Developing a joint concept for C2 and M&S systems

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ABSTRACT

The widespread introduction of C2 systems in the Netherlands armed forces changes operations and consequently Training and Simulation needs. C2 systems need to be integrated in many of the existing and future training systems. In order to reduce maintenance and development cost it is desirable to use the operational C2 systems also in the simulation environment. Both the C2 and M&S domain independently aim for interoperability, uniformity and reuse of methods and assets. These two domains now need to come together. The objective of our recent study was to align the Netherlands C2 and M&S architectural approaches, focusing on operational, training and technical needs. The Netherlands is developing a generic, configurable and distributed C2 information system using an evolutionary process. Based on this system, a suite of C2 applications will be deployed, providing staff, vehicles and individual combatants with a common operational picture. Joint and single-service collective training in the Netherlands requires interoperable systems that can be upgraded with the introduction of new weapon systems. The Netherlands armed forces Simulation Expertise Centre is closely involved in the acquisition of training systems and ensures that these adhere to open, international standards. The development cycles for the in-house developed C2 systems are typically much shorter than acquisition cycles for training systems. Programmatic and technical guidance is needed to assure continuing C2 and Training Systems interoperability. This paper presents and discusses the findings of the study, including technical guidelines and recommendations for evolutionary implementation.

ABOUT THE AUTHORS

Wim Huiskamp is a senior scientist in the M&S department at TNO Defence, Security and Safety in the Netherlands. His research area includes system architecture and distributed real-time simulation. Wim acted as project lead for several national and international simulation (interoperability) projects and currently works on C2-Simulation interoperability problems.

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INTRODUCTION

The operational processes of the Royal Netherlands armed forces are the guideline for the design and implementation of its other business processes. The widespread introduction of Command and Control (C2) systems impacts the operational process, and therefore also the Training and Simulation processes 'train as you fight'. On the system level, this means that C2 systems will be integrated with existing and future training systems. To avoid ad-hoc integration or -even worse- mimicking of operational C2 systems in training systems, an architectural concept is required for C2-simulation interoperability.

Joint and single-service collective training in the Netherlands requires interoperable systems that can be upgraded with the introduction of new weapon systems and C2 systems. The development cycles for the in-house developed C2 systems are typically much shorter than acquisition and upgrade cycles for weapon and training systems. This poses a challenge on training systems to keep up with C2 developments. Programmatic and technical guidance is needed to assure continuing C2 and training systems interoperability. Within the Netherlands, several organisations are involved in the process of developing a new concept for C2-simulation interoperability: The Royal Netherlands Armed Forces Command and Control Support Centre (C2SC) is tasked with developing a C3I Architecture and the corresponding C2 Framework (C2FW), and C2 systems. The Defence Materiel Organisation (DMO) acquires and maintains simulation and training systems. The Netherlands Armed Forces Simulation Expertise Centre (SEC) is closely involved in the acquisition of training systems and ensures that these adhere to open, international standards. The 'Netherlands Organisation for Applied Scientific Research' (TNO) Defence, Security and Safety supports the SEC through studies and demonstrators of applicable techniques and standards for distributed simulation systems.

The C2 and the Modelling & Simulation (M&S) domain both have aimed independently for interoperability, uniformity and reuse of methods and assets. These two domains need to be joined. The C2 Support Centre and the Simulation Expertise Centre have tasked TNO with a study aimed at aligning the Netherlands C2 and M&S architectural approaches, focusing on operational, training and technical needs. The study is aimed specifically at the Command & Control Framework (C2FW), a new C2 information system which is under development for the RNLA. The requirements for the design of the C2-Simulation interoperability architecture are: flexibility, scalability, robustness and compliance to international standards.

This paper presents and discusses the findings of the study so far, including technical guidelines and recommendations for evolutionary implementation of concepts that enable an integrated approach to C2-Simulation interoperability. This approach is named the 'SimStation' concept.

The next section of the paper addresses the need for linking C2 and simulations and the general concept of C2-Simulation interoperability. Sections 3, 4 and 5 discuss the background of the C2 Framework (C2FW) family development, the development of a family of national simulation systems (i.e. CaSTor/KIBOWI and TACTIS) and some C2-Simulation interoperability experiments involving these systems. The remaining sections discuss the requirements, architectural guidelines and implementation issues related to the proposed joint SimStation concept. The final paragraphs present recommendations and interim conclusions of the study.

