CENTRE NATIONAL D'ÉTUDES SPATIALES

REUSABLE TOOLSET FOR AN EASY-TO-BUILD PAYLOAD CONTROL CENTRE

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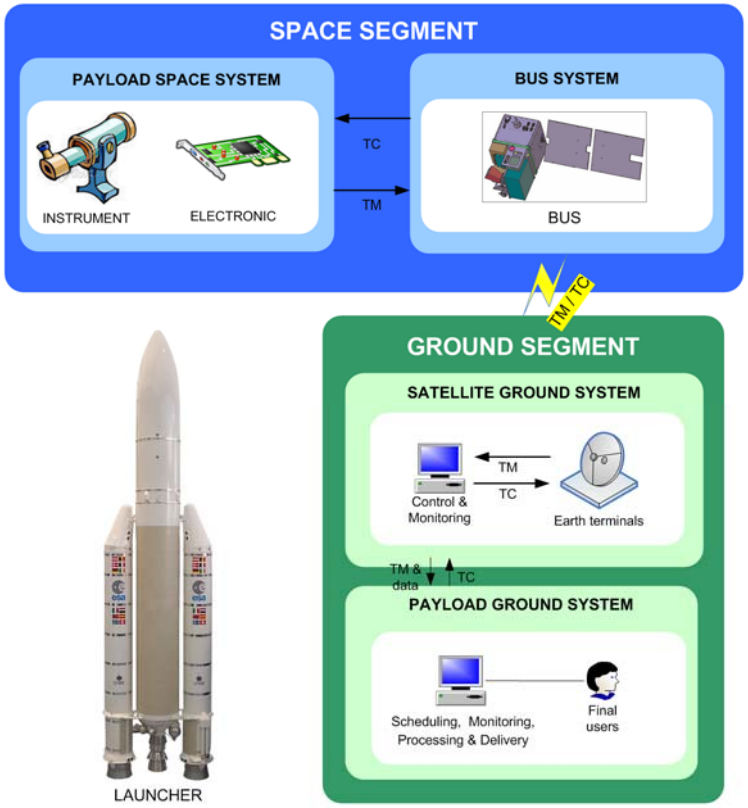
OVERVIEW

1. The context
2. Lessons learned and analysis
3. CNES solution & description of tools
4. Example of tool utilization
5. Conclusion

THE CONTEXT
CNES mini-micro satellites SERIES: PROTEUS & MYRIADE

The aim: to have generic parts to be re-used (limited adaptations) with reduced delay and cost

- A set of functional elements which constitutes a platform allowing several options
- A generic ground segment with a network of Earth terminals
- A multi-satellites control centre
- Tools to permit mission analysis, satellite design, and system validation.
- A human organization
- A mastered engineering process



Nominal architecture of a MYRIADE mission

PAYLOAD CONTROL CENTRE DEVELOPMENT: lessons learned

Lessons learned from previous missions

=> Operations are very time consuming

=> An efficient ground segment requires a precise idea of the operational concept

=> Lab priority is the payload…No time/money to develop a new ground system

However…

The payload control centre must be considered as an important element of the system, even for a microsatellite!

Few years ago => assumption

- Various payloads → various payload control centres
- Various scientific laboratories → various interfaces

➔ A payload ground segment is specific to the mission

But…

Ground segment responsibilities

Functions under ground segment responsibility *(ECSS-E-70)*

- Mission analysis;
- Operations preparation;
- Simulation;
- Mission planning and scheduling;
- Monitoring and control;
- Flight dynamics;
- On-board software maintenance and management;
- Data archiving;
- User services;
- Data processing & product delivery;
- Performance analysis and reporting;
- Configuration management (space segment, ground segment, mission information);
- System maintenance

