Long-term preservation and advanced access services to archived data: The approach of a system integrator

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Abstract – EADS Systems & Defence Electronics (EADS S&DE) have developed an expertise as integrator of archive management systems for both their commercial and defence customers (ESA, CNES, EC, EUMETSAT, French MOD, US DOD, etc.), especially in Earth Observation and in Meteorology fields.

The concern of valuable data owners is both their long-term preservation but also the integration of the archive in their information system with in particular an efficient access to archived data for their user community. The system integrator answers to this requirement by a methodology combining understanding of user needs, exhaustive knowledge of the existing solutions both for hardware and software elements and development and integration ability. The system integrator completes the facility development by support activities.

The long-term preservation of archived data obviously involves a pertinent selection of storage media and archive library. This selection relies on storage technology survey but the selection criteria depend on the analysis of the user needs. The system integrator will recommend the best compromise for implementing an archive management facility, thanks to its knowledge and its independence of storage market and through the analysis of the user requirements. He will provide a solution, which is able to evolve to take advantage of the storage technology progress.

But preserving the data for long-term is not only a question of storage technology. Some functions are required to secure the archive management system against contingency situation: multiple data set copies using operational procedures, active quality control of the archived data, migration policy optimising the cost of ownership.

Some archive management systems have set up the right mechanisms to preserve their valuable data for long term, but the access to these data by the user community remains painful. EADS S&DE have defined a reference architecture named “Advanced Archive Data Server” answering both objectives of preserving the data and providing advanced user services. This architecture allows providing tailored services to the designated user community with a strict separation between the view of the archived data presented to the users and the data themselves.

In conclusion, the pace of technology evolution especially for storage is both an opportunity and the cause of rapid archive system obsolescence. The role of the System Integrator is through the definition of a sound architecture, to avoid that the changes of hardware or software impacts the use of valuable data.

1. Introduction

EADS Systems & Defence Electronics (EADS S&DE) is an information systems integrator for both commercial and defence customers. The data managed by EADS S&DE information systems are are mainly images acquired by Earth Observation and by Meteorological satellites or by Airborne systems (surveillance aircraft or unmanned aerial vehicles). Because these data have to be maintained available for long-term, EADS S&DE have developed a comprehensive expertise as system integrator of archive management facilities (SPOT 1-5 archives for CNES & Spot Image and for direct receiving stations, AMS archive for ESA/ESRIN, U-MARF archive for EUMETSAT, HELIOS 1&2 archive for French MOD, Eagle Vision Transportable Station for US DOD, etc.)

For EADS S&DE customers, the long-term preservation of their data sets is a key issue and some of them have already been confronted with the necessary migration of their valuable data to a new storage technology.

But it is not sufficient to design an archive management facility with the only concern to achieve long-term preservation. Why preserving for long-term the valuable data if their access by a designated user community is impossible or very painful. The design of an archive management facility shall take into account both the long-term preservation and a complete set of access services adapted to these data.

2. A system approach for defining a long-term Archive Management System

The development of an Archive Management System can not be restricted to a procurement approach although the choice of technology in such a facility is a key issue. It requires a complete development process to fulfil with the user expectations.

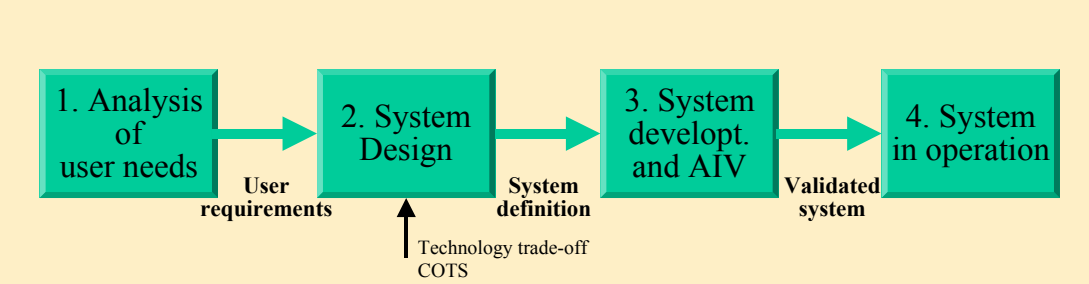

Fig. 1: process for the development of an Archive Management System

The typical process for the development of an archive management facility is composed of four phases:

1. **Analysis of user needs.** This phase aims to collect inputs about the data and the related services and to define with the customer the User Requirements:
   - Nature, format, size of data
   - Producers and consumers of the archived data
   - Operational scenarios: frequency of ingestion, profile of access, expected services and performances
   - Storage duration: typically “infinite” but can be time limited (e.g. 3 months for a rolling archive).
2. **Design of the facility.** This phase consists to define the hardware and the software architecture of the facility.
   - Selection of the storage technology taking into account both the state-of-the-art in storage media and automated libraries and the user requirements. Benchmarks can be required if case of specific customer requirements.

