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Environmental Monitoring Digital Library: Improving the Accessibility of the Russian Satellite Data

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Abstract

The main goal of the paper is to research techniques aimed at improving the accessibility of Russian Satellite Remote Sensing data. There are currently several large-scale efforts to build the distributed Digital Library of Space Data as comprehensive information Internet-based management system. Digital Library that is planned to provide: access data, search data, dissemination the resulting data.
For many years Russia has been carrying out an extensive programme of Earth Observation using a range of satellite remote sensing instruments. Relevant missions include PRIRODA-MIR, RESURS and METEOR. However, despite the large volumes of Russian datasets generated by these systems they are not exploited as much as they could be, especially outside Russia. It is important that such potentially useful datasets are utilised to the maximum extent possible in order to achieve maximum cost effectiveness from the previous space investments and to justify future expenditure on new and continuing programmes. Improving the accessibility of Russian satellite data could make a very substantial contribution to Environmental Monitoring and Natural Disaster mitigation. The goal the creation of Digital Library is to build a Web-based information system that is loaded with Earth Observation data sets as well as tools to help user access the Earth Observation data.

1. Global Infrastructure of data and Russian Remote Sensing Satellite data

Today, Digital Libraries of satellite data are being created in several countries in support of Earth investigation programmes. These national information systems use satellite data flows to deal with various problems of Remote Sensing.
For many years Russia has been carrying out an extensive programme of Earth Observation using a range of satellite remote sensing instruments. Russian satellites have collected large volumes of data over the years, and exploitation of this data World-Wide Web could have a wide variety of uses, notably environmental monitoring and natural disaster mitigation (Kudashev 2003a), **(**Kudashev 2001a), (Kudashev 2001b). Due to activities such as IGOS (Integrated Global Observing Strategy) and DMSP (Disaster Manager) there is a need for a global infrastructure of data. GMES (Global Monitoring for Environment and Security) aims to link major satellite and surface based systems for global environmental observations of the atmosphere, oceans, land and biota. For Russian data to be considered as part of this, it needs to be accessible, linked to, and interoperable with, other national and international information systems. However, despite the large volumes of data generated by these systems they are not exploited as much as they could be, especially outside Russia. It is important that such potentially useful datasets are utilised to the maximum extent possible in order to achieve maximum cost effectiveness from the previous space investments and to justify future expenditure on new and continuing programmes. The creation the distributed information resources uses the Information society' technologies (See Fig. 1).

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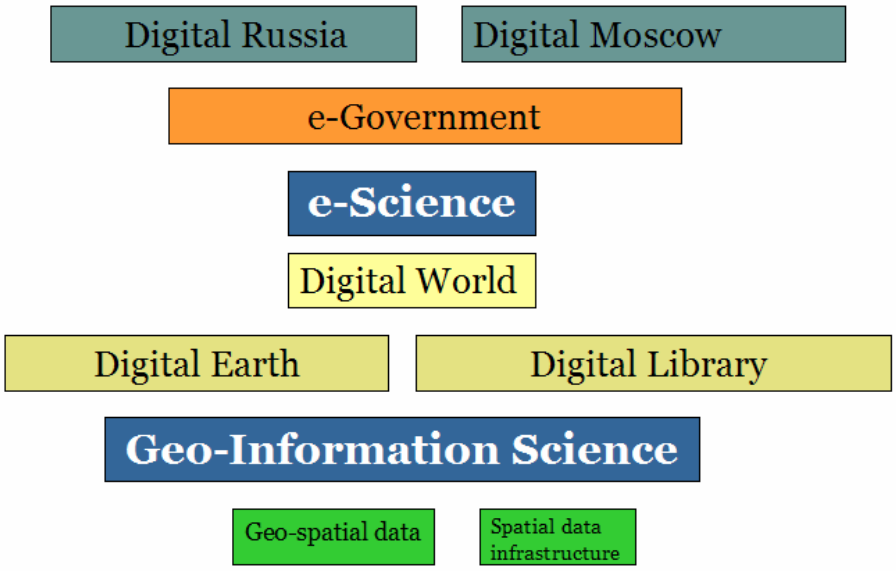

