KATHOLIEKE UNIVERSITEIT LEUVEN

AO/1-6738/11/NL/AT

# Virtual Space Weather Modelling Centre – Phase 1

Prof.Dr. Stefaan Poedts

SWWTmeeting, Ukkel, Belgium, June13, 2012

# Objective & Consortium

# Objective and Scope

1. The construction of a ***long term (~10 yrs) plan for the future development of a European virtual space modeling centre*** consisting of a new ***open*** and ***distributed framework*** for the ***coupling of physics based models*** for space weather phenomena;
2. The ***assessment of model capabilities and the amount of work required to make them operational*** by integrating them in this framework and the identification of computing and networking requirements to do so.
3. The ***design of a system*** to enable models and other components to be installed ***locally or geographically distributed*** and the creation of a validation plan including a system of metrics for testing results.

# Consortium Overview (1/6)

## ***KULeuven/CPA – Prime Contractor***

- *Experience in* **mathematical modeling in space plasma physics** **(**Fluid (MHD) and kinetic theory (+ hybrid); Magnetic Reconnection and multi-scale modeling)
- *Experience in* **Solar physics and Space Weather computer simulations** (Solar wind / CME initiation and evolution; Interaction solar wind/IP CMEs with magnetospheres…)
- *Experience in* **numerical algorithm development** (High performance and parallel computing, adaptive mesh, Particle In Cell treatments, Finite Difference/Finite Volume/FEM methods, large scale (generalized) eigenvalue solvers, ....)

***KULeuven/CPA takes the role of prime contractor with overall responsibility for the technical coordination of the project and for the management of the sub-contractors.***

# Consortium Overview (2/6)

## Belgian Institute for Space Aeronomy – Sub-contractor

- *The Space Physics Division at BIRA-IASB has for many years investigated the Earth's magnetosphere and its surroundings, specifically* ***the interaction of the solar wind with the magneto-sphere****, the dynamics of the plasma sphere, the auroral and polar cap processes, as well as the turbulence and nonlinear processes in space plasmas, both in data analysis and in modelling efforts.*
- *BIRA-IASB has participated in many space environment projects (e.g. ESA, EU, INTAS, National) and has acquired a* ***significant know-how in the space environment****, in the construction of* ***processing tools and models****, and the operation of* ***services****.*
- *Current ESA Activities: [1.] Prime contractor for* ***SPENVIS*** *[2.] Project lead for* ***SEPEM****. [3.] Part of the consortium running the Space Weather Element (****SWE****) Precursor Services – Part 1: Definition and Service Collaboration (SN-1). [4] The BIRA-IASB team is currently participating in ESA/Cluster and ESA/Rosetta science and operations.*

# Consortium Overview (3/6)

## Royal Observatory of Belgium (ROB) – Sub-contractor

- *The ROB participates to this project through its **Operational Directorate 'Solar Physics and Space Weather'** this OD*
  - *Is one of **Europe's leading institutes in observational solar physics research**, both ground based and from space*
  - *Houses the **Regional Warning Centre Belgium** (within ISES), a fully operational space weather forecasting and monitoring centre with 7/7 availability.*
  - *Has **direct links to users of space weather services** and*
  - *Is **experienced in defining and reviewing customer requirement documents**.*

# Consortium Overview (4/6)

## Von Karman Institute (VKI) – Sub-contractor

- *The Computational Fluid Dynamics group of the VKI has more than 20 years of **experience in the development of algorithms and simulation tools** for technical and scientific computing.*
- *Strong experience in the development of a computational software platform for multi-physics simulation and coupling named **COOLFluiD**.*
- *Developed and implemented **methods for simulation of the propagation of solar CMEs** and their **interaction with the solar wind and planetary magnetospheres**.*
- *VKI has **experience with kinetic models** in the context of rarified gas flows for **space reentry** under ESA support (e.g. IXV).*

# Consortium Overview (5/6)

***DH Consultancy (DHC) – Sub-contractor***

- ***Experience in space weather related activities*** *through a number of ESA contracts (SPENVIS, Vispanet, SEPEM, SSA SN-I, ODI, ...).*
- *Experience with* ***distributed modelling implementations through Vispanet*** *(implementation of a server node, web service protocols and VOTable data exchange format).*
- ***National representative and WP leader in COST Actions*** *724 and ES803 on space weather.*
- *Partner in EU FP7 projects* ***SPACECAST****,* ***SEPServer****, and* ***ESPAS*** *.*

