BASILES on its way up to a wide-spread Simulation Service

Bernard Delatte, Frédéric Manon

Centre National d'Etudes Spatiales (CNES)
18, Avenue Edouard Belin, 31401 Toulouse, Cedex 9, FRANCE
Email: bernard.delatte@cnes.fr

INTRODUCTION

The goal of this paper is to tell the story of BASILES, from the creation of the Simulation Service at CNES in 2004 up to now, and sketch the future of this Simulation Framework. Our first activity was to draw the picture of the Simulation domain in CNES, and to define the objectives of progress. Then we had to take into account a new context and new needs. Now BASILES is an operational Framework ready to support new projects.
BASILES stands for "Bancs, Simulateurs et Logiciels d'Etude Satellite" or in English "BEnches, Simulators and Satellite Study SofTware" (BESSST)!.

DRAWING THE PICTURE IN 2004

CNES has developed Space Missions for years, mainly with the role of System responsible for the missions that he operates.

System Responsible

Engineering teams conduct studies in the early phases of the projects to define the System to develop, write the requirements, and validate their coherency and completeness. Most of the times, the Satellite building is subcontracted; it is the reason why the CNES teams are not responsible for the AIV activities. CNES is then responsible for the System Validation and operation, and needs to manage and run the associated means.
We have now several validation frameworks dedicated to our main Satellite families (based on SINUS for the Observation family, on PRESTO for PROTEUS satellites, and on the BVSS for the Micro-satellites); they include home-made tools too. Numerous models have been developed, validated and assembled to build all the Simulators we have. This constitutes a large legacy that has been qualified over the years; this legacy being a real support to maintain and develop our System knowledge.
To sum up, we can say that CNES has developed Simulation means well suited to dimension missions in an adequate manner, and to qualify the Systems to operate.

The key position of Satellite Simulators in CNES

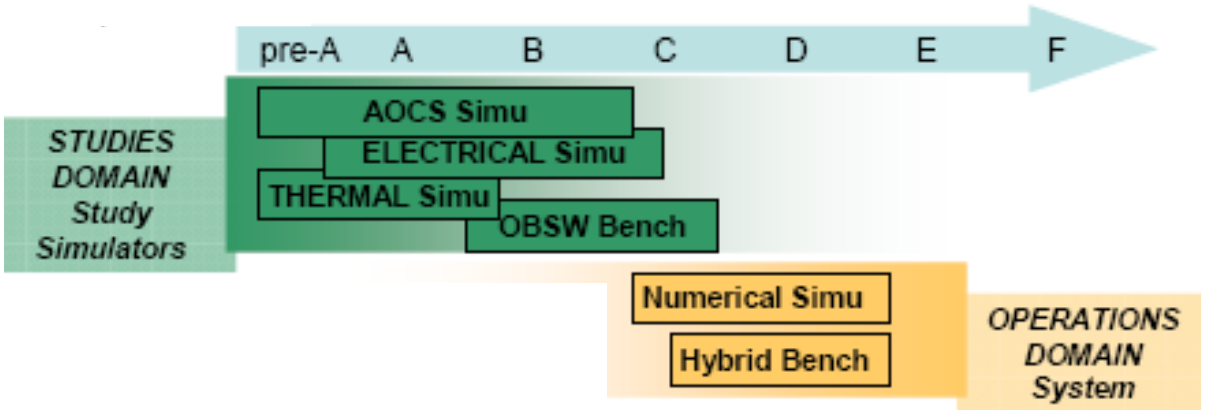


Fig. 1. the Satellite simulators position

During the phases preceding the development of the System itself, architects use study Simulators to do their job. For each functional chain, they design a solution, develop algorithms, and dimension equipments; all this is done in order to verify that user needs are fulfilled and to assess performances.
When the system is developed, the time of validation and operations arrive. The system validation team will first validate all functional chains, and then qualify technically and operationally qualify the ground and space segments and their interfaces. After this stage, the system is validated against the mission requirements, and the training of the operators take place before the launch.

The situation in 2004
It can be sketched along three points of view.

