
# PROTEC-1-2014: Space Weather

Grant agreement for: Research and Innovation action

## *Grant Agreement*

Action acronym: PROGRESS

Action full title: "Prediction of Geospace Radiation Environment and solar wind parameters"

Grant agreement no: 637302

**EUROPEAN COMMISSION**
Research Executive Agency (REA)

**Director**

# GRANT AGREEMENT

## NUMBER — 637302 — PROGRESS

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

**on the one part,**

*the **Research Executive Agency (REA)** ('the Agency'), under the power delegated by the European Commission ('the Commission')*[1],

represented for the purposes of signature of this Agreement by Christine BERNOT,

**and**

**on the other part,**

1. 'the coordinator':

**THE UNIVERSITY OF SHEFFIELD (USFD)**, RC000667, established in FIRTH COURT WESTERN BANK, SHEFFIELD S10 2TN, United Kingdom, GB648238808, represented for the purposes of signing the Agreement by Head of Research Development, Justine DANIELS

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

2. **ILMATIETEEN LAITOS (FMI)**, 02446647, established in Erik Palmenin aukio 1, HELSINKI 00560, Finland, FI02446647,

3. **THE UNIVERSITY OF WARWICK (UW)**, N/A, established in Kirby Corner Road - University House, COVENTRY CV4 8UW, United Kingdom, GB545270058,

4. **SKOLKOVO INSTITUTE OF SCIENCE AND TECHNOLOGY (Skoltech)** RU5, 1115000005922, established in NOYANA STR 100, Moscow 143025, Russian Federation, RU5032998454,

5. **UNIVERSITY OF MICHIGAN THE REGENTS OF THE UNIVERSITY OF MICHIGAN (UM)**, 386006309 , established in SOUTH STREET 3003 1068, ANN ARBOR 46109 1274, United States,

6. **SPACE RESEARCH INSTITUTE OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND THE NATIONAL SPACE AGENCY OF UKRAINE (SRI NASU-NSAU )**, 22971655, established in GLUSHKOV PROSPEKT 40 BUILD 4 1, KYIV 03680, Ukraine, UA229716526500,

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

8. **INSTITUTET FOR RYMDFYSIK (IRF)**, 2021003567, established in PO BOX 812, KIRUNA 98128, Sweden, SE202100356701,

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

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

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 Form

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 '***Prediction of Geospace Radiation Environment and solar wind parameters — PROGRESS***' **('action')**, as described in Annex 1.

## ARTICLE 3 — DURATION AND STARTING DATE OF THE ACTION

The duration of the action will be ***36*** **months** as of *01/01/2015* ('**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.

The beneficiaries may not however:

- add costs relating to subcontracts not provided for in Annex 1, unless such additional subcontracts are approved 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 2,358,230.50** (two million three hundred and fifty eight thousand two hundred and thirty EURO and fifty cents).

### 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 **2,359,235.00** (two million three hundred and fifty nine thousand two hundred and thirty five 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) *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**');

### 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 *Agency* — 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 *Agency* (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 *Agency*.

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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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, PointA)}

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;

'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**

**<u>Types of eligible personnel costs</u>**

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. 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 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 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:

{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) 1 720 hours for persons working full time (or corresponding pro-rata for persons not working full time);

(ii) 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 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) 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 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 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 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 or

(b) contributed in kind against payment and in accordance with Article 11.

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 *The **capitalised and operating costs of 'large research infrastructure'** [3] directly used for the action are eligible, if:*

*(a) the value of the large research infrastructure represents at least 75% of the total fixed assets (at historical value 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 [4]);*

*(b) the beneficiary's methodology for declaring the costs for large research infrastructure has been positively assessed by the Commission ('**ex-ante assessment**');*

*(c) the beneficiary declares as direct eligible costs only the portion which corresponds to the duration of the action and the rate of actual use for the purposes of the action, and*

*(d) they comply with the conditions as further detailed in the Horizon 2020 Grant Manual.*

## 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.*

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.

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[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.

[4] For the definition, see Article 2(6) of Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) (OJ L 347, 20.12.2013 p.104)-('**Horizon 2020 Framework Programme Regulation No 1291/2013**'): '**Research infrastructure**' are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Where relevant, they may be used beyond research, e.g. for education or public services. They include: major scientific equipment (or sets of instruments); knowledge-based resources such as collections, archives or scientific data; e-infrastructures such as data and computing systems and communication networks; and any other infrastructure of a unique nature essential to achieve excellence in research and innovation. Such infrastructures may be 'single-sited', 'virtual' or 'distributed'.

[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.

### 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.*

### 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.

### 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;

  (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 *Agency*;

  (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 *Agency* 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

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 *Agency* and the other beneficiaries for implementing the action.

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

#### 9.1 Rules for the implementation of action tasks by beneficiaries not receiving EU funding

*not applicable*

#### 9.2 Consequences of non-compliance

*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 *and the Agency*, 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.

### 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 *Agency* 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.

[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).

The beneficiaries must ensure that the Commission *and the Agency*, 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 *Agency* 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 *and the Agency*, 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 *Agency* 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 *and the Agency*, 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:*

- *UNIVERSITE D'ORLEANS, affiliated or linked to CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE*

*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 and the Agency, 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.*

### 14.2 Consequences of non-compliance

*If any obligation under Article 14.1.1 is breached, the costs of the 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*

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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 that is 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.

### 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 Obligation to provide information upon request

The beneficiaries must provide — during implementation of the action or afterwards — any information requested in order to verify proper implementation of the action and compliance with the obligations under the Agreement (see Article 41.2).

### 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' (in 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 *Agency* 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 *Agency* 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 *Agency*, 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 *Agency* 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 *Agency* may apply any of the measures described in Chapter 6.

## ARTICLE 20 — REPORTING — PAYMENT REQUESTS

### 20.1 General obligation to submit reports

The coordinator must submit to the *Agency* (see Article 52) technical and financial reports, including requests for payment.

The reports must be drawn up using the forms and templates provided by the *Agency* 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 12
- *RP2: from month 13 to the last month of the project*

### 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 *Agency*;

(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 *Agency*.

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 costs incurred in another currency 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, it 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 *Agency* 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 *Agency*, 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 **1,179,115.25** (one million one hundred and seventy nine thousand one hundred and fifteen EURO and twenty five cents).

The *Agency* 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 **117,911.52** (one hundred and seventeen thousand nine hundred and eleven EURO and fifty two cents), corresponding to the 5% of the maximum grant amount (see Article 5.1), is retained by the *Agency* 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 *Agency* 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 *Agency* 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 *Agency* (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 *Agency* 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 *Agency* 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 to a beneficiary by the *Commission* or an executive agency (from 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 *Agency* 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 *Agency* 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 *Agency* 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: LLOYDS BANK PLC
Address of branch: SHEFFIELD, United Kingdom
Full name of the account holder: THE UNIVERSITY OF SHEFFIELD HORIZON2020
Full account number (including bank codes):
IBAN code: GB40LOYD30975186497636

**21.9 Costs of payment transfers**

The cost of the payment transfers is borne as follows:

- the *Agency* 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 *Agency* 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 *Agency* 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 *and the Agency*

#### 22.1.1 Right to carry out checks

The Commission *or the Agency* 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 *or the Agency* may be assisted by external persons or bodies.

The Commission *or the Agency* may also request additional information in accordance with Article 17. The Commission *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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, concerning the action funded under the Agreement, 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.

[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 (OJ L 298, 26.10.2012, p. 1).

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**').

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

#### 22.5.2 Findings in other grants

The Commission *or the Agency* 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 *or the Agency* will formally notify the beneficiary concerned the systemic or recurrent errors, together with the list of grants affected by the findings.

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 *or the Agency* 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 *or the Agency* in justified cases.

The Commission *or the Agency* will determine the amounts to be rejected on the basis of the revised financial statements, subject to their approval.

If the Commission *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *or the Agency* 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 *Agency* may apply any of the 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.

## SUBSECTION 2 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND

### ARTICLE 24 — 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.

### 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.

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

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

[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.

(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.

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 *Agency* ownership, to protect results**

26.4.1 *The Agency* 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 *Agency* 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 *Agency* 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 *Agency* takes a positive decision, until it has taken the necessary steps to protect the results.

26.4.2 *The Agency* 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 *Agency* 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 *Agency* 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 General 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 *Agency* 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 Agency* 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 *Agency* 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 637302".

### 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 General 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 are incorporated in a standard, the beneficiary concerned must — unless the *Agency* 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 637302".

### 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 General 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 *Agency* 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 *Agency* 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 637302".

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 *Agency*.

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 *Agency* responsibility**

Any dissemination of results must indicate that it reflects only the author's view and that the *Agency* 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 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), any other beneficiary may object within 30 days of receiving notification, 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 *Agency* right to object to transfers or licensing

*The Agency may — up to four years after the period set out in Article 3 — object to a transfer of ownership or the exclusive licensing of results, if:*

*(a) it is to a third party established in a non-EU country not associated with Horizon 2020 and*

*(b) the Agency considers that the transfer or licence is not in line with EU interests regarding competitiveness or is inconsistent with ethical principles or security considerations.*

*A beneficiary that intends to transfer ownership or grant an exclusive licence must formally notify the Agency before the intended transfer or licensing takes place and:*

- *identify the specific results concerned;*

- *describe in detail the new owner or licensee and the planned or potential exploitation of the results, and*

- *include a reasoned assessment of the likely impact of the transfer or licence on EU competitiveness and its consistency with ethical principles and security considerations.*

*The Agency may request additional information.*

*If the Agency decides to object to a transfer or exclusive licence, it must formally notify the beneficiary concerned within 60 days of receiving notification (or any additional information it has requested).*

*No transfer or licensing may take place in the following cases:*

- *pending the Agency decision, within the period set out above;*

- *if the Agency objects;*

- *until the conditions are complied with, if the Agency objection comes with conditions.*

**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.

[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).

### 32.2 Consequences of non-compliance

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

## ARTICLE 34 — ETHICS

### 34.1 General 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

(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.

[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

### 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 *Agency* 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

*not applicable*

### 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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

[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).

(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 Activities raising security issues**

*not applicable*

**37.2 Classified deliverables**

*not applicable*

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

*not applicable*

**37.4 Consequences of non-compliance**

*not applicable*

## ARTICLE 38 — PROMOTING THE ACTION — VISIBILITY OF EU FUNDING

**38.1 Communication activities by beneficiaries**

**38.1.1 General 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 *Agency* (see Article 52).

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

Unless the *Agency* 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 funded by the grant 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 637302".

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 *Agency*.

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 *Agency* responsibility**

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

**38.2 Communication activities by the *Agency***

**38.2.1 Right to use beneficiaries' materials, documents or information**

The *Agency* 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 *Agency's* use of these materials, documents or information would risk compromising legitimate interests, the beneficiary concerned may request the *Agency* 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 *Agency* 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 *Agency*.

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 *Agency* will insert the following information:

> "© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the *Agency* under conditions."

### 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 *Agency*

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

Such data will be processed by the '**data controller**' of the *Agency* for the purposes of implementing, managing and monitoring the Agreement (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 (SSPS)' on the *Agency's* websites.

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[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.

[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).

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 *Agency*. For this purpose, they must provide them with the service specific privacy statement (SSPS) (see above), before transmitting their data to the *Agency*.

**39.3 Consequences of non-compliance**

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

## ARTICLE 40 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE *AGENCY*

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

If the *Agency* 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 *Agency*.

# CHAPTER 5 DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES

## ARTICLE 41 — DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES

**41.1 Roles and responsibilities towards the *Agency***

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 *Agency* 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 (in 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 *Agency* under the Agreement, unless the Agreement requires the beneficiary to submit this information directly to the *Agency*.

(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 *Agency* (in particular, providing the *Agency* with the information described in Article 17), unless the Agreement specifies otherwise;

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

(iv) submit the deliverables and reports to the *Agency* (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 *Agency* of the amounts paid to each beneficiary, when required under the Agreement (see Articles 44 and 50) or requested by the *Agency*.

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);*
- *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 *Agency* 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 *Agency* 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 *Agency* of its disagreement and the reasons why.

If the *Agency* 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 *Agency* 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 as set out in Articles 21.3 or 21.4 statement (see Articles 20.3 and 20.4). It will then calculate the interim payment or payment of the balance.

If the *Agency* — **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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* will recover the difference (see Article 44).

## ARTICLE 44 — RECOVERY OF UNDUE AMOUNTS

### 44.1 Amount to be recovered — Calculation — Procedure

The *Agency* will — after **termination of the participation of a beneficiary, at the payment of the balance** or **afterwards** — recover 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 Agency 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 *Agency* will recover 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 *Agency* 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 *Agency* may offset before the payment date specified in the debit note;

*(b) not applicable, and/or*

(c) by **taking legal action** or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) (see Article 57).

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 *Agency* 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

If the payment of the balance takes the form of a recovery (see Article 21.4), the *Agency* 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 *Agency* 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 *Agency* by the date in the debit note and has not submitted the report on the distribution of payments: the *Agency* will **recover** the amount set out in the debit note from the coordinator (see below).

If the coordinator does not repay the *Agency* by the date in the debit note, but has submitted the report on the distribution of payments: the *Agency* 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 *Agency* 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 Agency multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned}*

divided by

[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).

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 *Agency* 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 the *EU's* financial interests, the *Agency* may offset before the payment date specified in the debit note;

(b) by **drawing on the Guarantee Fund**. The *Agency* 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** or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) (see Article 57).

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 *Agency* 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 *Agency*.

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 *Agency* 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 Agency 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* may offset before the payment date specified in the debit note;

(b) by **drawing on the Guarantee Fund**. The *Agency* 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** or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) (see Article 57).

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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency*.

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

### 45.3 Procedure

Before applying a penalty, the *Agency* 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 *Agency* 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 *Agency* 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 *Agency* may offset before the payment date specified in the debit note;

(b) by **taking legal action** or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) (see Article 57).

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 *Agency* 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 *Agency*

The *Agency* 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 *Agency* cannot be held liable for any damage caused by any of the beneficiaries or third parties involved in the action, as a consequence on 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 *Agency* 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 *Agency* can claim from a beneficiary will correspond to the damage caused by that beneficiary.

#### 46.2.3 Procedure

Before claiming damages, the *Agency* 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 *Agency* 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 *Agency* 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 *Agency* may offset before the payment date specified in the debit note;

(b) by **taking legal action** or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) (see Article 57).

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

The suspension will **take effect** the day notification is sent by the *Agency* (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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency*.

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 *Agency* 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 *Agency* 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 *Agency*.

Once circumstances allow for implementation to resume, the coordinator must immediately formally notify the *Agency* 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 *Agency*

#### 49.2.1 Conditions

The *Agency* 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 *Agency* 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 *Agency* 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 *Agency* (see Article 46).

Suspension of the action implementation does not affect the *Agency'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 PARTICIPATION FOR 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 *Agency* (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 *Agency* 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 *Agency* 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 *Agency* 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 participation for 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 *Agency* (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 *Agency* 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 Article 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 *Agency*, 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 *Agency*, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The *Agency* 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 *Agency*). 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* the amount due and the *Agency* 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 *Agency* 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 *Agency* the amount due. The *Agency* 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 *Agency* 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 *Agency* 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 participation for one or more beneficiaries, by the *Agency*

#### 50.3.1 Conditions

The *Agency* 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 *Agency* 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 *Agency* of the measures to ensure compliance with the obligations under the Agreement.

If the *Agency* 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 (see above);

- for terminations under Points (a), (d), (f), (i), (k), (l.i) and (m) above: on the day after notification 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 *Agency* 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 *Agency* 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 *Agency'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 *Agency* (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 *Agency* 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 *Agency*, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The *Agency* 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 *Agency*). 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 *Agency* 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 *Agency* 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 *Agency* 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 *Agency* the amount due and the *Agency* 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 *Agency* 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 *Agency* the amount due. The *Agency* 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 *Agency* 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 *Agency* 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

### 51.1 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 to the *Agency* — 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 *Agency's* 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 *Agency* 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 *Agency*** must be sent to the following address:

*Research Executive Agency (REA)*
*Space Research*
*COV2 Single Entry Point 17/143*
*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 (in the electronic exchange system).

## 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.

The provisions in Annex 2 take 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.

## 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).

[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).

The *Agency* 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 *Agency* 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 *Agency'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).

*As an exception, if such a dispute is between the Agency and SKOLKOVO INSTITUTE OF SCIENCE AND TECHNOLOGY, UNIVERSITY OF MICHIGAN THE REGENTS OF THE UNIVERSITY OF MICHIGAN, SPACE RESEARCH INSTITUTE OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND THE NATIONAL SPACE AGENCY OF UKRAINE, the competent Belgian courts have sole jurisdiction.*

If a dispute concerns 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 *Agency* or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

Justine DANIELS with ECAS id ndanijst signed in the Participant Portal on 29/10/2014 at 12:53:18 (transaction id SigId-2515-oJ6RoJnCNrjDm2oWwLF1vJxvhYwywu5FHKOCUXDIs5sQOHzkeA4H8gPAJAfuE44mDPYfW8QmZIwzv4P6F8AQkL-Jj71zxYb8yrTnbawzV6c1R-xs3CWnaB93k7suMNhtkELbeDzr97djBYCQH34KcJ8gn). Timestamp by third party at
Wed Oct 29 12:53:22 CET 2014

For the *Agency*

Christine BERNOT with ECAS id bernoch signed in the Participant Portal on 29/10/2014 at 14:27:28 (transaction id SigId-2598-EMPqh1Ymezv2FIskDzKCVdpUxTIjk55zskUzRSDtobhMpUhvs7bvgOttAWR5md1UJxGpNDIH9IGv0PLtgPqXtum-Jj71zxYb8yrTnbawzV6c1R-r7ZPeBT9lzV9fgfbOstSfIrbZN6Q3wxEPdS5lJXEjUu). Timestamp by third party at
Wed Oct 29 14:27:31 CET 2014


# PROTEC-1-2014: Space Weather

Grant agreement for: Research and Innovation action

## *Annex 1 - Description of Action*

Action acronym: PROGRESS

Action full title: "Prediction of Geospace Radiation Environment and solar wind parameters"

Grant agreement no: 637302

# Table of Contents

# 1.1. The project summary

| Project Number [1] | 637302 | Project Acronym [2] | PROGRESS |
|---|---|---|---|

One form per project

General information

| | |
|---|---|
| Project title [3] | Prediction of Geospace Radiation Environment and solar wind parameters |
| Starting date [4] | 01/01/2015 |
| Duration in months [5] | 36 |
| Call (part) identifier [6] | H2020-PROTEC-2014 |
| Topic | PROTEC-1-2014<br>Space Weather |
| Fixed EC Keywords | Space weather |
| Free keywords | forecast, geomagnetic indices, electron fluxes, radiation belts, solar wind |


Abstract [7]

The smooth functioning of the European economy and the welfare of its citizens depends upon an ever-growing set of services and facilities that are reliant on space and ground based infrastructure. Examples include communications (radio, TV, mobile phones), navigation of aircraft and private transport via GPS, and service industries (e.g. banking). These services, however, can be adversely affected by the space weather hazards. The forecasting of space weather hazards, driven by the dynamical processes originating on the sun, is critical to the mitigation of their negative effects. This proposal brings world leading groups in the fields of space physics and systems science in order to develop an accurate and reliable forecast system for space weather. It combines their individual strengths to significantly improve the current modelling capabilities within Europe and to produce a set of forecast tools to accurately predict the occurrence and severity of space weather events. Within project PROGRESS we will develop an European tool to forecast the solar wind parameters just upstream of the Earth's magnetosphere. We will develop a comprehensive set of forecasting tools for geomagnetic indices. We will combine the most accurate data based forecast of electron fluxes at GEO with the most comprehensive physics based model of the radiation belts currently available to deliver a reliable forecast of radiation environment in the radiation belts. This project will deliver these individual forecast tools together with a unified tool that combines the forecasting tools with the prediction of the solar wind parameters at L1 to substantially increase the lead-time of space weather forecasts.

# 1.2. List of Beneficiaries

| Project Number [1] | 637302 | Project Acronym [2] | PROGRESS |
|---|---|---|---|

List of Beneficiaries

| No | Name | Short name | Country | Project entry month[8] | Project exit month |
|---|---|---|---|---|---|
| 1 | THE UNIVERSITY OF SHEFFIELD | USFD | United Kingdom | 1 | 36 |
| 2 | ILMATIETEEN LAITOS | FMI | Finland | 1 | 36 |
| 3 | THE UNIVERSITY OF WARWICK | UW | United Kingdom | 1 | 36 |
| 4 | SKOLKOVO INSTITUTE OF SCIENCE AND TECHNOLOGY | Skoltech | Russian Federation | 1 | 36 |
| 5 | UNIVERSITY OF MICHIGAN THE REGENTS OF THE UNIVERSITY OF MICHIGAN | UM | United States | 1 | 36 |
| 6 | SPACE RESEARCH INSTITUTE OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND THE NATIONAL SPACE AGENCY OF UKRAINE | SRI NASU-NSAU | Ukraine | 1 | 36 |
| 7 | CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE | CNRS | France | 1 | 36 |
| 8 | INSTITUTET FOR RYMDFYSIK | IRF | Sweden | 1 | 36 |

# 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 - USFD | 9.00 | 1 | 36 |
| WP2 | Propagation of the Solar Wind from the Sun to L1 | 3 - UW | 47.00 | 1 | 36 |
| WP3 | Forecast of the evolution of geomagnetic indices | 8 - IRF | 87.00 | 1 | 36 |
| WP4 | Development of new statistical wave models and the re-estimation of the quasilinear diffusion coefficients. | 7 - CNRS | 34.00 | 1 | 24 |
| WP5 | Low energy electrons model improvements to develop forecasting products | 2 - FMI | 41.00 | 1 | 36 |
| WP6 | Forecast of the radiation belt environment | 1 - USFD | 30.00 | 1 | 30 |
| WP7 | Fusion of forecasting tools | 1 - USFD | 18.00 | 18 | 36 |
| WP8 | Dissemination | 1 - USFD | 16.00 | 1 | 36 |
| | | **Total** | 282.00 | | |

## *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 | Minutes of First Stakeholder meeting | WP1 | 1 - USFD | Report | Confidential, only for members of the consortium (including the Commission Services) | 14 |
| D1.2 | Minutes of Second Stakeholder meeting | WP1 | 1 - USFD | Report | Confidential, only for members of the consortium (including the Commission Services) | 26 |
| D1.3 | Minutes of Final Stakeholder meeting | WP1 | 1 - USFD | Report | Confidential, only for members of the consortium (including the Commission Services) | 36 |
| D2.1 | Conversion of SWIFT to spherical geometry | WP2 | 3 - UW | Report | Public | 12 |
| D2.2 | The coupling of the AWSoM and SWIFT codes | WP2 | 3 - UW | Report | Public | 20 |
| D2.3 | SWIFT documentation | WP2 | 3 - UW | Report | Public | 36 |
| D3.1 | Existing Dst, Kp, and AEmodels | WP3 | 8 - IRF | Report | Public | 3 |
| D3.2 | Collection of data sets | WP3 | 8 - IRF | Report | Public | 6 |
| D3.3 | Model verification | WP3 | 8 - IRF | Report | Public | 9 |
| D3.4 | Kp and Dst models | WP3 | 8 - IRF | Report | Public | 24 |
| D3.5 | AE models | WP3 | 8 - IRF | Report | Public | 30 |
| D3.6 | Real-time model implementation | WP3 | 8 - IRF | Report | Public | 36 |
| D4.1 | Data availability and list of chosen locations for each wave emission | WP4 | 7 - CNRS | Report | Public | 2 |
| D4.2 | The database of wave occurrence. | WP4 | 7 - CNRS | Report | Public | 6 |
| D4.3 | Results of the Error Reduction Ratio analysis | WP4 | 7 - CNRS | Report | Public | 10 |
| D4.4 | Final version of the statistical wave models | WP4 | 7 - CNRS | Report | Public | 24 |

| Deliverable Number [14] | Deliverable Title | WP number [9] | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|---|
| D5.1 | Solar wind drivers of low energy plasmasheet electrons | WP5 | 2 - FMI | Report | Public | 12 |
| D5.2 | The incorporation of diffusion coefficients from VERB into IMPTAM | WP5 | 2 - FMI | Report | Public | 24 |
| D5.3 | The VERB-IMPTAM low energy seed population | WP5 | 2 - FMI | Report | Public | 26 |
| D5.4 | Trial version of forecast model for low energy electrons | WP5 | 2 - FMI | Report | Public | 36 |
| D6.1 | NARMAX models of electron fluxes sat GEO | WP6 | 1 - USFD | Report | Public | 6 |
| D6.2 | Use of data assimilation technique within VERB code model | WP6 | 4 - Skoltech | Report | Public | 26 |
| D6.3 | Results of the VNC model and two methods of model couplings | WP6 | 1 - USFD | Report | Public | 30 |
| D7.1 | The results of individual forecasts of geomagnetic indices | WP7 | 1 - USFD | Report | Public | 30 |
| D7.2 | Forecasts of the energetic electron populations within the inner magnetosphere | WP7 | 1 - USFD | Report | Public | 33 |
| D7.3 | On orbit forecasts of the energetic electron populations | WP7 | 1 - USFD | Report | Public | 30 |
| D7.4 | Summary of the space weather environment | WP7 | 1 - USFD | Report | Public | 36 |
| D8.1 | Project web site | WP8 | 1 - USFD | Websites, patents filling, etc. | Public | 3 |
| D8.2 | Exploitation and Dissemination Plan | WP8 | 1 - USFD | Report | Public | 24 |

## 1.3.3. WT3 Work package descriptions

| | | | |
|---|---|---|---|
| **Work package number** [9] | WP1 | **Lead beneficiary** [10] | 1 - USFD |
| **Work package title** | Management | | |
| **Start month** | 1 | **End month** | 36 |

**Objectives**

To ensure the smooth running of scientific, administrative, and financial aspects of the project.

**Description of work and role of partners**

**WP1 - Management** [Months: 1-36]
**USFD**
Work package leader: R. von Fay-Siebenburgen (USFD)
Participants: Simon Walker (USFD)
Background:
Whilst the Scientific Steering Committee (chaired by the Project Coordinator) is responsible for the scientific direction of the project the day-to-day management of the project will be handled by the Project Manager (PM). The PM will ensure the timely dissemination of information to the Committees, Work Package Leaders, researchers, and other collaborators and help to maintain communications between all participants and other external bodies as required. The PM will also organise project related meetings such as SSC, SAB, as well as preparation for review meetings with the Commission. He will also provide editorial support where required and be responsible (in conjunction with the Coordinator) for the archiving of reports and other project related information.
Financial and contractual issues will be handled by the Coordinator/Project Manager in association with the University of Sheffield Research and Innovation Services (RIS) department. Over the years, RIS has helped to manage numerous EU projects within the framework of FP6 and FP7.

Specific Tasks:
• Organise, attend, and record meetings with the Scientific Steering Committee
• Organise, attend, and record meetings with the Stakeholder Advisory Board
• Organise, attend, and record meetings with the Commission
• Ensure dissemination of meeting reports to the project participants
• Produce end of year and end of project reports for the Commission
• Manage project funds and monitor participant spending
• Monitor progress of workpackages and submission of deliverables to the Commission

Summary of facilities available at host:
University infrastructure to support project management and financial management (RIS).
Summary of funding requirements:
Funding is required to support the Coordinator and Project Manager, together with travel and subsistence to enable them to attend project related meetings.

**Participation per Partner**

| Partner number and short name | WP1 effort |
|---|---|
| 1 - USFD | 9.00 |
| **Total** | 9.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D1.1 | Minutes of First Stakeholder meeting | 1 - USFD | Report | Confidential, only for members of the consortium (including the Commission Services) | 14 |
| D1.2 | Minutes of Second Stakeholder meeting | 1 - USFD | Report | Confidential, only for members of the consortium (including the Commission Services) | 26 |
| D1.3 | Minutes of Final Stakeholder meeting | 1 - USFD | Report | Confidential, only for members of the consortium (including the Commission Services) | 36 |

## Description of deliverables

The deliverables represent the result of discussions between the Project and the Stakeholder Advisory Board on the direction of the Project and the applicability of its results from an industrial stand point.

D1.1 : Minutes of First Stakeholder meeting [14]

This report will be a record of discussions at the first Stakeholder Advisory Board meeting

D1.2 : Minutes of Second Stakeholder meeting [26]

This report will be a record of discussions at the second Stakeholder Advisory Board meeting

D1.3 : Minutes of Final Stakeholder meeting [36]

This report will be a record of discussions at the final Stakeholder Advisory Board meeting

## Schedule of relevant Milestones

| Milestone number [18] | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|---|---|---|---|---|

| Work package number [9] | WP2 | Lead beneficiary [10] | 3 - UW |
|---|---|---|---|
| Work package title | Propagation of the Solar Wind from the Sun to L1 | | |
| Start month | 1 | End month | 36 |

## Objectives

Forecast of solar wind transients and solar wind parameters at L1: modelling, forecast and model validation

## Description of work and role of partners

**WP2 - Propagation of the Solar Wind from the Sun to L1** [Months: 1-36]
**UW**, USFD, UM
Work package leader: T. D. Arber (UW)
Participants: K. Bennett (UW), B. van der Holst (UM), M. Liemohn (UM), Post-Doc (UM)
Background:
Accurate forecast of the southward interplanetary magnetic field (IMF) is critically important, as it allows for space weather predictions of the intensity of the ensuing geomagnetic storm and would minimize false alarms. In the coming years, the Sun's activity will decline towards solar minimum. During solar minimum, the geomagnetic and auroral activity is mostly due to southward Bz of Corotating Interaction Region (CIR) events. For space weather operational forecast it is critically important to have reliable knowledge of the IMF Bz and other solar wind parameter at L1 before these are measured in situ. This work package will deliver this data by coupling magnetograms of the solar surface to coronal physics models (AWSoM – Alfven Wave Solar atmosphere Model). These coronal physics simulations will provide the key MHD input parameters to a solar wind inner heliospheric code with the codes coupled at about 30 solar radii. The inner heliospheric codes (SWIFT - Solar Wind Flux Transfer) will use two-temperature MHD to transport the magnetic flux and fluid variables in spherical geometry out to L1 and beyond where they can be used as drivers for space weather predictions.
UW has MHD shock capturing codes that are optimised for 3D Cartesian grids, the Lare3d code, and 2D arbitrary geometry ALE grids, the Odin code. SWIFT will combine features of both of these codes by using a fixed, but spherical, grid which extends radially from ~30 solar radii out to at least L1. This will take advantage of the optimised scheme for fixed grids of Lare3d combined with the two-temperature, arbitrary grid MHD schemes used in the more general Odin code.
UM has a solar coronal model (AWSoM) that uses magnetograms to simulate the full three-dimensional magnetic field topology and plasma state of the corona. AWSoM uses a stretched spherical grid to resolve the upper chromosphere, transition region and corona accurately. AWSoM is part of the overarching Space Weather Modeling Framework (SWMF), which can couple various space weather models in one single tool. SWMF will be used to couple the AWSoM corona model to the University of Warwick SWIFT model for the inner heliosphere.

Specific tasks:

Task 2.1 Convert Warwick MHD code into the spherical geometry SWIFT code.
Month 1-6 (UW)
The UW Lare3d code [Arber et al. 2001] is a Lagrangian remap code in Cartesian geometry. It is essential that this is converted to spherical geometry for solar wind studies. This work involves low-level changes to both the Lagrangian and remap steps. In addition the compatible, mimetic shock viscosity [Campbell et al. 2001] used for Lare3d needs to be customised for a fixed spherical grid. These developments will be logged through a UW maintained source control management (SCM) repository to which researchers at UM will have access.

Task 2.2 Make the AWSoM time accurate using hourly ingested magnetograms (using GONG data products)
Month 1-9 (UM)
AWSoM will be adapted to stream data from the GONG network and use this as a driver, interpolating magnetograms if needed, for real-time coronal simulations. This work will include the modelled turbulence and transport of AWSoM across the steep density/temperature gradients of the lower atmosphere requiring HPC resources

Task 2.3 Extend SWIFT to a two-temperature model to allow shock heating of ions.
Month 7-9 (UW)
Moving from single temperature to two-temperature models is essential to allow the ions to be heated by shocks. This requires two separate energy equations to be implemented in the Lagrangian phase in which the shock heating is applied

only to the ions. During the Lagrangian phase PdV heating will be distributed between species based on fractions of total pressure.

Task 2.4 Add improved electron heat transport
Month 10-15 (UW, UM)
With separate ion and electron temperatures it is now possible to improve the modelling of the electron transport. A common approach to use a saturated electron heat transport [J.V. Hollweg, 1978]. This will be compared with similar techniques used in high energy density physics [Schurtz et al. 2001] and the optimal scheme adopted.

Task 2.5 Couple inner boundary of SWIFT to the Michigan AWSoM coronal model.
Month 16-21 (UW, UM)
Output from the AWSoM code can be taken once the solar wind is super-Alfvenic and used to drive the inflow on the inner boundary of SWIFT. This requires rezoning data from mismatched grids and time-steps and will be handled via the SWMF coupling toolkit. At the end of this process the codes will be made available to other work packages via the Warwick SCM repository.

Task 2.6 Validate the AWSoM/SWIFT codes using historical magnetograms and ACE data.
Month 19-27 (UW, UM, USD)
Extensive validation of the coupled codes is essential for confidence of the whole forecast package. Using historical data from GONG to predict the corresponding data measurements from Mercury MESENGER, Venus Express, and ACE will allow the team to tune, optimise and validate the AWSoM/SWIFT codes.