# Consortium Overview (6/6)

***Space Applications Services (SAS) – Sub-contractor***

- *Experience in **space weather related activities through projects such as SPENVIS I & II, SN-I** (Precursor Space Weather Services), and **SN-II** (Implementation Design Study of Space Weather Instruments).*
- *Experience in the **development of software systems in support of aerospace systems and missions**, including requirements analysis, system design, software development as well as prototyping, definition and implementation of user interfaces using state-of-the-art MMI technology and tools.*

# The Project

# Prime Goal

**Prime GOAL of the Project:**

- *to develop the proof-of-concept prototype version of an open end-to-end (= from Sun to Earth) space weather modelling system ("**Virtual SW Modelling Centre**"),*
- *enabling to **combine ("couple") various space weather models** in an integrated tool,*
- *with the models located **either locally or remotely**,*
- *so as to better understand the challenges in creating such an integrated environment,*
- *and at the same time **providing proof-of-concept** solutions to these challenges.*

***This is believed a viable roadmap to secure the development of a future complete VSWMC.***

# Desired Outcomes

There are **two main project outcomes**:

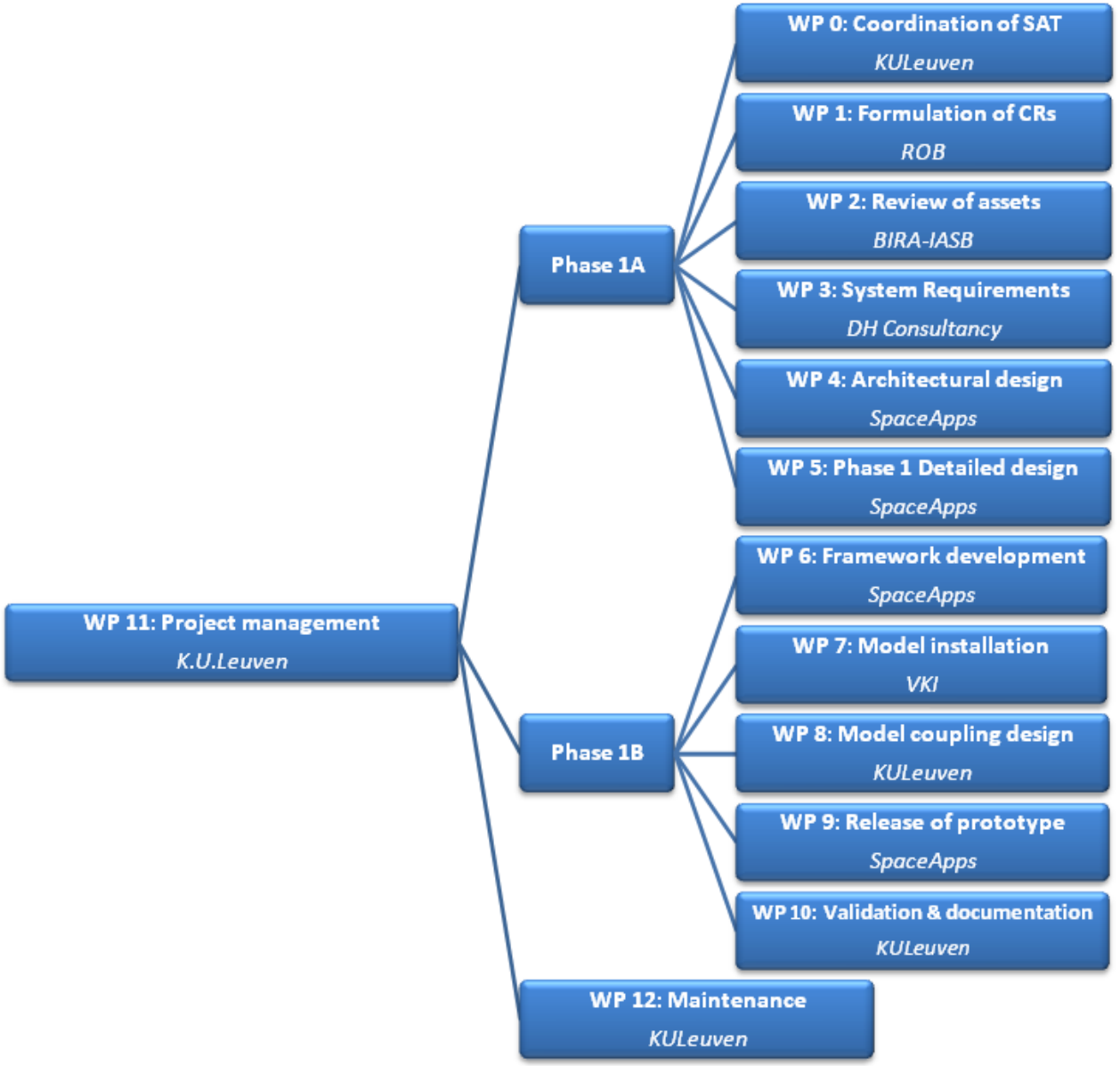
- **Phase 1A:** ***definition of a full-scale VSWMC of the future***, incl. a development roadmap for the next decades.
- **Phase 1B:** the ***proof-of-concept prototype version of the VSWMC***, that addresses the question of the feasibility of the most critical parts of the future complete VSWMC.

