SpaceOps 2010 Conference<br> Delivering on the Dream<br> Hosted by NASA Mars
25 - 30 April 2010, Huntsville, Alabama

AIAA 2010-2357

# Knowledge management tools downstream space operations: the ULISSE project.



*Didier Moreau, Christian Muller, Etienne Haumont*

*B.USOC, Belgian Users and operation Centre, avenue Circulaire, 3, B-1180 Brussels.*

*and*

*The ULISSE consortium*

**ULISSE (USOCs KnowLedge Integration and dissemination for Space Science and Exploration) is an FP7 European Commission project proposed by the USOC (User Support and Operation Centre) network in charge of the European operations on the International Space Station. The partners are led by TELESPAZIO in Italy and include as well knowledge management experts as data providers in all the related disciplines, life sciences have an important weight through the in involvement of the MEDES consortium, a space medicine group organised by CNES and research hospitals in Toulouse.**

## I. Introduction

ULISSE concerns primarily all the European data obtained in the ISS in life sciences, physical sciences, earth and space sciences. It is designed also for other scientific data bases relating to space environment and space conditions as the data obtained in related studies like bed rest tests. The objective of the project is to lead to a better dissemination of the results obtained in space and to a knowledge increase through the simultaneous use of several data sets. The methodology preserved the original data sets with their full content; it differs in this respect from the data bases built since the International Geophysical Year (1957-1958) and the beginning from the space age. To resume, ULISSE intends to supersede the data sets with a header set in a mark-up language, the user manages the data through this header and can treat simultaneously data sets of different origins. The different web tools used in this project will be discussed as well as the proposed user interfaces.

The objectives of the project are not only data preservation but the maintenance of the data base as a living archive of microgravity and life science on the ISS. The current ISS external payloads provide a link to the space science activities performed using free-flyers satellites. In a later stage, manned exploration will extend to the moon and Mars and knowledge from manned flight will have commonalities with planetary science data.

ULISSE meets currently interdisciplinary science concerns in several ways as it can be used for example to make the relation between space environment data and physiological data of the crew, it can be used also to compare environmental effects on subjects in hospital monitoring with simultaneous observations in space flight.

The partners in ULISSE are: Microgravity Advanced Research and Support Center S.r.l. (MARS), Italy, Telespazio S.p.A., Italy, Belgium Users support and Operation Centre, Belgium, Consiglio Nazionale delle Ricerche (CNR-ISTC), Italy, Institut de Médecine et de Physiologie Spatiales (MEDES), France, Space Applications Services (SpaceApps), Belgium, Centre National d'Etudes Spatiales (CNES), France, Università degli Studi di Roma "La Sapienza", Italy, Damec Research Aps - Danish Aerospace Medical Centre of Research, Denmark, Stichting Nationaal Lucht- en Ruimtevaartlaboratorium (NLR), The Netherlands, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Germany, Eidgenössische Technische Hochschule Zürich (ETH), Switzerland, NTNU Samfunnsforskning AS, Norway, Centrum Badań Kosmicznych Polskiej Akademii Nauk (SRC PaS), Poland, Universidad Politécnica de Madrid, Spain, Werum Software & Systems AG, Germany, European Low Gravity Research Association (ELGRA), The Netherlands. The SUVIM ground based data used to demonstrate the progrject at B.USOC belongs to the Institute for Space Aeronomy UV radiation group headed by D. Gillotay.

A future application of the project will be the operational use of the accumulated knowledge for the interpretation of results coming from space exploration results in terms of previous experience and to assist the replanning of on-going missions.

This communication describes the present status of the project, the specific role of the BUSOC and implication of this project for the future human exploration of space.

.



## II. The USOC's and their roles.

The USOC network originates from the European agreements on the use of the International Space Station, the User Support and Operation Centres support the scientific users of the station in the participating countries, they communicate with either the COLUMBUS Control Centre or the Marshall Space Flight Centre according to the location of the payload (either in the American or European part of the station). The USOC's obtain the data through the ESA IGS (Interconnected Ground System) and distribute it after agreed processing to the users in their User Home Base, this distribution is made through local or European academic networks. The USOC's follow also instrument operations and can have a commanding capability. In practice, the USOC's prepare command files which are uploaded either through ColCC or MSFC after approval by the payload operation direction. These changes correspond to modification of science operations decided by the scientists or corrective actions in case of malfunctions. The USOC's have also a mandate to store data. In the case of samples, USOC's assist also the PI's in their preparation before launch and in some cases receive them after return. In most cases however, the samples are directly analysed at the UHB's where typically analytical equipment which could never be flown in space is deployed.