Task 2.7 Run real-time test of predicted L1 variables based on coupled AWSoM/SWIFT codes.
Month 25-36 (UW, UM)
Begin real-time predictions with extensive runs of the MHD models stress test the codes, increase the confidence in the code validation and provide long-time series data for downstream magnetospheric work packages. For this data from GONG will be streamed into AWSoM whose output is then used to drive SWIFT. The final SWIFT output will be made available to other work packages via publically accessible ftp servers. The SWIFT code will run continuously on a dedicated server class workstation at UW. Throughout this time the codes will continue to be optimised for speed and resilience of data transfer as well as basic simulation accuracy. Real-time runs of AWSoM requires ~120 cores, real-time runs of SWIFT require ~10 cores of HPC.

Task 2.8 Write developer and user manuals.
Month 31-36 (UW, UM)
Throughout the code development required for PROGRESS the SWIFT code will maintain embedded Doxigen documentation. This level of documentation is ideal for developers but lacks the high level overview needed by users. In the final six moths a detailed user guide and fully documented validation tests will supplement this. Regression test suites for SWIFT will also be included as part of the documentation set.

Summary of facilities available at hosts:
Researchers at Warwick have access to a university 6000 core high bandwidth, low latency Linux cluster for testing, profiling and optimizing SWIFT. This is through Warwick's Centre for Scientific Computer of which Arber is a core member.

Summary of funding requirements:
Funding is required at Warwick to support code development (18 months Bennett and 8 months Arber). Travel for project meetings and annual reviews. We request funding for Arber and Bennett to visit UM for one week to work on code integration and validation.
Funding is required at UM to support code development (18 months unnamed Post-Doc, 1 month per year van der Holst, and 1 week per year Liemohn). Travel for annual reviews.

Participation per Partner

| Partner number and short name | WP2 effort |
|---|---|
| 1 - USFD | 1.00 |
| 3 - UW | 26.00 |
| 5 - UM | 20.00 |

| Partner number and short name | WP2 effort |
|---|---|
| **Total** | 47.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D2.1 | Conversion of SWIFT to spherical geometry | 3 - UW | Report | Public | 12 |
| D2.2 | The coupling of the AWSoM and SWIFT codes | 3 - UW | Report | Public | 20 |
| D2.3 | SWIFT documentation | 3 - UW | Report | Public | 36 |

## Description of deliverables

The deliverables for WP2 document the important phases in the production and testing of the SWIFT code.

D2.1 : Conversion of SWIFT to spherical geometry [12]

This report outlines the process by which the SWIFT code is converted to use a spherical geometry.

D2.2 : The coupling of the AWSoM and SWIFT codes [20]

This report outlines the process of coupling the AWSoM and SWIFT codes.

D2.3 : SWIFT documentation [36]

This deliverable will provide full user and developer documentation plus regression test suite for the SWIFT code developed within Project PROGRESS.

## Schedule of relevant Milestones

| Milestone number [18] | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|---|---|---|---|---|
| MS5 | Availabity of AWSoM/SWIFT for testing within the consortium. | 3 - UW | 20 | The AWSoM/SWIFT generated as part of WP2 will be made available to consortium members for testing. |

| Work package number [9] | WP3 | Lead beneficiary [10] | 8 - IRF |
|---|---|---|---|
| Work package title | Forecast of the evolution of geomagnetic indices | | |
| Start month | 1 | End month | 36 |

## Objectives

The objective of this WP is to provide forecast of Dst, KP and AE from L1 as measured by ACE.

## Description of work and role of partners

**WP3 - Forecast of the evolution of geomagnetic indices** [Months: 1-36]
**IRF**, USFD, SRI NASU-NSAU
Work package leader: P. Wintoft (IRF)
Participants: S. Walker (USFD), V. Yatsenko (SRI NASU-NSAU)
Background:
This WP concerns improvement and new development of models based on data driven modelling, such as CNN and NARMAX. Existing models for Dst and Kp will be analysed and verified with the aim of finding weaknesses and to suggest improvements. Solar wind and geomagnetic indices shall also be analysed in order to develop models for the identification of features, such as (but not limited to) shocks, sudden commencements, and substorms. Such categorisation will aid the model development and verification, and can also serve as alternative approach to models providing numerical input-output mapping. In addition to the development of Dst and Kp models new models will be developed to forecast AE. The models will be implemented for real-time operation at IRF and data and plots will be provided on a web server.

Specific tasks:

Task 3.1 – Survey of existing operational models forecasting Kp, Dst, and AE.
Month 1-3 (IRF,USFD,SRI NASU-NSAU)
Identify existing operational Kp, Dst, and AE forecast models. Analyse their respective requirements and benefits considering, e.g. inputs, latency, lead time, and resources. Detailed knowledge is available for the models available to the team.

Task 3.2 - Identify and collect relevant data
Month 4-6 (IRF)
Collect historic real time ACE data, Science Level 2 ACE data, Kp, Dst, and AE. An SQL database shall be set up where the data are collected. Analyse data sets with respect to quality and coverage. Also include the coming DSCOVR spacecraft in the study.

Task 3.3 - Evaluate and verify a set of selected existing models.
Month 7-9 (IRF, USFD, SRI NASU-NSAU)
The models from Task 3.1 that are available to the team shall be verified using the datasets identified in Task 3.2. In this activity it is important to consider both science level data and real time data. This task also includes the identification and application of appropriate verification methodologies. As inputs methodologies from the meteorological domain [Jollife and Stephenson, 2012] and previous COST ES0803 Action [Wintoft et al., 2012] shall be used.

Task 3.4 - Develop further existing Kp and Dst models.
Month 10-24 (IRF, USFD, SRI NASU-NSAU)
The verification carried out in Task 3.3 will provide insights on how to improve existing Kp and Dst models. Classifications and categorisation methods will also be developed and applied with the purpose of improving existing models. The formulated verification strategy (Task 3.3) shall also be applied to the models.

Task 3.5 - Develop new AE forecast models
Month 16-30 (IRF, USFD, SRI NASU-NSAU)
As a first step to provide a baseline the model in Gleisner and Lundstedt [2001] shall be implemented and verified (Task 3.3). The classifications and categorisation methods (Task 3.4) shall also be applied to provide insight to appropriate parametrisation of the high resolution (minute) solar wind and AE data. E.g., the approach in Gleisner and Lundstedt [2001] was to use 10 minute averages, however, averages are not always the most suitable way of reducing the

complexity as important features may be missed. Again, the formulated verification strategy (Task 3.3) shall also be applied to the models.

Task 3.6 - Implement models for real-time operation.
Month 28-36 (IRF, USFD, SRI NASU-NSAU)
The improved and developed models shall be implemented for real time operation. The contributing institutes have long experience in this field. The data needed to drive the models shall be downloaded and stored in the database in real time. Various checks considering data quality and timeliness shall be implemented and mitigated. The output from the models shall be stored in the database and also provided over ftp/http. Simple web site with the forecasts shall be implemented tailored for this project.

Summary of facilities available at hosts:
IRF-Lund has all the necessary computing and software facilities to retrieve, store, and analyse solar-terrestrial and space weather data. Data are analysed using Matlab, IDL, and Mathematica. Several software tools have been developed to make statistical analysis, wavelet analysis, and neural network models. Since several years we store data in SQL databases, this facilitates an organised approach to data storage and greatly improves on the accessibility of data. Several models runs automatically and are accessible over the Internet. The models are typically implemented using Java, Gnuplot, Matlab, Python, BASH, PHP, or Perl, or a combination thereof.

Summary of funding requirements:
It is expected that two scientists from IRF will take part in this WP spending in total 34 man-months. One person will take part in the 7 planned PMs.

## Participation per Partner

| Partner number and short name | WP3 effort |
|---|---|
| 1 - USFD | 15.00 |
| 6 - SRI NASU-NSAU | 38.00 |
| 8 - IRF | 34.00 |
| **Total** | 87.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D3.1 | Existing Dst, Kp, and AEmodels | 8 - IRF | Report | Public | 3 |
| D3.2 | Collection of data sets | 8 - IRF | Report | Public | 6 |
| D3.3 | Model verification | 8 - IRF | Report | Public | 9 |
| D3.4 | Kp and Dst models | 8 - IRF | Report | Public | 24 |
| D3.5 | AE models | 8 - IRF | Report | Public | 30 |
| D3.6 | Real-time model implementation | 8 - IRF | Report | Public | 36 |

## Description of deliverables

The deliverables for WP3 provide reports on the current models for geomagnetic indices available at the beginning of the Project and the further development of these and also new models.

D3.1 : Existing Dst, Kp, and AEmodels [3]

This report provides a survey of the currently existing models for the geomagnetic indices Dst, Kp, and AE that are used for forecasts at the beginning of the Project.

D3.2 : Collection of data sets [6]

This report provides details regarding the collection of historical data sets that are required by the Dst, Kp, and AE models as well as the actual indices themselves for comparison with the model output.

D3.3 : Model verification [9]

This report outlines the results of the verification of the models previously identified in Task 3.1 using the data collected in Task 3.2 using various methodologies.

D3.4 : Kp and Dst models [24]

This report will discuss the further developments to existing Dst and Kp models.

D3.5 : AE models [30]

This report outlines the development and results of new models for the AE index.

D3.6 : Real-time model implementation [36]

This report will present details of the real time online operation of the Dst, Kp, and AE models.

## Schedule of relevant Milestones

| Milestone number [18] | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|---|---|---|---|---|
| MS2 | Availability of models for Kp, Dst, and AE | 8 - IRF | 18 | Availability of models for Kp, Dst, and AE |

| Work package number [9] | WP4 | Lead beneficiary [10] | 7 - CNRS |
|---|---|---|---|
| Work package title | Development of new statistical wave models and the re-estimation of the quasilinear diffusion coefficients. | | |
| Start month | 1 | End month | 24 |

## Objectives

The objectives of this WP is to redevelop statistical wave models for whistler mode Chorus, hiss and equatorial magnetosonic waves, that are parameterised by geomagnetic index (KP,AE), solar wind velocity and density and accounts for the previous evolution these parameters.

## Description of work and role of partners

**WP4 - Development of new statistical wave models and the re-estimation of the quasilinear diffusion coefficients.** [Months: 1-24]
**CNRS**, USFD, Skoltech
Work package leader: V. Krasnoselskikh (CNRS/LPC2E)

Participants: Y. Shpritz (Skoltech), S. Walker (USFD)

Background:
Statistical wave models for Chorus, hiss and equatorial magnetosonic mode are required to calculate the tensors of quasilinear diffusion coefficients that numerical codes such as VERB use to model the evolution of particle fluxes within the inner magnetosphere. Current models are parameterised by location and geomagnetic indices. This assumes that the wave distribution in the magnetosphere is independent of preceding evolution of the magnetosphere. There is no experimental basis to assume that the spatial wave distribution in the main phase of a particular storm is the same as during the recovery phase of the same or another storm if these periods are characterised by the same values of geomagnetic indices. In addition it is known that statistically the velocity and the density of the solar wind have greater influence on the energetic electrons fluxes at GEO than other parameters such as geomagnetic indices [Paulikas and Blake 1979; Blake et al., 1997; Lyatsky and Khazanov 2008; Reeves, et al., 2011; Balikhin, et al., 2011; Boynton, et al., 2013]. Since the solar wind velocity and density are statistically related to the dynamics of energetic fluxes, their inclusion to the set of organizing parameters of statistical wave models should be investigated. The technical problem that needs to be solved is to determine the time delay (time lag) between the change in, say, the solar wind velocity upstream of the magnetosphere and the possible effect of these changes on the wave distribution at a particular location. A similar problem exists for the determination of which time lags for previous values of the geomagnetic indices should be used to organise the statistical wave model. To overcome these problems the Error Reduction Ratio (ERR) analysis, which is the part of the NARMAX methodology, will be employed to identify the set of solar wind parameters and geomagnetic indices that affect the spatial distribution of key magnetospheric emissions. A distinct set of organizing parameters will be identified for each type of waves: chorus, hiss and equatorial magnetosonic waves. The resulting newly parameterised statistical wave models will provide a more realistic view of the occurrence of plasma waves within the magnetosphere and their association with solar wind perturbations. These new models will then be used to calculate new and more realistic sets of tensors of quasilinear diffusion coefficients and hence improve the forecasting ability of physical models such as VERB and IMPTAM.

Specific tasks:

Task 4.1 Collection of data and the development of software for automatic identification of Chorus, hiss and equatorial magnetosonic emissions
Month 1-2 (CNRS/LPC2E, USFD)
Wave data from Double Star-TC1 will be provided to LPC2E by USFD in addition to the data from DE-1, CRRES, POLAR, Akebono, Cluster, THEMIS, are already available in CNRS/LPC2E. This will be augmented with solar wind data sets freely available from NASA Omniweb, geomagnetic indices (Kp, Dst, AE) from the World Data Centre for geomagnetism in Kyoto. A representative subset of locations for each wave emission type (Chorus, hiss, equatorial magnetosonic) will be identified for the subsequent Error Reduction Analysis. This set of locations will be subdivided into two groups, one to use for the modelling and the other for model validation.

Task 4.2 Preparation of data sets for Error Reduction Ratio analysis

Month 3-6 (CNRS/LPC2E, USFD)
For each location determined in task 4.1 CNRS/LPC2E will use their software for the automatic detection of Chorus, hiss, and EMW to identify occurrences of the corresponding emission. Sufficient number of emission occurrences for reliable application of Error Reduction Analysis will be identified (at least a few thousands). For each emission type the database organised by location that contains the wave amplitude and time of their occurrence will be developed. It is known that the obliqueness of waves can crucially change the characteristics of particle diffusion and losses especially due to chorus waves [Artemiev et al., 2013], the parameterization will take this effect into account.

Task 4.3 Error reduction analysis.
Month 7-10 (USFD)
For each location the Error Reduction Ratio analysis will be employed to identify the parameters and associated time lags that have greatest influence on the magnitude of the corresponding emission. In the application of Error Reduction Ratio analysis wave magnitudes will be considered as outputs and solar wind velocity, density and geomagnetic indices as inputs. For each emission type the results of the Error Reduction Ratio analysis will be compared quantitatively to identify an optimal set of parameters that are effective at controlling the mode from a global perspective. The size of the set of final parameters will be small enough to ensure that the resulting wave models are statistically significant.

Task 4.4 Development of the Statistical Wave Models and corresponding tensors of diffusion coefficients.
Month 11-24 (CNRS/LPC2E, Skoltech)
Based on the final set of parameters identified by ERR from Task 4.3 the whole wave data set will be reanalysed to generate new statistical models for the occurrence of Chorus, hiss and EMW.

Summary of facilities available at hosts:
CNRS/LPC2E already possesses much of the data required for these tasks as well as the algorithms to identify different wave emissions. Recently our group has actively worked on creation of the data base of wave measurements onboard Cluster, THEMIS, Polar, DE and Akebono satellites in the Earth magnetosphere with special attention to the vicinity of the radiation belts. This data base contains information on the statistical distribution of wave observations, including the probability of observations, amplitude of electric and magnetic field distributions upon several parameters such as the L-shell, MLT, and geomagnetic indices.
The activities to be performed by CNRS/LPC2E in the course of this work package will undertaken in the form on a collaboration between the work package leader, V Krasnoselskikh, and Dr. Oleksiy Agapitov from the Space Sciences Laboratory, The University of California, Berkeley, USA. The tasks performed by Dr. Agapitov will be carried out gratis i.e. at no expense to the Commission.

Summary of funding requirements:
Salaries for V. Krasnoselskikh, researcher and student.
Travel and subsistence to attend project meetings
Travel and subsistence to attend scientific conferences for dissemination of results
Publication fees

Participation per Partner

| Partner number and short name | WP4 effort |
|---|---|
| 1 - USFD | 6.00 |
| 4 - Skoltech | 8.00 |
| 7 - CNRS | 20.00 |
| **Total** | 34.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D4.1 | Data availability and list of chosen locations for each wave emission | 7 - CNRS | Report | Public | 2 |
| D4.2 | The database of wave occurrence. | 7 - CNRS | Report | Public | 6 |
| D4.3 | Results of the Error Reduction Ratio analysis | 7 - CNRS | Report | Public | 10 |
| D4.4 | Final version of the statistical wave models | 7 - CNRS | Report | Public | 24 |

## Description of deliverables

The deliverables associated with WP4 outline the data sets, methodology, and development of the statistical wave models

D4.1 : Data availability and list of chosen locations for each wave emission [2]

This report outlines the availability of data sets that will be used to construct the wave models and provide a list of the chosen locations at which the models are evaluated for each wave emission.

D4.2 : The database of wave occurrence. [6]

This report describes the organisation of the database to store information regarding the occurrence of the various modes of plasma wave activity.

D4.3 : Results of the Error Reduction Ratio analysis [10]

This deliverable is a journal paper ready for submission on the results of the Error Reduction Ratio analysis.

D4.4 : Final version of the statistical wave models [24]

This deliverable consists of the final version of the statistical wave models

## Schedule of relevant Milestones

| Milestone number [18] | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|---|---|---|---|---|
| MS3 | Statistical wave models | 7 - CNRS | 24 | Statistical wave models |

| Work package number [9] | WP5 | Lead beneficiary [10] | 2 - FMI |
|---|---|---|---|
| Work package title | Low energy electrons model improvements to develop forecasting products | | |
| Start month | 1 | End month | 36 |

## Objectives

The objectives of WP 5 are:
• Develop an empirical solar wind and IMF driven model for low energy electrons in the plasma sheet;
• Adapt the IMPTAM to include proper diffusion coefficients provided by VERB radiation belts model;
• Provide the low energy seed population to VERB radiation belts model;
• Develop a trial version of forecast model for low energy electrons.

## Description of work and role of partners

**WP5 - Low energy electrons model improvements to develop forecasting products** [Months: 1-36]
**FMI**, USFD, Skoltech
Work package leader: N. Ganushkina (FMI)

Participants: Y. Shpritz (Skoltech), (USFD)

Background:
The distribution of low energy electrons, the seed population (10 to few hundreds of keV), is critically important for radiation belt dynamics. This seed population is further accelerated to MeV energies by various processes. The electron flux at these energies is important for surface charging. The electron flux is largely determined by convective and inductive electric fields and varies significantly with substorm activity driven by the solar wind. Wave-particle interactions are very effective in precipitating electrons at energies of few hundred keV. Satellite measurements cannot provide continuous measurements at 10 to a few hundreds of keV at all MLT and L-shells. It is necessary to have a model that is able to specify the electron flux for all L shells for a given solar wind input and to provide the output of this model as an input for higher-energy radiation belt modeling. With the development of the Inner Magnetosphere Particle Transport and Acceleration model (IMPTAM) for low energy particles in the inner magnetosphere [Ganushkina et al., 2005, 2006, 2012] and the VERB full-diffusion code [Shprits et al., 2006b; 2008a, b], the computational view on the low energy electron fluxes important for radiation belts at L=2-10 is now feasible.

Specific tasks:

Task 5.1 – Developing a solar wind and IMF driven model for low energy electrons in the plasma sheet
Month 1-12 (FMI, USFD)
Low energy electrons are followed in IMPTAM from the plasma sheet at 10 Re to the inner magnetosphere regions. It is crucially important to have accurate solar wind and IMF driven boundary conditions in the plasma sheet. So far, IMPTAM has been using kappa distribution function for electrons with n and T parameters adapted from the empirical model derived from Geotail data by Tsyganenko and Mukai [2003] for ions with the same number density Te/Ti = 0.2. Set like this, the model for boundary conditions has a number of limitations. We will construct an empirical model for boundary conditions for low energy (from a few to tens of keVs) electron fluxes at L=8-10 dependent on solar wind and IMF parameters using the available data from the satellites including Polar HYDRA DDEIS (10 eV-10 keV), Cluster PEACE (0.7 eV-32 keV), THEMIS ESA (eV-30 keV) and Allen probes HOPE (20 eV-45 keV). Geostationary measurements at GOES MAGED (40-150 keV), LANL MPA (3–45 keV) and SOPA (50-200 keV) (when available). will be used to verify the model when tracing the electrons with the developed boundary distribution at L=8-10 and comparing the modeled fluxes with the observed ones at 6.6 Re.

Task 5.2 – Incorporating the proper diffusion coefficients into IMPTAM provided by VERB radiation belts model
Month 12-24 (FMI, Skoltech)
Wave-particle interactions play an important role in the variations of the electron fluxes, they have to be incorporated into the IMPTAM model via diffusion coefficients. At present, only electron lifetimes are taken into account following Shprits et al. [2007]. However Shprits et. al.,[2007] accounted only for the first order resonance and used a very simplified model of waves. Lower energy electron scattering is dominated by the Landau resonance that is mission in this formulation. The proper incorporation of wave-particle interactions is now possible due to the existence of Full Diffusion Code (FDC) model [Shprits and Ni., 2009;], which provides the diffusion coefficients and can now calculate

them in a non-dipole field [Orlova et al., 2012]. The matrix of diffusion coefficients as a function of L-shell, pitch-angle, and energy for various levels of geomagnetic activity will be computed by FDC. Using the diffusion coefficients, we will parameterize the loss and the computed lifetimes will be included in to the IMPTAM code. We will solve the diffusion coefficents IMPTAM will solve the Fokker-Planck Equation with the diffusion coefficients provided by VERB model. Available data on low energy electron fluxes (< 300 keV) both at geostationary and inside will be compared to model output for selected events to verify the improved IMPTAM.

Task 5.3 – Providing the low energy seed population to VERB radiation belts model
Month 24-30 (FMI, Skoltech)
The maps in (L, MLT, pitch angle, energy) of low energy electrons will be constructed as output from the improved IMPTAM. Both quiet and disturbed events will be selected according to data availability and modelled and the model output will be compared to the observed electron fluxes to further model verification. The low energy electron maps for the modelled events will be provided to the VERB code as seed keV population for further accelerations to MeV energies. VERB code will utilize the seed population and make its own verification. The results of the IMPTAM will be validated against satellite observations and will be also compared with the NARMAX predictions. We will couple VERB with IMPTAM and validate the results against observations in the heart of the outer radiation belts. VERB-IMPTAM will form alternative to NARMAX-VERB combination of codes. The detailed comparison between the codes and validation will help us improve and validate IMPTAM.

Task 5.4 – Developing a trial version of forecast model for low energy electrons
Month 24-36 (FMI, USFD, UW, UM, IRF)
At present, IMPTAM is the only model that provides nowcast of low energy electrons (< 200 keV) in the inner magnetosphere. The model operates online under the SPACECAST project (http://fp7-spacecast.eu). It is driven by the real time solar wind parameters such as solar wind number density, total plasma bulk velocity and solar wind dynamic pressure, components of IMF and Dst index. Forecast capabilities for geomagnetic indices and SW and IMF developed in PROGRESS in WP1 and WP3 will make it possible to extent IMPTAM from simply a nowcast model to a forecast tool. IMPTAM considers the effects which substorm activity has upon the transport and acceleration of low energy electrons by launching an electromagnetic pulse at substorm onset times. It is very difficult to incorporate the substorm activity effects even for nowcast modeling. To launch a pulse at a substorm onset with a magnitude scaled by a peak value of AE index, the substorm timing and AE peaks must be forecasted. With the development of the forecasting tools in PROGRESS for AE index in WP3, the substorm activity effects will be properly taken into account. A trial version of forecast model for low energy electrons will be put online.

Summary of facilities available at hosts:
FMI has already developed the IMPTAM model, and has access to appropriate computing facilities for its operation.

Summary of funding requirements:
Salaries for N. Ganushkina and junior researcher at FMI, and Y. Shprits (Skoltech).
Travel funding for attendance at Project Meetings, science conferences for dissemination.
Publication fees.

Participation per Partner

| Partner number and short name | WP5 effort |
|---|---|
| 1 - USFD | 6.00 |
| 2 - FMI | 27.00 |
| 4 - Skoltech | 8.00 |
| **Total** | 41.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D5.1 | Solar wind drivers of low energy plasmasheet electrons | 2 - FMI | Report | Public | 12 |
| D5.2 | The incorporation of diffusion coefficients from VERB into IMPTAM | 2 - FMI | Report | Public | 24 |
| D5.3 | The VERB-IMPTAM low energy seed population | 2 - FMI | Report | Public | 26 |
| D5.4 | Trial version of forecast model for low energy electrons | 2 - FMI | Report | Public | 36 |

## Description of deliverables

The deliverables for WP5 report key results in the process of coupling the VERB and IMPTAM simulation codes.

D5.1 : Solar wind drivers of low energy plasmasheet electrons [12]

This deliverable consists of a journal paper, ready for submission, discussing the solar wind and IMF driven model for low energy electrons in the plasma sheet

D5.2 : The incorporation of diffusion coefficients from VERB into IMPTAM [24]

This deliverable consists of a journal paper, ready for submission, discussing the results of incorporating of diffusion coefficients from VERB into IMPTAM

D5.3 : The VERB-IMPTAM low energy seed population [26]

This report will discuss the coupling of the VERB and IMPTAM models so that low energy seed population from IMPTAM is used to initialise the VERB radiation belt model for high energy electrons.

D5.4 : Trial version of forecast model for low energy electrons [36]

Report on the trial version of forecast model for low energy electrons

## Schedule of relevant Milestones

| Milestone number [18] | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|---|---|---|---|---|
| MS4 | Fusion of VERB and IMPTAM | 2 - FMI | 24 | Fusion of VERB and IMPTAM |

| Work package number [9] | WP6 | Lead beneficiary [10] | 1 - USFD |
|---|---|---|---|
| Work package title | Forecast of the radiation belt environment | | |
| Start month | 1 | End month | 30 |

## Objectives

The objectives of WP 6 are:
• To extend of SNB3GEO model to various to lower energy electrons (down to lowest range of GOES 15 data 30-50 keV) and to increase rate of prediction from 1 day at present to 2 hours, maintaining the same prediction lead of time 24 hours.
• To enhance the performance of VERB model by employing the tensors of diffusion coefficients from WP4 and incorporating real time data assimilation methodology into VERB forecast.
• To develop the VERB-NARMAX Coupled (VNC) model that will integrate forecasts of SNB3GEO model at GEO as boundary conditions for VERB model.

## Description of work and role of partners

**WP6 - Forecast of the radiation belt environment** [Months: 1-30]
**USFD**, FMI, Skoltech
Work package leader: M. Balikhin (USFD)

Participants: Y. Shpritz (Skoltech), N. Ganushkina (FMI)

Background:
WP6 is devoted to pioneering development of a novel forecasting technique that is based on the fusion of empiric models deduced by NARMAX the most powerful and robust technique of the System Science [Balikhin et al., 2011, Boynton et al., 2013], the most advanced physics based numerical model of radiation belts VERB full-diffusion code [Shprits et al., 2006b; 2008a, b], and state of the art methodology of data assimilation.
Data assimilation techniques can be used to improve the results of numerical models by incorporating physical measurements in order to constrain the output, These methods enable an optimal combination of model results and sparse measurements from various sources such as those available from satellites. Data assimilation enables the filling of temporal and spatial gaps left by sparse in-situ measurements by combining measurements from different spacecraft whose instrumental characteristics are quite different. PROGRESS will use data assimilation techniques, based on Kalman filters, to improve the forecasts produced by VERB.
Current physics based models have the advantage of being able to model the processes in the whole region of the radiation belts. However, the complexity of radiation belt dynamics involves a chain of simultaneous processes operating over an enormous range of space scales from scales of wave-particle interactions to the scale of magnetopause shadowing, hinders the performance of current physics based models. The data based SNB3GEO model provides reliable forecast at GEO but because of the lack of continuous data outside GEO cannot be extended in the whole region of the radiation belts. In this WP we will significantly improve both models by extending range of energies predicted SNB3GEO and increasing its rate of prediction. WP6 will follow the ideology of meteorological forecasts by incorporating data assimilation methodologies to exploit the vast quantity of data from the fleet of the magnetospheric spacecraft. In addition the novel advanced tensors of the diffusion coefficients that will be developed in WP4 will be incorporated in the VERB code. The ultimate goal of WP6 is couple the data based NARMAX methodology with the first principle based approach utilized by VERB to the develop a hybrid model that will have advantages of the both: forecast accuracy matching that of SNB3GEO and spatial coverage of VERB.

Specific tasks:

Task 6.1 – NARMAX modelling of energetic electron fluxes at GEO
Month 1-6 (USFD)
Create a set on forecast models based on the NARMAX methodology to forecast the fluxes on energetic electrons in all energy ranges sampled by the GOES 13 satellite [Boynton et al, 2013]. We will use the same methodology used to create the models for electron fluxes with energies >800keV and >2Mev that currently operate is Sheffield (www.ssg.group.shef.ac.uk/USSW/2MeV_EF.html) and to increase the temporal resolution of the forecasts.

Task 6.2 –Data assimilation extension for VERB
Month 1-26 (Skoltech)

This task involves the development of a set of methods, based on the Kalman filter, to forecast the evolution of the radiation belts. Special attention will be paid to the development a set of identification methods for unknown noise statistics, such as the bias and covariance matrix of model errors. Additional refinements to these techniques will involve estimation of the observation error statistics, identification of the coefficients of proportionality characterising the dependence of observation errors on satellite observations, and the use of the backward optimal smoothing procedure applied to the forward Kalman filter estimates to improve our understanding of the key physical mechanisms.

Task 6.3 – Development of the coupled VERB-NARMAX model (VNC)
Month 7-30 (USFD, Skoltech)
Currently the VERB code utilises the boundary condition at constant L, e.g. L=7. The SNB3GEO provides the forecast at GEO, which corresponds to a range of L values. Two methods of coupling between VERB and SNB3GEO will be implemented. The first method will involve the adaption the VERB code to a boundary with variable L-shell that corresponds to GEO, and development of the interface between SNB3GEO and VERB. In the second method the output from SNB3GEO will be propagated and scaled to the surface of constant L (e.g. L=7). To assess the quality of the results, a number of periods of Van Allen probe data sets in which the radiation belts exhibited strong activity will be identified. The coupled VNC models resulting from both approaches will be assessed by the comparison of their predictions with measurements. As result more accurate of the versions of VNC will be identified.

Summary of facilities available at hosts:
Both USFD and Skoltech have sufficient computing facilities to perform the above listed tasks.
Summary of funding requirements:
Salary for R. Boynton. Travel and subsistence for dissemination.

## Participation per Partner

| Partner number and short name | WP6 effort |
|---|---|
| 1 - USFD | 18.00 |
| 2 - FMI | 4.00 |
| 4 - Skoltech | 8.00 |
| **Total** | 30.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D6.1 | NARMAX models of electron fluxes sat GEO | 1 - USFD | Report | Public | 6 |
| D6.2 | Use of data assimilation technique within VERB code model | 4 - Skoltech | Report | Public | 26 |
| D6.3 | Results of the VNC model and two methods of model couplings | 1 - USFD | Report | Public | 30 |

## Description of deliverables

The deliverables for WP6 report on the results of key stages in the coupling between the VERB (physical) model and the NARMAX (systems) models

D6.1 : NARMAX models of electron fluxes sat GEO [6]

This deliverable consists of a journal paper, ready for submission, discussing a set of NARMAX models for the fluxes of electrons at GEO for various energy ranges.

D6.2 : Use of data assimilation technique within VERB code model [26]

This deliverable, in the form of a journal paper, ready for submission, discusses the results of the incorporation of data assimilation technique into the VERB model and two methods of model couplings

D6.3 : Results of the VNC model and two methods of model couplings [30]

This deliverable, a journal paper ready for submission, discusses the results of the two coupling methods used in the VNC model.

## Schedule of relevant Milestones

| **Milestone number** [18] | **Milestone title** | **Lead beneficiary** | **Due Date (in months)** | **Means of verification** |
|---|---|---|---|---|
| MS1 | NARMAX models for electrons at GEO | 1 - USFD | 6 | NARMAX models for electrons at GEO |
| MS6 | Fusion of NARMAX and VERB | 1 - USFD | 30 | Fusion of NARMAX and VERB |

| Work package number [9] | WP7 | Lead beneficiary [10] | 1 - USFD |
|---|---|---|---|
| Work package title | Fusion of forecasting tools | | |
| Start month | 18 | End month | 36 |

## Objectives

The objectives of WP 7 are:
• To collect the models developed in WP 3, implement them at USFD and the mirror site in the FMI and provide access to their forecasts via the project web page.
• To provide access to the forecasts of models developed in WP 4 via the project web page.
• To implement the VERB-NARMAX and VERB-IMPTAM models, developed in WP 5 and 6 at USFD, and provide access to their forecasts via the project web page.
• To develop a user friendly tool to calculate the integrated electron fluxes in various energy ranges along a user defined part of the orbit based on then past data to facilitate investigation of past spacecraft anomalies.
• To implement a traffic light system and create an automatic email circular (by free subscription) summarising the current space weather conditions and a forecast of their expected evolution.

## Description of work and role of partners

**WP7 - Fusion of forecasting tools** [Months: 18-36]
**USFD**, FMI, UW, IRF
Work package leader: S. Walker (USFD)

Participants: UW, FMI, IRF

Background:
Data fusion is the methodology of combining inputs from different sources in such a way that the output of this process results in a data set that is more complete, accurate, and reliable than any of the individual input data sources. Workpackages 2 - 6 involve the development of individual models to forecast space weather events. Each model provides some forecast of how the particular parameter modelled will evolve in the near future. In WP 7 we will bring them all together, within a single system, to generate a more complete picture of the evolution of the magnetosphere in general and the radiation belts in particular. Thus, all of the results from the project will be available from within a single interface accessed from the project web site.

