

SESP'2015 - Simulation & EGSE facilities for Space Programs

Java multi-mission simulation framework: evolutions and improvements



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AGENDA

- **Mission Simulation at CNES**
- **ALIS Infrastructure Characteristics**
- **ALIS Improvement of Computation Capacities**
- **ALIS Versatility: Emphasis on COTS Integration**
- **Conclusions**

ALIS: Atelier Logiciel pour l'Ingénierie Système
Simulation Framework for Mission Engineering



Mission Simulation at CNES

(Context / Acquisitions)

Aim at **elaborating the payload mission plan** regarding on board capabilities, transmission channel and ground resources

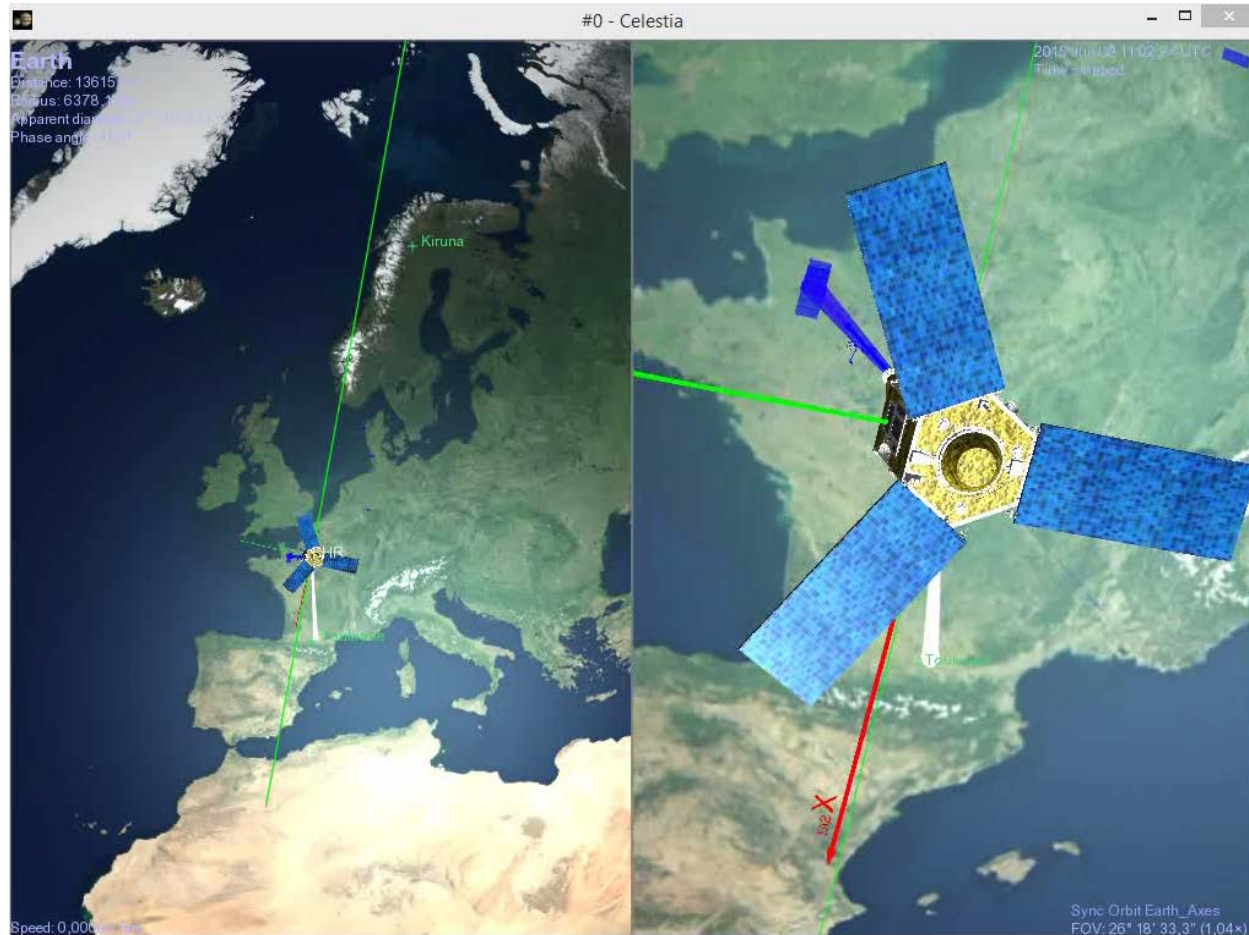
⇒ Mission Simulation at CNES

⇒ ALIS Infrastructure

⇒ Improve Computation Capacities

⇒ ALIS Versatility / COTS integration

⇒ Conclusions



Mission Simulation at CNES

(Mission Programming engineer's task)

⇒ Mission Simulation at CNES

⇒ ALIS Infrastructure

⇒ Improve Computation Capacities

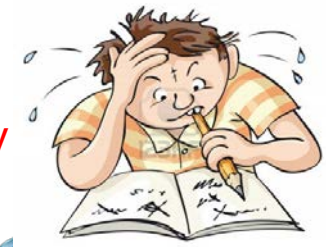
⇒ ALIS Versatility / COTS integration

⇒ Conclusions

- Examples of typical problems to deal with:
 - ◆ **System sizing**: ground networks, satellite configuration, agility...
 - ◆ **Scheduling optimization** according to:
 - » Number of images to take
 - » Customer Priority Requests
 - ◆ On board **Memory Capacity** and **electrical power** consumption
 - ◆ **Average delay** between request deposit and user delivery
 - ◆ Amount of 3D “useful” images accessible **during 6 months**, according to usual **climate**
 - ◆ Average System **capability** on a region, along one orbit
 - ◆ ...