Fig. 1: Information Society Programmes

The INTAS Project IRIS (**I**ntegration of **R**ussian Satellite data information resources with the global network of Earth Observation **I**nformation **S**ystems (IRIS) activity is linked to ESA's INFEO (**Inf**ormation on **E**arth **O**bservations) and is aimed at increasing international cooperation. Access to satellite datasets archived at the IRIS is achieved through INFEO Data Gateway http://iris.iki.rssi.
The main aim of IRIS project is to improve the accessibility of Russian satellite remote sensing data, and to make recommendations for the further development of regional satellite archives in Russia.
A number of objectives have been defined, including generating Russian satellite information resources, linking with the European INFEO (metadata/ catalogue) system in order to provide interoperable catalogue access and ensuring that end users are involved. Digitisalisation of datasets, data processing and data storing have had a major impact on the world. Establishing a Geo-Information Infrastructure SDI (Spatial Data Infrastructure) aims at making infrastructure on integration on the basis Web services and XML. SDI supports global access to geographic information achieved through co-ordinate action by nations and organizations, common standards and development and availability of interoperable digital geodata and technologies. Abbreviation SDI stands for a special kind of infrastructure for an acquisition, processing, management, maintenance, and distribution of geo-spatial data. SDI provides Web-based discovery of geospatial content. Data sharing is a key purpose of SDI.
Thus compatibility between SDIs is necessary. Compatibility requires use of common standards. SDI provides to harmonize data, services and procedures, and to promote modern information technologies and spatial data uses. INSPIRE strategy, which show on the figure 2, aims on creating large-scale interoperability on the European level between national datasets.

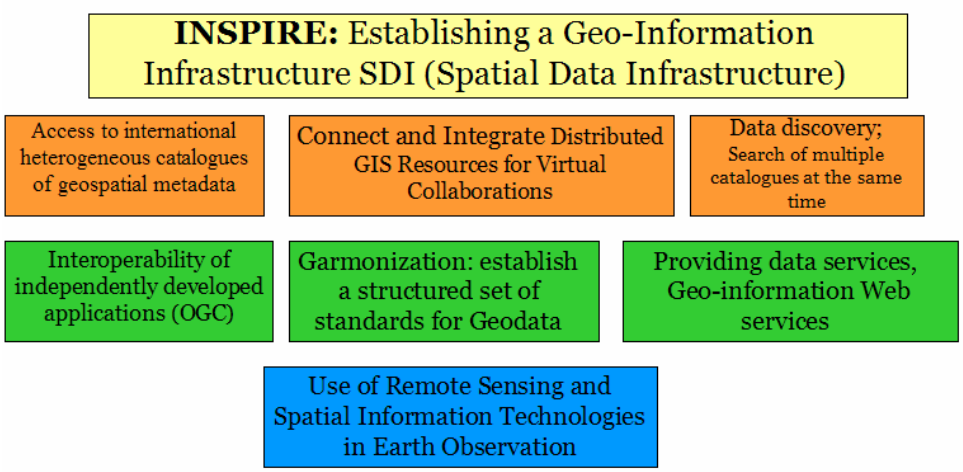

Fig. 2: INSPIRE programme

2. Infrastructure solutions for Space Environmental Monitoring

Developments in GIS and WWW technologies are providing new tools for finding and retrieving data over computer networks. Efficient organization of Remote Sensing Archives and open access to Data Bases are founded on the Web technology (access to data including data search and request). The development of satellite natural-resource information software targets the following problems: Real Time Earth Observation, thematic processing of Remote Sensing Data and filling in of the Digital Archive, ecological monitoring of the environment, ecosystem condition evaluation through space techniques, access to hydrometeorological data from around the globe.
Digital Libraries of Remote Sensing use satellite data flows to deal with various problems of Remote Sensing posed by both scientific community and specific industrial needs:

- The structure and generation of Russian satellite information resources (including database generation, archiving, metadata generation and catalogue creation).

- Linking regional satellite archives for acquisition, processing and distribution of remote sensing space data in a consistent manner to provide interoperable catalogue access and data delivery over the Internet.
- Integrating Russian satellite data information resources with the European INFEO system and other international networks of Earth Observation information systems (e.g. EOSDIS in the USA and EOIS in Japan).
- Ensuring end-users of the satellite data are involved in the project to ensure that the research is well directed and addresses the issues of concern to data users, particularly in the fields of environmental monitoring and natural disaster mitigation.
- Linking existing information dissemination and teaching activities to ensure efficient propagation of the results to a new generation of scientists.

