SimEC3: An Innovative Simulation Based Acquisition Tool for France's Cooperative Fighting System

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Keywords:
Simulation Based Acquisition, HLA/SEDRIS, VV&A process,
Agile architecture, Network Centric Warfare

ABSTRACT

The SimEC3 programme is developed by a Thales – GIAT consortium led by Thales for the French MOD Procurement Agency (Délégation Générale pour l'Armement – DGA) in the frame of the future developments of network centric warfare (NCW) weapon systems, in particular the future Light Armored vehicle (EC3).

The purpose of this system is to provide a complementary approach to traditional Systems Engineering activities, allowing placing models of future weapon systems in a variety of operationally sound contexts, for assessment of candidate architectures for the future Cooperative Fighting System (BOA).

To supply the capability of modeling future architectures and weapon systems, the outstanding requirements for the design of SimEC3 were to provide:

1. *an open and agile architecture based on simulation standards such as HLA and SEDRIS, to ensure that new models, either different or more detailed, could be easily added to the delivered system to extend its capabilities;*
2. *a preparation toolset to easily edit weapon systems, networks and CIS technical characteristics such as entity performances, doctrines, behavior rules, Order of Battle definitions, NCW operational scenario and metrics to be collected from the simulation for further analysis and assessment of the architecture under evaluation;*

Wiart, B.; Peyronnet, P.; Moity, N.; Pradeilles, F. (2005) SimEC3: An Innovative Simulation Based Acquisition Tool for France's Cooperative Fighting System. In *The Effectiveness of Modelling and Simulation – From Anecdotal to Substantive Evidence* (pp. 16-1 – 16-18). Meeting Proceedings RTO-MP-MSG-035, Paper 16. Neuilly-sur-Seine, France: RTO. Available from: http://www.rto.nato.int/abstracts.asp.

3. *a simulation execution kernel based on a distributed architecture, making best use of both the DGA Escadre framework and the Thales ATMS framework;*
4. *simulation models defined with the experts from the Thales Group and GIAT as well as those from various departments of the DGA, and assessed by applying a dedicated VV&A process;*
5. *assessment tools based on a very innovative Multi-Criteria Decision Making (MCDM) technology which uses a sophisticated aggregation model based on fuzzy logic combined with the "Choquet's Integral Mathematical Model". This provides on the one hand synthetic and detailed information on the forces efficiency related to their tactical performances, life cycle cost, human factors and programmatic aspects, and on the other hand recommendations to the analysts for further optimizations of the solution according to the main criteria being studied.*

The paper will deal with following aspects:

- *description of the SimEC3 product focusing on the innovative solutions implemented such as the MCDM assessment tool;*
- *information on expected outcomes from a DGA and Army end users perspectives;*
- *evolutions of the engineering processes of the DGA architects;*
- *indications on other potential uses for the product and / or technology;*
- *perspectives for the incorporation of such SBA environment into wider programmes such as multi-domain battlelabs.*

1.0 CONTEXT – BACKGROUND

France is facing, like many other countries, important changes in the acquisition of its defense systems. This situation results from changes in the geopolitical situation which induces new types of missions for armed forces such as peace keeping and enforcing, participation to homeland security, urban combat, asymmetric engagements, etc. Technology breakthroughs are required for implementing these new concepts of operations in an optimised way.

In particular, until recently, the acquisition process was focused on precisely specified individual platforms. It is now necessary to consider the platforms within their environment, as components of wider systems or "systems of systems" aiming at providing an "Operational Capability".

As a consequence of this the procurement process and the engineering activities for acquiring and designing such capabilities and systems of systems have to be redefined.

In addition to that, the defense systems are developed within different cooperation frameworks, mainly NATO, Western Europe Organization and of course the European Union, which has adopted a Common Foreign and Security Policy including the Security and Defense European Policy and an armament chapter. These cooperations increase the interoperability requirements for the development of new systems.

Finally, the role of civilian systems and infrastructures in the global defense system and the commonality between defense and "homeland security" are increasing and provide opportunities for dual technologies.

All these aspects conducted the Forces and the French MOD Procurement Agency (DGA) to launch advanced study programmes aiming at providing the end users with up to date tools, processes and methodologies for the design of future operational capabilities. The aim of these programmes is to endow the DGA with Simulation Based Acquisition tools for modelling candidate solutions and architectures for future systems.

The first one was for the Cooperative Fighting System (BOA – Bulle Opérationnelle Aéroterrestre) programme through the acquisition of the SimEC3 simulation environment that is further described in this paper.

2.0 THE BOA PROGRAMME

The BOA programme is the first of a series of transformation programmes, aiming at providing the French Forces with new doctrines and equipments for Network Centric Warfare (NCW) at Battlegroup level.

It was initiated from the AMX10RC light armored vehicle replacement programme, namely EC3 which stands for "Engin de Cohérence du Combat de Contact", or "Cooperative Close Combat Vehicle".

The goal was to design a multi-role platform with some very innovative capabilities in the field of NCW such as:

- Collaborative engagement and protection capabilities between combat platforms,
- NLOS firing capabilities,
- Integration – Interoperability with other assets, like unmanned ground or air vehicles,
- Use of unattended or abandoned sensors.

Because of the level of innovations required for this platform, it was also felt necessary to study the feasibility and the design of the BOA elements with a new approach, seeking for global optimization and considering:

- Future concepts of operations,
- Operational capability,
- Present and future technologies,
- Programmatic issues in making legacy and new systems interoperable.

Because of the complexity of the BOA system of systems, specific design tools where felt necessary to complement traditional system engineering techniques, specially to address issues related to Network Centric information systems.

One of the answers to this requirement to better address system complexity was to evaluate candidate architectures and technical solutions by means of simulations, conducting the Army and the DGA to launch the SimEC3 programme in order to provide its architects and experts in the experimentation centres with an innovative SBA tool for the design of the France's Cooperative Fighting System.

3.0 THE SimEC3 PROGRAMME

Programme Description

The SimEC3 programme has been awarded in December 2002 for a delivery during 2005 to the DGA and Armed Forces in two different locations (Arcueil and Angers).