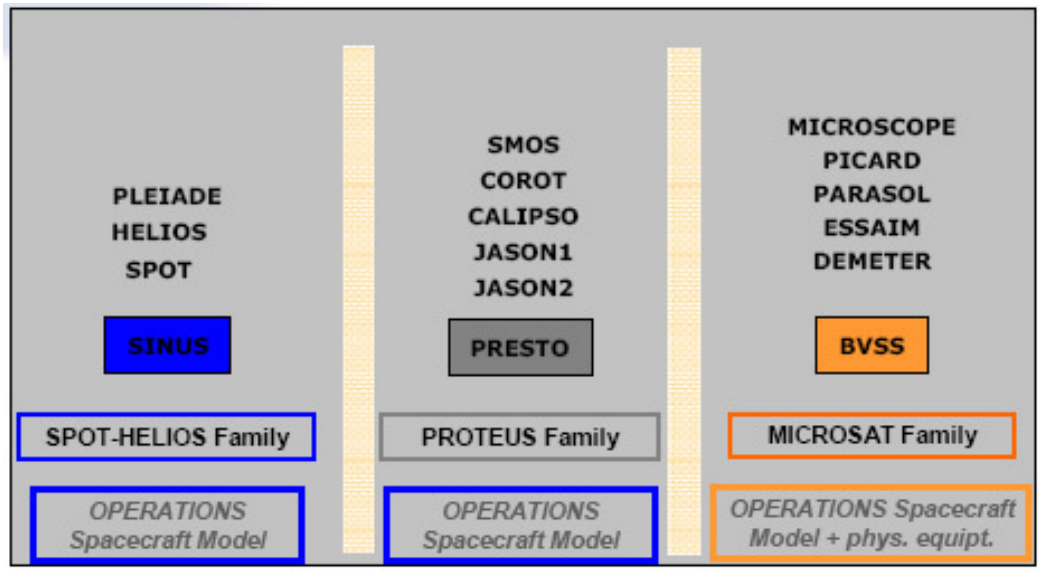


Fig. 2. a project-based organization

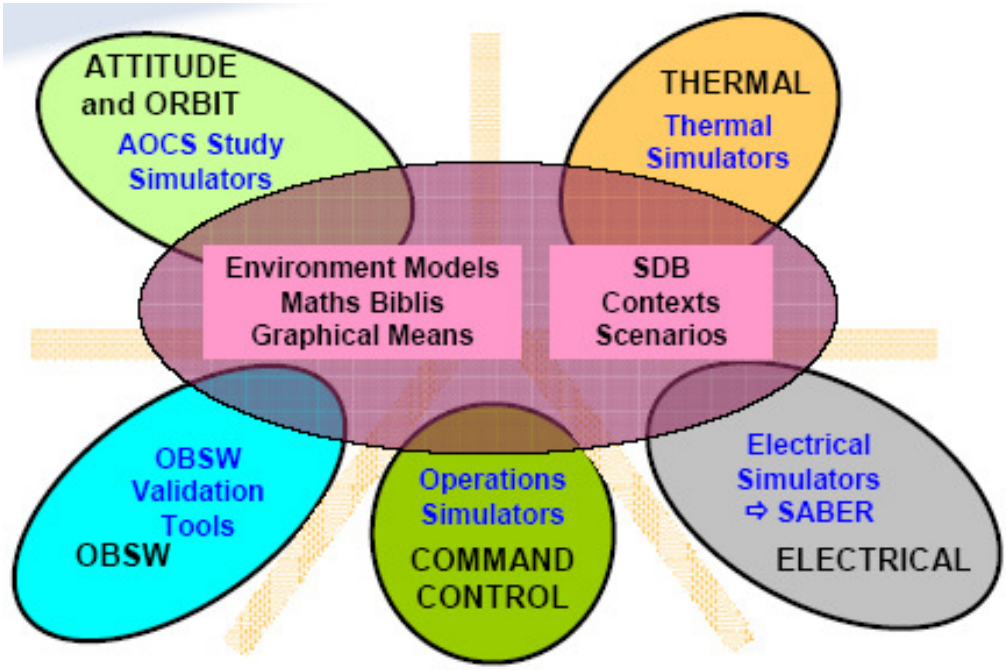


Fig. 3. partitioned architects platforms

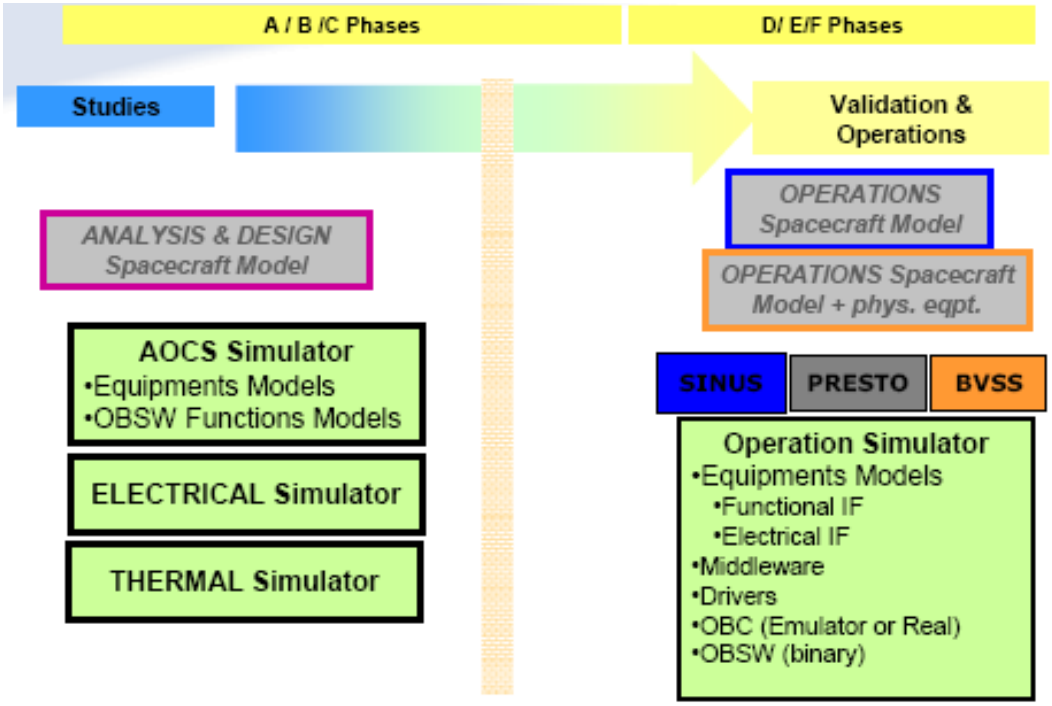


Fig. 4. partitioned developments

The objectives of the Simulation Service in 2004

The domain was clearly defined as being limited to the Satellite Simulation; for example, neither the images simulators are not part of our concerns, nor the missions simulators used in the earliest phases in our CDF facility named PASO.
The goal was to propose a process and to organize means in order to ease and harmonize the Satellites Simulators development in CNES. The people that should benefit of our activity were identified as being the developers, the integrators, and the users. In fact, we had to mutualise system simulation means inherited from the different satellites families (based on SINUS, PRESTO, BVSS), to be able to share models (environment, equipments…), to build a common infrastructure, and to favor models reuse through out the life of projects.

BASILES

The BASILES Factory shall be used to:

- Design, develop and maintain Study, Validation and Operations Simulators,
- Provide means to integrate needs of all teams of architects,
- Un-partition teams, means, and phases of the lifecycle of a project.

BASILES aims at reducing development costs of all our Simulators, at improving the synergy between teams of architects, and at improving the quality and repesentativeness of Operations Simulators.
To resume, BASILES is a development Factory for all Satellite Simulators, an environment to run and control simulations, and a set of tools to observe simulations and exploit their results.