There are 7 partner organisations involved in the project, 1 from the UK, 1 from Italy and 5 from Russia. The Partners involved in the project were: IRE (Institute of Radio Engineering and Electronics, Moscow) http://www.ire.rssi.ru/cpssi/cpssi.htm, IKI (Space Research Institute, Moscow) http://iris.iki.rssi.ru, Forest Institute (Krasnoyarsk) http://www.krasn.ru/Forest, IAPU (Institute Automation and Control Processes, Vladyvostok) http://www.dvo.ru, Faculty of Geography, MSU (Moscow State University). Coordinator: Space QinetiQ (UK) http://www.space.qinetiq.com. TERMA Electronica (Italy).

The IRIS is a consortium of researchers working together to develop distributed Digital Library for geterogeneous Earth Science Satellite Data. The tasks of IRIS Project are:

- Improvement of the infrastructure of archive and data exchange systems for processing and distribution of optical, IR and microwave information.
- To identify shortcomings in current technologies and provide inputs into the ongoing work of standards and co-ordinating bodies such as ISO TC211, CCSDS Panel2 and CEOS (Committee on Earth Observation Satellites).
- To create new information databases and information services using the experience databases of IKI, IRE, IAPU and Institute Forest, of covering unique multi-year (1974-1994) optical and microwave aircraft and satellite measurements in North-West Pacific (IKI) together with similar data collected by IRE over the territory of the former Soviet Union and Europe.
- To determine how best to provide users with prompt ecological and meteorological information available for environmental protection.
- To investigate the forecast methods for natural and technogenesis phenomena based on optical, IR and microwave information from RESURS and METEOR satellites, in particular, forecast methods for large-scale atmospheric phenomena (e.g. hurricanes).
- To determine how best to integrate Russian archives to create a Digital Library based on the concept of an interoperable distributed archives.

3. From Data Bases to Digital Library of Remote Sensing Data

With item "improve the accessibility of Russian satellite remote sensing data", it was recognized at the start of IRIS project that developments in Geographic Information Systems (GIS) and World-Wide Web (WWW) technologies were providing new tools for finding and retrieving data over computer networks. However, it was not clear at that time how best to exploit these new tools in the field of satellite Earth Observation in the Russia.

The specific objectives of the project in this area were to investigate issues concerning i) the structure and generation of Russian satellite information resources including database generation, archiving, metadata generation and catalogue creation; ii) catalogue access and data delivery over the internet; iii) integrating Russian satellite data information resources with the European INFEO and global network of Earth Observation information systems EOSDIS (Price, 1994), (Schwaller / Krupp, 1994). All these objectives were pursued and successful results obtained in IRIS system. In particular, some new catalogue databases were created and existing catalogue systems were reviewed and updated to conform to international standards. Web-page servers have been established to allow these catalogues to be searched through bi-lingual interfaces. High-level dataset descriptions were created and submitted to the International Directory Network (IDN). Data users are now able to search the IDN and become aware of the existence to the Russian datasets. Once discovered, the users can then access the specific websites to carry out more detailed searches and order the data required. In addition to the general cataloguing and establishing web access, two of the partners have installed "INFEO gateways". This software package allows the associated catalogues to be connected to the international INFEO catalogue searching system. Data users are now able, through a single entry point, to enter searches to all the associated catalogues around the world and see search results from Russian catalogues if they satisfy the search criteria. The success of this work has been reported through papers in scientific journals and at conferences (Kudashev 2003b), (Kudashev /Balashov 2003). However, the true success is not achieved through advertising but through users actually finding the data through searching, without knowing if it existed beforehand. It is also planned to report the activities to the next meeting of the International Committee on Earth Observation

Satellites (CEOS), Working Group on Information Systems and Services (WGISS). This body was the driving force behind the original development of the INFEO system.
With item "support the exploitation of such data", a range of processing algorithms have been developed and new applications pursued. A number of new data sources have also been established, including digitised data from old satellite photographic images and data from Chinese satellites. The focus of the data exploitation has been on ocean data from the Far East marginal seas and on forest management in Siberia.