Objectives

The objectives of SimEC3 are to support :

- Operational and Technical Evaluation

- Evaluation of systems and systems of systems candidate architectures in operationally sound contexts. These evaluations include:
    - Candidate technologies;
    - Candidate network centric architectures;
    - Operational key elements (doctrines, rules of engagement, …);
    - Programme constraints (replacement or enhancement of existing platforms, interoperability between legacy and new systems ….);
    - Human factors (warfighter workload, use of unmanned platforms, …);
    - Costs and Logistics constraints.

SimEC3 will be used through the development of the BOA. It has therefore to consider existing as well as future platforms used by the Army, such as UGVs, UAVs, UGSs, ACVs, APCs, MBTs, NLOS-G/M. The requirement for the capability of integrating models of future platforms induced very strong requirements in terms of:

- openness and agile architecture, in order for the end-user to be able to easily introduce new sensors or weapon systems data and models,
- interoperability, to allow the future connection of other elements such as new simulation federates, manned simulator, or possibly real equipments.

4.0 THE DESIGN OF SimEC3

Global Architecture

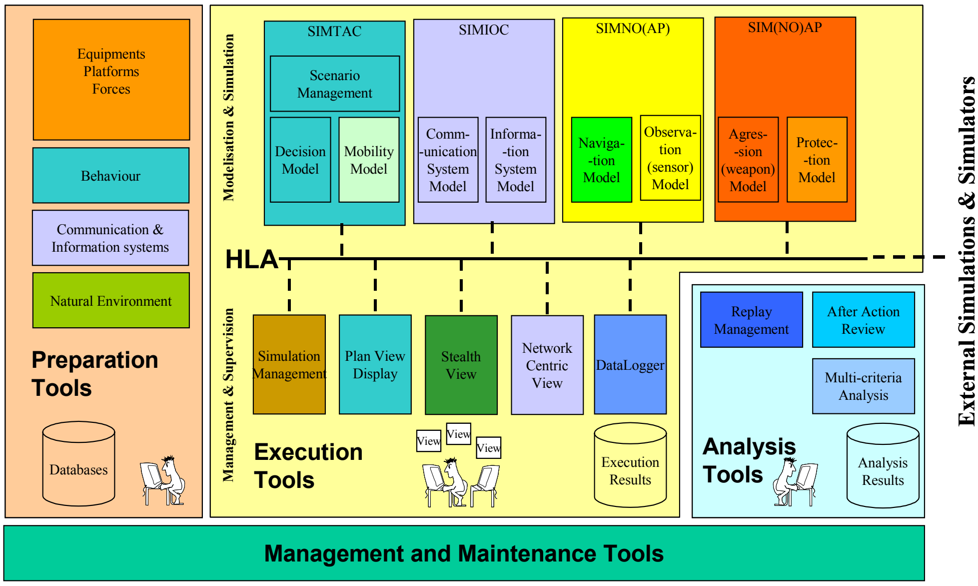
SimEC3 architecture addresses the 3 main operating phases (preparation, execution, analysis) of a simulation session, as well as its management and maintenance.

Preparation: provides services to support the acquisition of the various data describing the different architectures and environment (tactical and natural).

Execution: provides services to support the simulation models execution, the simulation management, the observation (views) of relevant simulation parameters, the log of relevant simulation dynamic parameters.

Analysis: provides services to analyse and interpret simulation results through indicators, metrics and criteria, and to produce reports.

Management and Maintenance: provides services for users management (access rights and profile), data management, configuration management, and for adaptation and modification of simulation environment tools and models.



Process & Standards

To ensure the required openness, evolution potential, and confidence in the simulation environment services and modelling, established standards and process have been selected:

HLA/ RTI/FOM

The simulation architecture is built as a federation of federates some supporting the models whereas others are ensuring simulation management, viewing, and datalogging functions.

HLA 1.3 standard, with the Mäk RTI v2.1 package is used (note : when the programme was launched the IEEE 1516 standard was not released).

A specific SimEC3 FOM based on RPR FOMv2 draft 17 with specific enhancements (especially for equipment command and response and for information system exchange) has been established.

FEDEP

Compliance with the FEDEP process model for the specification, design, development, integration & test of the simulation environment.

SEDRIS

The natural environment editors (terrain and 3D models) support import/export from/to SEDRIS databases. A specific TCRS (Transmittal Content Requirement Specification) has been established.

Verification & Validation (V&V)

A Verification and Validation approach has been defined with the customer. The approach addresses the elementary model level and the system behaviour level.

For the elementary model level V&V, a precise definition of each model has been established by industry and DGA experts including:

- origin (e.g. theorical study, existing formula, test campaign),
- source (e.g. literature, publication, industry, expert),
- referent (better knowledge of the object or phenomena to simulate according to the application constraint),
- modelling assumptions (limitations, validity range),
- description of the model (parameters, algorithms and formula, input/output, dynamics),
- description of the validation method to be used.

For the system behavioural level V&V, a validation scenario has been established based on several sketches (or story lines) each addressing a specific aspect or relation between systems (e.g. cooperative defence, or sensor to shooter loop). These sketches have been established early in the programme as elements concurring to the specification of the system.

Simulation Models

The following models are provided in SimEC3 to describe the different potential architectures of the BOA.

