF THE SAME CATEGORY CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH PROCEDURE A.2.* *HOURLY RATE FOR INDIVIDUAL ACTUAL PERSONAL COSTS:* *IT IS CALCULATED BY DIVIDING THE TOTAL AMOUNT OF PERSONNEL COSTS OF AN EMPLOYEE VERIFIED IN LINE WITH*	*For option I concerning unit costs and if the Beneficiary applies the methodology approved by the Commission (CoMUC):* 30) The Beneficiary used the Commission-approved methodology to calculate hourly rates. It corresponded to the organisation's usual cost accounting practices and was applied consistently for all activities irrespective of the source of funding.	
		For option I concerning unit costs and if the Beneficiary applies a methodology not approved by the Commission: 31) The unit costs re-calculated by the Auditor were the same as the rates applied by the Beneficiary.	
		For option II concerning individual hourly rates:	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	PROCEDURE A.1 BY THE NUMBER OF ANNUAL PRODUCTIVE HOURS VERIFIED IN LINE WITH PROCEDURE A.2.	32) The individual rates re-calculated by the Auditor were the same as the rates applied by the Beneficiary.	
A.4	**TIME RECORDING SYSTEM** To verify that the time recording system ensures the fulfilment of all minimum requirements and that the hours declared for the action were correct, accurate and properly authorised and supported by documentation, the Auditor made the following checks for the persons included in the sample that declare time as worked for the action on the basis of time records: o description of the time recording system provided by the Beneficiary (registration, authorisation, processing in the HR-system); o its actual implementation; o time records were signed at least monthly by the employees (on paper or electronically) and authorised by the project manager or another manager; o the hours declared were worked within the project period; o there were no hours declared as worked for the action if HR-records showed absence due to holidays or sickness (further cross-checks with travels are carried out in B.1 below) ;	33) All persons recorded their time dedicated to the action on a **daily/ weekly/ monthly** basis using a **paper/computer-based** system. (*delete the answers that are not applicable)*	
		34) Their time-records were authorised at least monthly by the project manager or other superior.	
		35) Hours declared were worked within the project period and were consistent with the presences/absences recorded in HR-records.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ the hours charged to the action matched those in the time recording system. *ONLY THE HOURS WORKED ON THE ACTION CAN BE CHARGED. ALL WORKING TIME TO BE CHARGED SHOULD BE RECORDED THROUGHOUT THE DURATION OF THE PROJECT, ADEQUATELY SUPPORTED BY EVIDENCE OF THEIR REALITY AND RELIABILITY (SEE SPECIFIC PROVISIONS BELOW FOR PERSONS WORKING EXCLUSIVELY FOR THE ACTION WITHOUT TIME RECORDS).*	36) There were no discrepancies between the number of hours charged to the action and the number of hours recorded.	
	<u>If the persons are working exclusively for the action and without time records</u> For the persons selected that worked exclusively for the action without time records, the Auditor verified evidence available demonstrating that they were in reality exclusively dedicated to the action and that the Beneficiary signed a declaration confirming that they have worked exclusively for the action.	37) The exclusive dedication is supported by a declaration signed by the Beneficiary's and by any other evidence gathered.	
B	**COSTS OF SUBCONTRACTING**		
B.1	**The Auditor obtained the detail/breakdown of subcontracting costs and sampled _____ cost items selected randomly** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest*). To confirm standard factual findings 38-42 listed in the next column, the Auditor reviewed the	38) The use of claimed subcontracting costs was foreseen in Annex 1 and costs were declared in the Financial Statements under the subcontracting category.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	following for the items included in the sample: o the use of subcontractors was foreseen in Annex 1; o subcontracting costs were declared in the subcontracting category of the Financial Statement; o supporting documents on the selection and award procedure were followed; o the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the subcontract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment). In particular, i. if the Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC or of Directive 2004/17/EC, the Auditor verified that the applicable national law on public procurement was followed and that the subcontracting complied with the Terms and Conditions of the Agreement. ii. if the Beneficiary did not fall under the above-mentioned category the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement..	39) There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. Subcontracts were awarded in accordance with the principle of best value for money. *(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the caption "Exceptions" of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)*	
	For the items included in the sample the Auditor also verified that: o the subcontracts were not awarded to other Beneficiaries in the consortium;	40) The subcontracts were not awarded to other Beneficiaries of the consortium.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	○ there were signed agreements between the Beneficiary and the subcontractor; ○ there was evidence that the services were provided by subcontractor;	41) All subcontracts were supported by signed agreements between the Beneficiary and the subcontractor.	
		42) There was evidence that the services were provided by the subcontractors.	
C	**COSTS OF PROVIDING FINANCIAL SUPPORT TO THIRD PARTIES**		
C.1	**The Auditor obtained the detail/breakdown of the costs of providing financial support to third parties and sampled _____ cost items selected randomly** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest*). The Auditor verified that the following minimum conditions were met: a) the maximum amount of financial support for each third party did not exceed EUR 60 000, unless explicitly mentioned in Annex 1; b) the financial support to third parties was agreed in Annex 1 of the Agreement and the other provisions on financial support to third parties included in Annex 1 were	43) All minimum conditions were met	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	respected.		