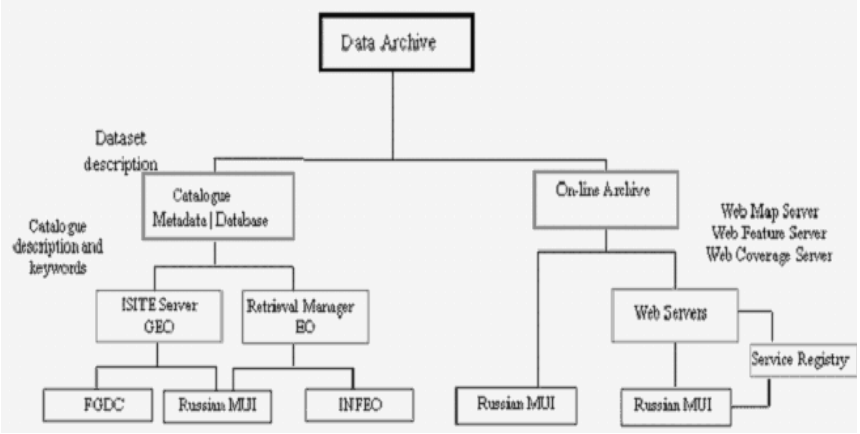

Fig. 3: Model of Individual Data Archive

The IRIS project has allowed firm relationships to be developed between the partners and future interaction will continue after the end of the project. The initial goal of connecting Russian satellite catalogues to the international INFEO system has been achieved although the work will need to continue with the addition of new datasets as they come along and upgrades to the software will need to be installed as computers and associated software continue to improve. However, the initial barriers have been overcome and it is expected that the on-going maintenance can now be achieved on the back of new data exploitation projects as they are established.
IKI have shown how to integrate regional satellite datasets and other archives to create a single EO Information System for sustainable development based on the concept of an interoperable distributed archive. New learning materials, published on the IKI Web server, have contributed to EO education. IAPU report that the results achieved thus far would impact on the fields of typhoon diagnosis, noise filtration of geostationary satellite data and also the automatic detection of sea surface eddies using satellite data. The results obtained by Institute Forest have more of an environmental impact, as the potential capability of satellites to detect disturbances such as pollution, gold mining and pest impact has been shown. This capability can be used on natural and anthropogenic disasters. The Internet-based seminars created, and hosted, by MSU have impacted the level of education in Russian universities. The atlas of space imaging highlighted other uses of remote sensing to a wider community. Training in GPS and other field equipment, and preparing of a text-book (Practicum), support the introduction of Russian specialists into a modern Informational society.

4. European Information system INFEO (Information on Earth Observations)

The INFEO system offers access to Earth Observation information, services and data catalogues around the world.
User easily exchanges data with the INFEO system. This simple point-and-click, search and order WWW interface is based an a hierarchical organization of data, displayed as tables, and will always return non-empty results.

Space data archive (See Figure 3) can hold various types of data ranging from satellite images and products processed from the images, to observation data and statistics. An archive may also contain documentation.
Digital library is the totality of many individual data sets, collected and held separately by many different organizations.