BACKGROUND

Linking C2 and Simulations

Interoperability is the cornerstone of modern military operations. The development and implementation of the network centric concept is considered as the key to operational effectiveness. Interoperability is required between coalition partners, between military branches (joint) and between systems (sensor, shooter, C2). Linking C2 systems and simulation systems can be seen as another step in this process towards comprehensive interoperability. There are many potential applications for C2-Simulation interoperability. The C2 system can be used to prepare a plan, which is then supplied to the simulation system as a ‘scenario’. The simulation system executes the scenario and provides the C2 systems with data that reflects the 'real-world'. This data, which appears to have been received from peer C2 systems, provides a Common Operational Picture (COP) based on a simulation scenario. This technique may be used to perform assessment of C2 systems (performance, user interface etc.) and to support ‘train as you fight’ training of C2 operators. The advantage of using simulations to ‘stimulate’ C2 systems, as opposed to 'role players', is that the simulation has a consistent, controlled and reproducible behaviour, which allows objective assessment of system and/or operator performance. The advantage of using the C2 system as a means to interact with the simulation is that in this way the operational military process is the guideline. The process includes configuration, planning, training/rehearsal and finally operation. This approach supports the objective analysis and assessment of each step of the C2 process.

Experts agree that future C2 systems will provide commanders with operational decision support. Simulation models can be used as decision support tools by executing 'what-if' scenarios and help the C2 staff in its decision making process (e.g. mission planning or assessment of an alternative course of action (COA)). The simulation can be 'initialised' from the existing ‘real world’ COP in the C2 system. The ‘blue force’ plans can be supplied to the simulation by the blue force staff and most likely ‘red force’ operations may be supplied by the S2 units (Intell) of the blue force. Based on this information a simulation can be performed for analysis or mission rehearsal purposes. The simulation may help to identify the critical aspects that decide mission success or failure. Note that it is not the objective of our research to develop a decision support system that will ultimately assume the human commander’s decision making responsibility.

The RNLA and TNO recognised the opportunities to support the staff training process through C2-simulation interoperability and initiated experimental studies on the coupling of our national simulation and C2 systems. During these experiments it became clear that decision support would also become an important future application and the research was focussed more towards developing a flexible and future-proof approach to the C2-simulation interoperability problem. This concept was named ‘SimStation’. However, before we discuss the requirements for SimStation, we first need to clarify what we really mean by 'interoperability'.

C2-Simulation Interoperability

Interoperability is the degree to which entities are able to co-operate in achieving a common goal. There are many interpretations of the concept of interoperability between computer systems. It varies from having a network connection and being able to transfer files (e.g. email) to using exactly the same applications at all systems and completely sharing the information they process. A commonly used form of interoperability is *'information interoperability'*, because it offers optimal connectivity between systems, while preserving maximum independence. Information interoperability is defined as the ability of systems to automatically exchange and interpret information that is common to those systems (Lasschuyt, van Hekken, 2000).

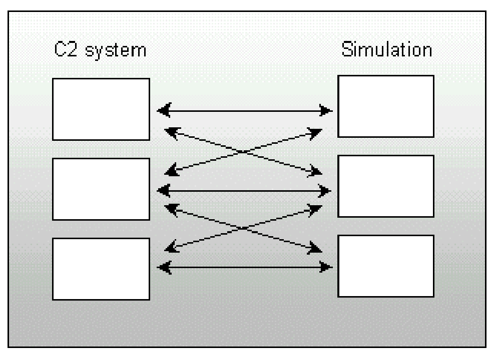

Figure 1 C2 and Simulation Interoperability (dedicated interface)

In this paper we focus on information interoperability that is achieved by the *automated exchange and interpretation of structured information* between systems. With minimum user intervention, C2 systems and simulation systems must be able to *automatically* interchange certain information and utilise that for further processing. This means that information must be *structured*, because this enables functionality such as distribution by subscription on certain topics and presentation of information and filtering by specific selection criteria. The emphasis here lies on the exchange of *information* (rather than 'free format' data), preserving its meaning, integrity and context. Structured information is described formally by a *'Datamodel'*. The datamodel thus represents the foundation for information interoperability. In the most common case where many systems have to exchange information, standardisation of a common 'interface' is a key factor to achieve information interoperability. Otherwise, dedicated interfaces are needed between every pair of interconnected systems leading to an exponential growth of the number of interfaces required (Figure 1).