Table of SimEC3 integrated models

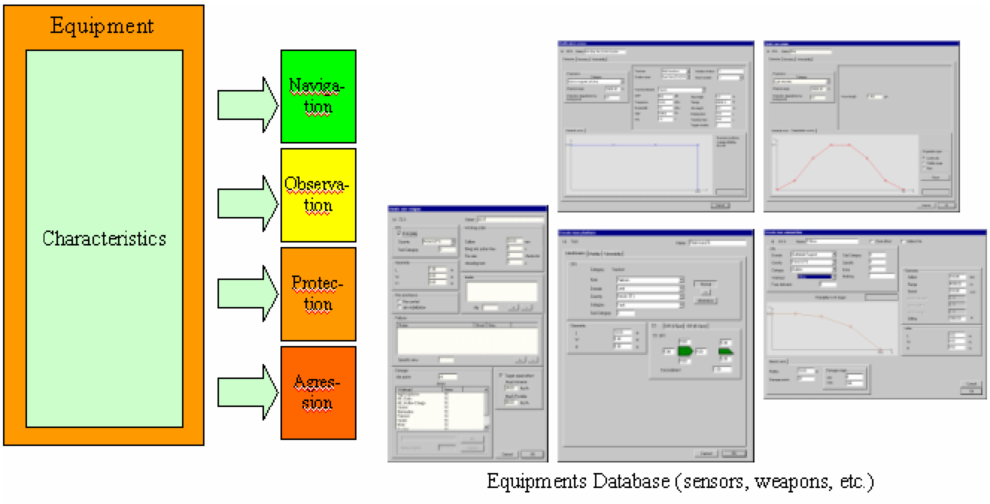
Mobility Models
Ground Vehicle (wheeled or tracked) Mobility Model
Fixed wing Air Vehicle Mobility Model
Rotor wing Air Vehicle Mobility Model
Unmanned Ground Vehicle Mobility Model
Unmanned Air Vehicle Mobility Model
Dismounted Infantryman Mobility Model
Navigation Model
Navigation system Model
Observation (Sensor) Model
Optical Sensor Model
Optronic Sensor Model
Laser telemeter & illuminator Model
Active Electromagnetic Sensor Model
Passive Electromagnetic Sensor Model
COMINT Sensor Model
Acoustic Sensor Model
Seismic Sensor Model
Laser, Radar, Missile Detector Model
Targeted Optical Detector Model
Platform stealthy Models
Battlefield Identifier Friend or Foe Model
Electromagnetic Jammer Model
Targeted Optical Jammer Model
Aggression (Weapon) Models
Direct Fire Weapon Model
Non Line of Sight Weapon Model (classic ammunition)
Non Line of Sight Weapon Model (smart ammunition)
Area Effect Weapon Model
Aimed Energy Weapon Model
Minefield Model
Non-lethal Weapon Models
Passive & Reactive Protection Model
Active (hard-kill) Protection Model
Smoke Model
Chaff and flare Model
Platform Non-lethal Weapon vulnerability Model
Platform Aimed Energy Weapon vulnerability Model
Information (system) Models
Directory Management Model
Database Management Model
Tactical Situation Setting-up Model
Tactical Situation Evaluation Model
Fusion Model
Communications Models
Communication system Model
Transmission Delay Model
Physical Layer Model
Command & Coordination Models
Decision Model (based on behaviour rules)

Tools

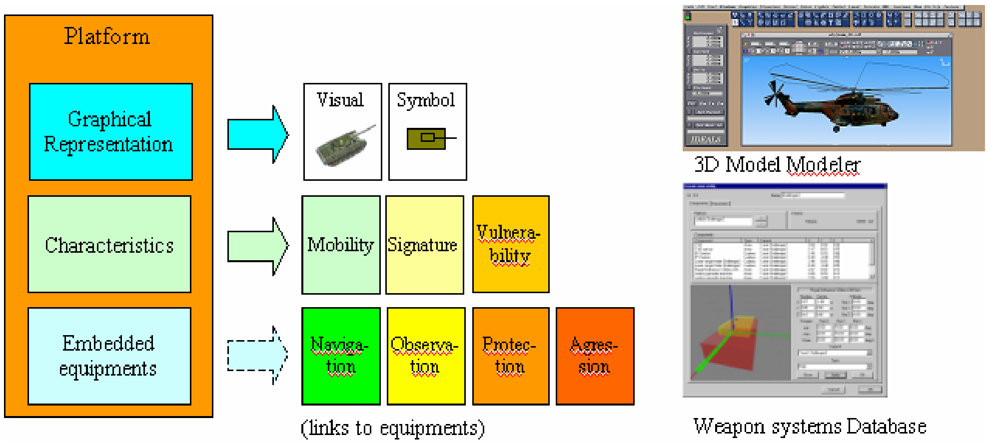
The implementation of the different SimEC3 available services is made through dedicated tools.

Preparation Tools

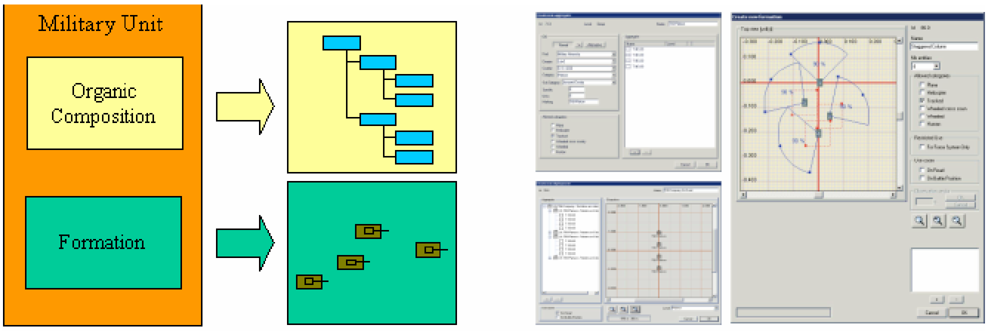
Equipment Preparation Tools: provide functions to edit equipments (sensors, weapons, navigation system, protection systems, and communication equipments) parameters.



Platform Preparation Tools: provide functions 1) to edit platform specific parameters (mobility, size, weight, signature, shield), 2) to identify platform embarked equipments (sensors, weapons, navigation system, protection systems, communication equipments), 3) to define realistic 3D representation (for Stealth viewer), and symbolic representation (for Plan view display).

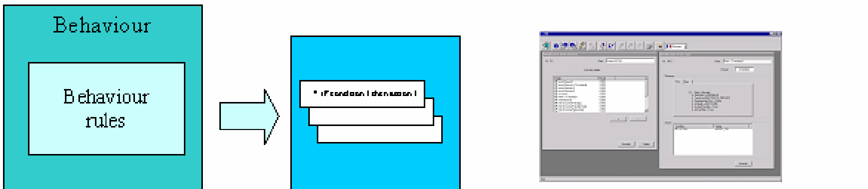


Force Preparation Tools: provide functions 1) to compose organic forces (platoon, company, etc.), 2) to define operational formations for each organic force according to their potential missions.