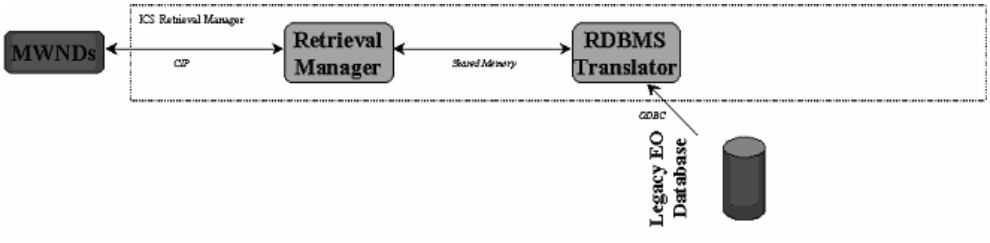

Fig. 4: The architecture of a CIP/ODBC Gateway

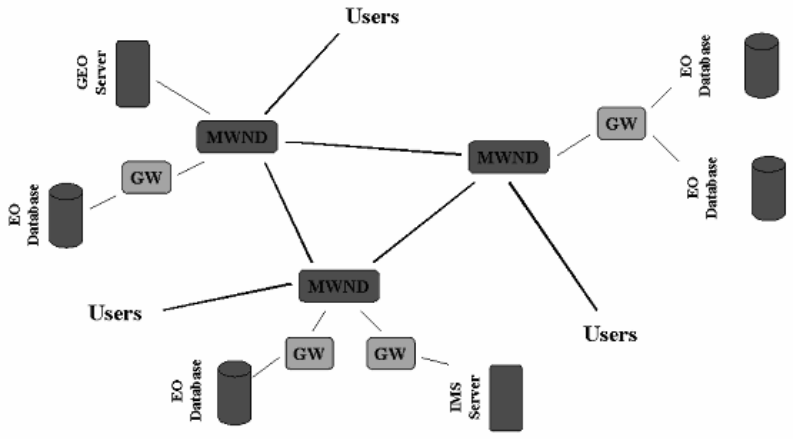

Fig. 5: CIP/ODBC Gateway

The INFEO system comprises Middleware Nodes (MWNDs) that, taken together (see Figure 5), define a distributed hierarchy of collections of data. Figure 4 shows a schematic INFEO architecture of several MWNDs each of which conceptually owning a number of gateways (GWs) or servers. The INFEO CIP/ODBC Gateway is one example of these components. The various databases and servers shown are typically legacy provider systems, e.g., existing archives and inventories. All Users can receive the access to INFEO data over MWNDs. A MWND (middleware node) in a top-level component of INFEO.

CIP/ODBC Gateway consists of following components: Retrieval Manager; Translator.
Figure 5 shows the architecture of a CIP/ODBC Gateway illustrating the management of user-driven CIP sessions and translation of CIP into ODBC. The installation of the CIP/ODBC Gateway and the configuration of its RDBMS Translator by mapping CIP to the schema of the relational database.
CIP/ODBC Gateway is intended to provide access to legacy databases by translating CIP requests from a MWND into ODBC (i.e., SQL) suitable for execution on the database. The Gateway is an example of an ICS Retrieval Manager. A Retrieval Manager manages CIP/Z39.50 sessions and services (and may be installed at) each catalogue site as well as each search server. It is used to integrate together the local catalogue systems and provide communication between users and other catalogue site Retrieval Managers.

Pre-Packaged Retrieval Manager consists of following components:
Customer User Interface (CUI); ICS Retrieval Manager (RM, Translator and Data Manager); Databases; Associated software.

5. Early stage of creating a Digital Library

Already at the early stage of creating a Digital Library of Remote Sensing data, it is essential to work out its adequate structure necessary for efficient data retrieval from the archive. The Digital Library structure is elaborated based on the understanding of typical requests of potential archive users. The experience of functioning space archives shows that user requests primarily focus on data representation levels, the name of the project under which the data is obtained and the name of the sensor that provided the data. Therefore, the archive should be divided into segments corresponding to different data representation (process) levels with each segment subdivided into data sets related to a certain project and instrument (sensor). Efficient organization of information resources and open access to spatially distributed experiment data are founded on the information services of Internet, i.e. on the Web technology. Appropriate metadata management systems are built to provide for the collection and distribution of experiment data and thematic processing results; while the Digital Library is linked to the regional archives of environmental monitoring via Internet. An important element is the elaboration of interface, archiving and network data exchange structures. This calls for the development of search engines and a remote interactive access regime for external users via Internet to catalogues of experiment data and processing results and the realization of the on-line access mode.

- Gateway software installation,
- And Gateway software
- configuration are presented.
- Digital Library uses a satellite image dataset model and
- CIP – Catalogue Interoperability Protocol

5.1. Gateway Software Installation

FTP-access gives us access to Gateway soft ODBC package (Open Database Connectivity) – Open Interface for interaction to database. Microsoft standart regulates the improved access of the applications to existing databases, allowing users without specific knowledge of data to search science data holding, retrieve high-level description of data sets and detailed descriptions of the data inventory, view browse images.

Collection can be form: 1) the product descriptors or 2) collection descriptors. User can search for and order data. Search Types: i) detailed descriptions about data sets, data sources, instruments, projects; ii) collections of observations of data (granules).
Results of Search are improved online access to existing data.

Schematized Collection Model includes: i) Terminal Collection – Earth Observation product data only; ii) Non-terminal Collection.

