Virtual sensor modelling and near real-time satellite image services

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Spacemetric has developed "virtual sensor models" for digital imaging sensors and combined them with online service protocols to enable rapid access to satellite Earth observation imagery. Virtual sensor modelling brings together rigorous photogrammetric methods with multi-threaded, on-the-fly processing techniques that enable raw sensor imagery to be transformed directly into map-compatible form, either within online services such as web mapping, or to deliver more traditional image products. The approach has been applied in operational image production systems including the NigeriaSat-2 mission, launched in August 2011, as well as to several airborne imaging sensors. The technique is currently being extended through the NGI project funded by the European Space Agency with the aim of demonstrating near real-time data access. While satellite and airborne images already feature as a backdrop in many online search services, the imagery offered as a background to geographical search results are fixed layers of ageing data. Meanwhile other applications are made difficult or even impossible by delays in access to new imagery. The techniques developed by Spacemetric break new ground by enabling a 'live' feed of the latest imagery. This can enhance users' online experience by serving fresh imagery into the location-based services they use. It can also facilitate and add value to applications such as rapid response and "now-casting" of environmental phenomena where delays in data access have previously been a hindrance. The methods are generic and can be applied to satellite imaging sensors, airborne cameras, and even video imagery such as from unmanned drones.

Keywords — *Rapid access, metadata, virtual sensor model, Pléiades, UK-DMC2, NigeriaSat-2*.

I. Introduction

THE Chernobyl disaster in April 1986 is an early example showing the potential value of rapid access to satellite data. Swedish authorities were among the first to detect fallout during routine radiation measurements. Having

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excluded a leak from their own nuclear facilities they turned their attention to possible sources in the Soviet Union.

The SPOT-1 satellite was launched only a few weeks before the accident at Chernobyl. Its data was being received at the Esrange ground station in Kiruna, Sweden, also a reception station for imagery from the US Landsat satellites. Calculations by the Swedish authorities pointed out Chernobyl as a possible site so SPOT was programmed by Sweden, as one of the satellite programme members, for a priority acquisition over the nuclear power plant located there. The image from 1st May 1986 was the first of the disaster site. It was received and processed in Kiruna and subsequently came to be distributed worldwide.

With the March 2011 incident at the Fukushima nuclear power plant in mind it is clear that there are long-established requirements for very rapid access to satellite imagery. In 1986 it was a very exceptional circumstance to achieve a turnaround of a few hours from data download to availability. Today we have technology that allows us to make imagery available to a global audience at a fraction of the time and cost compared with 25 years ago.

II. Service-oriented approach

The majority of satellite ground segment systems are batch-oriented stovepipes whose primary purpose is to process large amounts of homogeneous data. Typically the data is processed in large chunks such as "scenes" or as a continuous sequence of several scenes that corresponds to the stream of data dumped to the ground station as the satellite passed overhead. The results are typically then catalogued and presented via a download service, such as FTP, at the very end of the processing chain. This is efficient when there is demand for large portions of the data being processed and, in particular, if the same data is accessed many times by different customers. The downside is that because the data cannot be accessed until after the entire batch process is finished, the time from sensing until the image is in the user's hands can be fairly lengthy. The results are also file-based products, which means complete products have to be transferred before they can be used.

In contrast, the needs of a typical user often relate to data for a geographical location or region. These areas rarely if ever have any correspondence with satellite scenes and may only be part of one image, or might perhaps be a combination of parts of several images. A service-oriented infrastructure could provide the flexibility needed to meet these needs and as a consequence offers the opportunity for "mass customisation" of satellite image products.

Today there is growing use of services within data dissemination, but this is most often just an add-on after the initial batch process. What is required for faster data access is an increased upstream penetration of service-oriented processing, as illustrated in Fig. 1. The aim is that services should eventually penetrate throughout the entire processing chain, all the way back to the sensor. The ultimate goal would be to avoid batch processing and make as much of the chain as possible be driven by user demand.