Specific tasks:

Task 7.1 – Implementation of models for geomagnetic indices and electron flux forecasts at USFD
Month 18-30 (USFD,IRF)
The models for Dst and Kp, developed in WP 3 will be implemented at USFD. Initially the models will be driven using real time solar wind data from ACE/DSCOVR. Once their operation has been verified, the data interfaces will be modified to accept input from the SWIFT MHD solar wind simulation being developed in WP 2. A similar set of steps will be carried out to the models of AE when they become available. The activities of WP 6 will result in a number of NARMAX models for GEO and for the flux of high energy electrons in the radiation belts. The forecasts of these models will be displayed on the project web site, together with facilities to download the numerical values.

Task 7.2 – Implementation of VERB-NARMAX and VERB-IMPTAM models
Month 22-33 (USFD,Skoltech)
The VERB-NARMAX and VERB-IMPTAM models will be installed at USD and tested. Initially they will be driven using solar wind parameters from ACE/DSCOVR and forecasts of geomagnetic indices from the models developed in WP 3 and implemented at USFD. This output of these models will provide forecasts of the particle environment throughout the radiation belt region.

Task 7.3 – Orbit tool
Month 27-30 (USFD,Skoltech,FMI)
The VERB-NARMAX and VERB-IMPTAM models, implemented in task 7.2, will provide forecasts of the flux of electrons at various energies within the inner magnetosphere. This task will use these forecasts to determine the path integrated electron fluxes in various energy ranges encountered along the orbital path of a satellite.

Task 7.4 – Environmental summary
Month 30-36 (USFD)
In order to disseminate the results of the forecasts in a timely an email circular will be generated and circulated. It is envisaged that this circular will be distributed when forecasts show evidence of potentially hazardous conditions. The exact triggering factors will be defined as a result of meetings of the stakeholder advisory board. Subscription to the email list will be performed from the project web site.

Summary of facilities available at hosts:
USFD possesses the necessary hardware environment to perform these activities.

Summary of funding requirements:
Salary for S. Walker (USFD)
Travel and subsistence for dissemination of results.

## Participation per Partner

| Partner number and short name | WP7 effort |
|---|---|
| 1 - USFD | 10.00 |
| 2 - FMI | 3.00 |
| 3 - UW | 3.00 |
| 8 - IRF | 2.00 |
| **Total** | 18.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D7.1 | The results of individual forecasts of geomagnetic indices | 1 - USFD | Report | Public | 30 |
| D7.2 | Forecasts of the energetic electron populations within the inner magnetosphere | 1 - USFD | Report | Public | 33 |
| D7.3 | On orbit forecasts of the energetic electron populations | 1 - USFD | Report | Public | 30 |
| D7.4 | Summary of the space weather environment | 1 - USFD | Report | Public | 36 |

## Description of deliverables

These deliverables report on the generation of tools for use by end users to obtain forecasts of the space weather environment.

D7.1 : The results of individual forecasts of geomagnetic indices [30]

This report and accompanying web pages outlines the implementation and display of individual forecasts of geomagnetic indices

D7.2 : Forecasts of the energetic electron populations within the inner magnetosphere [33]

This report discusses the implementation and use of web page displaying forecasts of the energetic electron populations within the inner magnetosphere.

D7.3 : On orbit forecasts of the energetic electron populations [30]

This report discusses the implementation and use of web page displaying forecasts of the energetic electron populations along a user selected satellite orbit

D7.4 : Summary of the space weather environment [36]

This report discusses the implementation and interpretation of a set of web pages that summarise the forecasts of the short term evolution of the space weather environment and the dissemination of this information to stakeholders.

## Schedule of relevant Milestones

| **Milestone number** [18] | **Milestone title** | **Lead beneficiary** | **Due Date (in months)** | **Means of verification** |
|---|---|---|---|---|

| Work package number [9] | WP8 | Lead beneficiary [10] | 1 - USFD |
|---|---|---|---|
| Work package title | Dissemination | | |
| Start month | 1 | End month | 36 |

## Objectives

The main objectives of this work package are to monitor the dissemination of results obtained by the project.

## Description of work and role of partners

**WP8 - Dissemination** [Months: 1-36]
**USFD**, FMI, UW, Skoltech, UM, SRI NASU-NSAU , CNRS, IRF
Work package leader: R. von Fay-Siebenburgen (USFD)

Participants: All partners

Background:
The timely dissemination of results is an essential activity of project PROGRESS. The level and content of any dissemination activity needs to be targeted to the specific audience for whom the results are intended in order to maximise their benefit. The target audiences identified include the project participants, scientists working in the fields addressed by this project, stakeholders, and the general public. Identification of the various groups will enable dissemination activities to be specifically tailored to maximise the information flow.

Specific tasks:
- Establish project web site for public and project only access.
- Identify any newsworthy space weather events how they fit within the work of the project
- Identify potential stakeholders, inviting them to join the project as members of the SAB.
- Record all science publications and presentations and, subject to copyright, make them available via the project web page.
- Coordinate the activities of project PROGRESS with other EU funded projects, the ESA Space Situational Awareness programme, and the ESA Space Weather Working Team.
- Presentations of results at scientific meetings such as AGU, EGU, COSPAR, ESWW.
- Organisation/joint organisation of specific conference sessions.
- Organisation of summer school to introduce students to space weather, its effects, how to model its effects, and the results of the Project.

Summary of facilities available at hosts:
These tasks will be coordinated be the Project Coordinator and Project Manager. The web site will be hosted at USFD.

Summary of funding requirements:
Salaries for PC and PM. Travel and subsistence for all participants.

## Participation per Partner

| Partner number and short name | WP8 effort |
|---|---|
| 1 - USFD | 2.00 |
| 2 - FMI | 2.00 |
| 3 - UW | 2.00 |
| 4 - Skoltech | 2.00 |
| 5 - UM | 2.00 |
| 6 - SRI NASU-NSAU | 2.00 |

| Partner number and short name | WP8 effort |
|---|---|
| 7 - CNRS | 2.00 |
| 8 - IRF | 2.00 |
| **Total** | 16.00 |

## List of deliverables

| Deliverable Number [14] | Deliverable Title | Lead beneficiary | Type [15] | Dissemination level [16] | Due Date (in months) [17] |
|---|---|---|---|---|---|
| D8.1 | Project web site | 1 - USFD | Websites, patents filling, etc. | Public | 3 |
| D8.2 | Exploitation and Dissemination Plan | 1 - USFD | Report | Public | 24 |

## Description of deliverables

This deliverables introduce the project web site and the facilities it provides and outline the methods used within the Project to ensure dissemination and exploitation of the results.

D8.1 : Project web site [3]

Project web site

D8.2 : Exploitation and Dissemination Plan [24]

This deliverable outlines the methods used by the project for the dissemination and exploitation of the results gained during the Project.

## Schedule of relevant Milestones

| Milestone number [18] | Milestone title | Lead beneficiary | Due Date (in months) | Means of verification |
|---|---|---|---|---|

### *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 | NARMAX models for electrons at GEO | WP6 | 1 - USFD | 6 | NARMAX models for electrons at GEO |
| MS2 | Availability of models for Kp, Dst, and AE | WP3 | 8 - IRF | 18 | Availability of models for Kp, Dst, and AE |
| MS3 | Statistical wave models | WP4 | 7 - CNRS | 24 | Statistical wave models |
| MS4 | Fusion of VERB and IMPTAM | WP5 | 2 - FMI | 24 | Fusion of VERB and IMPTAM |
| MS5 | Availabity of AWSoM/SWIFT for testing within the consortium. | WP2 | 3 - UW | 20 | The AWSoM/SWIFT generated as part of WP2 will be made available to consortium members for testing. |
| MS6 | Fusion of NARMAX and VERB | WP6 | 1 - USFD | 30 | Fusion of NARMAX and VERB |

### *1.3.5. WT5 Critical Implementation risks and mitigation actions*

| Risk number | Description of risk | WP Number | Proposed risk-mitigation measures |
|---|---|---|---|
| R1 | Some of the Work Package Leaders may move to a different institution or post. | WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8 | If possible, their input and involvement will be maintained as outlined in the work packages. Each Work Package Leader has a named deputy who can take over the leadership role. Each Team Leader will have a deputy who can take over their responsibilities. |
| R2 | Some of key persons may leave the project | WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8 | The responsibilities will be redistributed between the rest of the participants or a new person will be invited to the project, subject to the approval of the Project Officer. |
| R3 | Participants disengagement. The deliverables will be compromised if one of the participants leaves the project. | WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8 | All the participants in the consortium are large organisations. If all the members of a Team decide to quit the project, new persons from inside an organization may be found for the continuation of the work. If this is not possible, then a redeployment of teams within the project may be considered by the Steering Committee. |
| R4 | Problem of data provision. | WP2, WP3, WP4, WP5, WP6, WP7 | All data used within the project to create the data driven models are either publically accessible via the internet or provided by a dedicated team or data centre/archive whose task is to provide data accessibility. |
| R5 | Problem of software and method development. Problem can arise if a person responsible for programming inside a WP leaves the project. | WP2, WP3, WP4, WP5, WP6 | The project partners have sufficient experience within their teams to continue the work. |
| R6 | Financial affairs. The funding for some participants may be lower than was planned owing to fluctuations in markets and exchange rates. | WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8 | Resources can be redeployed between WPs if necessary. |

| Risk number | Description of risk | WP Number | Proposed risk-mitigation measures |
|---|---|---|---|
| R7 | Delays in deliveries. There could be a number of technical or managerial reasons (some of them mentioned above) why deliverables will not be produced at the planned time. | WP2, WP3, WP4, WP5, WP6, WP7 | WPs are designed with some buffer in the schedule to offer reasonable flexibility. Delays on deliverables related to data selection, software development, background model computation etc. will not introduce a substantial restriction in the progress of the project. The works are planned in such a way that the next steps can start before the previous deliverables would be accomplished. Effects of delay of deliverables on the main results may be rather serious. Work Package leaders will plan ahead to analyse the effects of slippage that might occur and develop detailed contingency plans to manage the risk. Where the deliverables lie of a critical path alternate action plans have been identified. |

## *1.3.6. WT6 Summary of project effort in person-months*

| | WP1 | WP2 | WP3 | WP4 | WP5 | WP6 | WP7 | WP8 | Total Person/Months per Participant |
|---|---|---|---|---|---|---|---|---|---|
| 1 - USFD | 9 | 1 | 15 | 6 | 6 | 18 | 10 | 2 | 67 |
| 2 - FMI | 0 | 0 | 0 | 0 | 27 | 4 | 3 | 2 | 36 |
| 3 - UW | 0 | 26 | 0 | 0 | 0 | 0 | 3 | 2 | 31 |
| 4 - Skoltech | 0 | 0 | 0 | 8 | 8 | 8 | 0 | 2 | 26 |
| 5 - UM | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 2 | 22 |
| 6 - SRI NASU-NSAU | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 2 | 40 |
| 7 - CNRS | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 2 | 22 |
| · UO | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 - IRF | 0 | 0 | 34 | 0 | 0 | 0 | 2 | 2 | 38 |
| **Total Person/Months** | 9 | 47 | 87 | 34 | 41 | 30 | 18 | 16 | 282 |

### *1.3.7. WT7 Tentative schedule of project reviews*

| **Review number** [19] | **Tentative timing** | **Planned venue of review** | **Comments, if any** |
|---|---|---|---|
| RV1 | 12 | Brussels | Technical and financial review |
| RV2 | 24 | Brussels | Technical review |
| RV3 | 36 | Brussels | Final technical and financial review |

# 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.

# Horizon 2020

## PROTEC-1-2014: Space Weather

# Annex 1 – Description of Action (Part B)

*Grant agreement for: Research and Innovation action*

*Action acronym: PROGRESS*

*Action full title: "Prediction of Geospace Radiation Environment and Solar Wind Parameters"*

*Grant Agreement no: 637302*

## Table of Contents

## *2.1 Excellence*

This proposal addresses the Horizon2020 call H2020-PROTEC-1-2014: Space Weather.

Just as weather can be expressed as a set of atmospheric parameters that are important not only for our comfort but also determine the conditions for the operation of technological systems on the ground and in the atmosphere, space weather is expressed by the set parameters relating to the near Earth environment that determine important conditions for many modern technological systems operating on the terrestrial surface (e.g. power grids), in the atmosphere (aviation) and in the space (satellites, manned missions). Functions provided by spacecraft (communication, navigation) are critical for our modern post industrial society. Even the global financial industry requires spacecraft services both for communications and the time synchronisation of transactions, relying heavily of GNSS as a reference clock. With the exception of galactic cosmic rays, processes that occur on our nearest star, the Sun, drive space weather and may result in events such as magnetic storms, and drastic enhancements of the energetic particles fluxes in the near Earth space that are hazardous to the operations of technological systems. The advanced accurate forecast of these hazards is essential for the mitigation of their effects. The major advance of the current space weather forecasting capabilities is the major target of PROGRESS.

### 2.1.1 Objectives

The overall aim of the project PROGRESS is to exploit the synergy of the complementary expertise available within the partner groups, the available spacecraft and ground based data combined with state of art data assimilation methodologies in order to develop an accurate and reliable forecast of space weather hazards.

Particular objectives are:

- Develop a European numerical MHD based model that will enable the advanced forecast of solar wind parameters at L1 (WP2). This will give a direct simulation connection between observed photospheric drivers and solar wind parameters at L1.
- Use state of the art system science methodologies to develop new forecasting tools for geomagnetic indices and to assess the prediction efficiency of these new tools alongside those currently available to identify the most reliable techniques to predict the geomagnetic state of the magnetosphere, as expressed by geomagnetic indices, in relation to the solar wind input conditions (WP3).
- Construct a new set of statistical wave models to describe the plasma wave environment of the inner magnetosphere that will accurately reflect the physics of the dynamics of the radiation belts under the influence of the solar wind. These novel wave models will lead to more realistic tensors of diffusion coefficients that are critical for physics based models of the radiation belts (WP4).
- Incorporate forecasting capabilities into the physics based numerical model for low energy electrons IMPTAM that currently is able to provide a now-cast only (WP3, 5).
- Develop a novel, reliable, and accurate forecast of the radiation environment in the region of radiation belts exploiting the fusion between data based models for high energy fluxes at geostationary orbit SNB$^3$GEO, IMPTAM, the most advanced model for high energy electrons in the radiation belts – VERB, and state of the art data assimilation methodology (WP6).
- To combine the prediction tools for geomagnetic indices and radiation environment within the magnetosphere with the forecast of solar wind parameters at L1 and upstream of the magnetosphere to significantly increase the advance time of the forecast (WP7).

### 2.1.2 Concept and approach

Currently, the smooth functioning of the European economy and welfare of European citizens depends upon services provided by spacecraft. Space weather hazards can influence the proper operation of this space infrastructure with detrimental effects for economic activity, emergency services, security of European countries, and even the routine activities involving ordinary Europeans such as depositing or withdrawing money from your bank, driving using a satnav, flying away on holiday, or simply forecasting tomorrows weather. The impact and cost of space weather on our modern economy can be illustrated by information published online by the National Oceanic Atmospheric Agency (http://www.swpc.noaa.gov/info/Satellites.html). During the period 1994-1999 a single major spacecraft insurance company estimated that over $500M in insurance claims were disbursed due to in-orbit failures related to space weather. Since that time the amount of space based hardware infrastructure has vastly increased, both in the number of operational satellites and the cost of each satellite. Since 2003 the number of operating satellites has increased from about 460 to more than 1000 today. Even a temporary disruption in the services of these commercial satellites incurs a high cost for their operators. As an example of the disruptive effects, consider the case of the communication satellites Anik-E1 and Anik-E2 launched by Canadian company TELESAT. On January 20$^{th}$, 1994 the electronic unit controlling a momentum wheel failed on Anik-E1 as the result of a space weather induced electrostatic discharge (ESD), followed about 8 hours later by the failure of similar units on Anik-2E [Gubby and Evans, 2002]. During the following 7-hour period of disruption to the operations of Anik-E1 the Canadian press were unable to deliver news to 100 newspapers and 450 radio stations, and the telephone service to 40 isolated communities was interrupted. An hour after Anik-E1 recovered Anik-E2 went off-air. It took half a year and $50M to restore its operation. This cost does not include the loss in revenue resulting from the interruption of services across Canada.

ESD is one example of the effects that space weather hazards can have upon our satellite infrastructure. Surface ESD occurs when low energy electrons in the surrounding plasma deposit charge on the spacecraft surface. Eventually the gradient of the electrostatic potential exceeds the material breakdown potential causing an impulsive discharge of energy, which can result in either a Single Event Upset (SEU) or anomalies in electronic components [e.g. Lohmeyer and Cahoy, 2013]. It is currently accepted that electrons with an energy range from a few keV to a few tens of keV are the main cause of surface ESD. High-energy electrons, in contrast, are able to penetrate spacecraft shielding and deposit their charge directly into dielectric components or circuit boards, leading to internal ESD. By analysing satellite anomalies from data bases at NOAA, NASA, and US Air Force 55$^{th}$ Space Weather Squadron, Koons et al., [2000] determined that ESD is the main cause of spacecraft anomalies (54% of total anomalies). The second most frequent reason for spacecraft anomalies was SEU caused by South Atlantic Anomaly (6.7% of total anomalies), galactic cosmic rays (5%), solar energetic particles (3%). In 13.5% of these SEU anomalies the cause was not identified. In 5.3% of cases the anomaly was related to the degradation of solar arrays caused by solar particle events, total radiation dose, the South Atlantic Anomaly or material damage. According to the databases analysed by Koons et al., [2000] 11 missions were lost or terminated as the result of the space environment effects. Among these 11 cases 5 were caused by ESD. This cause exceeds even that of micrometeorite impacts (3 cases). More recent studies based on new data confirm the significant role of ESD in the occurrence of satellite anomalies [Choi et al., 2011,2012]. Whilst the prolonged exposure of satellites to enhanced fluxes of relativistic electrons leads to internal ESD, surface charging depends upon on a number the details of the electron distribution [Mazur, Obrien, 2013; Fennell et al., 2001]. Accurate models for the electron fluxes in the low and high-energy ranges will enable the provision of warnings of possible ESD hazards to operational spacecraft and may also assist in the analysis of historical anomalies.

The inner and outer radiation belts are regions in the magnetosphere that are saturated with energetic particles. Whilst the inner radiation belt of very high-energy protons and electrons is

rather stable, the fluxes of energetic electrons in the outer radiation belt are very dynamic, capable of increasing by a few orders of magnitude on a time scale of a few hours. The radiation environment in the outer radiation belt is important for satellites with Medium Earth Orbits (MEO) that pass through its heart. While only a few per-cent of the currently operating spacecraft fleet use MEO orbits, these satellites provide extremely important services including navigation systems such as GPS, GLONASS and, importantly from the standpoint of European space infrastructure and security, Galileo. The geostationary orbit (GEO) is of no less importance with about 400 satellites operating as of the February 2014. GEO spacecraft provide communications, weather forecast and services for security and military requirements. While GEO lies on the periphery of the outer radiation belt this region is still home to high fluxes of relativistic MeV electrons that can prove hazardous to spacecraft hardware. In addition, night side sector of the GEO orbit is situated in the region where electrons with energy in the range from a few keV to a few hundred keV are accelerated during substorm activity as they propagate into the inner magnetosphere. The project PROGRESS aims to develop a set of accurate models and forecast tools to describe the spatio-temporal dynamics of electron population from low energies up to above 2 MeV.

The FP7 programme devoted significant resources to the development of forecast tools and physical models for the forecast of low and high energy electron populations in the inner magnetosphere. In particular, the SPACECAST project pioneered the consolidation of European modelling resources to create a forecast for the radiation environment within the inner magnetosphere. The real time, physics based forecast of high energy fluxes and the now-cast of low energy fluxes was developed and is still currently maintained (http://fp7-spacecast.eu). However, while the now-cast of low energy electron fluxes provided by the IMPTAM model are close to those observed, the 3 hour ahead forecast of the high energy fluxes by the ONERA and BAS models is not of the same quality. Validation of the forecasts may be performed by comparing the results directly with measurements from the GOES satellites at GEO. During 2013 the highest daily fluxes of electrons with energies > 2 MeV was measured on May 30-31. Three current data based models (NOAA, University of Colorado and the USFD model SNB$^3$GEO) provided quite accurate 24 hour-ahead warnings regarding the enhancement of fluxes of energetic electrons in this energy range. SNB$^3$GEO predicted the flux value to within 25% of the actual values measured by GOES 13. At the same time both the ONERA and BAS models under predicted the fluxes by 2 orders of magnitude (100 times). Currently the ONERA and BAS models provide only a 3 hour-ahead forecast. Since the time scale for the enhancement of the 2 MeV electron flux at GEO due to the solar wind drivers is about 2 days [Balikhin et al., 2013] a forecast with a lead-time significantly longer than 3 hours is feasible. While data based models (NOAA, University of Colorado and SNB$^3$GEO) provide an accurate forecast of the electron fluxes at GEO 24 hours in advance, their forecast cannot be easily expanded to cover the whole region of the radiation belts because a continuous set of measurements is required to develop this class of model. Such continuous measurements are currently available only at GEO. The disadvantages of the current European physics based models (BAS and ONERA) for high energy fluxes are due to unclear boundary conditions (often assumed to be constant), deficiencies in the statistical wave models implicitly used by these codes to develop the diffusion tensor coefficients, disregard of the mixed diffusion terms within these codes, and the assumption of a dipolar field for the calculation of the diffusion coefficients. PROGRESS aims to develop a forecast that overcomes these disadvantages. The SNB$^3$GEO NARMAX model for electron fluxes at GEO, which has shown its capability to provide reliable, online forecasts for the past two years, will be used to determine the boundary condition for the physics based models. PROGRESS will redevelop the statistical wave models to account for the dependence of the magnetospheric electron fluxes upon the solar wind parameters and for recent findings on the dynamics of inner magnetosphere waves obtained during the Cluster spacecraft mission Inner Magnetosphere Campaign.

The physics based models used by PROGRESS (IMPTAM and VERB) require geomagnetic indices such as Kp, AE, and Dst as input parameters. These values reflect the configuration of

the terrestrial magnetic field and the level of geomagnetic substorm activity that is responsible for the seed populations of particles that may be accelerated to extremely high energies within the outer radiation belt. One of the aims of PROGRESS is, therefore, to re-evaluate and improve the current tools used to forecast geomagnetic indices. The location of the magnetopause is also a very important parameter for the evolution of electron fluxes within the outer radiation belt. Earthward displacement of the dayside magnetopause leads to "magnetopause shadowing" which is an extremely important mechanism for the loss of relativistic electrons. While it takes about 2 days for the MeV electron to react to the solar wind drivers, the low energy electrons respond on the same day [Balikhin et al., 2012, Boynton et al., 2013]. Therefore, the forecast of their fluxes will greatly benefit from knowing the solar wind parameters before a spacecraft situated at the L1 point measures them. PROGRESS will develop an MHD model (SWIFT) coupled with the model of the solar corona (AWSoM). This new suite of combined solar corona and inner heliosphere tools will provide an advanced forecast of the solar wind parameters at L1. There are three separate pillars of the PROGRESS forecast, namely

- The forecast of parameters at L1,
- The forecast of geomagnetic indices
- The forecast of radiation environment in the inner magnetosphere.

It must be emphasized that all three pillars have critical independent importance for the forecast of the space weather.

The complexity of the dynamics of geospace (and therefore space weather) is related to its constant evolution under the influence of the solar wind. This involves a chain comprising of an enormous number of coupled physical processes operating on spatial scales from meters to tens of thousands of kilometres [Balikhin et al., 2010]. Two complementary approaches to the understanding of such complex systems exist. The first one, which is as old as physics itself, is to advance our knowledge from first principles by building models of increasing complexity that reflect our understanding of each individual process and then, finally, to conjugate all these links into a comprehensive mathematical/numerical model that can be used to forecast the evolution of the dynamical system in a bottom-up approach. First principles based models have been developed for many aspects of space weather. However, our current knowledge of the physics involved does not allow the development of first principles based models that provide reliable and accurate forecasts. The second approach, which is often referred to as system science, is relatively young and advances our understanding about a particular system in the opposite direction, i.e. top-down, beginning with the overall system behaviour and working towards an understanding of the underlying physical processes and components. This second approach relies heavily on advanced data analysis methodologies developed in systems science from models based on Neural Networks and sophisticated optimisation techniques to Nonlinear AutoRegressive Moving Average models with eXogenous inputs models (NARMAX). The NARMAX models allow physical interpretation and provide insight into the physics of the dynamical processes involved. While system science models deliver an accurate and reliable forecast for some space weather parameters, this approach can only be applied to specific aspects of space weather for which a continuous set of measurements is available. For example SNB$^3$GEO, the USFD NARMAX model for the daily averaged fluxes of relativistic electrons at geostationary orbit, has been operating for the last two years, providing an accurate 24 hour ahead forecast (http://www.ssg.group.shef.ac.uk/USSW/2MeV_EF.html). However the expansion of this forecast to the entire region of the inner magnetosphere, for which only sparse satellite measurements are available, is not possible in the frame of the systems science approach. *The fusion between the first principles based numerical models, empirical models developed by systems science techniques and comprehensive validation these models using actual measurements is the cornerstone of the PROGRESS methodology*. This is the concept underpinning much of the activity within PROGRESS.

The PROGRESS consortium possess expertise in two high performing data based approaches to the forecast of complex dynamical systems: NARMAX and Neural Networks.

NARMAX (Nonlinear Autoregressive Moving Average Model with Exogenous inputs) modelling has been developed by USFD (participant 1) to analyse and forecast dynamical systems about which very little is known. Artificial Neural Networks (ANN) and similar kernel based approaches can be used to address the problem of prediction. However, the disadvantage of ANN is that to produce a reliable model a priori knowledge about the system, for example all the system inputs and lags, are required. If some inputs or lags are not known, these methods will attribute the response variations only to the set of inputs included in model. Therefore, such methods will provide reliable models only in the case when the "physics of the systems inputs is known". In addition, ANN often result in opaque models that are difficult to relate to the physics of the underlying system and are difficult to analyse [Billings and Chen, 1998]. In contrast, NARMAX is not only able to provide a reliable forecast for the evolution of complex systems with unknown physics, but also provides insights into the nature of the physical processes underlying the system dynamics. NARMAX is based on developing physically interpretable models that can be related to analytical models deduced from first principles. So if, for example, a system has a first order dynamic response with a cubic effect in the output then the model identified should have exactly this form. This is the basic philosophy behind the NARMAX model and what have now become known as 'NARMAX methods' developed by Billings, his Sheffield co-workers, and other USFD partner team members over several years. The only disadvantage of this method is that expertise in nonlinear system identification and estimation is required to fit the models but this is easily outweighed by the additional insight and properties of the system that are revealed. Application of NARMAX methodologies have led to major advances in such fields as the growth stem cells, animal vision, neuroscience and brain imaging [Billings, 2013].

The theory behind ANN originates from the 1940's of studies of the brain being a highly connected network with biological neurons. One rationale behind this is the brain's capability of modelling and learning complex non-linear systems. Simple mathematical models of the neurons were constructed but it was not until the 1970's that algorithms were proposed that could provide a learning mechanism (for an overview see e.g. Anderson and Rosenfeld, 1988). Studies of ANNs have two main branches: 1) understanding and modelling of the brain; 2) modelling of complex and non-linear systems. The latter is not about the biological counterpart but is a set mathematical tools that collectively may be called computational neural networks (CNN). Two basic categories of CNN exist: unsupervised (UCNN) and supervised (SCNN). The UCNNs find patterns in the underlying data based on some defined criteria, like Euclidian distances between pairs of input vectors. The SCNN finds an input-output mapping from given sets of input-output data pairs. In the context of input-output mapping models (SCNN) two basic types of CNNs exist, models with only exogenous inputs and models with both endogenous and exogenous inputs, where the latter can be interpreted as differential equations in their linear regime.

The basic approach of PROGRESS is:

i) To develop new empirical and physics based models, in particular of the solar wind propagation to L1.

ii) To exploit recent experimental findings and the vast amount of existing space missions data to further to improve state of the art physics based existing models for geospace environment (e.g. IMPTAM, VERB) and expand their capabilities.

iii) To develop new forecasting tools that will be based on fusion of first principle numerical models and empirical models (e.g. VERB-NARMAX, IMPTAM-NARMAX, IRF-CNN) that will possess advantages of the both types: forecast accuracy of data-based models and wide area of applicability of the physics based models.

These three concepts have been split into 6 scientific work packages (WP2-7).

#### 2.1.2.1 WP2 Propagation of the Solar Wind from the Sun to L1:

Current simulation tools that connect the observed solar photospheric magnetic field to solar wind variables at L1, and beyond, either rely on semi-empirical models, e.g. the Wang-Sheeley-Arge model, or require large-scale computing resources. The first approach can be tuned to reasonable accuracy but lacks the predictive power of a first-principles based solution. The direct first-principle approach requires substantial computing power and is correspondingly slower thus limiting its appeal as a real-time predictive tool. PROGRESS will address these two issues by adopting a coupled model approach. From the photosphere out to ~ 20-30 Solar radii PROGRESS will use the recently developed AWSoM code [van der Holst et al. 2014]. This proven code combines large-scale MHD with modelled turbulence and thermal transport in a multi-temperature plasma. This captures the physics of the solar wind drive and coronal heating allowing for a self-consistent physical model. Since this code must capture the steep gradients near the solar surface this modelling requires at least 100 cores of a HPC cluster to simulate in real time. Once the solar wind has become super-sonic and super-Alfvenic much of the detailed physics included in AWSoM becomes less important. Therefore to avoid the substantial computing cost of running AWSoM in high resolution out to L1 a more efficient, but reduced physics, code will be used from 20-30 radii to L1.

The use of an ideal-MHD model from beyond the solar-wind sonic transition to L1 is common in space weather prediction, e.g. the ENLIL code [Odstrcil and Pizzo, 1999]. In PROGRESS this approach will be improved upon by allowing for different ion and electron temperatures. This two-temperature model will allow correct handling of CME shocks and improved modelling of electron thermal conduction. PROGRESS will therefore deliver a coupled model with the essential physics include near the Sun generating the solar wind data self-consistently to drive an MHD model for the solar wind transport to L1. The MHD model will be based on the extensively used Lare3d code [Arber et al. 2001], which while needing modification for solar wind studies, see Work Package details, is a well used and robust algorithm. The new solar wind version of Lare3d will be specifically customised for PROGRESS called SWIFT (Solar WInd Field Transport).

Partner 3 (UW) has a three-dimensional MHD code (Lare3d) that includes resistivity, thermal conduction, optically thin radiative losses and tensor shock viscosity. Once modified to spherical geometry this will be suitable for simulating the solar wind of the inner heliosphere. The code works by taking a fully three-dimension Lagrangian step followed by a geometry remap. This allows the code to easy include additional physics such as different ion and electron temperatures, ion shock heating and electron thermal transport.

Partner 5 (UM) has a three-dimensional Alfven Wave Solar atmosphere Model (AWSoM) that is suitable for simulating the upper chromosphere, transition region and corona. The coronal heating and solar wind acceleration are addressed with low-frequency Alfven wave turbulence. AWSoM uses a spherical grid in which the radial coordinate is highly stretched towards the Sun to numerically resolve the steep density gradients in the upper chromosphere and transition region. The only observational input is the ingestion of magnetograms as boundary conditions for the magnetic field. This model is part of the overarching Space Weather Modeling Framework (SWMF), a software tool to couple various space weather models into one new combined model [Toth et al. 2012]. Both the SWMF and AWSoM have been installed at the Community Coordinated Modeling Center, part of NASA Goddard Space Flight Center.

These models will form the basis of a brand new code to model the solar wind from the surface of the Sun to L1 and beyond.

#### 2.1.2.2 WP3 Forecast of the evolution of geomagnetic indices:

Within the consortium there are a number of codes available that have been developed to model the evolution of various geomagnetic indices.

*Models from partner 8 (IRF):* In solar-terrestrial physics and space weather SCNNs have been applied in many domains and especially for the mapping from solar wind at L1 to various geomagnetic indices and other geomagnetic quantities: AE [Gleisner and Lundstedt, 2001], Dst [Lundstedt and Wintoft, 1994; Gleisner et al., 1996; Wu et al., 1998; Lundstedt et al., 2001], Kp [Boberg et al., 2000], local ground dB/dt [Wintoft 2005; Wintoft et al., 2005; Wintoft et al., 2014]. Models for Dst and Kp have been implemented for real-time operation driven by ACE solar wind data, and have been in operation since many years at IRF (http://src.irf.se/forecast/dst/, http://src.irf.se/forecast/kp/). In the recently finished EU/FP7 project EURISGIC data and forecasts tools were developed for local dB/dt and set up for real-time operation. The project is described at http://www.eurisgic.eu and the service is found at *http://src.irf.se/eurisgic*.

*Models from partner 1 (USFD):* Single and multiple input models to forecast Dst and Kp indices have been developed by USFD exploiting the NARMAX approach [e.g. Boaghe et al., 2001; Wei et al., 2004, 2006; Wing et al., 2005; Zhu et al., 2005; 2007]. These models are driven by real time solar wind IMF parameters measured at L1 with a time shift to account for the solar wind propagation from L1 to the Earth's magnetopause. These models are able to provide a forecast that requires knowledge of solar wind parameters and does not require measured values of the geomagnetic indices. With the present availability of solar wind measurements at the L1 point this translates to a one hour ahead forecast for the Dst index with respect to the current time and a few hours ahead with respect to the calculation of the "final" Dst value by the World Data Centre for Geomagnetism in Kyoto. Based on the success of forecast models, USFD team members H. Wei and R. J. Boynton were the only European researchers invited to join the Dst Challenge led by NASA CCMC and developed an advanced NARMAX Dst model in frame of this challenge [Rastätter et al. 2013].