In any case, the USOC's play a role in the processing of electronic data and have the capability to store them and perform treatment according to the requirements of the PI's. It was thus natural to use this network when the synergistic use and preservation of all ISS data was envisaged.


**Figure.1: the current partners of B.USOC, N-USOC, ERASMUS, CADMOS, E-USOC, DAMEC, MUSC, BIOTESC and MARS are USOC's, COL-CC is the COLUMBUS control centre and the others are academic and industrial partners. Unsurprisingly, most of the B.USOC partners of this second category are situated in Belgium. The ESA IGS connects only ESA facilities and the USOC's. Most of the European USOC's are ULISSE partners.**

In the USOC organisation, the ESA management (Human Space flight, Microgravity and Exploration (HME)) assigns Facility Responsible Centres (FRC) and Facility Support Centres (FSC), B.USOC is FRC for the SOLAR package of COLUMBUS, a set of three instruments monitoring the solar output from the far-UV to the infrared. B.USOC is FSC for the PCDF (protein crystallisation diagnostics facility), a payload inside the European Drawer Rack inside COLUMBUS. In both cases, the B.USOC experience antedates COLUMBUS as space solar instrument are operated by teams of all three institutes present in Uccle since 1983 (Belgian Institute for Space Aeronomy, Royal Meteorological Institute and Royal Observatory). Similarly, B.USOC operates protein crystallisation experiments since 2002. In the future, B.USOC will operate also for CNES the solar science monitoring satellite PICARD to be launched in 2010.

**Figure 2: COLUMBUS in flight, SOLAR is indicated by the arrow (NASA document)**.

## III. Data provided by B.USOC to ULISSE.

B.USOC intends at project end to provide the SOLAR package data base as well as protein crystallisation data obtained on the ISS. Later, B.USOC will use its Belgian Institute for Space Aeronomy connection to add space science data from other platforms. This is unfortunately not possible at this stage because these data are still owned by ESA and the PI's and thus cannot yet be released to ULISSE and the synergistic studies that will be initiated by the existence of the tool. Thus, in order to begin without waiting for the release of the data rights, a ground base network of solar UV measuring station in Belgium and Luxembourg will be first introduced in the ULISSE data base. This network provides already an operational UV index and climatology of the solar radiation received at the surface in Belgium. The five stations operate continuously and the Belgian Institute for space Aeronomy is fully owner of the data and has authorized B.USOC to diffuse it. This project is called SUVIM.

The specificity of ULISSE is to define for each data set topics maps and ontology; these will be then translated by in the XML language and will allow an access to the data without altering its original format. This process will be iterated with the knowledge management partners in the project so that a common access procedure exists for all the data sets managed by the different USOC's.