D	OTHER ACTUAL DIRECT COSTS		
D.1	**COSTS OF TRAVEL AND RELATED SUBSISTENCE ALLOWANCES** **The Auditor sampled _____ cost items selected randomly** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest*). The Auditor inspected the sample and verified that: ○ travel and subsistence costs were consistent with the Beneficiary's usual policy for travel. In this context, the Beneficiary provided evidence of its normal policy for travel costs (e.g. use of first class tickets, reimbursement by the Beneficiary on the basis of actual costs, a lump sum or per diem) to enable the Auditor to compare the travel costs charged with this policy; ○ travel costs are correctly identified and allocated to the action (e.g. trips are directly linked to the action) by reviewing relevant supporting documents such as minutes of meetings, workshops or conferences, their registration in the correct project account, their consistency with time records or with the dates/duration of the workshop/conference; ○ no ineligible costs or excessive or reckless expenditure was declared.	44) Costs were incurred, approved and reimbursed in line with the Beneficiary's usual policy for travels.	
		45) There was a link between the trip and the action.	
		46) The supporting documents were consistent with each other regarding subject of the trip, dates, duration and reconciled with time records and accounting.	
		47) No ineligible costs or excessive or reckless expenditure was declared.	
D.2	**DEPRECIATION COSTS FOR EQUIPMENT, INFRASTRUCTURE OR OTHER ASSETS** **The Auditor sampled _____ cost items selected randomly** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest*). For “equipment, infrastructure or other assets” [from now on called “asset(s)”] selected in the	48) Procurement rules, principles and guides were followed.	
		49) There was a link between the grant agreement and the asset charged to the action.	

	sample the Auditor verified that: ○ the assets were acquired in conformity with the Beneficiary's internal guidelines and procedures; ○ they were correctly allocated to the action (with supporting documents such as delivery note invoice or any other proof demonstrating the link to the action) ○ they were entered in the accounting system; ○ the extent to which the assets were used for the action (as a percentage) was supported by reliable documentation (e.g. usage overview table); The Auditor recalculated the depreciation costs and verified that they were in line with the applicable rules in the Beneficiary's country and with the Beneficiary's usual accounting policy (e.g. depreciation calculated on the acquisition value). The Auditor verified that no ineligible costs such as deductible VAT, exchange rate losses, excessive or reckless expenditure were declared (see Article 6.5 GA).	50) The asset charged to the action was traceable to the accounting records and the underlying documents. 51) The depreciation method used to charge the asset to the action was in line with the applicable rules of the Beneficiary's country and the Beneficiary's usual accounting policy. 52) The amount charged corresponded to the actual usage for the action. 53) No ineligible costs or excessive or reckless expenditure were declared.	
D.3	**COSTS OF OTHER GOODS AND SERVICES** **The Auditor sampled _____ cost items selected randomly** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest*). For the purchase of goods, works or services included in the sample the Auditor verified that: ○ the contracts did not cover tasks described in Annex 1;	54) Contracts for works or services did not cover tasks described in Annex 1. 55) Costs were allocated to the correct action and the goods were not placed in the inventory of durable equipment.	

	○ they were correctly identified, allocated to the proper action, entered in the accounting system (traceable to underlying documents such as purchase orders, invoices and accounting); ○ the goods were not placed in the inventory of durable equipment; ○ the costs charged to the action were accounted in line with the Beneficiary's usual accounting practices; ○ no ineligible costs or excessive or reckless expenditure were declared (see Article 6 GA). In addition, the Auditor verified that these goods and services were acquired in conformity with the Beneficiary's internal guidelines and procedures, in particular: ○ if Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC or of Directive 2004/17/EC, the Auditor verified that the applicable national law on public procurement was followed and that the procurement contract complied with the Terms and Conditions of the Agreement. ○ if the Beneficiary did not fall into the category above, the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement. For the items included in the sample the Auditor also verified that: ○ the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the contract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Auditor also verified that the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment); *SUCH GOODS AND SERVICES INCLUDE, FOR INSTANCE, CONSUMABLES AND SUPPLIES, DISSEMINATION (INCLUDING OPEN ACCESS), PROTECTION OF RESULTS, SPECIFIC EVALUATION OF THE ACTION IF IT IS REQUIRED BY THE*	56) The costs were charged in line with the Beneficiary's accounting policy and were adequately supported. 57) No ineligible costs or excessive or reckless expenditure were declared. For internal invoices/charges only the cost element was charged, without any mark-ups. 58) Procurement rules, principles and guides were followed. There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. The purchases were made in accordance with the principle of best value for money. *(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the*	