- Definition of a software and hardware architecture based as far as possible on existing components (COTS, MOTS). For the requirements not covered by existing solution, the specific elements are designed in detail. EADS S&DE have developed the SatSTORE [2] product based on ADIC AMASS [3] to support an efficient integration of the archive management facility with the customer application by providing advanced services.

3. **Facility development and AIV (Assemblage, Integration and Validation).** This phase consists in:
   - The development of the specific elements or the customisation of existing MOTS (Modifiable Off The Shelf).
   - The procurement of existing components (both hardware and software)
   - The Integration, Validation then Acceptance of the facility with the customer representatives
4. **Support to system operations.** This phase can be different according to the customer requirements:
   - Maintenance activities: correction of hardware or software failures, on-demand evolutions of the facility.
   - Support to operations: training, on-site support to operate the system.
   - Possibly, the operations can be out-sourced: in this case, the customer pays for a service, not for the procurement of a facility. As an example, EADS S&DE provide such a service to the European Commission for the EUDOR Archive System in charge of the Official Documentation of European Union.

The development process described above is applicable to large archive facilities such as AMS for ESA or U-MARF for EUMETSAT as well as to small archive facilities (e.g. the archive components included in multi-mission direct receiving stations).

3. How to ensure the long-term preservation of valuable data

3.1 CCSDS OAIS Reference Model and the long term preservation

The Consultative Committee for Space Data Systems (CCSDS) has defined the Open Archival Information System (OAIS) reference model [1] as a common framework of terms and concepts for the definition and the design of future archive systems facing with permanent or indefinite long-term preservation of digital information.

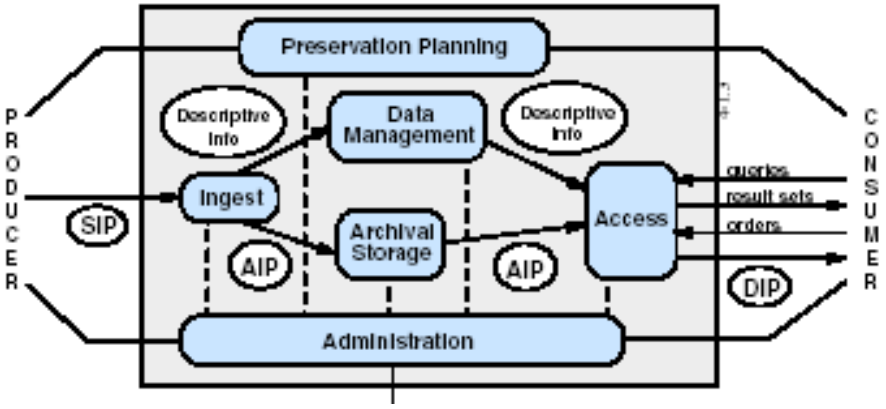

Fig. 2: Functional entities of the OAIS Reference Model

Regarding the long-term preservation of valuable data, the OAIS model identifies some recommendations and features:

- For the storage technology:

  - To select a media technology, the criteria identified in the model are the error rate, the performances, the cost of ownership, but also the long-term stability of the media
  - To protect the Archive Management System, several functions are defined such as the "disaster recovery", the "replace media" and the "media migration" functions
- Long-term stability of the access to the archived data:
  - Data have to be archived with all the information required for the use ("submission agreement" function)
  - The descriptive information used by the consumers for querying archived data are separated to the archived data themselves

3.2 Choice of storage technology

For the choice of a storage technology, the system integrator considers various criteria, which are assessed with the user requirements.

The user requirements impacting the choice of a storage technology are typically:

- Sizing inputs: number and size of the products
- Performances: ingestion and retrieval scenarios
- Operation requirements: availability, unmanned operations

These inputs are key elements for the selection of a storage technology. For a same volume of archived data, the technology can be very different according to:

- the average size of the products (from few megabytes to several gigabytes),
- the required access time (e.g. tapes do not allow the access to archived data in few seconds),
- the age distribution of retrieved products (e.g. if 90% of retrieved products are archived since less of one week).

