European Node of the Urban Application Center for KOMPSAT-1/2 derived products

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ABSTRACT

The well established scientific and technological collaboration between the Korean Aerospace Research Institute (KARI) and the Austrian Research Centers - Seibersdorf research (ARCS) triggered the idea for the joint development of an Urban Application Center, targeting the needs of the urban planning and urban monitoring domain of governmental and other non-profit organizations. Data from the Very-High-Resolution Multi-Spectral-Camera mounted on KOMPSAT-2 misson (operated by KARI) will provide the major input to a semi-automated processing chain, delivering geocoded and thematic products. As a first step the thematic information extracted from the satellite data will use a classification scheme based on 6 classes. The European Regional Node, located in ARCS, of the Urban Application Center will provide coverage of larger cities in Europe, Africa and the Near East.

To access the Urban Application Center for searching the catalog, presenting and selecting the results and later to access the available data at the Urban Application Center a WebMapServer (WMS) has been implemented. The OpenSource WMS of the University of Minnesota, which already provides a WebFeatureServer (WFS) and soon will provide a WebCoverageServer (WCS), together with the spatial enabled PostGIS/PostgreSQL database was chosen and extended to the special needs of the intended services provided by the Urban Application Center.

1 INTRODUCTION

With the signature of a Memorandum of Understanding (MoU) for space research cooperation by the Ministers of Science and Technology from Austria and Korea, a very important milestone in the well established scientific and technological collaboration between the Korea Aerospace Research Institute (KARI) and the Austrian Research Centers - Seibersdorf research (ARCS) was achieved. This MoU was signed in September 2002 and was a starting point to develop an extended cooperation between KARI and some European aerospace organizations for KOMPSAT mission utilization.

One of the ideas which were triggered was the joint development by KARI and ARCS of an Urban Application Center, which should target the needs of the urban planning and urban monitoring domain of governmental and other non-profit organizations. It was further envisaged that the high-resolution (HR) Earth Observing Camera (EOC) on the KARI KOMPSAT-1 satellite should provide the major input to fit the needs of this user community. This concept was soon after extended to target the future KOMPSAT-2 Satellite as the major data input source. A second MoU, signed by the two Ministers of Science and Technology in November 2004, confirmed the ideas and themes developed and established by the team so far.

While the EOC delivers panchromatic images with a spatial resolution of 6.6 x 6.6 m and an image swathwidth of approx. 17 km, the very-high-resolution (VHR) Multi-Spectral-Camera (MSC) mounted on KOMPSAT-2 (scheduled for launch in December, 2005) will provide one panchromatic channel with a spatial resolution of 1 x 1 m and four multi-spectral channels with 4 x 4 m spatial resolution with an image swathwidth of approx. 15 km. These basic conditions make images recorded by the KOMPSAT satellites very suitable for the application in and around urban and sub-urban areas.

In this paper, the concept of a KOMPSAT regional application center, a joint development between KARI, ARCS and other European partners is presented. This includes the establishment of an additional KOMPSAT-2 downlink in Europe, and the developments of a state-of-the-art user service system for urban and sub-urban monitoring.

2 COOPERATION: KARI - ARCS - DLR - NLR

One of the limitations for KOMPSAT-2 data acquisition is the available downlink capacity. The increase of this capacity, has been another target of the joint work of KARI and ARCS. An European downlink facility was conceived to be installed to increase the accessibility of KOMPSAT data especially to the Urban Application Center but also to European users in general [1]. As a side effect such an additional downlink opportunity would assist KARI in optimizing the utilization of KOMPSAT-2 without impact on its original mission. The use of download facilities in Europe will greatly increase its capacity without loosing any coverage over Korea. While the ability to record and download data is a prerequisite for any further uses, it is by no means a guarantee that the data will be accepted and used by the community. In Europe this data archiving and retrieval system for KOMPSAT-2 data is currently under development. This catalogue will also be linked to metadata catalogues as run by the European Space Agency (ESA), to ensure even wider access [2].