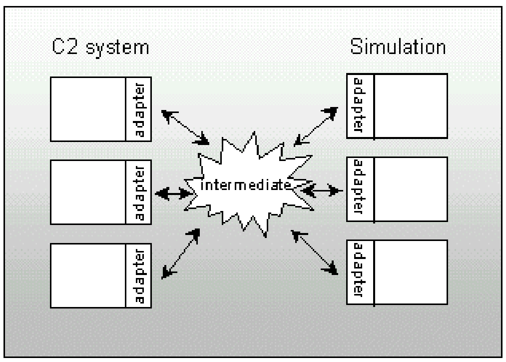

Figure 2 C2 and Simulation Interoperability (standard interface)

Preferably the exchange should not depend on products with proprietary interfaces, but rather use open standards and tools. The key notion for information interoperability is *standardisation*. By having common agreements on which information is exchanged, in what format, and under what conditions (business rules), it becomes easier to allow systems of different types to interoperate (Figure 2).

THE C2 FRAMEWORK FAMILY

The RNLA is developing a generic, configurable and distributed Command and Control information system in an evolutionary process. This system, known as C2 Framework (C2FW), is the baseline for a suite of C2 applications that will provide staff sections, vehicles and individual combatants with a common operational picture (RNLA C2 Support Centre, 2000). The C2FW is a configurable *application platform* and information system that provides generic functionality to support the C2 process. The C2FW supports the users in building and maintaining a COP that provides adequate Situational Awareness. The C2FW is developed by the RNLA C2 Support Centre in Ede. The system architecture of the C2FW (Figure 3) comprises four layers: presentation services, business services, data services and communication services. Note the commonality of the C2FW architecture with the architectural layers of a typical simulation system. The SimStation concept intends to promote the full alignment of the two domains.

The **presentation services layer** is responsible for gathering information from the user and presenting information to the user using the services of the business services layer.

The **business services layer** provides services to access and update business objects and contexts. Role based access controls determine which user is allowed to view or change what business object.

The **data services layer** is responsible for caching, storage, retrieval, maintenance and integrity of data using the C2 business rules, schema and datamodel.

The **communication services layer** provides automated and manual synchronisation and distribution of data over C2 networks using publish and subscribe techniques and an information exchange language.

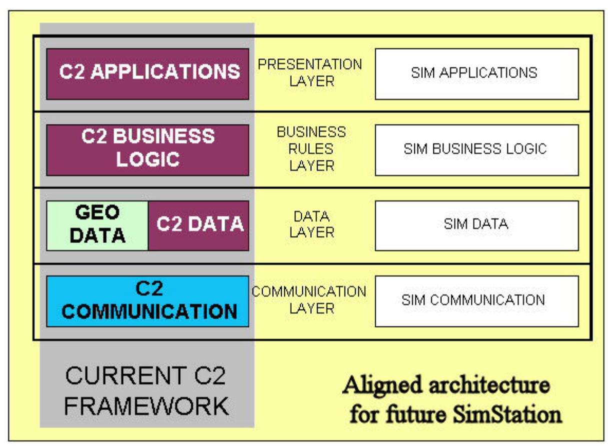

Figure 3 The C2FW Architecture in relation to the architecture of a typical Simulation and the alignment of the two under the SimStation concept

The presented C2 Framework is the foundation for a family of C2 Information Systems that is being developed (Figure 4). The Integrated Staff Information System (ISIS) is aimed at the static domain (compound, command post). ISIS is developed and used as main C2 application for delivering a COP throughout the mission. OSIRIS, currently under development, delivers a COP for the mobile domain (command vehicles, tanks e.g.) using compact, robust touch screen platforms. XANTHOS, also currently under development, delivers COP for dismounted commanders and soldiers using platforms like the Commander Digital Assistant (CDA) and Soldier Digital Assistant (SDA). The CDA is a PDA-like device, while the SDA is intended for a helmet mounted ocular.

Future C2 development will diminish the programmatic borders between these separate information systems, using declarative configurations, schema based, abstract object- and data models, resulting in maximum flexibility, scalability and robustness of the C2 Framework and supported C2 information systems. New generation C2 software is based on specialized, uniform and autonomous components working together using uniform and extensible structures.

