Executive Summary:

The ULISSE project

ULISSE (USOC knowLedge Integration and dissemination for Space Science Experimentation) is a research project, funded within the first Space Call of the European FP7, aimed at improving preservation, valorisation and exploitation of the data produced across multiple domains by European scientific experimentation in space on the International Space Station (ISS) and other space platforms.

In this effort all the European USOC (User Support and Operation Centres) for the ISS utilization have been involved, for their strong links with the user community and the highly specialized knowledge of the space experimentation domains.

ULISSE has played the role of pathfinder for almost the key aspects of a data e-infrastructure for the ISS, particularly those related to legal issues and intellectual property preservation.

ULISSE main activities and achievements are:

- -Survey and analysis of user needs for data valorisation
- -Collection and harmonization of legal constraints to dissemination of ISS data
- -Survey of available datasets and identification of an experiment catalogue suitable for demonstration purposes
- -Identification and implementation of tools for data and knowledge management using also semantic technologies
- -Definition of a metadata standard and creation of the metadata describing the experiments of the catalogue
- -Identification and implementation of a number of tools for data exploitation
- -Development of a middleware for the integration of distributed resources
- -Development of a Promotional Portal for the information and the involvement of the community
- -Implementation at Demonstrator level of:
- -Networking and integration of a subset of distributed resources
- -Provision of a subset of services as demo of the system capabilities: searching, browsing, metadata creation and management, data integration/fusion, repository management tools, knowledge base management with semantic features

ULISSE has provided a very fruitful experience and the results of the Demonstrator have proven the feasibility and usefulness of an e-infrastructure to interoperate the ISS distributed repositories in accordance with the applicable legal constraints.

The scientific community has evaluated the ULISSE Demonstrator as a very useful platform, confirming the need for such an infrastructure able to provide through advanced searching tools, access to scientific data, metadata, documentation and publications and to support networking between members of the scientific community.

At the same time, interviewed scientists provided the clear indication that the scientific community cannot sustain the non-negligible task of feeding such an infrastructure with databases, repositories and metadata, being already a relevant amount of time dedicated to the preparation of research proposals and reports. This outcome confirms the necessity of support

entities like the USOCs that, for their role in the execution of space experiments, have the required competences and access to the data and related documentation; therefore the exploitation of the USOC network, as proposed in ULISSE, would allow an efficient implementation of a space data infrastructure.

The ULISSE public web site is: http://www.ulisse-space.eu

Project Context and Objectives:

1. Description of the context

1.1 Space experimentation on the International Space Station

The International Space Station (ISS) is the largest international space programme currently operating [1, 5]. This large enterprise is the product of the international partnership of USA, Russia, Canada, Europe and Japan. In Europe, 10 European Countries have participated in the realization of ISS within the coordination of the European Space Agency (ESA). The ISS has been completed in 2010 and it will be operative beyond 2020 (extension of ISS exploitation until 2028 is envisaged).

The ISS offers the unique opportunity of a permanent orbital laboratory with 6 crew members continuously operating to perform technological and scientific experiments. ISS has been realized with state-of-art space technologies and its laboratories and equipment are extremely more advanced than those used in the past on other space missions. Due to the large increase of operative time and to the relevant advancement of the instruments' technologies, the ISS is leading a new phase of space experimentation, characterised by a quantitative and qualitative increase of its scientific relevance.

In addition to the experiments already performed during the assembly period of ISS (since 1998 to 2010), there is a large number (of the order of thousands) of future experiments to be performed within the life-time of this space platform.

ISS hosts every day experiments in almost all scientific disciplines. Experiments installed on the external pallets are exposed at the harsh conditions of space (vacuum, radiations, large temperature variations, …); these experiments concern mainly space science, plasma physics, radiation physics, solar physics, atmosphere and environment sciences, space technology and astrobiology. Inside the pressurized laboratories of the ISS experiments are performed in the fields of biology, plant, animal and human physiology, fluid science, material science [1-5].

Experiments performed in space (not only on ISS) have some peculiar aspects:

- -Experiments concern a large number of scientific domains;
- -Preparation requires a long time (typically several years) during which adequate equipment qualified for being operated in the difficult conditions of space environment is designed and developed;
- -Costs are generally large, due to the very large investments required for space missions and possibilities for repeating and improving experiments are limited;
- -Repetition of successful experiments, which is desirable for improving statistics or test different conditions, also requires long time and relatively large costs.

For the above reasons, space experiments are selected by the Space Agencies according to a rigorous peer review.

It is then expected that the data, information and knowledge produced by space experiments acquire a very relevant scientific value.

Therefore, the scientific relevance of space data, the time and costs spent for its acquisition demand for paying special attention to:

- -preserving in the long term the space data;
- -supporting the exploitation of space research results.

It is worth noting that space data exploitation requires also the knowledge required for data interpretation, which generally concerns experimental protocols, environmental data and housekeeping information about space platform and instruments.

1.2 Data from space experiments on ISS

In Europe the control of the experiments on ISS including the acquisition of data is performed by the Ground Segment established by ESA. The European Ground Segment is based on a decentralised architecture: the Mission Control Centre in Germany coordinates a network of scientific space facility operations centres, named User Support and Operation Centres (USOC).

The USOC have been established in various EU countries with the support of national space agencies and are engaged by the ESA to conduct the operations of European scientific experiments on board Columbus and other modules of the ISS. To this purpose USOCs use an ad-hoc infrastructure, dedicated to space operations only. Through the space infrastructure USOCs exchange data and commands with the ISS. USOCs send data to the scientific investigator(s) responsible for the experiments, storing a master copy of data in their infrastructure for operations.

Therefore, scientific data produced by experiments on the ISS cannot be accessed straightforwardly. Currently no standard procedure has been established to promote the dissemination of scientific information and data of ISS experiments. Space data and experiment results are presently dispersed over numerous archives and databases in Europe. An interested user may request data individually from the investigator or from ESA, once reference persons have been identified, on a case by case basis.

The present situation represents a bottle-neck for the complete exploitation of the scientific data of ISS experiments. Considering the large number of experiments to be still performed on ISS in the next 10-15 years, an infrastructure supporting access and exploitation of this huge amount of data would be needed.

2. ULISSE main objectives

The ULISSE project intends to prepare the exploitation of the huge amount of scientific data that will be produced in the coming years by experiments on board the International Space Station.

Moreover, to ensure the usability of space data in the future, it is necessary to provide also a description of the data (metadata), technical information about the experiment equipment and the space platform and knowledge about environmental conditions.

ULISSE is aimed at addressing all the issues related to the preservation and exploitation of space data in the ISS domain with the final goals of demonstrating the feasibility and the usefulness of a data e-infrastructure for ISS.

