CALIPSO

M&S to Support MPO French Armed Forces Planning Process
(La simulation instrumente la méthode de planification opérationnelle)

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OVERVIEW

CALIPSO (acronym for "Concepts avancés pour la connexion de la simulation avec les SIO") is a French MoD R&T program which aims to support M&S (Modeling and Simulation) army higher level commanders and staffs in generating CONOPS (Concept of Operations), OPLAN (Operational Plan) and OPORDs (Operational Orders) at Corps or HRF (High Readiness Forces) and Division level.

The paper first introduces the RRC-FR (Rapid Reaction Corps - France), its organization and highlights cells which could better perform their activities by using M&S. At first glance, G5 responsible to provide CONOPS and OPLANs is the logical user. Furthermore, G3 and more specifically G35 in charge to produce OPORDs based on approved OPLAN and JEC (Joint Effect Center) responsible for targeting and 3D coordination are also candidates to take advantages of M&S.

In the second part, the paper presents the NATO OPP (Operational Planning Process) and explains how this process is consistent with the French MPO (Méthode de Planification Opérationnelle). It details the OPP different stages (Initiation, Orientation, Concept Development, Plan Development, Plan Review) and underlines where M&S could perform functions to aid operational planers.

The paper ends with major M&S requirements and technical solutions to support Head Quarter planning process. If the planners must be confident in M&S results, simulation has to require no additional resources and must not be time consuming to cope with the crisis response planning tempo. It then appears that in most cases simulation must run with a time acceleration ratio up to 1:400. As a result of these considerations it appears that current M&S techniques do not provide effective solutions and new modeling approaches have to be explored.

At last, for C4ISR and M&S coupling the paper introduces different approaches to solve existing gaps. The CBML (Coalition Battle Management Language) is foreseen as a promising concept that requires further experimentations. Thus, ET-016 has just proposed the creation of a CBML Technical Activity.

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1 INTRODUCTION

CALIPSO (acronym for "Concepts avancés pour la connexion de la simulation avec les SIO") is a multi year French MoD R&T program which aims to analyze higher level Army user needs for C4ISR-M&S (Modeling and Simulation) coupling and to provide advanced solutions to solve existing issues. This program is also focusing on the development and experimentation of new M&S techniques for operational planning.

The CALIPSO program started early 2005 and is divided into three phases over four years. At the end, CALIPSO shall provide an initial M&S capability to the third version of the French Army Brigade to Corps C4I system called SICF V3 to support both French and NATO MDMP (Military Decision Making process).

The first phase of this program addresses the capture of higher level operational requirements and the analysis of technical issues. It ends with the development of a first demonstrator which will be the core for the future operational planning system.

The purpose of this paper is to describe the results of the initial phase of this program and orientations given to the first implementation. The paper will first introduce the military context: the French HRF (High Readiness Force) also called RRC-FR (Rapid Reaction Corps - France) and its planning process. It will then walk through the operational and technical requirements for M&S to support the RRC-FR planning process, and finally it will conclude with the proposed architectural approach for M&S and SICF V3 coupling.

2 OPERATIONAL ENVIRONMENT

The CALIPSO operational user requirements have been collected to RRC-FR and deal with both NATO and National procedures.

2.1 The RRC-FR

The RRC-FR, led by France and officially created the first of July 2005 in Lille, is a multinational Army Corps Head Quarter (50 000 soldiers). It is made of 400 Army Officers and Non Commissioned Officers, 70 of them coming from other voluntary European Nations. Depending on its assigned mission, it could be commanded by a NATO, European or French Operative Command Post like the Naples (HQ Land North Heidelberg) and Brunnsum (HQ Land South Madrid) JFC (Joint Force Command), the Lisbon Joint Command or the National Joint Force Command, EMIA-FE. However, it can embrace alternative positions such as Joint Task Force HQ for Land-centric operations or Land Component Command HQ in operations smaller than corps size.

Today the RRC-FR is under the NATO HRF certification process. Following the FOC (Final Operational Certification) foreseen for June 2007, the RRC-FR will join from July 2008 to January 2009 the NRF (NATO Response Force) 11. The NRF is a NATO HRF able to be deployed within a five days delay to execute an operational mission during thirty days without any additional re-supply.