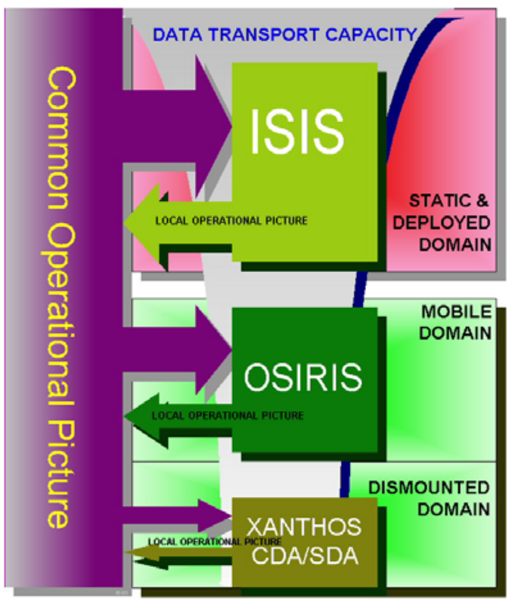

Figure 4 C2FW system. Consistent C2 functionality is made available in each domain on most appropriate platform

These developments simplify component-based expansion of the C2 framework, including for instance components exposing rich featured training functionality and the easy availability of C2 data that is needed for training, monitoring, analysis and after action review.

A FAMILY OF SIMULATION SYSTEMS

Military missions are becoming more complex given the wide range of contemporary assignments. As a result, the need for advanced defence systems and the call for more flexible and better trained personnel are also much stronger. That places increasingly tough requirements on the processes of acquisition, training, mission preparation (Figure 5), and operational analysis. The extensive use of simulation helps tackling these problems across all phases of a system's life-cycle.

The Royal Netherlands Armed Forces Simulation Expertise Centre (SEC) supports and directs the concept of creating a 'family' of simulation assets that is available to the Armed Forces. This family of simulations is realised by applying SEC guidelines and principles to new developments and in acquisitions of new systems. The guidelines and architectural principles are continuously maintained and updated based on the Defence Corporate Architecture, Defence Policy Directions, research and lessons-learned.
Standardisation is of the utmost importance and that is why the national policies and guidelines are always based on open standards like the High Level Architecture (HLA) and follow relevant recommendations out of NATO working groups (e.g. NATO Modelling and Simulation Group).

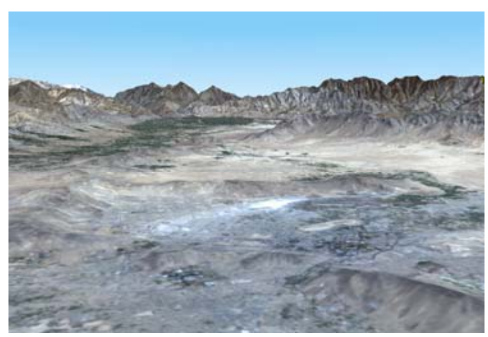

Figure 5 - 3D Visualisation of Kabul area for Mission Preparation purposes

The EBF 'Simulation Testbed'

TNO Defence, Security and Safety supports the Dutch MoD by developing and enhancing a distributed simulation infrastructure, the *Electronic Battlespace Facility (EBF)*, to provide simulation services for research, development, engineering, and training purposes. The EBF serves as testbed for new concepts, guidelines and standards that help to achieve more flexibility and reuse of our national family of simulation assets. The objective of the family concept is that simulators can be developed, maintained or upgraded faster and at lower cost by reuse of already existing simulator components. For example, instructor tools should be generic and suitable for multiple training systems. Reuse implies using clear interface descriptions of commonly used systems-of-systems that are loosely connected and tightly bounded in functionality.

HLA, the accepted international standard for reuse and interoperation of simulations (DMSO), is based on the very premise that no single simulation can satisfy the requirements of all uses and users. The intent of HLA is to provide a structure that will support reuse of simulation components and ultimately reduce the cost and time required to create a synthetic environment. The HLA standard forms the backbone for the EBF and our family of simulations.

The HLA standard uses a federation specific datamodel, known as Federation Object Model (FOM), to specify which data is exchanged within the federation. A commonly used FOM within the international HLA community is the “Real-time Platform Reference” FOM (RPR-FOM).

The ‘CaSTor’ Family Member

The RNLA’s Command and Staff Trainer ‘CaSTor’ is a detailed constructive combat simulation model that takes into account manoeuvre, fire support, combat engineering, air defence, air support, combat service support operations and amphibious operations. The model is capable of simulating ground operations at battalion, brigade and division levels. CaSTor can represent entities on a platform (e.g. vehicle) and aggregate (e.g. platoon, company) level. CaSTor will be used by the RNLA as the new exercise driver for Command Post Exercises (CPX). CaSTor and its predecessor KIBOWI have been developed by TNO. KIBOWI has been used by the RNLA for many years and is also in use by Belgian brigades and the Bulgarian army. Primary training audiences are typically staffs at battalion, brigade, and division level.