External interfaces

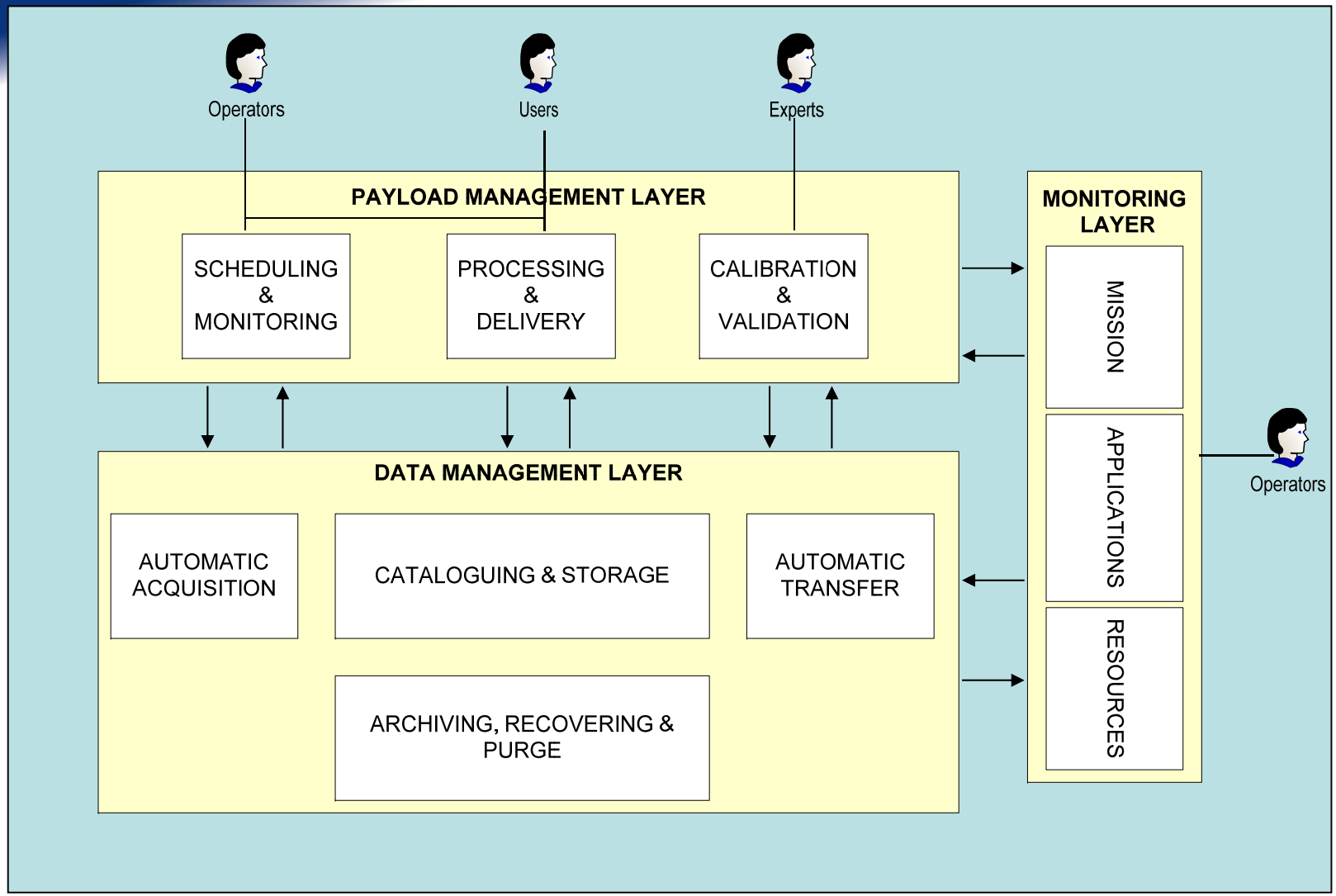
- Satellite control centre
- Payload experts
- Scientific experts
- Exogenous operational centers
- Scientific community

A functional architecture common to most of the ground segments can be proposed, split into 3 layers:

1. ***Payload management layer***
2. ***Data management layer***
3. ***Ground monitoring layer***

A microsatellite does not mean a micro-ground segment !

FUNCTIONAL ANALYSIS



OPERATIONAL and RESOURCES ANALYSIS

- **Operational analysis:**
  - Similar concept
  - Often operated by laboratories
  - Payload programming function may be complex (automatic & manual operations)

- **Resources:**
  - Few human resources but high level of activity - not only top level functions – but workload due to the data management layer and the monitoring layer, not to mention validation activities.
  - The volume of data managed quite big (4GB/day Taranis)

=> To be on time in the development process

  - Increase team size
  - Reduce the functional perimeter
  - **Benefit from an existing system**

CNES SOLUTION

Engineering process

- Phases A & B:ground system requirement defined and specified (CNES & Labs)
- Phases C/D: system designed and produced by external contractor
- Phase E: validation of the system

→ Often delay in scientific data processing definition (focus on payload definition)