Since there already are highly qualified antenna systems in Europe, either under the auspices of the ESA or under the patronage of national space agencies, it was decided that KOMPSAT reception should be organized based on partnerships with European organizations operating these receiving stations. Consequently, the German Aerospace Center (DLR) and the Dutch National Aerospace Laboratory (NLR) could be successfully taken aboard and have upgraded their systems for the reception of KOMPSAT-1 and KOMPSAT-2 data streams.

The successfully performed, experimental reception of data from KOMPSAT-1 at European stations is seen as a test case to build-up the necessary institutional communication channels, process mechanism and partnership confidence:

KARI (Fig. 1) builds and operates the KOMPSAT satellite series, provides access to the data, and also plays a key role in the development of the Urban Application Center.

DLR currently makes available resources at the wide coverage Neustrelitz receiving station (Fig. 1) and storage capacity. Future plans may include the provision of additional downlink stations as well as the development of services based on KOMPSAT data, positioned mainly in the "Disaster-domain".

NLR brings into the cooperation their small, robust and highly mobile RAPIDS station (Fig. 1), which can easily be transferred to any place in the world and be operational within a day after arrival. It can provide a local real time reception capability to support disaster management activities and data acquisition campaigns in remote areas. NLR is colocated with the Geomatics Business Park (GBP). For the companies of GBP, the RAPIDS ground station is meant to serve as an access point for real time high resolution imagery for monitoring and mapping of urban and agricultural areas.

ARCS is Austria's largest Contract Research Organization (Fig. 1) and well established in the European Earth Observation community with respect to both data user and information infrastructure programs. In this cooperation ARCS is responsible for the coordination of this initiative, the development of the Urban Application Center and is the primary interface between Europe and KARI.

On May 19th, 2004 the first 17 x 784 km image strip from the KOMPSAT-1 satellite was successfully downloaded in Europe at the Neustrelitz receiving station [3]. Soon after that an image acquisition from the KOMPSAT-1 satellite was also successfully carried out at NLR's RAPIDS system.

