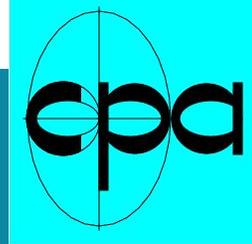# ESA VSWMC-Part 2
and opportunities for CCMC-VSWMC partnership

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Annapolis, Maryland, USA, 15 April 2016

Contents

- The new ESA VSWMC-Part 2 project
  - Objectives and scope
  - consortium
- Similarities and differences with CCMC
  - Setup/philosophy
  - framework
- Opportunities for CCMC-VSWMC partnership

Old prime VSWMC-Phase 1 GOALS:

- to **develop the proof-of-concept prototype** version of an **open end-to-end** (Sun to Earth) space weather modeling system,

- enabling to **combine ("couple") various space weather models** in an integrated tool,

- with the models located **either locally or geographically distributed**,

- so as to *better understand the challenges* in creating such an integrated environment.

➢ **VSWMC aims to combine three roles**:
   - *A repository for models and data*
   - *A facility offering a model coupling infrastructure*
   - *A facility that executes coupled model simulations*

New VSWMC-Part 2 objective and scope

- The **further development of the VSWMC** building on the Phase 1 prototype system and focusing on the interaction with the SSA SWE system.

- Efficient integration of **new models and new model couplings**, including a first demonstration of an *end-to-end simulation capability*.

- Further development and wider use of the **coupling toolkit** and **the front-end GUI** which will be designed to be accessible via the SWE Portal.

- Availability of more **accessible input and output data** on the system and development of **integrated visualization tool** modules.

Consortium overview

1. **KU Leuven/CmPA** (prime contractor)
2. **Belgian Institute for Space Aeronomy** (sub-contractor)
3. **Royal Observatory of Belgium** (sub-contractor)
4. **Von Karman Institute** (sub-contractor)
5. **DH Consultancy** (sub-contractor)
6. **Space Applications Services** (sub-contractor)
7. **British Antarctic Survey** (sub-contractor)

Science Advisory Team:

A. Aylward, S. Bruinsma, P. Janhunen, T. Amari, D. Jackson,

S. Bourdarie, B. Sanahuja, P.-L. Blelly, R. Vainio
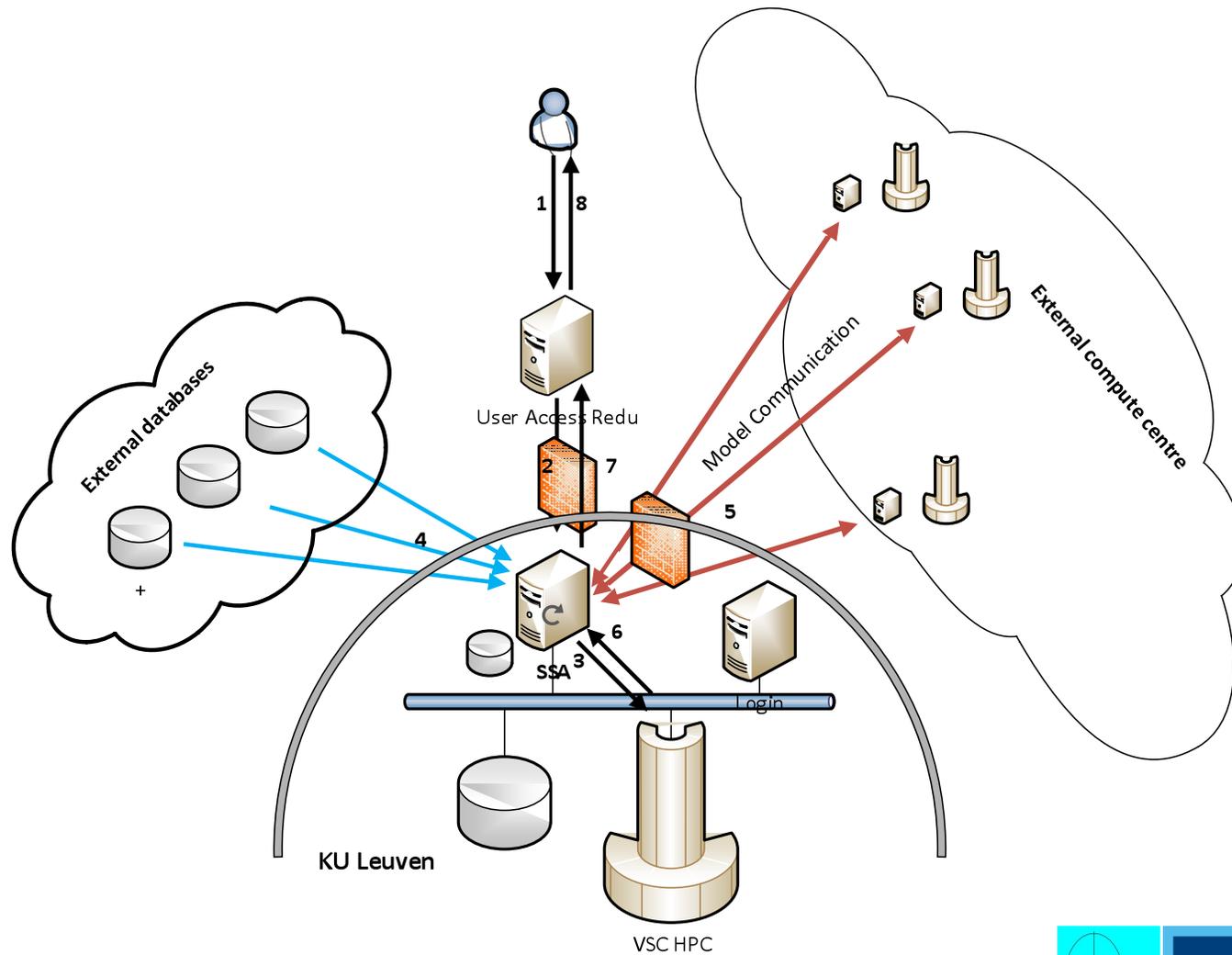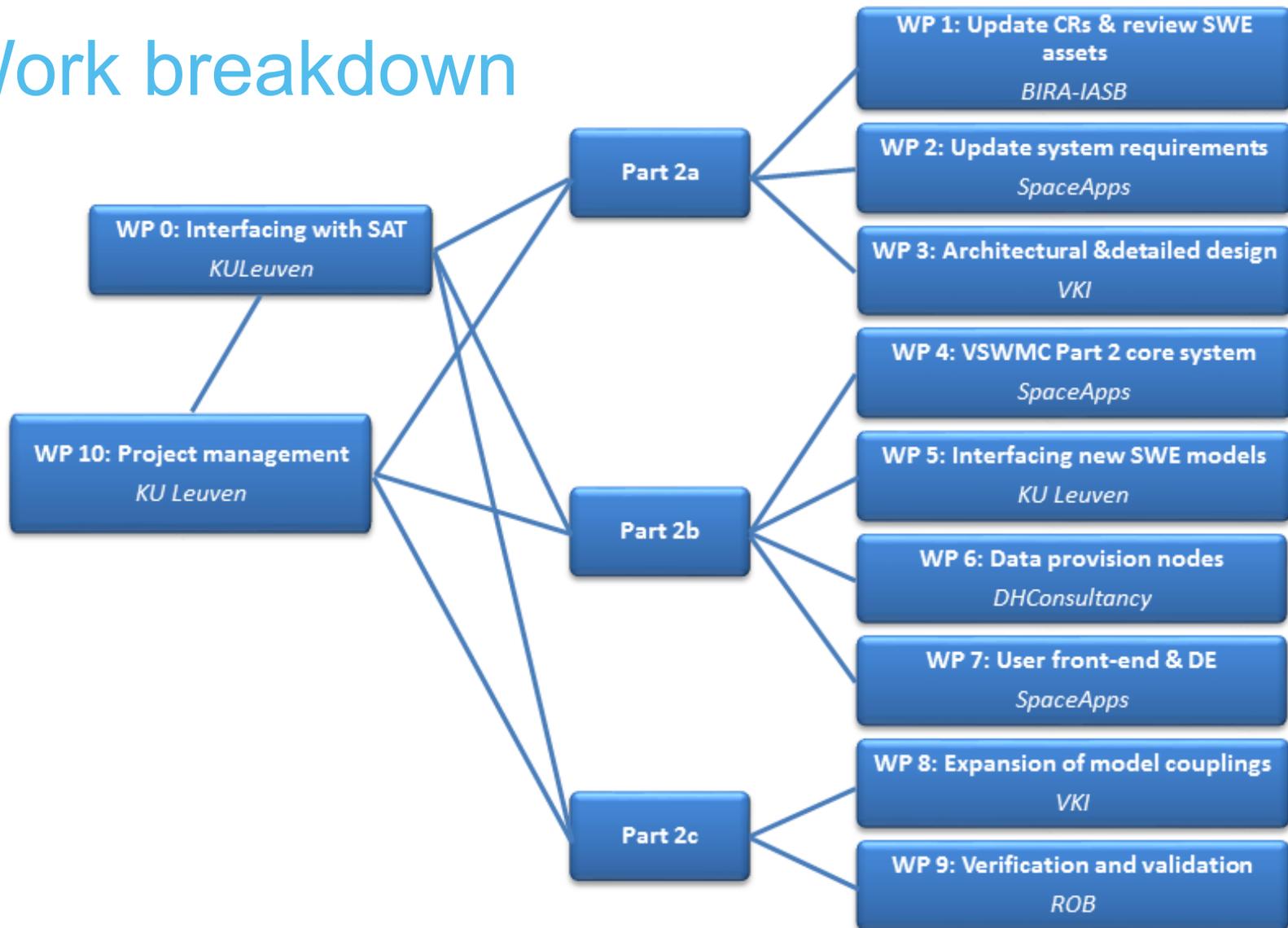
ESA: J.-P. Luntama, P. Jiggens, R. Keil, A. Hilgers