This HQ is organized into 10 conventional cells referred to as G1 to G9, plus Engineer, as depicted in the figure hereunder.

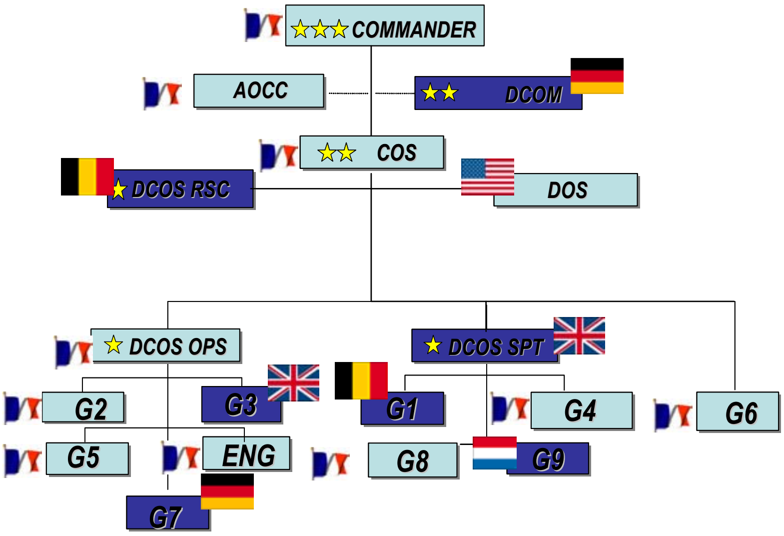

Figure 1: RRC-FR Organization

G3 and G5 are the core cells concerned with operational planning even if G4 (Logistic) and G2 (Intelligence) are also involved to provide inputs.

G5 is responsible to execute the planning process in order to develop future plans from higher authority's directives. Such plans describe the missions assigned to the subordinate units beyond 3 days and above.

G3 which is the execution cell is in charge to define OPORDs and FRAGOs (Fragmentary Order) according to the G5 plans. This task is assigned to G35 which performs its own MDMP to develop an OPORD that will be effective in the forth-coming 72 hours. In addition the JEC (Joint Effect Center) belonging to G3 defines targeting objectives to execute in a short delay in order to secure the execution of the OPORD in preparation at G35. Such effects concern INFO CAMPAIGN, PSYOPS, EW, Field Artillery.

2.2 Planning Process

As a NATO HRF, the RRC-FR uses the standard NATO planning process also called OPP (Operational Planning Process) which is described in the GOP (Guidelines for Operational Planning) [1] . In addition, as the RRC-FR could serve for National purposes the French operational planning process MPO (Méthode de Planification Opérationnelle) [2] is also used.

2.2.1 GOP Overview

The NATO OPP describes sequences and procedures undertaken by commanders and staffs to analyze a situation, deduce mission requirements and determine the best method for accomplishing assigned tasks and a desired military end-state. The OPP is designed to support both military missions Article V Collective Defense and Non-Article V Crisis Response at strategic, operational and tactical levels. It comprises five planning stages as depicted in the figure hereunder.

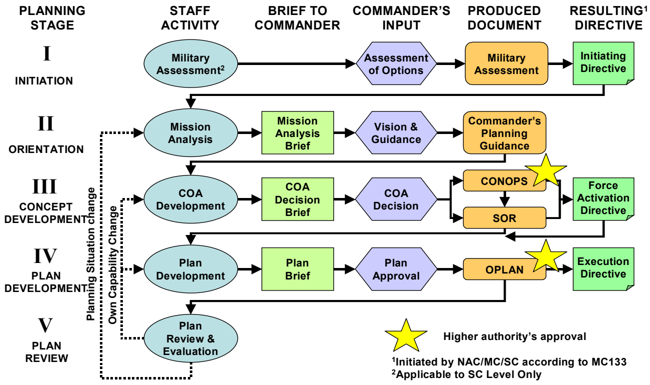

Figure 2: Operational Planning Process

Typically, the Commander activates an CPG (Corps Planning Group) led by G5. It comprises staff with expertise from across the HQ including all relevant cells. It can be expanded to include representation from subordinate commands to facilitate rapid concept development. The CPG is in charge of executing the different stages described below.