To this purpose, one specific objective of ULISSE is the definition of the reference scenario for the exploitation and valorization of ISS scientific data, through:

- -collecting requirements for providing reliable access to scientific data and related information (metadata) in the long term
- -investigating the knowledge representation through appropriate ontologies
- -identifying applicable data policies and related constraints
- -defining the services required for ISS data preservation and exploitation
- -creating metadata and knowledge for a subset of experiment data
- -analysing the sustainability of a ISS data e-infrastructure

The second specific objective of ULISSE is the study and development of tools for the implementation of services, specifically:

- -developing tools to support data and metadata storage and management
- -developing tools for information and data search, access and exploitation
- -developing a middleware for the integration of distributed resources and repositories
- -integrating tools, repositories and services into a Demonstrator to verify the feasibility and the benefits of an e_infrastructure for the preservation and exploitation of scientific space data, also collecting feedbacks from users

The project intends also contributing to increase the information exchange among different components of the scientific community (promoting particularly cross-disciplinary information share), Space Agencies, public bodies and citizens.

3. References

[1] http://www.esa.int/export/esaHS/iss.html

[2] The Era of International Space Station Utilisation: Perspectives on Strategy from International Research Leaders, http://www.nasa.gov, NP-2010-03-003-JSC

[3] ESA SP-1251, Seibert, G. et al, A World Without Gravity - Research in Space for Health and Industrial Processes, ESA Publication Division, ESTEC, Noordwijk 2001. ISBN 92-9092-604-X

[4] Utilization of Space: Today and Tomorrow, by Berndt Feuerbacher, Heinz Stoewer Editors (2006)

[5] Laboratory Science with Space Data, by L. Carotenuto, D. Beysens, J. van Loon, M. Zell Editors, Springer (2011)

Project Results:

Main S & T results/foregrounds

ULISSE is a pathfinder for the data e-infrastructures in the ISS domain. For this reason, as first result the project has produced a reference scenario for the preservation and exploitation of scientific ISS data. Successively, ULISSE has developed a set of tools for data valorisation, a platform for integration of distributed resources and a Demonstrator. A summary of these results is described in the following.

1. ULISSE Scenario

The ULISSE scenario is composed of the following main elements.

1.1 Requirements identification

The main requirements for ISS experiment data preservation and exploitation have been identified integrating the expertise of the USOC (the European operative centres responsible for scientific operations on ISS) with the outcome of interviews of potential users of a data e-infrastructures. Potential users belong mainly to the scientific community, but including also engineers involved in space activities (representatives of space industries or agencies); potential users have been contacted and interviewed using a questionnaire and their feedback confirm the need for an e-infrastructure for ISS data and the approach followed by the ULISSE project.

Main collected requirements and related share among the interviewed users are summarised below:

a) Access to data from past space experiments (97,3%); calibrated data are preferred

b) Mandatory information is the description of experimental conditions/procedures/protocols, hardware/equipment, technical expertise, algorithms & methods, sample extraction and storage method (82,4%), possibly associated software tools (56,8%)

c) Data is required in a form suitable for processing/analysis with the purpose of check / re-process / confirm / optimize results (from previous experiments) and/or models, and as knowledge (75,7%) or education (9,5%)

d) Availability of already published results obtained from data analysis (83,0%)

e) Possibility to pursue research actions (as proposals, publications) based on data analysis (56,8%)

f) Metadata of experiments within the “restricted period” in which the PI only can use the data (52,7%)

g) Required preservation time is at least 10 years (58,8%), at least 15 years (64,7%)

h) All space missions and carriers are of interest (77,0%)

i) Mandatory information for data search is mainly keywords, topics and sub-topic, experiment description (79,7%)

j) Mandatory information for data process is mainly data collection date, data collection site and data source (79,7%)

k) Preferred access method is through WEB/Http browser and downloads (73%)

l) Tools for data re-utilisation shall be platform-independent (54,1%)

m) When possible and convenient, it is accepted that data processing is performed by the platform (50,0%)

1.2 Definition of services

The required functionalities of a platform for ISS data valorisation have been defined on the basis of the identified requirements; the main functionalities are:

- Knowing: this functionality provides a standard access to the sources that already have the needed information structured as required by user
- Browsing: navigation through the information (retrieved by a knowing functionality) to identify and select the required part of interest for the user
- Matching: this functionality identifies associations (matches) among heterogeneous information which could be retrieved using a knowing functionality. The matches are defined on the basis of specific correspondence rules.
- Practical explanation: starting from a specific user request of information that is not explicitly present in the involved sources, this functionality is able to collect the available data/information (through the knowing function) to compose a possible explanation of the user request
- Data integration: this functionality integrates homogeneous data retrieved using a knowing functionality, in order to create new data that is not explicitly present in the involved data source; integration rules depend on the particular desired correlation between datasets
- Tool identification: provision of information on the available tools, identification and activation of the tool required by the user

1.3 Data survey

A set of 100 past experiments and related datasets has been identified in almost science disciplines studied on ISS. Due to the experiment relevance, the scientific discipline coverage and the availability of the datasets, the identified catalogue of experiments is suitable for being used in the Demonstrator.

Each dataset has been described; for this purpose, a common metadata structure has been defined customizing the ISO19115 metadata standard. The metadata (in XML format) of the datasets have been created using the GeoNetwork tool described in the following.

A review process of the produced records has been established, in order to ensure homogeneity of the contents and compliance with the ULISSE metadata standard. This review process (managed through GeoNetwork) has validated the 56 experiment records in the ULISSE metadata repository.

The ULISSE team includes many experts of the ISS domain which contributed to the record production ensuring the scientific validity of the contents; however a centralised review is mandatory to ensure the semantic homogeneity of the data description.

Moreover, five repositories containing the experiment datasets have been established at the premises of the corresponding data provider. To this purpose, data from past experiments has been retrieved and, in some cases, digitalised and formatted for being used in the Demonstrator.

1.4 Knowledge representation

Knowledge representation is based on Topics Maps technology. A large amount of information on the scientific domains related to the experimentation on the ISS has been provided by experts during dedicated workshops.

On that basis, two ontologies have been defined, upgraded and updated during the project:

- -an experiment ontology representing the metadata structure that is common to all disciplines and that includes information on the data and on the experiment;
- -an ontology of the scientific domain (mainly focused on physics and material science) which captures some main concepts of the scientific domain enabling the association among them.

The experiment topic maps have been created importing the XML metadata with the Locksmith tool described in the following. The domain topic map has been populated during a dedicated workshop.