Basic set-up of the federated service

Work breakdown

Project Milestones

Milestone ID	Purpose	Date
KOM Part 2	Kick-Off Meeting Part 2	17/02/2016
M1	Completion and approval of Critical Design Review	17/08/2016
M2	Completion and approval of TRR	17/08/2017
Final	Completion of Part 2 and approval of FR	17/02/2018

Similarities with CCMC…

Like CCMC, the VSWMC is/will provide:

- *A repository for models (and data!)*
- *A facility that enables to execute models and coupled model simulations*

… and differences!

- **VSWMC just started**: only a prototype version is available at the moment
- **Combination of local and distributed models**, so models can run remotely, but still be coupled (over the internet)
- **Interactive**: via a **'developer tool'** the modelers will be able to install/adjust their own model and couple it to another model in the repository (at end of Part 2 project)
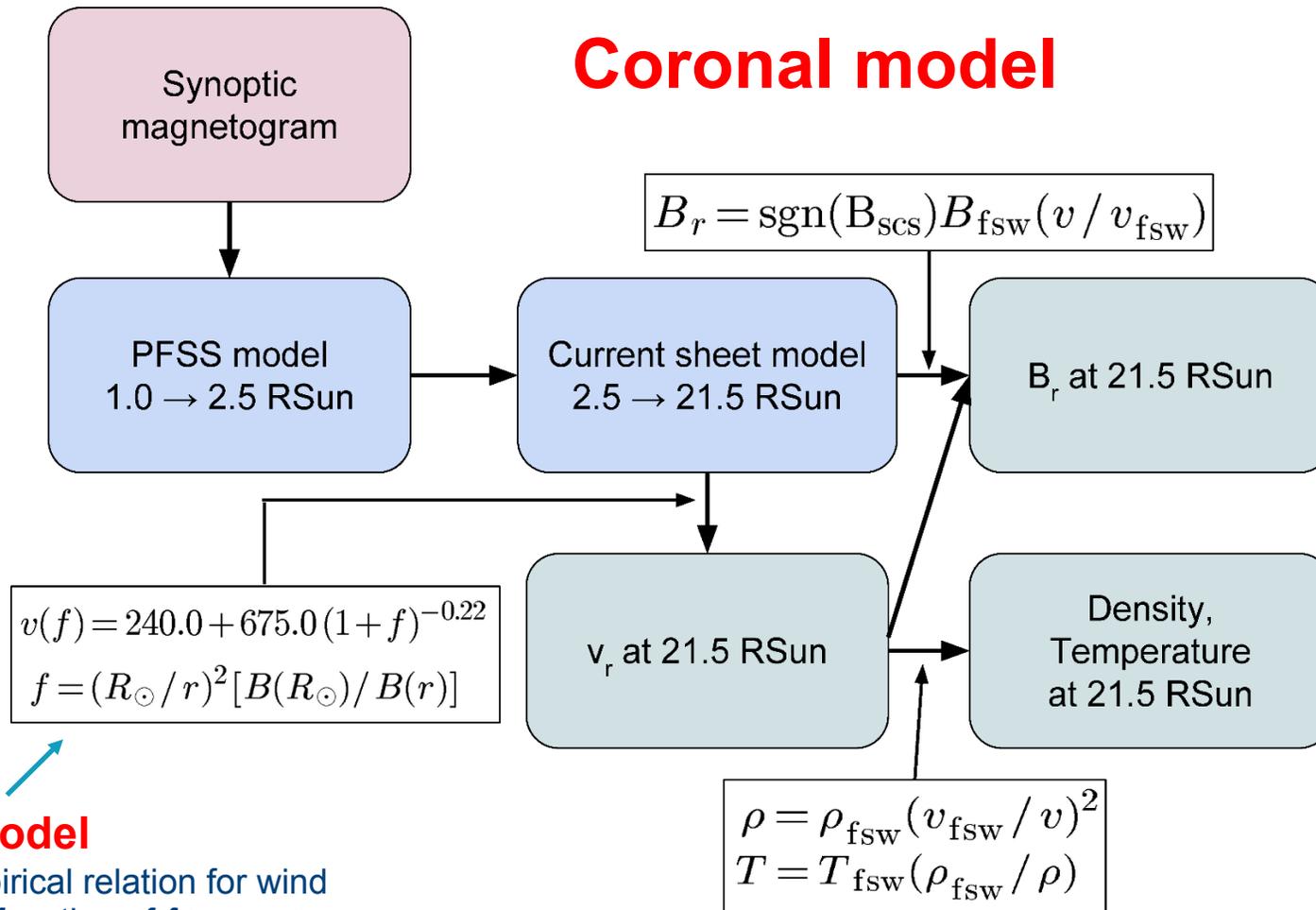
… and even more differences!

➢ **Different operation mode(s), because of different kinds of 'users':**

- **System operator(s)**: need *operator interface*, statistics (use, demand, waiting times, I/O, etc.), alarms (when model did not run, communication failed, etc.), …

- **Model contributors**: need *developer tool* to provide (updates of) their own models, integrating them into the system and coupling them to other models or data providers and/or visualization models

- **End users**:
  - *Forecasters:* running *pre-installed simulations* on a regular basis and integrated in the operational procedures
  - *scientists/researchers* using the *models and couplings for setting up and performing individual simulations runs* in the framework of their research

Euhforia

'European heliospheric forecasting information asset'