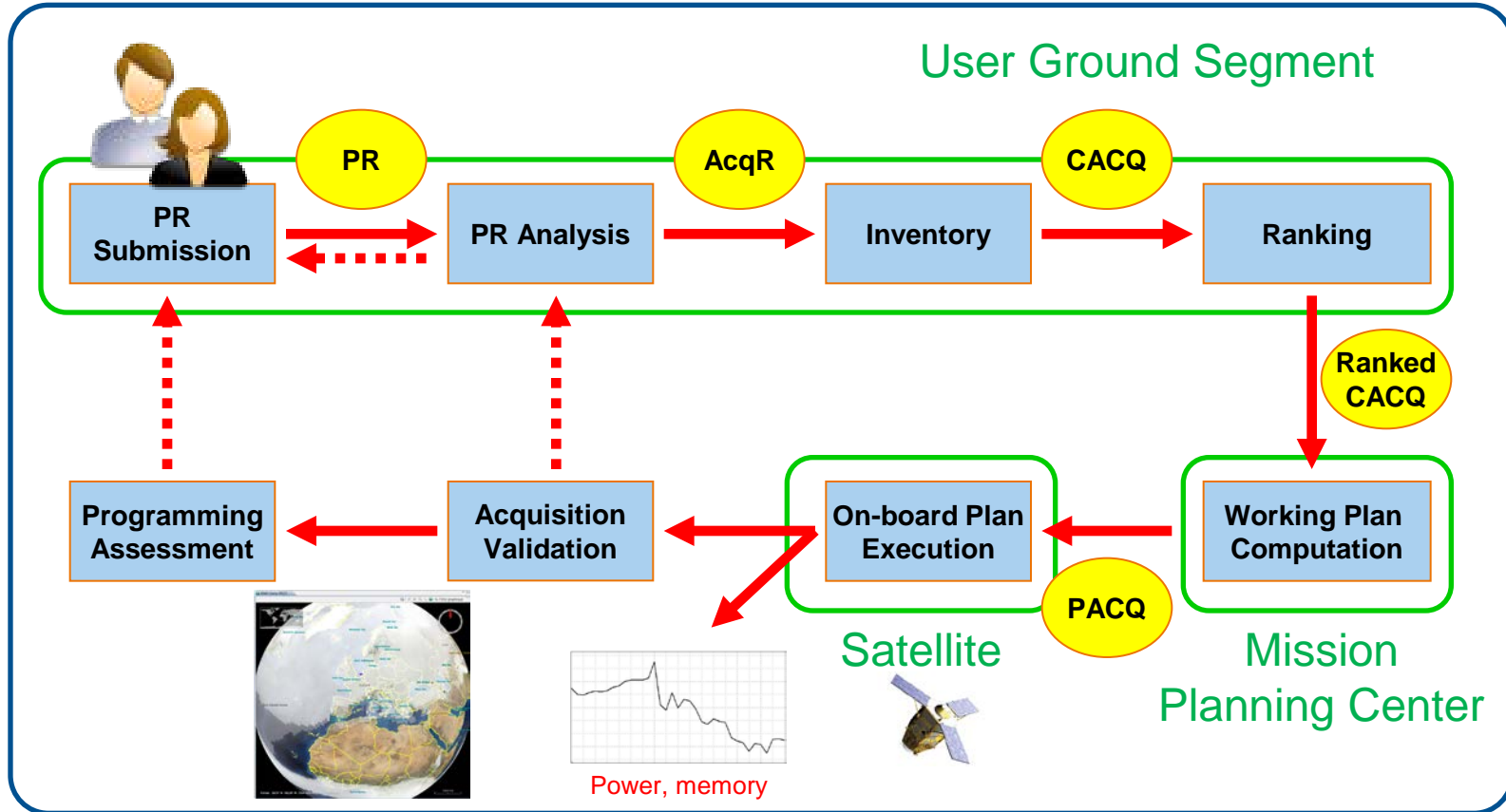
- Multiple satellites, ground networks, thousands of images to acquire
 - ➔ Combination is so enormous and complexity so high that **mission planning simulators** are **mandatory**



Mission Simulation at CNES

(Mission planning loop)