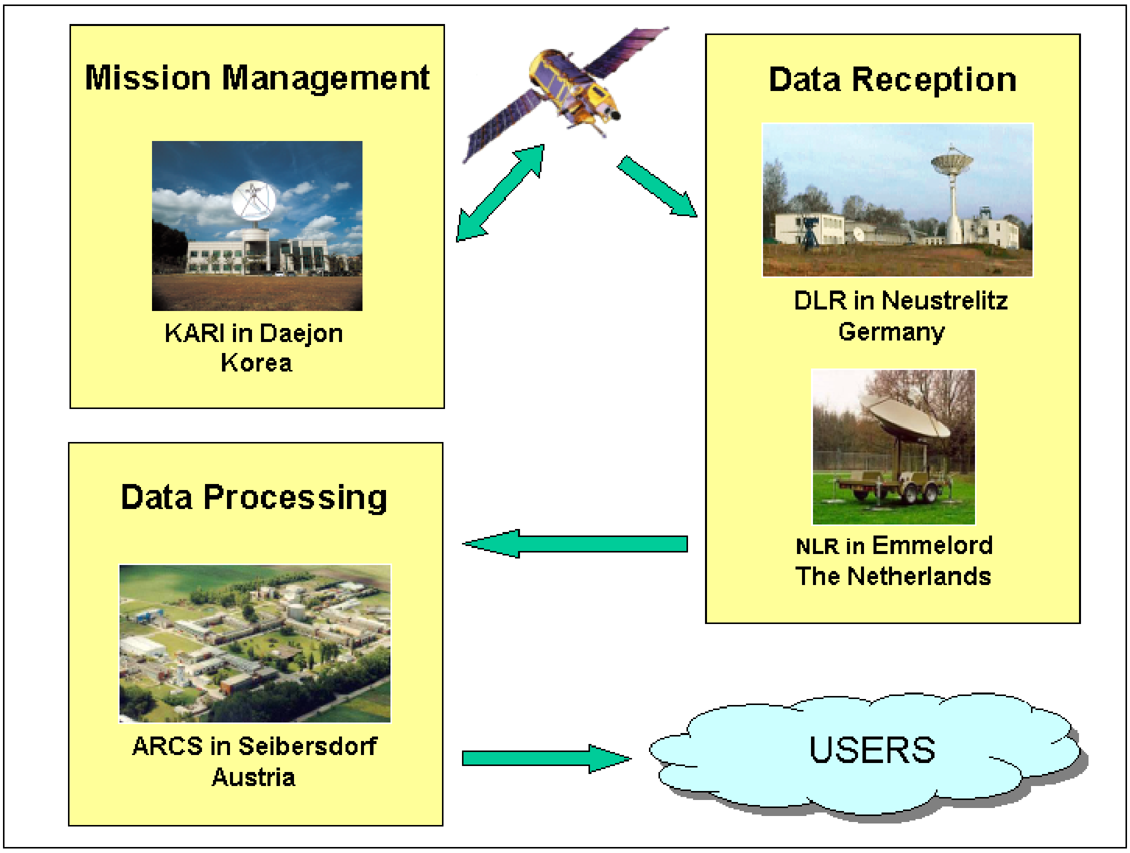

Figure 1: The basic concept of the work-sharing and data flow of the international cooperation

3 PRINCIPLES OF THE URBAN APPLICATION CENTER

The aim of the Urban Application Center is to offer enhanced products derived mainly from KOMPSAT-2. These services will be based on the principles of a high degree of automation, easy access to data and services and availability to both expert and non-expert users. Processing will be carried out with a high degree of automation, ideally without any interaction by a human operator. This way the data can be generated online, on demand or directly after reception. If any human interaction is necessary or should be made available in order to enhance the quality of the results this might be provided only on a special request basis. The results of this automated processing will probably not match those that can be obtained by custom made processing and they are not meant to replace them. However, they will be sufficient for many applications requiring a fast overview over an area and offer enhanced products to customers who do not have the means to carry out the tasks themselves. At a first step the thematic information extracted from the satellite data will use a classification schema based on 6 classes (vegetation, sealed areas, arable land, water, shadow, clouds).

The European Node of the Urban Application Center, located in ARCS, will provide coverage of larger cities in Europe, Africa and the Near East. The corresponding Korean Node, located in KARI, will cover Asia, Australia, and for the time being the American Continent. However, similar processing routines are applied to ensure that consistent quality is maintained independent of the processng node. Special attention will be placed on urban change products over so called third-world "Megacities". There, often the most basic spatial planning tools and maps do not exist and satellite based imagery and derived information products can provide valuable guidance and tools to locate where and which changes are taking place in and around fast changing sub-urban areas.

4 SERVICES OFFERED BY THE URBAN APPLICATION CENTER

4.1 User groups

As already pointed out, easy access to data is crucial for successful data dissemination. While access to data has been very much improved in the past few years, finding suitable data is still cumbersome as numerous portals have to be searched and querying of archives is often limited. So far the use of satellite images has therefore been limited to expert users who have the technical know how and equipment to find, access and process these data. This has also limited the acceptance of the use of satellite data in administration and other institutions. By making satellite data more accessible and by reducing the necessity to invest in software and time to learn the handling of it, the acceptance and number of uses can be greatly increased. With the internet being more and more part of our everyday lives, many barriers have already been removed and, provided that access is easy enough, satellite images could be enjoyed by a wider audience.

4.2 Metadata Catalog

The developments for the Urban Applications Center will include the possibility to search, view, and order available data and derived products. To attain this, metadata (information about the data) needs to be generated and made available as a catalog via various means. Here, the future clearly points to build and implement interoperable systems which can connect to and be accessed by larger entities (e.g. portals of space agencies like KARI or ESA) allowing a wider community to gain information about the existence of a certain service and access to the data and products available.

So far many space agencies and data providers already have catalogs [4] in place, each of them acting differently and often only accessible via its own interface. To find available data one needs to canvass multiple sites using many different interfaces and logistic systems.

ARCS and industry partners are currently enhancing the existing INFEO [5] catalog system, to be reinitiated by ESA in the eoPortal [6], by adding XML/SOAP (Extensible Markup Language/Simple Object Access Protocol) interfaces to overcome many existing problems, hindering an interoperable strategy allowing mutual interconnectivity and searches in multiple catalogs.