1.5 Data policies

The applicable data policies for ISS data have been identified during the data survey. Most of experiment (raw and calibrated) data, with very few exceptions, result to be a property of the space agency that funded the experiment; accordingly, data access and use is subjected to the corresponding limitations and constraints stated by the data policy issued by the space agency. The data policy defined by the Human Spaceflight and Operations Directorate of the European Space Agency (ESA) has been recognised as the reference data policy also for nationally funded experiments.

A preliminary workflow for data release to users in compliance with the ESA data policy has been defined and presented to ESA HSO. ESA has acknowledged the need to implement a process for data release that is currently under evaluation. A fruitful cooperation has been established with ESA HSO, which has expressed its interest in exploiting the ULISSE achievements for the future implementation of an ISS data infrastructure.

1.6 Sustainability and exploitation

Possible funding sources have been evaluated to assess the sustainability of ULISSE. Most of the interviewed users (67,6%) are not willing to pay for accessing scientific space data. In addition, the data is a property of a public entity, the space agency, which normally does not pursue a commercial scope.

Moreover, also the public agencies that are members of the ULISSE Consortium could not pursue commercial utilization of the project products; therefore, commercial services that have been identified in the sustainability analysis are not considered a driver for the project implementation.

It has been recognised that ULISSE is mainly oriented at providing a public utility service and, consequently, its sustainability is mainly due to the support of the interested public entities, namely ESA and other space agencies.

The European Space Agency has been identified as main stakeholder for coordinating the future exploitation of the project results, while the European Commission, through FP7 Calls, may support additional technology development and implementation.

In parallel, each partner will pursue the possible exploitation of its products (particularly for the tools).

2. ULISSE Tools for data valorisation

During the project the following data valorisation tools have been developed in support of improving data distribution, adding metadata and knowledge representation, allowing exploring experiment data and simplifying access, improving experiment data generation and data presentation.

2.1 e-collaboration portals

2.1.1 Promotional web portal

The promotional web portal primarily intends to promote space research showing the societal benefits of space research and to promote ULISSE project towards the general public.

The main idea of the portal is so to provide contents in order to:

- allow the general public to understand the basic underlying principles of space research i.e. what space environment is, what it means in terms of physics, biology, physiology.
- provide an overview of most of the fields of space research, accessible and understandable by the general public and for each field to make the link with descriptions of space experiments accessible to the public, again showing the application potential and the relation with our daily life on earth.

Three independent instances of the promotional and educational portal are available respectively in English, French and Polish languages.

Any user may submit an article, an idea or a question. The Portal is developed using Drupal, an advanced Content Management System (CMS). Thanks to this CMS, the portal allows

- individuals and communities of users to easily publish, manage and organize a wide range of content on a website.
- administration to manage easily and securely the site, through authentified / secured access for administrator and users, and the contents, , through a network of experts able to validate or update content and reply to the questions of users

The Drupal-based ULISSE portal is served by an Apache PHP module deployed on a Linux environment. Full open source system is implemented.

2.1.2 Web services for solar UV data and UV climatology

The relevant solar UV studies began in the late sixties with sounding rockets and stratospheric balloon flights and had a space segment since SPACELAB-1 in 1983. However, the systematic archiving of data began only in 1993 and continues now for five ground stations: Uccle (Brussels), Mons, Redu, Mol and Ostend. All five stations are situated on Belgian territory and a sixth station in Diekirch (Luxemburg) will be included in the project soon.

The solar data from the IASB-BIRA ground based network are free of rights, they have been in part integrated in the FP-5 project EDUCE. The list of experiments contains the ground based observations since 1993 to November 2009.

The UV data are already used in an operational service distributing the UV indexes and solar irradiances in real time together with ancillary meteorological parameters. Before ULISSE in 2010, there was no access of the public to the original data, available in the international 'flexstor' (ASCII) format.

The entire data set has been made available in 2010 for transfer on a dedicated ftp server located with the B.USOC data servers and procured by the project. However, a user-friendly interface is available to navigate through the dataset.

The metadata description is provided by the GeoNetwork tool, according to the ULISSE Metadata Standard. Metadata provides all information needed for data access and utilization.

2.2 ScienceCast

Knowledge management in ULISSE is based on the Topics Maps approach. The ScienceCast tool is a browser-based tool that supports:

- Editing topic maps and topic maps ontology's.
- Browsing and navigating through knowledge stored as topic maps.
- Natural language querying of information stored in topic maps.

ScienceCast is meant to support knowledge management processes and procedures while still providing a natural and flexible way to represent disparate sources of information.

ScienceCast is a stand-alone, web-based system developed to facilitate sharing, browsing and editing scientific research data. The system is a data browser and editor integrated with a natural language question answering component developed within the LINDO project, to allow users to query data in a natural way. The system front-end is implemented using SmartGWT, a Google Web Toolkit (GWT) frame-work with an extensive widget library, available under the LGPL licence. The client communicates with a java back-end through HTTP requests using JSON. ScienceCast provides a user account and authorization service.

The ScienceCast Environment allows to manage Topic Maps by managing the different features of a topic map.

- -Types, SuperTypes and SubTypes
- -Occurrences.
- -Names and Variants.
- -Associations
- -Instances.

The structure of a Topic Map is represented by an ontology; any subject in the knowledge domain ontology is represented by a topic. Each topic may have a type, structured in a hierarchy.

Each topic can hold extra information called occurrences. These are pieces of information about the topic similar to the paragraphs in a book that are referenced by the book index. Occurrences can be simple textual information or references to any other media (such as web pages, audio, video, etc.).

Topics of an ontology are linked through associations; each association is characterized by a name and other features, as multiplicity (number and types of topics to be connected).

Topic Maps technology also provides the ability to associate different topics, forming a structure that provides a way to navigate between the topics in the Topic Map.

ScienceCast allows the creation of the Topic map structure according to the desired ontology and its population through the creation of the instances of topics, occurrences and associations.

In addition, ScienceCast allows the user to query using a natural language dialogue window; the reply is presented in the form of the graph representing the part of the topic map linking the topic contained in the query and the instances that represent the answer.

2.3 GeoNetwork

The ULISSE version of GeoNetwork is based on the freshly released 2.6.1 version of GeoNetwork, open source tool available to the public. the main technologies that are used in GeoNetwork are:

- -Java server page: In order to be independent on platform, GeoNetwork is based on Java Server Pages (JSP) which provide an easy way for building a web application.
- -Database connection: GeoNetwork uses standardized interface for connection to database - Java DataBase Connectivity (JDBC).
- -Jeeves: All HTML or XML GeoNetwork's outputs are provided by Jeeves (Java Easy Engine for Very Effective Systems). Jeeves allows separation of presentation layer from logic layer. It uses XML as data internal representation and it uses XSL to produce HTML output.
- -Lucene search: GeoNetwork uses Apache Lucene (powerful full-text search engine library) for indexing and searching on metadata.

