System architecture for Earth observation data centre

by Dr. Corné Eloff, CSIR SAC

The objective of the South African Earth Observation System (SAEOS) is to coordinate the collection, assimilation and dissemination of Earth observations, in order that their full potential to support policy, decision-making, economic growth and sustainable development in South Africa may be realised.

This will be achieved by adding value to the existing expenditure on Earth observations (EO) and related activities in South Africa, by making the information available to a broad spectrum of users in an integrated, timely and easily accessible form.

The centralisation of an Earth observation spatial portal as a final result of the SAEOS project also requires an advance Earth observation data centre (EODC) to feed the EO portal with a remote sensing archive and new products and imagery. The collection and image processing of terabytes of imagery requires an advanced automated supply chain to control and manage the workflow of image processing. An advanced customer interface to order and search for the required products from the EODC is essential and after intensive research the product, DIMS-EO, from German company Werum was chosen. This product has been utilised by both DLR (German Space Agency) and ESA (European Space Agency). This system will enhance operational control, quality and throughput within SAC’s remote sensing supply chain.

DIMS-EO system software elements

The system elements depicted in Fig. 1 consists of the following modules:

- Product ingestion
- Catalogue harvesting
- Product library with RDBMS and Data archive
- Production control
- Processors and processing management
- Online/offline product delivery
- User interface loader (UL) and user information services interface (UI)
- EO web (search catalogue)
- Order control
- Production interface
- Definiens Intelligence suite
- PCI Geomatics integration
- SARMES integration (automated image processing system)

Product ingestion

The ingestion service is in charge of accepting data from the various data producers and of coordinating the archiving and inventorisation of the data. The ingestion component implements a workflow that consists of the following steps:

- Data detection
- Metadata extraction
- Data and metadata submission to the product library

Catalogue harvesting

The catalogue harvesting module retrieves metadata from third party catalogues to make the data available for ordering. The component implements a workflow that is performed at regular intervals and that consists of the following steps:

Fig. 1: DIMS-EO system software elements.
The Earth observation data product, or simply any kind of large digital data item with geospatial reference, is the central management unit of the EODC product library (PL). A product typically groups metadata describing the item and several logical components (e.g. browse data, primary data, auxiliary data, processing log or report) which themselves are composed of different physical data files of any format.

**Production control**

The management of digital production chains is mainly provided by the service component production control, which is the component to control and monitor complex production workflows in DIMS. It knows about capabilities of processing systems and it has rules on how to produce products of requested types and how to manage complex workflows.

**Processors and processing management**

In DIMS processors like SARMES or Definiens workflows are wrapped into operational processing systems. Processing systems consist of one or several processors and a framework layer named processing system management (PSM).

The PSM covers common functions of processing systems and supports different processing scenarios. The PSM is able to receive production requests from production control, the operating tool or XML encoded requests via a command line tool. The PSM can itself become active upon reception of trigger events from the product library (PL). Processing input data originates from the PL, a pickup point or the local file system. Output data is stored in the PL or the local file system.

**Online/offline product delivery**

Online/offline product generation and delivery (OPG) generates custom-made delivery packages of ordered product items, either for online transfer or on media. It controls devices like CD/DVD production systems (e.g. Rimage) or tape autoloaders.

To cater for printed data delivery, the OPG can also be configured to feed the product data to a printer driver, e.g. PDF writer software.

**UIS interface**

The components user interface loader (UL) and user information services interface (UI) use the PL insert and update event subscription to systematically upload product data into the EOWEB user services and external data management systems. Thereby the UI component provides an interface framework that is easily adapted to foreign data structures and protocols of external data management systems. Product availability and licensing constraints are taken into account in a configurable manner.

**EOWEB**

EOWEB is the user information service of the data information and management system DIMS. It provides catalogue, order and data services to end users and to external systems (e.g. via the standard access protocols HTTP/SOAP, CIP).

**Order control**

Ordering control is the component to handle and process user orders in DIMS-based systems. It covers aspects from validation to on-demand production to accounting. Orders arise from EOWEB user services or external data management systems. The component user information services interface is responsible for the download and format transformation of original user orders and the forward of order status information back to the user information service system.

**Production interface**

The production interface (PI) component is a lightweight component to exchange requests and, optionally, data with external production or acquisition systems. The PI implements the internal native DIMS interfaces and provides an application programming interface (API) to implement external interfaces. An available default implementation for ordering is based on XML files placed in a file system location. The XML files contain all available order information. The default
The implementation assumes that the remote system reacts on the placed XML file with the provision of a result product in an output directory. When the external system reports successful production, the product file is retrieved by the DIMS system using protocol and product specific plug-ins.

**Definiens Intelligence suite**

The Definiens software suite provides image analysis for Earth observation data. The software is used to create higher level thematic mapping from Earth observation data. The output of a Definiens processing are thematic maps and feature extraction information. The output of a Definiens workflow either creates a new product to be archived or is stored as a component of an existing product.

**PCI Geomatics**

The PCI Geomatics software suite needs to be integrated into the system to support post processing workflows during ordering, e.g. to extract subsets from mosaics to be supplied to the user. The integration will be based on the available PCI APIs.