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Mission Planning Simulator

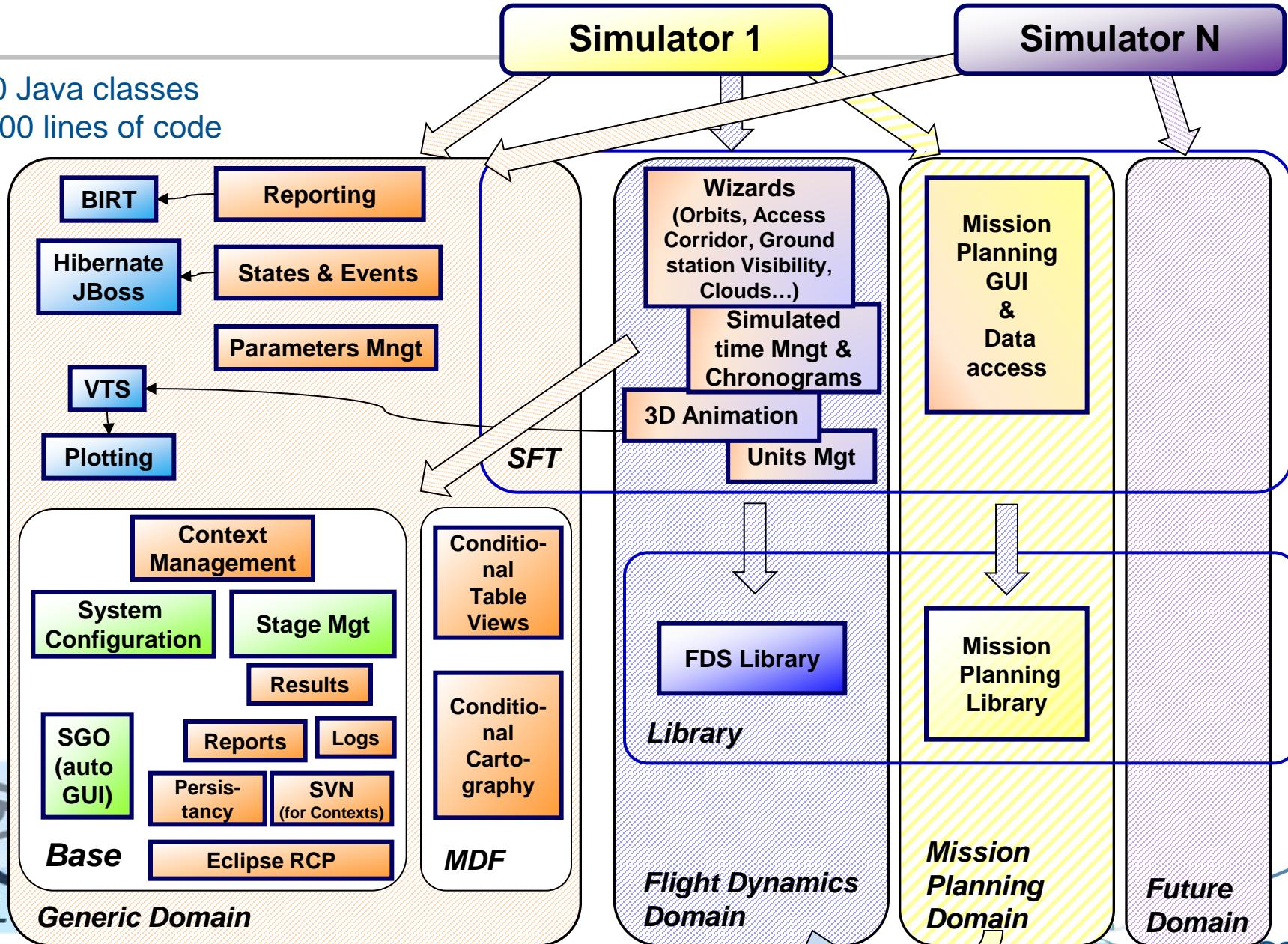
PR: Programming Request
AcqR: Acquisition Request

CACQ: Candidate ACQuisition
PACQ: Planned /Programmed ACQuisition



ALIS Infrastructure Characteristics

23 000 Java classes
500 000 lines of code



ALIS Infrastructure Characteristics

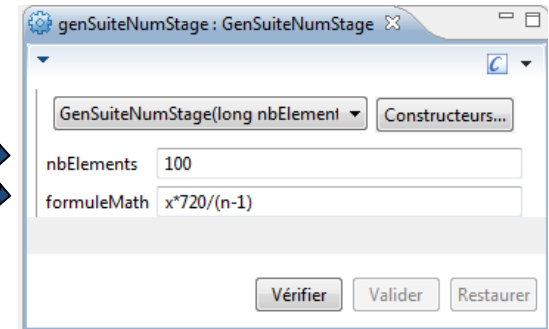
(ALIS versatility / SGO)

- ⇒ Mission Simulation at CNES
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● SGO: Show Generic Objet

- ◆ Automatic generation of **Graphical User Interfaces** through source code inspection