KARI is participating in this project and currently develops a new catalog system fully compatible with the specifications applying XML and SOAP technology. The final catalog will be connected with ESA's INFEO catalog systems and from both ends all connected catalogs will be accessible via their single entry points. The Urban Application Center's catalog will be built following the same standards and will finally also be connected to ESA's eoPortal.

4.3 Data Access: WMS - WFS - WCS

To access and search the catalog of the Urban Application Center directly, but also to select, view, and later also access the available data at the Urban Application Center a WebMapServer (WMS) has been implemented. The software is based on the OpenSource WMS of the University of Minnesota [7], which already provides a WebFeatureServer (WFS) and soon will provide a WebCoverageServer (WCS) which is compliant with the standards of the OpenGis Consortium (OGC). While the WMS allows maps to be constructed and viewed (i.e. as pictures in standard formats like JPG, PNG, etc.), the WFS can be used to distribute vector data (e.g. thematic products). Finally, the WCS will provide a way to access the full raster data and will therefore be used as a distribution mechanism.

The data management backbone of the implemented system is formed by the Postgres/PostGIS database connected to the WMS/WFS via extensive processing functions (using PHP as a programming language) developed at ARCS (Fig. 2). The functionality of the system is fully implemented on the server side, making it unnecessary to install any software (e.g. plug-ins, applets, etc.) at the client side. This is especially of interest for public entities where the users may not be able to install or download any software, whatsoever, due to security restrictions.

The implemented WMS can also act as a cascading WMS, combining layers of information of other WMS with the local available datasets and vice versa. After beeing released to the public, it will also allow to be accessed by other WMS and may deliver certain information contents to be included by those WebMapServers.

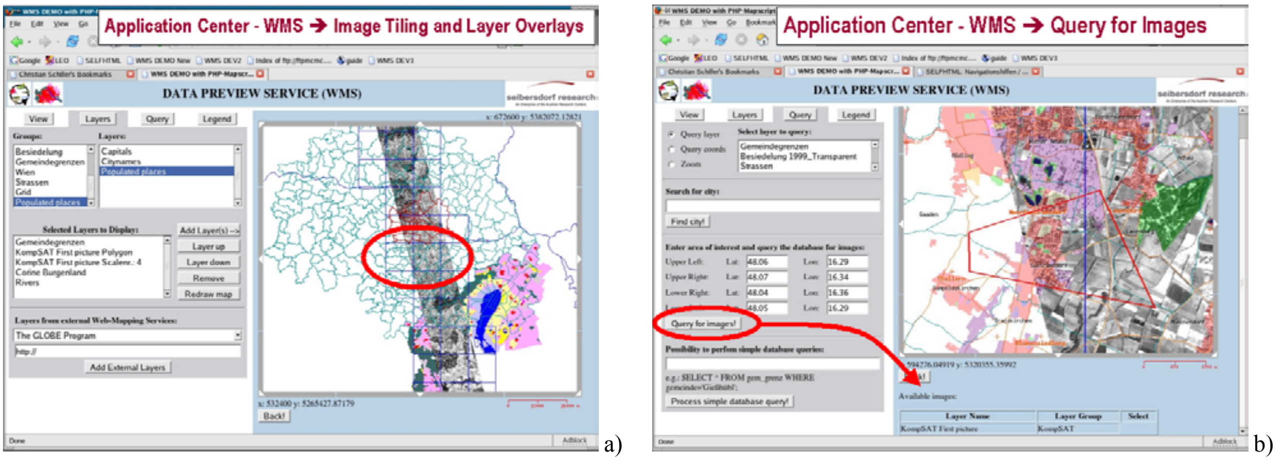

Figure 2: Prototype example snapshots of the WMS Interface for the Urban Application Center currently under development at ARCS. Beside the basic WMS functionality feature querying, a gazetteer, and WMS-cascading is implemented. a) for fast access a tiling scheme of large images is implemented. b) use query coordinates to search for available images and/or products

4.4 Service Support Environment (SSE)

The data processing steps required in the Urban Application Service will form a workflow which is intended to be implemented using recent European EO system developments. The SSE [8] currently developed for the European Space Agency will be used as system platform. Not only catalogs are combined but complete service chain building blocks are made accessible via a common interface. The SSE toolbox will provides the utilities for service and data providers to present their services and make them directly accessible by users. Furthermore, the possibility exists to combine such building blocks of services of various providers, forming new processing chains and products according to the users needs needs. The service providers formulate encapsulate tasks for a single well defined service by describing the input and output interface in a standardized way using XML and WSDL (Web Service Definition Language). With this technique an automated and controlled data flow is possible in a synchronous (online) or asynchronous (offline) way. ARCS already obtained system provider status for the SSE and will tie the Urban Application Center service chain into the SSE system.