Stage 1 – Initiation

The Commander initiates the planning process through the use of an Initiating Directive. The Initiating Directive outlines what has to be accomplished. It clearly details the elements needed for effective planning to commence, such as the desired end-state(s) and the higher Commander's intent.

Stage 2 - Orientation

This phase begins with the mission analysis. It determines the boundaries and nature of the problem and confirms the desired end state to be achieved. The conclusion of this analysis phase is submitted to the Commander (Mission analysis briefing) and finally the Commander's Planning Guidance is written to serve as a base for stage 3.

Stage 3 – Concept development

Concept Development begins with a staff analysis. The purpose of this analysis is to examine a set of key factors (friendly and enemy situation, terrain…) and to identify assumptions relevant to the mission in order to develop COAs (Courses of Action) that are both viable and supportable.

A comprehensive range of COAs which achieve the mission are then developed. G5 is responsible for producing friendly COAs while G2 produces enemy COAs.

Each COA is then tested against the opposing force's most likely and most dangerous COAs. This process helps to identify advantages and disadvantages of each COA. Once COAs have been tested, they are compared through an examination of advantages and disadvantages, and consideration of selected criteria (surprise, flexibility, economy of force, simplicity, relevance…).

The COAs are then briefed to the Commander at a Decision Briefing where he will select a COA to be refined and finally developed into a CONOPS (Concept of Operations). The CONOPS contains sufficient details to express the Commander's view of the overall conduct of the forth-coming operation. It is finally submitted to the Initiating Authority for approval.

Stage 4 – Plan development
The OPLAN (Operational Plan) is now developed based on the approved CONOPS. The format of the plan is standardized throughout NATO and the main body (CONOPS) and annexes of the plan must be written in accordance with the GOP.

Stage 5 – Plan review
During an operation, the plan must be continuously reviewed because of the unexpected events that make it invalid. This is called the Progress Review and it focuses on the new threat, availability/flow of forces, suitability of contingency plans, requirements for additional branch plans… Depending on the situation, previous steps 1 to 4 can be processed again to change plans.

2.2.2 MPO Overview

The GOP document provides the maximum freedom for planning staffs to develop ideas and concepts. It is composed of chapters defining on the one hand procedures and output documents and on the other hand principles and processes (especially the Operational Planning Process known as the OPP). French doctrine documentation separates those two aspects respectively into the IM 4000 and a recent document that defines the French Operational Planning Method. This method, named MPO, relies on a logical reasoning process, subdivided in clearly defined phases and stages. This properly "marked" sequence enables every staff member to keep reference points at any time in the process development.

This process is consistent with the OPP and the main differences between the two are:

- MPO applies only to phases 2 and 3 of the OPP;
- MPO gives more details and advices to the planners for organizing staffs and for reasoning. As an example, the wargaming stage than can occur for COA comparison, is mentioned in 5 lines in the GOP while it is described in a few pages in the MPO.

The details given into the MPO served the Commander to answer the question "How to help planners with M&S?"

3 M&S WITHIN THE PLANNING PROCESS

3.1 Application areas

An examination of both previous planning process leads to the conclusion that M&S may have two main application domains:

- it can be used to predict situation evolution in real time;
- it can serve as a tool to support wargaming.

The use cases for situation prediction could be the following:

- overall situation prediction for planners: simulation would help to extrapolate current G3 reference situation to future G5 reference situation as a basis for long term planning. This will help in advance the need for Branch Plans;
- for G4 purposes: logistics situation evaluation;
- for G2 purposes: evaluation of the enemy perception of the current friendly operation.