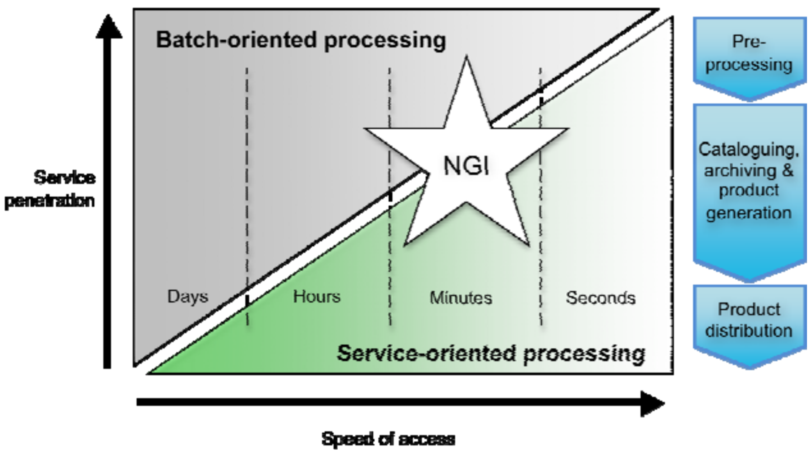

Figure 1. NGI in the context of increasing penetration of service-oriented processing.

As discussed in more detail later, in the NGI project the service concept extends beyond just retrieval of finished products from an FTP server. Instead it involves the user in the definition, creation and refinement of the products they access. Exposing this service to the user means that much of the time-consuming batch processing is unnecessary. Indeed the only step required is to expose sufficient metadata to enable a search and browse service.

Some progress has already been made in increasing the upstream penetration of the service-oriented approach and demonstrating the potential of this approach[1]. In particular this is true of the on-the-fly processing enabled by the "virtual sensor models" supported by Spacemetric's Keystone system.

III. Virtual sensor models

The fundamental goal of satellite photogrammetry is to relate an image pixel to its correct location on the Earth's surface. The most effective way to achieve this is using an analytical model that provides a complete description of the path by which the light travelled from the Earth's surface to reach the sensor focal plane. This "line-of-sight" model is defined mathematically through a number of distinct sub-models that can be independently modified or replaced. Fig. 2 illustrates the relations between these sub-models and the flow of coordinate system transformations this involves.

The rigorous sensor modelling described here is in itself not a new technique and was first applied early in the history of imaging satellites. What is new are the opportunities presented by the power of modern computers. The batch-oriented processing model breaks up the transformation from image pixel to ground coordinate into several discrete stages, each resulting in an intermediate product, typically at boundaries between the sub-models of Fig. 2.

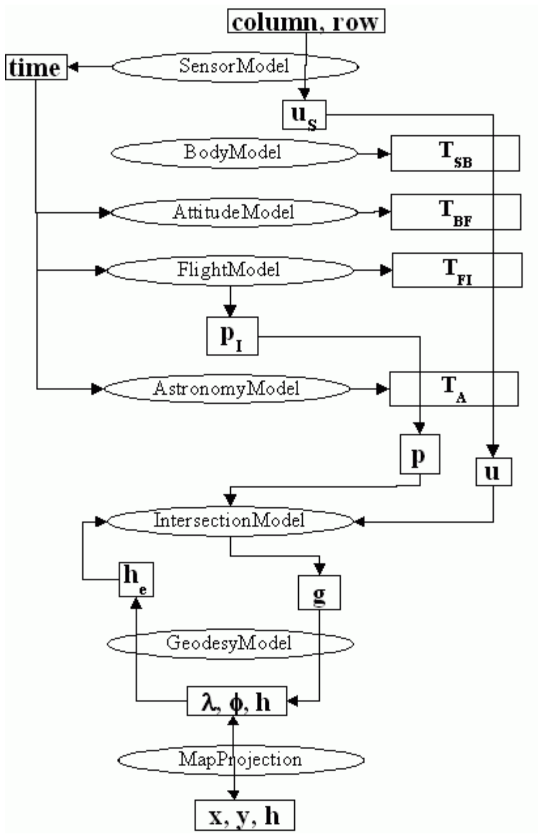

Figure 2. Generic line-of-sight model for optical sensors.

The first of the intermediate products typically incorporates corrections for the effects of the imaging system itself, resulting in a "system-corrected" or "perfect-sensor" product. This then forms the input to the next stage where the image is transformed into a coarsely Earth-located image or "geocorrected" product. In a final stage, with the help of additional external information or "ground control" and a target coordinate system, the final stage is generation of an accurate orthoimage product, several of which can be combined to create a mosaic with continuous coverage of a larger area. The processing in each step is computationally demanding since it involves a resampling of all the image pixels, and the multiple intermediate outputs demanding of data storage.