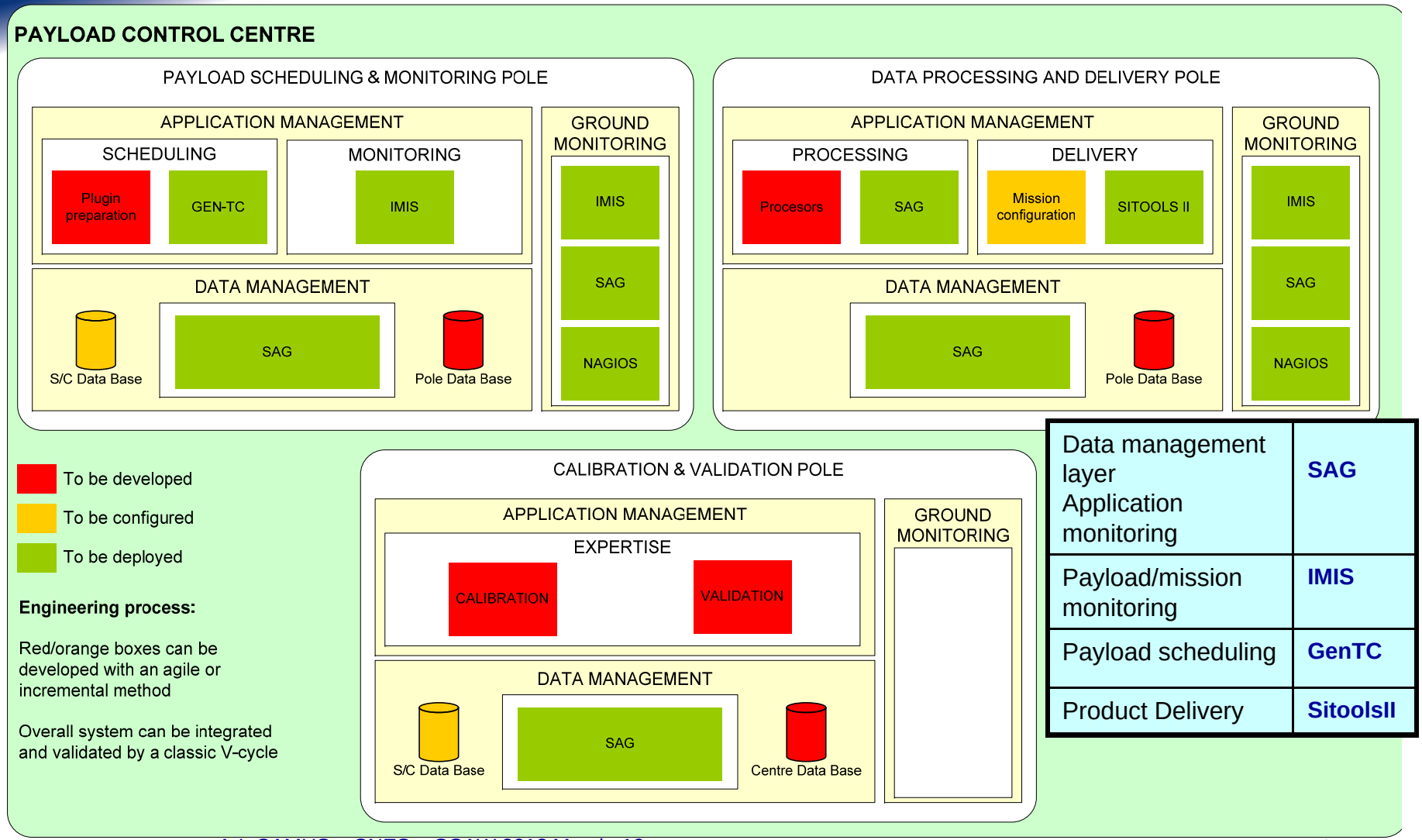
=> CNES SOLUTION = 2 types of toolsets

1. A set of documents and tools for phases A/B
   - Feasibility phase (A)
     - A set of slides to fix the ground segment bases quickly
     - A tool to assess costs → to justify the amount of required resources
   - Preliminary Design (B)
     - A set of template documents:
       - » Ground segment requirements
       - » Scientific interfaces (in/out, performance, constraint, products, …)
       - » Product insurance requirements
       - » Organization and development plan

     Composed of common requirements (80%)