*Models from partner 6 (SRI NASU-NSAU):* SRI NASU-NSAU possesses two models for the prediction of geomagnetic indices. The first, a recursive, robust bilinear dynamical model (RRBDM) [Yatsenko et al, 2008 and references therein] has minimal complexity and the same prediction limit as NARMAX. RRBDM provides forecasts of the Dst and Kp indices based on new robust algorithms and is driven by real time solar wind parameters measured at L1 with a time shift to account for the propagation of the solar wind to the terrestrial magnetopause and the real time Dst and Kp indices. The second, the Guaranteed NARMAX Model (GNM), [e.g. Semeniv and Yatsenko 2010 and references therein] also provides predictions of the Dst index. Its main advantage is that it delivers an increased prediction reliability in comparison to earlier SRI NASU-NSAU models.

A comparison of the strengths and weaknesses of these models will be used to decide when each of these models performs at its best and to create a new forecasting tool based on the fusion the results of all models.

#### 2.1.2.3 WP4 Development of new statistical wave models and the re-estimation of the quasilinear diffusion coefficients.

Numerical codes that are currently used to model the evolution of high energy electrons

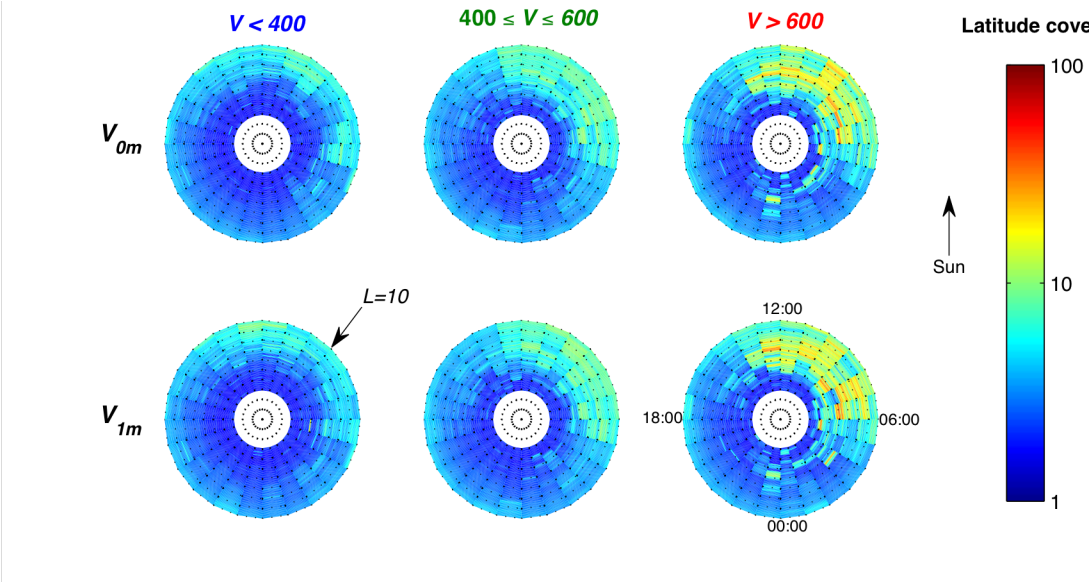


**Figure 1: Distribution of wave intensity as a function of solar wind velocity and time**

within the radiation belts such as VERB involve solving a set of diffusion equations. These codes require tensors of the quasilinear diffusion coefficients to account for particle pitch angle and energy diffusion due to their interaction with various wave modes. The main types of waves that affect the energetic particles within the radiation belts are Chorus, hiss, Equatorial Magnetosonic Waves (EMW), Electromagnetic Ion Cyclotron waves (EMIC) and lightning whistlers.

Diffusion coefficient tensors for Chorus, EMW and hiss are based on wave models that represent the statistically averaged wave power of a particular wave type organised according to local time, L-shell and the current value of geomagnetic index (Kp or AE). The Kp index reflects the average value of geomagnetic disturbances as measured on the ground whilst AE attempts to quantify the Auroral Electrojet. This classification of wave amplitudes, however, has several major drawbacks. Currently, these models assume that the state of the magnetosphere is memory-less and does not depend upon the short-term historical evolution of the magnetosphere, i.e. whether geomagnetic activity is constant, increasing, or decreasing. In a simple extreme example the wave amplitude for a case when Kp was zero for the previous 21 hours and is currently 9 will be added to the same cell of the wave model as that measured in the situation when Kp was 9 for the whole 24 hours period. Another weakness of the currently used wave models is related to the results of Reeves et al., [2003] who, after studying a number of strong geomagnetic storms, concluded that only 50% of storms resulted in enhancement of electron fluxes at GEO, whilst 25% caused a decrease and the final 25% had no substantial effect. Thus, whilst Kp and AE can be used to indicate the current level of geomagnetic

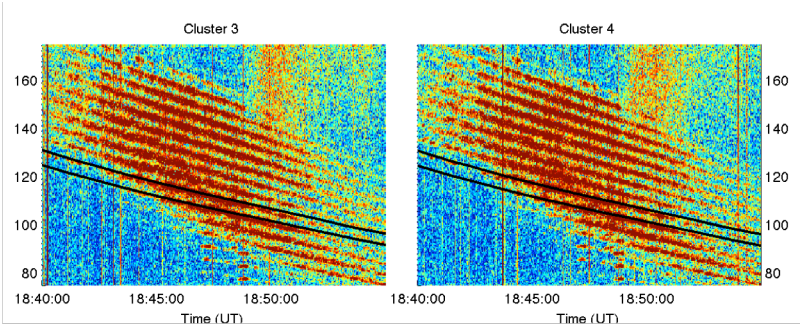


**Figure 2: Observations of EMW by Cluster 3 and 4 during the Cluster Inner Magnetospheric Campaign.**

activity they do not reflect the observed wave activity. If these models are used to simulate the evolution of energetic particle fluxes in the radiation belts they should be organized by the parameters that affect the evolution of these fluxes. Recent studies at USFD used the Error Reduction Ratio concept to identify the parameters that affect the evolution of the daily averaged electron fluxes in various energy ranges at GEO. The results showed that the solar wind velocity, density and, therefore, dynamical pressure are the most effective parameters that control the energetic electron fluxes [Balikhin et al., 2011; Boynton et al., 2013]. Recent results [Kim et al. 2013] have also shown that the solar wind parameters can provide a better indication of the occurrence of wave activity than geomagnetic indices. The strong dependence of the wave amplitude upon the solar wind parameters, based on Double Star measurements of upper band chorus, is shown in Figure 1. The six panels show the distribution of wave intensity as functions of L-shell and local time for different ranges of the solar wind velocity (columns) The top row shows the correlation between wave intensity and solar wind velocity measured on the same day, the lower row shows the correlation with the solar wind velocity measured on the previous day. The figure shows that the intensity distribution of the observed Chorus waves for different solar wind velocity regimes varies depending upon the time lag of the solar wind velocity measurements. PROGRESS will redevelop the current wave models for chorus, hiss and EMW to include the solar wind velocity and density as organisational parameters as well as geomagnetic indices (separate models for Kp and AE) based on data from Cluster, THEMIS, Akebono, Polar, and CRRES. The wave models that will be developed in frame of PROGRESS will account for previous states of the magnetosphere as well as its current state. This will be done by exploiting the nonlinear Structure Detection techniques that constitute the first stage of the NARMAX procedure and is based on the concept of Error Reduction Ratio developed by a member of the participant 1 team USFD [e.g. Billings et. al., 1989].

The necessity of another important modification of the EMW model has arisen from recent Cluster Inner Magnetosphere Campaign (July-October 2013) that targeted the study of various types of magnetospheric waves. The uniqueness of this data set lies in the very small inter-satellite separations (down to 4 km) employed. This situation is extremely favourable for probing waves and is beyond the capabilities of any other current or previous missions. The developers of the current EMW models assumed a Gaussian shaped wave spectrum. However, the Cluster measurements (Figure 2) show that the EMW spectrum consists of a number of discrete emissions at harmonics of proton gyro-frequency and, importantly, that the Chirikov resonance overlap criterion is not satisfied, indicating that the contribution of each harmonic to the quasilinear diffusion should be calculated separately to avoid erroneous results. PROGRESS will re-estimate the diffusion coefficients resulting from EMW models taking into account the discrete structure of the EMW emission.

#### *2.1.2.4 WP5 Low energy electrons model improvements to develop forecasting products.*

The approach of WP5 is based on the Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM) [Ganushkina, et al., 2005, 2012], available within the consortium through partner 2 (FMI). This code traces ions and electrons with arbitrary pitch angles from the plasma sheet to the inner L-shell regions with energies reaching up to hundreds of keV in time-dependent magnetic and electric fields. The tracing of a distribution of particles is conducted in the drift approximation under the conservation of the 1st and 2nd adiabatic invariants. Liouville's theorem is used to gain information of the entire distribution function. The IMPTAM version to nowcast low energy (< 200 keV) electrons in the inner magnetosphere [Ganushkina et al., 2013a, b] is currently operating online under the FP7 funded SPACECAST project (http://fp7-spacecast.eu).

The present model provides the low energy electron flux at all L-shells (L=2-8) and at all satellite orbits, when necessary. The IMPTAM model is driven by real time solar wind and IMF parameters measured at L1 with time shift to account for the solar wind propagation to the Earth's magnetopause, and by the real time Dst index. For electrons, the radial diffusion equation is solved, in addition to convection and drifts, and the effects of losses are

incorporated due to convection outflow and pitch angle diffusion based on the electron lifetimes. The remarkable advantage of IMPTAM is that it takes into account the substorm-associated electromagnetic fields by launching an electromagnetic pulse at substorm onsets determined by AE index. The proper forecast of AE index is essential for accuracy of substorm representation in IMPTAM. The significance of IMPTAM within PROGRESS is related to the low energy electron fluxes that are critical to the processes involved in satellite surface charging phenomena. In addition, the low energy electron population constitutes the seed population for the high-energy MeV particles in the radiation belts

#### 2.1.2.5 WP6 Forecast of the radiation belt environment.

The approach of WP6 is based on improvements to the current Versatile Electron Radiation Belt (VERB) code that is available in the consortium through partner 4 (Skoltech), [e.g. Subbotin et al., 2011, and references therein] and its fusion with the NARMAX SNB$^3$GEO model from USFD and also a fusion between VERB, SNB$^3$GEO and IMPTAM. VERB is a diffusion code that models radiation belt particle dynamics using the bounce-averaged Fokker-Planck equation [e.g. Schultz and Lanzerotti, 1974] with diffusion in radial distance, pitch angle and energy. One of the main advantages of the VERB code in comparison to the models available in Europe (e.g. BAS and ONERA models) is the inclusion of the mixed diffusion terms that are not accounted in European models. The VERB code uses tensor diffusion coefficients that are parameterised according to the location (L*, local time) and geomagnetic index (available options are Kp or AE). The significance of the VERB code within PROGRESS is related to the importance of high-energy electron fluxes to the spacecraft hardware damage. The NARMAX SNB$^3$GEO model is a Multi Input Single Output (MISO) NARMAX model that is developed to provide a forecast of the daily averaged electron flux at GEO for energy ranges >800 keV and >2MeV. NARMAX is a black box methodology and was trained on electron flux data from GOES13. The inputs to the model are the daily averaged L1 solar wind velocity and density, along with the fraction of time that the IMF is southward. SNB$^3$GEO has been operating online for the last two years, providing accurate 24 hour ahead forecasts of the daily averaged fluxes of relativistic electrons with energies in excess of 800 keV (http://www.ssg.group.shef.ac.uk/USSW/800keV_EF.html) and in excess of 2 MeV (http://www.ssg.group.shef.ac.uk/USSW/2MeV_EF.html) [Boynton et al, 2013]. Since the Sheffield SNB$^3$GEO model provides reliable forecast it has been solicited by the CCMC at GSFC NASA and currently operates from their web site as well as from Sheffield. Accurate forecast by SNB$^3$GEO will be exploited by WP6 to provide a boundary condition for VERB.

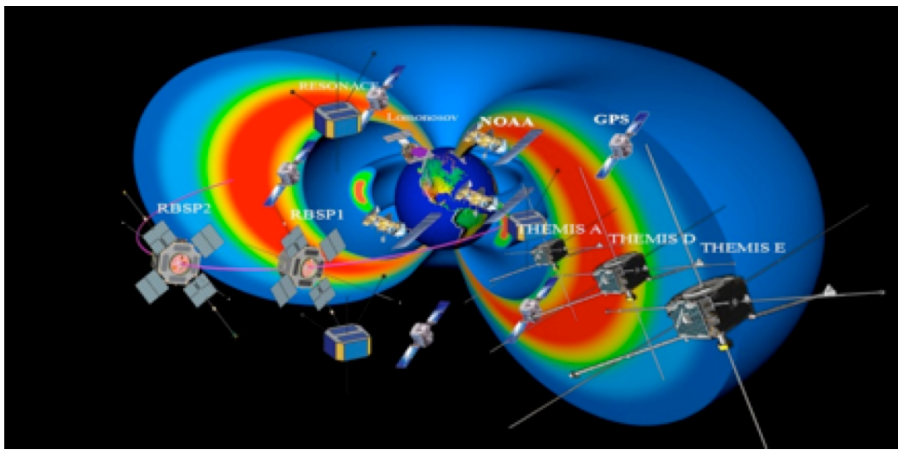


**Figure 3: Earth's radiation belts with key satellite missions overlaid. Missions include: the THEMIS mission, NASA RBSP mission, UCLA-MSU mission Lomonosov, Russian RESONACE mission, and multiple GPS and NOAA and GOES spacecraft**

The output of the IMPTAM model will be employed to provide low energy seed population for the VERB model.

Data assimilation is an algorithm that allows for an optimal combination of model results and sparse data from various sources

contaminated by noise [e.g. *Kalman*, 1960; *Ghil*, 1997; *Ghil and Malanotte-Rizzoli*, 1991; *Shprits et al.,* 2007]. Satellite observations are often restricted to a limited range of radial distances and energies and have different observational errors. Data assimilation allows us to fill in the temporal and spatial gaps left by sparse in-situ measurements. It also allows for combining measurements from different spacecraft with different uncertainties according to the underlying errors of each of the instruments.

Members of the Skoltech participant team have used data assimilation with CRRES data and a simple one dimensional radial diffusion model to reconstruct the radiation belt electron PSD for a period of 50 days and found that radial diffusion, which produces monotonic profiles in PSD, cannot explain peaks in PSD that are clearly seen in the reanalysis [*Shprits et al.* 2007]. This result was consistent with earlier findings [*Green and Kivelson*, 2004*, Chen et al*., 2007] and consistent with a recent study of *Reeves et al*. [2013]. Similar results were obtained by *Koller et al*. [2007] for one storm in 2003.

Members of the Skolkovo participant team, in collaboration with colleagues at UCLA, performed data assimilation studies with a 1D radial diffusion code using data for a period of up to 1.5 years in 1990-1991 and for 160 days in 2003 [*Shprits et al.,* 2007; *Kondrashov et al*., 2007; *Ni et al.,* 2009a; 2009b; *Daae et al*., 2011; *Kondrashov et al*., 2011; *Shprits et al*., 2012; *Kondrashov et al*., 2012], and a LANL study of a storm in October 2003 [*Koller et al.,* 2007; *Reeves et al*., 2012], showed that data assimilation with a simple radial diffusion model can reconstruct radial profiles of the drift-averaged phase space density. We have performed validation and verification of the data assimilative code and also performed sensitivity simulations to the assumed boundary conditions and magnetic field models.

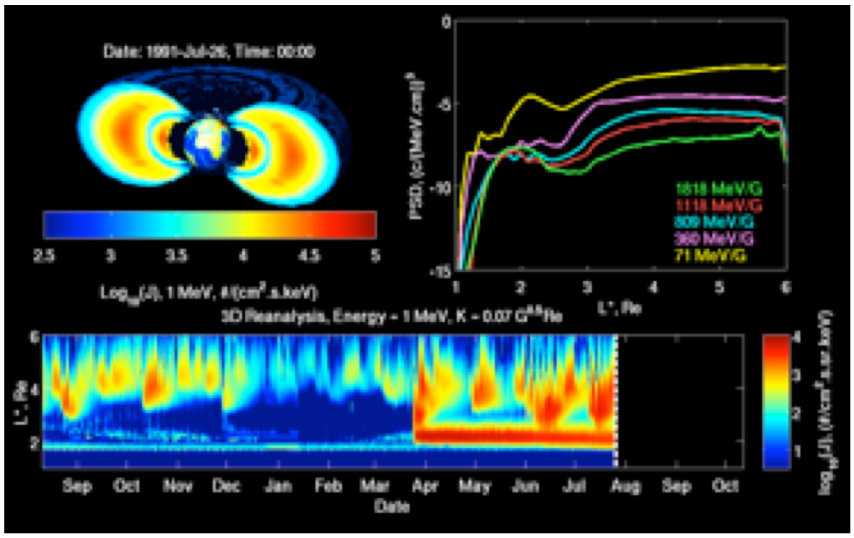


**Figure 4: 3D reanalysis during 1990. The top 2 panels show a snapshot on the 13th Oct 1990. The left panel shows 1 MeV integrated flux to scale around the Earth, and right panel shows PSD versus L* at multiple values of the first invariant m. The bottom plot shows 1 MeV differential flux obtained from long-term 3D reanalysis in an L* versus time format. All plots are for a fixed K value of 0.07.**

The results of the reanalysis revealed a number of key processes that determine the dynamic evolution of the radiation belts. Data assimilation showed evidence that there are peaks in phase space density associated with the local acceleration that occurs at around 5 $R_E$, right outside of the plasmasphere. The reanalysis results also showed evidence that dramatic depletions of the radiation belts occur when the magnetosphere is compressed, and particles escape to the interplanetary medium. Reanalysis have been recently made public as in an AGU publication as auxiliary material [e.g., *Shprits et al.,* 2012]. Our results are already used by a number of research groups around the world. To fully understand the complex nature of acceleration and loss, reanalysis should be done in terms of three dimensions (radial distance, pitch-angle, and energy), use a vast amount of observations including pitch-angle

distributions and energy spectra. We need to be able to assimilate into the code all available information from different satellites (Figure 3). The computational requirements of the optimal Kalman filter become very large in the case of a multidimensional system. In a recent study *Shprits et al*. [2013] demonstrated computational efficiency of a split-operator method for data assimilation with the VERB 3D code In particular we will perform 1D data assimilation for each of the directions separately (radial diffusion, pitch-angle, energy). Special attention will be paid to estimating the errors of each of the measured and modelled quantities. Observational errors will be inferred from the inter-calibration of different satellites and from comparison of satellite measurements with reanalysis results for selected time intervals. Model errors will be estimated by a detailed analysis of the innovation vector. We will also verify the model and observational error estimates by the covariance matching method [*Fu et al.,* 1993]. Examples of 3D-data assimilation using five satellites during the CRRES era are shown in Figure 4.

Reanalysis of the radiation belts in 3D allows us to obtain a global picture of the radiation belts and the inner magnetosphere and to identify and quantify acceleration and loss mechanisms. A comparison of the reanalysis with the coupled code results with no data assimilation will indicate what processes are missing in the model and how accurately the code can predict the evolution of the radiation belt fluxes at various energies, pitch-angles, and radial distances. Such comparison will identify the conditions when these processes are most efficient and the spatial scales on which they operate.

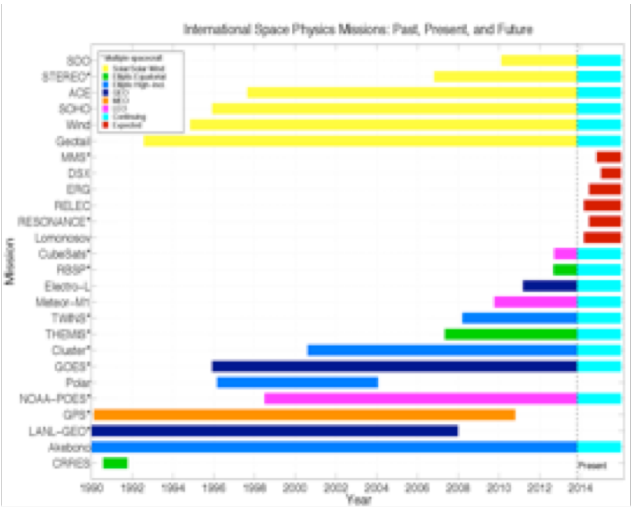


**Figure 5: Available satellite data. Color-coded are various satellite orbits. Missions beyond 2011 are projected/continuing. Intervals with CRRES, Polar, THEMIS and RBSP data will be used for detailed validation of coupled codes and data assimilation, and cover all 4 phases of the solar cycle over a 25 year period**

We will perform model runs from the start of the CRRES era to the current era (1990 – 2015). We plan to use the SSA method as was recently done by *Kondrashov et al.* [2010;] to fill gaps in solar wind data from 1990-1994, and utilize OMNI1-minute data thereafter. This period contains two full solar cycles with various satellites covering the solar maximum, declining phase, solar minimum and ascending phase periods. This interval included the very quiet conditions during 2007-2009 and time intervals that are well observed by a number of satellites during CIR and CME dominated storm time intervals. A list of the satellite data available during the interval is shown in Figure 5.

We will perform validation of the data assimilation by comparing the results of the reanalysis using different satellites. We will perform data assimilation for all available data for 1991 and compare the results using different sets of satellites.

#### *2.1.2.6 WP7 Fusion of forecast tools*

Data fusion is the methodology of combining inputs from different sources in such a way that the output of this process results in a data set that is more complete, accurate, and reliable than any of the individual input data sources. Thus, by combining the results of forecasts of the various geomagnetic indices it is possible to obtain a more complete picture of the way the magnetosphere is evolving due to changes in the solar wind. This picture is supplemented

further by combining it with forecasts of the activity of the radiation belts and in particular the fluxes of electrons that inhabit this region. As a result, a more comprehensive overview of the effects of the interaction of space weather events will be produced, leading to a better scientific understanding of this interaction and vastly improved system for monitoring and warning of hazards to our susceptible space and ground-based infrastructure.

### 2.1.3 Ambition

The overall ambition of PROGRESS is to exploit the synergy between world leading experts in the fields of solar physics, magneto-hydrodynamics, magnetospheric physics, system science, and data assimilation to achieve radical advances in our capabilities of forecasting space weather. These advances will result from both a significant improvement in the forecast accuracy and a major increase in the forecast lead-time.

As was demonstrated in Section 1.3, Europe possesses a number of individual models that are used as stand alone systems to forecast particular features of space weather such as geomagnetic indices or the fluxes of energetic electrons within the radiation belts. These stand-alone models have been developed and their results validated, showing them to be mature technologies at a readiness level (TRL) of 4-5 (as defined in Annex G of the Horizon 2020 Space Work Program). Within project PROGRESS, we aim to take these models, and to build them into a prototype operational system (TRL 7) to demonstrate the advantages of using the models concurrently in order to achieve a bigger, more detailed picture of how space weather affects our planet. This ambition is supplemented by the drive to improve these existing models and their forecasting abilities, particularly in the development, validation and operation of the new solar wind model SWIFT. At the end of the project, Europe will possess a new, sophisticated tool to enable forecasts of the space weather environment. In addition, UW will be routinely running a local version of AWSoM, and USFD the new upgraded version of VERB, giving scientists within Europe access to these models.

This ambition will be achieved in the following six goals, each mapped to a separate work package:

#### *2.1.3.1 WP2 – Propagation of the solar wind from the Sun to L1*

In developing this new, coupled model approach PROGRESS will specifically address the following shortcomings of current state-of-art real-time space weather predictive packages. 1) Parameter tuned semi-empirical models will be replaced by first principles physics simulations to derive the solar wind properties from the photosphere out to 20-30 solar radii. 2) The solar wind transit from 20-30 radii outwards will be modelled with a customised MHD model including a two-temperature plasma and improved electron transport. These two advances will lead to increased fidelity in the L1 predictions in real-time from GONG magnetogram data. The PROGRESS MHD models will also be able to give predictions at the inner planets for comparison with Mercury MESSENGER and Venus Express, compare changes in the regions Sun to Mercury, Mercury to Venus and Venus to Earth, calculate SW parameters that drive accurate Dst, Kp, AE forecasts. This will transform the EU's ability to predict space weather.

#### *2.1.3.2 WP3 – Forecast of the evolution of geomagnetic indices*

The forecasting of geomagnetic indices from upstream solar wind data has a long history and has evolved from linear filters for Dst [*Burton et al.*, 1975] to more complex non-linear and dynamic approaches [*Lundstedt and Wintoft*, 1994; *Yatsenko et al.*, 2008], but also to include other indices such as Kp [*Boberg et al.*, 2000; *Yatsenko et al.*, 2008], AE [*Gleisner and Lundstedt*, 2001], and local magnetic field disturbances [*Wintoft et al.*, 2014]. Today, several institutes provide real-time forecasts of Dst and Kp.

The aim within this project is to survey existing models, with special emphasis on the models available to this team, and perform verification to identify weaknesses and limitations, which will be used as inputs to improve the forecast models. Forecast verification is a mature subject within the meteorological research from which methodologies can be applied, especially for

problems related to forecasting of extreme events. A subgroup within the COST ES0803 Action was devoted to this [*Wintoft et al*., 2012].

For real time operation it is important to note that the ACE science level data, from which models usually are derived, are not identical to the ACE real time data. Of special importance are the plasma instrument outages that occur during proton events. These aspects must be considered during the verification. And it is not known how the coming DSCOVR will perform during these events. During the more severe events the plasma density and velocity are not known and models must be developed that rely on the magnetic fields only.

The standard approach to forecast indices from the solar wind is to map state-space vectors of solar wind quantities, like magnetic fields and plasma (either directly or parameterized) to the index, where the mapping function is found from the data. This is a powerful technique that has been applied to Kp, Dst, and AE [see references above]. The verification that will be carried out will help on how the models may be improved. Related to this are the onsets of major geomagnetic disturbances that are determined by the detailed solar wind evolution (minute resolution) which to a great degree is lost if temporal averaging are applied. Figure 6 illustrates an ICME with following geomagnetic response described by AE. However, moving towards high temporal resolution solar wind data raise another level of complexity as ballistic propagation from L1 to the magnetopause is not possible. Different approaches will be studied for shock identification [e.g. *Kartalev et al.*, 2002; *Clarke et al.*, 2005]. It should be noted that for extreme events the propagation time from L1 to the magnetopause is typically less than 30 minutes, and may reach down to only 10 minutes. From a practical point of view the L1-magnetopause modelling can be considered as now-casting, while the following substorm evolution may be forecast due to timescales of magnetospheric and

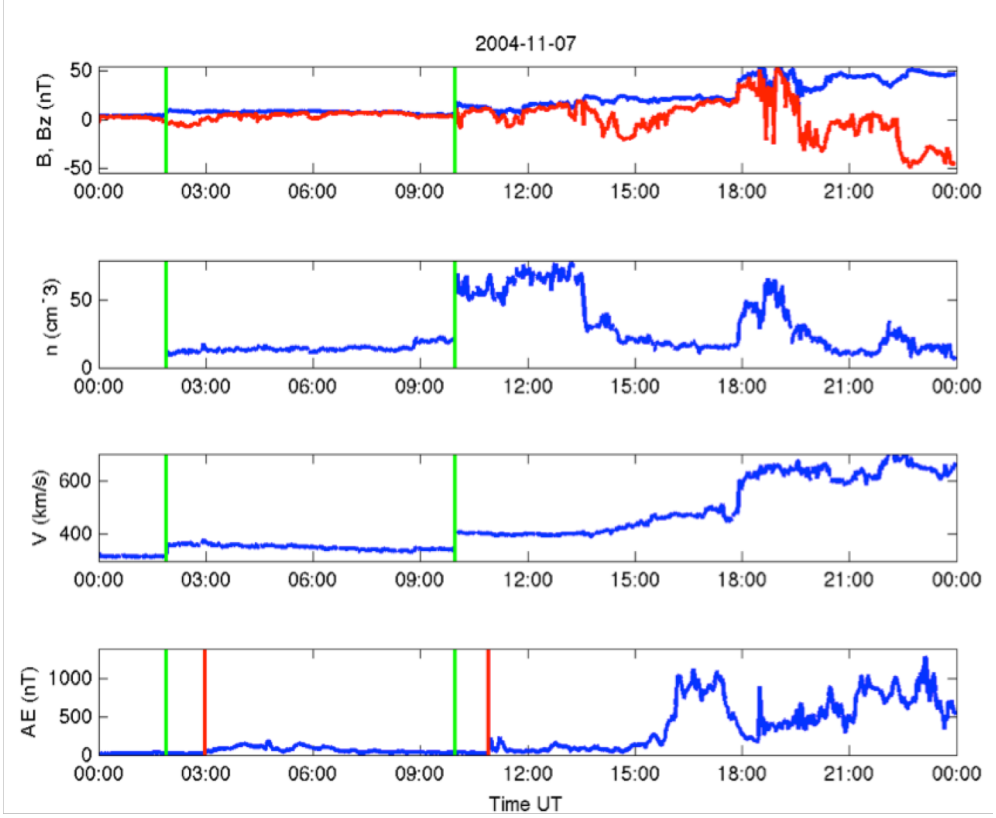


**Figure 6: The solar wind magnetic field, density, and velocity for an ICME hitting the Earth on Nov. 7, 2004. The geomagnetic response in terms of the AE index is shown in the bottom panel. The green lines mark shocks in the solar wind and the red lines the sudden commencements. Later in the afternoon and evening the substorm activity sets in.**

ionospheric dynamics.

The solar wind and geomagnetic response will also be explored using categorization and classification methods, which will provide information on e.g. shocks, sudden commencements, and sub-storms. This is a complex task but with a significant impact and the results can be used in the modelling mentioned above to improve Kp and Dst forecasts, and to develop the AE forecast models. This will also provide insights on how to capture the evolution of AE, like envelope or power spectrum, without having to know the detailed minute-to-minute variability.

The models, both updated and newly developed, connecting the L1 solar wind to the geomagnetic indices will provide forecasting from tens of minutes up to hours and may be driven by real time solar wind data. However, the models will also be used with inputs from forecast solar wind based on the Sun-L1 forecast models, thus providing forecasts of the indices 15 hours to days in advance.

We are planning to develop the following new methods, algorithms, and software for the identification of RRBDM models: 1) a novel robust recursive least-squares method with modified weights for the identification of bilinear model structure and unknown parameters; 2) a novel robust subspace identification of multivariate bilinear state space system based on separable least squares optimization; 2) robust algorithms for identification of RRBDM models using input-output data; 3) the software for the RRBDM model identification; 4) recommendation for improving of the existing services.

We propose the following new methods and algorithms for improving of the existing services using guaranteed NARMAX models (GNM): 1) a novel method for the identification of GNM model that based on the maximal and minimal Dst-index values forming an interval tube and a polynomial discrete input-output dynamical system; 2) a novel algorithm for the automatic selection of regressors for NARMAX models; 3) a novel algorithm for the automatic selection of the optimal model structure and unknown parameters by solving the corresponding mathematical programming problem using genetic algorithms.

#### *2.1.3.3 WP4 – Improving current physics based models for the energetic electron fluxes in the magnetosphere.*

Currently, all physics based models for energetic electron fluxes in radiation belts are based on the solution to the bounce-averaged Fokker-Planck equation and include terms for diffusion in radial distance, pitch angle and energy. The most advanced codes, such as VERB (Skoltech, Russia) or RAM (LANL, USA), incorporate mixed diffusion terms, factors that are lacking in current European models (BAS, ONERA). These diffusion codes require tensors of diffusion coefficients parameterised by location (L, local time) and the current level of geomagnetic activity, usually specified by the Kp or AE geomagnetic indices. These diffusion tensors are deduced, in turn, from statistical models of the observed wave amplitudes in the magnetosphere. Individual wave models have been developed for the key types of waves observed in the inner magnetosphere: chorus, hiss and equatorial magnetosonic waves [e.g. *Meredith et al.*, 2008, 2012] and have typically been parameterised by location and geomagnetic index, which then determines the parameterisation of the tensor diffusion coefficients. However, this parameterisation does not reflect recent findings regarding the evolution of the radiation belts. Parameterisation using the current value of geomagnetic index alone, neglects any knowledge we may have regarding the dynamics of the magnetosphere in general and the radiation belts in particular. It is known that the response of the radiation belts to magnetic storms driven by the high speed solar wind associated with co-rotating interaction regions differs from the response to storms of similar strength (and therefore similar variation of geomagnetic indices!) caused by coronal mass ejections [*Miyoshi and Kataoka*, 2005, 2008]. The current methodology used for these wave models is based on the implicit assumption that the spatial distribution and intensity of magnetospheric waves are the same in both cases mentioned above. This assumption, however, has not been proven by experimental studies. It is also doubtful that it will be proven in the future since

waves are key to the processes of the electrons local acceleration or loss and the dynamics of energetic electrons differs in these two cases. PROGRESS will re-develop the wave models and corresponding diffusion tensors to account for this shortcoming in the current wave models by incorporating parameters of the solar wind within the classification scheme. According to recent studies, the solar wind velocity and density are the most effective parameters in the control of the energetic electron fluxes [*Boynton et al*., 2013]. PROGRESS will use these parameters to organize the wave models and sets of diffusion coefficients. The other drawback with the current methodology is the parameterisation of wave models using the current value of the geomagnetic index. This parameterisation assumes that the wave distribution is independent of the previous evolutionary state of the magnetosphere. Again, there is no experimental evidence to support this assumption. However, it is known that the dynamics of the high-energy particle fluxes is different during an interval corresponding to the main phase of a particular magnetic storm and an interval occurring in the recovery phase of a stronger storm even though these two intervals are characterized by the same value of geomagnetic index.