What Spacemetric's virtual sensor modelling approach does is to compress the whole processing chain, from as near as possible to the sensor to the final orthoimage or mosaic, into a single processing step. This is achieved thanks to a metadata "recipe", built from ingredients that are both inherent to the imagery and from inputs from the user. The former consist of the metadata provided with the image data (e.g. platform position, attitude and timing information) and the rigorous line-of-sight model that is derived from it. Inputs from the user include their preferences for things such as any fine adjustments to image geometry, the extent of the final product, the map system to be used and how to combine multiple images into a mosaic. All of this information is also described in metadata and, although it is complex, it is fast to compute.

When the actual result is to be generated the virtual sensor model leads to considerable time gains. Firstly, the only the pixels that need to be processed from a given image are those explicitly identified by the "recipe". Then there is only a single resampling step needed, going directly from source data to the end product. This effectively removes one or more intermediate processing stages and the associated time and storage overheads. And finally, the output generation process employed by Spacemetric is both highly parallelised and generic, regardless of whether the result is being written to a file-based product, such as a GeoTiff, or being served up via a web service.

IV. NGI project

A. Purpose

The NGI (Near Real-Time Geo-annotated Imagery) project is a technology demonstration being led by Spacemetric on behalf of the European Space Agency and carried out with partners SSC, Metria and Magellium Ltd. The purpose of the NGI project is to demonstrate a generic approach to providing very rapid, user-driven access to satellite imagery to support time-critical workflows. The goal is to make satellite imagery for selected applications accessible to users via a range of on-demand, online services within 10 minutes from the data's downlink to a satellite ground station. Not all elements of the processing chain can be optimised within the scope of the NGI project. For this reason the main focus is on extending the service-orientation to elements farther upstream as illustrated in Fig. 1. The NGI System will offer a range of capabilities including:

- Image search and browse
- Visualisation of imagery from overview level to full resolution
- Collaborative tools enabling synchronised viewing and annotation of imagery
- Notification of new imagery meeting pre-defined criteria
- Updating of image geometry with automated and manual methods.

B. Physical architecture

The service-oriented approach being employed for NGI relies upon a client-server paradigm (see Fig. 3). The orbiting satellite gathers the imagery and downlinks it to the ground receiving station. Some amount of decryption and pre-processing occurs immediately after the data is received and it is then ingested into the NGI System.

The NGI Server is typically co-located with the ground station. It stores and catalogues the data and is the point from which the NGI Services are provided. The NGI Clients that access the NGI data can be located at any Internet-enabled location in the world. The locations to be used for the NGI Demonstrations are described in more detail later in this article.

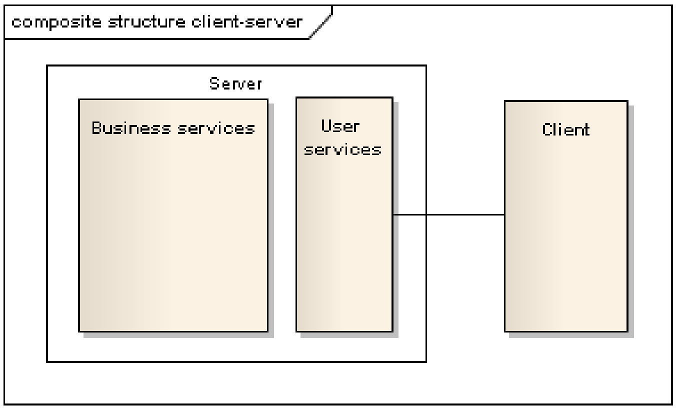

Figure 3. NGI client-server relationship.

C. NGI Services

The NGI System provides a range of services in two distinct groups:

1. Business services
2. User services.

The Business Services support the User Services with business logic. They have transactional responsibility and own the information available through each service. They are the fundamental services of the NGI System.

The User Services are services interacting directly with the user client. They are a kind of middleware that use the Business Services and deliver simplified services directly to the user. The User Services and Business Services together make up the NGI Server.

V. Business Services

The NGI architecture is based on eight Business Services. Each is a building block with a well-defined interface. The service components are (see Fig. 4):

- Pre-processor
- Catalogue
- Image store
- Model refinement
- On-the-fly processor
- Processing
- FTP
- ImagePlan.

A. Pre-processor

The pre-processor, where necessary, is responsible for transforming the image data received by the ground station into a system-corrected image. The process of system correction to achieve band alignment can be performed by resampling the image. It can also be achieved in metadata, thereby creating a virtual system-corrected image.

Resampling takes significant computational effort and is therefore a delaying factor. The virtual system-corrected image is an alternative approach where no pixels are altered. The image is left “as is” but with the geometric and radiometric transformations for the image expressed in the metadata.