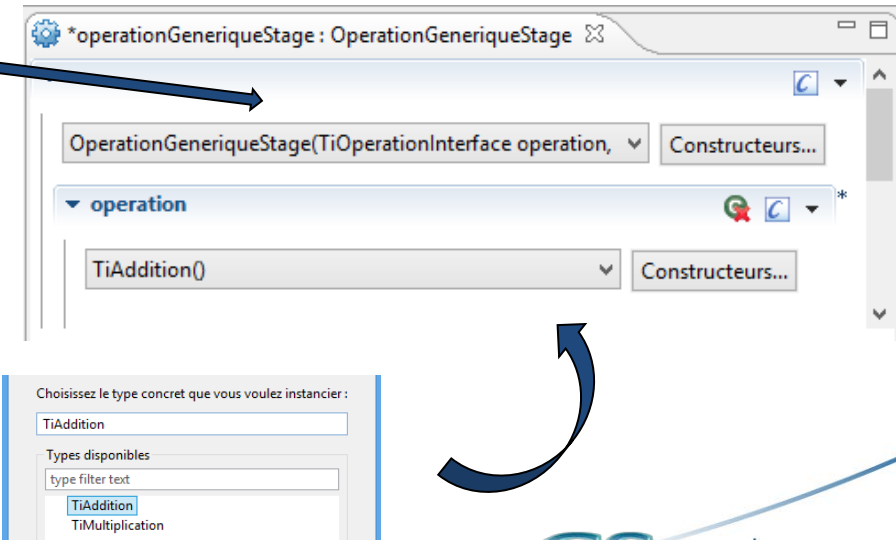
```
public class GenSuiteNumStage {  
    protected long _nbElements;  
    private String _formuleMath;  
    ...  
}
```



◆ Strategy Design Pattern

```
public OperationGeneriqueStage(  
    TiOperationInterface operation)  
{  
    ...  
}
```

```
public class TiAddition implements  
TiOperationInterface  
{  
    ...  
}  
  
public class TiMultiplication  
implements TiOperationInterface  
{  
    ...  
}
```

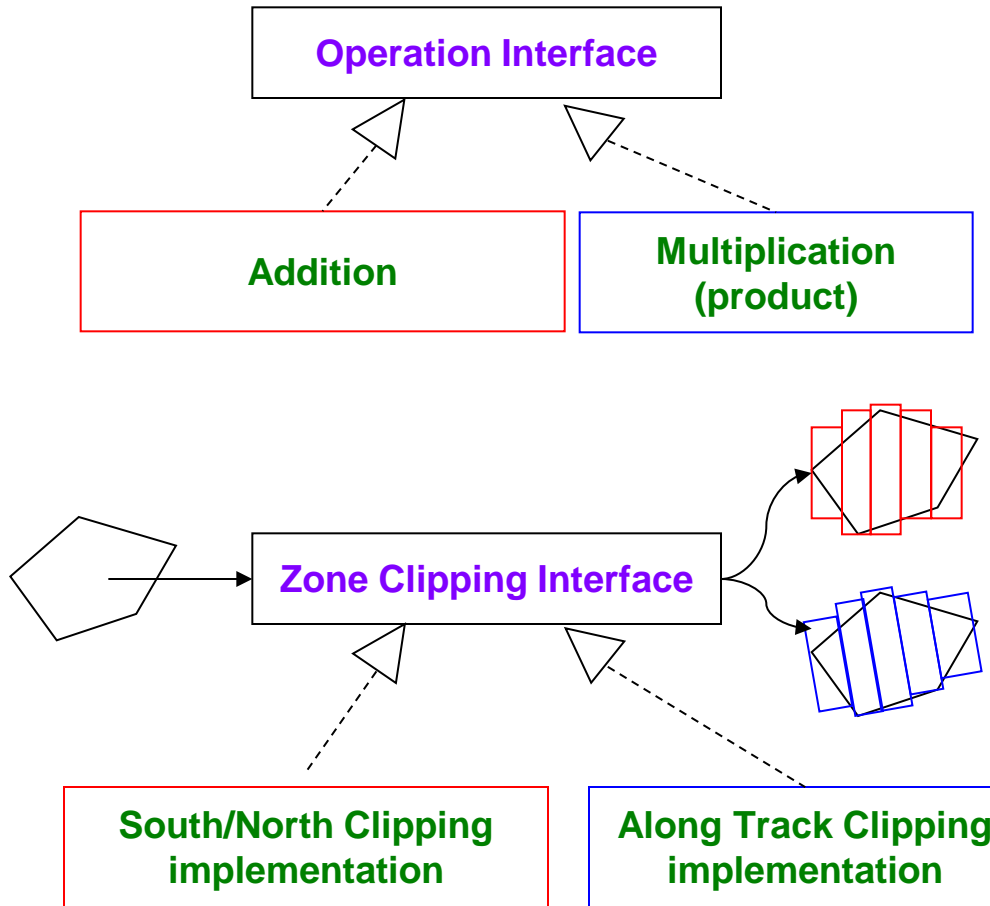


ALIS Infrastructure Characteristics

(ALIS versatility / SGO)