The software implementation of the algorithms for automatic identification of chorus, hiss and equatorial magnetosonic waves [*Bortnik et al*., 2011; *Mourenas et al*., 2013] is currently available within CNRS/LPC2E (partner 7), Skoltech (partner 4) and USFD (partner 1). However in the development of the new wave models PROGRESS must address the following problems 1) How to identify the time lag (time delay) between solar wind velocity/density changes and corresponding response of waves? and 2) Which time lags of the preceding values of geomagnetic indices should be used to account for the previous evolution of the magnetosphere. The existence of the first problem is evident from Figure 1 as the intensity of Chorus waves correlates with the maximum of the solar wind velocity both on the current and the previous day. To overcome these problems PROGRESS will exploit the Black Box System Structure detection methodology that is based on the Error Reduction Ratio and has been developed by USFD. This methodology has been successfully applied to the quest of the solar wind/magnetosphere coupling functions [*Boynton et al*., 2011, *Balikhin et al*., 2010] and to determine the time lags involved in the solar wind control of relativistic electron fluxes at GEO [*Boynton et al*., 2013, *Balikhin et al*., 2011]. Finally, the wave model for the equatorial magnetosonic waves will need to take into account the recent findings from the Cluster mission that the discrete nature of this emission should be not neglected in the contribution of these waves to the pitch angle and energy diffusion of magnetospheric electrons. The data from the Cluster Inner Magnetosphere campaign gives a clear indication of the harmonic structure of the Equatorial magnetosonic emission (see Figure 2). The data of this campaign proved that the previously used methodology that fitted Gaussian spectral shape in the calculation quasilinear diffusion coefficients [*Mourenas et al*., 2013] since the Chirikov criteria is not satisfied for all harmonics. WP4 will readjust methodology to calculate diffusion coefficients, using statistics gained by Cluster on the spectral widths of discrete harmonic line. As it is measurements from the spectral analyser data which are unable resolve the harmonic structure of these emission are used to develop wave models for equatorial magnetosonic waves, the new methodology will be developed. Instead of fitting Gaussian spectrum the discrete harmonic spectrum will be fitted. The number of and width of the harmonics will be identified using local magnetic field measurements, frequency range of the emission observed by spectral analyser, results of statistical study of the width of harmonics from Cluster Inner Magnetosphere campaign data.

Summarising, this new approach to the parameterisation of wave models and diffusion coefficients has never been performed before and requires the combination of expertise in the physics of the radiation belts and systems science that is available within the PROGRESS consortium. These novel diffusion tensors, developed by PROGRESS, will reflect the realistic conditions of wave particle interactions in the magnetosphere. The incorporation of the resulting diffusion tensors into the VERB code will significantly improve its modelling and forecasting capabilities. The development of these statistical models requires access to large amounts of satellite data. Between them, the PROGRESS partners have access to data

from a large number of magnetospheric missions, including not only the freely available data from Cluster, THEMIS, and POLAR, but also from missions with limited access to data such as Akebono, CRRES and the Double Star mission for which the whole five year period of validated wave data is currently available only within the Sheffield partner.

#### 2.1.3.4 WP5 – Low energy electron model and improvements to develop forecasting products.

The crucially important population in the inner magnetosphere, the low energy (< 200 keV) electrons, will be modelled with the Inner Magnetosphere Particle Transport and Acceleration (IMPTAM) model. The ability of the model to output realistic low energy electron fluxes depends on the several model constituents, one of the most important being the distribution at the model boundary. Electrons start to move from the plasma sheet towards the inner regions. It is vital to set time-dependent, solar wind driven boundary fluxes in the plasma sheet. There are no models like this currently available at present. We will construct an empirical model for the boundary conditions for the low energy (from a few to tens of keVs) electron fluxes at L=8-10 dependent on solar wind and IMF parameters using the available data from the satellites including Polar HYDRA DDEIS, Cluster PEACE, THEMIS ESA and Allen probes HOPE. Geostationary measurements at GOES MAGED, LANL MPA and SOPA (when available) will be used to verify the model when tracing the electrons with the developed boundary distribution at L=8-10. This will be a significant step forward, since the model output is highly determined by the accuracy of the boundary conditions.

Another important factor for proper modelling of low energy electrons is taking into account the loss processes determined by wave-particle interactions. A lot of effort has been put into studying wave-particle interactions when modelling high energy radiation belts. Low energy electrons have not been usually considered. The proper incorporation of wave-particle interactions is now possible due to the existence of the Full Diffusion Code (FDC) model (VERB) which provides the diffusion coefficients and can now calculate them in a non-dipole field. The matrix of diffusion coefficients as a function of L-shell, pitch-angle, and energy for various levels of geomagnetic activity will be computed by FDC. Using the diffusion coefficients, we will parameterize the loss and the computed lifetimes will be included in to the IMPTAM code.

IMPTAM will be extended from simply a nowcast model to a forecast tool. Since IMPTAM is driven by the real time solar wind and IMF parameters and Dst index, forecasting these input parameters will greatly advance the forecasting capabilities of IMPTAM. Substorm activity is a key player in the low energy electrons transport and acceleration. It is very difficult to incorporate the substorm activity effects even for nowcast modelling. IMPTAM considers the effects which substorm activity has upon the transport and acceleration of low energy electrons by launching an electromagnetic pulse at substorm onset times. To launch a pulse at a substorm onset with a magnitude scaled by a peak value of AE index, the substorm timing and AE peaks must be forecasted. With the development of the forecasting tools in PROGRESS for AE index in WP3, the substorm activity effects will be properly taken into account. A trial version of forecast model for low energy electrons will be put online. This is an innovative approach which has never been done before.

#### 2.1.3.5 WP6 – Incorporation of data assimilation methodologies into current physics based models for the high-energy particle fluxes in the magnetosphere.

Data assimilation of the electron radiation belt observations is needed for the understanding and forecasting of physical processes in the radiation belts, prediction, and mitigation of space weather effects in the hazardous space environment. Over a period of less than 10 years, there has been a steady increase in Kalman filter applications to solve the assimilation problem of satellite observations. However, a fundamental problem in the application of the Kalman filter is the assumption about values of the noise statistics that describe the model errors arising from the imperfect description of the process dynamics. Additional difficulties appear in the assimilation of multiple-satellite observations characterized by large variety of

unknown observation error statistics. The effectiveness of estimation and forecasting of radiation belts dynamics depends on how well the dominant physics is described by the model and the accuracy of the unknown noise statistics. However, accurate parameter estimation is a challenging problem when only sparse satellite observations are available coupled with the highly variability of radiation belts dynamics. This explains the wide application of the Kalman filter on the basis of empirical choice of noise statistics without sufficient justification that may significantly distort the assimilation output and provide false conclusions about the dynamics of the radiation belts.

Therefore, the development of consistent identification methods for physical model errors and satellite observation errors and the construction of an adaptive Kalman filter on the basis of parameter identification that optimizes the assimilation output is of prime importance for the estimation and prediction of radiation belt dynamics. Project PROGRESS aims to develop a set of identification methods for unknown noise statistics, such as the bias and covariance matrix of model errors, characterizing the uncertainty of radiation belts dynamics. These techniques will be further refined to estimate the observation errors statistics that are crucially important for optimal assimilation output, identifying the coefficients of proportionality that characterise the dependence of observation errors on satellite observations. Additional improvements and an increase in the accuracy of the assimilation of the electron radiation belt observations will result from the use of the backward optimal smoothing procedure applied to the forward Kalman filter estimates providing further refinement in our knowledge of the key physical mechanisms and leading to the operational forecasting of radiation belts.

One of the important weaknesses of the currently available European physics based forecast tools, including those that were developed in frame of the SPACECAST, is the absence of comprehensive dynamic models to define the boundary conditions. PROGRESS is going to overcome this weakness by exploiting the accuracy and reliability of data based models deduced for GEO. The availability of continuous and uniform (i.e. instruments with the same sensitivity range etc.) data is critical to the development of data based models. In the entire magnetosphere such data are available only at GEO. In other regions the measurements are sparse and not uniform since the observations are made by different satellites. Therefore there is no possibility to extend data based forecasting tools outside GEO. PROGRESS proposes to overcome this problem by incorporating data based forecast at GEO as a boundary condition for the physics based numerical models. The SNB$^3$GEO model for electron fluxes at GEO has proven reliability since online operations began in 2012. The accuracy of the USFD SNB$^3$GEO model was the reason why CCMC GSFC NASA requested and now operates this model from their web site. PROGRESS will couple the SNB$^3$GEO model with the VERB code. VERB is the only existing code that can accurately calculate diffusion coefficients in a non-dipole magnetic field, includes mixed term diffusion, and accounts for hiss, MLT dependent chorus, EMIC, and magnetosonic waves. Such codes are not currently available in Europe. The VERB-NARMAX coupled code will have advantage of accurate forecasts and the ability to model and forecast energetic electron fluxes in the whole entirety of the outer radiation belts. PROGRESS is planning to develop and run the code on the computing facilities of the Sheffield partner and make this code available in Europe after the completion of the project. The code similar to the VERB-NARMAX coupled code currently is not available either in Europe or outside.

#### *2.1.3.6 WP7 – Coupling the solar wind forecast at L1 with the geomagnetic indices and radiation environment models.*

In the final stages of the project the forecast of the solar wind at L1 will be conjugated with the forecast models developed for geomagnetic indices and radiation environment. The predicted solar wind parameters will be used as inputs to the geomagnetic indices forecasting tools, to increase the lead-time for the forecast of geomagnetic indices. Both the predicted solar wind parameters and the forecasted values of geomagnetic indices will be used as inputs to the IMPTAM and VERB-NARMAX coupled code. This will result in the forecast of electron fluxes in the inner magnetosphere with significantly increase lead-time in

comparison to the present capabilities. Whilst it is useful to see an overview of the electron fluxes within the inner magnetosphere, it is important to use these forecasts to estimate the electron fluxes that occur along actual spacecraft orbits in order to estimate the probability that ESD may occur. PROGRESS will develop a tool to estimate the fluxes if electrons at different energies along an orbital track.

## *2.2 Impact*

### 2.2.1 Expected impacts

According to the Horizon2020 work program call PROTEC-1-2014 projects are "… expected to **deliver new insights** into the detailed processes that generate space weather. This should contribute to **new services** able to predict, with a **significantly higher precision** than today, space weather events affecting the Earth and the near Earth space environment".

Project PROGRESS meets the expected impact through the analysis and modelling of data and processes within the geospace environment to develop of a set of tools to forecast the short term (up to a few days) evolution of this environment based on the observed changes of the Sun and solar wind. In particular:

PROGRESS will provide a set of '… ***new services*** …' that will deliver

- Forecast of the conditions in the solar wind as it propagates from the Sun towards L1 and the Earth from a new European MHD model of the solar wind. This will be achieved by the development the European SWIFT code and installation of the U. Michigan code AWSoM at Warwick. Currently, this code is unavailable in Europe.
- Forecasts of the evolution of the state of the magnetosphere as expressed by geomagnetic indices such as Dst, Kp, and AE.
- Significantly more accurate and reliable forecasts than those currently available from the models developed in framework of FP7. These forecasts of the radiation environment in the entire region of radiation belts will be achieved by the fusion of the most accurate European data derived tool SNB3GEO and the most advance physics based numerical code of radiation belts
- Forecasts of the electron fluxes along satellite orbits that pass through the inner magnetosphere.

PROGRESS will deliver forecasts with a '… ***significantly higher precision*** …' than those available today. This will be achieved by

- The use of data driven modelling techniques to forecast the geomagnetic indices and electron fluxes at GEO
- The use of data driven models to provide the boundary conditions for physical models such as VERB and IMPTAM.
- The re-engineering of statistical wave models to account for the short-term historical evolution of the magnetosphere as well as changes in the solar wind. These models are used to calculate the quasilinear tensors of diffusion coefficients that are used within numerical models.

The models developed within project PROGRESS will provide '… ***new insights*** …' into the physics of space weather processes. In particular

- The solar wind model will be used to trace and investigate the evolution of disturbances as they propagate from the Sun, passed Mercury, Venus, and on to the Earth.
- The use of the NARMAX modelling methodology naturally results in physically interpretable models describing the underlying processes occurring. These results

may be compared with physical models to highlight possible differences, which may then be investigated further thus improving the physical model.

- The relationship between changes in the solar wind and the response of the magnetosphere and the fluxes of energetic electrons in the radiation belts will be investigated to determine which solar wind parameters have the greatest influence on their evolution.

#### 2.2.1.1 Science impact

PROGRESS will achieve scientific impact on four fronts. Firstly, PROGRESS will develop an MHD model to describe the evolution of the solar wind from the point at which it leaves the solar locality, typically from ~25Rs, and propagates to the Earth at 1AU and beyond. This code will include the propagation of CMEs and CIRs to provide an estimate of the time for their arrival at Earth, together with expected values for the solar wind plasma density, temperature, and velocity. These predicted values will be compared against measurements from Mercury MESSENGER, Venus Express, and ACE and its future replacement DSCOVR (planned launch date January 13, 2015).

Secondly, the evolution of state of the magnetosphere, as expressed in the form of geomagnetic indices, will be investigated based on the comparative results obtained from existing models as well as new ones determined using data driven modelling methods such as NARMAX and CNN. These data driven modelling techniques have been shown to provide models with a markedly higher accuracy than those based solely on physical principles. This aspect of PROGRESS will result in the best models to use for prediction of geomagnetic indices depending upon the state of the solar wind driver.

The third scientific aspect addressed by PROGRESS will be the forecasts of particle fluxes within the radiation belts. This will be achieved by coupling existing physics based models for the low (IMPTAM) and high (VERB) energy electron fluxes with the more accurate but spatially limited NARMAX models for the electron fluxes at GEO. This coupling of the models will enable forecasts to be made for the changes in the particle environment throughout the inner magnetosphere.

The fourth science aspect is the improvement of statistical wave models used within numerical codes to describe the interaction between the waves and electrons. Current numerical models use a set of diffusion tensors to describe the interaction between particles and waves. These tensors are, in turn, calculated using statistical models for the occurrence and amplitude of various wave types observed in the inner magnetosphere. These current models, however, neglect the effects of the time evolution of the magnetosphere and also the solar wind conditions that are driving the system. Both of these effects have been demonstrated to have significant impacts on the state of the magnetosphere and the particle environment of the radiation belts. Our new models will take these new factors into account, producing statistical models that more accurately reflect the wave-particle interaction process.

#### 2.2.1.2 Commercial Impact

PROGRESS will also achieve significant impact from a commercial perspective. The models and prediction tools produced as a result of the above mentioned research will be amalgamated into one easy to use interface will cater to the requirements of both scientific and commercial users. This interface will provide users with an overall assessment of the current space weather conditions together with an accurate forecast for their short-term evolution. Satellite operators will be able to use the results of the data assimilation of past events to estimate the probabilities that a particular anomaly has been associated with space weather.

#### 2.2.1.3 Challenges

Project PROGRESS brings together experts in the fields of numerical and data driven modelling and data analysis to combine their talents in pursuit of excellence in the forecasting

of space weather events and their effects on the magnetosphere. The new knowledge gained as a result of these innovative activities will strengthen the level of science within Europe and it competitiveness on the world stage. The mix of scientists and stakeholders (via the SAB) will ensure that the resulting forecast tools within project PROGRESS will meet both scientific and commercial requirements, thereby increasing the competitiveness of in the global market place.

There are two technical challenges associated with the project. The first involves the propagation of the solar wind from the vicinity of the Sun to the L1 point and the accuracy of forecasts. In order to fulfil this task successfully the consortium includes experts in in the field of MHD modelling (University of Warwick) and is supplemented with further specialists from the University of Michigan who have extensive experience in the modelling of the solar wind and its interactions with planetary obstacles. Currently, there is no European model to compare our results against, only either actual measurements from Mercury MESSENGER, Venus Express, and ACE/DISCOVR or the online American model ENLIL.

The second technical challenge is to find a methodology to couple the physical models (IMPTAM and VERB) with the output of models based on data driven modelling. Preliminary studies in this area using NARMAX and VERB have already investigated some simple methods based on rescaling. Project PROGRESS will refine these methods based on comparisons of the output from the coupled model with measurements from missions such as Cluster, THEMIS, and Van Allen Probes to achieve realistic results.

A final challenge, related to the commercialisation of the results, centres around a system to express the forecasts such that they will be instantly comprehensible in the market place. This requires a set of standards by which to express the results in a way understood by industrialists and scientists alike. This aspect will be one of the items addressed in the meetings of the Stakeholder Advisory Board.

#### *2.2.1.4 Advantages of a European Approach*

As is evident from the number of participant, spread throughout Europe and also including important collaborators in USA and Russia, no single group has the expertise to complete this project alone. PROGRESS utilises expertise from around Europe to fulfil its aims, creating a collaboration between groups of differing interests to apply their knowledge in a concerted way to the study of Space Weather. However, in order to reduce the risk in one particular area of the project, the expertise required to complete the tasks resides at more than one of the participating institutions (this point is addressed further in Section 3.2 – risk mitigation).

Within ESA, space weather activities are coordinated by Space Situational Awareness (SAA) project, one segment of which is concerned with the impacts of Space Weather (SWE). The activities of SSA SWE focus on the monitoring of the Sun and conditions in the solar wind, magnetosphere, and ionosphere that can affect space based and groundbased infrastructure, concentrating on the development of services to suit the requirements of commercial and scientific operations. These targets are strongly aligned with those of PROGRESS, which will provide additional benefits to SSA activities.

### 2.2.2 Measures to maximise impact

#### *2.2.2.1 Dissemination and exploitation of results*

In his role as Work Package Leader for WP8 "Dissemination" the Coordinator of PROGRESS will monitor the dissemination activities in order to achieve maximum impact for the project. In particular he will

- Work to increase the awareness of the results and achievements of the project
- Be instrumental in the design and contents of the project web site.
- Promote the project through scientific and public presentations, press releases for the media, and articles in EC brochures and newsletters.

Project PROGRESS will result in a number of tools, models, and data products that will be of interest to other parties, both commercial and scientific, working in the field of space weather. The results from project PROGRESS, such as forecasts etc., will be made available to all users to all users via the project web site. This will allow interested parties to see our predictions in graphical form and download the numerical results. It is also envisaged to distribute the resulting models to external parties, provided it does not infringe on intellectual property rights, to implement within their own systems as is currently done at the CCMC at NASA/GSFC who run a copy of the USFD model to predict high energy electron fluxes.

The project will also generate new, more realistic set of statistical models to describe the role of waves in the process of particle acceleration and loss within the inner magnetosphere. These results, available from the web server, will be of interest to the numerical modelling community who use the currently available databases to determine various coefficients used within their models.

#### *2.2.2.2 Communication activities*

Dissemination of results involves the identification of target audiences, and tailoring our outputs to suit these groups. Within project PROGRESS we have identified three target audiences: scientists, stakeholders, and the general public. We recognise that it is important to broadcast our results at the right level to each of these groups.

**Scientific dissemination**

The main tools for dissemination to the scientific community include the production of papers describing the models, their results, and predictions in leading scientific journals in the field such as Journal of Geophysical Research (Space Physics), Geophysical Research Letters, Annales Geophysicae, Journal of Space Weather and Space Climate, Space Weather, Solar Physics, and Astrophysical Journal as appropriate, using the Open Access 'Gold' model. At the end of the project, we aim to produce a set of overview papers to be published together as a special section within an appropriate journal such as Space Science Reviews to summarise our results and outline further extensions to the studies. In addition, it is important to provide presentations at conferences such as European Geosciences Union, European Space Weather Week, US Space Weather Week, American Geophysical Union, COSPAR, and IAGA. We aim to propose suitable sessions at these conferences and also at scientific workshops, such as the Cluster-THEMIS series, to highlight our results and, if accepted, act as convener to organise and direct the focus. All scientific participants have requested funding provision (travel and subsistence) to enable these activities.

The European and American Space Weather Week meetings are of particular importance because they attract both scientific and commercial representatives. Therefore they provide an ideal opportunity for meetings and discussions between both communities, obtain feedback on the current situation of the project, to determine user requirements that will be used to shape some of the future activities within PROGRESS to ensure delivery of a system that can satisfy end users, and to recruit new parties to our Stakeholders Advisory Board.

As part of its scientific dissemination activities, PROGRESS will organise a Summer School during its final year and invite up to 25 students to learn about Space Weather, its effects on our technology, the methods used to forecast changes within the local geospace environment. The lectures will be based on the results obtained during project PROGRESS and be delivered by project participants in conjunction with other external experts from the science and commercial communities. A budget for this activity has been included within the costing of the project Coordinator (USFD).

In order to foster stronger ties between the participants within project PROGRESS the Coordinator institute has requested funds to allow young researchers working within the project to gain further experience by visiting other project institutions to enable them to increase their visibility within the scientific community and their network of contacts.

**Stakeholder dissemination**

An important part of project PROGRESS is the involvement of stakeholders who represent the commercial interests of space such as satellite and launch operators, satellite and aviation manufacturers, space agencies, and the space insurance sector. Dissemination of project results to these user groups will take place via meetings of the SAB, together with demonstrations of the resulting forecast tools at meetings such as the European and American Space Weather Weeks. At the same time it is invaluable to obtain their support and feedback on the work performed within PROGRESS to allow the convergence of commercial and scientific requirements for a set of useable tools whose results clearly meet the defined requirements. Wider commercial interest will be sought through engagement at meetings such as the European Space Weather Week, attended by scientists and stakeholders alike. This provides an ideal opportunity to publicise project PROGRESS to a wider commercial audience, obtain their direct feedback, recruit further members to the project SAB, and publicise the project website and the forecast tools and results available. The Coordinator institute has included provision of funds for stakeholders to attend meetings of the SAB.

To further increase dissemination among stakeholders we propose to submit high quality articles to the Commissions Research and Innovation website and the various EC/REA research publications and newsletters.

**Dissemination to the general public**

Opportunities for project PROGRESS to communicate with the public can result from the occurrence of natural events. Large space weather related events, such as the recent solar activity and aurora observable that occurred at the end of February 2014 made headlines around the world. Many news web sites carry pictures of the aurora observed around this period, inspiring the public to learn more about space. Thus it is important to engage the mass media such as the local, national, and international press to reach the widest dissemination of results. An example of this may be the summary of an article published in a high profile journal, e.g. Nature or Science. Such publications will be accompanied by a press release to bring these important findings to a greater audience. In order to maximise the potential, the Coordinator will make use of the Public Engagement Team here at USFD, who provide advice and organise a number of opportunities for USFD members to take their research to a wider audience.

As well as press releases, we hope to foster this aspect of outreach by providing a public access area on the project web site. This will explain, in layman's terms, the occurrence and problems that may be caused by space weather and how it could impact on the everyday lives of European citizens, our results in forecasting their effects together with examples of past-casts using historically significant events such as the one that caused the 'Quebec blackout' in 1989. Access to the website will be monitored to determine the key audiences using it and to help define the nature of new articles which will be added as the project evolves.

High quality articles will also be submitted to the Commissions Research and Innovation website and the various EC/REA research publications and newsletters (via the Project Officer) for wider dissemination of results to a space oriented audience.

#### *2.2.2.3 Intellectual property rights*

The rules concerning Intellectual Property Rights (IPR) will be addressed within the Consortium Agreement, a document signed by all participants before the start of the project. The protection and sharing of IPR will be overseen by the SSC and comply with the guidelines on IPF specified within the framework of Horizon 2020. The SSC will be the final arbiter on the dissemination of intellectual property, seeking to protect the owners/developers rights.

IPR is divided into two main areas. The first, background, covers intellectual property that is owned by the participants prior to the beginning of the project. Any background intellectual

property rights will be respected by the project. The existence of all such items should be declared within the Consortium Agreement.

The second is foreground intellectual property rights. This covers intellectual property developed within PROGRESS and depends on the type of property, namely models, data, and data products.

*Models* – The models developed within PROGRESS will remain the property of the developers/owners. They will not be freely distributed outside the project. This ensures the control of future developments and usage of the models. However, after consultation within the SSC, models may be distributed to interested parties upon request subject to certain conditions being fulfilled.

*Data* – The policy towards the distribution of data used within project PROGRESS will reflect that of the source from which the data was obtained. Since PROGRESS is a scientific project and uses data without commercial gain it is envisaged that there should be no difficulties obtaining data, especially since most is publically accessible. PROGRESS will not redistribute any data sets that it receives from non-public sources.

*Data products* – Data products, resulting from the analysis carried out within project PROGRESS will be made publically accessible.

Within the project collaboration all data and models will be freely distributed for use within the project.

The project will also allow the participants to protect their results through a patent. Participants thinking of pursuing this form of protection for their property shall inform the SSC of their intention to apply.

## 2.3 Implementation

### 2.3.1 Work plan — Work packages, deliverables and milestones

#### 2.3.1.1 Overview of work packages

The main research related work packages within the project are WP2, WP3, WP4, WP5, WP6 and WP7. They provide the framework for the modelling and data analysis tasks, resulting in expanding our understanding of the processes involved in the propagation of space weather disturbances from the Sun to the Earth and the changes they cause to the magnetospheric environment. The individual predictive models they generate will be combined within WP7 resulting in a practical tool to qualitatively access the level of risk to space assets. The other workpackages enable the dissemination of results to scientists, stakeholders, and the general public and feedback from scientists (WP8) and project management (WP1).

#### 2.3.1.2 WP1 – Management

This WP encompasses the scientific, administrative, and financial management aspects of the project and ensure the necessary communications between the participants, the Scientific Steering Committee, the Stakeholder Advisory Board, and the Commission/REA.

#### 2.3.1.3 WP2 – Propagation of the solar wind from the Sun to L1

The concept of WP2 is to provide forecasts of the solar wind parameters (e.g. density, electron and ion temperatures, velocity and magnetic field) at L1 based on magnetogram observations from GONG. It will result in the forecast of potential space weather hazards up to 2 or so days before they arrive at the Earth.

#### 2.3.1.4 WP3 – Forecast of the evolution of geomagnetic indices

Geomagnetic indices are used to express the current state of the magnetosphere and quantify geomagnetic activity. Their evolution is a key indicator to the response of the magnetosphere

to space weather disturbances and they are used as inputs to numerous models for assessing their impact. Hence the accurate forecast of their evolution is vital to provide timely warnings of potential hazards. WP3 will produce tools to provide such forecasts based on both measurements from ACE at L1 and/or the outputs of predictions from WP2.

#### 2.3.1.5 WP4 – Development of new statistical wave models and the re-estimation of the quasilinear diffusion coefficients.

Current numerical models for the forecast of the radiation belt environment use statistical models to describe the interaction of particles and waves. However, current models have several disadvantages. This WP intends to create new models that reflect the evolution of the magnetosphere mode accurately and therefore provide improved forecasts from numerically based models.

#### 2.3.1.6 WP5 – Low energy electrons model improvements to develop forecasting products.

The goal of this WP is to develop the existing now-cast IMPTAM model into a forecasting tool. This will require the construction of an empirical solar wind and IMF driven model for low energy electrons in the plasma sheet using all available data, inclusion of proper diffusion coefficients provided by VERB radiation belts model, and incorporation of the developed in PROGRESS forecasting capabilities for solar wind and IMF parameters and Dst and AE indices.

#### 2.3.1.7 WP6 – Forecast of the radiation belt environment.

This work package will combine the results from the two numerical codes IMPTAM (low energy particles) and VERB (high energy particles) with the data driven NARMAX model for the particle environment at GEO to provide forecasts of the particle environment within the whole of the inner magnetosphere region. The use of novel data assimilation tools will enable a further improvement of the forecasting and nowcasting capabilities.

#### 2.3.1.8 WP7 – Fusion of forecast tools

The outputs of WP2, 3, and 6 involve the generation of models to forecast the state and particle environment of the inner magnetosphere. This goal of this WP is to link these individual models together under a single interface to provide stakeholders with a tool to provide an assessment of the local geospace environment with up to a couple of days advanced warding of potential space weather hazards.

#### 2.3.1.9 WP8 – Dissemination activities

This WP focuses on the communication of results from the project to scientists, stakeholders, news agencies, and the general public. It will also be the primary means to receive peer feedback from scientists and commercial requirements and guidance from the stakeholders.

### 2.3.1.10 Timing of work packages

| | | Month | 1-3 | 4-6 | 7-9 | 10-12 | 13-15 | 16-18 | 19-21 | 22-24 | 25-27 | 28-30 | 31-33 | 34-36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Work package 1 – Management | | | | | | | | | | | | | | |
| | All tasks | | | | | | D1.1 | | | | D1.2 | | | D1.3 |
| | Milestones | | | | | | | | | | | | | |
| Work package 2 – Propagation of the Solar Wind from the Sun to L1 | | | | | | | | | | | | | | |
| | Task 2.1 | | | | | | | | | | | | | |
| | Task 2.2 | | | | | | | | | | | | | |
| | Task 2.3 | | | | D2.1 | | | | | | | | | |
| | Task 2.4 | | | | | | | | | | | | | |
| | Task 2.5 | | | | | | | | D2.2 | | | | | |
| | Task 2.6 | | | | | | | | | | | | | |
| | Task 2.7 | | | | | | | | | | | | | |
| | Task 2.8 | | | | | | | | | | | | | D2.3 |
| | Milestones | | | | | | | | M2.1 | | | | | |
| Work package 3 – Forecast of the evolution of geomagnetic indices | | | | | | | | | | | | | | |
| | Task 3.1 | | D3.1 | | | | | | | | | | | |
| | Task 3.2 | | | D3.2 | | | | | | | | | | |
| | Task 3.3 | | | | D3.3 | | | | | | | | | |
| | Task 3.4 | | | | | | | | | D3.4 | | | | |
| | Task 3.5 | | | | | | | | | | | D3.5 | | |
| | Task 3.6 | | | | | | | | | | | | | D3.6 |
| | Milestones | | | | | | | M3.1 | | | | | | |
| Work package 4 – Data assimilation | | | | | | | | | | | | | | |
| | Task 4.1 | | D4.1 | | | | | | | | | | | |
| | Task 4.2 | | | D4.2 | | | | | | | | | | |
| | Task 4.3 | | | | D4.3 | | | | | | | | | |
| | Task 4.4 | | | | | | | | | D4.4 | | | | |
| | Milestones | | | | | | | | | M4.1 | | | | |
| Work package 5 – Development of IMPTAM | | | | | | | | | | | | | | |
| | Task 5.1 | | | | | D5.1 | | | | | | | | |
| | Task 5.2 | | | | | | | | | D5.2 | | | | |
| | Task 5.3 | | | | | | | | | | | D5.3 | | |
| | Task 5.4 | | | | | | | | | | | | | D5.4 |
| | Milestones | | | | | | | | | M5.1 | | | | |
| Work package 6 – Forecast of the radiation belt environment | | | | | | | | | | | | | | |
| | Task 6.1 | | | D6.1 | | | | | | | | | | |
| | Task 6.2 | | | | | | | | | | D6.2 | | | |
| | Task 6.3 | | | | | | | | | | | D6.3 | | |
| | Milestones | | | M6.1 | | | | | | | | M6.2 | | |
| Work package 7 – Fusion of forecasting tools | | | | | | | | | | | | | | |
| | Task 7.1 | | | | | | | | | | | D7.1 | | |
| | Task 7.2 | | | | | | | | | | | | D7.2 | |
| | Task 7.3 | | | | | | | | | | | D7.3 | | |
| | Task 7.4 | | | | | | | | | | | | | D7.4 |
| | | | | | | | | | | | | | | |
| Work package 8 - Dissemination | | | | | | | | | | | | | | |
| | All tasks | | D8.1 | | | | | | | D8.2 | | | | |

#### 2.3.1.11 Overview of work flow

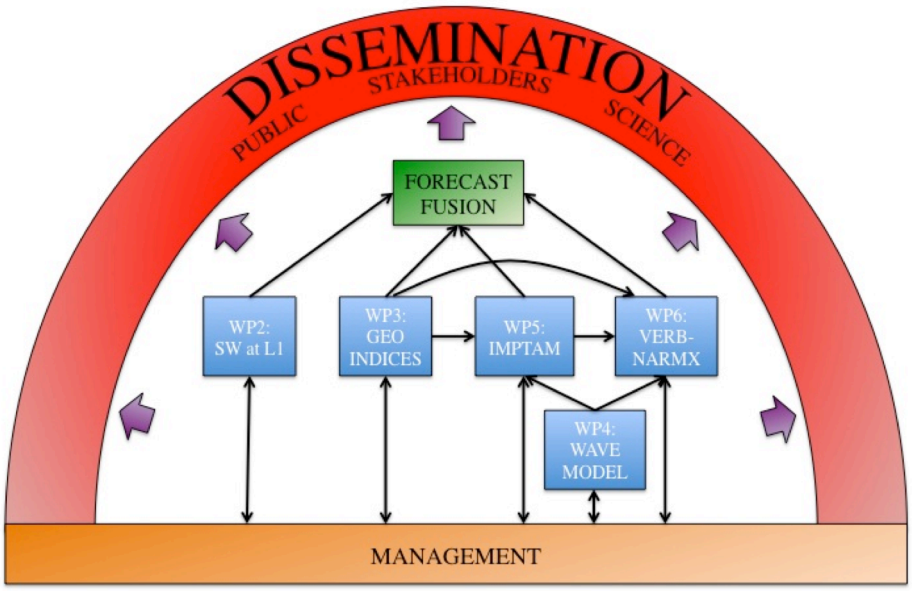


**Figure 7: Workflow of project PROGRESS**

Figure 7 shows a graphical overview of the workflow within project PROGRESS. Each of the scientific tasks in work packages (WP2-6) contains both a modelling and a forecasting component with the latter being the product resulting from the modelling tasks. Finally, the scientific task of WP 7 is to combine the various forecast tools in a single user interface to provide a complete picture of the current and future (2 day ahead) potential space weather hazards together with an estimate of their expected impact. Dissemination (WP8) of the results from both the modelling and forecast tool aspects of the project activities will enable the project to receive peer feedback from the scientific community (via conference presentations and journal publications) and the Stakeholder Advisory Board as to the direction of the project and the definition and fulfilment of any specific commercial requirements for a forecast system.