GeoNetwork has been customized to implement the ULISSE Metadata Standard. Metadata of all ULISSE experiments could be inserted using the GeoNetwork metadata editor and browsing is possible using the search user interface.

The tool is very useful for establishing a repository of XML files through a user-friendly interface; the tool allows also the user management, through a configurable accounting and authorization service.

2.4 SITools2

SITools2 is an open source framework currently developed by CNES and AKKA technology. The main scopes of the tool are to setup easily an archival system based on the Open Archival Information System standard (OAIS) and to federate the development in scientific laboratories. The key points of SITools2 are the following:

- implementing the data access layer part of the OAIS and its administration,
- modular approach allowing both the addition of new functionalities and a simple way to share specific development between developers,
- web API for querying the system via various ways: SITools2 web client or other clients provided by someone else
- an easy installation and configuration.

SITools2 is a client-server architecture based on REST (Representational State Transfer) architecture. The server, based on RESTlet, is composed of two APIs: one handling the administration capabilities of the system and another one handling the interaction with the users. At this level, a software client can interact with the system to discover data.

The chosen client is a RIA (Rich Internet Application) client based on AJAX technology, which offers a better interaction with the user because it is able to run asynchronous tasks.

SITools2 has been designed to handle large datasets. For this, several features have been implemented:

- Streaming and pagination of the response at the server side.
- Multi-threading management. RESTlet allows a certain number of concurrent threads. This number can be configured to prevent simultaneous access for large queries
- JSON as Exchange format. JSON has been chosen because this format is a structural format and less verbose than XML format.

SITools2 is proposed as standard tool for managing repositories of space data.

2.5 BEST

BEST is a data workshop relying on the EAST technology which consists in the following international recommendations:

- EAST (Enhanced Ada SubseT) primarily designed by CNES in the framework of CCSDS Panel II (CCSDS 644.0-B-1 and ISO 15889:2000). EAST is based upon the Ada language. EAST is designed to create non-ambiguous descriptions of data formats including syntactic (logical and physical) information.
- DEDSL (Data Entity Dictionary Specification Language) designed in the framework of CCSDS Panel II. DEDSL allows user to add semantic information to data by the means of semantic attributes. Two implementations are available: in PVL (Parameter Value Language), or in XML (eXtensible Markup Language).

The EAST/DEDSL technology has been developed to achieve the following major objectives:

- To provide complete, perennial, easily understandable and evolutionary descriptions of data formats, including syntactic and semantic information
- To provide engineers, scientists and end-users with generic tools for supporting the technology:
- To easily describe the data formats and make them evolve,
- To quickly produce test data independently from storage media,
- To access and extract the values of the data without having to write specific code,
- To format the data on their storage medium with a structure that matches their description.

2.6 Data Integration tool

The tool, developed by NLR, is aimed at comparing data from different sources. It is based on the PET (Packet Evaluation Tool) format that is a general purpose format based on a header in front of a comma separated value (CSV) format description of the data.

The ULISSE Data Integration Tool has been developed in the NetBeans environment. The main functionalities are:

- Select two or more experiment facilities (which may also be identical, in case the user desires integrate data from different instruments of the same facility).
- Select an instrument that belongs to the selected facility.
- Select a time frame for data selection for the selected instrument / facility.
- Select parameters that belong to the selected instrument / facility.

For the first version of the experiment data integration tool two instrument facilities within EuTEF are selected as a baseline.

2.7 Planning and Validation tool

The goal of the ULISSE Planning and Validation Tool (PVT) is to facilitate the USOC activities during the Increment Planning Process for ISS Payloads. Main elements of the tool are:

- PSS (Planning and Scheduling Service) which synthesizes flexible experiment plans and schedules (based on the Timeline Representation Framework);
- FVS (Formal Verification Service) which verifies correctness of plans (implemented through the Murphi model checker)
- P2VS (Planning to Verification Translation Service), which translates from a planning input specification to model checker input language
- PVS (Planning and Validation Service) which synthesizes flexible experiment plans and schedules and verifies their correctness (implementing sequentially PSS, P2VS and FVS);
- ProcVS (Procedure Validation and Verification Service) which validates and verifies onboard operational procedures that are used to carry out experiments automatically.

The optical checkout of the Fluid Science Laboratory on board Columbus has been selected as use case has been identified for the development and testing of the tool. A model of the facility has been generated: it consists mainly of possible facility states, allowed transitions between states and corresponding resources (as power, crew time, data link, etc.) required by each state; this information represents the needed input to the PSS, together with the goal to be reached and the applicable constraints and availability of resources. The facility model and rules are described using the Domain Description Language (DDL) while the goal and resources are described using the Problem Description Language (PDL); the .ddl and .pdl files are the input required by the PSS.

2.8 Augmented/Virtual reality tools

Towards visualisation ULISSE metadata, two different approaches are being studied.

Augmented Reality (AR) allows the combination of physical real-world data and computer-generated data, where computer graphic object are blended into reality in real-time. In the context of ULISSE an AR viewer enables the visualisation of 3D models of an experiment platform or facility in a physical environment. A printed marker pattern in the view of a camera guides the rendering of 3D data into the camera view. That allows an intuitive exploration of 3D models in combination with real physical models. The AR Realtime Interactive Filter Tool (ARRIFT) has been implemented; it uses a camera setup and markers to integrate data.

Virtual Reality (VR); the VR Locator tool (ViRLoc) is a location-based approach for presentation of ULISSE (meta-)data in 3D virtual reality models. ViRLoc has different viewer modes. One mode using a GlobeViewer allows, for example a quick location-based overview of different USOCs, who are involved in a certain research topic. Another viewer mode of ViRLoc can be used to replay datasets in combination with a 3-D visualization of the Space platform position.

Because of the complex rendering process of 3D content and the processing of real time video data, ViRLoc is provided as standalone client at user's end device. The client tools should be available by downloading from the ULISSE platform. The ULISSE data are obtained by requests to ULISSE RESTful web service. ViRLoc provides three main features:

- The ISS Positioning Viewer; this mode supports the visualization and animation of ISS positions at a certain time range. When a position file is loaded, the corresponding performed ISS experiments are loaded and displayed as link in the menu. After clicking on the link, detailed information about the experiment appears in a separate window.
- 3D model viewer; this mode is a generic viewer to load and explore 3D models within a 3D space. The viewer also supports interactive models, which map the models geometry to its semantic meaning. The ViRLoc Demonstrator enables an interactive 3D model of the Biolab.
- Augmented Reality viewer; it is a generic viewer to load and explore 3D models in physical reality. The viewer provides marker-based tracking which allows the computation of the inverse cameras position and orientation. Resulting from this, it is possible to locate a 3D model or other synthetic information on the computed position to overlay the camera image.