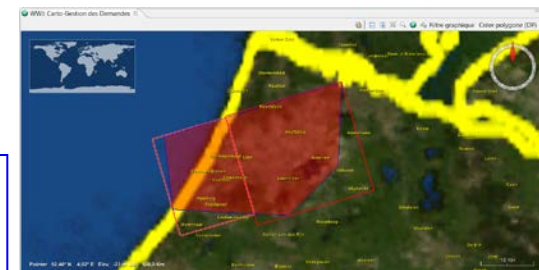
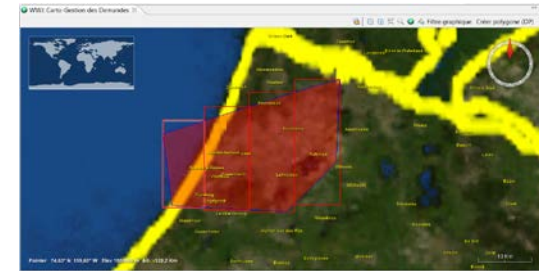
- ⇒ Mission Simulation at CNES
- ⇒ **ALIS Infrastructure**
- ⇒ Improve Computation Capacities
- ⇒ ALIS Versatility / COTS integration
- ⇒ Conclusions

- **SGO: Show Generic Objet**
 - ◆ Strategy Design Pattern



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ALIS Improvement of Computation Capacities

(Need for high performances)

⇒ Mission Simulation at CNES

⇒ ALIS Infrastructure

⇒ Improve Computation Capacities

⇒ ALIS Versatility / COTS integration

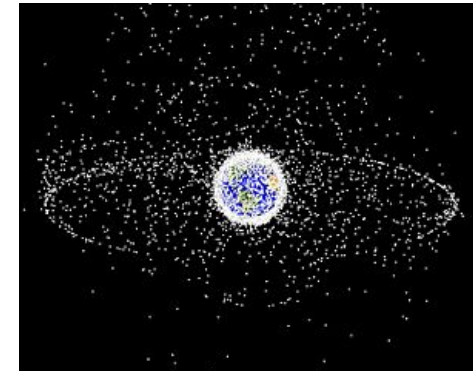
⇒ Conclusions

Initial design: standalone infrastructure

- Simulation execution engine embedded with GUI layer

SSA simulator: ALIS' user with its own specifics

- Very large number of space objects (> 20 000 debris)
- Wide quantity of orbitographic data
- Synchronous / asynchronous processes integrating SSA algorithms



Source: Wikipedia

Consequence: need for increased computation capabilities

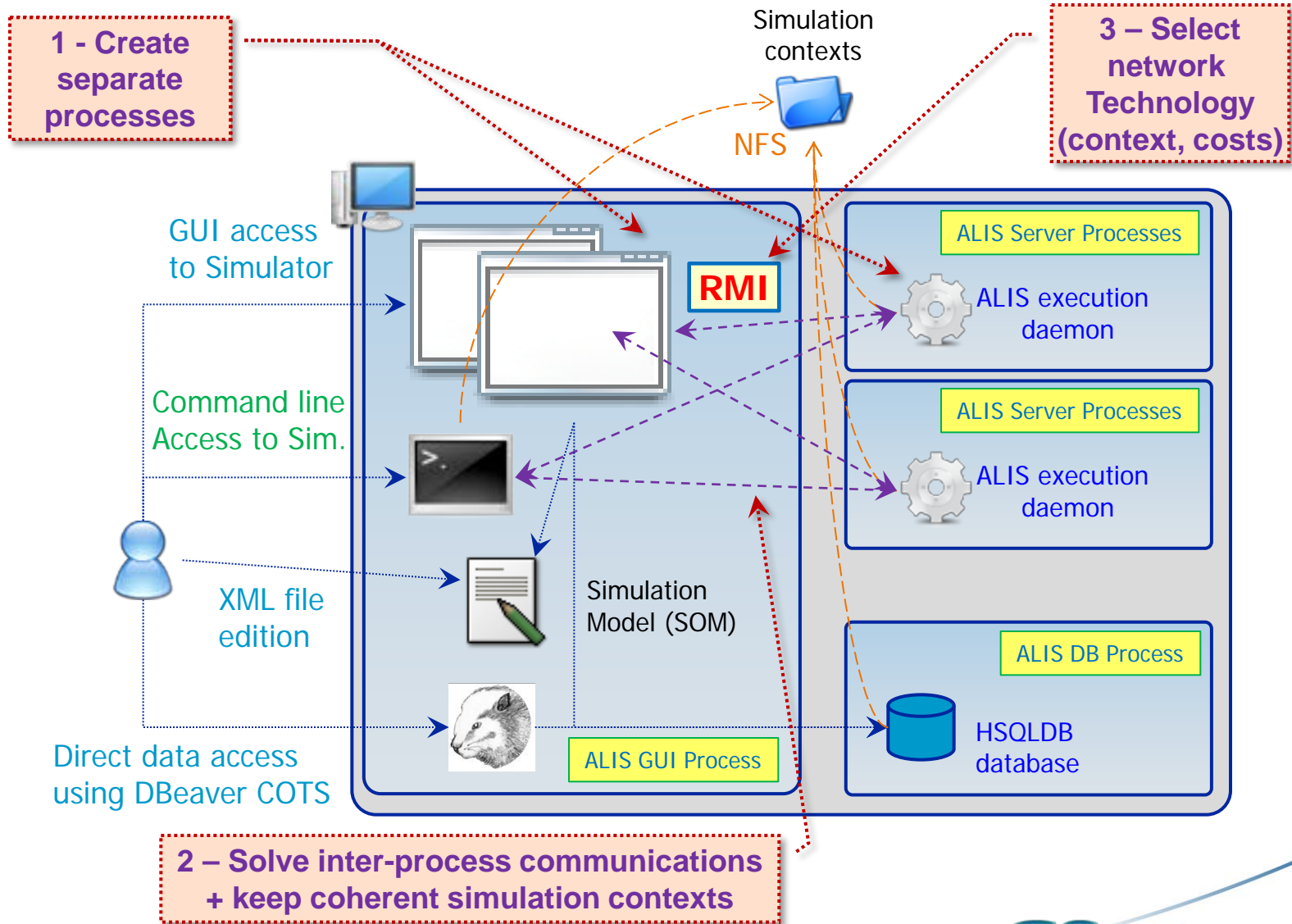
- Use on a Linux cluster, with technical constraints
- Needed split of simulation execution engine and GUI
- Deep ALIS' architecture re-engineering required
- Move to a distributed application (multi-process)