	AGREEMENT, CERTIFICATES ON THE FINANCIAL STATEMENTS IF THEY ARE REQUIRED BY THE AGREEMENT AND CERTIFICATES ON THE METHODOLOGY, TRANSLATIONS, REPRODUCTION.	*caption "Exceptions" of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)*	
D.4	**AGGREGATED CAPITALISED AND OPERATING COSTS OF RESEARCH INFRASTRUCTURE** The Auditor ensured the existence of a positive ex-ante assessment (issued by the EC Services) of the cost accounting methodology of the Beneficiary allowing it to apply the guidelines on direct costing for large research infrastructures in Horizon 2020. ***In the cases that a positive ex-ante assessment has been issued*** *(see the standard factual findings 59-60 on the next column)****,*** The Auditor ensured that the beneficiary has applied consistently the methodology that is explained and approved in the positive ex ante assessment; ***In the cases that a positive ex-ante assessment has NOT been issued*** *(see the standard factual findings 61 on the next column),* The Auditor verified that no costs of Large Research Infrastructure have been charged as direct costs in any costs category;	59) The costs declared as direct costs for Large Research Infrastructures (in the appropriate line of the Financial Statement) comply with the methodology described in the positive ex-ante assessment report. 60) Any difference between the methodology applied and the one positively assessed was extensively described and adjusted accordingly. 61) The direct costs declared were free from any indirect costs items related to the Large Research Infrastructure.	

	In the cases that a draft ex-ante assessment report has been issued with recommendation for further changes *(see the standard factual findings 61 on the next column),* • The Auditor followed the same procedure as above (when a positive ex-ante assessment has NOT yet been issued) and paid particular attention (testing reinforced) to the cost items for which the draft ex-ante assessment either rejected the inclusion as direct costs for Large Research Infrastructures or issued recommendations.		
E	**USE OF EXCHANGE RATES**		
E.1	a) For Beneficiaries with accounts established in a currency other than euros **The Auditor sampled _____ cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest)*: *COSTS INCURRED IN ANOTHER CURRENCY SHALL BE CONVERTED INTO EURO AT THE AVERAGE OF THE DAILY EXCHANGE RATES PUBLISHED IN THE C SERIES OF OFFICIAL JOURNAL OF THE EUROPEAN UNION (https://www.ecb.int/stats/exchange/eurofxref/html/index.en.html), DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.* *IF NO DAILY EURO EXCHANGE RATE IS PUBLISHED IN THE OFFICIAL JOURNAL OF THE EUROPEAN UNION FOR THE CURRENCY IN QUESTION, CONVERSION SHALL BE MADE AT THE AVERAGE OF THE MONTHLY ACCOUNTING RATES ESTABLISHED BY THE COMMISSION AND PUBLISHED ON ITS WEBSITE (http://ec.europa.eu/budget/contracts_grants/info_contracts/inforeuro/inforeuro_en.cfm),*	62) The exchange rates used to convert other currencies into Euros were in accordance with the rules established of the Grant Agreement and there was no difference in the final figures.	

	DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.		
	b) For Beneficiaries with accounts established in euros **The Auditor sampled _____ cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement** (*full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest)*: *COSTS INCURRED IN ANOTHER CURRENCY SHALL BE CONVERTED INTO EURO BY APPLYING THE BENEFICIARY'S USUAL ACCOUNTING PRACTICES.*	63) The Beneficiary applied its usual accounting practices.	

[legal name of the audit firm]

[name and function of an authorised representative]

[dd Month yyyy]

<Signature of the Auditor>

ANNEX 6

MODEL FOR THE CERTIFICATE ON THE METHODOLOGY

- **For options [*in italics in square brackets*]: choose the applicable option. Options not chosen should be deleted.**
- **For fields in [grey in square brackets]: enter the appropriate data.**

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Terms of reference for an audit engagement for a methodology certificate in connection with one or more grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the '**Terms of Reference (ToR)**' under which

[OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')]

agrees to engage

[**insert legal name of the auditor**] ('the Auditor')

to produce an independent report of factual findings ('the Report') concerning the *[Beneficiary's] [Linked Third Party's]* usual accounting practices for calculating and claiming direct personnel costs declared as unit costs ('the Methodology') in connection with grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme.

The procedures to be carried out for the assessment of the methodology will be based on the grant agreement(s) detailed below:

[title and number of the grant agreement(s)] ('the Agreement(s)')

The Agreement(s) has(have) been concluded between the Beneficiary and *[OPTION 1: the European Union, represented by the European Commission ('the Commission')][OPTION 2: the European Atomic Energy Community (Euratom,) represented by the European Commission ('the Commission')][OPTION 3: the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] ('the Agency'), under the powers delegated by the European Commission ('the Commission').]*.

The *[Commission] [Agency]* is mentioned as a signatory of the Agreement with the Beneficiary only. The *[European Union] [Euratom] [Agency]* is not a party to this engagement.

1.1 Subject of the engagement

According to Article 18.1.2 of the Agreement, beneficiaries *[and linked third parties]* that declare direct personnel costs as unit costs calculated in accordance with their usual cost accounting practices may submit to the *[Commission] [Agency]*, for approval, a certificate on the methodology ('CoMUC') stating that there are adequate records and documentation to prove that their cost accounting practices used comply with the conditions set out in Point A of Article 6.2.