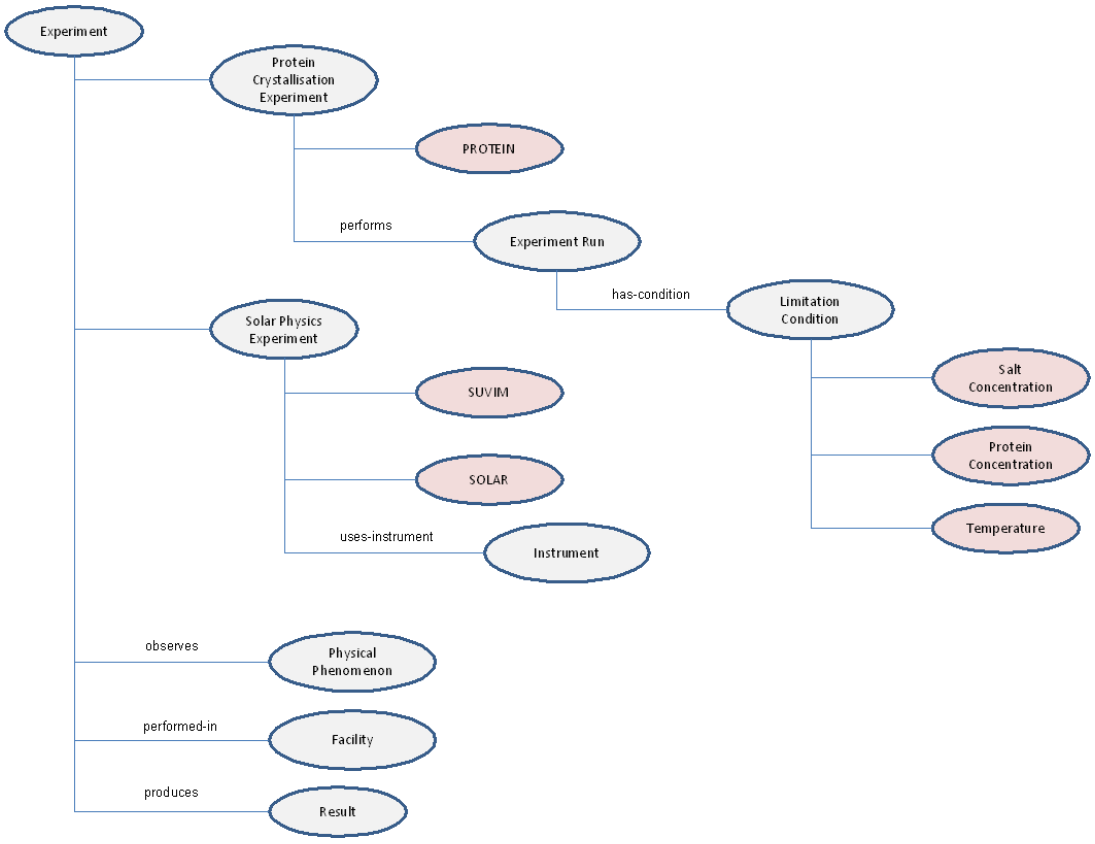


**Figure 3: Ontology diagram of the data introduced by B.USOC, only SUVIM can be entered now in the project.**

.

## IV. Example of process: the UV ground based data as a demonstrator.

B.USOC has the responsibility of applying the ULISSE concept to two experiments it manges on COLUMBUS: the SOLAR package and the PCDF, as these two experiments are still processed by ESA and the PI's, their data will thus not be immediatly released to the process. The PCDF and SOLAR data are moreover received at the USOC's by the secure HRDP (High Rate Data Processor) and archived in servers behind the USOC firewalls, the data, including the headers can then be retrieved for use by proprietary programs. The use by ULISSE requires thus the implementation of a complex retrieval program which has to be executed in the secure area and has to be followed by an external transfer. The total amount of concerned data is of around 1Tbyte.

In order to demonstrate the concept on a more accessible real case, it was decided to use data related to SOLAR from an actual network. The Belgian Institute for Space Aeronomy (Dr. D. Gillotay) accepted to provide the data of an already operational ground based solar radiation monitoring network to the project to act as a concept demonstrator. This concept demonstrator is the main 2010 task of the ULISSE project; several data sets will be put together by the different partners in order to test the functionalities of a semantic web service using real data.