2. A set of software and platform for phases C/D

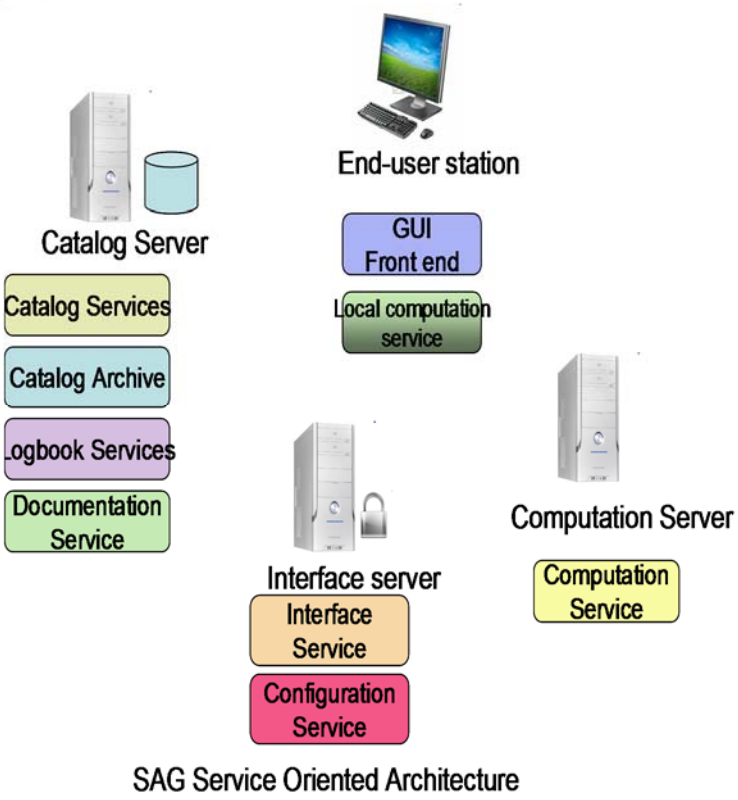
CNES SOLUTION
Framework for phase C/D



Data management layer Application monitoring	**SAG**
Payload/mission monitoring	**IMIS**
Payload scheduling	**GenTC**
Product Delivery	**SitoolsII**

SAG (Structure d'Accueil Générique)

Designed for Pleiades Earth Observation Program



Framework which provides:

- Software to access catalog data
- Integration of processing components
- Interfaces between data and processing modules

Elements to be configured for each new project:

- External interfaces management and processes to be launched on new data acquisition
- Data base definition
- Number of users, data volume

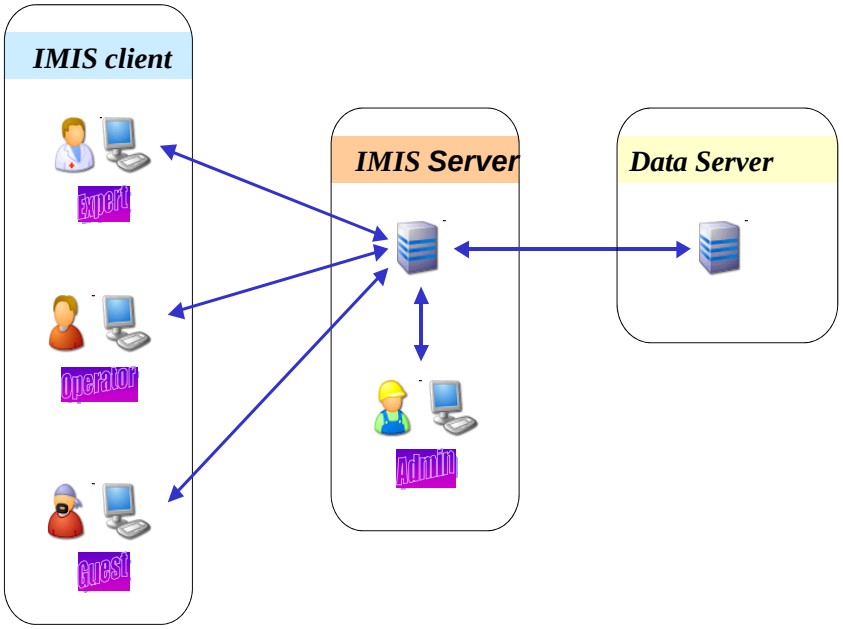
COTS used

- Apache HTTPd Tomcat Axis
- Eclipse RCP
- PostgreSQL
- Java, Python
- OpenLDAP

Have already benefited from this framework :
Pleiades and scientific missions : MegaTropiques, VENµS and Mars Science Laboratory (MSL French part)