4.5 Geocoding

When working with HR and VHR data, especially the geocoding of satellite data (applying geographic coordinates to the imagery) is known to be a very tedious, time consuming and therefore expensive task. Sensor models, as will be provided with KOMPSAT-2, will help reduce the time and costs for this necessary procedure. NLR knowledge and experience in development and integration of highly automated orthorectification tools – for rapid mapping applications - will support automation of this procedure. At the beginning of the service provision the geocoding will be based solely on the KOMPSAT-2 sensor model and ephemeris data provided. At a later stage the collection and implementation of a ground control chip database (GCC), which would allow better orthorectification results, is under investigation.

4.6 Image Transformation

In the context of this paper image transformation refers to the integration of two images in order to create a new one which contains characteristics of both images, a process also called image fusion. In our case the aim will be to use the multispectral bands together with the higher resolution panchromatic band to create high resolution color images. Various algorithms have been developed and for the planned services the emphasis will be on two which offer very different advantages to the users. One is called adaptive image fusion (AIF) [9], the other is a Hue-Saturation-Intensity (HSI)-transformation [10].

The AIF applies a modified sigma filter [11] to the panchromatic image with a given window size. At each position the two sigma range related to the central pixel is calculated and all pixels that fall into that range are selected. The position of the selected pixels is then transferred to the multispectral band where an averaging of these sub-pixels is performed. As by this process no spectral information is transferred from the panchromatic image to the multispectral bands, the spectral information is not significantly changed. This allows the resulting high resolution images to be used for classification purposes just as the original multispectral images.

The AIF leads to results that are spectrally very close to the original but not necessarily very suitable for visual interpretation tasks. For this purpose other methods have been developed such as the HSI-transformation. This technique converts the red, green and blue color bands into hue (dominant wavelength of the color), saturation (degree of purity of a color) and intensity (measure of brightness of color). In order to create a high-resolution multispectral image, the intensity band is replaced by the panchromatic band. While this method delivers good visual products its uses are limited to three bands and it is not suitable for further multispectral processing although very well suited for visual interpretation tasks.

4.7 Image Segmentation

Satellite data with high spatial resolution as provided IKONOS-2, QUICKBIRD and, in the near future, KOMPSAT-2 pose new challenges where data processing and classification routines are concerned. A high spatial resolution not only means more detailed images but also more complex images with many unwanted artifacts. One way to reduce this complexity and also create a basis for further processing is image segmentation [12]. The aim is to separate the image into homogenous regions. Size and shape of these regions depends on parameters selected for the segmentation. As it is planned to have as much automation as possible the initial segmentation parameters are calculated from the image based on its heterogeneity. On this the second segmentation is built by combining neighboring segments based only on color differences. This results in a segmented image were large homogenous areas, e.g. grassland, water bodies and clouds form large segments and heterogeneous areas such as urban areas remain divided into smaller segments. Based on features calculated for teach segment describing color, shape, neighborhood, and so forth, classifications can be carried out. A number of routines have been developed for the purpose of image segmentation [13], although at this stage processing is limited to using eCognition for segmentation and classification experiments.

4.8 Image Classification

The third category of services is the creation of thematic products, i.e. converting data into information. Traditional classification schemes such as the Maximum Likelihood Classifier tend to perform rather poorly on high resolution data, leading very often to an unwanted salt-and-pepper effect [13]. In the past few years, segmentation based classification procedures have proofed to be more suitable. Starting point for the classification provided by the Urban Application Center will be a segmentation as described in section 5.7. At this stage it is planned to concentrate on 6 classes (vegetation, sealed areas, arable land, water, shadow and clouds) although the proposed procedure makes it easy to add new classes if that is feasible. The classification is carried out on the bases of the segmented image. Features, which are calculated for each segment, are used to assign one of the six classes. These features draw on spectral as well as shape and neighborhood characteristics and are selected in such a way that they are as typical as possible to describe the classes in a very general way. As one of the premises for this center is high automation of services, it is the challenge to find parameters, or better yet, derive them from each image that lead to satisfactory results.