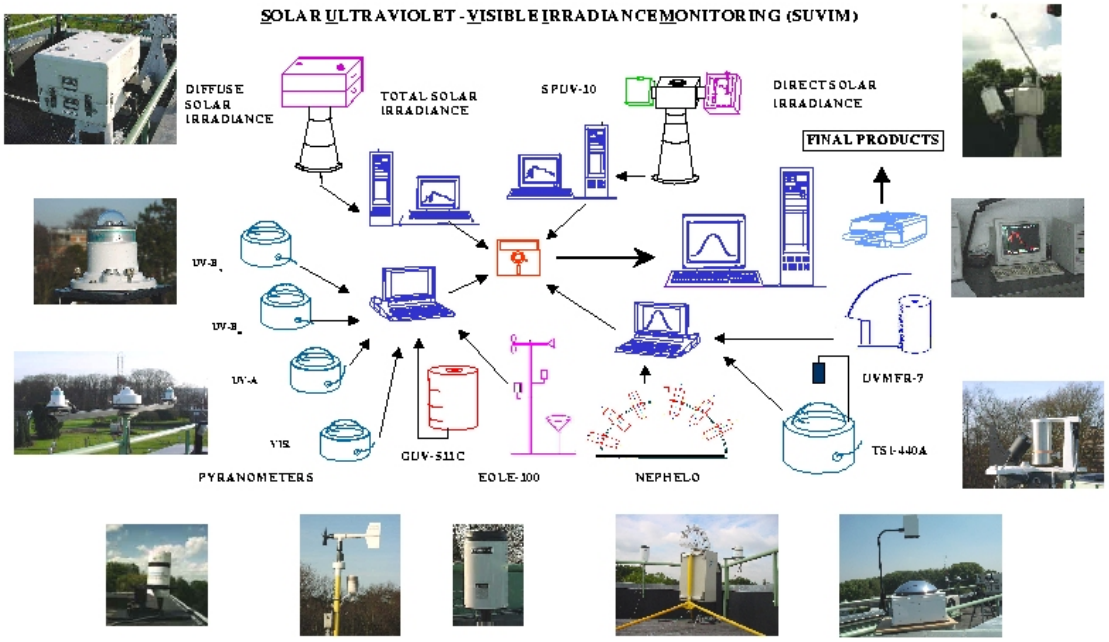


**Figure 4: Description of the complement of ground-based instruments, these instruments measure spectral irradiance, spectral bands and total radiation both on the direct sun and in diffuse radiation.**

The instruments, stations, current applications and evolution are described on http://www.aeronomie.be/en/topics/interplanetary/sci/solarrad_station_sci.htm, their data are already used in an operational service distributing the UV indexes and solar irradiances in real time together with ancillary meteorological parameters. This service uses functions of the original data and has for main purpose to alert the public to the maximum exposure times for sensitive human skins and to give references for solar energy applications. Phenomena with short time periods are not explicitly detected and the ULISSE treatment should lead for this data set to solar weather studies and correlative phenomena research which cannot be performed now.

The following tables give a description of the data as they are available now.

| **Name of experiment** | SUVIM |
|---|---|
| Acronym(if any) | |
| Project | |
| Data provider | IASB-BIRA |
| Storage place | IASB-BIRA server (restricted access)<br>Accessible mirror maintained by B.USOC |
| Date of experiment | 1993-2010 and further |
| Type of data (for example digital, figures, others..) | Digital, the format is a text format compatible with the European Commission EDUCE project; these data can be used and addressed without altering their format. |
| Discipline | Environmental science, solar physics |

The data have been collected in Brussels every day almost continuously since 1993. The stations have increased their complement of instruments since; the following data are now available for the demonstrator.

**Brussels (Uccle) data**

| | |
|---|---|
| 1993 | Spectral irradiance data |
| 1994 | Spectral irradiance data |
| 1995 | Spectral irradiance data + UV-A, UV-B and total irradiance. |
| 1996 | Spectral irradiance data + UV-A, UV-B ,total and direct irradiance. |
| 1997 | Spectral irradiance data + UV-A, UV-B ,total and direct irradiance. |
| 1998 | Spectral irradiance data + UV-A, UV-B ,total and direct irradiance. |
| 1999 | Spectral irradiance data + UV-A, UV-B ,total and direct irradiance. |
| 2000 | Spectral irradiance data + UV-A, UV-B ,total and direct irradiance. |
| 2001 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance |
| 2002 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance |
| 2003 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance |
| 2004 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance, UV data obtained by supplementary Bentham instr. |
| 2005 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance, UV data obtained by supplementary Bentham instr., diffuse UV. |
| 2006 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance, UV data obtained by supplementary Bentham instr., diffuse UV. |
| 2007 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance, diffuse UV. |
| 2008 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance, diffuse UV. |
| 2009 | Spectral irradiance data + UV-A, UV-B ,nebulosity, total and direct irradiance, diffuse UV. |
| 2010 and further | Spectral irradiance data + UV-A, UV-B, nebulosity, total and direct irradiance, diffuse UV. There is no planned date for the end of the service. |
| Note: Bentham instrument | The Bentham data will be included in the 2007, 2008, 2009 and further files, all the described data are available for ULISSE. |

**Redu data:** Redu is the location of the EURO-Space centre (education and space exhibit), an ESA receiving station and a future new ESA operation centre.