5.2. A distributed hierarchy of collections data

We will be describe in this section the hierarchical approach. The definition of
collection to be considered in designing a browsing and navigation service are: a grouping of item descriptors that have commonality.
Within a single grouping or 'collection' the item descriptors must be
of the same type (i.e. the items can be described with the same set of attributes).
In the Earth Observation Collections at a MWND only contain other collections.
No product or document descriptors are held at the MWND.
Each collection is defined by a descriptor that describes the data it contains by means of metadata and typically represents a theme, e.g., a collection of data from a particular satellite or sensor processed in a particular way.
Each terminal collection in the hierarchy represents the data available at a particular provider gateway or server. The intention is that users find collections of data of interest based on the collection metadata (by performing a collection search at a MWND) or by perusing the collection hierarchy and then finds data of interest within particular collections (by performing a product search).

5.3. Catalog Interoperability Protocol (CIP)

Standard of protocol CIP is based on Z39.50. Protocol CIP is a profile of Z39.50. Z39.50 Protocol means for Search and Remote Sensing data presentation. In the case of Digital Library CIP uses Z39.50 means for distribution search.

6. Conclusion

The paper describes technological (software) aspects of building the distributed Digital Library for Satellite Based Data. Remote Sensing is one of important sources for geospatial data and environmental information. Considerable progress has been made in: i) data access, ii) interoperability, iii) management of very large volumes of data. A Satellite Image Datasets is open for researchers and can be accessed via Internet. Thank to data harmonization efforts, using ISO and OGC standards, we are building the Digital Library as Information System with increasing the number of Earth Observation Data from now on to be

further easy to utilize. The example of INFEO Simple Search to get Satellite Based Data, including Data Exchange the Environmental Information among satellite archives on the Web will show in report.
Those successful demonstrations and uses Digital Library of IRIS system
how it is feasible for the data interoperability based on the Open Geospatial Consortium (OGC) at http://www.opengeospatial.org, Web Coverage Service (WCS) at http://ip.opengeospatial.org/ows1/docs/01-018r1.doc.
It also demonstrates that providing interoperable, personalized, on-demand data access and services to the data users greatly enhances the use of Remote Sensing Earth Observation data in scientific research and Environmental applications.

Bibliography

Kudashev, E.B. (et. al.) (2003a): Early Warning Systems for Large Towns and Megacites, in: Zschau, J. and Kuppers, A. (Eds), The Satellite Techniques in Early Warning Systems. Springer, pp. 741-744

Kudashev E., (2003b): From Data Bases to Digital Library of Remote Sensing Data, in: Proceedings of the 23 EARSEL Symposium Held in June 2003 University of Ghent, pp. 142-143

Kudashev, E.B., Balashov, A.D. (2003): Integration of Digital Library of Remote Sensing Data to Earth Observation Information System, in: Proceedings of Fifth National Russian Research Conference. Digital Libraries: Advanced Methods and Technologies, Digital Collections, Held in October 2003 University of S. - Petersburg University, pp. 88-95

Kudashev, E.B. (et. al.) (2001a): Using the Russian Satellite Data in support of Environmental Monitoring and Emergency Forecast for Vast Syberian and from Moscow to Arctic territories, in: 21st EARSeL Symposium, Observing our Environment from Space/ New Solutions for a New Millennium, Held in May 2001 by European Association of Remote Sensing Laboratories, Paris, p. 83

Kudashev E.B. (et. al.) (2001b): Remote Sensing and development of databases/ large GIS for Environmental Monitoring of the Moscow megacity", in: Proceedings of IEEE/ ISPRS Workshop URBAN Held in October 2001 University La Sapienza, Rome

Price R.D. (et. al.) (1994): Earth Science Data for all: EOS and EOS Data and Information System, in: Photogrammetric Engineering and Remote Sensing. V. 60. P. 277- 285

Schwaller M.R., Krupp B. (1994) Science Data Plan for the EOS Data and Information System, in: NASA / Goddard Space Flight Center, 1994

A new stage of satellite environmental monitoring started when Internet and modern information technologies emerged. It is marked by a wide use of telecomm.Â The INTAS IRIS Project main goal is to research techniques aimed at improving the accessibility of Russian satellite remote sensing data [1], [2]. The Project IRIS Tasks include: investigation of new information technologies aimed at information system interoperability: evaluation of the impact of new technologies on the development of Centre of satellite data. Important activities consist of â€“ identification of the Russian datasets held. creation of the IDN (International Directory Network) entries. creation of the INFEO (Information from Earth Obser-vation). entries and its Russian Node.