The subject of this engagement is the CoMUC which is composed of two separate documents:

- the Terms of Reference ('the ToR') to be signed by the *[Beneficiary] [Linked Third Party]* and the Auditor;

- the Auditor's Independent Report of Factual Findings ('the Report') issued on the Auditor's letterhead, dated, stamped and signed by the Auditor which includes; the standard statements ('the Statements') evaluated and signed by the *[Beneficiary] [Linked Third Party]*, the agreed-upon procedures ('the Procedures') performed by the Auditor and the standard factual findings ('the Findings') assessed by the Auditor. The Statements, Procedures and Findings are summarised in the table that forms part of the Report.

The information provided through the Statements, the Procedures and the Findings will enable the Commission to draw conclusions regarding the existence of the *[Beneficiary's] [Linked Third Party's]* usual cost accounting practice and its suitability to ensure that direct personnel costs claimed on that basis comply with the provisions of the Agreement. The Commission draws its own conclusions from the Report and any additional information it may require.

1.2 Responsibilities

The parties to this agreement are the *[Beneficiary] [Linked Third Party]* and the Auditor.

The *[Beneficiary] [Linked Third Party]:*

- is responsible for preparing financial statements for the Agreement(s) ('the Financial Statements') in compliance with those Agreements;
- is responsible for providing the Financial Statement(s) to the Auditor and enabling the Auditor to reconcile them with the *[Beneficiary's] [Linked Third Party's]* accounting and bookkeeping system and the underlying accounts and records. The Financial Statement(s) will be used as a basis for the procedures which the Auditor will carry out under this ToR;
- is responsible for its Methodology and liable for the accuracy of the Financial Statement(s);
- is responsible for endorsing or refuting the Statements indicated under the heading 'Statements to be made by the Beneficiary/ Linked Third Party' in the first column of the table that forms part of the Report;
- must provide the Auditor with a signed and dated representation letter;
- accepts that the ability of the Auditor to carry out the Procedures effectively depends upon the *[Beneficiary] [Linked Third Party]* providing full and free access to the *[Beneficiary's] [Linked Third Party's]* staff and to its accounting and other relevant records.

The Auditor:

- *[Option 1 by default: is qualified to carry out statutory audits of accounting documents in accordance with Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts, amending Council Directives 78/660/EEC and 83/349/EEC and repealing Council Directive 84/253/EEC or similar national regulations]*.
- *[Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary]*.
- *[Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation]*.

The Auditor:

- must be independent from the Beneficiary *[and the Linked Third Party]*, in particular, it must not have been involved in preparing the Beneficiary's *[and Linked Third Party's]* Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with these ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the *[Beneficiary] [Linked Third Party]*.

The Commission sets out the Procedures to be carried out and the Findings to be endorsed by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement the Auditor does not provide an audit opinion or a statement of assurance.

1.3 Applicable Standards

The Auditor must comply with these Terms of Reference and with[1]:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the Commission requires that the Auditor also complies with the Code's independence requirements.

The Auditor's Report must state that there was no conflict of interests in establishing this Report between the Auditor and the Beneficiary *[and the Linked Third Party]* that could have a bearing on the Report, and must specify – if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7 of the Agreement).

Under Article 22 of the Agreement, the Commission, *[the Agency]*, the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are claimed from [*the European Union*] [*Euratom*] budget. This includes work related to this engagement. The Auditor must provide access to all working papers related to this assignment if the Commission*, [the Agency]*, the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by [dd Month yyyy].

[1] Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services ('ISRS') 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.

1.6 Other Terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor's fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor]	[legal name of the [Beneficiary] [Linked Third Party]]
[name & title of authorised representative]	[name & title of authorised representative]
[dd Month yyyy]	[dd Month yyyy]
Signature of the Auditor Signature	Signature of the *[Beneficiary] [Linked Third Party]*

Independent report of factual findings on the methodology concerning grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

(To be printed on letterhead paper of the auditor)

To

[name of contact person(s)], [Position]

[[Beneficiary's] [Linked Third Party's] name]

[Address]

[dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with *[OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')]*,

we

[name of the auditor] ('the Auditor'),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],

have carried out the agreed-upon procedures ('the Procedures') and provide hereby our Independent Report of Factual Findings ('the Report'), concerning the *[Beneficiary's] [Linked Third Party's]* usual accounting practices for calculating and declaring direct personnel costs declared as unit costs ('the Methodology').

You requested certain procedures to be carried out in connection with the grant(s)

[title and number of the grant agreement(s)] ('the Agreement(s)').

The Report

Our engagement was carried out in accordance with the terms of reference ('the ToR') appended to this Report. The Report includes: the standard statements ('the Statements') made by the *[Beneficiary] [Linked Third Party]*, the agreed-upon procedures ('the Procedures') carried out and the standard factual findings ('the Findings') confirmed by us.

The engagement involved carrying out the Procedures and assessing the Findings and the documentation requested appended to this Report, the results of which the Commission uses to draw conclusions regarding the acceptability of the Methodology applied by the *[Beneficiary] [Linked Third Party]*.