# Science Advisory Team (SAT)

**SAT consists of the following modelers:**

1. Richard Horne
2. Alan Aylward
3. Sean Bruinsma
4. Pekka Janhunen
5. Fernando Moreno-Insteris
6. Sebastien Bourdarie
7. Tahar Amari
8. Blai Sanahuja
9. Pierre-Louis Blelly (TBC)
10. Kalevi Mursula
11. Aake Nordlund
12. Volker Bothmer
13. Lyndsay Fletcher

# Work Breakdown Structure



# Tasks of Phase 1A

- **Task 0:** Co-ordination of Science Advisory Team
- **Task 1:** Formulation of Customer Requirements
- **Task 2:** Review of Existing European Modelling Assets
- **Task 3:** System Requirements Analysis
- **Task 4:** Architectural Design of the VSWMC
- **Task 5:** Detailed Design of the Phase 1B VSWMC

# Work Breakdown Structure

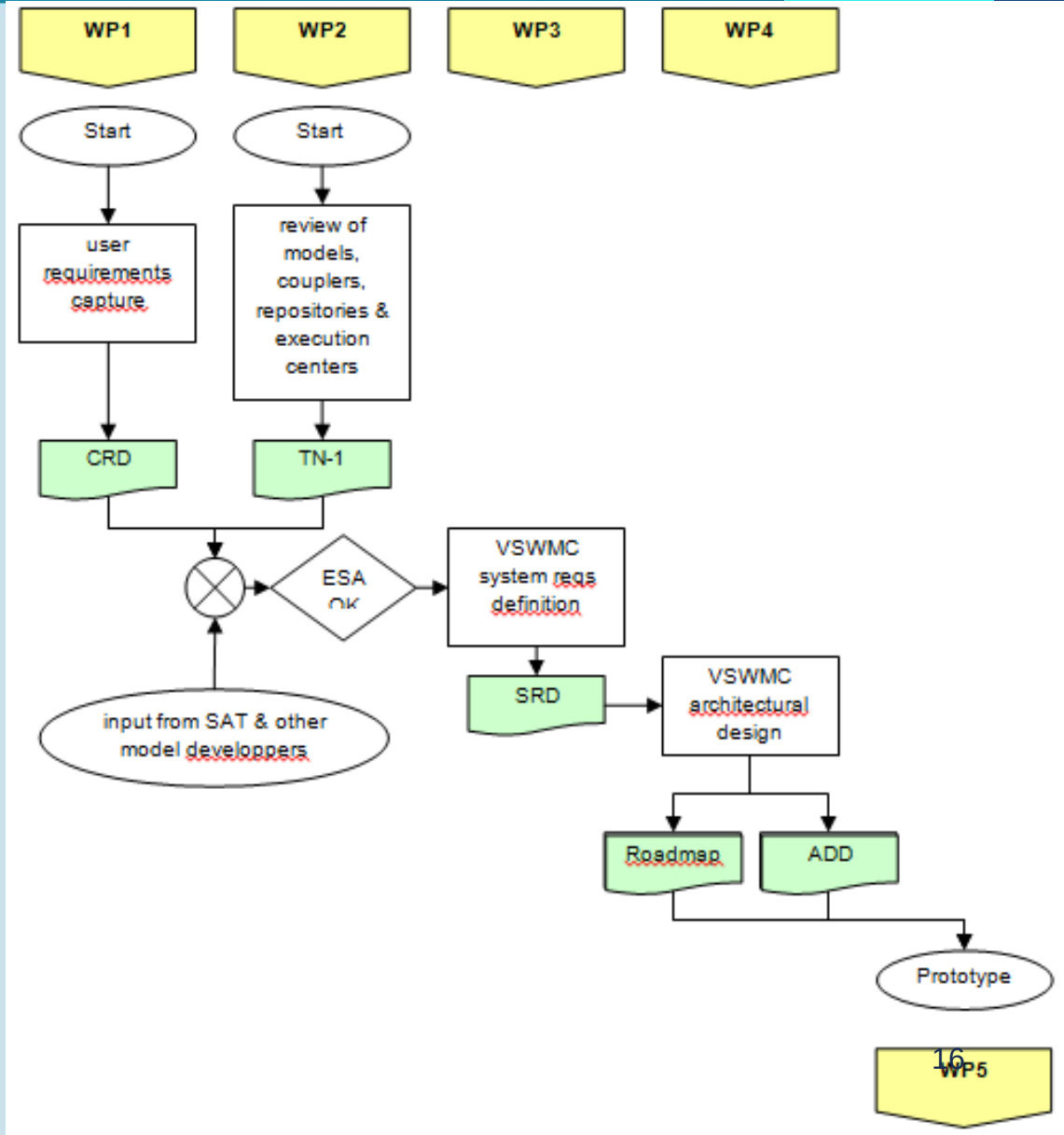



**Fig. 1:** Overview of Phase 1A and its major products

# Task 3: System Requirements Analysis

**Objective(s):**

- To ***establish the System Requirements*** for the *full-fledged version* of the VSWMC.
- To initiate the selection (to be confirmed by end of Task 5) of the requirements for the prototype counter-part.

**Input(s):**

- CRD
- TN 1
- list of models proposed for deployment in Phase 1.

**Output(s):**

- System Requirements Document (SRD)

# Task 4: Architectural Design

**Objective(s):**

- To define the ***architecture of the full-fledged VSWMC***.
- To establish an ***implementation roadmap covering ±10 years*** for the VSWMC, and select the parts of the implementation already for implementation in Phase 1B of this study.

The following steps are envisaged:

- A **framework** will be designed composed of two main components:
  - Modeling Framework offering the required tools and infrastructure to efficiently implement new models and couple existing models as well as running those models.
  - Web portal allowing remote users to execute and retrieve results of model runs.

# Task 5: Detailed Design of the Phase 1B VSWMC

## Objective(s):

- To produce the *detailed design and the validation approach specifically of the proof-of-concept* ***Prototype VSWMC System*** that will be implemented in Phase 1B.

## Input(s):

- **From WP4**: Architectural Design Document (ADD)
- **From WP3**: System Requirements Document (SRD)
- **From WP1:** Customer Requirements Document (CRD)