### 2.3.2 Management structure and procedures

The PROGRESS proposal is a new collaboration between 8 research groups in 7 countries, and also draws on currently established collaborations for the free exchange of data. In addition, a number of potential external stakeholders have been identified from across Europe whose input to the project will help to maximise the benefits for both science and industry. Thus the project will forge new links between academia, industry, and service providers.

#### 2.3.2.1 Structure

Successful delivery of the project requires firm and clear guidelines in terms of responsibility, communication, and financial control as well as risk analysis and mitigation. The following five areas of management have been identified:

- Liaison with the Commission/REA

- Oversight, risk mitigation, and strategic management
- Scientific management and leadership
- Activity monitoring, and the coordination of deliveries and reporting
- Administrative and financial management

To successfully carry out these tasks, the PROGRESS project will establish a management structure consisting of:

- Project Coordinator (PC)
- Project Manager (PM)
- Work package leaders (WPL)
- Scientific Steering Committee (SSC)
- Stakeholder Advisory Board (SAB)

**The role of the Project Coordinator (PC)**

The PC of the project PROGRESS will be Professor R. von Fay-Siebenbergen. He will take overall responsibility for the project and its activities, including implementation and delivery. In particular, he will be responsible for

- Implementation of the consortium agreement
- Main point of liaison with the Commission/Research Executive Agency (REA)
- Representing the PROGRESS project externally
- Chairing meetings of the Scientific Steering Committee and Stakeholder Advisory Committee
- Monitoring the progress of the project in terms of deliverables and milestones
- Identifying risks to the schedule and, in conjunction with the Scientific Steering Committee, the negotiation and implementation mitigation solutions to the project work plan
- The PC will have the casting vote on decisions for which the SSC cannot reach a majority consensus.

**The role of the Project Manager (PM)**

The PM will, in conjunction with the PC, take the lead in the day to day running of the project, aided by clerical and financial support provided by the University of Sheffield. He will be responsible for

- Monitoring of the completion of tasks, achievement of milestones, and submission of deliverables.
- Organisation of Project, SSC, and SAB committee meetings
- Preparation of the annual, formal reports for the Commission/REA
- Monitor partner budgets

The PM will report to the PC.

**The role of the Work Package Leaders (WPL)**

Each work package will have a named leader and deputy. The WPL will be responsible for the scientific coordination of their assigned work package, including its deliverables,

milestones, and dissemination of results, reporting their fulfilment to the PC and PM. The WPL will also highlight any discrepancies and risks to the project schedule, reporting any instances and possible mitigation solutions to the PC/PM who, with the aid of the SSC, will advise the WPL on the appropriate course of action to take to minimise the risk to the rest of the project. The identified WPLs and their deputies are listed in Table 1.

**Table 1: List of work package leaders**

| WP | Leader (institute) | Deputy (institute) |
|---|---|---|
| 1 | R. von FaySiebenbergen (USFD) | N. Ganushkina (FMI) |
| 2 | T. Arber (UW) | B. van der Holst (UM) |
| 3 | P. Wintoft (IRF) | R. Boynton (USFD) |
| 4 | V. Krasnoselskikh (CNRS/LPC2E) | Y.Shprits (Skoltech) |
| 5 | N. Ganushkina (FMI) | R. Boynton (USFD) |
| 6 | M. Balikhin (USFD) | Y.Shprits (Skoltech) |
| 7 | S. Walker (USFD) | T. Arber (UW) |
| 8 | R. von FaySiebenbergen (USFD) | T. Arber (UW) |

**The role of the Scientific Steering Committee (SSC)**

The SSC is the project's key management and scientific leadership committee. It is responsible for the overall direction of the project, assessing progress with respect to the schedule, identifying possible risks and proposing mitigation actions to minimise there effect on the rest of the project. Steering committee decisions will be made following open discussions. These will be based on the evidence available so that an informed decision may be reached ensuring transparency and traceability. The SSC is composed of:

- Project Coordinator (Chair)
- Project Manager
- Work Package Leaders
- At least one Stakeholder to provide an external view

**The role of the Stakeholder Advisory Board (SAB)**

The SAB, a body external to the project, will take a wider view of the project, advising the SSC and PC with respect to project direction and commercial interests. The main purpose of this body is to provide the commercial requirements that may be addressed by the project, resulting in a set of useful tools and standards. We feel that this mechanism is the most effective way to disseminate our results to the industrial sector and to obtain their feedback and guidance.

#### *2.3.2.2 Procedures*

**Project Meetings**

The PM will organise two Project Meetings per year during which the Project Teams will meet physically for a period of one to three days. One of these meetings will correspond to the Annual Review Meeting and will involve representatives of all project partners in addition to the Project Officer and External Project Evaluators. During each meeting the Workpackage Leaders (or their representative) will present the scientific and technological work carried out,

comparing it against the project schedule and list of deliverables/milestones and also outline the future agenda for their workpackage.

**SSC and SAB meetings**

The PM will organise face to face meetings of the SSC (two per year) and SAB (one). These will, where possible, occur in conjunction with the Project Meetings or other scientific/industrial meeting such as European Space Weather Week (ESWW) to minimise their cost and maximise attendance. It would be envisaged to hold the SAB meeting first to inform the stakeholders of the current progress of the project, and then receive their feedback and advice that would then be discussed at the SSC.

**Review meetings**

It is expected that the Commission/REA will require yearly review meetings for the project with an external assessor. These meetings will take place shortly after the yearly reports are submitted. These meetings are attended by the PC, PM, and the Project Officer. Participation of the WPL may be required via phone/VoIP.

A provisional timetable for project meetings is shown in Table 2. Where possible meetings should run in tandem to reduce costs and travel time etc.

**Table 2: Proposed meeting timetable**

| Meeting | Location | Date |
|---|---|---|
| PM1, SSC1 | Sheffield, UK | T0 |
| PM2, SSC2 | Warwick, UK | T0+6 months |
| PM3, SSC3, SAB1 | European Space Weather Week, Belgium | T0+12 months |
| RM1 | Brussels, Belgium | T0+14 months |
| PM4, SSC4 | CNRS/LPC2E, Orleans, France | T0+18 months |
| PM5, SSC5, SAB2 | European Space Weather Week, Belgium | T0+24 months |
| RM2 | Brussels, Belgium | T0+26 |
| PM6, SSC6 | Lund, Sweden | T0+30 months |
| PM7, SSC7, SAB3 | European Space Weather Week, Belgium | T0+36 months |
| RM3 | Brussels, Belgium | T0+38 months |

**Project Communications**

The day to day communications within the project include:

- A project web site that will have links describing the research themes and of the project, material for training and dissemination activities, access to public reports generated by the project with a password protected area for reports private to the project, links to external resources, etc.
- List mailers will be setup and maintained by USFD for general e-mails to be circulated to the whole consortium, together with a separate list for e-mails related to the management of the project.
- Use of VoIP applications (e.g. Skype) for direct communications. This provides the easiest mechanism to resolve issues between the participants and keep the PC/PM informed.

**Conflict resolution and decision making**

The principles governing decision-making are evidence based decisions and transparency. This will be enshrined in a partnership agreement that clearly defines lines of responsibility and formal communication between partners, and the decision-making processes within the SSC. The main evidence base for decisions will be the performance data on progress against the scheduled deliverables, as well as technical briefings to the SSC meetings. Transparent decisions will be made through open discussion in the SSC, with agendas prior to meetings and the subsequent posting of meeting records with necessary background information, decisions and actions. These will be posted on the internal web pages of the project for all partners to consult and contribute. Major strategic decisions that affect the partnership and direction of research as a whole will be made by the SSC in consultation with the SAB. With clear evidence and open discussion, the main route to decisions will be through consensus building in these open meetings. If consensus cannot be reached, the final decision will be taken by the PC after he has consulted partners widely and been given as much information as possible. Partners will always be kept informed so they can feed in their views.

#### *2.3.2.3 Reporting*

The Project will produce three types of formal reports

**Annual Progress Reports** will be compiled every year in accordance with Commission/REA guidelines. These reports will summarise the achievements of the project by attaining the specified milestones and the production of the deliverables. It will also provide a work plan for the year ahead.

**Financial reports** Financial reports will be compiled on an annual basis in accordance with Commission/REA guidelines, and will be accompanied by an Auditor certificate for each Partner when necessary. The reports will indicate both the overall project expenditures and the expenditures of single partners.

**Technical reports** will be produced as the outputs for the workpackages. These will usually take the form of a report outlining the progress achieved as a result of working on the tasks listed in the individual work packages. Before submission to the Commission/REA, a member of the SSC will review the report to ensure their quality and accuracy. A standard template will be used to ensure all reports conform to a standard, well-structured layout. For those reports that are defined with a dissemination level as public the reports will be made available via the Project web site.

#### *2.3.2.4 Financial management*

USFD has managed and coordinated finances for grants in FP5, FP6 and FP7 and brings this experience to manage PROGRESS. The PC also has considerable experience in managing research grant budgets. A dedicated team in USFD financial services is experienced in Commission/REA project administration and formal reporting to funders, and will provide this service and advice to the PC.

#### *2.3.2.5 Risk management*

Risk management will be implemented as a three-stage plan within the Project. These steps are:

1. Identification of the main risk areas, assessment of their magnitude and their likely occurrence. These potential risks to the Project will be entered into a Risk Register from where they can be continually tracked.

2. Avoidance of the risk situation where ever possible.

3. If the risk cannot be avoided then contingency plans will be put into place to mitigate their effect to the rest of the Project. The main risks identified during the proposal phase are listed in the Table in Section 1.3.5 of Part A of the Description of Action.

To help minimise the risks, the proposed consortium possesses some degree of redundancy in the expertise required within the project as listed in Table 3 with the primary institute(s) marked in bold.

**Table 3: Areas of expertise**

| Area of expertise | Institute |
|---|---|
| MHD modelling | **UW,** UM, USFD |
| Modelling of geomagnetic indices | **IRF**, USFD, SRI NASU-NSAU |
| Analysis of wave data | **CNRS/LPC2E**, USFD |
| Numerical models of the radiation belts | **FMI,** Skoltech |
| NARMAX modelling | **USFD**, SRI NASU-NSAU |
| Data assimilation | **Skoltech**, CNRS/LPC2E |

During the project kick-off meeting The Coordinator and Team Leaders will identify and discuss the potential risks that could develop within the project. Once the main risks have been identified contingency plans will be designed to overcome these problems and keep the project back on track. Details of these risks and strategies to resolve them will be entered into the Project Risk Register. This evaluation of the potential risks and formulation and implementation of related contingency plans will continue throughout the Project to ensure the timely identification of problems and possible mitigation steps. In general, these processes will be carried out by the Work Package Leader responsible for that particular WP for which a problem has been identified. Hopefully a quick solution to the problem will be found and put in place to enable the work to continue unimpeded. The Steering Committee should be kept informed of these problems and their solution. If a local solution cannot be found, then the Steering Committee should be informed and a teleconference organised to discuss the problem, assess its impact and define a contingency plan that will minimise any disruption to the rest of the project. Table 1.3.5 (WT5 Critical Implementation risks and mitigation actions) in Part A of the DoA provides a preliminary outline of the currently perceived main risks and the mitigation steps required to correct them.

### 2.3.3 Consortium as a whole

Europe possesses a strong research community in the field of space science, with many outstanding individuals and research institutes. This, coupled to a large number of high quality space and ground based data sets, and current modelling expertise puts Europe in the forefront of space research. The proposal takes advantage of this strength to bring together a multidisciplinary team of researchers to answer the present call.

The project PROGRESS brings together top researchers in the fields of satellite data analysis (USFD, CNRS/LPC2E), numerical modelling (UW, FMI), systems science (USFD), neural networks (IRF), solar, and space physics (All) to harness their joint expertise to significantly improve Europe's potential to forecast the arrival of space weather disturbances and assess their probable effects on the magnetosphere. The fact that most areas of expertise are available at more than one institute provides joint studies to be performed and, at the same time, provides a level of redundancy should one of the partners have to leave the project, reducing the possibilities of single point failures. The nature of the challenge within this call is that no one institute could achieve the desired results single-handed. However, the collaborative efforts of all participants within project PROGRESS may be combined to yield a consortium that may tackle the problems associated with this call head on and make valuable scientific and commercial progress.

To further strengthen the profile of the consortium we have included experts from the USA and Russia. The project acknowledges the fact that the USA and Russia are two countries that are not listed in the Horizon 2020 list of Associated Countries. However, since this level of expertise is not available within Europe, we feel strongly that the inclusion of the following partners as official participants within PROGRESS significantly strengthens the level of expertise and knowledge available within the consortium. This inclusion also allows PROGRESS use of two models, AWSoM and VERB, that have no European equivalents.

Prof. M. Liemohn and Dr. B. van der Holst (University of Michigan) have extensive experience in the development of MHD codes for the solar wind and its interaction with planetary bodies. He is a member of the group that has developed the highly successful BATS-R-US code and can provide valuable expertise and guidance for the development of the model for solar wind propagation (WP2). UM has developed a model, AWSoM, that couples GONG magnetograms of the solar surface to coronal physics models. The output of this model is used to define the inner boundary conditions for SWIFT. Currently, Europe has no counterpart to the AWSoM.

Prof. Y. Shpritz (Skolkovo Institute of Science and Technology) is an expert on the physics of the radiation belts. He has been instrumental in the development of the numerical VERB code. VERB includes mixed diffusion terms that have been neglected in similar codes developed within Europe. The inclusion of Prof. Shpritz within the project provides access to this important tool, and enables further development of the code by incorporating data assimilation techniques as well as linking it with the USFD developed SNB$^3$GEO model to create a tool to accurately model the electron environment of the radiation belts. This tool will be able to produce reliable forecasts as well as prove an invaluable tool for investigating previous satellite anomalies.

#### *2.3.3.1 Specific strengths*

**USFD** are the world leading group in the development of data based models, their analysis, and interpretation. USFD has already used this methodology to develop online forecasting tools for both the Dst geomagnetic index and the flux of high-energy electrons at GEO. This later model has also been implemented on the NASA CCMC web site. USFD also has expertise in the analysis of satellite measurements plasma waves in the radiation belts

**FMI** provides expertise in the particles observed in the radiation belts and, in particular, the numerical modelling of low energy electron fluxes. FMI are the developers of the IMPTAM numerical simulation code, a nowcast model for low energy (E<200keV) electrons in the inner magnetosphere.

**UW** has internationally leading expertise in developing and using plasma simulation codes. This includes the Lare3d and Odin MHD codes but also extends to direct Vlasov solvers (Valis) and relativistic multi-scale kinetic plasma codes (EPOCH). Of these codes EPOCH and Odin were developed as part of a multi-institutional programme in collaboration with Warwick computer scientists. UW therefore has a proven record of developing World-leading simulations tools as part of a multi-institution collaboration, employing cutting edge techniques from both computational physics and computer science. In addition UW continues to support EPOCH and Lare3d for the international community.

**Skoltech** are internationally known for their research into the evolution of relativistic electron fluxes in the radiation belts and the development of the VERB diffusion code to model these processes.

**UM** are the world-leading group in the development of MHD simulation codes. They have immense experience in the development and coupling of MHD codes to model the solar atmosphere, the solar wind, the magnetosphere, and inner magnetosphere.

**SRI NASU-NSAU** provides expertise in the development and use of the dynamic-information and guaranteed approaches to space weather prediction using NARMAX and bilinear input-output models. SRI NASU-NSAU has already used these approaches to

develop online forecasting tool for the Dst geomagnetic index and risk assessment of space radiation effect on satellite devices.

**CNRS/LPC2E** are world-leading researchers in the field of space plasma physics and the analysis of satellite based data sets and actively worked on the creation of the data base of wave measurements onboard Cluster, THEMIS, Polar, DE and Akebono satellites in the Earth magnetosphere with special attention to the vicinity of the radiation belts.

**IRF** performs basic and applied research in the Earth's upper atmosphere, the ionosphere, and planetary magnetospheres, and the Sun. IRF has been active in space weather since the 1990's and been involved in several international projects, both ESA and EU funded. Forecast models have been studied, developed, and implemented for various geomagnetic indices and ground geomagnetic field. IRF has well established relations with Swedish stakeholders, such as national electric grid and civil contingencies agency.

As well as the inclusion of UM and Skoltech within the consortium other collaborations will be undertaken within PROGRESS. These collaborations will be carried out at zero cost to the Commission/REA.

The activities to be performed by CNRS/LPC2E in the course of work package 4 will undertaken in the form on a collaboration between the work package leader, V Krasnoselskikh, and Dr. Oleksiy Agapitov from the Space Sciences Laboratory, The University of California, Berkeley, USA.

The activities to be performed by Skoltech in the course of work package 6 will undertaken in the form on a collaboration between the work package leader, Prof. Y. Shpritz, Dr. Dmitri. Kondrashov, and Dr. Adam Kellerman from the Institute of Geophysics and Planetary Physics, The University of California, Los Angeles, USA.

### 2.3.4 Capacity of participants and links to third parties

#### *2.3.4.1 Participants*

##### 2.3.4.1.1 USFD - University of Sheffield

Web page: http://www.shef.ac.uk

*Description*

USFD is one of the largest UK universities with over 24,000 students from more than 124 countries. Six Queen's Anniversary prizes (the most distinguished UK educational award) awarded to USFD since 1998. USFD has been named UK University of the Year in the 2011 Times Higher Education Awards. USFD is proud to have 5 Nobel Prize winners associated with it. USFD has a long-standing tradition of collaborative research in the UK and overseas and has much experience managing large European research projects. Project PROGRESS brings together expertise in two research centres, Solar physics and Space Physics Research Centre and Centre for Signal Processing and Complex Systems.

*Solar physics and Space Physics Research Centre*

The Solar physics and Space Physics Research Centre comprises two research groups, the Solar Wave Theory Group (SWAT) in the Department of Applied Mathematics and the Space Systems Laboratory (SSL) in the Department of Automatic Control and Systems Engineering.

The principle aims of SWAT are to understand the key important physical processes governing the energy flow from the convective zone to the solar atmosphere and down to the Earth's upper atmosphere using analysis of observational data together with mathematical and computational models.

*Space Systems Laboratory*

The Space System Laboratory plays an active role in the development of hardware and software for ESA space missions. SSL is the PI group for the Cluster Digital Wave Processor (DWP), the central part of the Cluster Wave Experiment Consortium. Currently the group has Co-I involvement in the Cassini and VEX missions. The scientific interests of the group that are relevant to the project include dynamical processes in space and astrophysical plasmas, space weather, the dynamics of the radiation belts, nonlinear processes, plasma turbulence, and methods for spacecraft data analysis.

*Centre for Signal Processing and Complex Systems*

The aims of the Centre for Signal Processing and Complex Systems at the department of Automatic Control and Systems Engineering (ACSE) are twofold: First, to elaborate developments of nonlinear signal and information processing methods from a generic systems engineering perspective. Secondly, to extend and develop the systems engineering algorithms to address the specific problems associated with each of the multi-disciplinary topics in diverse fields such as signal processing, system identification, dynamical analysis, control and modelling to support emerging multi-disciplinary research themes in medicine, systems and synthetic biology, stem cell dynamics, neuro-imaging, bio-imaging, neural processing in Drosophila, reaction-diffusion systems, non-equilibrium growth processes, studies of solar terrestrial systems, mobile robots, volatility modelling and financial systems, climate dynamics, nonlinear materials design and many other complex systems.

*Key publications relevant to the proposal:*

Boynton, R. J., M. A. Balikhin, S. A. Billings, and O. A. Amariutei, Application of nonlinear autoregressive moving average exogenous input models to geospace: advances in understanding and space weather forecasts, Ann. Geo. 31, 1579-1589, 2013.

Boynton, R. J., M. A. Balikhin, S. A. Billings, G. D. Reeves, N. Ganushkina, M. Gedalin, O. A. Amariutei, J. E. Borovsky, and S. N. Walker, The analysis of electron fluxes at geosynchronous orbit employing a NARMAX approach, J. Geophys. Res. (Space Physics) 118, 1500-1513, 2013.

Boynton, R. J., S. A. Billings, O. A. Amariutei, and I. Moiseenko, The coupling between the solar wind and proton fluxes at GEO, Ann. Geo. 31, 1631-1636, 2013.

Boynton, R. J., M. A. Balikhin, S. A. Billings, A. S. Sharma, and O. A. Amariutei, Data derived narmax dst model, Ann. Geo. 29, 965-971, 2011.

Boynton, R. J., M. A. Balikhin, S. A. Billings, H. L. Wei, and N. Ganushkina, Using the NARMAX OLS_ERR algorithm to obtain the most influential coupling functions that affect the evolution of the magnetosphere, J. Geophys. Res. (Space Physics) 116, A05218, 2011.

*Main tasks:*

- Management/Coordination of the project (WP1).
- Oversee the dissemination and communication activities related to the project (WP8).
- Lead science WP 6, and 7
- Contribute to WP 3, 4, 5

*The key participants in project PROGRESS at USFD are:*

*Prof. Robertus von Fay-Siebenburgen* (Erdelyi) is a world renown authority on the solar atmosphere, the wave processes occurring within it, their propagation in the solar wind and its influence on the terrestrial magnetosphere. His main research interests include the theoretical study of linear and nonlinear processes for MHD wave heating and solar magneto-seismology

in the solar atmosphere and the use of computational magnetohydrodynamics to investigate small-scale structures such as spicules, explosive events, blinkers, nano-flares, and solar tornadoes together with comparison of the results with the latest space (e.g. Hinode, DO, IRIS) and ground-based (SST, DST/NSO) observations. His most prestigious papers (3xNature; 2xScience, numerous in ApJ, 7xSSR, etc.) and extensive network of collaborators affirm his international standing. He is an invited CoI on the SDO mission, and invited international expert to ATST. RvFS has received a number of collaboration awards from Royal Society, British Council, ESA SP, IAU, IUPAP, and ISSI. RvFS was involved as a Co-I for three successful NASA SR&T collaborations with LMSAL and raised substantial funding for research (STFC, EPSRC, NATO, ESA, etc.). He has organized and chaired sessions at many conferences including SOHO, IAU, EGU, and AOGS. As a member of the White Rose Consortium, RvFS has participated in two successful Sheffield-led bids: (i) establishment of the White Rose Grid; (ii) establishment of a High Throughput Computing Grid System. In association with the UKMHD Consortium, he is a CoI in the upgrading of a UKMHD Grid System. He was Chairman of UK Solar Physics for seven years.

Prof von Fay-Siebenburgen is the Coordinator of project PROGRESS, and will lead WPs 1 (Management) and 7 (Dissemination).

*Prof. Stephen Billings* is the world leading expert in the field of nonlinear systems. His main expertise relates to aspects of signal processing and nonlinear and complex systems. Prof. Billings is one of the world's top 100 cited researchers in all engineering disciplines and is currently the fourth most cited engineer in the UK based on Web of Science. He has played a key role in the development of various methods for processing spacecraft wave data such as wave dispersion identification, determination of wave growth/damping rates and identification of nonlinear processes within plasma turbulence using frequency and time domain methods. These methods have been successfully applied to plasma turbulence observed in various regions: foreshock; shock front and the magnetosheath.

Prof. Billings is the pioneer of the NARMAX modelling methodology. He will provide advice on the use and interpretation of the NARMAX models resulting from WP 3, 4, and 6

*Prof. Michael Balikhin* is a world renown expert in the field of space plasma physics, plasma turbulence, satellite data analysis and nonlinear dynamical systems and is currently an editor for Journal of Geophysical Research-Space Physics, the most prestigious journal in the field of space physics. He has pioneered the use of advanced system dynamics methodologies within the field on space physics played a key role in the development of an online tool that provides reliable 24 hour ahead forecasts of relativistic electron fluxes at GEO (http://www.ssg.group.shef.ac.uk/USSW/2MeV_EF.html). In collaboration with UCLA, MB leads the development of the VERB-NARMAX-Coupling (VNC) code that combines the UCLA VERB model with the Sheffield NARMAX model to forecast the fluxes of high energy electrons throughout the whole region of the radiation belts.

Prof. Balikhin will lead WP 6 and provide scientific expertise to the modelling and interpretation for work packages 3, 4, and 7.

*Dr. Simon Walker* graduated with a PhD from USFD in 1991. After a short spell working at ESA/ESRIN, Frascati he returned to Sheffield, using Cluster data to investigate the structure and processes at the bow shock and wave activity in the magnetosheath. As part of the Sheffield led Cluster Inner Magnetosphere Campaign he is in the process of investigating the occurrence and properties of equatorial magnetosonic waves and their role in the acceleration and scattering of electrons. In addition, Dr. Walker is responsible for SSL data input to the Cluster Active Archive database. He is an author of over 60 papers in refereed journals.

Dr. Walker is the PROGRESS Project Manager. He is an expert satellite based data analysis and will provide technical and scientific input to WP 3 and 6 as well as leading WP 7. He has previously acted as coordinator for the FP7 funded project SEMEP.

*Dr. Victor Fedun*, graduated from physics department at Kiev National University (Ukraine) in 1994, PhD from Main Astronomical Observatory of the National Academy of Sciences of Ukraine He is the author/co-author of over 35 papers in space physics.

Dr. Fedun will provide support to WP 4.

*Dr. R. Boynton* completed his PhD at the end of 2011. Since then he has focused on the development of advanced methods for the analysis of space physics data. He has 13 publications in leading journals (e.g. JGR, GRL), 5 as 1st author and 9 related to RB physics and has delivered an invited presentation on radiation belt physics at the Cluster-THEMIS workshop 2012. RJB, together with Prof. Balikhin and Prof. Billings, has developed a set of online space weather forecasting models including the most accurate 24hour ahead forecast of >2MeV electrons at GEO. Based on the success of these models, RJB was invited to join the Dst Challenge led by NASA CCMC in which leading groups were tasked with the creation of a reliable tool to forecast the Dst index.

Dr. Boynton will provide advice on the application of NARMAX methods within WP 3 and 6.

#### 2.3.4.1.2 FMI - Finnish Meteorological Institute

Web page: http://www.fmi.fi/

*Description:*

The Finnish Meteorological Institute (FMI, http://www.fmi.fi/) is a governmental research institute of about 690 employees providing the national weather service in Finland. Besides topics related to the neutral atmosphere, space research belongs to the statutory tasks of FMI, with about 50 employees. One of the challenges for the research of solar-terrestrial physics in FMI is to support the attempts to predict space weather. FMI has a crucial role especially in the establishment of European space weather activities. FMI is or has been a partner in about 25 FP6 projects, and is presently participating in about 15 FP7 projects. FMI has the coordinator status in two ERC projects and in one Marie Curie Grant Agreement. Besides these, FMI coordinates one and is a partner in two other EU LIFE+ 07 projects. FMI jointly with the Department of Physics of the University of Helsinki forms the Kumpula Space Centre to foster scientific collaboration in space sciences and Earth observation activities.

*Key publications relevant to the proposal:*

Ganushkina, N. Yu., T. I. Pulkkinen, T. Fritz (2005), Role of substorm-associated impulsive electric fields in the ring current development during storms, Ann. Geophys., 23, 579-591.

Ganushkina, N., T. I. Pulkkinen, M. Liemohn, and A. Milillo (2006), Evolution of the proton ring current energy distribution during April 21-25, 2001 storm, J. Geophys. Res., 111, A11S08, doi:10.1029/2006JA011609.

Ganushkina N. Yu., M. W. Liemohn, and T. I. Pulkkinen (2012), Storm-time ring current: model-dependent results, Ann. Geophys., 30, 177-202.

Ganushkina, N. Yu., O. A. Amariutei, Y. Y. Shprits, and M. W. Liemohn (2013), Transport of the plasma sheet electrons to the geostationary distances, J. Geophys. Res., 118, doi:10.1029/2012JA017923.

Ganushkina, N. Yu., M. W. Liemohn, O. A. Amariutei, and D. Pitchford (2014), Low energy electrons (5-50 keV) in the inner magnetosphere, J. Geophys. Res., 119, doi:10.1002/2013JA019304

*Previous projects or activities, connected to the subject of this proposal;*

The Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM) was developed at FMI and used successfully to model ions (including protons) and electrons in the inner Earthís magnetosphere. IMPTAM version to model low energy (< 200 keV) electrons in the inner magnetosphere [Ganushkina et al., 2013, 2014] was developed and now operates online under the SPACECAST project (http://fp7-spacecast.eu, projects ends on February 28, 2014).

*Significant infrastructure and/or any major items of technical equipment, relevant to the proposed work*

The team will utilise the resources provided by FMI, including computer and IT support. Administration can provide contractual and juridical support throughout the project.

*Main tasks:*

The main tasks that will be performed at FMI are:

(1) Develop an empirical solar wind and IMF driven model for low energy electrons in the plasma sheet;

(2) Adapt the IMPTAM to include proper diffusion coefficients provided by VERB radiation belts model;

(3) Provide the low energy seed population to VERB radiation belts model;

(4) Develop a trial version of forecast model for low energy electrons.

*Key participants:*

Dr Natalia Ganushkina will lead the work. She is a female Research Scientist at the Earth Observations Research Unit at FMI. She has more than 15 years of experience in space physics, with 66 scientific papers in peer-reviewed journals (h-index of 14), covering a wide range of topics on the Earth's magnetospheric physics. She is highly experienced and qualified in space environment modelling and has a wide experience in various types of inner magnetosphere models and data analysis. She has developed the IMPTAM model, which will be used in the proposed project. She was a National Representative from Finland in the Management Committee of the recently accomplished COST ES0803 Action 'Developing space weather products and services in Europe'. She was a member of AGU (American Geophysical Union) Publications Committee during 2010-2012. She is currently a Secretary on Magnetospheric Physics in Division of Solar-Terrestrial Sciences of European Geosciences Union.

A post doc researcher will be hired to conduct the actual work required for the project under the supervision of Dr. Natalia Ganushkina.

#### 2.3.4.1.3 UW - University of Warwick

Web page: http://www.warwick.ac.uk/

*Description:*

Number of Employees: 4912, Number of Students: 23420, Number of Researchers: 702, Number of Academics: 687.

Date of Creation: 1965, Annual Turnover 2012/13: £459.6m

The University of Warwick is one of the UK's leading universities with an acknowledged reputation for excellence in research and teaching, for innovation, and for links with business and industry. Founded in 1965 with an initial intake of 450 undergraduates, Warwick now has in excess of 22,000 students and is ranked comfortably in the top 10 of all UK university league tables.

Warwick is one of the top ten universities targeted by the Times Top 100 Graduate Employers. Warwick is renowned for excellence and innovation within research and in the 2008 Research Assessment Exercise, was ranked seventh overall in the UK, with 65% of the University's research rated as 3* (internationally excellent) or 4* (world leading). Warwick's mission is to become a world leader in research and teaching.

*The Physics Department*

The Physics Department at Warwick currently has some 60 research active academic staff, a similar number of Research Assistants, and strong technical and administrative support. This represents a rapid expansion and a doubling in size over the past ten years. Postgraduate students form an important part of the research community, with a population of over 150 in 2012. Research in the Warwick Physics Department was rated as internationally prominent in the 2008 Research Assessment Exercise.

*Centre for Fusion, Space and Astrophysics (CFSA)*

Within UW Physics Arber and Bennet are also members of CFSA is one of the largest interdisciplinary plasma physics centres in Europe. Its mission is to address key physics questions that arise from the grand challenges of fusion energy and the solar-terrestrial environment, and that require deep expertise in plasma physics to solve. The twin-track approach of contributing to fundamental physics and mission-led programmes ensures CFSA's activity is relevant to diverse funding sources: EPSRC and STFC; Euratom and ESA; and aligns with the UK's strategic energy and environmental needs. The group has a strong international reputation that is sustained through close partnerships with large facilities and their communities.

*Centre for Computational Sciences (CSC)*

Arber is also a core member of The Centre for Scientific Computing which employ state-of-the-art high performance computing tools to nurture internationally competitive research groups within Warwick

This is achieved by maintaining and enhancing an inter-disciplinary research environment which develops and shares computational expertise for the resolution of significant research goals.

In addition CSC manages a strategy for making a range of high performance computing environments available at Warwick so that research groups are well-placed to use larger national and international facilities.

*Key publications relevant to the proposal:*

T D Arber, A W Longbottom, C L Gerrard and A M Milne, A Staggered Grid, Lagrangian-Eulerian Remap Code for 3-D MHD Simulations, J. Computational Physics 171, 151-181, 2001

J A Merrifield, T D Arber, S C Chapman and R O Dendy, The scaling properties of two-dimensional compressible magnetohydrodynamic turbulence, Physics of Plasmas 13, 012305, 2006

G J J Botha, T D Arber and Abhishek K Srivastava, Observational Signatures of the Coronal Kink Instability with Thermal Conduction, Astrophysical Journal 745, 53-61, 2012

T D Arber, G J J Botha and C S Brady, Effect of Solar Chromospheric Neutrals on Equilibrium Field Structures, Astrophysical Journal 705, 1183-1188, 2009.

*Previous projects relevant to the proposal:*

2008-2012 STFC funded project 'Fundamental Plasma Physics of the Solar Corona'. This grant funded one PDRA under Prof. Arber's supervision to study solar coronal MHD, chromospheric physics and flux emergence.

2009 STFC funded 'Parallel computing resource for the UKMHD community' grant to cover MHD research and computing.

2011-2013 EPSRC funded project 'A radiation hydrodynamic ALE code'. This funded three PDRA, one each in Warwick, Oxford and Imperial College, to develop ALE codes for laboratory and space physics applications.