In parallel with the analysis of these user requirements, the system integrator considers the state-of-the-art and its own experience for the storage technology. The choice of a storage solution consists in selecting a media (and thus a drive) and in most of the archive management systems a library.

The two elements (library and media) are not independent even if not manufactured by the same company because the media has to be supported by the library. The key advantage of a system integrator is its independence with manufacturers, which allows selecting the best solution for a customer among the storage market.

The main criteria for the selection of a media are:

- Reliability: Bit error rates, media lifetime
- Performances: media capacity, throughput but also access time
- Cost of ownership, including the concept of storage family ensuring an ascending compatibility between generations of media.

The main criteria for the selection of a library are:

- Minimum and maximum capacity in term of number of media and number of drives allowing the required scalability
- Reliability and maintainability
- Capability to support heterogeneous media types: this feature allows taking advantage of future media technology when available

3.3 How to preserve archived data against contingency?

The choice of a storage technology is a key issue but is not sufficient for ensuring the long term preservation whatever the contingency situations. Some functions have to be implemented in the archive management facilities for this purpose:

- Multiple copies of valuable data is often recommended: for instance, in U-MARF for EUMETSAT, a second copy of valuable data is performed in the same library during data ingestion but in a separate set of tapes, which are periodically moved into a remote location. In EUDOR for the European Commission, three copies are generated, two in real time on two different libraries and storage technologies (Hewlett-Packard Optical disks and Sony AIT-2 tapes) and a third copy transferred once a day to a remote site. In this case, the long-term preservation is reinforced by the use of two different technologies for the copies.

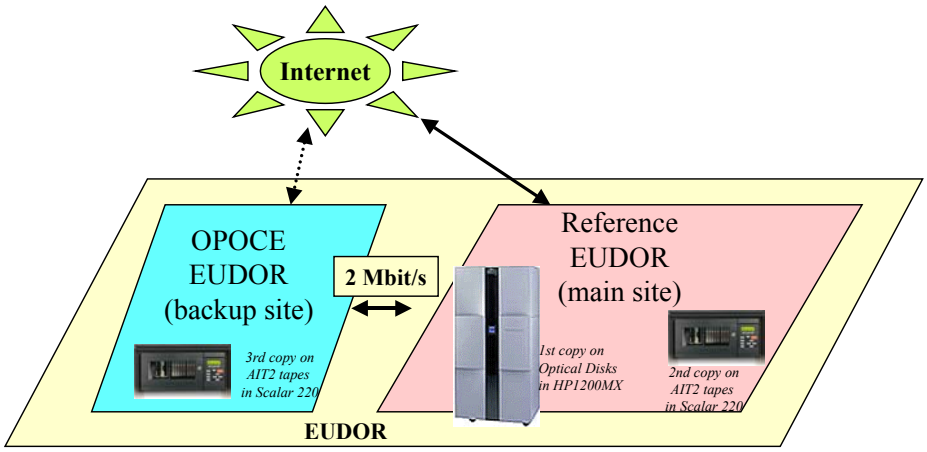

Fig. 3: Principle of the EUDOR archiving architecture

- System failure with corrupted archive management system: a periodical backup of the archive management system databases is done on a daily basis, the transactions between two backups being stored for contingency.
- Active quality control of the archived data: usually, the problem of media degradation is detected only when the data recorded on the media are accessed. But it can be too late if the media is then too much degraded. The "Infinite File Life" feature integrated in the SatSTORE/AMASS solution ensures the "infinite" preservation of archived data by an active monitoring of media taking into account their use and performing periodic exhaustive check-up. When the degradation of a media reaches a pre-defined threshold, the migration of its content is automatically scheduled, with possible use of a different storage technology for the new media.