<table>
<thead>
<tr>
<th>Department</th>
<th>Application description</th>
<th>Historical image use</th>
<th>Temporal frequency</th>
<th>Geographical area</th>
<th>Spatial and spectral requirement</th>
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<tbody>
<tr>
<td>SANDF</td>
<td>Image intelligence</td>
<td>Landsat 7</td>
<td>Based on mapping</td>
<td>Africa outside SA</td>
<td>20% low resolution (30 m)</td>
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<td></td>
<td>Mapping</td>
<td>Spot 2/4/5</td>
<td>Intelligence</td>
<td></td>
<td>20% medium resolution (5 - 10 m)</td>
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<td></td>
<td>Geo-visualisation</td>
<td>Ikonos</td>
<td>requirements</td>
<td></td>
<td>60% high resolution (50 cm)</td>
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<td>Map substitutes</td>
<td>Quickbird</td>
<td>High turn-around</td>
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<td></td>
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<td>Kompasat</td>
<td>times required</td>
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<td>Municipal Demarcation Board (MDB)</td>
<td>Municipal demarcation</td>
<td>Spot 5 mosaics</td>
<td>Annual</td>
<td>National</td>
<td>Very high in urban areas</td>
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<td></td>
<td>Population analysis</td>
<td></td>
<td></td>
<td></td>
<td>Moderate (Spot 2,5 m) in rural areas</td>
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<td>Socio economic information</td>
<td>Spot 5 mosaics</td>
<td>Annual</td>
<td>National</td>
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<td>Infrastructure backlog assessments</td>
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<td>Possibly SADC</td>
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<td>Infrastructure access (water, elec, sanitation, roads, clinics)</td>
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<td></td>
<td>Social infrastructure (stadiums, community halls, parks, etc)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Spot 5 derived products</td>
<td>exp dwelling count</td>
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<tr>
<td>SAPS</td>
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<td>Spot 2/4/5</td>
<td>2 - 4 per annum</td>
<td>National including 500 km border buffer</td>
<td>5 m / 1 m / 50 cm /&gt;50 cm</td>
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<td>Safety and security</td>
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<td></td>
<td>16 Presidential Precincts</td>
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<td></td>
<td>Planning</td>
<td>Quickbird</td>
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<td>340 Priority Precincts</td>
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<td>Eros</td>
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<td>Border control</td>
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<td>Special ops</td>
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<td>Independent electoral commission (IEC)</td>
<td>Election planning</td>
<td>Aerial photography</td>
<td>Annual to every second year</td>
<td>National</td>
<td>0,5 urban, 1 - 2,5 m rural</td>
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<td>Election management</td>
<td>Spot 5</td>
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<td>Statistics SA</td>
<td>Dwelling Frame inventory</td>
<td>Aerial</td>
<td>Annual</td>
<td>National</td>
<td>Rural - 2,5 m</td>
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<td>Demarcation</td>
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<td>Urban &gt;0,5 m</td>
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<td></td>
<td>EA map production</td>
<td>Quickbird</td>
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<td></td>
<td>Population change</td>
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<tr>
<td>Eskom</td>
<td>Dwelling inventory</td>
<td>Spot 5</td>
<td>Annual</td>
<td>National</td>
<td>5 m - 2,5 m and &gt;0,6</td>
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<td>Fire history analysis</td>
<td>Landsat</td>
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<td>AFIS</td>
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<td>5 m DEM urgently required</td>
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<td>Informal settlement monitoring on servitudes</td>
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<td></td>
<td>Infrastructure development monitoring</td>
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**Table 1: Examples of user requirements.**
SARMES

The SARMES system, based on PCI Geomatics software is used to perform various types of processes. Level 1 satellite image data is converted to level 3 and 4 data products. The process includes radiometric and geometrical correction steps. The production with SARMES can be performed in parallel up to level 3. The assembly of the L3 products into the L4 then follows as a step requiring all level 3 products as inputs. Structuring the processing management control properly allows implementing a very efficient handling of the production where all input products are processed to L3 as soon as they have been ingested into the system. The L3 products are stored in the product library. The geographical query capabilities of the product library can then be used to select all relevant L3 products for the generation of the L4 product (see Fig. 2).

Remote sensing user requirements

The CSIR SAC hosted a user requirement workshop on 14 February 2008 to understand and align current and future Earth observation satellite sensors. Over 30 government departments were invited to the workshop. Invitations were also extended to parastatals and representatives from the media. Attendance was overwhelming with over 50 delegates representing 23 government departments participating on the day.

The purpose of the workshop is outlined below:

- Inform stakeholders of the role of the South African Space Agency in coordinating Earth observation data access through a presentation from the Department of Science and Technology.
- Understand available imaging technologies for a potential follow on reception agreement post March 2009. The following satellite and aerial imaging suppliers presented their capabilities to the stakeholders;
  - Infoterra on TerraSAR-X
  - DigitalGlobe on Quickbird and the new Worldview satellite
  - GeoEye on Ikonos and the new GeoEye-1 satellite
  - RapidEye on its new high resolution constellation
  - Antrix on the Indian ResourceSat and CartoSat 1 and 2 satellites
  - SpotImage on Spot 5 and AstroTerra (Spot 6)
  - CDSM on the new digital airborne imager

- Understand user requirements for 2008-2011 per department through a questionnaire survey
- Assess available departmental budgets for 2008-2011
- To ultimately agree on a suitable sensor portfolio for 2009-2011 and beyond.

Summarised user requirements

A selection of summarised user requirements can be seen in Table 1.

Recommendations

The recommendations arising from the workshop were as follows:

- Renew SPOT 5 and consider engagement into AstroTerra (SPOT 6)
- Direct telemetry access to CartoSat (P5) and ResourceSat (P6)
- Sub-one metre satellite imagery to be procured on an ad hoc basis where CDSM airborne camera is unavailable
- Secure “emergency/rapid response” contract with TerraSAR-X

Conclusion

The SAEOS programme initiated by the Department of Science and Technology enabled CSIR SAC to re-engineer its EODC service. The hardware architecture and software components as described, DIMS-EO system, will result in a world class remote sensing supply chain centre. The SAEOS three year implementation plan for EODC will conclude in March 2009. This centre will contribute to various national, regional and international programmes. The Earth observation service provided by SAC will play a vital role in the South African National Space Agency and impact positively through its service to the person in the street.

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