Obviously, staff training includes the use of ISIS, the RNLA operational C2 tool. ISIS will provide the COP and ultimately transform into an integrated C2 environment for planning and real-time control. CaSTor is an HLA compliant simulation that uses TNO’s HLA middleware to link into a federation. The CaSTor FOM is based on the RPR-FOM with a number of extensions. These extensions include support for ‘Order of Battle’ (Orbat) management and logging of ‘chat’ traffic between ISIS operators.

The ‘TACTIS’ Family Member

The Tactical Indoor Training System (TACTIS) will be a next generation tactical training environment for the RNLA, aiming at multiple training objectives: individual functions, system operations, weapons operations team building, and tactical team building.

The TACTIS system is currently under contract by Thales Training & Simulation for delivery to the RNLA in 2008. TACTIS is a distributed simulation system that consists of manned mock-ups, computer generated forces and scenario support tools (loggers, viewers etc). TACTIS simulations and tools can be quickly prepared and configured to support varying training sessions which include tanks, armoured vehicles, reconnaissance vehicles and other systems. The TACTIS architecture is based on HLA and its datamodel is derived from the RPR-FOM with a number of modifications for amongst others exercise control.

The planned introduction of Battle Management System (BMS) in the RNLA’s operational environment, and thus in TACTIS, serves multiple purposes. BMS provides a higher situational awareness for trainees. Without BMS, orientation in a hatch down vehicle is not easy. In a virtual environment this is even more difficult, due to limited depth cues and limited details in the virtual environment. BMS will also serve as the platform for the Advanced Fire Support Information System (AFSIS), the RNLA’s new fire support system. In TACTIS, the ‘Forward Observer’ trainee receives visual information from the simulation environment, interprets the information and decides to call for fire support if required. The call will be submitted through the AFSIS planning and control tool. AFSIS will process the call either automatically or with additional input from role players and submit a fire command to TACTIS. The simulation will generate artillery fire and compute its effects on enemy forces, which are then monitored by the forward observer.

’BRIDGING THE GAP’ BY EXAMPLES

Previous attempts to couple C2 systems with simulations were often *ad hoc* and resulted in tailor-made connections for every specific combination of C2 systems and simulation models (Figure 1). This approach required many new connections when either a C2 systems or a simulation model was added. A more flexible approach is the use of an intermediate layer as shown in Figure 2. Once a new system or simulation has a (tailor made) adapter for the intermediate layer, the system can be connected to all other systems or simulations without any additional work on the other players. The next paragraphs describe two experiments that TNO performed on C2-Simulation interoperability. These served as research projects to gain experience with the problem area and test different approaches.

ISIS-CaSTor demonstrator

As a first demonstration of interoperability between C2 systems and simulations, the CaSTor simulation system was coupled with ISIS (Huiskamp, Kwaijtaal, Fiebelkorn, 2003). The demonstration intended to provide situational awareness for trainees through the use of their operational ISIS tools. CaSTor drives the scenario in the ISIS - CaSTor federation. The operational context simulated by CaSTor consists of formations of own and hostile ground forces. These units provide a dynamic and representative environment for the ISIS operations. During a scenario run, each CaSTor unit executes a predefined list of orders. This largely eliminates the need for role-player interaction during execution and ensures repeatability of the scenario.

The approach that was followed to achieve C2-simulation interoperability resembles the 'intermediate layer' solution, but with an important difference: both the C2 systems and the simulation systems already support interoperability within their own domain. ISIS uses the ‘C3I Framework’ middleware. The simulation systems use the HLA interoperability standard. A 'C2FW-HLA gateway' was developed to connect the C2 world on one side to HLA on the other side (see Figure 6).

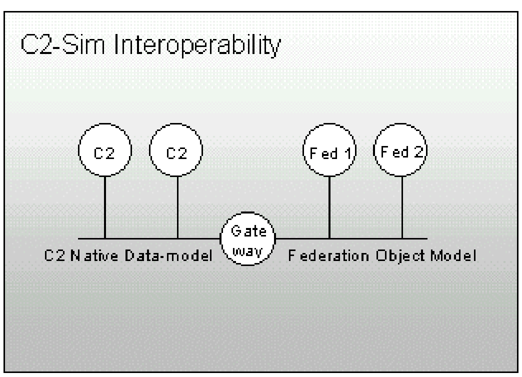

Figure 6 C2 - Simulation Interoperability

In addition to interoperability at the technical level (protocols, networks etc), we first need to develop the information interoperability for the gateway which aligns the Datamodels and provides a two-way mapping for all relevant attributes. The C2FW Datamodel describes four generic objects:

- Weather,
- Stationary,
- StationaryMultiLocation and
- Mobile

The information that is exchanged via the CaSTor FOM includes the position of the object and depending on the object information, such as status, speed and detection. Given the different development history of the C2FW and the RPR-FOM it is often impossible to directly map the information exchanged between C2 systems onto the FOM.