The use cases for wargaming could be the following:

- for G5 COA development to provide early force ratio estimate, time and space sequencing, and to quickly discard invalid COAs;

- for G5 COA evaluation where simulation would provide an objective basis for COA comparison. Simulation would be used to compare each friendly COA against each enemy COA. These results would then be used to characterize advantages and weaknesses of each COA and to brief the Commander;
- for G35 COA refinement: selected COA would be refined and improved at a lower level of detail. This play would provide elements to fill synchronisation matrix and some other required documents;
- for G3 COA rehearsal: after plan development, this plan would be played in details with key staff in order to have a comprehensive and common understanding of the plan in the HQ.

The operational requirement being more mature, the first phase of the CALIPSO program is focusing on COA evaluation. However, the door is still open to take into account the other mentioned needs and they could be fulfilled later on in further phases of the program.

This application area has been defined with two important additional operational requirements:

- the M&S customers shall be G5 and G35 planners;
- for G5 planners who plan an overall campaign (typically of 4-6 days) simulation would be used on such critical time windows

Based on this initial need, operational and technical requirements have been written for a M&S based system to support the HRF planning process. These requirements and encountered issues are described hereafter.

3.2 Main requirements

The two main issues that need to be considered are relative to time consumption and confidence in M&S results.

The time consumption issue leads to the following requirements:

- planning information that have been entered once into the G5 C4ISR must not be hand typed a second time into the simulation by an OA (Operational Analyst). This means that a close connection has to be established between the C4ISR and the simulation, both technical and conceptual, to export efficiently the initial state of the simulation and understandable COAs;
- all available information that have been produced by (or during) simulation runs must be delivered to G5 by the OA to aid the Commander decision;
- the use of M&S must not be a time constraint, especially during COAs development or evaluation: the simulation must be able to run a COA described on C4ISR side without having to further detail the plans for each COAs on M&S side;
- the duration allowed for G5 wargaming is approximately 4 hours. In order to play a complete COA matrix, the consequence is that a run must last about a quarter of an hour. This results in a time contraction of 1/400.

The confidence aspect has been captured in the following requirements:

- the need for validated models is a first and obvious requirement. The simulation architecture including command agents implies to execute a VV&A (Validation Verification & Accreditation) process. The one previously developed and experienced for French SCIPIO Brigade and Division training system will be reused and adapted to the CALIPSO planning tool;

- as the simulation results rely on command agents behaviors, the OA has to know and understand what important decisions have been taken by these automatic subordinate commanders. This property has been called "explainability".

In addition, important complementary requirements were established to cope with a multi-usage system:

- depending on the phase of the OPP, the simulation can be used in close or open loop: for COA comparison, simulation is launched in batch mode without any human intrusion while for COA development or COA refinement, OA may interact by issuing orders.
- G5 will consider N-1 units manoeuvre (Divisions) while G3 will be interested in N-2 ones (Brigades).

Consequently, both batch and interactive modes shall be possible and simulation resolution shall be at brigade level.

4 ISSUES AND SOLUTIONS

Many architectural issues have been discussed for the first demonstrator development. This paragraph focuses on the two major ones which are the simulation architecture and the C4ISR-M&S coupling.

4.1 Simulation architecture

Simulation will rely on a multi-layered architecture:

- The bottom level represents physics of operations. This level comprises a digitized terrain and a physical representation of the brigade level units;
- Three levels of command agents are piled up over this physical layer: the first one controls brigade entities actions, the second one represents division level command and the last one models corps level coordination in batch mode.

The next paragraphs present first a synthetic view of the technique used for developing command agents and then the application of this technique to CALIPSO.

4.1.1 The command agents engine

The CALIPSO command agent engine named DirectIA® [3] (Direct Intelligent Adaptation) allows simulating autonomous agents in their environment. It is made of two main decisional modules: the motivational module which allows modelling the motivations of an agent and the behavioural module which allows selecting its actions. This specific architecture aims at solving the double problem of goal generation and action selection.

The decision engine can be described as a three-layer architecture as depicted hereunder.