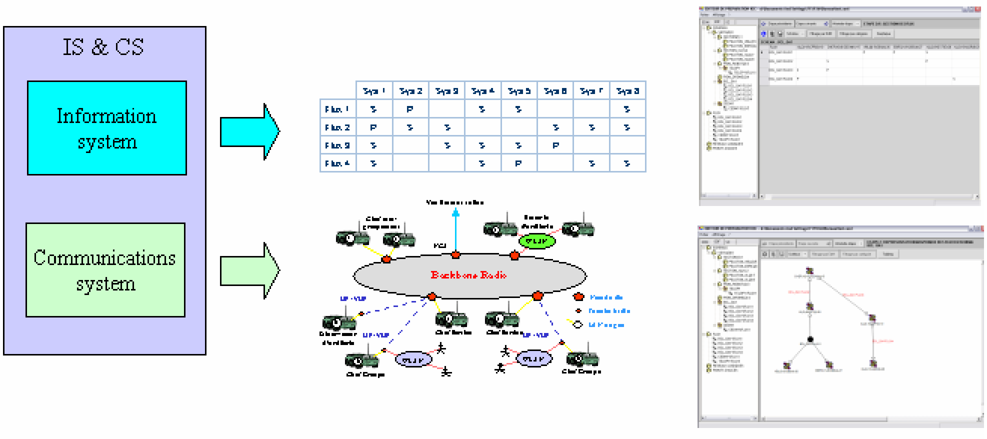
Force systems Database

Behaviour Preparation Tools: provide functions to edit rules (situation evaluated parameters, associated actions/reactions) and sets of rules to describe the doctrine to be followed and the behaviour for each organic force structure (from the platform to the company level) according to the tactical situation and their mission.



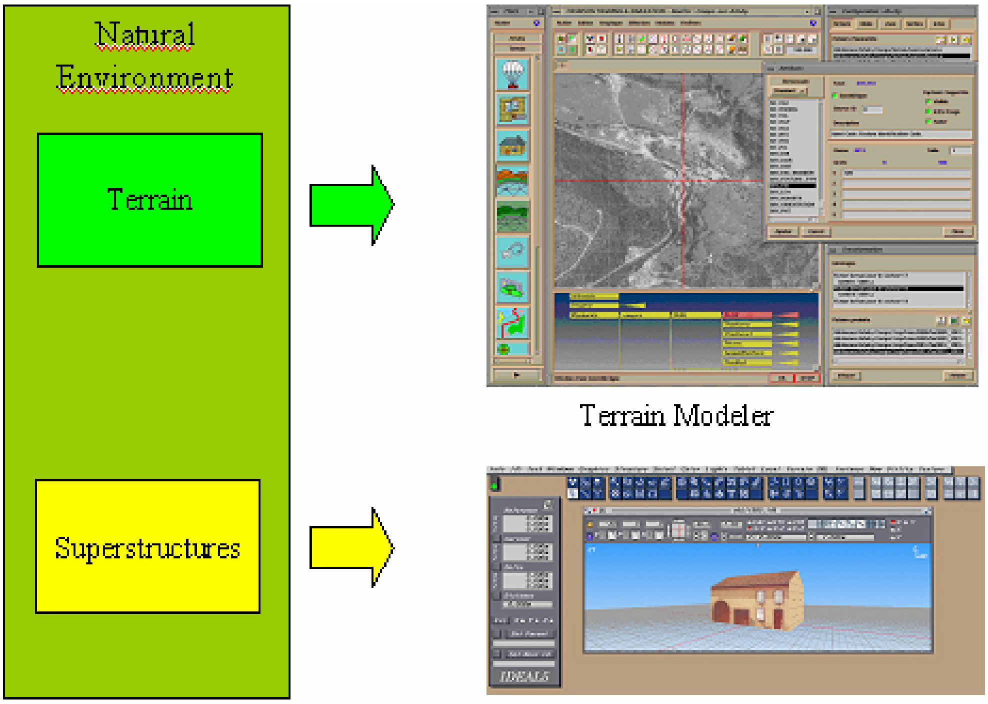
Behaviour rules Database

Information & Communications Preparation Tools: provide functions 1) to describe the operational information system by identifying the dataflow between the platforms 2) to describe the communication network.



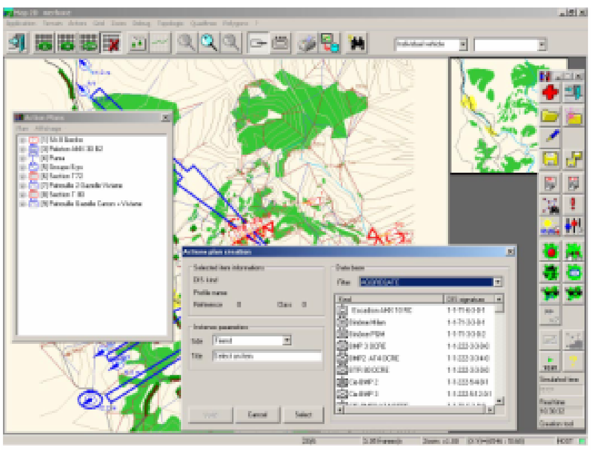
Information & Communications systems Database

Natural Environment Preparation Tools: provide functions 1) to import, edit and transform terrain data (elevation, features) into terrain databases dedicated for the different simulations, 2) to edit 3D models to represent superstructures.



3D Modeler

Scenario Preparation Tools: provide functions 1) to define the initial positions and status of the different organic forces (friend, foe, neutral), their missions, and the synchronisation of the missions, 2) to define the weather conditions and their evolution during the exercise.



Tactical scenario Preparation

Wind	....
Luminosity	....
Visibility	....
Hygrométry	....
Temperature	....

Weather data Editor

Execution Tools

Management Tools: provide functions to monitor and control the execution of the simulation and of the federates.

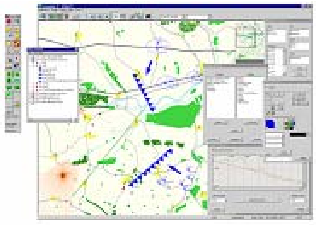
Scenario Management Tools: provide functions to control and to modify missions of the different simulated actors.

