

## **Virtual Solar Inc.**

Robert Bentley

*University College London, Mullard Space Science Laboratory,  
Holmbury St. Mary, Dorking Surrey RH5 6NT, UK*

Frank Hill

*National Solar Observatory*

Neal Hurlburt

*Lockheed-Martin Corp.*

**Abstract.** The need to develop new ways of accessing solar observations, coupled with rapidly increasing volumes of data and the desire to share data with other communities, has led to several projects intended to create virtual solar observatories. We outline the three main initiatives, EGSO, VSO and CoSEC, and describe how the combined effort will result in a facility that will better match the needs of the community. Interaction with related communities are discussed, including similarities and differences with the IVOA and interoperability.

## **1. Introduction**

Many of the research problems in solar physics require access to large amounts of data of different observables in various wavelength bands. Analysis can only start following the identification of events, features and phenomena and the location and retrieval of the required data. The rapidly increasing volumes of data and the desire to share data with other communities has led to several projects intended to create virtual solar observatories to facilitate access.

There are three main initiatives: the European Grid of Solar Observations (EGSO), funded by the European Commission; the US Virtual Solar Observatory (VSO), funded by NASA; and the Sun Earth Connector (CoSEC), funded by NASA under the International Living with a Star (ILWS) program. EGSO and CoSEC are coordinating these activities and, where possible, share resources.

Here we outline the three projects and describe how the combined effort will result in a facility that will better match the needs of the community. Interaction with related communities are discussed, including similarities and differences with the IVOA and interoperability.

<b>European Grid of Solar Observations (EGSO)</b>	
University College London ( <i>PI Group</i> )	UK
<i>MSSL and Dept. Computer Science</i>	
Rutherford Appleton Laboratory	UK
University of Bradford	UK
Institut d'Astrophysique Spatiale	France
Observatoire de Paris-Meudon	France
Istituto Nazionale di Astrofisico	Italy
<i>Obs. Turin, Trieste, Naples and Florence</i>	
Politecnico di Torino	Italy
University of Applied Sciences, Aargau	Switzerland
NASA-GSFC Solar Data Analysis Center	USA
National Solar Observatory	USA
<b>US Virtual Solar Observatory (VSO)</b>	
National Solar Observatory ( <i>Lead Group</i> )	USA
Stanford University	USA
Montana State University	USA
NASA-GSFC Goddard Space Flight Center	USA
<b>Sun Earth Connector (CoSEC)</b>	
Lockheed Martin Corp.	USA
<i>NSO (US) and UCL-MSSL (UK) are CoIs</i>	

Table 1. The partners in the three solar VO projects

## 2. Similarities and Differences

The three projects differ in scope and the emphasis that they place on various components. There have been continued discussions between EGSO and VSO about how all encompassing the project visions should be – the “big box” vs “little box” question. VSO is thinking small and hopes to expand – EGSO is trying to understand the larger picture and build within the context of this wider view of things. CoSEC is seen as a prelude to work that will be done later under ILWS, but tends to take the wider view.

The EGSO and VSO projects both offer:

- Virtualisation of data search, data discovery, and query refinement
- Multiple interfaces (browsers, application-programming interface)
- Leveraging of existing data services
- Direct user access to data (without the system as an intermediary)
- The ability to expand to several more data sources (although VSO is concentrating initially on four)

However, while VSO say it will NOT include a central catalogue, grid computing, or any features that limit or restrict access to data or software (e.g. authentication), EGSO is addressing the same issues because a view of the larger picture says it must.