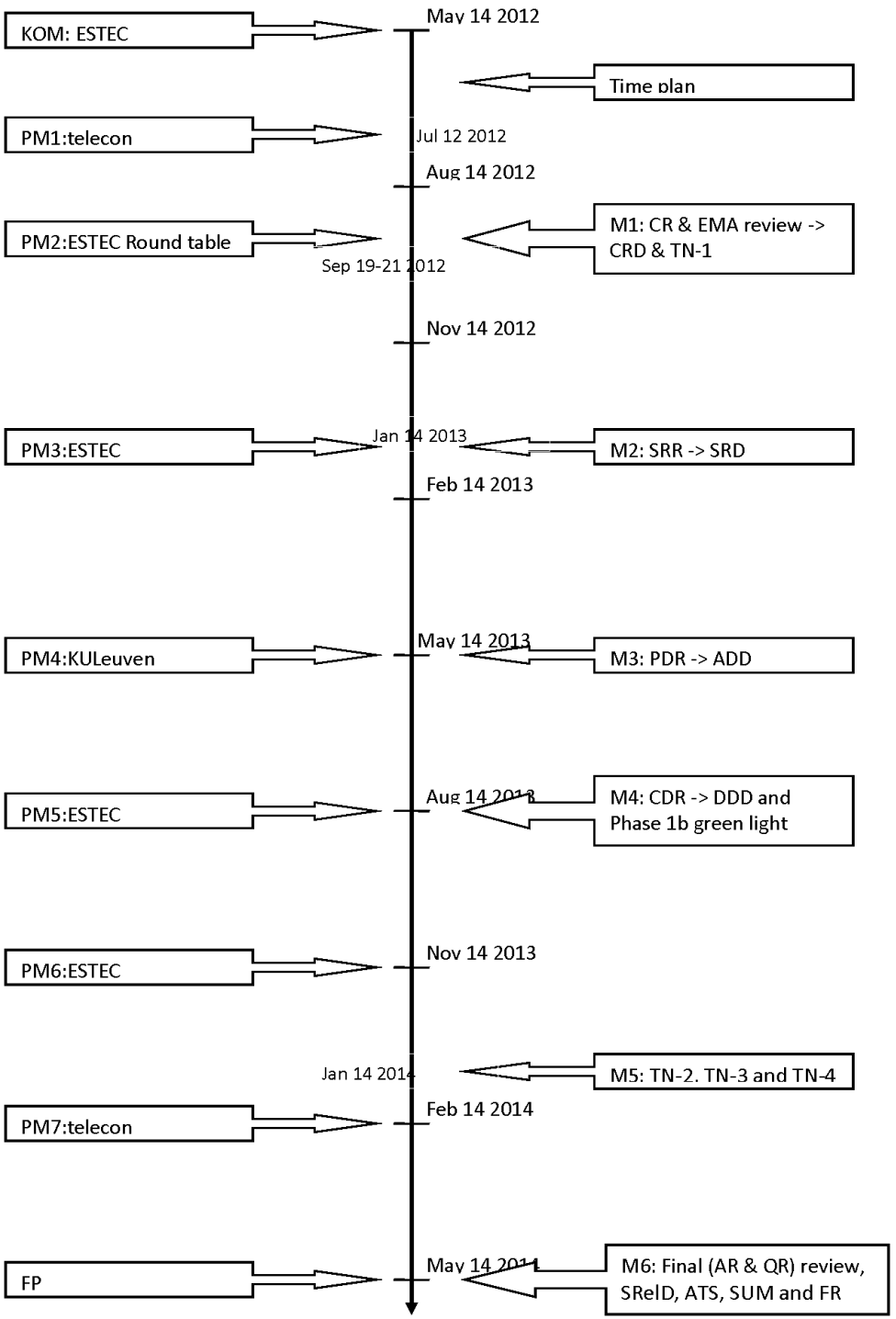
## Output(s):

- Detailed Design Document (DDD, Prototype VSWMC System).

# Tasks of Phase 1B

- **Task 6: Development of the VSWMC Framework Prototype**
  - To *implement the **VSWMC Framework Prototype** software*
- **Task 7: Model Installation**
  - ***To adapt the models chosen in WP5 and package them*** in such a way that they become usable in the Prototype VSWMS System.
- **Task 8: Model Coupling Design**
  - To ***implement the Software Library of Couplers*** of the Prototype VSWMS System that allow to combine models
- **Task 9: Preparation of Release of Prototype VSWMC system**
  - To *assemble the **Prototype VSWMC System** from its components*
- **Task 10: System Validation and Documentation**
  - To ***validate the VSWMC system components***, provide a ***user manual*** and a ***final project report***.

# Time line


KOM: ESTEC
May 14 2012
Time plan
PM1:telecon
Jul 12 2012
Aug 14 2012
PM2:ESTEC Round table
M1: CR & EMA review -> CRD & TN-1
Sep 19-21 2012
Nov 14 2012
PM3:ESTEC
Jan 14 2013
M2: SRR -> SRD
Feb 14 2013
PM4:KULeuven
May 14 2013
M3: PDR -> ADD
PM5:ESTEC
Aug 14 2013
M4: CDR -> DDD and Phase 1b green light
PM6:ESTEC
Nov 14 2013
Jan 14 2014
M5: TN-2. TN-3 and TN-4
PM7:telecon
Feb 14 2014
FP
May 14 2014
M6: Final (AR & QR) review, SRelD, ATS, SUM and FR