3. ULISSE Platform

The ULISSE Platform is the back-end on which various tools are built. It exposes a set of services that can be used by those access the data and metadata of the experiments that ULISSE contains.

The ULISSE Platform that has been delivered at the end of the project consists of:

- A three-layer software component, which implements the services of the ULISSE Platform.
- A software layer implementing the ULISSE Platform API.
- A Knowledge Base (the ULISSE Knowledge Base) storing experiment metadata and scientific discipline metadata.

The Platform has been designed in order to implement an integrated services architecture. In particular a middleware layer to integrate distributed heterogeneous resources has been designed on the basis of the identified user needs:

- Identifying and analysing the existing resources and existing data, defining associated services and available interfaces.
- Identifying new classes of services and additional resources which will be useful to implement a cooperative approach.
- Identifying the service flows for fruition of the domain knowledge represented in the KB as Topic Maps formalism.

The ULISSE middleware platform is based on a 3-tiers architecture, composed of:

- Acquisition Services Layer
- Integration Services Layer

- Management Services Layer.

The Acquisition layer ensures the interface standardisation with heterogeneous information sources establishing a common communication protocol with respect to the integration layer. So the system is really modular and this approach proves very effective in case that an additional source would be integrated.

The Integration layer, interfaced to the acquisition layer, receives and organizes the information associated with the sources. The information organization is accomplished through an explicit representation of the services which need that information.

The Management layer guarantees the access to all the services of the system. The services are defined at this level and they are activated at this level on the basis of the resource availability and users requests.

A dedicated Application Programming Interface (API) has been defined to manage the interface development. The Representational State Transfer (REST) Framework is the basis for the interaction between the platform and components of ULISSE system.

3.1 Architecture

The ULISSE Platform has been designed and developed following the principles both of the decoupling and of the REST architecture.

The decoupling of software is realized both by the distribution on functionalities on multiple layers and by the modularization of functionalities and responsibility in each layers.

The advantages of this approach can be easily summarized:

- The communication among the layers is possible by well-defined REST API, in this way it is possible to replace modules without affecting the interfaces (API) that allow access to them;
- Increase the software maintainability - the different software blocks can easily maintained (without strong impact on the other software blocks) in order to:
- correct defects;
- meet new requirements;
- make future maintenance easier;
- cope with a changed environment;
- reduce the risk of malfunction in one part of the system when another part changes.

The three layers of ULISSE Platform can be deployed both as an unique component or as three different components and possibly installed on three different servers.

In the first case, the communication among the layers uses the RIAP protocol in order to avoid the unnecessary overhead of the communication due to HTTP protocol; otherwise, their communication uses the HTTP protocol.

3.2 The Management Service

The Management Service acts as gateway to the platform and handles the user requests.

In the current version of the Management Service, the software module “Integration Client Resource” is the interface of Integration Service, this means that this software module manages both the ingoing and outgoing messages with this layer.

The Management Service allows the accessing to the ULISSE services according to the defined data policy; this explains the presence of

- A database (LDAP server), that is not a component of ULISSE Platform but it is necessary to store the user credentials.
- Guard and Filter modules to filter the accessing to services based on the user's profile and access rights.

The ULISSE data policy requests the user authentication only for the accessing to the data files, then the current implementation of the software modules 'Guard' and 'Filter' is very simple but they have been designed to manage more complex criteria of data policy in the future.

In current version of ULISSE, the data policy follows these steps:

- When the ULISSE user asks for the data files, the Management Service verifies the user authentication:
- If the user is not authenticated the Management Service asks for authentication
- If the user is authenticated the Management Service verifies the credential for accessing to the requested file.
- If the user has the right to access to the requested files then the download of the file starts
- If the user does not have the credential to access to the requested file then the form to request the accessing to the file is shown.
- If the user does not have an ULISSE account then the form to request the accessing to the file is shown.

The data policy envisages that the granularity of the accesses is managed at level of the single experiment; this means that currently the access authorization concerns the whole set of data files of an experiment. However, the system can support also a granularity at the level of the single data file.

3.3 The Integration Service

The Integration Service is composed of:

- The software module 'Router' - that invokes the right service in response to the request coming from the Management Service;
- A set of modules dedicated to the implementation of the services, which presently include the software modules 'Searching', 'Browsing' and 'Practical Explanation', 'Data Access' respectively for searching, browsing, practical explanation services and access to the data. The 'Data Access' module includes the sub - module 'Data Policy'; even though the current data policy does not strictly require the presence of this

software module because the accessing rights are managed at level of single experiment dataset, it has been included because in the future implementation of ULISSE platform the data policy could require a management of accessing right at level of single data file. In this case, to valuate the right for accessing to the data files would need both the information about the user (stored in the LDAP server and available by the Management Service) and the information about the data file (stored in the Knowledge Base and available by the Integration Service).

The software module 'Knowledge Base Client Resource' dedicated to the integration with the Knowledge Base. These modules represent the interface to the Knowledge Base and implement the following steps:

- Composition of the TOLOG queries;
- Sending of the query/ies built in the previous step;
- Parsing the answer coming from the Knowledge Base;

The module 'Acquisition Client Resource' dedicated to the interfacing with the Acquisition Layer. This module sends to the Acquisition Service the path of data that the users are asking for because this information is stored in the Knowledge Base.

3.4 The Acquisition Service

The Acquisition Service Layer allows to access the data associated to the experiments and to use the data according to the requested service.

The actual version of the Acquisition Service consists of the client to the REST interface of the data source that is made available by SiTools server, which has been recognised as standard repository management system in ULISSE; anyway the Acquisition Service can be enriched with the clients of the other type of server.

The Acquisition Service checks if the requested file belonged to the ULISSE's web addresses space, in this case, it provides the translation from the public address to the private address in order to access the data file.

3.5 The Knowledge Base

The Knowledge Base is based on Ontopia, an open source, Java-based Topic Maps engine. For external communication, it uses Tropics which is a Representational State Transfer (REST)-based layer on top of Ontopia.

The ULISSE Knowledge Base consists of three core components:

- DB: A relational database used for persistence of topic maps.
- Ontopia: A Java-based Topic Maps engine.
- Tropics: A REST-based layer on top of Ontopia for remote access to the contents of the ULISSE Knowledge Base. As Tropics is the only visible core component outside of the ULISSE Knowledge Base, the name Tropics will be used hereafter to refer to the combination of the three core components as the core software item.