Metadata is complex but also small in volume and so fast to compute. Taking this approach avoids the need to process image pixels within the pre-processor. This saves time and storage and Spacemetric has shown the use of virtual system-corrected images as a working concept for operational sensors including the NigeriaSat-2 satellite.

The functions of the pre-processor are usually specific to a given satellite mission. For the NGI project the pre-processor will support the plug-in concept. This means there is an efficient mechanism to add support for additional satellite missions.

The main drawback of the virtual system-corrected image is the greater complexity of the metadata and the time this takes to implement and test. This can be weighed against the otherwise recurring costs of processing and storing intermediate products.

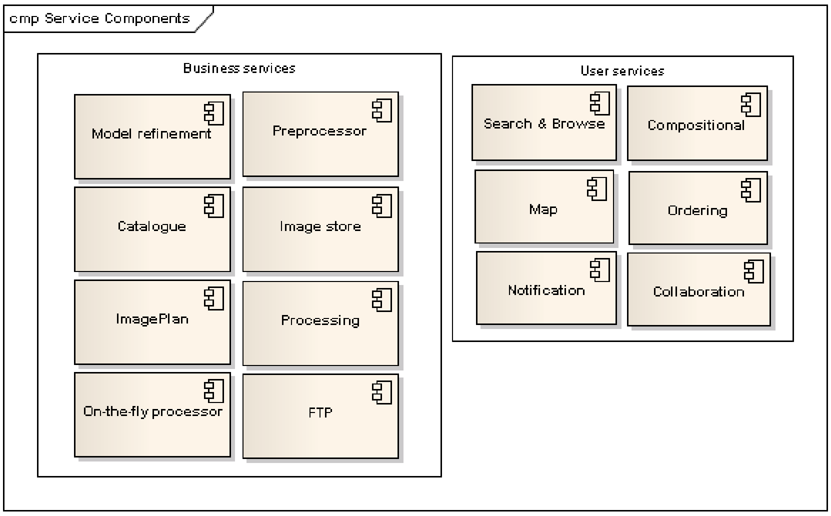

Figure 4. NGI service components.

B. Catalogue

The catalogue is the brain of the NGI System. It is where all the ingested and derived metadata are stored for later access. This includes references to the location in the image store where the pixels are located.

The catalogue contains a geometric model for each image. Multiple model versions can exist for each image. The initial version of the geometric model is generated when first ingesting the image into the pre-processor. For unprocessed data this is based solely on the metadata parameters from the satellite. Updated models are generated by the model refinement component.

C. Image store

The image store contains all the image files in as unaltered a form as possible. The specific format depends on the pre-processor. They can either be wholly unchanged if using the virtual system-corrected metadata or be rectified to a system-corrected product.

The image store is optimised both for large volumes of data and for very fast access to pixels. Image pyramids are used to store the image at different levels of generalisation and provides efficient access at different levels of detail, from overviews to full resolution. Meanwhile the image at each level in the pyramid is also tiled. This means each image is divided into many smaller image elements making it efficient to access just small regions of an image.

Both the catalogue and image store support extensions by adding plug-ins. These can for example provide support for new storage formats or for different compression algorithms.

D. Model refinement

The model refinement component provides the ability to improve or alter the geometry of an image using reference data. This can be necessary if an image location is initially too inaccurate or where it needs to match the geometry of pre-existing data.

The starting point for the model refinement is the initial geometric model whose parameters can be adjusted using comprehensive statistical methods to adapt the image geometry to account for the new information. The process of capturing the new geometrical information can be carried out either manually or automatically, using either interactive tools or automated image matching respectively. The model refinement process uses these measurements to update the geometrical model, supporting both numerical and visual feedback on the results.

The model refinement step adds a new version of the geometric model to the catalogue. The original model is always retained. All geometrical models are expressed in the metadata and no pixels are altered in the model refinement process.

E. On-the-fly processor

The workhorse of the NGI System is the on-the-fly processor. This is where pixels are shuffled and recombined from their initial state into their final form within, say, a high quality orthoimage.

The on-the-fly processor responds to requests received from a User Service. The request contains the area of the output image and other parameters such as sensor, time boundaries and other image attributes that make it possible to find the input images. The processor sends a request to the catalogue and asks what images to include and how to access them. A second request is sent to the image store to retrieve the pixels. Metadata is used to calculate which pixels to use for each pixel in the output image. Only the pixels needed for the final image are retrieved from the image store. It is the responsibility of the User Service to combine output image tiles into a complete image if needed.