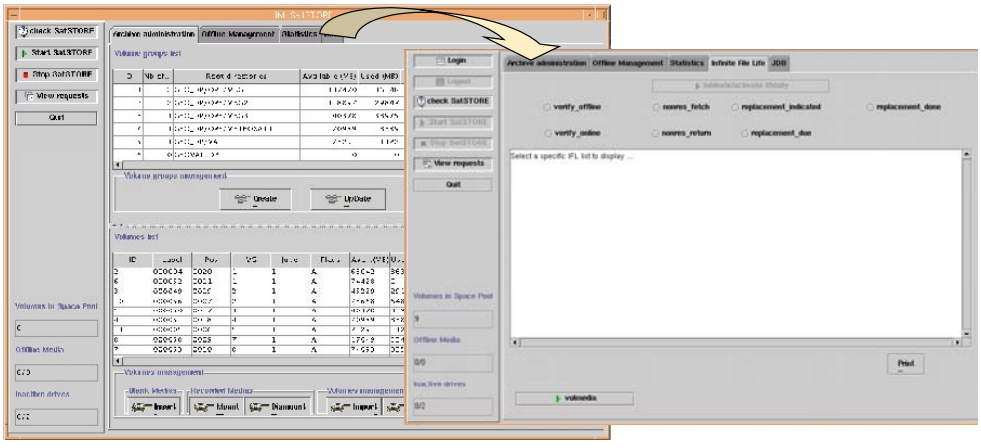

Fig. 4: SatSTORE main window and its "Infinite File Life" monitoring & control tab

3.4 How to preserve the archived data in spite of the technology evolution

The pace of technology evolution is causing some hardware and software systems to become obsolete in a matter of a few years. This is a key factor to consider when designing an archive management facility.

The architecture of the archive management facility shall allow separating the descriptive information used by the consumers for querying archived data and the archived data themselves as recommended in the OAIS reference model [1]. Moreover, the archived data must be consistent in term of application point of view and the storage software shall propose access services independently of the data storage location.

- Application oriented storage organisation: the interest of the concept of archived products instead of a simple file handling is that all the components of a product (image, metadata, browses, other) are archived together under an application-oriented archive product identification.

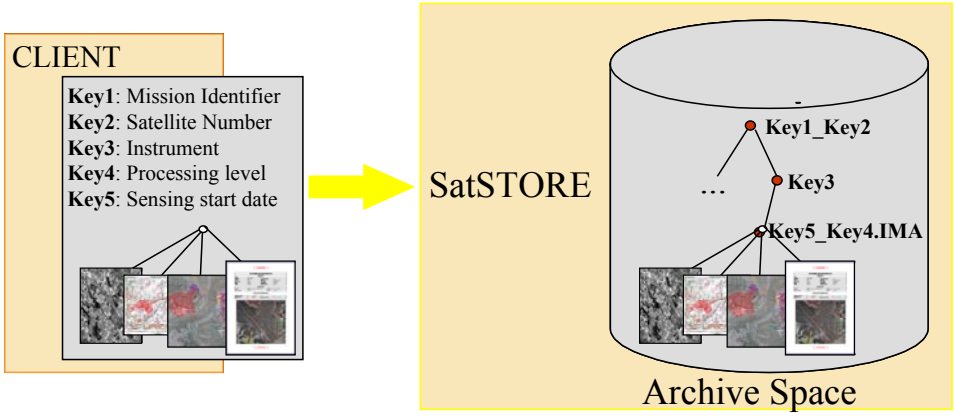

Fig. 5: SatSTORE Product concept separates the client view on archived data and their internal storage organisation

- Data migration: data have to be migrated when a technology becomes obsolete or when its cost of ownership (in particular, maintenance costs and storage volume in term of square metres) justifies the migration to a new one. Several scenarios are possible. If the old technology belongs to a family of storage technology (e.g. DLT from Quantum and AIT from Sony), the library is likely to be upgradable with new drives with higher capacity but providing backward compatibility to read the old media without migration. Some multi-media technology libraries allow benefiting from new technology without migrating the old media. In this case, the data migration can be delayed until the cost of ownership justifies it and only for the set of media involved. So the data migration becomes a smooth process optimising the cost of ownership.

4. Advanced access services to archived data

The long-term preservation is a key issue for any archive management system. But preserving the data is useless if their access by the user community is impossible or painful. This is why the design of an archive management facility shall take into account the consumers needs in term of access services.

4.1 The EADS S&DE Advanced Archive Data Server architecture

EADS S&DE as integrator of archive system have identified reference architecture addressing the dual objectives: preserving the data while providing advanced user services.