Viewer Tools: provide functions to observe simulation dynamic parameters, 1) tactical cartographic situation through Plan View Display, 2) realistic 3D view of the battlefield, 3) network centric view showing instantaneous status of the network (messages exchanged, interrupted links).

Recording Tools: provide functions to record identified dynamic simulation parameters exchanged between the different simulation federates.

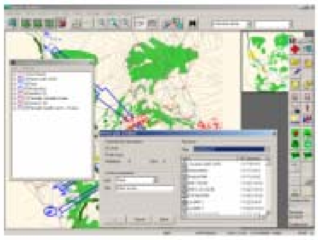
Network Centric View

3D terrain View



Battlefield cartographic View

Simulation Management



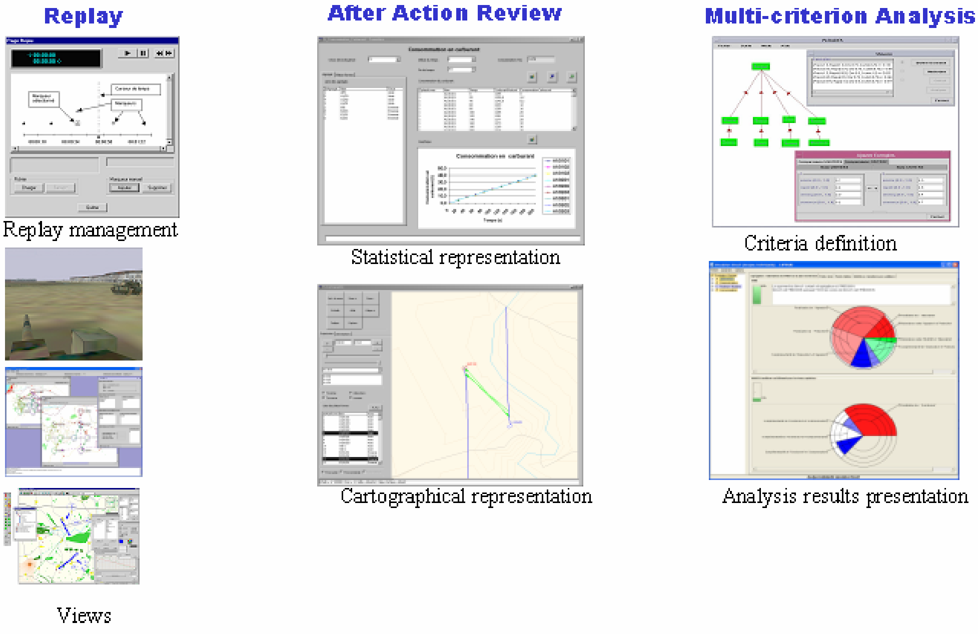
Scenario Management

Analysis Tools

Replay Tools: provide functions to replay recorded dynamic simulation parameters and to review replayed tactical, environmental, and network situations and dynamic status.

After Action Analysis Tools: provide functions to perform statistical analysis from recorded dynamic simulation parameters and to produce reports at .doc, .xls format.

Multi-criteria analysis Tools: provide functions 1) to elaborate criteria, 2) to evaluate performance of candidate architecture related to defined criteria (cf. innovative solutions §5).



5.0 INNOVATIVE SOLUTIONS

The SimEC3 Simulation Based Acquisition tool will be used for studies all along the development of the BOA components and concepts of operations, requiring an outstanding evolution capability. This was expressed in the following requirements:

- The system shall be easily upgradeable through the replacement of existing models, the addition of new models, the connection of other simulations
- The system shall to provide an interpretable and synthetic vision of the simulation results, providing assistance to the user in the interpretation of the simulation outcomes for the scope of its studies.

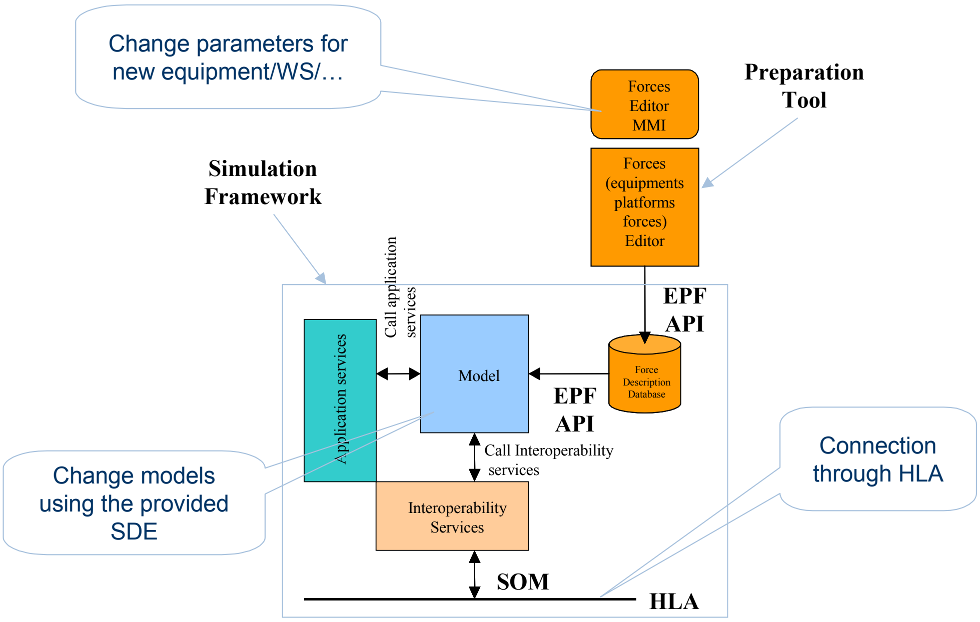
This chapter will describe in detail the two innovative solutions implemented during the design of SimEC3 to comply with these requirements.