The plug-in concept is also used for the on-the-fly processor, making it possible to add new algorithms for resampling and higher-level products suited to the on-the-fly approach, for example NDVI calculation and pan-sharpening.

The on-the-fly processor is designed for parallel processing. The work is divided into relatively small portions before reaching the processor. This means that multiple requests can be sent simultaneously. This approach makes it possible to scale the resampling step in the processor up to hundreds of parallel requests. The Consortium experience is that it is usually the speed of the file store that becomes the key to high throughput.

F. Processing

The processing component is used for scheduling many processes, such as product generation, in a structured manner. This supports both batch processing as well as limiting the strain on the system by only allowing a certain number of processes to run at the same time. The processing component is very generic with the exact behaviour dependent on the script that is executed. Nonetheless it most makes frequent use of the on-the-fly processor.

G. FTP

The FTP component is a simple FTP server. It is used for storing finished products while waiting for a user to download them. It is also used for transferring data from the ground station systems to the NGI System.

H. ImagePlan

The ImagePlan service component is a system for calculating satellite positions, trajectories and their acquisition opportunities. It enables the presentation of information of the type: “where is my satellite” or “when is the next possibility for a satellite image to be taken of my house”.

VI. User Services

The User Service components are responsible for delivery of the NGI functionality to the user clients. The components use the Business Services in combination to be able to offer optimal services. The services typically use standardised interfaces from OGC (Open Geospatial Consortium) such as WMS (Web Map Service), CSW (Catalogue Service for the Web) and Ordering Services, but also make heavy use of proprietary interfaces when needed for optimal functionality.

Six fundamental User Services will be supported within NGI. These are:

- Search and browse service
- Composition service
- Map service
- Notification service
- Ordering service
- Collaboration service.

A. Search and browse service

The search and browse service helps the user find images and information on images. The service request contains a number of conditions that constrain the selection of results to send as a response. The service interface is through the CSW[2] and Keystone API interfaces which both provide access to the catalogue Business Service. The Keystone API can also access the ImagePlan functionality.

B. Composition service

The composition service enables the user to alter the properties of an image. One such alteration is adjustment of the image radiometry to better suit the application. Another is updating the geometry of the image when the initial image is misaligned compared to the user's reference data.

The composition service does not give a physical image as its output but rather a definition of the recipe of how to process the image. It is defined but not processed, but can be previewed using the recipe through an on-the-fly process and then be generated at a later time once the user is satisfied.

The composition service is an advanced service with many specialised features. It is supported through the Keystone API interface. The service uses the catalogue and model refinement Business Services.

C. Map service

The map service renders the resulting image that is defined by a recipe, whether developed in the compositional service or any other image or mosaic in the NGI System. The result can be either a single image or a combination of images in a mosaic. A request to the map service contains a bounding box, a coordinate system and some formatting attributes. The response is an image map including one or more rectified images. If the Keystone API is used then it also allows for streaming images from the server.

The map service provides access through both the WMS EO profile of 1.3.0[3] and older WMS 1.1.1 standards as well as the Keystone API interfaces. The WMS implementations are fully featured but there are possibilities within the map service that go beyond simple map requests, which is why the Keystone API interface exists in parallel to WMS. The map service makes use of the on-the-fly processor, the catalogue and the image store Business Services.

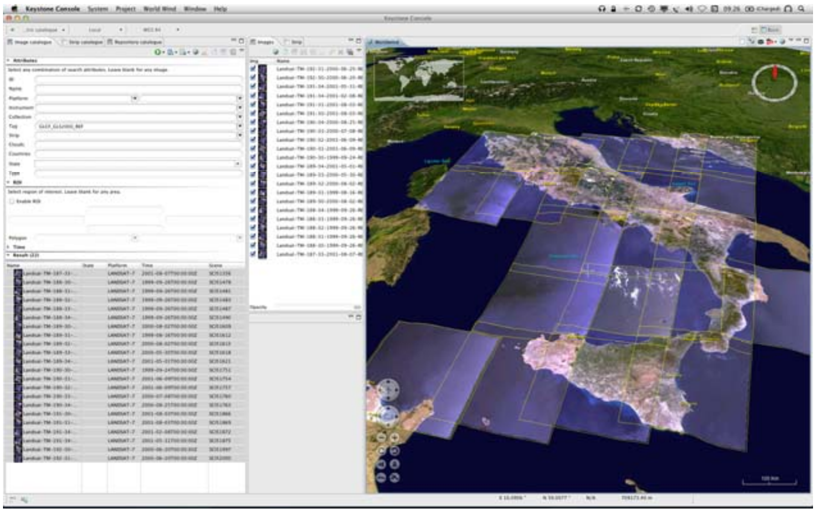

Figure 5. NGI client is provided by the Keystone Console.