The Report covers the methodology used from [dd Month yyyy]. In the event that the *[Beneficiary] [Linked Third Party]* changes this methodology, the Report will not be applicable to any Financial Statement[2] submitted thereafter.

The scope of the Procedures and the definition of the standard statements and findings were determined solely by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence.

Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, we do not

[2] Financial Statement in this context refers solely to Annex 4 of the Agreement by which the Beneficiary declares costs under the Agreement.

give a statement of assurance on the costs declared on the basis of the *[Beneficiary's] [Linked Third Party's]* Methodology. Had we carried out additional procedures or had we performed an audit or review in accordance with these standards, other matters might have come to its attention and would have been included in the Report.

Exceptions

Apart from the exceptions listed below, the *[Beneficiary] [Linked Third Party]* agreed with the standard Statements and provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and corroborate the standard Findings.

List here any exception and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, also indicate the corresponding amount.

…..

Explanation of possible exceptions in the form of examples (to be removed from the Report):

i. the [Beneficiary] [Linked Third Party] did not agree with the standard Statement number … because…;

ii. the Auditor could not carry out the procedure … established because …. (e.g. due to the inability to reconcile key information or the unavailability or inconsistency of data);

iii. the Auditor could not confirm or corroborate the standard Finding number … because ….

Remarks

We would like to add the following remarks relevant for the proper understanding of the Methodology applied by the [Beneficiary] [Linked Third Party] or the results reported:

Example (to be removed from the Report):

Regarding the methodology applied to calculate hourly rates …

Regarding standard Finding 15 it has to be noted that …

The [Beneficiary] [Linked Third Party] explained the deviation from the benchmark statement XXIV concerning time recording for personnel with no exclusive dedication to the action in the following manner: …

Annexes

Please provide the following documents to the auditor and annex them to the report when submitting this CoMUC to the Commission:

1. Brief description of the methodology for calculating personnel costs, productive hours and hourly rates;
2. Brief description of the time recording system in place;
3. An example of the time records used by the [*Beneficiary] [Linked Third Party*];
4. Description of any budgeted or estimated elements applied, together with an explanation as to why they are relevant for calculating the personnel costs and how they are based on objective and verifiable information;
5. A summary sheet with the hourly rate for direct personnel declared by the [*Beneficiary*] [*Linked Third Party*] and recalculated by the Auditor for each staff member included in the sample (the names do not need to be reported);
6. A comparative table summarising for each person selected in the sample a) the time claimed by the [*Beneficiary*] [*Linked Third Party*] in the Financial Statement(s) and b) the time according to the time record verified by the Auditor;
7. A copy of the letter of representation provided to the Auditor.

Use of this Report

This Report has been drawn up solely for the purpose given under Point 1.1 Reasons for the engagement.

The Report:

- is confidential and is intended to be submitted to the Commission by the [*Beneficiary*] [*Linked Third Party*] in connection with Article 18.1.2 of the Agreement;
- may not be used by the [*Beneficiary*] [*Linked Third Party*] or by the Commission for any other purpose, nor distributed to any other parties;
- may be disclosed by the Commission only to authorised parties, in particular the European Anti-Fraud Office (OLAF) and the European Court of Auditors.
- relates only to the usual cost accounting practices specified above and does not constitute a report on the Financial Statements of the [*Beneficiary*] [*Linked Third Party*].

No conflict of interest[3] exists between the Auditor and the Beneficiary *[and the Linked Third Party*] that could have a bearing on the Report. The total fee paid to the Auditor for producing the Report was EUR _____ (including EUR _____ of deductible VAT).

[3] A conflict of interest arises when the Auditor's objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:

- was involved in the preparation of the Financial Statements;

We look forward to discussing our Report with you and would be pleased to provide any further information or assistance which may be required.

Yours sincerely

[legal name of the Auditor]

[name and title of the authorised representative]

[dd Month yyyy]

Signature of the Auditor

- stands to benefit directly should the certificate be accepted;

- has a close relationship with any person representing the beneficiary;

- is a director, trustee or partner of the beneficiary; or

- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.

Statements to be made by the Beneficiary/Linked Third Party ('the Statements') and Procedures to be carried out by the Auditor ('the Procedures') and standard factual findings ('the Findings') to be confirmed by the Auditor

The Commission reserves the right to provide the auditor with guidance regarding the Statements to be made, the Procedures to be carried out or the Findings to be ascertained and the way in which to present them. The Commission reserves the right to vary the Statements, Procedures or Findings by written notification to the Beneficiary/Linked Third Party to adapt the procedures to changes in the grant agreement(s) or to any other circumstances.

If this methodology certificate relates to the Linked Third Party's usual accounting practices for calculating and claiming direct personnel costs declared as unit costs any reference here below to 'the Beneficiary' is to be considered as a reference to 'the Linked Third Party'.

Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	**Procedures to be carried out and Findings to be confirmed by the Auditor**
A. Use of the Methodology I. The cost accounting practice described below has been in use since *[*dd Month yyyy*]*. II. The next planned alteration to the methodology used by the Beneficiary will be from [dd Month yyyy*]*.	**Procedure:** ✓ The Auditor checked these dates against the documentation the Beneficiary has provided. **Factual finding:** 1. The dates provided by the Beneficiary were consistent with the documentation.
B. Description of the Methodology III. The methodology to calculate unit costs is being used in a consistent manner and is reflected in the relevant procedures. *[Please describe the methodology your entity uses to calculate personnel costs, productive hours and hourly rates, present your description to the Auditor and annex it to this certificate]* *[If the statement of section "B. Description of the methodology" cannot be endorsed by the Beneficiary or there is no written methodology to calculate unit costs it should be listed here below and reported as exception by the Auditor in the main Report of*	**Procedure:** ✓ The Auditor reviewed the description, the relevant manuals and/or internal guidance documents describing the methodology. **Factual finding:** 2. The brief description was consistent with the relevant manuals, internal guidance and/or other documentary evidence the Auditor has reviewed. 3. The methodology was generally applied by the Beneficiary as part of its usual costs accounting practices.

Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	**Procedures to be carried out and Findings to be confirmed by the Auditor**
Factual Findings: - *…]*	
C. **Personnel costs** <u>General</u> IV. The unit costs (hourly rates) are limited to salaries including during parental leave, social security contributions, taxes and other costs included in the remuneration required under national law and the employment contract or equivalent appointing act; V. Employees are hired directly by the Beneficiary in accordance with national law, and work under its sole supervision and responsibility; VI. The Beneficiary remunerates its employees in accordance with its usual practices. This means that personnel costs are charged in line with the Beneficiary's usual payroll policy (e.g. salary policy, overtime policy, variable pay) and no special conditions exist for employees assigned to tasks relating to the European Union or Euratom, unless explicitly provided for in the grant agreement(s); VII. The Beneficiary allocates its employees to the relevant group/category/cost centre for the purpose of the unit cost calculation in line with the usual cost accounting practice; VIII. Personnel costs are based on the payroll system and accounting system. IX. Any exceptional adjustments of actual personnel costs resulted from relevant budgeted or estimated elements and were based on objective and verifiable information. *[Please describe the 'budgeted or estimated elements' and their relevance to personnel costs, and explain how they were reasonable and based on objective and verifiable information, present your explanation to the Auditor and annex it to this certificate].* X. Personnel costs claimed do not contain any of the following ineligible costs: costs related to return on capital; debt and debt service charges; provisions for future losses	**Procedure:** *The Auditor draws a sample of employees to carry out the procedures indicated in this section C and the following sections D to F.* *[The Auditor has drawn a random sample of 10 full-time equivalents made up of employees assigned to the action(s). If fewer than 10 full-time equivalents are assigned to the action(s), the Auditor has selected a sample of 10 full-time equivalents consisting of all employees assigned to the action(s), complemented by other employees irrespective of their assignments.].* For this sample: ✓ the Auditor reviewed all documents relating to personnel costs such as employment contracts, payslips, payroll policy (e.g. salary policy, overtime policy, variable pay policy), accounting and payroll records, applicable national tax , labour and social security law and any other documents corroborating the personnel costs claimed; ✓ in particular, the Auditor reviewed the employment contracts of the employees in the sample to verify that: i. they were employed directly by the Beneficiary in accordance with applicable national legislation; ii. they were working under the sole technical supervision and responsibility of the latter; iii. they were remunerated in accordance with the Beneficiary's usual practices; iv. they were allocated to the correct group/category/cost centre for the purposes of calculating the unit cost in line with the Beneficiary's usual cost accounting practices; ✓ the Auditor verified that any ineligible items or any costs claimed under other costs categories or costs covered by other types of grant or by other grants financed from the European Union budget have not been taken

Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	**Procedures to be carried out and Findings to be confirmed by the Auditor**
or debts; interest owed; doubtful debts; currency exchange losses; bank costs charged by the Beneficiary's bank for transfers from the Commission/Agency; excessive or reckless expenditure; deductible VAT or costs incurred during suspension of the implementation of the action. XI. Personnel costs were not declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU budget and grants awarded by bodies other than the Commission/Agency for the purpose of implementing the EU budget). <u>If additional remuneration as referred to in the grant agreement(s) is paid</u> XII. The Beneficiary is a non-profit legal entity; XIII. The additional remuneration is part of the beneficiary's usual remuneration practices and paid consistently whenever the relevant work or expertise is required; XIV. The criteria used to calculate the additional remuneration are objective and generally applied regardless of the source of funding; XV. The additional remuneration included in the personnel costs used to calculate the hourly rates for the grant agreement(s) is capped at EUR 8 000 per full-time equivalent (reduced proportionately if the employee is not assigned exclusively to the action). *[If certain statement(s) of section "C. Personnel costs" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor in the main Report of*	into account when calculating the personnel costs; ✓ the Auditor numerically reconciled the total amount of personnel costs used to calculate the unit cost with the total amount of personnel costs recorded in the statutory accounts and the payroll system. ✓ to the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, the Auditor carefully examined those elements and checked the information source to confirm that they correspond to objective and verifiable information; ✓ if additional remuneration has been claimed, the Auditor verified that the Beneficiary was a non-profit legal entity, that the amount was capped at EUR 8 000 per full-time equivalent and that it was reduced proportionately for employees not assigned exclusively to the action(s). ✓ the Auditor recalculated the personnel costs for the employees in the sample. **Factual finding:** 4. All the components of the remuneration that have been claimed as personnel costs are supported by underlying documentation. 5. The employees in the sample were employed directly by the Beneficiary in accordance with applicable national law and were working under its sole supervision and responsibility. 6. Their employment contracts were in line with the Beneficiary's usual policy; 7. Personnel costs were duly documented and consisted solely of salaries, social security contributions (pension contributions, health insurance, unemployment fund contributions, etc.), taxes and other statutory costs included in the remuneration (holiday pay, thirteenth month's pay, etc.); 8. The totals used to calculate the personnel unit costs are consistent with those registered in the payroll and accounting records; 9. To the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, those elements were

Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	**Procedures to be carried out and Findings to be confirmed by the Auditor**
Factual Findings: - *…]*	relevant for calculating the personnel costs and correspond to objective and verifiable information. The budgeted or estimated elements used are: — (indicate the elements and their values). 10. Personnel costs contained no ineligible elements; 11. Specific conditions for eligibility were fulfilled when additional remuneration was paid: a) the Beneficiary is registered in the grant agreements as a non-profit legal entity; b) it was paid according to objective criteria generally applied regardless of the source of funding used and c) remuneration was capped at EUR 8000 per full-time equivalent (or up to up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).
D. Productive hours XVI. The number of productive hours per full-time employee applied is *[delete as appropriate]*: A. 1720 productive hours per year for a person working full-time (corresponding pro-rata for persons not working full time). B. the total number of hours worked in the year by a person for the Beneficiary C. the standard number of annual hours generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the standard annual workable hours. <u>If method B is applied</u> XVII. The calculation of the total number of hours worked was done as follows: annual workable hours of the person according to the employment contract, applicable labour agreement or national law plus overtime worked minus absences (such as sick leave and special leave). XVIII. 'Annual workable hours' are hours	**Procedure (same sample basis as for Section C: Personnel costs):** ✓ The Auditor verified that the number of productive hours applied is in accordance with method A, B or C. ✓ The Auditor checked that the number of productive hours per full-time employee is correct and that it is reduced proportionately for employees not exclusively assigned to the action(s). ✓ If method B is applied the Auditor verified i) the manner in which the total number of hours worked was done and ii) that the contract specified the annual workable hours by inspecting all the relevant documents, national legislation, labour agreements and contracts. ✓ If method C is applied the Auditor reviewed the manner in which the standard number of working hours per year has been calculated by inspecting all the relevant documents, national legislation, labour agreements and contracts and verified that the number of productive hours per year used for these calculations was at least 90% of the standard number of working hours per year.

Please explain any discrepancies in the body of the Report.	
Statements to be made by Beneficiary	**Procedures to be carried out and Findings to be confirmed by the Auditor**
during which the personnel must be working, at the employer's disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation. XIX. The contract (applicable collective labour agreement or national working time legislation) do specify the working time enabling to calculate the annual workable hours. <u>If method C is applied</u> XX. The standard number of productive hours per year is that of a full-time equivalent; for employees not assigned exclusively to the action(s) this number is reduced proportionately. XXI. The number of productive hours per year on which the hourly rate is based i) corresponds to the Beneficiary's usual accounting practices; ii) is at least 90% of the standard number of workable (working) hours per year. XXII. Standard workable (working) hours are hours during which personnel are at the Beneficiary's disposal preforming the duties described in the relevant employment contract, collective labour agreement or national labour legislation. The number of standard annual workable (working) hours that the Beneficiary claims is supported by labour contracts, national legislation and other documentary evidence. *[If certain statement(s) of section "D. Productive hours" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:* - *…]*	**Factual finding:** <u>General</u> 12. The Beneficiary applied a number of productive hours consistent with method A, B or C detailed in the left-hand column. 13. The number of productive hours per year per full-time employee was accurate and was proportionately reduced for employees not working full-time or exclusively for the action. <u>If method B is applied</u> 14. The number of 'annual workable hours', overtime and absences was verifiable based on the documents provided by the Beneficiary and the calculation of the total number of hours worked was accurate. 15. The contract specified the working time enabling to calculate the annual workable hours. <u>If method C is applied</u> 16. The calculation of the number of productive hours per year corresponded to the usual costs accounting practice of the Beneficiary. 17. The calculation of the standard number of workable (working) hours per year was corroborated by the documents presented by the Beneficiary. 18. The number of productive hours per year used for the calculation of the hourly rate was at least 90% of the number of workable (working) hours per year.
E. Hourly rates The hourly rates are correct because: XXIII. Hourly rates are correctly calculated since they result from dividing annual personnel	**Procedure** ✓ The Auditor has obtained a list of all personnel rates calculated by the Beneficiary in accordance with the methodology used. ✓ The Auditor has obtained a list of all the relevant employees, based on which the