Openness

The openness of the SimEC3 simulation environment is met through three complementary mechanisms:

- the use of generic models with dedicated instances of parameters to represent specific equipments, platforms, force organisation, information systems. The introduction of new items is performed by the use of preparation tools, to edit / update the relevant parameters.
- the use of a simulation framework providing common application and interoperability services makes easier the development, the integration and the replacement of models, and hosting these models during simulation execution.
- the use of HLA to develop the system by applying the FEDEP, and to exchange information (objects and interactions) between the different models provides the capability to connect other federates 1) to observe the simulation dynamic parameters, 2) to subscribe to relevant objects and interactions in order to export this information to external simulation, 3) to publish (objects and interactions) information to the SimEC3 federates.

These three complementary mechanisms are illustrated in the figure below.



The SimEC3 architecture integrates two different frameworks :

- a C++ Simulation Framework (ATMS) from THALES;
- an Ada Simulation Framework (ESCADRE) from the DGA;

to allow the reuse of existing models from both environments.

Although they come from different origins, the solution adopted for the two frameworks was to harmonize and make consistent –or even identical- some common simulation services:

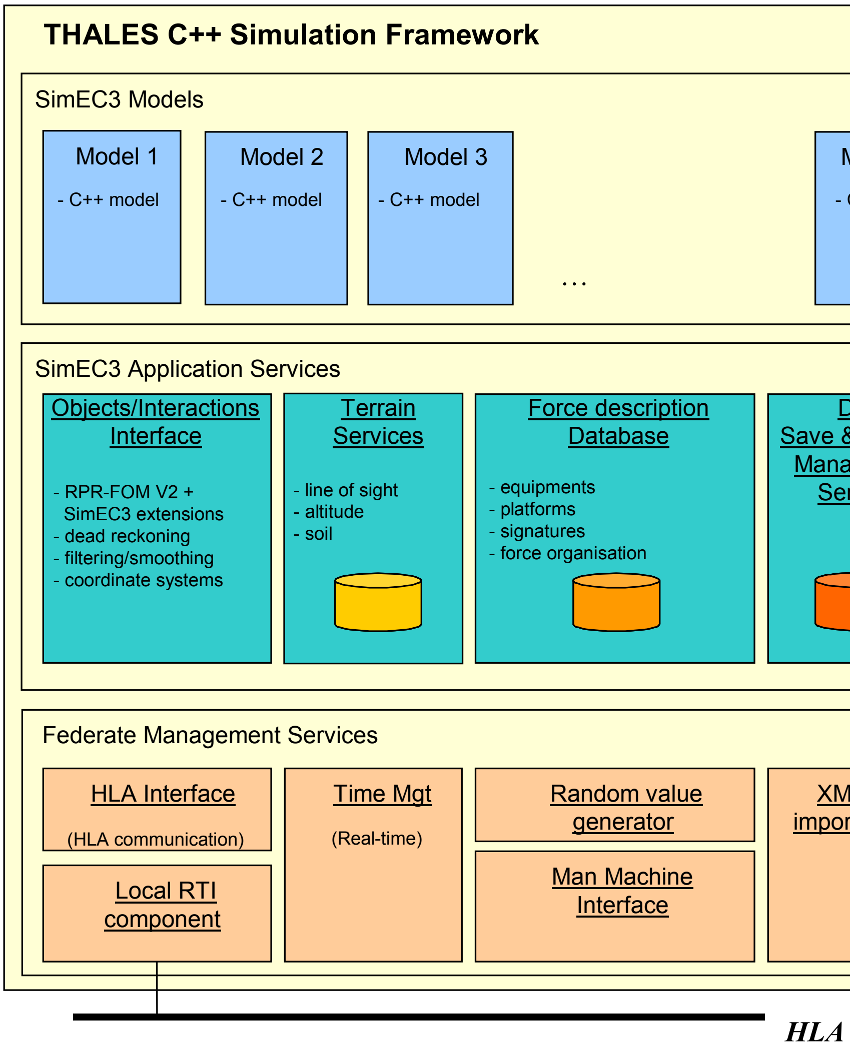
- Applications services: object/interactions (FOM, dead-reckoning, filtering/smoothing, coordinate systems), terrain services (line of sight detection, height above terrain, soil characteristics), access to Force (architecture) description database;
- Interoperability services: HLA/RTI interface, XML files access, time management.

These common services where developed in the C++ ATMS framework and brought to ESCADRE using the Ada binding.

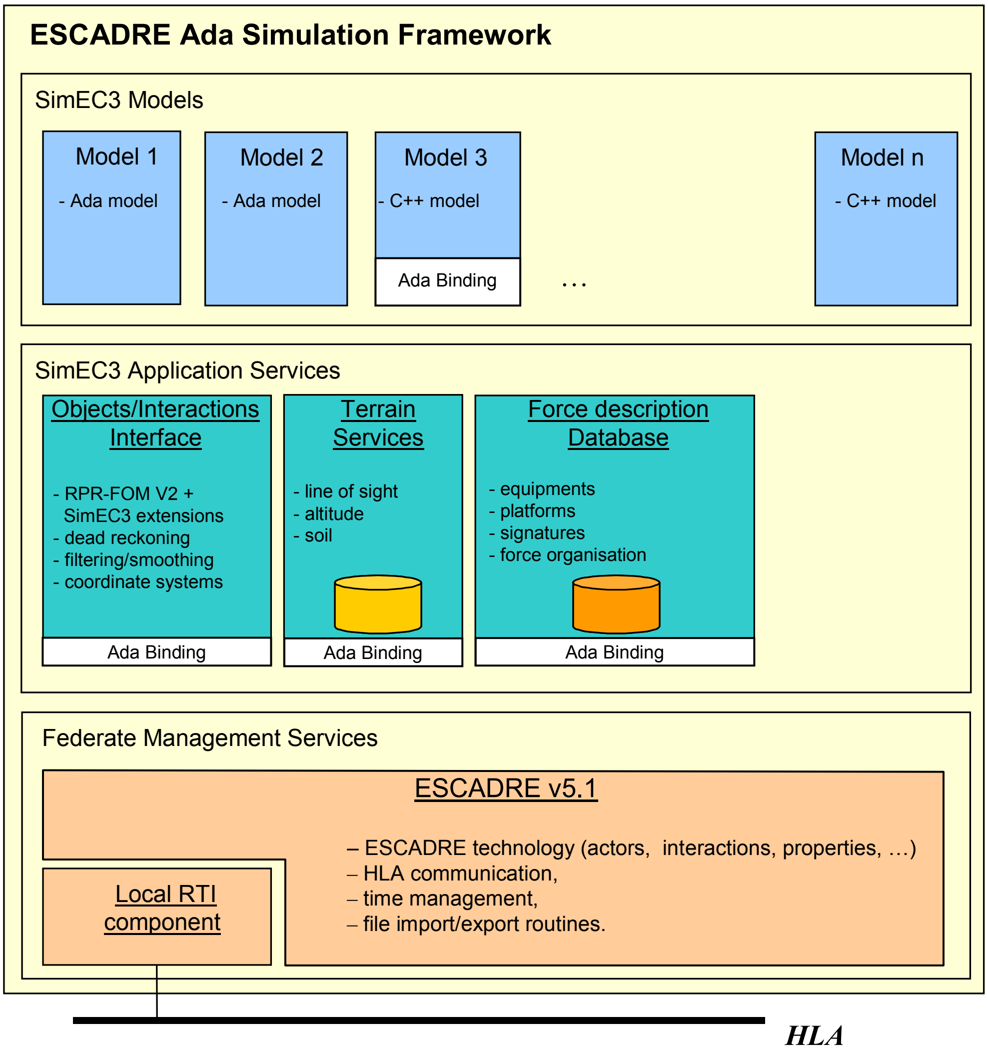
Of course, the services already existing and strongly tight in the frameworks (such as some interoperability services) were kept specific to the framework.