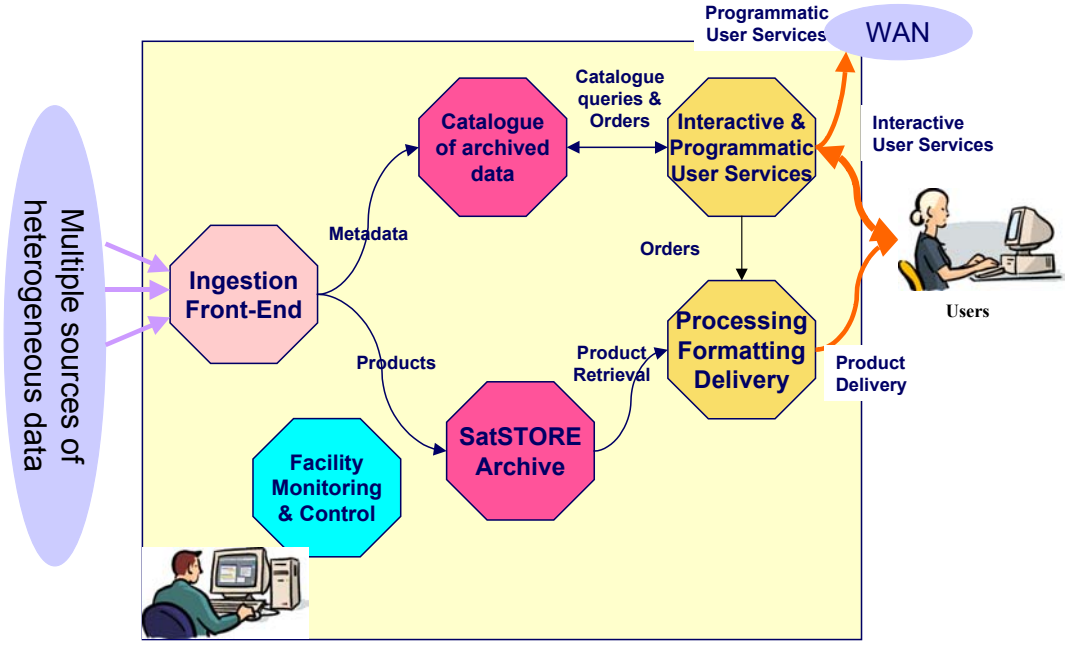

Fig. 6: the EADS S&DE Advanced Archive Data Server architecture

The EADS S&DE reference architecture is close to the principles of the OAIS reference model [1]:

- separation of the archival storage (archive) and of the data management (catalogue),
- access services providing query and dissemination services,
- ingest function (ingestion front-end) synchronising the archive and the catalogue update.

This architecture is composed of the following components:

- **The Archive**: manages the product archiving, their long-term preservation and the product retrieval services. SatSTORE is the solution proposed by EADS S&DE for implementing this component, providing to the other components a large set of services throughout an Application Programming Interface or throughout CORBA services. The specific storage hardware is managed by the archive component.
- **The Catalogue:** handles the descriptive information (metadata) related to archived products. This component is typically based on a relational database system with a database model depending on the nature of the data managed by the facility. The catalogue provides performing query services to the User Services.
- **The Ingestion Front End:** receives the data from multiple producers, check the consistency of ingested data, extracts the descriptive information (metadata), creates the products from ingested data and ensures a consistent transfer of the product into the archive and of the metadata into the catalogue. A Generic Ingestion Front-End solution has been developed by EADS S&DE, which is customised to the specific needs of each facility.
- **The User Services:** propose a complete panel of services including user management, guide information, catalogue queries, product ordering, order follow-up, billing, etc. These User Services are typically web services supporting interactive accesses. But they can also be implemented as programmatic services for application interface.
- **The Product Formatting & Delivery:** is in charge of processing the orders. The selected products are retrieved from the archive, then they are possibly post-processed and reformatted (HDF, JPG, etc.) as required by the user and the output data are disseminated to the user either on delivery media

(CDR/DVDR, tapes) or by electronic delivery. The operations are automated as far as possible. A Generic Product Formatting & Delivery solution has been developed by EADS S&DE, which is customised to the specific needs of each facility.

- **The Facility Monitoring & Control:** provides some tools to the facility administrator and operators for managing the facility: administration HMIs, event logs, reports.

The EADS S&DE reference architecture described above is applicable to large archive facilities as well as to small ones, the hardware configuration being sized to fit with the performance requirements.