And one additional utility:

Locksmith: A synchronization tool for automatic conversion of metadata descriptions in GeoNetwork to topic maps for storage in the ULISSE Knowledge Base.

4. Demonstrator

The prime objective of the Demonstrator is to allow the utilization of the main functionalities and resources of ULISSE in a unified context, with the involvement of the public, implementing realistic use cases that are representative of the main user needs, with the purpose of testing the infrastructure and evaluating the performances of service provision with particular attention to the fulfillment of the user expectations and the implementation of the identified innovative aspects. Demonstrator sessions are also the opportunity for collecting feedbacks from external users for future improvement of ULISSE.

4.1 Demonstrator functionalities

The main functionalities integrated in the ULISSE Demonstrator are:

- on-line management and distribution of metadata, including creation, editing, releasing, searching and browsing of metadata (GeoNetwork/ScienceCast/Searching and Browsing)
- online controlled access to experiment data stored in remote distributed repositories in compliance with data policies (Portal authentication, SITools, user accounting and authorization)
- guided search capability (Searching and Browsing)
- semantic-based interdisciplinary searching (ScienceCast)
- data integration capability from different resources (Data Integration tool)
- Support to planning and validation of experimental sequences (Planning and Validation tool)
- provide software services to support the USOC's in their role as data custodians (GeoNetwork, SITools)
- advanced metadata visualization with AR/VR techniques (ViRLoc)
- support to education (Practical explanation service)
- outreach toward the community and new European research projects (Promotional portal to the general public)

In addition to that, an online questionnaire was prepared to gather user feedback during the demonstrator sessions.

Most of the experiments of the ULISSE catalogue are subjected to the ESA data policy; for this reason, access to data for the demonstrator purposes has been discussed with representatives of the ESA Human Spaceflight and Operations (HSO) Directorate. A subset of experiments has been identified as representative of different disciplines and data typologies; data of this subset could be accessed and displayed to the public with the authorization of the ESA HSO Director.

4.2 Demonstrator implementation and integration

Due to the different technologies used for the different components we have opted for a reverse proxy scenario where multiple ULISSE server applications running on a single server or on multiple servers inside of a LAN can be reverse proxied as to appear as a monolithic system to the WAN (Internet) and hence to the client/user.

An LDAP server has been set up to meet the requirements imposed by ESA and the local data policies on user authentication. All application resources can be granularly granted access to by the ULISSE LDAP administrator (TPZ Napoli, ETH Zurich). The LDAP tree structure allows for a sub-tree synchronization to the USOC sites through the ULISSE VPN network. Thus each USOC can control the access to the local data sources. All technologies and structures used here are fully compatible with the ESA USOC infrastructure.

LDAP controls the user access also to the tools, with the exception of GeoNetwork and ScienceCast, which have their own authentication services, administrated respectively by CNES and TPZ and by SpaceApps.

The ULISSE Administration comprises resource and user administration via phpLDAPadmin that is configured and skinned to meet the ULISSE demonstrator needs. The resource is on the one hand protected on the reverse proxy level and on the other hand by its internal user management, both of which are represented on the LDAP server.

The Demonstrator relies on a network that ensures secure connectivity between five European USOC/data providers and one gateway centre. The connected data providers are:

- B-USOC, located at the Royal Observatory of Belgium in Brussels
- SRC PAS, located at Space research Centre in Warsaw
- MUSC USOC, located at DLR premises in Cologne
- MARS USOC, located at Telespazio Naples site
- E-USOC, located at UPM in Madrid

The Gateway Centre is located at Telespazio premises in Rome. It hosts the platform with the related Knowledge Base and the tools.

The data providers nodes are connected to the 'ULISSE Gateway Node' using Internet and a Virtual Private Network (VPN). The Promotional Web Portal (provided by MEDES) and the Questionnaire server (provided by ETH) were reverse-proxied through the Internet. Only the 'ULISSE Demonstrator Gateway Node' provides Internet access for the External End User through Secure WEB capabilities. The Network is monitored with dedicated tools.

4.3 Demonstrator deployment and users' feedbacks

A preliminary version of the ULISSE Demonstrator has been implemented at the conclusion of the second year of the project and deployed at the 7th Space Weather Week (Bruges, November 2010). The final version of the Demonstrator has been implemented as scheduled and deployed at:

- ELGRA Congress (Antwerp, September 2011)
- Bilateral Polish-Russian Meeting on Space (Olsztyn, November 2011)
- POPDAT project progress meeting (Warsaw, November 2011)
- Kiev University 'Taras Schevchenk' (Kiev, November 2011)
- 8th European Space Weather Week (Namur, November 2011)

A total of 30 questionnaires has been collected during the Demonstrator sessions. the limited number of collected questionnaires prevents a real statistical analysis; however, the typical deviation of the answers is rather small and the following indications can be clearly drawn:

Positive indications:

- The mean of all scores is 4,24/5, indicating a general appreciation of the work done
- Contents are considered meaningful (not redundant) and representative of the space domain; this outcome is an indirect appreciation of the ULISSE metadata standard
- Attendees find generally that ULISSE is usable, indicating that it is effective in getting access to scientific data, through different tools
- The format of the contents presentation is found satisfactory; this aspect is not trivial, considering the large amount of information related to each space experiment
- Almost 100% of replies indicate ULISSE extremely useful; this feedback confirms definitely the need of a data e_infrastructure for space research

Aspects to be improved:

- Amount of space experiments presently contained in ULISSE is sufficient for demo purposes only; it is recognised the need of completing the set of performed and ongoing space experiments as a pre-requisite for the deployment of services to the users
- Replies indicate that the graphics of the Portal could be more attractive

Main general comments received by the users are:

- the importance of space data preservation and accessibility in the long term is acknowledged
- ULISSE is deemed very useful for space research and also ground-based studies; potentiality of ULISSE also for education is recognized

Scientists are willing to have access to data of other experiments, and sometimes limitations as those imposed by the ESA data policy in accessing data of other experiments are considered restrictive and an open access is required.

On the other hand, scientists are not willing to share "their" data that often are considered as their own property. Most of scientists would like to be involved in the future re-use of the data of their experiments (pursuing possible cooperation with the new users of the experiment data for publications or research actions).

Also, scientists are not willing to spend any effort to produce archives and metadata.

This feedback confirms:

- the role of public institutions, such as EC and ESA, in driving scientists toward a more cooperative approach (ie adoption of a sharing philosophy) through adequate policies that would motivate scientists in sharing data and knowledge
- the need of a support infrastructure for the service provision as that one represented by USOC network.