D. Ordering service

The ordering service allows users to place product orders with the NGI System. A product order could be for an entire image or a section of an existing image or image mosaic. It is also possible to order products from images that have not yet been acquired. Ordering of future products requires NGI integration with the operators of the particular satellite.

When ordering it is also possible to couple the order to the notification service so that the user is notified once the order or individual parts of the order have been fulfilled.

The OGC Ordering Services and Keystone API interfaces for the ordering service component rely upon the processing service, the on-the-fly processor and the notification service.

E. Collaboration service

The collaboration service allows several users to collaboratively add annotations to images. Annotations added by one user are visible to other users working with the same image. Annotations can be symbols, text, geometrical shapes such as lines, polygons and circles or even generic files such as a Word document or a photo. It has a single Keystone API interface and uses the catalogue component for storing the annotations.

F. Notification service

The notification service is a way of asynchronously notifying a user that some event has occurred within the NGI Server, most notably that a new image is available. Subscriptions to such a notification event can be coupled to an order through the Ordering Service. It can also be set up as a standalone subscription for notifications of all new imagery that matches a specific set of attributes provided when the subscription request is issued. These attributes are similar to the ones provided for a Search & Browse request and include parameters such as time, platform, sensor and area of interest.

The notification service is accessed through the Keystone API interface. It is different from the other User Services in that it is also frequently accessed by Business Services. This is because the notification service has two endpoints: one is for users to register their notifications and the other for internal services within NGI to trigger the notifications.

VII. NGI Clients

A client is required in order to access the functionality of the NGI server. The NGI project will provide three different clients that each serves a particular purpose. In addition to these, much of the NGI functionality is accessible by third-party clients implementing the OGC interfaces supported by NGI.

A. NGI Client (Keystone Console)

The NGI Client is provided through the Keystone Console (see Fig. 5). This is the workhorse client for the Keystone system that supports the core of the NGI System.

Keystone Console is an Eclipse-based client run on the user's machine. It uses the NASA WorldWind SDK to provide a spinning globe viewer where the images are projected. There is extensive integration with the Keystone Server via the Keystone API. This gives the Keystone Console access to most of the capabilities within NGI.

The Keystone Console uses the Search & Browse, Map, Ordering, Notification, Compositional and Collaboration services.

B. NGI web client (Keystone Portal)

The Keystone portal is a web-based client that displays images on a global map background (See Fig. 6). It supports viewing of full-resolution data as well as product ordering.

The Keystone Portal will use the Search & Browse, Map, Ordering and Notification services.

C. NGI web client (WebGL)

The WebGL client is a web-based client providing a spinning globe. It has less functionality that the other clients but can be used as an effective demonstration system. Its intended use is to show "slideshows" of recently acquired imagery projected onto the globe. Being web based it is easy to set up and does not require specialised hardware or software

The WebGL client will use the Search & Browse and Map services.

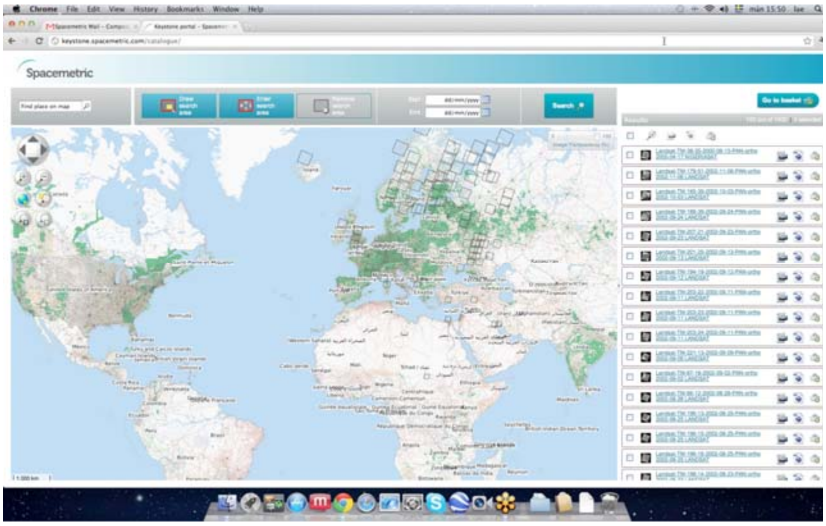

Figure 6. NGI web client is provided by the Keystone Portal.