BASILES is designed as an integration of all the best efficient means we have at CNES; for example, it derives from an existing monitoring and control tool, it inherits from the SINUS/PRESTO kernel. This infrastructure accompanies the engineering activities of a project from the studies in the CDF (called PASO at CNES), up to the Electrical, Thermal, Command-Control, OBSW studies. Two examples of the inter-operability are the connection with SABER, a specific electrical simulation tool, and the SIMULINK wrapper we developed.

New Context, new Needs

The first one is the Distributed Simulation: we need to make different simulators cooperate (for example the specialized simulators shall be connected to BASILES, in order to run an orbital scenario to see how the thermal functional chain behaves). An other upcoming need is the Formation Flying concept, where several satellites support the same virtual instrument.
SMP (Simulation Modeling Platform) is an upcoming ECSS standard whose goal is to foster models exchanges among the space simulation community.
The progress in computers architecture shall be taken into account, to improve the efficiency of our simulators; next simulators will be based on multi-core and multi-thread computers. In the same domain, we have to address the problem of hybridization: to interface numerical simulators with Hardware. This means that we have to pace numerical simulators in a suitable way to make them dialog with HITL.
The link with the System Database is a complex problem. It is obvious that the simulators shall be constructed and configured by System Data. The next step is to consider the System Data lifecycle (it evolves from design to implementation, validation and operations). The knowledge associated to representativeness shall be maintained too.
The modularity and agility of productions, means, and activities shall be improved in order to better support parallelized developments, and always different projects organizations and constraints.

Improving BASILES

This paragraph summarizes the different activities we have conducted to fulfill these new needs, and to adapt to the new context.