The two figures below provide a synthetic view of the two frameworks including the common services.

ATMS Framework.



ESCADRE Framework



Multi-criteria Analysis

To provide the users with the level of information required for interpretation of simulation results, two sets of tools were developed.

The first one is a statistical tool which provides statistics from the huge amount of data logged during the simulation execution. It is a classical way to provide synthetic data through metrics, graphs, etc.

The second one is a very innovative tool called MYRIAD®, providing aggregated information i.e. a high level vision of the results by modelling the experts decisional process.

This is done by applying the following process:

- **Creation of the evaluation model, in 3 phases:**

Phase 1: Determination of the performance criteria applicable to the architecture under evaluation;

Phase 2: Determination of the utility functions of each criteria;

Phase 3: Determination of the aggregation function as a mathematical representation of utility functions.

➢ **Validation of the evaluation model by reference to subject-matter experts.**

➢ **Application of the evaluation model.**

The model parameters are determined by a "learning process", using examples supplied by the subject-matter expert. The expert has full latitude to select which examples he considers more representative of his own decision strategy.

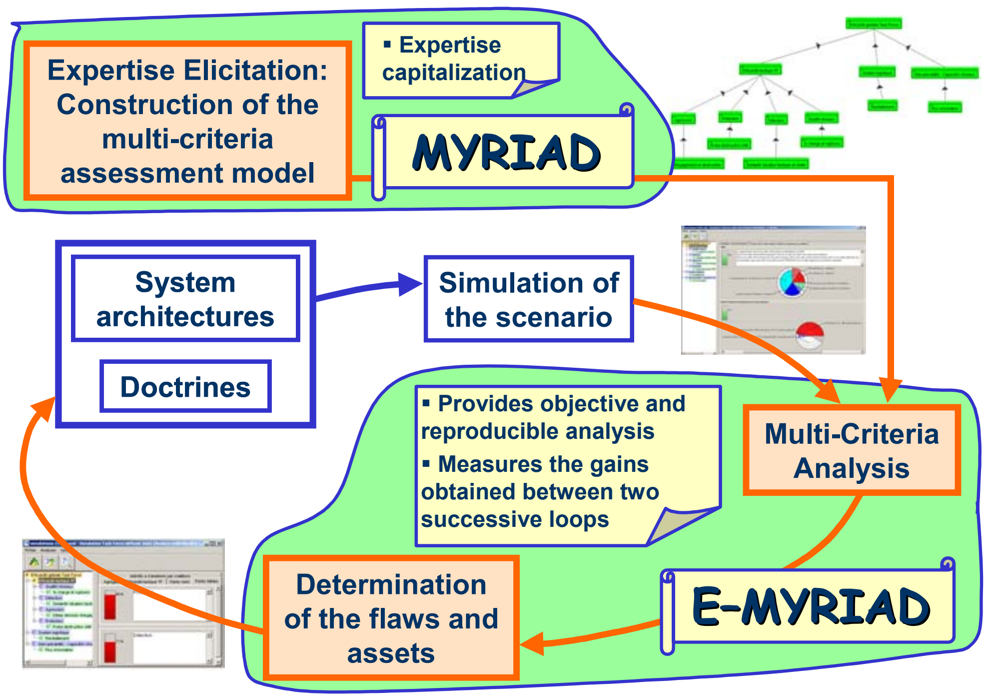
The MYRIAD® system assists the users and experts in the performance of the learning process by the following auxiliary functions:

- Detection and identification of incoherent input data.
- Detection and identification of missing input data. If the data supplied do not allow MYRIAD® to create a meaningful model, the system detects this situation, and it may even propose new examples in order to generate these missing data.
- Explanation of the final model generated: requirement traceability and sensitivity analysis.