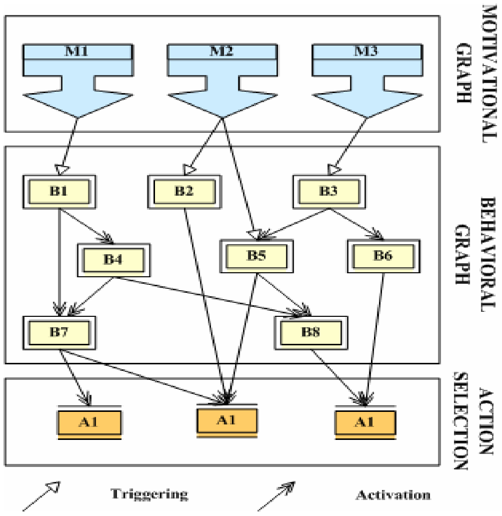

Figure 3: General principles

Two decisional layers (the motivational graph and the behavioral graph) propagate an activation to the final actions layer which causes the agent to select the most adapted actions according to the current context (i.e. to take an appropriate decision).

This engine has been developed from ethological research, and therefore borrows ideas and concept from that field. From such a point of view, a motivation can be viewed as an internal variable that accounts for both the internal state of the entity and the stimuli it receives.

This motivation defines possible goals for the entity (such as mission goal, decisive points, survivability…) and is used to trigger behaviors (e.g. withdrawal associated to the survivability motivation). By reaching such goals, the entity tries to maintain the variable in an "acceptable" state, thus "satisfying the motivation". In that respect, the DirectIA® motivational system can be viewed as a dynamic system, able to generate its own goals and to assess its own needs in order to ensure the stability of its internal state.

The engine relies, in fact, on a hyper-connected graph (an oriented graph, without cycles). This graph is defined by comparison with a traditional decision tree. In a decision tree, nodes represent states (goals that can be subdivided into sub-goals) and leaves represent agent actions. Each goal subdivision implies a selection that relies on decision rules (such as evaluating functions) associated with the states. Thus, an iterative walk in the decision tree produces an action plan.

A DirectIA® behavioural graph also uses a "decision tree", but in a completely different manner. Instead of selecting subdivision branches, agent motivations generate an activation that is propagated in a behavioural network until it reaches the final nodes.

These final nodes correspond to the elementary actions (move, engage, apply indirect fire…) that directly correspond to the physical effectors of an agent. As in artificial neural networks, decision rules are applied at each node level for modulating the activation propagation and trigger corresponding behaviours.

This iterative assessment of the graph avoids the backtracking bottleneck. Once the assessment of the behavioral graph has been completed, the agent selects the most appropriate actions according to the behaviors strength propagation. The elementary actions are directly bound to the agent physical effectors in order to interact with the environment.

Advantages of such a structure are manifold:

- Several action plans can be explored in parallel before action selection;
- Several tasks can be handled at the same time; thus, the system can exhibit compromise behaviors;
- Decision rules are simpler since they are responsible for activation modulation and not sub-goal selection;
- A small number of rules are sufficient in order to simulate a complex behaviour. The set of the behavioural graph activation states defines the continuous state space of the system.

DirectIA® technology has been integrated in several existing legacy simulations: improvement of the Rolands and Associates JTLS (Joint Theatre Level Simulation) for the French Joint Forces, and as the core component of the SCIPIO command post training system of the French Army.

4.1.2 Application to CALIPSO

This paragraph describes the four conceptual layers that compose the simulation software: physical level and three command agent levels.

Physical entities
Physical models implement a representation that accounts for the capabilities (mobility, fire, protection, detection…) of brigade entities. This representation is based on two concepts which are potential and effects.

Potential represents the actual location of brigade subordinates. It is characterized by surfacic densities within the brigade action zone. Potentials are distinguished to take the main Army domains into account (Cavalry, Infantry, Artillery, Intelligence, Engineers…) and to finally represent the full capability of the brigade.

Each Army domain local potential can apply its own effects locally or distantly, immediately or with a delay. For example engineer potential permits to build a local obstacle more or less quickly depending on the potential amount. Then this obstacle will remain on the terrain to produce the desired effect against the enemy. An equivalent reasoning can be done for intelligence with immediate local effects for HUMINTs and distant effects for stand-off devices, or for the artillery with immediate distant effects. Attrition models are Lanchester based.