IMIS

Main goal : to allow the operator of a scientific payload control centre to monitor the payload instrument health on a daily or weekly basis



IMIS deals with:
- TM parameters
- executed commands
- ancillary data

Correlation between TM parameters and commands executed on-board

Open-source COTS
- Tomcat
- Eclipse RCP
- PostgreSQL
- JSE
- Log4J

Has already benefited from IMIS: Mars Science Laboratory

GENTC, SITOOLS II,…

- **GENTC: graphical tool for Telecommand plan elaboration**
  - Plan is built by successive introduction of TC configured and timestamped
  - Plan is built by activation of a plug-in that computes the TC sequence automatically (plug-in to be developed)

GENTC already used in Picard – Jason mission

Client-server application with COTS (JSE, Eclipse RCP)

- **SITOOLS II: open source Web application offers a data access layer**

highly tunable – allows connection to different data sources

Extensible by adding modules and advanced graphical components

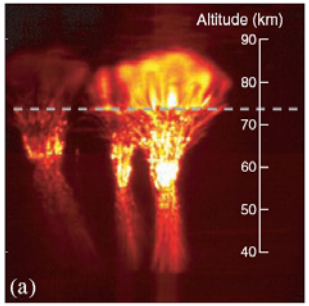
http://sourceforge.net/projects/sitools2/

- **Additional tools:**
  - **BEST workbench to describe data and improve reliability in data**