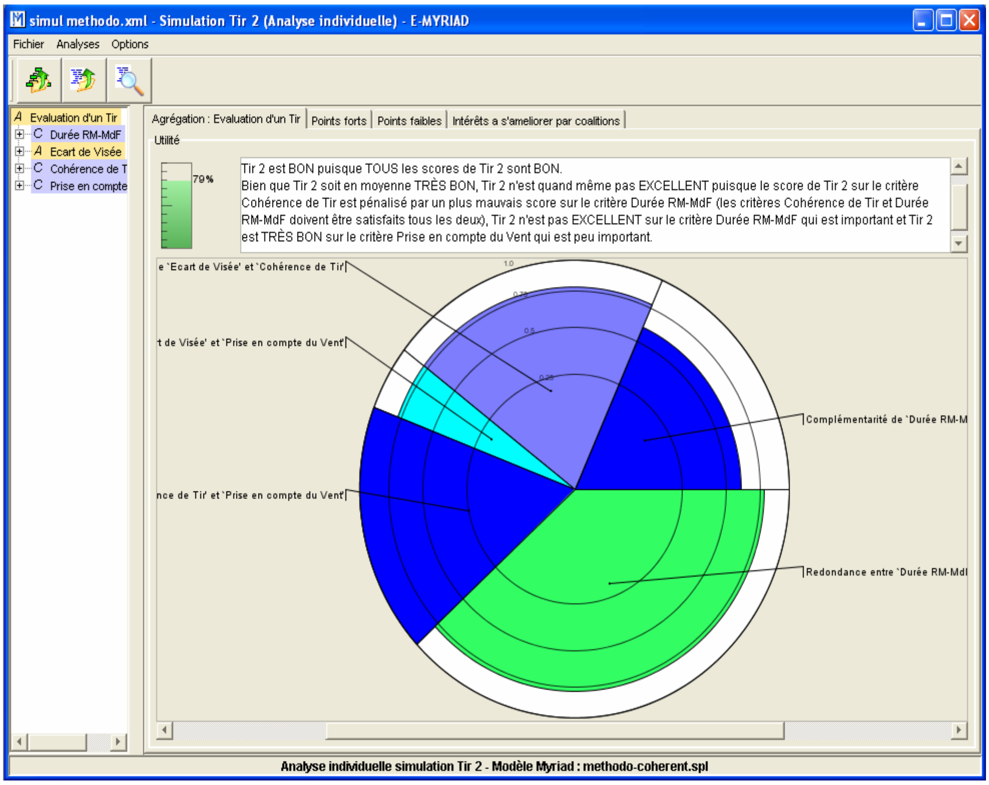
If the subject-matter expert does not agree with model results and explanations, then MYRIAD® will indicate which input data would need to be modified.

It should also be mentioned that the combined criteria may address different aspects such as technical, operational, economical or logistic aspects, and can provide a global comparison between candidate architectures.

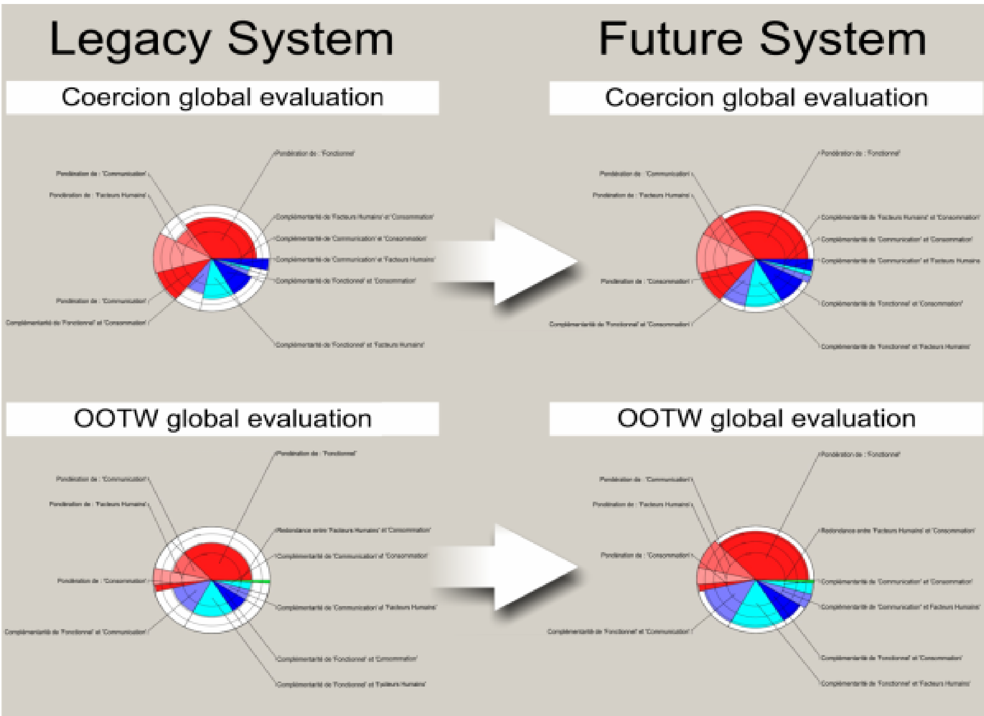
The process is illustrated in the figure below.



With each set of collected simulation results (e.g. for a dedicated architecture) MYRIAD® performs automatically (using the relevant analysis model) the analysis and presents graphically the global analysis results with explanation.



MYRIAD® provides also global views of the performances of each analysed system (or from the same system with different scenarios, or both) that allow the analyst to compare more easily the different systems integrating the various criteria.



6.0 CONCLUSION – PERSPECTIVES

In this paper SimEC3 and its innovative solutions were described as a simulation environment focused on the assessment of candidate architectures and technology for the future France's cooperative fighting system.

Because of its outstanding capabilities, this simulation environment is already used as background for new programmes and can also be considered for different applications envisaged by the DGA but also by other MODs. This chapter will provide an overview of these different opportunities.

At the time this paper is written, a programme similar to SimEC3, based on the same technology, architecture and solution was awarded to Thales, aiming at modeling candidate solutions for large area surveillance (SCE-SUZON). This programme is now in the design phase and will be delivered to the DGA in 2006.

Similar programmes are also envisaged in the frame of ground based air defense, logistics and support or medical chain just to mention some of them, for which the solutions implemented for SimEC3 and SCE-SUZON could be capitalized and further enhanced.

During the development of SimEC3, it also appears that this SBA tool could be used to contribute to new CONOPS evaluation, addressing not only technical but also operational issues including Forces organizations. Although this type of usage is not in the scope of the actual end users, this opportunity will be considered for a future use of the product, potentially in the BOA Battlelab.

Effectively, it shall also be stressed that in order to address the BOA feasibility as a whole the DGA has decided to implement a Battlelab in which SimEC3 will be the simulation cornerstone for implementing the environment in which real equipments will be immersed during experiments or technology demonstrators.

Conforming to simulation interoperability standards like HLA and SEDRIS, it can also be envisaged that remote battlelabs located in different countries could be interconnected to implement multi-national interoperability experiments.

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