4.8.1 Application Example - Classification

As the AIF has already been presented in another context [14], results of the first classification experiments will be presented here. As a substitute for the type of data that may be expected from KOMPSAT-2, an IKONOS-2 scene, recorded over the city of Vienna on September 1st, 2000 (Fig. 3) was selected for the classification example. The study area covers approximately 5 x 5 km.

For the classification experiment both the multispectral and panchromatic images were segmented together on two levels using eCognition. On the first level a combination of form and color parameters were used (scale 10, shape 0.1, compactness 0.9). These segments were merged together on a second level on the basis of color difference between neighboring segments, using a threshold of 40 pixel-values. This leads to larger homogenous areas, without changing heterogeneous areas.

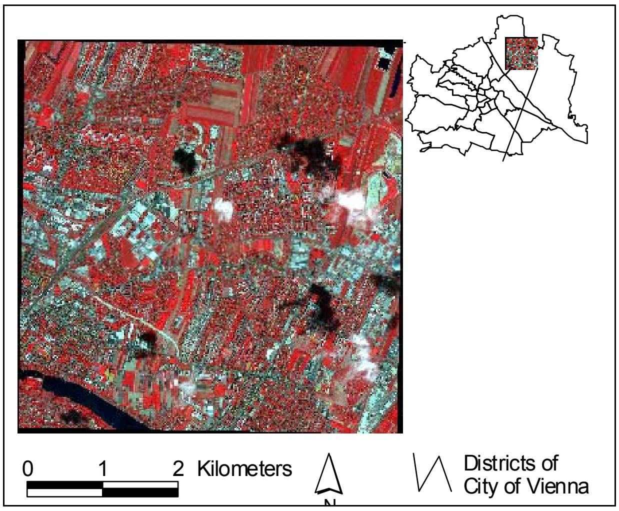

Figure 3: 432-False color IKONOS image of study area

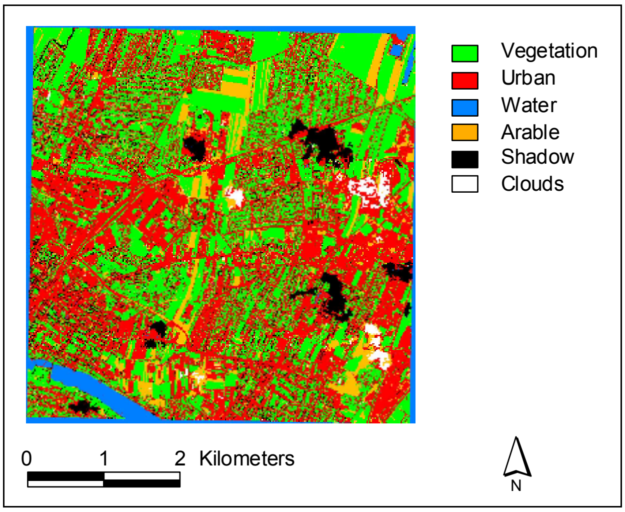

Figure 4: Result of classification

Class	Feature
Vegetation	Ratio of near infrared
Water	Ratio of near infrared
Sealed urban	Ratio of near infrared
	Std.dev. of near infrared
	Std.dev. of green
Shadow	Brightness
Clouds	No class of the above
	Brightness
Arable	No class of the above
	Brightness

Table 1: Features used for classification

For the classification, 6 classes (vegetation, sealed areas, water, arable land, shadow and clouds) were defined on the basis of selected features which are calculated for each segment. Table 1 gives on overview over the type of features used for each class. Ratio is defined as the mean value of an image segment divided by the sum of all spectral layer mean values. Brightness is the spectral mean value of all selected bands (here all bands were selected for the calculation of brightness) of an image object. The number of features was kept to a minimum in order to ensure that the classification can be easily transferred from one image to another. If the features are selected correctly then a transfer should only involve adjusting the parameters governing the functions for each selected feature.