➔simulation, checking and validation of data

http://logiciels.cnes.fr/BEST/FR/best.htm

Example of toolset utilization
TARANIS

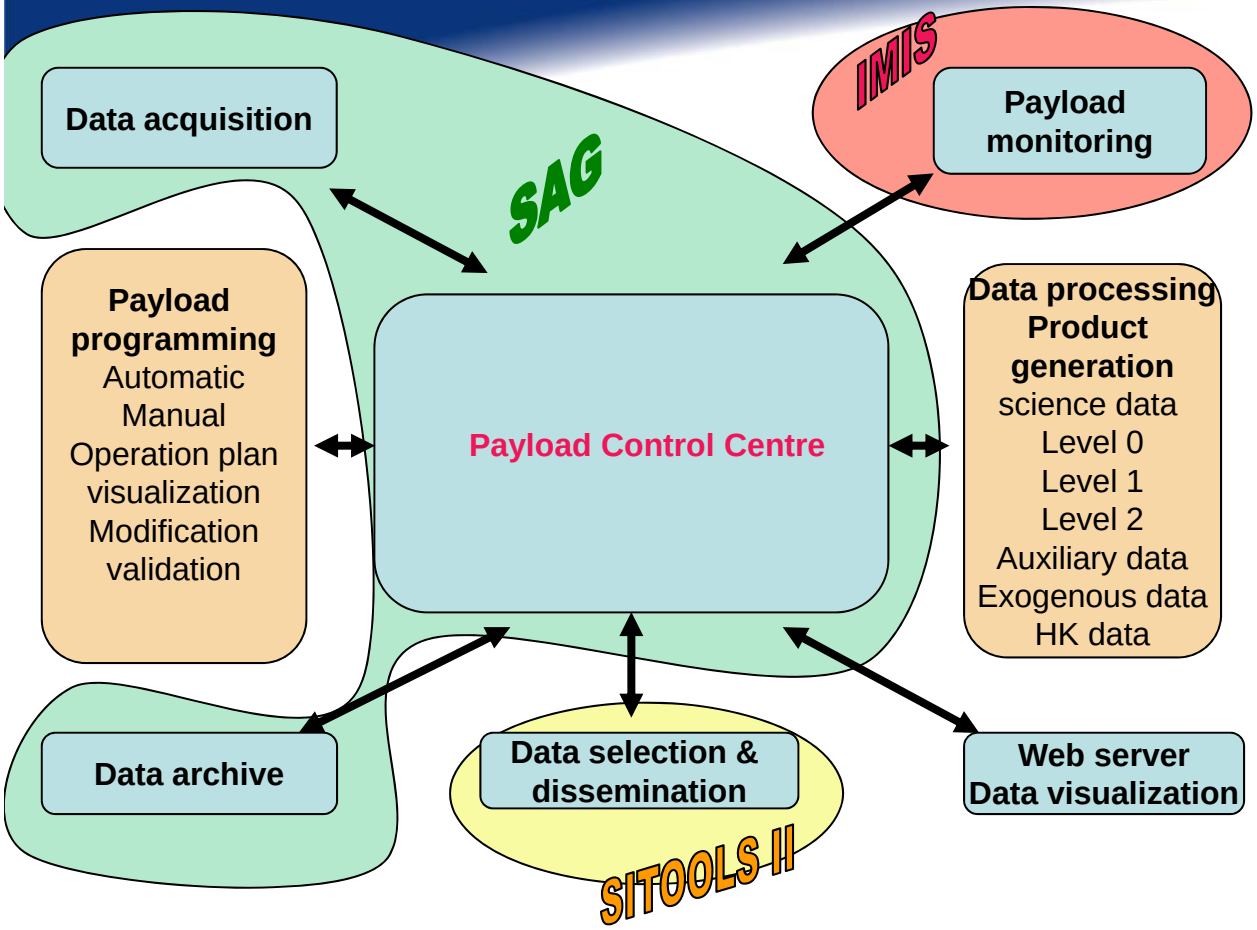


- Objective : study magnetosphere-ionosphere-atmosphere coupling via transient processes (red sprites, blue jets, elves…)
- Micro-satellite: maximum use of elements of CNES Myriade µ-satellite series

Main functions

- automatic data acquisition
- payload scheduling
- payload monitoring
- data processing & product generation
- data and product selection, visualization and delivery
- data archiving.

Laboratories develop their own instrument data processing



SAG functionalities:
catalog management,
data processing management,
users rights management, logbook service and GUI to launch processes
Components = any kind of executable files
easily integrated using command line file parameters
(without specific skill)

IMIS *facilitates operations thanks to payload monitoring functions*

SITOOLS II *performs data access*

Function covered by a generic tool

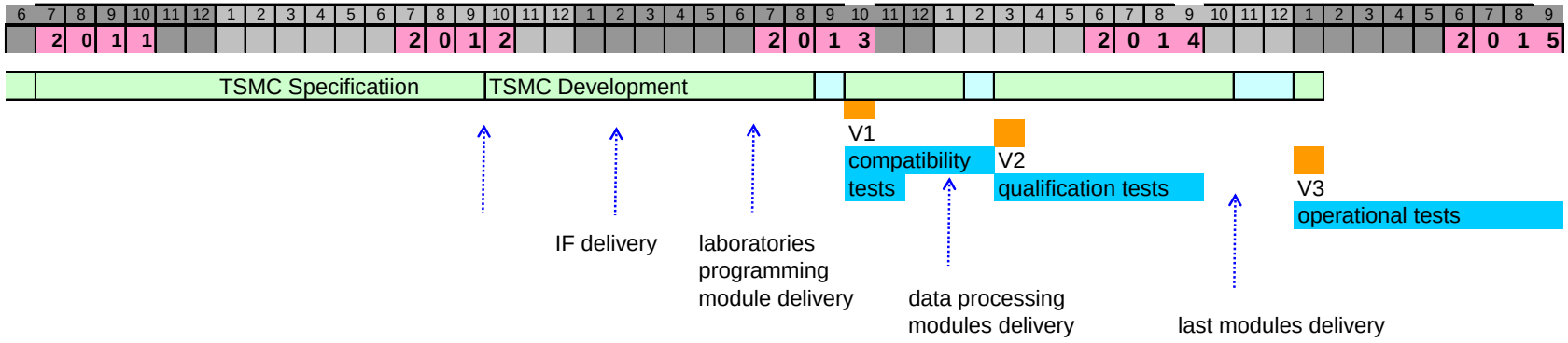
SitoolsII
SAG
IMIS

BENEFITS

Incremental method (3 versions) => flexibility

Integration & reduced validation process allow close versions delivery

=> Confidence in the whole process as main functions already tested



CONCLUSION

- Although resources usually focus on payload development Payload Control Centre must be considered as an important project, even for a small satellite.

- A large part of the system is similar whatever the payload (functions, operations, requirements, etc)

A set of tools (improved with each use) can be proposed for any new mission

=> System to be developed = frame (maintained by CNES) + mission specificities (developed by CNES or laboratories)

This solution brings improvements for every phase (time, cost and reliability)

- ⇒ Design with templates of documents
- ⇒ Development and validation : use of tools already qualified
- ⇒ Operations with friendly tools dedicated to payload monitoring

Thanks to the reuse of software components,

the CNES solution allows us to build the architecture of a payload control centre easily and have a qualified system very quickly,

Any questions?

Slowly, please,…I'm french!