The Advanced Archive Data Server architecture has already been experimented by EADS S&DE for operational systems. In particular, the U-MARF facility for EUMETSAT and the EUDOR facility for the European Commission is based on this design and on the generic components mentioned above.

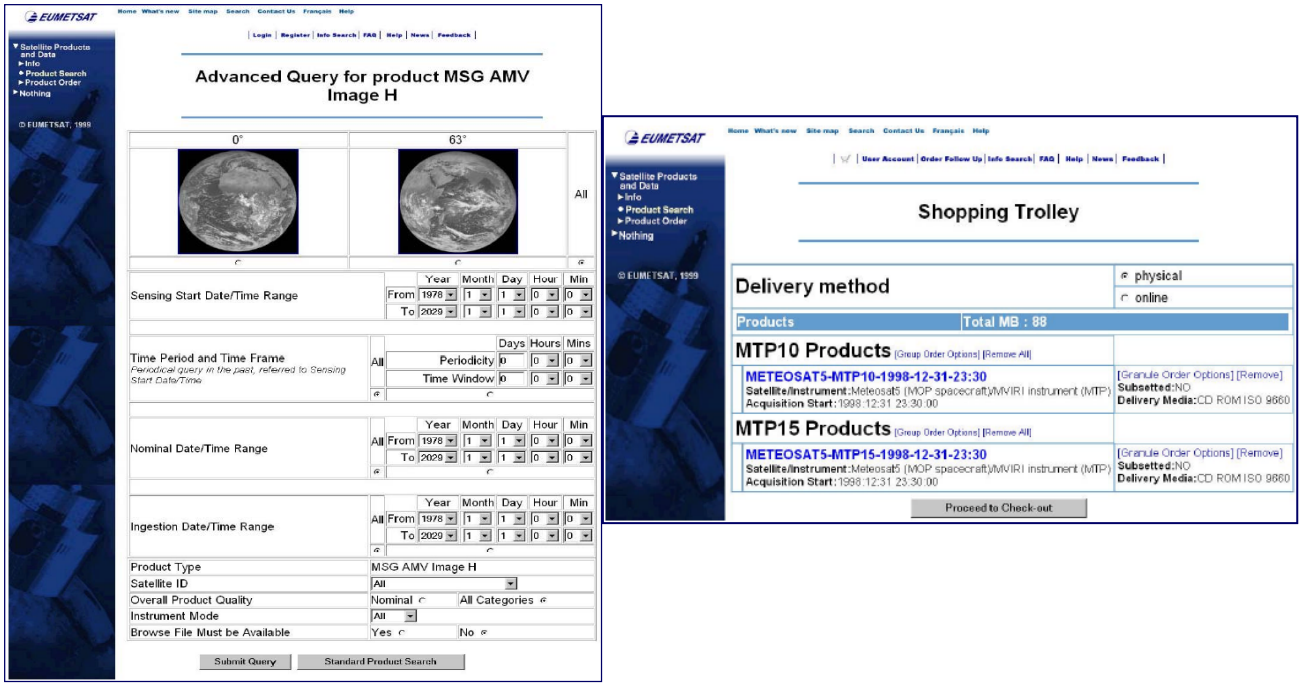

Fig. 7: Example of catalogue query and order services implemented for MSG products in U-MARF

4.2 Heterogeneous data handling

The problem of a generic architecture for data management is its ability to handle heterogeneous data set, without impacting the interfaces between components and by limiting the impacts to the application dependent parts of the architecture.

- **The Archive**: is nominally not impacted by the heterogeneous data handling if its design remains independent of the data formats. With the EADS S&DE SatSTORE solution, this is the case. Whatever the data, SatSTORE can manage them by a simple configuration of the storage space. The only exception to this principle is partial extraction services for Earth Observation archived data, where the extraction of only a subset of archived data can dramatically improve the performances. A plug-in solution has been implemented by SatSTORE for different EO formats (e.g. for the GERALD CNES format). A generic solution for partial retrieval has been studied and implemented for the ESA AMS archive system based on the EAST technology and is in operation for ERS data.
- **The Ingestion Front End and the Product Formatting & Delivery:** are both impacted by the formats of heterogeneous data. The ingestion front-end has to extract metadata from ingested data and possibly to generate browses from these data. On the other side, the post-processing and the formatting are obviously format dependent. In the generic components developed by EADS S&DE, the dependencies to

the data formats are limited to plug-ins. In addition, EADS S&DE is studying for ESA the Advanced Data Archive for Earth Observation (ADAR), in which it is foreseen to implement the heterogeneous data handling by using XML descriptions.