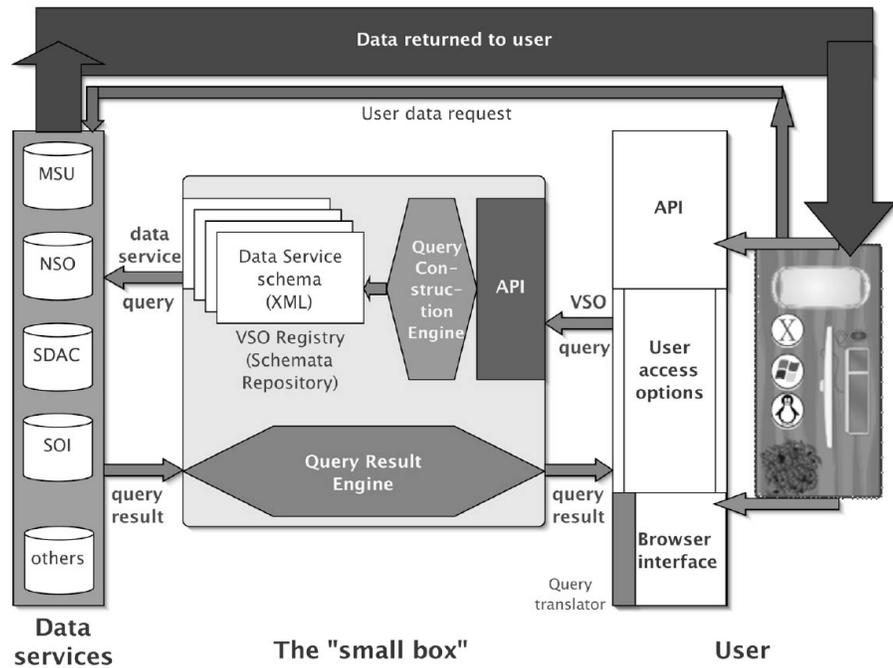


Figure 1. Conceptual Diagram of the VSO

CoSEC and EGSO share the vision of coordinating data services for more complex analysis and processing than the VSO project. While their architectures are similar to that of the VSO, they provide a more general framework of web or grid services. CoSEC’s particular focus is on methods and tools to coordinate, or orchestrate, distributed data analysis services, rather than on the data itself.

### 3. Architecture

Figure 1 shows the conceptual design of the prototype VSO. As in all virtual observatory concepts, a broker facility mediates between the data user (right) and the data services (left). In this design, however, only queries and query results pass through the broker; the actual data transfer occurs outside the VSO, thus significantly reducing network data traffic – a similar approach is used by EGSO.

The user initiates a query via either a browser interface, which communicates with the VSO API or directly through the VSO API. The query is then routed to a query construction engine that uses the XML schemata describing the data services to determine the service(s) to which to route queries in formats native to them. The query results from the data services are routed by the query result engine back to the API or browser; the user or the user’s software then decides whether to request the data from the data service(s). (The user’s

desktop is drawn in such a way as to be platform-agnostic.) While the prototype will probably include only the four named data services, more could be added at any time thereafter.

#### **4. Standards and Interoperability**

The three virtual solar observatory projects have close links with related communities, particularly those involved in Space Weather. The data models for the various projects are a major area where careful design can facilitate future interoperability. EGSO has been developing a Data Model that will also encompass in situ data as well as remote sensed solar and heliospheric data, and has been asking members of both communities to review the model – CoSEC is funded under the ILWS programme which involves both communities.

A joint technical meeting between the three virtual solar observatory projects is scheduled for December 2003 – representatives of the Virtual Heliospheric Observatory (VHO) and Virtual Space Physics Observatory (VSPO), both funded by NASA, will also attend. Another meeting is planned early in 2004.

In addition, all three solar VO projects are members of a new Working Group on “International Data Access” that was created under Division II of the IAU, the “Sun and Heliosphere”. The Working Group involves solar and heliospheric physicists from around the world and also includes the VHO and VSPO. The intent of the Working Group is to help coordinate the existing and growing data exchange through the Internet and work with the virtual observatory initiatives to propose guidelines that will aid this and encourage community participation in the projects. It will try to ensure that the standards and techniques employed that are acceptable to the worldwide communities and will encourage interoperability between the projects.

Where it makes sense, the projects will adopt technologies suggested by organizations such as the IVOA – for example, there are plans to use VOTable to pass certain types of information. However, it should be recognized that the data of the solar and heliospheric communities differs in content and usage from the astrophysics community and that the virtual observatory initiatives are not necessarily all addressing the same problems.

#### **References**

- Bentley, R. D. and the EGSO Consortium 2002, “EGSO - the European Grid of Solar Observations” in *Solar variability: from core to outer frontiers*. The 10th European Solar Physics Meeting, 9 - 14 September 2002, Prague, Czech Republic. Ed. A. Wilson. ESA SP-506, Vol. 2. Noordwijk: ESA Publications Division, ISBN 92-9092-816-6, 923
- Bose, P., Woodward, M., Hurlburt, N. & Freeland, S. (2003) ‘Middleware Infrastructure for Semantic Composition and Execution of Distributed Services,’ (2003) in proceedings of 2003 IISCE.
- The VSO Study Group, 2002: The Virtual Solar Observatory Design Proposal, [http://umbra.nascom.nasa.gov/vso/docs/VSO\\_strawman\\_20021125.pdf](http://umbra.nascom.nasa.gov/vso/docs/VSO_strawman_20021125.pdf)