Coronal model

Synoptic magnetogram

$$B_r = \mathrm{sgn}(\mathrm{B_{scs}}) B_{\mathrm{fsw}}(v / v_{\mathrm{fsw}})$$

PFSS model
$1.0 \rightarrow 2.5$ RSun

Current sheet model
$2.5 \rightarrow 21.5$ RSun

B_r at 21.5 RSun

$$v(f) = 240.0 + 675.0\,(1+f)^{-0.22}$$
$$f = (R_\odot / r)^2 [B(R_\odot)/B(r)]$$

v_r at 21.5 RSun

Density, Temperature at 21.5 RSun

$$\rho = \rho_{\mathrm{fsw}}(v_{\mathrm{fsw}}/v)^2$$
$$T = T_{\mathrm{fsw}}(\rho_{\mathrm{fsw}}/\rho)$$

WSA model

Semi-empirical relation for wind speed as function of *f* (magnetic flux tube expansion factor)

cpa KU LEUVEN

Euhforia

'European heliospheric forecasting information asset'

Heliosphere model with cone & Flux-ROPE CMEs

**AIM:** Compute time dependent evolution of MHD variables from 0.1 AU to 1 AU and beyond (up to a few AU)

INPUT: Plasma properties at 0.1 AU from coronal model, self-similar **G-L flux-rope or cone model** CME parameters from fits to observations