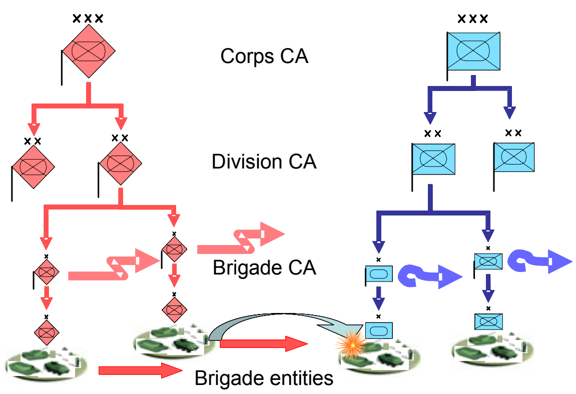

Figure 4: Simulation structure

Brigade level command agents
Brigade level command agents control internal physical representation of the brigade by manoeuvring potential depending on the mission they were assigned by the division level and according to the perception they have of their environment (terrain, enemy, friendly forces). When required, they apply effects depending on the availability of their potential.

For example, internal representation of the brigade takes two echelons of Cavalry or Infantry into account. The first echelon is only used by the command agent to apply direct fire. When necessary, the second echelon in support will be played by getting some second echelon potential into the first one. Left or right effort is played by using the same kind of mechanism.

Another brigade command agent role is to evaluate force ratio against the enemy. Depending on it, the command agent will move on or stop or ask for indirect fire.

Division level command agents
Division command agent is the key element of the system, because most of the information enclosed in the COA addresses this level. Such a command agent has two main tasks to perform: first to conceive the division maneuver and second to execute it.

Experiences in the past warned that achieving a command agent that could conceive an entire division maneuver would be doomed to failure. Thus, the division maneuver is based onto flexible patterns that correspond to typical COA. For example for an attack mission, the eligible COAs can be frontal attack, attack by encirclement, infiltration, and raid.

Based on a selected pattern, the division level command agent will then execute its maneuver in a way that is close to the brigade one, except that it will command entire brigades instead of potentials. Its main roles are to balance and to coordinate front line efforts, to deliver support with second echelon brigades when necessary and to evaluate division global force ratio to decide of next actions.

Corps level command agents
This last level is used in batch mode to execute the corps maneuver according to the COA defined by the OA. This command agent is similar to the previous one except that it is reasoning onto actual planners orders instead of reasoning onto patterns.

4.2 C4ISR and M&S coupling

One of the key issues of the project is to link M&S with the RRC-FR C4ISR which is SICF in order to provide the planning staff with a direct connection between SICF and the M&S system able to configure the simulation with "orders" contained into the COA.

The main problem is that the intent expressed in a COA is currently expressed with SICF as free text or graphical orders, while the command agents require an unambiguous set of orders. This point is really critical and up to now no real effort has been done to standardize COAs definition. The main reason is because they remain internal to HQs and are not to be communicated to other HQs.

Nevertheless, the good point is that graphical orders, which are the actual way for defining COAs, are not so ambiguous that they seem to be at first glance. They are drawn with a vector representation that enables to interpret their geometric meaning, limits, phase lines, actions, … given a geographical local sense.

What is really missing is the relationship between drawn elements. Such relationship is implicit for interpersonal communication while it is lacking for use with M&S. For example, in the following pictures, the fact that the second echelon unit supports both first echelon units is semantically and unambiguously expressed by the two doted arrows pointing at the first echelon units. Unfortunately, this can't be interpreted by a simulation and it needs to be expressed explicitly:

- the support between the second echelon unit and the two first echelon units;
- the "or" connector between the two support arrows.

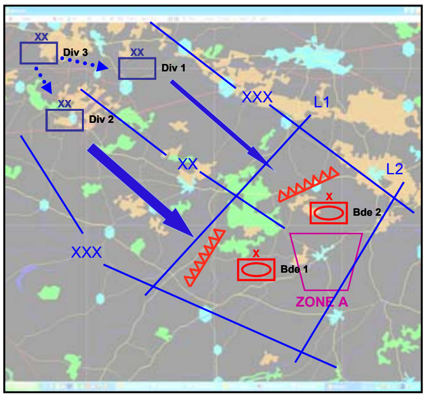

Figure 5: A course of action

Similar comments could be done regarding the relationship between the blue attack arrows and the blue first echelon, between the units and the different lines (phase lines, limits, defence lines…).and finally about the meaning of the thickness of blue arrows.