| | |
|---|---|
| 2004 | UV-A, UV-B , total irradiance |
| 2005 | UV-A, UV-B , total and direct irradiance |
| 2006 | UV-A, UV-B , total and direct irradiance |

| | |
|---|---|
| 2007 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2008 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2009 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2010 and further | UV-A, UV-B , total and direct irradiance, nebulosity.. There is no planned date for the end of the service. |

**Ostend data**: the Ostend station is at the sea-side location of the Earth Explorer science park.

| | |
|---|---|
| 2006 | UV-A, UV-B , total and direct irradiance |
| 2007 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2008 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2009 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2010 and further | UV-A, UV-B , total and direct irradiance, nebulosity.. There is no planned date for the end of the service. |

**Virton data**: the Virton station is at the top of a public building in the more Southern Belgian city.

| | |
|---|---|
| 2007 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2008 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2009 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2010 and further | UV-A, UV-B , total and direct irradiance, nebulosity.. There is no planned date for the end of the service. |

**Mol data**: the Mol station is in a science campus in the North of Belgium including a nuclear research facility and a technology centre.

| | |
|---|---|
| 2008 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2009 | UV-A, UV-B , total and direct irradiance, nebulosity. |
| 2010 and further | UV-A, UV-B , total and direct irradiance, nebulosity.. There is no planned date for the end of the service. |

**Table 1: data set description and availability of data for the current stations.**

A metadata description will be developed for SUVIM in the frame of ULISSE. The data description will be aimed at providing all information needed for data access and utilization. The identified data are currently archived in the international "flexstor" format used in the EDUCE European Commission FP-5 program, this text format already contains standardized headers that could easily lead to the automatic production of metadata descriptors. This operation will be done in close contact with ULISSE partners already experienced in the process. The current approach is to put the data in a MySQL database using descriptors extracted by a PHP program from the original files, this data base is then converted to XML and becomes thus compatible with the ULISSE format. Presently, the

original SUVIM data are on a restricted server at the Belgian Institute for Space Aeronomy, when the ULISSE demonstrator will become operational, the total data set will be accessible through ULISSE at a mirror on the B.USOC server. The total amount of data is around 50 Gbytes and thus, global tests are much easier than on the entire B.USOC COLUMBUS data set.

After completion of the demonstrator, the same operation will be applied to the PCDF and SOLAR data using the best available platform at B.USOC hoping that this data will have been approved for release to the project at that time.

## V. Conclusion: operational value of ULISSE.

The ULISSE program is a necessity to both preserve and use data obtained in the ESA HME program and especially COLUMBUS, the metadata approach (table of topics, ontologies) allows not only a platform independent access to leaving data, it leads also to a new knowledge enhancement. Two aspects are present: synergetic studies especially important in life sciences and second: the operational use of knowledge acquired through previous observations in the understanding of unexpected signals.

Synergetic studies will first benefit life science data including both telemetry acquired during flights as well as hospital experiments; the ULISSE concept will allow a much better exploitation of these data in flight medicine by correlating them with external forcings determined by space and earth science data, it will also gibe a boost to chronobiological studies. The supreme success will happen when new knowledge unexpected to the experiments original PI's will arise from the data by use of the ULISSE semantic web service.

In the case of science operations, ULISSE by a rapid access to all previous experiments will allow planners to perform new experiments knowing exactly which previous ones have been performed, it will also lead to dysfunction analysis with all the knowledge coming from previous operations and failures directly available at hand.

The total amount of data used by BUSOC in the demonstrator is around 50 Gbytes, the data managed by B.USOC reach now about 1 Tbyte while, the entire HME data sets has still to be estimated but the amount is still far from the data managed by ESA in earth observations and space sciences where the total archives are counted in Petabytes. The USOC data sets present thus also an ideal laboratory to test semantic web techniques on real data in space exploration and will contribute to the extension of knowledge associated with the space research effort.



## Acknowledgments

B.USOC is part of the service division of the Belgian Institute for Space Aeronomy and is funded through the ESA Prodex and other programs by the Belgian Science Policy Office. This work has received funding from the European Commission through the Seventh Framework Programme (FP7/2007-2013) within the Space Theme, under grant agreement n°218815 for the ULISSE Project (USOCs KnowLedge Integration and Dissemination for Space Science Experimentation).