VIII. NGI Use Scenarios

A number of scenarios have been identified where user requirements indicate that rapid data delivery would offer added value and there is an available source of relevant imagery. These scenarios are:

- Daily Wide Area Monitoring Scenario (regional monitoring)
- Hot Spot Monitoring Scenario (crisis monitoring)
- Emergency Response Scenario (one off)
- Public Use Scenario.

The Daily Wide Area Monitoring Scenario (regional monitoring) requirement is a standing order for acquisition of daily data during several months covering a predefined area. Then the Hot Spot Monitoring Scenario (crisis monitoring) is a scenario triggered in response to a specific event with a subsequent need for satellite tasking for monitoring of a small area defined prior to the satellite pass. The Emergency Response Scenario (one-off) is similar to the Hot Spot scenario in that some aspects of the triggering event and the need for data acquisition can be very urgent. On the other hand, the area coverage is usually larger while the spatial accuracy needs to be higher for the emergency product. Finally, the Public use scenario is a limited, predefined user service with a large number of unknown end-users.

IX. NGI Demonstrations

The NGI project includes demonstrations of the scenarios identified above. The selected demonstrations are:

- Daily wide area daily monitoring (DWA) – Baltic Sea algal bloom monitoring
- Hot-spot monitoring (HSM) – Nuclear facility monitoring
- Public use scenario – ESA and the general public.

A. Demonstrations schedule

The Daily Wide Area Monitoring demonstration was expected to be carried out during Q2 and Q3 of 2012 in cooperation with the Swedish Meteorological and Hydrological Institute (SMHI). This is now called into question by the recent failure of Envisat whose MERIS instrument was to be the primary data source. The Terra MODIS instrument is being investigated as an alternative.

The Hot Spot Monitoring scenario is planned to be conducted during Q3 & Q4 2012 together with a VHR (Very High Resolution) satellite operator.

The Public demonstration is expected to form part of a workshop to be organised with ESA.

B. Scenarios vs. Services

Each of these scenarios has different requirements and ways to interact with the NGI System. Table 1 shows the correspondence between the identified scenarios and the NGI Services used. Here it is clear that all of the scenarios access multiple services and thereby achieve a high level of process complexity. It also shows that all of the NGI Services will be demonstrated in at least one of the demonstrations.

Service / Scenario	Search & browse service	Composition service	Map service	Notification service	Ordering service	Collaboration service
Daily wide-area monitoring	yes	no*	yes	yes	no*	no*
Hot spot monitoring	yes	yes	yes	yes	yes	yes
Public use	yes	no	yes	yes	yes	no

* The possibility to use these services exist but it is not currently foreseen that they will be used within the scenario.

Table 1. NGI Services used in the various scenarios.

X. SpaceOps demonstration

An early prototype of the NGI System is being demonstrated during the SpaceOps conference. It is planned to demonstrate rapid access to data from each of two satellites on all four exhibition days – 11^{th} to 14^{th} June inclusive. This involves coordinating several cooperating organisations with contributing space and ground infrastructures:

1. Satellite operators – Astrium GEO-Information Services (Pléiades) and DMCii Ltd (UK-DMC2)
2. Satellite ground station – Esrange ground station in Kiruna, Sweden, operated by SSC
3. Rapid-access system provider – Spacemetric’s Keystone image management system.

A. Pléiades

The Pléiades satellites (Fig. 7) are highly capable imaging systems with 50-cm resolution imagery and 20-km ground footprint at nadir and up to 100 km x 100 km in strip mapping mode. The satellite can acquire data in a 5 modes encompassing Target, Strip Mapping, Tristereo, Corridor and Persistent Surveillance. The first satellite, Pléiades 1a, was launched on 16 December 2011. The satellite is operated by Astrium GEO-Information Services of Toulouse, France, and a second satellite is due for launch during 2012.

The whole Pléiades system was designed for maximum responsiveness. High-performance gyros give excellent agility and can switch the satellite's gaze by 800 km within 25 seconds. The ground operations are also organised with the same goal in mind. Work plans are uploaded to the satellite three times a day from three stations around the globe, making it possible to use fresh weather forecasts and task requests up to just two hours before the satellite pass. This reduces to a minimum the lead-time between tasking requests and image acquisitions. Customers with receiving stations configured for direct tasking are able to refine their plans at the last moment (30 minutes prior to satellite arrival) to account for weather forecasts or emergency requests.