METHOD: Second order finite volume MHD scheme

CMEs inserted at 21.5 AU as time-dependent boundary condition

CCMC StereoCat
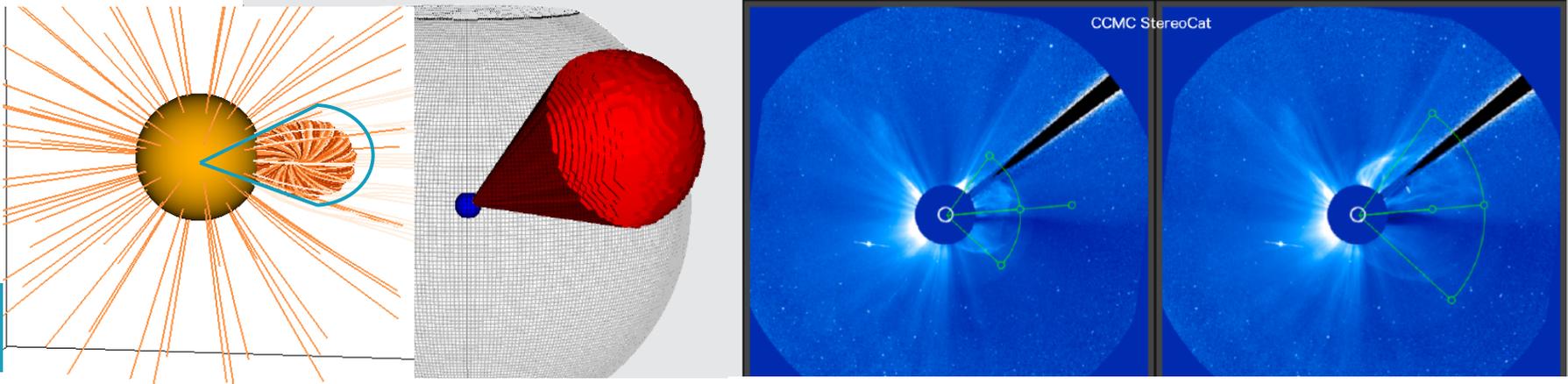
Euhforia: *radial velocity V_r vs ACE data*
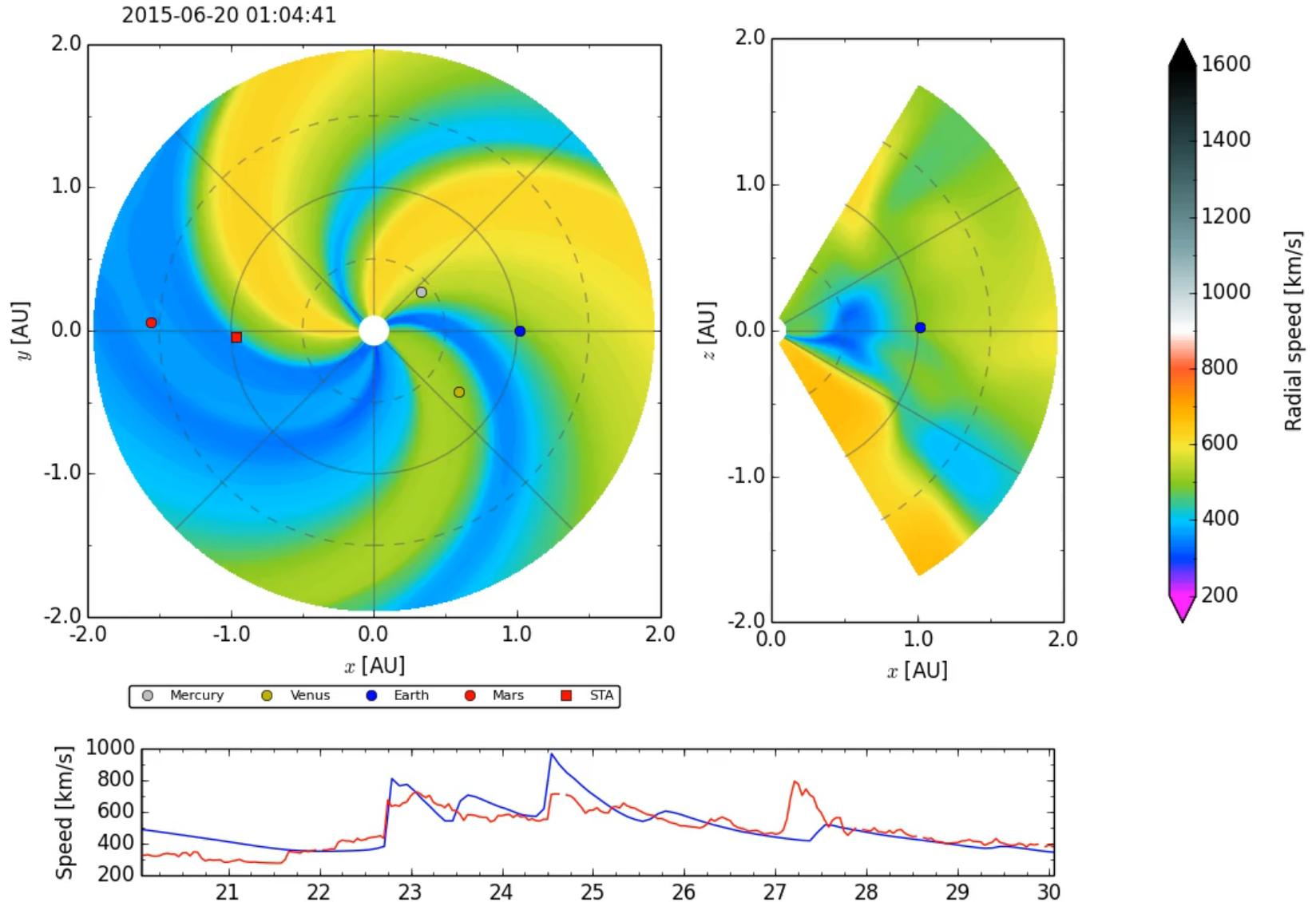
HOW?: High-Level Architecture (HLA)

- **High-Level Architecture (HLA)** is a general purpose architecture for *distributed computer simulation systems (across heterogeneous hardware and software platforms)*

- HLA enables computer simulations *to interact* (to communicate data and to synchronize actions) with other computer simulations *regardless of the computing platforms: reuse without significant code change or development cost*

- interaction between simulations is *managed by a Run-Time Infrastructure* (RTI)

- interoperability **standard** (IEEE 1516-2000) for distributed simulation used to support analysis, engineering and training in a number of different domains such as: Defence, Space, Air Traffic Management, Energy, Off-shore, Railway and car industry, Manufacturing

High-Level Architecture (HLA) components

A high-level architecture consists of the following **components:**

- **Interface specification**, that defines how HLA compliant simulators interact with the Run-Time Infrastructure (RTI). The RTI provides a programming library and an application programming interface (API) compliant to the interface specification.