International cooperation between space agencies is recommended to develop a standard approach to knowledge representation and to data policy as well as to ensure global coverage As first achievement of ULISSE on the subject, the implementation of the Demonstrator has stimulated the involvement of ESA in the development of processes for an effective implementation of the data policy. Moreover, representatives of NASA, JAXA UN and research institutions expressed interest in the initiative and are looking for possible cooperation with Europe to exploit this experience. Then, there could be the opportunity to promote an international cooperation on preservation of space data in which Europe may have a driving role. Such an infrastructure would also yield to further, initially unexpected opportunities of exploiting the results of space research in the context of the cooperation with developing Countries.

Potential Impact:

1. Potential impact of the project

1.1 Strategic impact

The domain of space experimentation on board the International Space Station (ISS) is not supported by any data e-infrastructure; the current scenario of space operations for ISS does not foresee any supporting tool or even a best practice for the preservation and exploitation of scientific data beyond the horizon of the usual data analysis activities performed by the investigators who are responsible for their own experiment.

In this context, the ULISSE project has produced a very relevant strategic impact that is summarised below.

Following the ULISSE Demonstration sessions and related dissemination activities, the scientific community involved in ISS research has acknowledged the value of preserved data from past space experiments as an asset for the research. It is worth noting that even during the relatively short Demonstration sessions some scientists have identified specific cases of relevant re-utilization of scientific data from past experiments in Physical Science.

The need for an infrastructure able to ensure the preservation and exploitation of scientific space data of ISS has been clearly stated by the potential users during the requirement assessment performed at the beginning of the project and confirmed two years later in the feedbacks collected at the Demonstrator sessions.

During the ULISSE Demonstration sessions, scientists confirmed that they are willing to use a scientific data e-infrastructure as ULISSE; At the same time, scientists provided the clear indication that the scientific community cannot sustain the non-negligible task of establishing and operating such an infrastructure. This outcome confirms the necessity of:

- support entities like the USOCs that, for their role in the execution of space experiments, have the required competences and access to the data and related documentation;
- an institutional support for establishing and operating a data e-infrastructure.

ULISSE has then identified the need for a coordinated intervention of all the relevant stakeholders.

To this reference, ULISSE has pursued opportunities to enforce international exchanges and cooperation between institutional entities such as space agencies. The German and French Space Agencies (members of ULISSE) have already started national programmes on data preservation and exploitation and ULISSE provided the opportunity to share their achievements on an European scale, through the involvement of the USOC network and other space agencies, as the Italian Space Agency, which have followed the progress of the project.

In this context the case of the European Space Agency (ESA) deserves particular consideration. During the project meetings with representatives of the Human Spaceflights and Operations (HSO) Directorate of ESA have been held regularly; as main outcome, HSO

has recognised the need for pursuing preservation and exploitation of ISS data, implementing already the following actions:

- supporting the ULISSE implementation by authorising the use of data from ESA past experiments in the Demonstrator
- Starting the definition of an internal process to sustain the data exploitation
- Evaluating the possible use of some of the ULISSE achievements for the ESA Long Term Data Preservation (LTDP) initiative

Moreover, ULISSE has highlighted the specific role of the space agencies in steering the scientific community toward a fully cooperative approach for data sharing and re-use. In this perspective, a possible impact of ULISSE actions would include:

- a review of the legal agreement between space agency and scientific investigators for the implementation of a space experiment to upgrade rights and constraints for data utilisation
- the improvement of the data policies to promote access to data while protecting intellectual property rights

Therefore, ULISSE has paved the way to the establishment of a data e-infrastructure for ISS, stimulating and involving all the main stakeholders, defining the main requirements and specifications, demonstrating the feasibility and the usefulness of such an infrastructure.

1.2 Global impact

ULISSE Consortium has given a specific attention to integration and knowledge exchange with the new member states in the eastern part of Europe, through the direct involvement of Space Research Centre (SRC) of the Polish Academy of Science. ULISSE, with the support of SRC, has promoted coordination actions with respect to other member states in Eastern Europe for their joining the ULISSE project, for integration of relevant data and exchange of information.

In addition, as confirmed by representatives of the space agencies of US, Canada and Japan, no programme on ISS data preservation has been undertaken yet by those agencies; therefore, through ULISSE, Europe may play a prime role in a possible (and advisable) international cooperation with the other Countries participating in the ISS programme.

Moreover, in the context of education, a platform like ULISSE could provide a relevant support to international formation programmes allowing low cost access of students from developing Countries to the knowledge and expertise generated by ISS activities.

1.3 Impact on standards

ULISSE has contributed to the further development of standards for Topics Maps technology; a member of ULISSE Consortium has participated to the meetings of the ISO/IEC JTC1/SC34/WG3 (a working group of SC34, which itself is a subcommittee of Joint Technical Committee 1 of the ISO and IEC). Main contributions concern finalizing ISO

19756 (TMCL - Topic Maps Constraint Language) and drafting ISO 18048 (TMQL - Topic Maps Query Language).

Moreover, ULISSE has developed a common structure of metadata proposed as standard for all space experiments; this ULISSE metadata standard is expected to ensure the interoperability of the repositories related to different scientific disciplines.

Finally, ULISSE has contributed to the development of SITool2. This tool is freely available and is proposed as standard tool for managing repositories of scientific data.

1.4 Socio-economic impact

Data re-use would increase scientific productivity and the return of investment sustained for space experiments. It is worth noting that the establishment of a data e-infrastructure for ISS as that one depicted by ULISSE, would be very efficient because it would make an optimal exploitation of the existing USOC network as part of the ground segment for ISS mission; such an infrastructure would lead to a reduction of specific cost of experiment result (cost per publication or patent) with only a very marginal increase of total costs for space experimentation (of the order of 1% or less).

The use of semi-formal knowledge representation and of semantic technologies allows also those users that are not acquainted with the ISS research domain to access the information in an easy and natural way; the previous knowledge of specific information (as on space missions or experiments) is not necessary any more for retrieving the data of interest. As a consequence, a much wider public (as members of the scientific community not involved in space research or general public as well) may become a user of space data.

In addition to the general public, a major impact has been recognised for education; the knowledge captured in the ULISSE Topic Maps can be used to construct dynamically explanations of phenomena or instruments, linking also these explanations to experiment data for a better comprehension. These features allow a fundamental level of knowledge transfer from space specialized research to students.

ULISSE experience and technology can be easily exported to other knowledge domains.

A common representation of the specific domain, through semi-formal knowledge representation languages and through the development of domain ontologies for a structured data representation and semantic coherence, would allow the integration of different pieces of information enabling the possibility to deploy new services for the users.

This possibility may be envisaged in many fields of public interest, as monitoring and management of natural resources, climate monitoring, transportation, just as examples.

Moreover, ULISSE has proven that the adoption of standardised knowledge representation enables the association between different disciplines and knowledge domains; pursuing this feature on a larger scale would multiply the opportunities for re-use research results also for applications.