ALIS Improvement of Computation Capacities

(New ALIS distributed architecture)

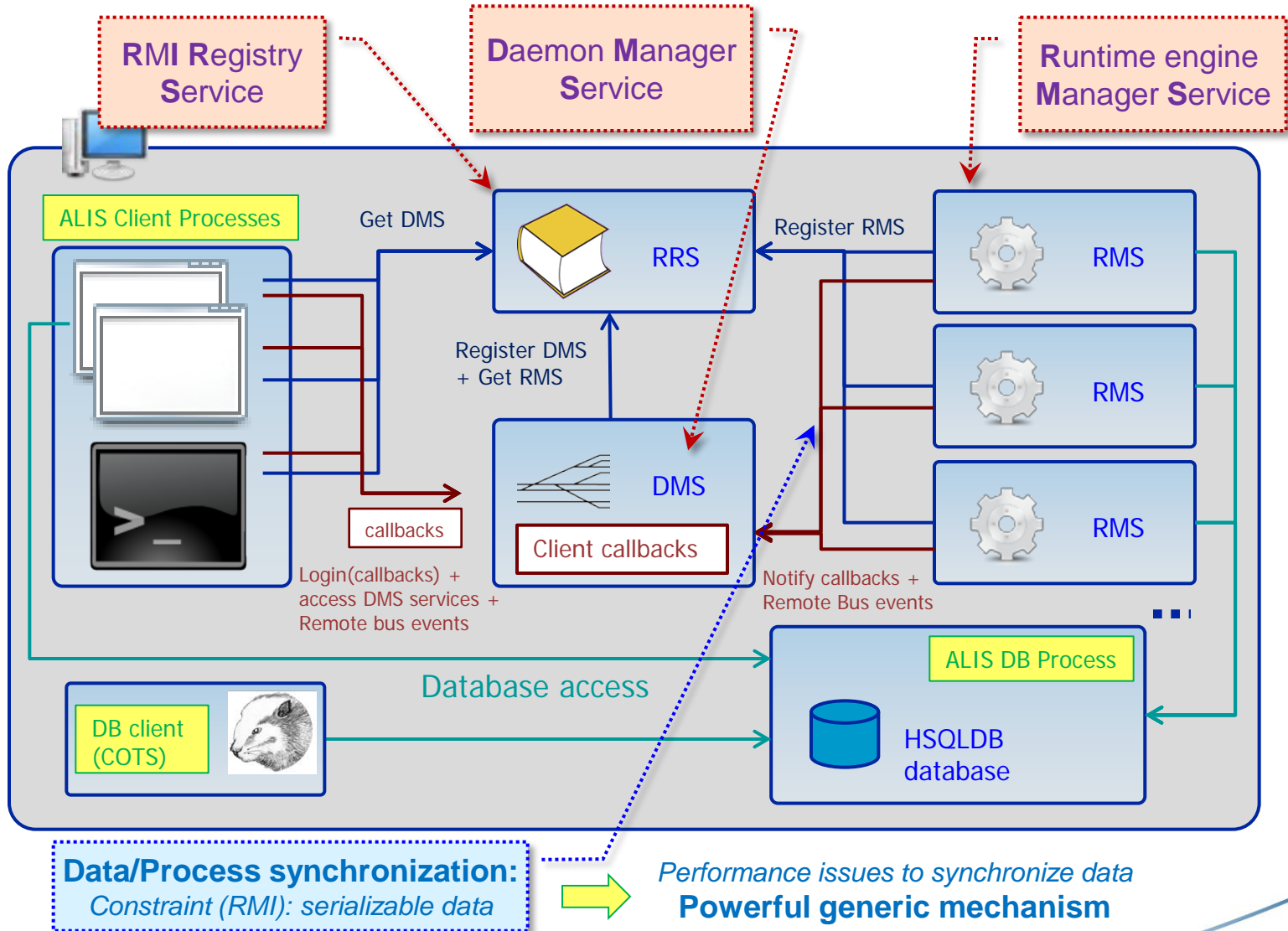
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ALIS Improvement of Computation Capacities