- **Object model template (OMT)**, that specifies what information is communicated between simulations, and how it is documented.

- **10 simple Rules**, that simulation models must obey in order to be compliant to the standard.

HLA terminology

- **Federate**: an application which supports the HLA and is capable of participating in a simulation.

- **Federation**: a declaration between federates describing how and what will be simulated, i.e. multiple simulation entities connected via the RTI using a common OMT.

- **Federation Execution**: a run-time instantiation of a Federation; i.e. an actual simulation execution.

➢ In short: HLA provides the **Federation** formalism by which **Federates** can be modelled/coupled such that the framework can support the **Federation Execution**

British Antarctic Survey
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Recommendation/hope

The VSWMC will be as 'open' as possible!

HLA enables such an open system**, in which modellers can couple HLA compliant models from anywhere in the world(!) with their own MCI to already existing 'federates' and 'federations'** (*data sources*, other models, data analysis tools, *visualization tools*, etc.) **in the system.**

This is key to success, guaranteeing a larger and growing VSWMC user community at low(er) cost.

Metaphor

Modeler part of VSWMC is set up as a **'meccano set'**, or perhaps the more modern version of that, **'Lego technic',** i.e. it should be providing the standards, the building blocks and some simple tools to use them and provide a clear 'user guide'.

Metaphor

Provided a sufficient amount of basic building blocks and easy-to-use coupling tools is available, the users of the meccano set (or Lego technic), in this case the modelers, will use their imagination and creativity to *build an astonishing diversity of the most remarkable models*.
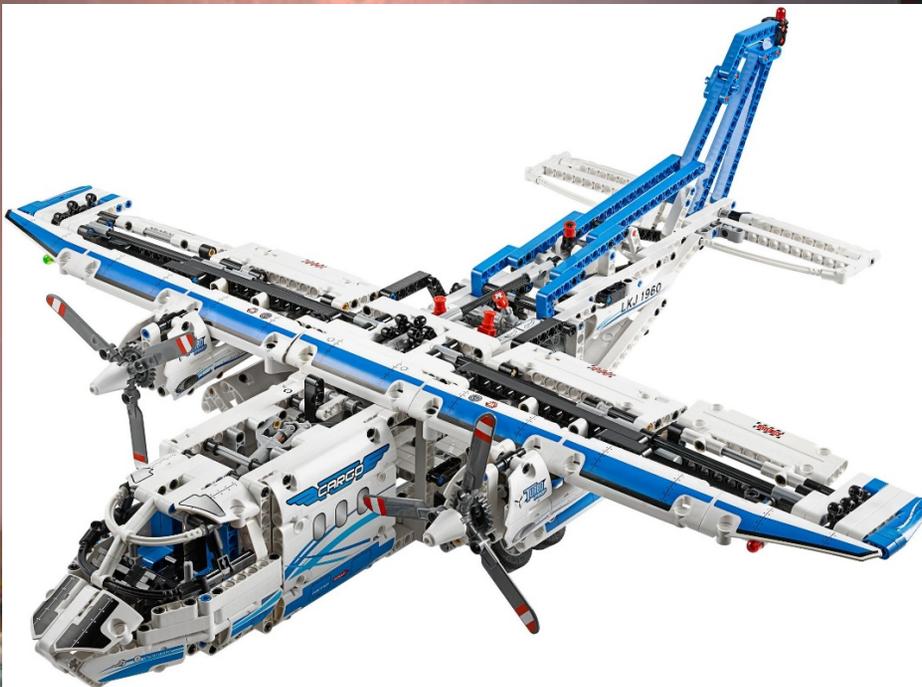
Opportunities

- **Politically**: depending on how 'open' ESA will want the system to be

- **Technically**: **a lot of opportunities**
  - Verification and assessment
  - Validation and metrics
  - Education & training (ICCMC/IREDI/…)
  - Complementary models
  - Benchmark database
  - Visualization, outreach,…
  - …
  - even inter-centra couplings of models are technically possible!