Most of this vocabulary is expressed within the APP6A [4] NATO standard. However, what is really needed is a formal language with grammar that will enable an unambiguous understanding of the overall COAs. In this area, the only initiative is the C-BML (Coalition Battle Management Language) works that take place under an ad-hoc SIW Study Group [5] and under NATO (ET-016).

In addition, some other aspects can't be totally described in the above picture, especially time and conditions which require different ways of representation.

Finally today options to perform SICF-M&S coupling are the following:

- directly link the CALIPSO simulation with the SICF DB;
- connect the simulation through MIP (Multilateral Interoperability Program) [6] compatible DB;
- use an XBML (eXtended Battle Management Language) interface.

The first option is probably the most efficient in term of performance. However, it is not flexible and not open to the wide community to be used in a coalition arena. Furthermore, the SICF internal model is a compromise between several standards and is not a standard itself. Thus, it would be difficult to enrich it in order to satisfy the CALIPSO requirements.

Consequently, it is decided to develop a loose coupling between CALIPSO simulation and SICF in order to experiment Conceptual Model alignments and finally to propose recommendations to SISO, NATO and standardization organizations.

CALIPSO first phase demonstrator will be developed in order to provide lessons learned and inputs to the SIW CBML SG and NATO ET-016. SICF being MIP compatible it can format XML files corresponding to existing C2IEDM [7] data representation, which is the underlying existing model for the XBML [8].

The chosen architectural approach is described in the following figure.

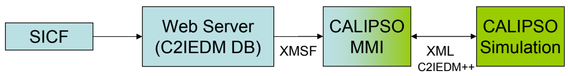

Figure 6: SICF-CALIPSO Simulation coupling

SICF exports COAs through a web server to a C2IEDM database. The COAs are displayed in the CALIPSO MMI and can be enriched by the OA to cope with what is required by the simulation to actually run. The detailed COA is then transferred via web services to the simulation in a C2IEDM extended model (C2IEDM++ on the picture).

This architecture offers two advantages:

- The CALIPSO interface is compatible with the C2IEDM international standard and is coherent to the BML architecture;
- The internal interface between the MMI and the simulation, based on the C2IEDM++, provides flexibility to experiment extensions to the C2IEDM, and then to propose them to international standardization organisations.

5 CONCLUSIONS & RECOMMENDATIONS

This paper presenting the French CALIPSO program focused on three major topics. The first deals with operational requirements to provide a M&S system to the RRC-FR G5 and G3 cells for planning purposes. The requirements captured raised technical issues that need to be solved in order to deliver in 2009 a brand new M&S operational planning system allowing COAs comparisons for higher army commanders and interoperability with SICF for Operational Analysts.

The M&S is the second major topic addresses within this paper. The architecture described is based on command agents that will enable an operational use of such a system by decreasing both delays and personal required to bring simulation into play. The command agents engine was explained and its relevance with high level units models was highlighted. Its most important feature is its capacity to take into account units motivations allowing the definition of simple rules to describe a complete COA.

The last topic addresses the C4ISR-M&S coupling. It is recognized that both C2IEDM and APP6-A are core basis to reach the interoperability between the C4ISR and M&S areas like these standards are common references used by the C4ISR international community. The lack of an unambiguous language to define COAs is highlighted and CBML works must continue in order to propose a new path to bridge the existing gap between C4ISR and M&S.

CALIPSO works will progress in the next four years through the development of three incremental versions of a planning system. Results will be reported on a regular basis and lessons learned will feed the future NATO Technical Activity on CBML.

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- CFAT: LCL Gaulin, CNE Druon
- CDEF: CBA Bernard, CNE Florek

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8 AUTHOR BIOGRAPHIES

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