2. Dissemination of results

The dissemination activities of the project aim to provide awareness of the project to the scientists and to the general public throughout the European countries (including new members) by:

- Promoting ULISSE tools and services (effective exploitation of the data of space research with acquisition, access, sharing, collaboration)
- Enhancing the awareness of the public in the contribution of space investigations.

The main targets of the dissemination are the scientific community (both involved and not involved in space research) and the general public.

Specific dissemination tools have been developed:

- a project logo
- a project brochure
- a set of posters describing space experiments and the project
- a dedicated project web site with a dedicated domain
- a promotional portal

The dedicated project web site describes the project context and main objectives, the research fields involved, the project partners and activities.

The promotional portal has been developed in 3 languages (English, French, Polish); its main features are:

- E-collaboration portal based on recognized open source CMS technology (Content Management System - Ametys).
- Targeted towards the general public and potential users.
- Any user can submit an article, a subject or a question.
- Validation process: articles completed and validated by a network of experts.
- No need for a specific background to submit an article or to administer it.
- Contents edited in a content editor similar to a simplified 'Word'.
- Administration tool to manage the site, the contents, the questions of users, the professionals able to validate or update content…
- Authentified / secured access for administrator, authors…

Moreover, dissemination activities include publications, participation to public events and publication of a book to support education and formation in the space field.

A Scientific Board formed by distinguished scientists of all the main disciplines related to ULISSE has been established in the first year of the project ton give advice on the preparation of the book.

The participation to events has also included specific events for the presentation of the ULISSE Demonstrator to the scientific and general public.

ULISSE has contributed to enhance the awareness of the general public on the relevance of the space investigations for our knowledge on the earth, universe and environment through:

- Implementing the promotional web portal. The promotional portal shows the links between life and the environment (Earth or Space), the similarities between the life of any citizen on Earth and life in space and the benefits of space research in daily life on Earth. Showing also how life in space can be considered as a model of hyper-sedentary lifestyle, the Portal contributed to promote the need for physical activity, good nutrition and more generally for a healthy lifestyle. Space research is presented to promote information of the public on scientific and technological research, always explaining the potential terrestrial application of the space research. The Portal will allow any user to submit a question or an article. The article will be published once corrected, completed or just validated by the reference experts.
- Organising specific press events and communicating with journalists to ensure publications in journals and magazines papers with a large distribution, as the CNES Magazine.
- Organising nine events targeted to the general public and to the youngest, with the participation of astronauts, as in November 2009 in Toulouse, two events in Rome and two in Warsaw in 2010 and 2011.
- Organising three events and communications towards teachers and students, as the seminar in Rome in 2010 and the two Respiratory Event in Copenhagen.
- Publishing the book 'Laboratory Science with Space Data' (published by Springer) to support professors for preparing university courses on space engineering and space research. The dissemination of the book has been started within the project and about 400 copies have been distributed to researchers and students members of ELGRA (European Low Gravity Research Association) and several hundreds copies have been distributed to universities and space agencies.

ULISSE has disseminated the project achievements toward the scientific community through:

- contributing with lectures to 24 scientific congresses
- publishing a total of 38 scientific papers on Conference Proceedings and scientific journals and books

Further dissemination has been pursued even after the conclusion of the project period, participating to the Space Conference organized by EC in Brussels in 2012.

3. Exploitation of results

In the first year a sustainability analysis has been performed to identify possible ULISSE services/products and related sources of funding. The analysis has indicated that:

- data cannot be commercialized straightforwardly, being a third party property;
- only a part of the interviewed potential users are willing to pay a fee for data provision; corresponding income would be marginal with respect of the infrastructure costs;
- public partners of ULISSE (as DLR and CNES) cannot participate in commercial enterprises, being this activity domain excluded by their mission;
- several commercial services could be supported by a platform like ULISSE (as, for instance, advertisements of scientific instrumentation or laboratories, networking for space companies in support of teaming-up for ESA or EC Invitation to Tenders)

As a conclusion, the analysis has indicated that:

- an e-infrastructure for scientific data preservation and exploitation represents mainly a tool for research and a service for the citizens in valorizing the public investment in space research; consequently, public funding sources are needed for its establishment and sustainment;
- such an infrastructure could be the driver for a number of commercial services, which should be pursed possibly through spin-offs or well-designed public-private cooperation, in order to cope with the statutory mission of public entities.

On these bases, in the second year the following guidelines for exploitation have been defined:

- public stakeholders of the space field, as space agencies and research ministries, may support the continuation of the ULISSE “core” activities after the completion of the present Grant. In this perspective, ESA has been identified as representative stakeholder to explore possibilities of future exploitation.
- Further development has to be envisaged for the provision of additional services also through the implementation of additional technologies. To this aim, EC FP7 Calls may offer a real support; more specifically:
- FP7 Calls on Space may offer the opportunity of exploiting space data (through ULISSE) in specific research projects;
- FP7 Calls on ICT-Infrastructure may offer the opportunity for implementing a permanent infrastructure, developing new services and implementing new technologies

According to these guidelines, in the second year the following proposals have been submitted by members of the ULISSE Consortium:

- ULISSE participates in 2 proposals submitted to the FP7-SPACE-2011-1 Call;
- The 'ITHACA' proposal has been submitted to the FP7-INFRASTRUCTURE-2011-2 Call for the future ULISSE services upgrade and for the establishment of a permanent infrastructure for the continuative provision of services to the users based on the valorisation of scientific data; the proposal has been evaluated positively, but its score is not sufficient to get access to funding.

In addition, bilateral meetings with ESA representatives have been held regularly till the end of the project.

In the third year the 'CIRCE' proposal for a coordination action has been submitted to the FP7-INFRASTRUCTURES-2012-1 Call; the proposal has been approved.

ULISSE experience is going to be exploited also in the FP7 POPDAT research project.

The possible follow-on of ULISSE has been presented to the scientific board (PSWG) and delegates board (EUB) of ESA for their endorsement and possible inclusion into the ESA future activities.

An exploitation plan has been defined, having the following objectives:

- pursue the exploitation of ULISSE platform

- pursue the commercial opportunities for tools and services derived from ULISSE

To this aim, the following strategy has been identified:

- Sustain the operability of the ULISSE Demonstrator at least in 2012 and possibly later
- Make the important core and key generic elements of the project open, reusable and accessible to a wide audience
- Retain some IPR with partners for commercial exploitation in other more commercial and richer markets

List of Websites:

The ULISSE Demonstrator is not public; it can be made accessible to a restricted audience upon authorization.

The project website is public and reachable at: http://www.ulisse-space.eu