- **But let us first deploy the full VSWMC !**

Thank you very much!
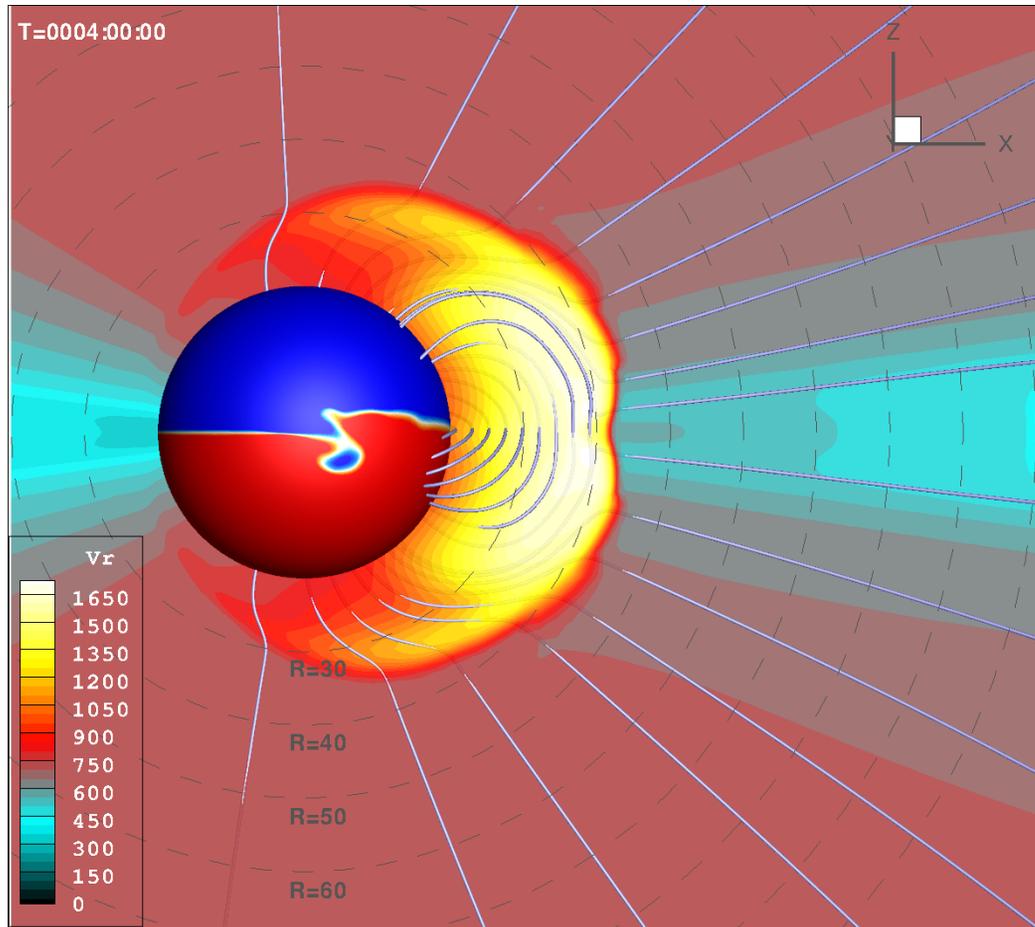
Questions?

- *How do you know so much?*
- *I asked them.*
McCoy and Spock (Star Trek)