(Close-up on processes interactions)

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Data/Process synchronization:
Constraint (RMI): serializable data

Performance issues to synchronize data
Powerful generic mechanism



ALIS Improvement of Computation Capacities

(Technical issues)

RMI in an Eclipse-RCP / Spring context

- Two different dependencies resolution paradigms
 - ◆ Eclipse OSGi environment → dependencies solved using OSGi manifests
 - ◆ Other technologies (RMI, Spring, XStream) → standard Java classpath mechanisms to solve dependencies
- Eclipse provides the “**Buddy Class loading**” mechanism
 - ◆ Integration strategy to dynamically discover and load classes



Plugin A

```
(MANIFEST file)  
Eclipse-RegisterBuddy ::= plugin-B
```

Plugin B

```
(MANIFEST file)
```

Declaring plugin B as registered “Buddy” of plugin A
→ plugin B gains visibility on plugin A

→ Minimizes modifications on existing source code

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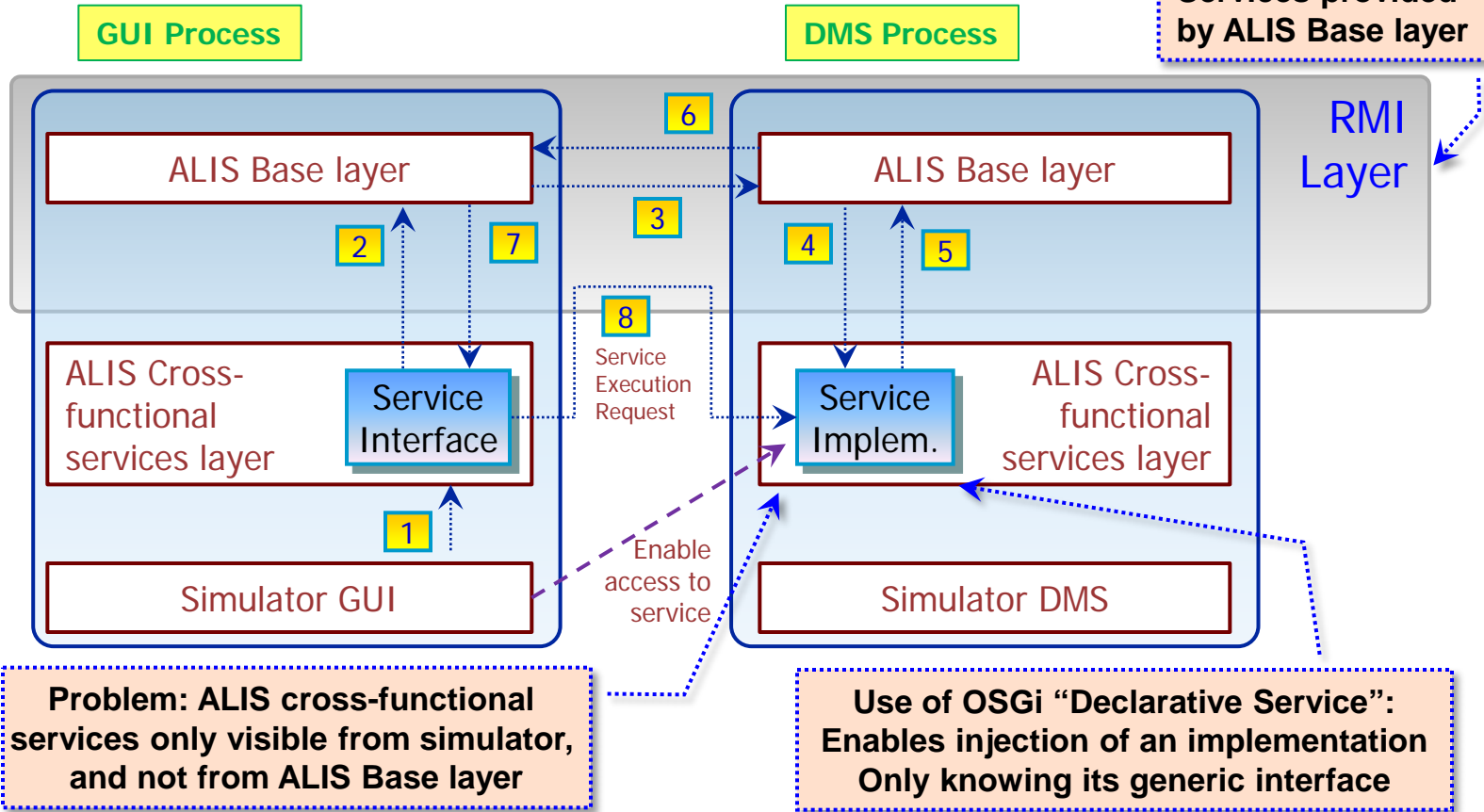


ALIS Improvement of Computation Capacities

(Technical issues)

Dynamic services management via injection

- ⇒ Mission Simulation at CNES
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→ Enables extending ALIS remote services offered by the simulator processes without knowing their implementation



ALIS Versatility: Emphasis on COTS integration

(COTS licenses issues)