- HLA

An API has been developed upon the CERTI (RTI provided by the French lab ONERA). The role of this API is to ease connecting or distributing simulators. The main progress in this domain comes from the methodology we have settled, which permits to connect two existing simulators in a few days, and to distribute a monolithic simulator in a few hours.
A prototype has been realized on the PRISMA project. HLA is used too to connect BASILES with the specialized study simulators we run.
The SMOS project will see an experiment involving ESA and CNES: we planned to make the two SMOS standalone simulators (Operations and Payload) cooperate. The PRESTO Operations simulator developed by SPACEBEL is fully representative of the Platform, but limited to the operational command-control level for the Payload. The MIRASIM Payload simulator developed by SCISYS is representative of the full mission command-control level for the Payload. The exercise consists in defining a proper communication interface, and then implementing this interface in both simulators. This study shall hopefully result in architectural guidelines on how to modularize simulators.

- SMP

SMP (Simulation Modeling Platform) is the simulation model portability standard developed by the ECSS E-40-07 working group. We decided to make an experiment of industrial use of SMP in order assess the behavior of the method and of the teams in the context of a real distributed development. The details of this study are in the paper entitled “An industrial Validation of SMP”.
BASILES will be fully SMP compliant by the end of 2008; the only missing service is the save/restore.

- Separability

A theoretical study has been conducted by a laboratory (IRIT in Toulouse) to define slices of time allocated to each part of a simulation; depending of the characteristics of the sub-systems, a strategy based on frequencies or on delays has to be used. The application of the results is conducted by Spacebel that has developed a set of tools; an application has been made on the DORIS on Pleiades simulator; it has been demonstrated by applying the results that several constraints could be released, speeding up the whole simulation. Basiles will benefit of this study.
This study will be completed by the end of this year. More details are given in the “Formation flying: what’s coming up?” paper.

- OBSW

The objective is to be able to run the functional part of the OBSW. The behaviour of the DHU up to the IO between DHU and the equipment has been simulated. A model of standard interface and behaviour of the layer has been developed. This is currently tested through a R&D project which addresses the enhanced autonomy of future satellites. Within this R&D project the OBSW has been limited to the functional layer. This new facility has to be integrated in

the design of the architecture of the OBSW. This implies at least that the functional part can be easily isolated from the others OBSW layers.

- Link with the SDB

We know how to generate and configure a simulator using the System DataBase; this is normal work during the development phases; but another problem is to be able to make the simulator stick to the reality of the satellite in operation; we have to fill the gap between the validation reference and the operations set of data. It is the reason why we planned to settle a "System Data Factory" to manage the data lifecycle. The exchanges between SDBs tools, and simulators will be based on XTCE.

- LEON 2 and 3 simulation

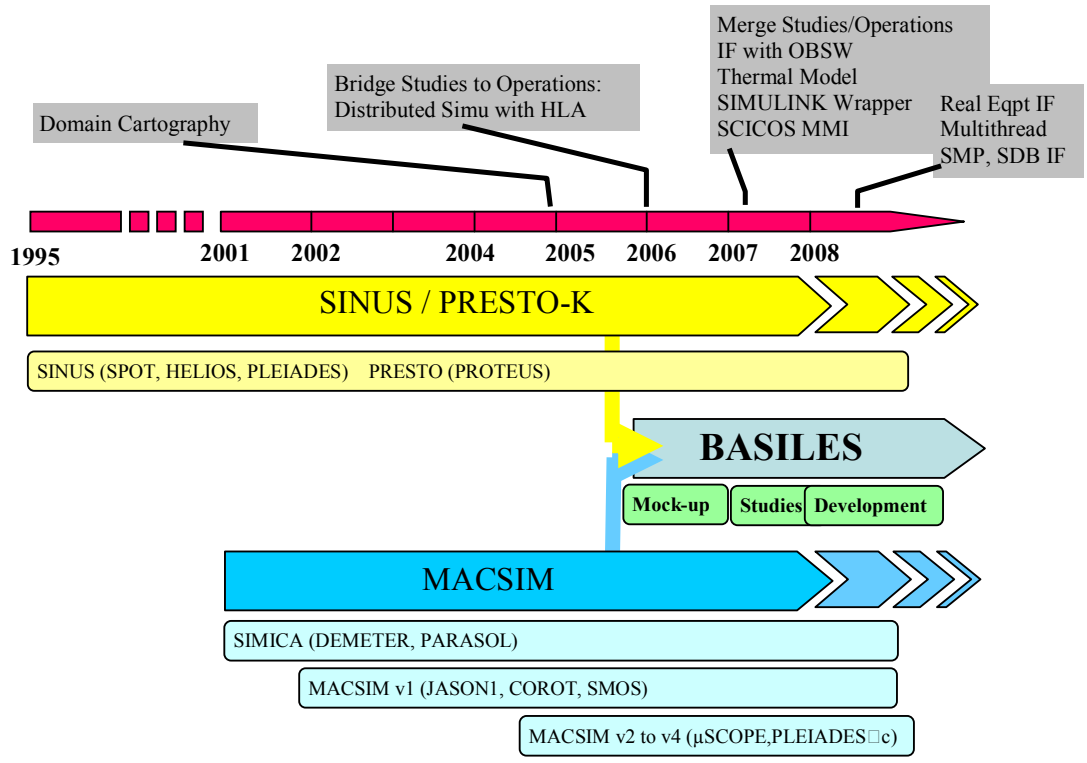
As critical part of the DHU modeling, special attention has been paid to the development of an efficient LEON simulation. Nevertheless the performance of the full representative LEON behavior is still limited and the real time execution should be achievable by end of the year. To go forward with the target to run at least 2 times the real time two R&D will start next year. For the time being the target is achievable but with a limitation in the representativity of the instruction cache.