Figure 4 shows the result of the classification. The density of urban structure (red) can be seen clearly in contrast to vegetation (green) and arable land (brown). Water bodies (blue) were classified as well as clouds (white) and shadows (black), cast either by buildings and clouds. Misclassification occurs where some shadows have been mistaken as water and where the contrast of roofs is very low, especially in areas with small individual houses.

5 CONCLUSION

The use of already existing European downlink facility will increase the accessibility of KOMPSAT data to the Urban Application Center and the European users. In addition it will assist KARI in optimizing the utilization of KOMPSAT-2 without impact on its original mission. The German Aerospace Center (DLR) and the Dutch National Aerospace Laboratory (NLR) could be successfully taken aboard an already ongoing cooperatioan between the Korean Aerospace Research Institute (KARI) and the Austrian Reseach Center -Seibersdorf research (ARCS).

The aim of the development of the Urban Application Center is to offer enhanced products based on the principles of a high degree of automation, easy access to data and services and availability to both expert and non-expert users. The results of this automated processing will be sufficient for many applications requiring a fast overview over an area and offer enhanced products to customers who do not have the means to carry out the tasks themselves. As services, which will be also accessible via the SSE, gecoding, image transformation, image segmentation, and image classification will be developed and offered. During the development of the Urban Application Center major attention is paid to stay interoperable with current systems allowing metadata (catalog) searching, data access, and service chaning (e.g eoPortal, SSE). This priciple is also realized for the interface, where an OGC conformant WebMapServer, WebFeatureServer and a WebCoverageServer together with a spatial enabled Database provide the necessary functionality for searching, viewing, and delivering data and information products to the user.
We hope that by making satellite data more accessible and by reducing the necessity to invest in software and time to learn the handling of it, the acceptance and number of uses can be greatly increased.

6 REFERENCES

[1] Schiller, C, G. Triebnig, Y. Kim, B. Moll, H. Maass, F. Kressler, S. Ahn, A. van der Kamp, J. Schwarz: KOMPSAT European Cooperation; Proceedings of International Symposium on Remote Sensing, Oct.27-Oct.29, Jeju, Korea, 2004

[2] Kressler, F. P., Y. S. Kim, K. Steinnocher, G. Triebnig: KOMPSAT - Urban Application Center; Proceedings of the International Symposium on Remote Sensing, Oct..27-29, Jeju, Korea, 2004

[3] URL: First KOMPSAT-1 Earth Observation Data downlink at European Receiving Stations; Available at: http://www.space-research.at/space/.First_Image_Kompsat.html

[4] URL: http://catalogues.eoportal.org

[5] URL: http://www.infeo.org

[6] URL: http://www.eoportal.org/about.html

[7] URL: http://mapserver.gis.umn.edu

[8] URL: http://services.eoportal.org

[9] Steinnocher, K.: Adaptive fusion of multisource raster data applying filter techniques; International Archives of Photogrammetry and Remote Sensing, Vol. 32, Part 7-4-3, Joint ISPRS/EARSeL Workshop, Valladolid, Spain, 1999

[10] Mather, P.M.: Computer Processing of Remotely-Sensed Images; John Wiley & Sons, Chichester, 1999

[11] Smith, A.: Digital change detection techniques us-ing remotely-sensed data; International Journal of Remote Sensing, 17(11): 2043-2057, 1996

[12] Benz, U.C., P. Hofmann, G. Willhauck, I. Lingenfelder, M., Heynen.: Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information, Photogrammetry & Remote Sensing, Vol. 58: 239-258, 2004

[13] Meinel, G., M. Neubert.: A comparison of segmentation programs for high resolution remote sensing data; International Archives of Photogrammetry and Remote Sensing, Vol. 35, Part B, XXth Congress of the International Society for Photogrammetry and Remote Sensing, Istanbul: 1097-1105, 2004

[14] Kressler, F.P., Y.S. Kim, K. Steinnocher.: Texture Analysis, Image Fusion and KOMPSAT-1; Proceedings of International Symposium on Remote Sensing, Oct.30-Nov.1, Sokcho, Korea, 792-792, 2002