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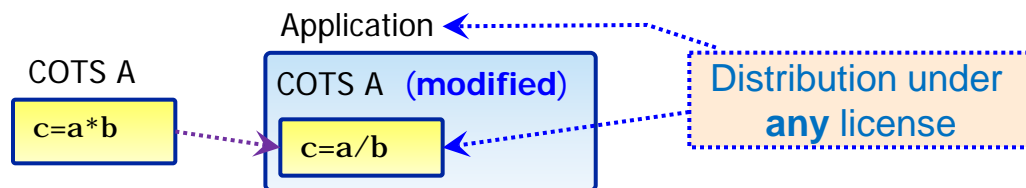
More and more services and functionalities are required
Strong drivers: development costs + quick availability

→ Use of COTS with **high-readiness level**
and **adequate licenses**

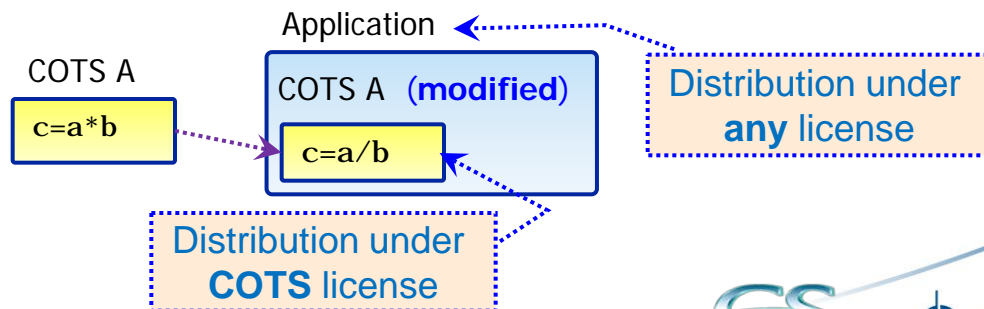
COTS licenses

- Privileged approach: select free open-source COTS with permissive or weak “copyleft” licenses

- **Permissive** license



- **Weak copyleft** license



ALIS Versatility: Emphasis on COTS integration

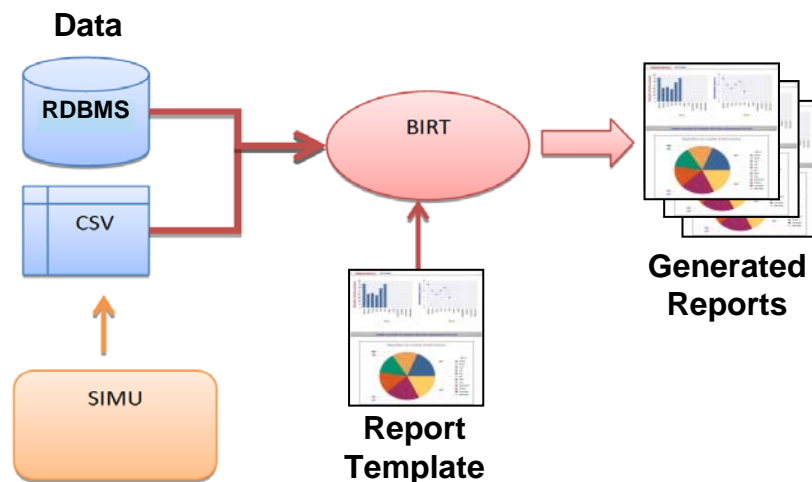
(COTS integration levels / sample)

COTS levels of integration

- From **low-level** libraries to **high-level** components with **GUI**
- Eclipse/**OSGi** facilitates COTS integration and ALIS increase of **high readiness level services** to simulators' users / developers

GUI COTS integration with GUI adapters (BIRT Sample)

- Users need to produce, collect and analyze statistics about algorithms / parameters
- **BIRT** (high-level & powerful reporting tool) easily integrated in ALIS
- **Improvements added:** generate **PDF exports** and update reports' views during stages runs



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ALIS Versatility: Emphasis on COTS integration

(COTS integration sample)

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View including a BIRT report generated as a PDF document

The screenshot displays the Simulsi software interface. The main window shows a 3D globe with a red polygonal zone over Europe. A BIRT report titled 'Simulation Analysis' is open in the foreground, featuring three charts:

- Acquisition Request by origin:** A pie chart showing the distribution of acquisition requests by country: Belgium (18%), England (8%), France (30%), Germany (22%), and Netherland (22%).
- Average Cost:** A bar chart showing the average cost for each country: Belgium (44,286), England (53,333), France (52,083), and Germany (56,111).
- Radar Chart Title:** A radar chart with axes for Belgium, England, and Netherland.

The BIRT report also includes a table of coordinates:

latitude	longitude
51.194019...	-9.056529...
55.882322...	9.4726116...
36.091883...	22.712904...
35.018121...	-12.73047...



Conclusions

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- **ALIS** is a **scalable infrastructure** designed to build mission simulators, allowing CNES to rapidly conduct **Mission Expertise Studies**
- **CS SI** brings to ALIS development its **skills** and **experience** to manage **complex projects**.