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costs by the productive hours of a given year and group (e.g. staff category or department or cost centre depending on the methodology applied) and they are in line with the statements made in section C. and D. above. *[If the statement of section 'E. Hourly rates' cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:* - *…]*	personnel rate(s) are calculated. For 10 full-time equivalent employees selected at random (same sample basis as Section C: Personnel costs): ✓ The Auditor recalculated the hourly rates. ✓ The Auditor verified that the methodology applied corresponds to the usual accounting practices of the organisation and is applied consistently for all activities of the organisation on the basis of objective criteria irrespective of the source of funding. **Factual finding:** 19. No differences arose from the recalculation of the hourly rate for the employees included in the sample.
F. Time recording XXIV. Time recording is in place for all persons with no exclusive dedication to one Horizon 2020 action. At least all hours worked in connection with the grant agreement(s) are registered on a **daily/weekly/monthly** basis *[delete as appropriate]* using a **paper/computer-based system** *[delete as appropriate]*; XXV. For persons exclusively assigned to one Horizon 2020 activity the Beneficiary has either signed a declaration to that effect or has put arrangements in place to record their working time; XXVI. Records of time worked have been signed by the person concerned (on paper or electronically) and approved by the action manager or line manager at least monthly; XXVII. Measures are in place to prevent staff from: i. recording the same hours twice, ii. recording working hours during absence periods (e.g. holidays, sick leave), iii. recording more than the number of productive hours per year used to calculate the hourly rates, and	**Procedure** ✓ The Auditor reviewed the brief description, all relevant manuals and/or internal guidance describing the methodology used to record time. The Auditor reviewed the time records of the random sample of 10 full-time equivalents referred to under Section C: Personnel costs, and verified in particular: ✓ that time records were available for all persons with not exclusive assignment to the action; ✓ that time records were available for persons working exclusively for a Horizon 2020 action, or, alternatively, that a declaration signed by the Beneficiary was available for them certifying that they were working exclusively for a Horizon 2020 action; ✓ that time records were signed and approved in due time and that all minimum requirements were fulfilled; ✓ that the persons worked for the action in the periods claimed; ✓ that no more hours were claimed than the productive hours used to calculate the hourly

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iv. recording hours worked outside the action period. XXVIII. No working time was recorded outside the action period; XXIX. No more hours were claimed than the productive hours used to calculate the hourly personnel rates. *[Please provide a brief description of the time recording system in place together with the measures applied to ensure its reliability to the Auditor and annex it to the present certificate[4]].* *[If certain statement(s) of section "F. Time recording" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:* *- …]*	personnel rates; ✓ that internal controls were in place to prevent that time is recorded twice, during absences for holidays or sick leave; that more hours are claimed per person per year for Horizon 2020 actions than the number of productive hours per year used to calculate the hourly rates; that working time is recorded outside the action period; ✓ the Auditor cross-checked the information with human-resources records to verify consistency and to ensure that the internal controls have been effective. In addition, the Auditor has verified that no more hours were charged to Horizon 2020 actions per person per year than the number of productive hours per year used to calculate the hourly rates, and verified that no time worked outside the action period was charged to the action. **Factual finding:** 20. The brief description, manuals and/or internal guidance on time recording provided by the Beneficiary were consistent with management reports/records and other documents reviewed and were generally applied by the Beneficiary to produce the financial statements. 21. For the random sample time was recorded or, in the case of employees working exclusively for the action, either a signed declaration or time records were available; 22. For the random sample the time records were signed by the employee and the action manager/line manager, at least monthly. 23. Working time claimed for the action occurred in the periods claimed; 24. No more hours were claimed than the number productive hours used to calculate the hourly

[4] The description of the time recording system must state among others information on the content of the time records, its coverage (full or action time-recording, for all personnel or only for personnel involved in H2020 actions), its degree of detail (whether there is a reference to the particular tasks accomplished), its form, periodicity of the time registration and authorisation (paper or a computer-based system; on a daily, weekly or monthly basis; signed and countersigned by whom), controls applied to prevent double-charging of time or ensure consistency with HR-records such as absences and travels as well as it information flow up to its use for the preparation of the Financial Statements.

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	personnel rates; 25. There is proof that the Beneficiary has checked that working time has not been claimed twice, that it is consistent with absence records and the number of productive hours per year, and that no working time has been claimed outside the action period. 26. Working time claimed is consistent with that on record at the human-resources department.

[official name of the** [Beneficiary] [Linked Third Party]**]	***[official name of the Auditor]***
[name and title of authorised representative]	***[name and title of authorised representative]***
[dd Month yyyy]	***[dd Month yyyy]***
<Signature of the** [Beneficiary] [Linked Third Party]**>	***<Signature** of the Auditor**>***

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