4.3 Performances of concurrent data archiving and retrieval

The performances of an archive management system are of key importance both for allowing a correct ingestion of produced data and for disseminating the data to the user community.

The system integrator defines the performance requirements with the customer at the beginning of the project. Then it defines the architectural design in particular the hardware architecture, which is critical in this phase. The main elements to be studied carefully are:

- the storage architecture: on-line storage with disk arrays, near-line storage with the library configuration, the interfaces between the servers and the peripherals,
- the User Services and the catalogue: to face with the number of concurrent accesses for catalogue consultation and ordering (e.g. the EUDOR facility for the European Commission disseminates up to 5,000 documents per day),
- the dissemination architecture: this architecture depends on the volume of data to be disseminated, on the type of reformatting and the type of data delivery (network or media).

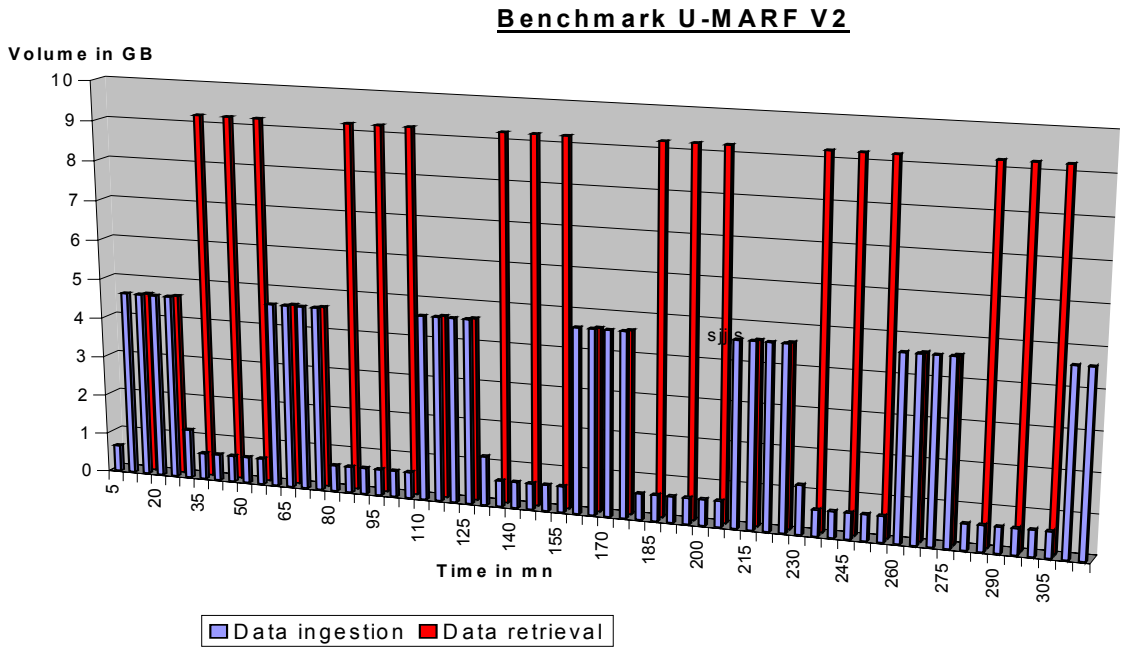

Fig. 8: Benchmark performed during the definition phase of U-MARF V2 for EUMETSAT showing the ability of both SatSTORE and selected technology to fit with the performance requirements: 670GB daily ingested with 1000GB of concurrent retrievals

References:

[1] *Reference Model for an Open Archival Information System (OAIS)*
CCSDS 650.0-B-1 Blue Book January 2002

[2] *SatSTORE - High Capacity Archiving System*
EADS Systems & Defence Electronics documentation

[3] *AMASS Overview – Version 5.2*
ADIC documentation

[4] *EUDOR web site – The portal to European Law*
http://europa.eu.int/eur-lex

[5] *Unified Meteorological Archive & Retrieval Facility (U-MARF) Requirements Specifications*
EUMETSAT document – EUM/UMA/SPE/001 Issue 2 Rev.0

[6] *Archive Management System (AMS) for ESRIN EO Data – Software Requirement Document*
ESA document – AMS/LR/SRD/001 Issue 2.0