2014-2017 STFC funded Consolidated grant at Warwick. This grant funded one PDRA under Prof. Arber's supervision to study chromospheric heat via Alfvenic turbulence, chromospheric reconnection and coronal MHD.

*Main tasks:*

- Development of SWIFT code.
- Oversee the integration of SWIFT and AWSoM codes in WP2.
- WP2 integration to whole PROGRESS forecast model in WP7.
- Dissemination of results and methods in WP8.

*The key participants in project PROGRESS at UW are:*

*Professor Tony Arber* is a world-renowned expert in computational plasma physics. His research interests span kinetic plasmas, QED-plasma, MHD and fluid models all applied to either laboratory plasma devices or to space physics. Within space physics he has concentrated on MHD modelling of the solar chromosphere and corona and was the lead developer of the Lare3d MHD shock capturing code that is used extensively by the solar community. Other major code initiatives include the EPOCH code, a relativistic kinetic plasma model, which is now used worldwide by over 300 users. The development of Lare3d and EPOCH have demonstrated Arber's international standing in developing community codes developed across multiple sites. A skill of direct relevance to the PROGRESS project. Arber is the Chair of the UK's Collaborative Computational Project in Plasmas (CCPP) that coordinates UK efforts in plasma software development and training as well as being Chair of the UK Plasma Physics High End Computing Consortium (Plasma HEC) which manages the UK's allocation of national supercomputing time for plasma physics and coordinates efforts to optimise codes for such architectures. He is also a CoI on the UK MHD Consortium grant which hosts one of its HPC clusters at Warwick University's Centre for Scientific Computing. Arber's work has resulted in substantial research grants from the UK research councils SFTC, EPSRC as well as ESA and industrial sponsorship. He has organised conferences on computational plasma physics and chaired many sessions and international conferences. Professor Arber will lead WP2 on MHD code development, coordinating input from UM and UW, and is involved in the final integration of the PROGRES tool-chain (WP7) and dissemination (WP8)

*Dr Keith Bennett* is an expert in large-scale software development for plasma physics. Following his PhD in solar MHD from St. Andrews (2000) was the Scientific Computing Officer in St Andrews responsible for all scientific computing support and as lead developer

of Lare3d. From 2005 he worked in industry as a scientific programming consultant for Fluid Gravity Engineering ltd. Much of this work involved fluid simulations and advanced visualisation. Since 2010 he has been at Warwick as the lead developer of the EPOCH project. This is a multi-institute, multi-national collaborative software development project to write a relativistic, including QED, kinetic plasma physics code. This project ends in March 2014 with the final code used by ~300 international researchers. From April 2014 he will move on to become the lead developer of the Odin MHD ALE code. He therefore has the ideal academic background, industrial experience and has been lead developer of Lare3d and Odin. He is the ideal candidate to develop SWIFT.

#### 2.3.4.1.4 Skoltech - Skolkovo Institute of Science and Technology

Web page: http://www.skoltech.ru/

*Description:*

The Skolkovo Institute of Science and Technology (Skoltech) is a private graduate research university in Skolkovo, Russia, a suburb of Moscow. Established in 2011 in collaboration with MIT, Skoltech educates global leaders in innovation, advance scientific knowledge, and fosters new technologies to address critical issues facing Russia and the world. Applying international research and educational models, the university integrates the best Russian scientific traditions with twenty-first century entrepreneurship and innovation. Skoltech initially has five primary education and research programs, corresponding to priority areas as defined by Russia: these are Programs in Information Science and Technology, Energy Science and Technology, Biomedical Science and Technology, Space Science and Technology, and civilian Nuclear Science and Technology. Fifteen Centers for Research, Education and Innovation (CREIs) are associated with Skoltech, each residing under one or more of the programs.

Space Research and Technology Center is aiming to develop innovative space sensors, payloads and onboard systems to conduct new observations and measurements from Earth orbit, thus supporting observation and navigation on Earth and nearby bodies

Further, the center will also investigate technologies supporting human preparation for longer-term exploration, particularly in regards to radiation and microgravity environments, and human displays and controls to lessen human workload when supervising robotic systems in space or on planetary surfaces. In addition, researcher of the center will explore technologies in the area of geodesy and earth Observations, such as high-quality maps in real-time, Planetary Geodesy Global Navigation Satellite Systems; Deep Space Navigation Optical Navigation and Tracking.

*Key publications relevant to the proposal:*

Shprits, Y. Y., D. Subbotin, A. Drozdov, M. E. Usanova, A. Kellerman, K. Orlova, D. N. Baker, D. L. Turner & K.-C. Kim (2013), Unusual stable trapping of the ultrarelativistic electrons in the Van Allen radiation belts, Nature Physics, doi:10.1038/nphys2760

Shprits, Y. Y. and R. M. Thorne (2004), Time dependent radial diffusion modeling of relativistic electrons with realistic loss rates, Geophys. Res. Lett., 31, L08805, doi:10.1029/2004GL019591.

Horne, R. B., R. M. Thorne, Y. Y. Shprits, N. Meredith , S. Glauert , A. Smith , S. Kanekal , D. Baker , M. Engebretson , J. Posch , M. Spasojevic , U. Inan , J. Pickett , P. Decreau (2005), A critical test of electron acceleration in the Van Allen radiation belts, Nature, 437, 8 doi:10.1038/nature03939.

Shprits, Y. Y., D. A. Subbotin, N. P. Meredith, S. R. Elkington (2008), Review of modeling of losses and sources of relativistic electrons in the outer radiation belts: II. Local acceleration and loss, J. Atmos. Sol. Terr. Phys., 70, 14, 1694-1713, doi:10.1016/j.jastp.2008.06.014.

Shprits, Y., D. Kondrashov, Y. Chen, R. Thorne, M. Ghil, R. Friedel, and G. Reeves (2007), Reanalysis of relativistic radiation belt electron fluxes using CRRES satellite data, a radial diffusion model, and a Kalman filter, J. Geophys. Res., 112, A12216, doi:10.1029/2007JA012579.

*Main tasks:*

Skolkovo Institute of Science and Technology will be responsible for coupling the Versatile Electron Radiation Belt (VERB) 3D code with NARMAX and will implement the state of the art data assimilation tools (work package 6).

*Key participants:*

*Prof. Yuri Shprits* has a joint appointment at Skoltech and UCLA. UCLA and Skoltech will be closely collaborating on this project. Yuri Shprits is the author of over 80 publications related to the radiation belt modelling. Currently, the modelling methodology developed by Yuri Shprits and his groups is used by a number of groups around the world. He was also one of the first to apply data assimilation for the radiation belts. Skoltech and UCLA have a unique experience of using data assimilation. Members of the Skoltech team have recently demonstrated [Podladchikova et al., 2014 a, b] how to evaluate model related errors and measurement errors in an objective way. Yuri has served as PI on 15 projects funded by NASA, NSF, AFRL, and UCOP. He is the recipient of 2012 Presidential Early Career Award for Scientists and Engineers, Washington DC and 2011 Arne Richter Award for Outstanding Young Scientists, Union award of the European Geosciences Union, Vienna, Austria.

*Dr.Tatiana Podladchikova* is a postdoctoral fellow at Skolkovo Institute of Science and Technology, Russain Federation. Dr. Tatiana Podladchikova is an expert in the developing of data assimilation tools, an adaptive Kalman filter and parameter identification. Her research experience is related to the developing of space weather forecasting techniques for mitigation hazards of space accidents and their consequences. She developed and implemented real-time space weather forecasting services of the sunspot number prediction (http://sidc.be/products/kalfil/) and geomagnetic storm forecasting several hours ahead (http://spaceweather.ru).

#### 2.3.4.1.5 UM – University of Michigan

Web page: http://www.umich.edu/

*Description:*

The University of Michigan is a public research university located in Michigan, United States. UM has more than 43,000 enrolled students from more than 100 countries. Both *Dr. Bart van der Holst* and *Prof. Michael W. Liemohn* are faculty members of the Department of Atmospheric, Oceanic, and Space Sciences at UM and members of the Center for Space Environment Modeling (CSEM). CSEM is an interdisciplinary research organization of the College of Engineering at UM. CSEM is comprised of a tightly integrated group of faculty, students and staff from the Departments of Aerospace Engineering, Atmospheric, Oceanic and Space Sciences, and Electrical Engineering and Computer Science. The overall goal of CSEM is to develop high-performance, first-principles based computational models to describe and predict hazardous conditions in the near-earth space environment extending from the sun to the ionosphere, called space weather.

*Key publications relevant to the proposal:*

Van der Holst, B., I.V. Sokolov, X. Meng, M. Jin, W.B. Manchester IV, G. Toth, and T.I. Gombosi, Alfvén wave solar model (AWSoM): coronal heating, Ap.J. 782, 81, 2014.

Manchester IV, W.B., B. van der Holst, and B. Lavraud, Flux rope evolution in ICMEs: The 2005 May 13 event, Plasma Phys. Control. Fusion 56, 064006, 2014.

Toth, G., B. van der Holst, I.V. Sokolov, D.L. De Zeeuw, T.I. Gombosi, F. Fang, W.B. Manchester IV, X. Meng, D. Najib, K.G. Powell, Q.F. Stout, A. Glocer, Y.-J. Ma, and M. Opher, Adaptive Numerical Algorithms in Space Weather Modeling, J. Comp. Phys. 231, 870-903, 2012.

Sokolov, I.V., B. van der Holst, R. Oran, C. Downs, I.I. Roussev, M. Jin, W.B. Manchester IV, R.M. Evans, and T.I. Gombosi, Magnetohydrodynamic waves and coronal heating: unifying empirical and MHD turbulence models, Ap.J. 764, 23, 2013.

Van der Holst, B., W.B. Manchester IV, R.A. Frazin, A.M. Vasquez, G. Toth, and T.I. Gombosi, A data-driven, two-temperature solar wind model with Alfvén waves, Ap.J. 725, 1373-1383, 2010.

*Main tasks:*

The University of Michigan plays a key role in WP2, the development of a model for the solar wind.

*Key participants:*

*Dr. Bart van der Holst* (Co-I, University of Michigan) and *Prof. Michael W. Liemohn* (Co-I, University of Michigan) are two of the leading developers of the Space Weather Modeling Framework (SWMF) numerical software tool. They will both assist an unnamed Post-Doc of the University of Michigan to make the solar corona model (AWSoM) of the SWMF time-accurate using hourly updated magnetograms. They will also assist this Post-Doc in coupling the solar corona model (AWSoM) of the SWMF to the new to be developed inner heliosphere model (SWIFT) at University of Warwick.

#### 2.3.4.1.6 SRI NASU-NSAU

Web page: http://www.ikd.kiev.ua/

*Description:*

Space Research Institute of the National Academy of Sciences of Ukraine and National Space Agency of Ukraine has been active in investigating the need within Ukraine for increased space weather activities. Our activities included: analysis of space weather impact on spacecraft, communication system, climate change, networks; development of dynamic-information approach to space weather prediction using NARMAX and bilinear input-output models; development of risk assessment methods for space radiation effect estimation on satellite devices; development of algorithms and software for geomagnetic indices prediction based on dynamic-information approach. Project PROGRESS brings together expertise in two research department, Space Plasma and Remote Sensing and Advanced Instrumentation.

*Key publications relevant to the proposal:*

Agapitov O., Cheremnykh S. MHD Waves in the Plasma System with Dipole Magnetic Field Configuration, Advances in Astronomy and Space Physics 2, 103-106, 2011.

Cheremnykh O., Yatsenko V., Semeniv O., Shatokhina Iu. Nonlinear Dynamical Model for Space Weather Prediction. Ukr. J. Phys 53(5), 502-504, 2008.

V. Yatsenko, N. Boyko, S. Rebennack, P. Pardalos, Space Weather Influence on Power Systems: Prediction, Risk Analysis, and Modeling.-Energy Systems, Pub Springer, 1, 197-207, 2010.

Pardalos, P. and Yatsenko. Optimization and control of bilinear systems: theory, algorithms, applications, Pub. Springer, Dordrecht–Boston–London, p370, 2008.

O. Semeniv and V. Yatsenko, Identification of Dynamical Models for Dst-Index Forecasting. Control Problems and Informatics 16(1), 51–56, 2010.

*Main tasks:*

SRI NASU-NSAU will participate in WP3 and WP8.

*Key participants:*

*Prof. Vitaliy Yatsenko* is Head of Department ”Remote Sensing and Advanced Instrumentation” at the Space Research Institute of the Ukrainian Academy of Sciences and the Space Agency of Ukraine. He is the world leading expert in the field of nonlinear control systems. His main expertise relates to aspects of signal processing, control systems, identification, optimization and space weather prediction. He is author of more than 270 scientific articles and developed several well known software packages. He will provide input to WP 3 and 8.

*Prof. Oleg Cheremnykh* is Head of Department “Space Plasma” at the Space Research Institute of the Ukrainian Academy of Sciences and the Space Agency of Ukraine. Engaged in plasma physics from 1978. He is the author of 171 scientific publications. He will developed physical-based dynamic models of space weather prediction.

*Dr. Oleh Semeniv* is senior researcher at the Space Research Institute of the Ukrainian Academy of Sciences and the Space Agency of Ukraine. His investigation deals with modeling and space weather prediction. He is the author of 21 scientific publications. In the framework of the Project he will develop software related to space weather prediction.

Maksym Makarychev is PhD student at the Space Research Institute of the Ukrainian Academy of Sciences and the Space Agency of Ukraine. His investigation deals with nonlinear analysis of time series and reconstruction of dynamic models using satellite data. He is the author of 6 scientific publications. He will develop software related to space weather prediction.

#### 2.3.4.1.7 CNRS: Centre National de la Recherche Scientifique

Web page: http://www.lpce.cnrs-orleans.fr/

*Description:*

The Centre National de la Recherche Scientifique is a government funded research organization under the administrative authority of the French Ministry of Research. CNRS research laboratories, spread all over France and often partnered with universities, carry out research in all fields of science. Those focusing on the studies in space plasma, planetary environment, solar physics, astrophysics and geophysics are coordinated by one of the Institutes of the CNRS, the "Institut National des Sciences de l'Univers" (INSU).

The Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E) is a Joint Research Unit (JRU) operated by the French Centre National de la Recherche Scientifique (CNRS) and the University of Orleans (UO). The Centre National de la Recherche Scientifique (CNRS) is the legal entity acting on behalf of LPC2E.

The research done in LPC2E is related to the study and modelling of physical processes occurring in the neutral environment (atmosphere) or ionized environment (ionosphere, magnetosphere, solar wind) of the Earth and other planets. This research is carried out in the frame of national, European, and international programmes. The different activities of LPC2E are: the physic of the space plasmas, the physico-chemistry of the planetary environments, the physico-chemistry of the atmosphere, astrophysics.

The group at CNRS/LPC2E has a great experience in analysis of satellite data of wave experiments onboard satellites. The group was one of the first to develop and apply tools for the determination of k-vectors making use of multi-satellite data. This technique was applied to analyze the data of Cluster project. It was one of the first groups to develop and apply the technique for the identification of non-linear processes in space plasmas, in particular bi-coherence and tri-coherence methods that allow one to establish the presence of wave-wave interactions. This technique was applied to the data of AMPTE project and on the basis of this development the special package SWAN was developed by LPC2E and delivered to scientific community of Cluster project. Recently our group has actively worked on creation of the database of wave measurements onboard Cluster, THEMIS, Polar, DE and Akebono satellites in the Earth magnetosphere with special attention to the vicinity of the radiation belts. The data base realized by Orleans group represent statistical distribution of wave observations that includes the probability of observations, amplitudeof electric and magnetic field distributions upon several parameters such as the L-shell, MLT, and geomagnetic indices. The database includes also the distribution of wave vectors upon latitudes that is crucially important for the calculation of the diffusion coefficients that determine the time of life of energetic particles. The group will lead activities of package 4 where similar database should be created but it should include the dependencies of wave characteristics upon solar wind parameters.

*Key publications relevant to the proposal:*

1. Artemyev, A. V., Mourenas, D., Agapitov, O. V., and Krasnoselskikh, V. V.: Parametric validations of analytical lifetime estimates for radiation belt electron diffusion by whistler waves, Ann. Geophys., 31, 599-624, DOI:10.5194/angeo-31-599-2013, 2013.

2. Mourenas, D.; Artemyev, A. V.; Agapitov, O. V.; Krasnoselskikh, V., Analytical estimates of electron quasi-linear diffusion by fast magnetosonic waves, Journal of Geophysical Research: Space Physics, Volume 118, Issue 6, pp. 3096-3112, DOI 10.1002/jgra.50349, 2013 ;

3. Arpad Kis, O. Agapitov, V. Krasnoselskikh, Yu. Khotyaintsev, Gyrosurfing Acceleration of Ions in Front of Earth's Quasi-parallel Bow Shock , Ap.J., **771** 4, 2013;

4. Krasnoselskikh, V.; Balikhin, M.; Walker, S. N.; Schwartz, S.; Sundkvist, D.; Lobzin, V.; Gedalin, M.; Bale, S. D.; Mozer, F.; Soucek, J.; Hobara, Y.; Comisel, H., The Dynamic

Quasiperpendicular Shock: Cluster Discoveries, Space Sci. Rev., DOI 10.1007/s11214-013-9972-y, 2013;

5. Agapitov, O., A. Artemyev, V. Krasnoselskikh, Y. V. Khotyaintsev, D. Mourenas, H. Breuillard, M. Balikhin, and G. Rolland (2013), Statistics of whistler-mode waves in the outer radiation belt: Cluster STAFF-SA measurements, J. Geophys. Res. Space Physics, 118, 3407–3420,DOI :10.1002/jgra.50312 ;

*Main tasks:*

The group will lead activities of package 4. The analysis of the CLUSTER, Helios, WIND and STEREO satellite data sets will be performed at LPC2E by the participants named below. The main tasks of LPC2E within the PROGRESS project are the participation in creation of the data base of wave characteristics in the inner magnetosphere of the Earth and around radiation belts and evaluation of the diffusion coefficients due to wave-particle interaction, that is one of the critical parameters that determine particle losses.

*Key participants:*

The group consists of one permanent scientist, Dr. Krasnosselskikh V., one Post Doc, one engineer and Ph. D. student Andrii Voshchepynets.

*Dr. Vladimir Krasnosselskikh* (leader) is a research scientist responsible for the search coil instrument in the Solar Orbiter project that will study the turbulence characteristics and the wave activity in the solar wind. Dr. Krasnosselskikh was born in Russia, in 1952. After receiving his 3rd cycle thesis at the Moscow Physical Technological Institute in Moscow under the supervision of Academician Galeev in 1978, he began working at Space Research Institute in Moscow. In the beginning of 1991 he moved to France and joined LPCE/INSU/CNRS. His recent research activities are related to the studies of statistical characteristics of waves in the radiation belts and their role in particle acceleration and angular diffusion in the inner magnetosphere. He works as the theoretician and he performs the analysis of wave activity in the magnetosphere. He is author/ co-author of about 120 papers published in refereed journals.

#### 2.3.4.1.8 IRF – Swedish Institute for Space Physics

Web page: http://www.irf.se/

*Description:*

The Swedish Institute of Space Physics is a governmental research institute with about 100 employees. The research activities concern studies of phenomena in the Earth's upper atmosphere, ionosphere, and planetary magnetospheres. Ground-based measurements of ionospheric parameters, geomagnetic field, optical aurora, and radio wave propagation, as well as in situ measurements with satellites are being performed. The group in Lund (IRF-Lund, http://lund.irf.se/) was formed in 1996 as a part of IRF's Solar Terrestrial Physics Research Programme. IRF-Lund studies the solar driver of space weather, the solar activity, and also the link between solar activity and climate changes. IRF-Lund runs the Swedish Space Weather Center (http://src.irf.se/) and is also a Regional Warning Center (RWC-Sweden, http://www.lund.irf.se/rwc/) within the International Space Environment Service (ISES).

*Key publications relevant to the proposal:*

**Wintoft**, P., M. Wik and A. Viljanen, Empirical solar wind driven model for real time forecasting of local ground magnetic field variation, To be submitted to Journal of Space Weather and Space Climate, 2014.

Watermann, J., P. **Wintoft**, B. Sanahuja, E. Saiz, S. Poedts, M. Palmroth, A. Milillo, F. A. Metallinou, C. Jacobs, N. Ganushkina, I. Daglis, C. Cid, Y. Cerrato, G. Balasis, A. Aylward and A. Aran, 2009. Models of Solar Wind Structures and Their Interaction with the Earth's Space Environment. Space Science Reviews.

**Wintoft**, P., 2005. Study of the solar wind coupling to the time difference horizontal geomagnetic field. Ann. Geophys., 23, 1949–1957, doi:10.5194/angeo-23-1949-2005.

**Wintoft**, P., 2011. The variability of solar EUV: A multiscale comparison between sunspot number, 10.7 cm flux, LASP MgII index, and SOHO/SEM EUV flux, Journal of Atmospheric and Solar-Terrestrial Physics, 73, 1708–1714.

**Wintoft**, P., M. Wik, H. Lundstedt and L. Eliasson, 2005. Predictions of local ground geomagnetic field fluctuations during the 7-10 November 2004 events studied with solar wind driven models. Ann. Geophys., 23, 3095–3101, doi:10.5194/angeo-23-3095-2005.

*Main tasks:*

Leader of WP3 *Forecast of the evolution of geomagnetic indices*: improvement and new development of models based on data driven modelling to forecast geomagnetic indices *Kp*, *Dst*, and *AE*; classification of relevant solar wind and geomagnetic structures (shocks, sudden impulses, sub-storms); verification of existing and future models.

*Key participants:*

Dr. Peter Wintoft (M)

- Scientist at IRF-Lund

- Scientific expertise: wavelet analysis, neural networks, forecast verification, space weather analysis and forecasting

- Development of AI Methods in Spacecraft Anomaly Predictions, (SAAPS), ESA funded project, http://www.lund.irf.se/saaps/, 1999–2001, Lead by IRF.

- Real-time forecast service for geomagnetically induced currents, ESA Space Weather Applications Pilot Project, http://www.lund.irf.se/gicpilot/, 2003–2006, Lead by IRF.

- Virtual observatory for space weather data and models (VISPANET), ESA funded project, 2009–2011, IRF subcontractor.

- Developing Space Weather Products and Services in Europe, COST Action ES0803, http://www.costes0803.noa.gr, 2008–2012, Leader of subgroup on "Performance of available research and operational models".

- Solar storms and space weather, MSB funded project, http://www.lund.irf.se/msb/, 2012–2014. Lead by IRF.

- EURISGIC (European Risk from Geomagnetically Induced Currents, 2011-2014), funded by EU/FP7; coordinator: FMI

#### 2.3.4.2 *Third parties involved in the project (including use of third party resources)*

There is no subcontracting of work in the Project.

For this Project, the University of Orléans is linked to CNRS as third party. The Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E) is a Joint Research Unit (UMR n° 7328). The LPC2E is under the control of the CNRS and the University of Orléans. All staff associated with project PROGRESS for the partner CNRS will work in LPC2E. As LPC2E is a Joint Research Unit, the LPC2E staff may belong either to the CNRS or to the University of Orléans. The financial and administrative issues concerning CNRS and the third parties will be managed by CNRS as a whole. For this reason the clause 14.1 is to be inserted in the Grant Agreement.

A description of the partner LPC2E may be found in section 2.3.4.1.6. The costs associated with the participant CNRS, the third party (UO), and the JRU (LPC2E) are to enable LPC2E to fulfill the tasks assigned to them within the workpackages of the Project. A small provision of 6363 Eur for Personnel Costs has been allocated to UO. This financial split is reflected in the Annex 2 Budget table.

### 2.3.5 Resources to be committed

#### 2.3.5.1 *Cost justifications.*

**USFD**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 76534 | 1. Project, Steering Committee, and Stakeholder meetings (travel €300, subsistence €156, 4 nights, 4 people * 7 meetings) €21991<br>2. Funds for stakeholders to attend meetings (travel €360 (€840 from US), subsistence €156, 2 nights, 6 people * 3 meetings) €14851<br>3. EC/REA review meetings (travel €300, subsistence €156, 2 nights, 3 people * 3 meetings) €5462<br>4. Scientific conferences 3* Fall AGU, 3* EGU, COSPAR, 3 * ESWW, 2*US SWW, GEM €15951<br>5. Post doc travel fund for post doc researchers to travel between participant groups €18279 |
| Equipment | 0 | |
| Other goods and services | 25,692<br>14,200<br>2,017 | Costs of running summer school and Sheffield in year 3<br>Publication fees, consumables<br>Audit fee |
| Total | 118,443 | |

**FMI**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 19,600 | Project meetings 8,000 Eur, EC/REA review meetings 3150Eur<br>Scientific conferences (AGU, EGU, COSPAR, European |

| | | |
|---|---|---|
| | | Space Weather Week) 8450 Eur |
| Equipment | 0 | |
| Other goods and services | 4,900 | Publication charges 3,000 Eur<br>Conference abstract and registration fees (AGU, EGU, ESWW) |
| Total | 24,500 | |

**UW**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 26,300 | 1. Project meetings in Sheffield (€162 travel, €270 accommodation, €108 subsistence for two days per meeting) x7 = €3,780<br>2. One week research visit to UM for Arber and Bennett (€1,300 flight, €8,400 hotel, €560 subsistence) x2 = €20,520<br>3. Scientific conferences EGU (€250 travel, €150 hotel, €100 subsistence, 3 nights) x2 = €2,000 |
| Equipment | 7,000 | High end workstation, 8 core, 64GB RAM for software development |
| Other goods and services | 53,845 | Access charges to UW HPC services at €0.04725 per CPU hour for 12 months use of 130 cores |
| Total | 87,145 | |

**Skoltech**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 7,000 | Project meetings 7* (250Eur flight + 3 nights subsistence 250Eur) for one person |
| Equipment | 0 | |
| Other goods and services | 2,000 | Computer (1500Eur)<br>Publication fees (500Eur) |
| Total | 9,000 | |

**UM**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 8,267 | Project meetings 1 person* 6 meetings travel 6604 Eur, subsistence 1663Eur |
| Equipment | 0 | |
| Other goods and services | 9,067 | AOSS Network computing services 4,279 Eur<br>Books/Publications 4788 Eur |
| Total | 17,334 | |

**SRI NASU-NSAU**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 11,974 | 1. Project meetings - 300Eur travel + 200Eur subsistence per night, 2 nights per meeting, 7 meetings<br>2. Scientific conferences e.g. AGU, EGU, COSPAR |
| Equipment | 0 | |
| Other goods and services | 0 | |
| Total | 11,974 | |

**CNRS/LPC2E**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 14,000 | 1. Project meetings 7 meetings * 3 nights, subsistence 300Eur per night, 300Eur flight = 8400 Eur<br>2. Scientific conferences (AGU, EGU, COSPAR, Space Weather Week 5600Eur |
| Equipment | 0 | |
| Other goods and services | 4,000 | Publication fees 4000 Eur |
| Total | 18,000 | |

**IRF**

| | Cost (€) | Justification |
|---|---|---|
| Travel | 10,400 | Project meetings<br>€300 flight, €200 accommodation, €200 subsistence, 6 meetings, two persons €8400 + organization of meeting in Lund |
| Equipment | 4,000 | Work station for database and running models |
| Other goods and services | 0 | |
| Total | 14,400 | |

### 2.3.6 Ethics and Security

#### *2.3.6.1 Ethics*

The EC/REA advice of ethical issues has been noted. No ethical issues, as listed within the ethical issues table within the proposal administrative forms, arise from project PROGRESS. In particular we confirm that there are no activities that require informed consent, no data protection issues regarding the collection and storage of personal data, no use of animals, animal tissues, or embryonic stem cells.

#### 2.3.6.2 Security

There are no activities or results that raise security issues.

There is no EU-classified information arising from project PROGRESS.

# Appendix 1 References


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## Appendix 2 List of Acronyms

| | |
|---|---|
| ACE | Advanced Composition Explorer |
| AE | Auroral Electrojet geomagnetic index |
| AGU | American Geophysical Union |
| ANN | Artificial Neural Network |
| AWSoM | Alfven Wave Solar atmosphere Model |
| BAS | British Antarctic Survey |
| BATS-R-US | US MHD simulation code |
| CCMC | Community Coordinated Modelling Center |
| CIR | Corotating Interaction Region |
| CME | Coronal Mass Ejection |
| CNN | Computational Neural Network |
| CNRS | Centre National de la Recherche Scientifique |
| COSPAR | Committee on Space research International Association of |
| CRRES | Combined Release and Radiation Effects Satellite |
| DSCOVR | Deep Space Climate Observatory |
| Dst | Disturbance Storm Time geomagnetic index |
| EC | European Commission |
| EGU | European Geosciences Union |
| EMIC | ElectroMagnetic Ion Cyclotron |
| EMW | Equatorial Magnetosonic Waves |
| ENLIL | Solar wind model named after the Sumerian god of winds and storms |
| ERR | Error Reduction Ratio (part of the NARMAX methodology) |
| ESA | European Space Agency |
| ESD | ElectroStatic Discharge |
| ESWW | European Space Weather Week |
| FDC | Full Diffusion Code |
| FMI | Finnish Meteorological Institute |
| GEO | Geosynchronous Earth Orbit |
| GLONASS | Globalnaya navigatsionnaya sputnikovaya sistema (Russian satellite based navigational system) |
| GNSS | Global Navigation Satellite System |
| GOES | Geostatinary Operatinal Environment Satellite |
| GOES MAGED | Magnetspheric Electrn Detector onboard the GOES series of satellites |

| | |
|---|---|
| GONG | Global Oscillation Network Group |
| GPS | Global Positioning System |
| HOPE | Helium Oxygen Proton Electron plasma particle detector on Van Allen probes |
| HPC | High Performance Computer |
| HYDRA DDEIS | Duo-Decker Electron Ion Spectrometer |
| IAGA | International Association of Geomagnetism and Aeronomy |
| IMF | Interplanetary Magnetic Field |
| IMPTAM | Inner Magnetospheric Particle Transport and Acceleration Model |
| IPR | Intellectual Property Rights |
| IRF | Swedish Institute for Space Physics (Institut for Rymdfysik) |
| JRU | Joint Research Unitgalileo |
| Kp | Planetary K geomagnetic index |
| L1 | LeGrange point 1 |
| LANL MPA | Los Almos National Laboratory Magnetospheric Plasma Detector (particle instrument) |
| LANL SOPA | Los Almos National Laboratory Synchronous Orbit Particle Analyser (particle instrument) |
| LPC2E | Laboratoire de Physique et Chimie de l'Environnement et de l'Espace |
| MEO | Medium Earth Orbit |
| MESSENGER | MErcury Surface, Space Environment, Geochemistry and Ranging |
| MHD | MagnetoHydroDynamic |
| NARMAX | Nonlinear Autoregressive Moving Average Model with eXogenous inputs |
| NASA | National Aeronautical and Space Agency |
| NOAA | National Ocianic and Atmospheric Administration |
| ONERA | French Aerospace Laboratory |
| PC | Project Coordinator |
| PEACE | Plasma Electron and Current Experiment (instrument onboard Cluster satellites) |
| PM | Project Manager |
| PROGRESS | Prediction Of Geospace Radiation Environment and Solar wind ParameterS |
| PSD | Phase Space Density |
| REA | Research Executive Agency (European Commission) |
| RRBDM | Recursive, Robust, Bilinear Dynamical Model |
| SAB | Stakeholder Advisory Board |
| SCNN | Supervised Computational Neural Network |
| SEU | Single Event Upset |
| Skoltech | Skolkovo Institute of Science and Technology |
| SNB$^3$GEO | Sheffield NARMAX model for electron fluxes at Geostationary orbit |

| | |
|---|---|
| SRI NASU-NSAU | Space Research Institute of the National Academy of Sciences of Ukraine and the National Space Agency of Ukraine |
| SSA | Space Situational Awareness |
| SSC | Scientific Steering Committee |
| SWIFT | Solar Wind Flux Transfer model |
| SWMF | Solar Wind Modelling Framework |
| THEMIS | Time History of Events and Macroscale Interactions during Substorms |
| TRL | Technology Readiness Level |
| UCNN | Unsupervised Computational Neural Network |
| UM | University of Michigan |
| USFD | University of Sheffield |
| UW | University of Warwick |
| VERB | Versatile Electron Radiation Belt particle model |
| VoIP | Voice over Internet Protocol |
| WPL | Work Package Leader |

# ESTIMATED BUDGET FOR THE ACTION (page 1 of 3)

| | Estimated eligible* costs (per budget category) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A. Direct personnel costs | | | | B. Direct costs of subcontracting | [C. Direct costs of fin. support] | D. Other direct costs | E. Indirect costs | Total costs |
| | A.1 Personnel<br>A.2 Natural persons under direct contract<br>A.3 Seconded persons<br>[A.6 Personnel for providing access to research infrastructure] | | A.4 SME owners without salary<br>A.5 Beneficiaries that are natural persons without salary | | | | D.1 Travel<br>D.2 Equipment<br>D.3 Other goods and services<br>D.4 Costs of large research infrastructure | | |
| Form of costs**** | Actual | Unit (1) | Unit (2)<br>EUR/hour | | Actual | Actual | Actual | Flat-rate (3)<br>25% | |
| | (a) | Total (b) | No hours | Total (c) | (d) | (e) | (f) | (g)=0,25x ((a)+(b)+ (c)+(f)-(m)) | (i)= (a)+(b)+(c)+ (d)+(e)+(f)+ (g) |
| 1. USFD | 441213.00 | .00 | | | .00 | .00 | 118443.00 | 139914.00 | 699570.00 |
| 2. FMI | 195016.00 | .00 | | | .00 | .00 | 24500.00 | 54879.00 | 274395.00 |
| 3. UW | 222080.00 | .00 | | | .00 | .00 | 87145.00 | 77306.25 | 386531.25 |
| 4. Skoltech | 135000.00 | .00 | | | .00 | .00 | 9000.00 | 36000.00 | 180000.00 |
| 5. UM | 149055.00 | .00 | | | .00 | .00 | 17334.00 | 41597.25 | 207986.25 |
| 6. SRI NASU-NSAU | 80000.00 | .00 | | | .00 | .00 | 11974.00 | 22993.50 | 114967.50 |
| 7. CNRS | 120895.00 | .00 | | | .00 | .00 | 18000.00 | 34723.75 | 173618.75 |
| UO | 6363.00 | .00 | | | .00 | .00 | .00 | 1590.75 | 7953.75 |
| Total Beneficiary | 127258.00 | .00 | | | .00 | .00 | 18000.00 | 36314.50 | 181572.50 |
| 8. IRF | 236970.00 | .00 | | | .00 | .00 | 14400.00 | 62842.50 | 314212.50 |
| Total Consortium | 1586592.00 | .00 | | | .00 | .00 | 300796.00 | 471847.00 | 2359235.00 |