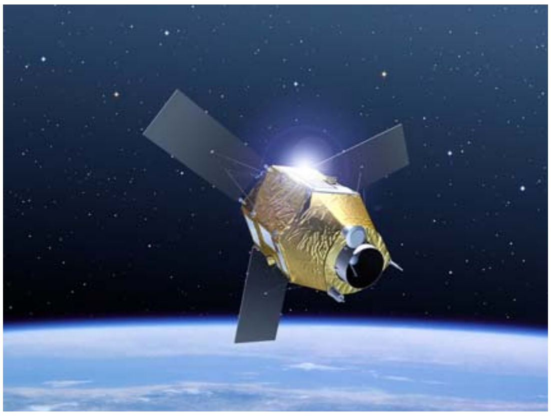

Figure 7. Pleiades satellite. Copyright © CNES

The Esrange ground station outside Kiruna in Sweden is a cooperating station within the Pléiades programme. For the SpaceOps demonstration the Pléiades satellite will be tasked to image targets and then download the data directly to Kiruna ground station. Here it will pass through an Astrium-supplied pre-processor generating a "Primary" basic product. This data will then be ingested into a Keystone Server co-located at the Esrange Space Center facility.

B. UK-DMC2

The UK-DMC2 satellite is a mission within the Disaster Monitoring Constellation built by Surrey Satellite Technology Ltd in the UK and operated by DMC International Imaging. The satellite was launched in July 2009 and carries a multispectral imager of model SLIM-6-22, a dual-bank linear CCD pushbroom imager capturing data within a 660 km swath in near infrared, red and green channels matching those of the Landsat ETM+ sensor.

For the SpaceOps demonstration the UK-DMC2 data will be tasked with imaging targets and then downloading the data directly to the Kiruna station. Here it will be radiometrically corrected via SSTL-developed components into a low-level L0R product. The data will then be ingested into the co-located Keystone Server.

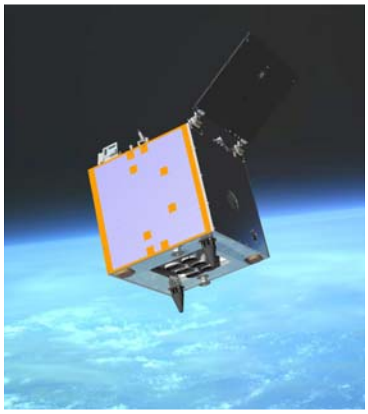

Figure 8. UK-DMC2 satellite. Copyright © SSTL

C. Keystone Server

The Keystone Server already supports a number of the services envisaged within the NGI project. As an initial prototype the upstream integration with the participating missions is not of a consistent level and some pre-processing takes place in both cases prior to data ingestion in Keystone. The imagery from the Pleiades satellite already has co-registered spectral bands, while the UK-DMC2 data is ingested with spectral bands that each still have a separate geometry. For Pleiades this means the virtual sensor modelling is limited to treating all spectral bands as geometrically identical while for the UK-DMC2 imagery the entire geometrical processing will be performed within the Keystone System.

As soon as the imagery from the Pleiades and UK-DMC2 satellites are ingested into Keystone they will be available at the SpaceOps venue through a subset of the various User Services. These will consist at least of the search & browse service, the composition service, the map service, the notification service and the ordering service.

D. Keystone clients

The Keystone Console and Keystone Portal will act as clients for the SpaceOps demonstration. They will access the User Services provided by the Keystone Server in Kiruna through an Internet-enabled PC located at the SpaceOps venue in Stockholm.

XI. Conclusion

The work within the NGI project is building upon a firm foundation already established by Spacemetric within the company's Keystone Image Management System. A service-oriented approach and techniques such as virtual sensor modelling and on-the-fly processing already form part of Keystone's capabilities. These are being extended within the NGI project and being applied to a wide range of clearly identified applications. Rapid data access is being enabled through a well-defined set of services that form a generic framework for effective access to satellite imagery.

An initial demonstration of the NGI concept will take place in June 2012 during the SpaceOps conference held in Stockholm, Sweden. This will involve the UK-DMC2 and Pléiades satellites and the ground station facilities of the Esrange Space Center.

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