- HITL

The current framework not allowed developer to build a simulation which interface with a real hardware. The problem to face is related to on one hand the execution of the OBSW based on a simulated time (eg: 10ms of execution run within 1ms if the framework runs ten time the real time) and the real hardware which signals are pure real time. The prototype of the model which will managed this interface is under development and should be valid by beginning of 2009. This new facility will enlarge the field of validation area based of this simulation approach.

BASILES ON A MAP

More than long sentences this scheme sum up the BASILES life cycle.



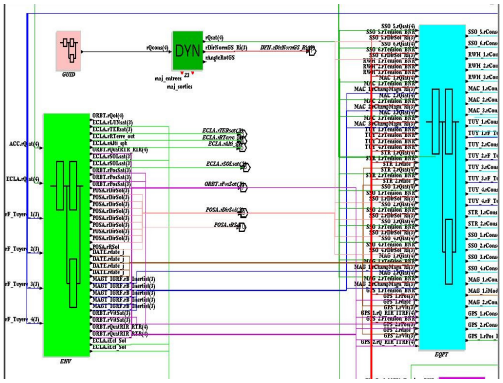
The current version of the framework offers yet:

- Support for the design of a simulator for study phase and for system validation phase
- Support for the development of new models at SMP2 standard (interface level), BASILES proprietary standard,
- Support to import models developed with MATLAB/SIMULINK or SMP2 models developed with other tools
- Building feature of a complete simulator for study phase and for system validation phase
- Set of tolls to drive the simulator and analyze and present the results

TESTING SUPPORT

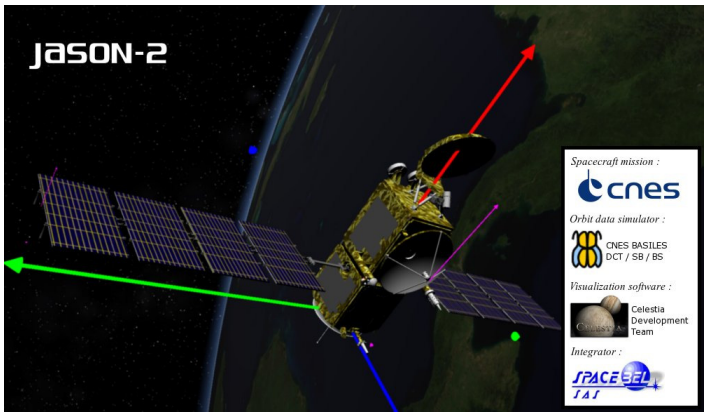
- Common MMI

A common MMI eases the simulator management, and the work of developers. It support all current activities to develop models: creation, connection, grouping by drawing blocks, visualization, code generation…
The learning curve has been observed to be shortened.



- Results visualization: CELESTIA

CELESTIA is a freeware dedicated to3D space animations. A cooperation between CNES, Spacebel and ESA will make it providing a full support for space users. At the moment, real time extensions are under development.



TO CONCLUDE

BASILES is the result of a step-by-step action centered on the engineering of Space Systems. As you can see in this paper, it is real stuff, and operational; training courses are organized for our users.
Let's make success wishes for BASILES, waiting for the deployment on upcoming projects; the first two are SIMBOL-X and ISIS (Initiative for Space Innovative Systems), the next satellites family to be developed by CNES.