# ESTIMATED BUDGET FOR THE ACTION (page 2 of 3)

| | | EU contribution | | | Additional information | |
|---|---|---|---|---|---|---|
| | Total costs | Reimbursement rate % | Maximum EU contribution *** | Maximum grant amount | Information for indirect costs | Information for auditors |
| | | | | | Costs of in-kind contributions not used on premises | Declaration of costs under Point D.4 |
| | (i)= (a)+(b)+(c)+ (d)+(e)+(f)+ (g)+(h1)+(h2) | (j) | (k) | (l) | (m) | Yes/No |
| 1. USFD | 699570.00 | 100.00 | 699570.00 | 699066.00 | .00 | No |
| 2. FMI | 274395.00 | 100.00 | 274395.00 | 274395.00 | .00 | No |
| 3. UW | 386531.25 | 100.00 | 386531.25 | 386031.00 | .00 | No |
| 4. Skoltech | 180000.00 | 100.00 | 180000.00 | 180000.00 | .00 | No |
| 5. UM | 207986.25 | 100.00 | 207986.25 | 207986.00 | .00 | No |
| 6. SRI NASU-NSAU | 114967.50 | 100.00 | 114967.50 | 114967.50 | .00 | No |
| 7. CNRS | 173618.75 | 100.00 | 173618.75 | 173618.75 | .00 | No |
| UO | 7953.75 | 100.00 | 7953.75 | 7953.75 | .00 | No |
| Total Beneficiary 7 | 181572.50 | | 181572.50 | 181572.50 | .00 | |
| 8. IRF | 314212.50 | 100.00 | 314212.50 | 314212.50 | .00 | No |
| Total Consortium | 2359235.00 | | 2359235.00 | 2358230.50 | .00 | |

# ESTIMATED BUDGET FOR THE ACTION (page 3 of 3)

* See Article 6 for conditions for costs to be eligible
** Depending on its type, this cost will or will not include indirect costs.
Costs that include indirect costs are: costs of energy efficiency measures in buildings, costs of providing trans-national access to research infrastructure and costs of clinical studies.
*** This is the theoretical amount of EU contribution if the reimbursement rate is applied to all the budgeted costs. The theoretical amount of EU contribution for the action is capped by the maximum grant amount.
**** See Article 5 for forms of costs
(1) unit : hours worked on the action; costs per unit (hourly rate) : calculated according to beneficiary's usual accounting practice
(2) unit : hours worked on the action; cost per unit : XX EUR
(3) 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 Point F if they include indirect costs
(4) unit : … ; costs per unit : XX EUR
(5) unit : ….. costs per unit …… (the units,the costs per unit and the estimated number of units will be agreed with the beneficiaries in a separate document that becomes part of Annex 2 of their grant agreement)
(6) only unit costs not including indirect costs to be added

**ANNEX 3**

# ACCESSION FORM FOR BENEFICIARIES

**ILMATIETEEN LAITOS (FMI)**, 02446647, established in Erik Palmenin aukio 1, HELSINKI 00560, Finland, FI02446647, ('the beneficiary'), represented for the purpose of signing this Accession Form by Yrjö VIISANEN, Research Manager,

**hereby agrees**

**to become beneficiary** (‘2’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Yrjö VIISANEN with ECAS id nviisayr signed in the Participant Portal on 12/11/2014 at 14:30:47 (transaction id SigId-530-zk18ZlL7nvRmRcg9OzRlzTZBWitMkYbNVnJ1qfOzLuYns60lICW0rpD6NQ6lHiJ4nEzgssHkXSbLT1zZYG7PSaFG-PHslUMVSXYClnYAYQXS7fK-yzSW5LolwS6T8cNXW0MPoHdSG5JoWaJIozdZfBzJH2lC). Timestamp by third party at Wed Nov 12 14:30:53 CET 2014

**ANNEX 3**

## ACCESSION FORM FOR BENEFICIARIES

**THE UNIVERSITY OF WARWICK (UW)**, N/A, established in Kirby Corner Road - University House, COVENTRY CV4 8UW, United Kingdom, GB545270058, ('the beneficiary'), represented for the purpose of signing this Accession Form by Jane PREWETT, Deputy Director - Head of Research Governance,

**hereby agrees**

**to become beneficiary** (‘3’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Jane PREWETT with ECAS id nprewjan signed in the Participant Portal on 06/11/2014 at 21:26:12 (transaction id SigId-25-zxzauYVK1c38Wc3bcsYvSyHXdDC1AEVvsy1KJmMmAPgviSmHMdOORdvNKhNVyzzJOj9iIKTizIZTdkvXng4J6bA-PHslUMVSXYChtIaOEGs514-gVlAKKHGwlip6fP84uKGVU1Z3rRC31q0gXHwMzfFEVw). Timestamp by third party at
Thu Nov 06 21:26:19 CET 2014

**ANNEX 3**

## ACCESSION FORM FOR BENEFICIARIES

**SKOLKOVO INSTITUTE OF SCIENCE AND TECHNOLOGY (Skoltech)** RU5, 1115000005922, established in NOYANA STR 100, Moscow 143025, Russian Federation, RU5032998454, ('the beneficiary'), represented for the purpose of signing this Accession Form by Mikhail BASS,

**hereby agrees**

**to become beneficiary** (‘4’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Mikhail BASS with ECAS id nbassmik signed in the Participant Portal on 14/11/2014 at 13:28:16 (transaction id SigId-2211-xAfzIdzeGy1YidKEHKScOnGNaKdKuQkPlKfaA8UIUqqsavzzNNUwOTeVQyJ6G8MBlboioZwvBA7ssakMSLvlhia-PHslUMVSXYClnYAYQXS7fK-vJVRIZVHGVpozTaHYxNJTdQYSaVWUWwzfFLLkw66rcvW).
Timestamp by third party at
Fri Nov 14 13:28:21 CET 2014

**ANNEX 3**

## ACCESSION FORM FOR BENEFICIARIES

**UNIVERSITY OF MICHIGAN THE REGENTS OF THE UNIVERSITY OF MICHIGAN (UM)**, 386006309 , established in SOUTH STREET 3003 1068, ANN ARBOR 46109 1274, United States, ('the beneficiary'), represented for the purpose of signing this Accession Form by Ryan LANKTON,

**hereby agrees**

**to become beneficiary** (‘5’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ryan LANKTON with ECAS id nlanktry signed in the Participant Portal on 18/11/2014 at 20:57:37 (transaction id SigId-1646-6gFluzeiOVbpqgfGGzdzfA9XlMAKl2BRQzgw8ztxBIcOwEK5tNStAGHoSzJ4hPEYB1zWmTbmqMLwJOY21UTzioCzW-Jj71zxYb8yrGkT3b6dcQFG-kvH2zj7hagmo8PxUNeskqQBlLbPjrgmtqvbIPKBTv4B). Timestamp by third party at
Tue Nov 18 20:57:42 CET 2014

**ANNEX 3**

## ACCESSION FORM FOR BENEFICIARIES

**SPACE RESEARCH INSTITUTE OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND THE NATIONAL SPACE AGENCY OF UKRAINE (SRI NASU-NSAU )**, 22971655, established in GLUSHKOV PROSPEKT 40 BUILD 4 1, KYIV 03680, Ukraine, UA229716526500, ('the beneficiary'), represented for the purpose of signing this Accession Form by Oleg FEDEROV,

**hereby agrees**

**to become beneficiary** (‘6’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Oleg FEDEROV with ECAS id nfederol signed in the Participant Portal on 31/10/2014 at 12:02:53 (transaction id SigId-300-pBHgtoFG19cOlkfEl1qfVuW8kxW1yhaPWto78dTOx8zMRv5oyU5zufW29IvkRIWpzegIFTCdpB0zj1xzzV0abQTG-Jj71zxYb8yrTZK84SBCVye-zNpYdzRV5CYhO3j4cQF4I1eZAv4xwcv9iSAKozsUD0Ry). Timestamp by third party at
Fri Oct 31 12:03:00 CET 2014

**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 Patrice SOULLIE, Legal representative,

**hereby agrees**

**to become beneficiary** (‘7’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Patrice SOULLIE with ECAS id nsoulpat signed in the Participant Portal on 29/10/2014 at 15:02:47 (transaction id SigId-2661-9FrA9FW16bS5h4K7YuzXjuvpeSBAFrD7zWBzHDEXvzszcQufaT9J9FCgexs7gxQSH0Wl4Tn6OykzTRAEp2zsQ9ze-Jj71zxYb8yrTnbawzV6c1R-GtVHSx5QgPr4CGn9gZEkn7YnfxUoq6dklRgoktHPi64). Timestamp by third party at
Wed Oct 29 15:02:52 CET 2014

**ANNEX 3**

## ACCESSION FORM FOR BENEFICIARIES

**INSTITUTET FOR RYMDFYSIK (IRF)**, 2021003567, established in PO BOX 812, KIRUNA 98128, Sweden, SE202100356701, ('the beneficiary'), represented for the purpose of signing this Accession Form by Lars ELIASSON,

**hereby agrees**

**to become beneficiary** (‘8’)

**in Agreement No** 637302 (‘the Agreement’)

**between** THE UNIVERSITY OF SHEFFIELD **and***the Research Executive Agency (REA) ('the Agency'), under the power delegated by the European Commission ('the Commission'),*

**for the action entitled** ‘Prediction of Geospace Radiation Environment and solar wind parameters (PROGRESS)’.

**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 action in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Lars ELIASSON with ECAS id neliasla signed in the Participant Portal on 29/10/2014 at 20:51:57 (transaction id SigId-5-D2IycmeWY60zqbEvUyuSMm9QMRl5IzPasfewB0tizbKiYJHoiJIs4uGef8kBGk8hOrw9OVs2LGYLy63bWLL8L5m-PHslUMVSXYCySG0uzXFBAg-9P5Ic1KG9SJ9vzvYSJtbq5zvzidyk8rbc2giRKJnadu0). Timestamp by third party at Wed Oct 29 20:52:02 CET 2014

ⓘ print format A4 landscape

## MODEL ANNEX 4 FOR GENERAL MGA - MULTI-BENEFICIARY

### FINANCIAL STATEMENT FOR *[BENEFICIARY [name]/ LINKED THIRD PARTY [name]]*

| | Eligible* 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 | *[F. Costs of … ]* | | Total costs | Receipts | Reimbursement rate % | Maximum EU contribution *** | Requested EU contribution | Information for indirect costs : |
| | A.1 Personnel<br>A.2 Natural persons under direct contract<br>A.3 Seconded persons<br>*[A.6 Personnel for providing access to research infrastructure]* | | A.4 SME owners without salary<br>A.5 Beneficiaries that are natural persons without salary | | | | D.1 Travel<br>D.2 Equipment<br>D.3 Other goods and services | D.4 Costs of large research infrastructure | | *[F.1 Costs of …] ** | *[F.2 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**** | Actual | Unit ① | Unit ② | | Actual | Actual | Actual | Actual | Flat-rate ③ | Unit ④ | | Unit ⑤ | | | | | |
| | | | XX EUR/hour | | | | | | 25% | XX EUR/unit | | | | | | | |
| | (a) | Total (b) | No hours | Total (c) | (d) | (e) | (f) | (g) | (h)=0,25x((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) |
| | | | | | | | | | | | | | | | | | |

**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).

ⓘ The beneficiary/linked party 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 not declared in the individual financial statement will not be taken into account by the *[Commission][Agency]*

* See Article 6 for conditions for costs to be eligible
** Depending on its type, this cost will or will not include indirect costs.
Costs that include indirect costs are: costs of energy efficiency measures in buildings, costs of providing trans-national access to research infrastructure and costs of clinical studies.
*** This is the theoretical amount of EU contribution if the reimbursement rate is applied to *all* the reported costs. At the payment of the balance, the theoretical amount of EU contribution for the action is capped by the maximum grant amount.
**** See Article 5 for forms of costs
① unit : hours worked on the action; costs per unit (hourly rate) : calculated according to beneficiary's usual accounting practice
② unit : hours worked on the action; cost per unit : XX EUR
③ 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 Point F if they include indirect costs
④ unit : … ; costs per unit : XX EUR
⑤ unit : ….. costs per unit …… (the units and the costs per unit are set out in Annex 2 of the grant agreement)
⑥ only unit costs **not including indirect costs** to be added

**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**

**TABLE OF CONTENT**

**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)[47] 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').]*

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;

[47] By which costs under the Agreement are declared (see template 'Model Financial Statements' in Annex 4 to the Grant Agreement).

- 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 Commissionsets 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[48]:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Federation of Accountants (IFAC);
- the *Code of Ethics for Professional Accountants* issued by the IFAC. 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*]. 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*]*.

### 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]* |

[48] 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 IFAC.

**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)[49] 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.

[49] By which the Beneficiary declares costs under the Agreement (see template 'Model Financial Statement' in Annex 4 to the Agreement).

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.

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[50] 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

[50] 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** | | |
| | 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.<br>(*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)*<br>The Auditor sampled _____ people out of the total of _____ people. | | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| **A.1** | **PERSONNEL COSTS**<br><br>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)<br><br>To confirm standard factual findings 1-5 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary:<br>o 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;<br>o the payslips of the employees included in the sample;<br>o reconciliation of the personnel costs declared in the Financial Statement(s) with the accounting system (project accounting and general ledger) and payroll system;<br>o information concerning the employment status and employment conditions of personnel included in the sample, in particular their employment contracts or equivalent;<br>o the Beneficiary's usual policy regarding payroll matters (e.g. salary policy, overtime policy, variable pay);<br>o applicable national law on taxes, labour and social security and<br>o any other document that supports the personnel costs declared.<br><br>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. | 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 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*<br><br>To confirm standard factual findings 6-9 listed in the next column, the Auditor:<br>o reviewed relevant documents provided by the Beneficiary (legal form, legal/statutory | 6) The Beneficiary paying "additional remuneration" was a non-profit legal entity. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | obligations, the Beneficiary's usual policy on additional remuneration, criteria used for its calculation…);<br>o 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').<br><br>*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:*<br><br>*(A) IF THE PERSON WORKS FULL TIME AND EXCLUSIVELY ON THE ACTION DURING THE FULL YEAR: UP TO EUR 8 000/YEAR;*<br><br>*(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*<br><br>*(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.* | 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.<br><br>8) The criteria used to calculate the additional remuneration were objective and generally applied by the Beneficiary regardless of the source of funding used.<br><br>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:*<br><br>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 | 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 | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | factual findings 10-13 listed in the next column:<br>o obtained a description of the Beneficiary's usual cost accounting practice to calculate unit costs;.<br>o reviewed whether the Beneficiary's usual cost accounting practice was applied for the Financial Statements subject of the present CFS;<br>o 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;<br>o 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;<br>o 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. | used in all H2020 actions.<br>11) The employees were charged under the correct category.<br>12) Total personnel costs used in calculating the unit costs were consistent with the expenses recorded in the statutory accounts.<br>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><br>To confirm standard factual findings 14-18 listed in the next column the Auditor reviewed following information/documents provided by the Beneficiary:<br>o the contracts, especially the cost, contract duration, work description, place of work, ownership of the results and reporting obligations to the Beneficiary;<br>o the employment conditions of staff in the same category to compare costs and;<br>o any other document that supports the costs declared and its registration (e.g. invoices, | 14) The natural persons reported to the Beneficiary (worked under the Beneficiary's instructions).<br>15) They worked on the Beneficiary's premises (unless otherwise agreed with the Beneficiary).<br>16) The results of work carried out belong to the Beneficiary. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | accounting records, etc.). | 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><br>To confirm standard factual findings 19-22 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary:<br>o their secondment contract(s) notably regarding costs, duration, work description, place of work and ownership of the results;<br>o 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;<br>o 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;<br>o any other document that supports the costs declared (e.g. invoices, etc.). | 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:*<br>21) The costs declared were supported with documentation and recorded in the Beneficiary's accounts. The third party did not include any profit. | |
| | | *If personnel is seconded free of charge:*<br>22) The costs declared did not exceed the third party's cost as | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | | recorded in the accounts of the third party and were supported with documentation. | |
| **A.2** | **PRODUCTIVE HOURS**<br><br>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:<br>o the annual productive hours applied were calculated in accordance with one of the methods described below,<br>o the full-time equivalent (FTEs) ratios for employees not working full-time were correctly calculated.<br><br>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.<br><br>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.<br><br>*BENEFICIARY'S PRODUCTIVE HOURS' FOR PERSONS WORKING FULL TIME SHALL BE ONE OF THE FOLLOWING METHODS:*<br>***A.*** *1720 ANNUAL PRODUCTIVE HOURS (PRO-RATA FOR PERSONS NOT WORKING FULL-TIME)*<br>***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* | 23) The Beneficiary applied method [*choose one option and delete the others*]<br>[**A**: 1720 hours]<br>[**B**: the 'total number of hours worked']<br>[**C**: 'annual productive hours' used correspond to usual accounting practices] | |
| | | 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.*<br>26) The calculation of the number of 'annual workable hours', overtime and absences was verifiable based on the documents provided by the Beneficiary. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | *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).*<br><br>***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.*<br><br>*'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 Beneficiary applied method C.*<br><br>27) The calculation of the number of 'standard annual workable hours' was verifiable based on the documents provided by the Beneficiary. | |
| | | 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**<br><br><u>I) For unit costs calculated in accordance to the Beneficiary's usual cost accounting practice (unit costs):</u><br><br>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.<br><br>If the Beneficiary does not have a "Certificate on Methodology" (CoMUC) approved by the Commission, or if the methodology approved was not applied, then the Auditor: | 29) The Beneficiary applied [*choose one option and delete the other*]:<br><br>[Option I: "Unit costs (hourly rates) were calculated in accordance with the Beneficiary's usual cost accounting practices"]<br><br>[Option II: Individual hourly rates were applied] | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | o reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;<br>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.<br><br>II) For individual hourly rates:<br>The Auditor:<br>o reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;<br>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.<br><br>*"UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES":*<br>*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.*<br><br>*HOURLY RATE FOR INDIVIDUAL ACTUAL PERSONAL COSTS:*<br>*IT IS CALCULATED BY DIVIDING THE TOTAL AMOUNT OF PERSONNEL COSTS OF AN EMPLOYEE VERIFIED IN LINE WITH PROCEDURE A.1 BY THE NUMBER OF ANNUAL PRODUCTIVE HOURS VERIFIED IN LINE WITH PROCEDURE A.2.* | *For option I concerning unit costs and if the Beneficiary applies the methodology approved by the Commission (CoMUC):*<br>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:*<br>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:*<br>32) The individual rates re-calculated by the Auditor were the same as the rates applied by the Beneficiary. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| **A.4** | **TIME RECORDING SYSTEM**<br><br>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:<br><br>o description of the time recording system provided by the Beneficiary (registration, authorisation, processing in the HR-system);<br><br>o its actual implementation;<br><br>o time records were signed at least monthly by the employees (on paper or electronically) and authorised by the project manager or another manager;<br><br>o the hours declared were worked within the project period;<br><br>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) ;<br><br>o the hours charged to the action matched those in the time recording system.<br><br>*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).* | 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. | |
| | | 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><br><br>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. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | | | |
| **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*).<br><br>To confirm standard factual findings 38-42 listed in the next column, the Auditor reviewed the following for the items included in the sample:<br><br>o the use of subcontractors was foreseen in Annex I;<br><br>o subcontracting costs were declared in the subcontracting category of the Financial Statement;<br><br>o supporting documents on the selection and award procedure were followed;<br><br>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).<br><br>In particular,<br><br>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.<br><br>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 | 38) The use of claimed subcontracting costs was foreseen in Annex I and costs were declared in the Financial Statements under the subcontracting category. | |
| | | 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.<br><br>*(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)* | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | Conditions of the Agreement..<br><br>For the items included in the sample the Auditor also verified that:<br>o the subcontracts were not awarded to other Beneficiaries in the consortium;<br>o there were signed agreements between the Beneficiary and the subcontractor;<br>o there was evidence that the services were provided by subcontractor; | 40) The subcontracts were not awarded to other Beneficiaries of the consortium. | |
| | | 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*).<br><br>The Auditor verified that the following minimum conditions were met:<br>a) the maximum amount of financial support for each third party did not exceed EUR 60 000, unless explicitly mentioned in Annex I;<br><br>b) the financial support to third parties was agreed in Annex I of the Agreement and the other provisions on financial support to third parties included in Annex I were respected. | 43) All minimum conditions were met | |
| **D** | **OTHER ACTUAL DIRECT COSTS** | | |
| **D.1** | **COSTS OF TRAVEL AND RELATED SUBSISTENCE ALLOWANCES**<br>**The Auditor sampled _____ cost items selected randomly** (*full coverage is required if there* | 44) Costs were incurred, approved and reimbursed in line with the | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | *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*).<br><br>The Auditor inspected the sample and verified that:<br>o 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;<br>o 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;<br>o no ineligible costs or excessive or reckless expenditure was declared. | Beneficiary's usual policy for travels.<br><br>45) There was a link between the trip and the action.<br><br>46) The supporting documents were consistent with each other regarding subject of the trip, dates, duration and reconciled with time records and accounting.<br><br>47) No ineligible costs or excessive or reckless expenditure was declared. | |
| **D.2** | **DEPRECIATION COSTS FOR EQUIPMENT, INFRASTRUCTURE OR OTHER ASSETS**<br><br>**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*).<br><br>For "equipment, infrastructure or other assets" [from now on called "asset(s)"] selected in the sample the Auditor verified that:<br>o the assets were acquired in conformity with the Beneficiary's internal guidelines and procedures;<br>o they were correctly allocated to the action (with supporting documents such as delivery | 48) Procurement rules, principles and guides were followed.<br><br>49) There was a link between the grant agreement and the asset charged to the action.<br><br>50) The asset charged to the action was traceable to the accounting records and the underlying documents. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | note invoice or any other proof demonstrating the link to the action)<br>o they were entered in the accounting system;<br>o the extent to which the assets were used for the action (as a percentage) was supported by reliable documentation (e.g. usage overview table);<br><br>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).<br><br>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). | 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.<br><br>52) The amount charged corresponded to the actual usage for the action.<br><br>53) No ineligible costs or excessive or reckless expenditure were declared. | |
| **D.3** | **COSTS OF OTHER GOODS AND SERVICES**<br><br>**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*).<br><br>For the purchase of goods, works or services included in the sample the Auditor verified that:<br><br>o the contracts did not cover tasks described in Annex 1;<br>o 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);<br>o the goods were not placed in the inventory of durable equipment; | 54) Contracts for works or services did not cover tasks described in Annex 1.<br><br>55) Costs were allocated to the correct action and the goods were not placed in the inventory of durable equipment.<br><br>56) The costs were charged in line with the Beneficiary's accounting policy and were adequately supported. | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | o the costs charged to the action were accounted in line with the Beneficiary's usual accounting practices;<br>o no ineligible costs or excessive or reckless expenditure were declared (see Article 6 GA).<br>In addition, the Auditor verified that these goods and services were acquired in conformity with the Beneficiary's internal guidelines and procedures, in particular:<br>o 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.<br>o 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.<br>For the items included in the sample the Auditor also verified that:<br>o 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);<br>*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 AGREEMENT, CERTIFICATES ON THE FINANCIAL STATEMENTS IF THEY ARE REQUIRED BY THE AGREEMENT AND CERTIFICATES ON THE METHODOLOGY, TRANSLATIONS, REPRODUCTION.* | 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.<br>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.<br>*(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)* | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| **D.4** | **AGGREGATED CAPITALISED AND OPERATING COSTS OF RESEARCH INFRASTRUCTURE**<br>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.<br><br>***In the cases that a positive ex-ante assessment has been issued*** *(see the standard factual findings 59-60 on the next column)**,***<br>The Auditor ensured that the beneficiary has applied consistently the methodology that is explained and approved in the positive ex ante assessment;<br><br>***In the cases that a positive ex-ante assessment has NOT been issued*** *(see the standard factual findings 61 on the next column),*<br>The Auditor verified that no costs of Large Research Infrastructure have been charged as direct costs in any costs category;<br><br>***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),*<br>• 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. | 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.<br><br>60) Any difference between the methodology applied and the one positively assessed was extensively described and adjusted accordingly.<br><br>61) The direct costs declared were free from any indirect costs items related to the Large Research Infrastructure. | |
| **E** | **USE OF EXCHANGE RATES** | | |
| **E.1** | a) For Beneficiaries with accounts established in a currency other than euros<br>**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* | 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 | |

| Ref | Procedures | Standard factual finding | Result (C / E / N.A.) |
|---|---|---|---|
| | *is highest)*:<br><br>*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.*<br><br>*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 ), DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.* | figures. | |
| | b) For Beneficiaries with accounts established in euros<br><br>**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)*:<br><br>*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.**

**TABLE OF CONTENTS**

**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[52]:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Federation of Accountants (IFAC);
- the *Code of Ethics for Professional Accountants* issued by the IFAC. 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*]. 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].

### 1.6 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]* |

[52] 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 IFAC.

**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[53] submitted thereafter.

[53] Financial Statement in this context refers solely to Annex 4 of the Agreement by which the Beneficiary declares costs under the Agreement.

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 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, why they are reasonable 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[54] 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).

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

[54] 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.

## 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**<br><br>I. The cost accounting practice described below has been in use since *[*dd Month yyyy*]*.<br><br>II. The next planned alteration to the methodology used by the Beneficiary will be from [dd Month yyyy*]*. | **Procedure:**<br><br>✓ The Auditor checked these dates against the documentation the Beneficiary has provided.<br><br>**Factual finding:**<br><br>1. The dates provided by the Beneficiary were consistent with the documentation. |
| **B. Description of the Methodology**<br><br>III. The methodology to calculate unit costs is being used in a consistent manner and is reflected in the relevant procedures.<br><br>*[Please describe the methodology your entity uses to calculate <u>personnel</u> costs, productive hours and hourly rates, present your description to the Auditor and annex it to this certificate]*<br><br>*[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 Factual Findings:*<br>- *…]* | **Procedure:**<br><br>✓ The Auditor reviewed the description, the relevant manuals and/or internal guidance documents describing the methodology.<br><br>**Factual finding:**<br><br>2. The brief description was consistent with the relevant manuals, internal guidance and/or other documentary evidence the Auditor has reviewed.<br><br>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** |
| C. **Personnel costs**<br><br>General<br>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;<br>V. Employees are hired directly by the Beneficiary in accordance with national law, and work under its sole supervision and responsibility;<br>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);<br>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;<br>VIII. Personnel costs are based on the payroll system and accounting system.<br>IX. Any exceptional adjustments of actual personnel costs resulted from relevant budgeted or estimated elements, were reasonable 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]*.<br>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 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.<br>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 | **Procedure:**<br><br>*The Auditor draws a sample of employees to carry out the procedures indicated in this section C and the following sections D to F.*<br>*[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:<br>✓ 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;<br>✓ in particular, the Auditor reviewed the employment contracts of the employees in the sample to verify that:<br>i. they were employed directly by the Beneficiary in accordance with applicable national legislation;<br>ii. they were working under the sole technical supervision and responsibility of the latter;<br>iii. they were remunerated in accordance with the Beneficiary's usual practices;<br>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;<br>✓ 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 into account when calculating the personnel costs;<br>✓ 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.<br>✓ to the extent that actual personnel costs were adjusted on the basis of |

| ***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** |
| purpose of implementing the EU budget).<br><br><u>If additional remuneration as referred to in the grant agreement(s) is paid</u><br><br>XII. The Beneficiary is a non-profit legal entity;<br>XIII. The additional remuneration is part of the beneficiary's usual remuneration practices and paid consistently whenever the relevant work or expertise is required;<br>XIV. The criteria used to calculate the additional remuneration are objective and generally applied regardless of the source of funding;<br>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).<br><br>*[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 Factual Findings:*<br>*- …]* | 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;<br>✓ 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).<br>✓ the Auditor recalculated the personnel costs for the employees in the sample.<br><br>**Factual finding:**<br><br>4. All the components of the remuneration that have been claimed as personnel costs are supported by underlying documentation.<br>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.<br>6. Their employment contracts were in line with the Beneficiary's usual policy;<br>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.);<br>8. The totals used to calculate the personnel unit costs are consistent with those registered in the payroll and accounting records;<br>9. To the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, those elements were relevant for calculating the personnel costs, reasonable and correspond to objective and verifiable information. The budgeted or estimated elements used are: — (indicate the elements and their values).<br>10. Personnel costs contained no ineligible elements;<br>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 |

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| | objective criteria generally applied regardless of the source of funding used and c) remuneration was capped at EUR 8 000 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**<br><br>XVI. The number of productive hours per full-time employee applied is *[delete as appropriate]*:<br>A. 1720 productive hours per year for a person working full-time (corresponding pro-rata for persons not working full time).<br>B. the total number of hours worked in the year by a person for the Beneficiary<br>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.<br><br><u>If method B is applied</u><br><br>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).<br>XVIII. 'Annual workable hours' are hours 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.<br>XIX. The contract (applicable collective labour agreement or national working time legislation) do specify the working time enabling to calculate the annual workable hours.<br><br><u>If method C is applied</u><br><br>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 | **Procedure (same sample basis as for Section C: Personnel costs):**<br><br>✓ The Auditor verified that the number of productive hours applied is in accordance with method A, B or C.<br>✓ 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).<br>✓ 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.<br>✓ 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.<br><br>**Factual finding:**<br><u>General</u><br>12. The Beneficiary applied a number of productive hours consistent with method A or B detailed in the left-hand column.<br>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.<br><br><u>If method B is applied</u><br>14. The number of 'annual workable hours', overtime and absences was verifiable based on the documents provided by the Beneficiary and the |

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| number is reduced proportionately.<br>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.<br>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.<br>*[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:*<br>- *…]* | calculation of the total number of hours worked was accurate.<br>15. The contract specified the working time enabling to calculate the annual workable hours.<br><u>If method C is applied</u><br>16. The calculation of the number of productive hours per year corresponded to the usual costs accounting practice of the Beneficiary.<br>17. The calculation of the standard number of workable (working) hours per year was corroborated by the documents presented by the Beneficiary.<br>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**<br>The hourly rates are correct because:<br>XXIII. Hourly rates are correctly calculated since they result from dividing annual personnel 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.<br>*[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:*<br>- *…]* | **Procedure**<br>✓ The Auditor has obtained a list of all personnel rates calculated by the Beneficiary in accordance with the methodology used.<br>✓ The Auditor has obtained a list of all the relevant employees, based on which the personnel rate(s) are calculated.<br>For 10 full-time equivalent employees selected at random (same sample basis as Section C: Personnel costs):<br>✓ The Auditor recalculated the hourly rates.<br>✓ 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.<br>**Factual finding:**<br>19. No differences arose from the recalculation of the hourly rate for the employees included in the sample. |

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| **F. Time recording**<br><br>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]*;<br><br>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;<br><br>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;<br><br>XXVII. Measures are in place to prevent staff from:<br>i. recording the same hours twice,<br>ii. recording working hours during absence periods (e.g. holidays, sick leave),<br>iii. recording more than the number of productive hours per year used to calculate the hourly rates, and<br>iv. recording hours worked outside the action period.<br><br>XXVIII. No working time was recorded outside the action period;<br><br>XXIX. No more hours were claimed than the productive hours used to calculate the hourly personnel rates.<br><br>*[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[55]].* | **Procedure**<br><br>✓ The Auditor reviewed the brief description, all relevant manuals and/or internal guidance describing the methodology used to record time.<br><br>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:<br><br>✓ that time records were available for all persons with not exclusive assignment to the action;<br><br>✓ 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;<br><br>✓ that time records were signed and approved in due time and that all minimum requirements were fulfilled;<br><br>✓ that the persons worked for the action in the periods claimed;<br><br>✓ that no more hours were claimed than the productive hours used to calculate the hourly personnel rates;<br><br>✓ 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;<br><br>✓ 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 |

[55] 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

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| *[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:*<br>*- …]* | 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.<br><br>**Factual finding:**<br><br>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.<br><br>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;<br><br>22. For the random sample the time records were signed by the employee and the action manager/line manager in reasonable time.<br><br>23. Working time claimed for the action occurred in the periods claimed;<br><br>24. No more hours were claimed than the number productive hours used to calculate the hourly personnel rates;<br><br>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.<br><br>26. Working time claimed is consistent with that on record at the human-resources department. |

***[official name of the** [Beneficiary] [Linked Third Party]**]***
***[name and title of authorised representative]***
***[dd Month yyyy]***
<***Signature of the** [Beneficiary] [Linked Third Party]*>

***[official name of the Auditor]***
***[name and title of authorised representative]***
***[dd Month yyyy]***
<***Signature** of the Auditor*>

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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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