In most cases it is necessary to combine information fields from the C2 system in order to get it mapped onto the FOM and vice versa. For example, the following fields were identified for a unit message that need adaptation before they can be mapped on either the FOM or on the C2 information.

Table 1 Data mapping fields (not exhaustive)

FOM	C2WS
ObjName	Name
PartyNumber	Nationality
Velocity	SpeedQty
Position	Position
Front	BearingAngle

Specific conversions and layout issues had to be resolved and implemented to realise any coupling between the two domains: A name in the FOM needed to be restricted to 10 characters, the FOM only identified four different parties while the C2FW allows many more different sides, and the location of a unit in the UTM system of the C2FW needed to be translated into the relative map co-ordinates used by the FOM.

BMS-TACTIS demonstrator

The BMS-TACTIS demonstration target was to achieve interoperability between a prototype of the operational BMS system and a prototype of TACTIS as provided by TNO’s EBF (Huiskamp, Gouweleeuw, Coetsier, 2003). The objectives of the experiments were:

- Demonstrate the potential of BMS for training simulators as Situational Awareness support tool.
- Investigate the requirements for C2 systems as training support tools (e.g. monitoring and control by instructors).
- Evaluate the operational value of BMS before purchase or even before full development.

The BMS-"Tactical Team training" Federation consists of the following Federates:

- Leopard 2A5 Main Battle Tank simulators;
- YPR-PRI (Dutch Armoured Infantry Fighting Vehicles) simulators;
- Computer Generated Forces (ModSAF);
- Several scenario management applications to monitor and control the exercise e.g.:
  - Stealth Federate, a 3D viewer into the virtual environment;
  - Communication tool to visualise the tactical radio communication;
  - Training Objective tool to monitor the trainees behaviour based on training objectives;
  - Datalogger;
- DIS-BMS converter.

This federation was used during an exercise for aspirant company (team) commanders. Three platoon commanders manned a single Leopard MBT and two YPR-PRI vehicles. A team commander operated from a second Leopard MBT. All other platoon vehicles, flanking units, fire support, engineering support and opposing forces are computer generated.

Figure 7 Exercise Briefing in EBF

Manned simulators generate a simulated GPS signal to insert their own position into the BMS (automatic 'blue force tracking').

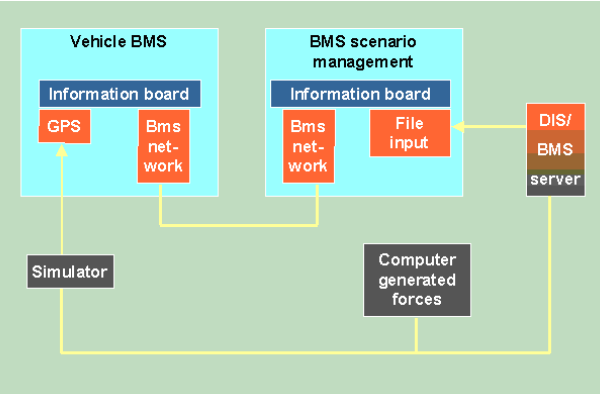

Figure 8 BMS-TACTIS Information transfer

A gateway was developed to automatically feed BMS with data on Computer Generated Forces (CGF) blue forces. This gateway reads entity data of the own forces from the simulation network and inserts this into a dedicated BMS system with the right attributes (position, speed etc). This dedicated BMS system updates the other BMS systems through the BMS network at a rate of once per second.

Computer generated forces of the opposing forces were not inserted automatically. These need to be provided manually by the trainees (based on observations) or are inserted at the discretion of the training staff (Intell role player).

Demonstrator conclusions

The results and findings of the C2-simulation demonstrators are both in the technical and user requirements area.

The prototype demonstrator for the ISIS-CaSTor federation is capable of constructing a COP in ISIS based on data from the CaSTor simulation ('simulation => C2' traffic). The gateway handled a limited set of units and other C2 items, which shall be extended for the future CaSTor. Data transfer between the C2 system and the simulation ('C2 => simulation' traffic) currently consists mainly of scenario preparation related data (e.g. entities and Orbat). What is still missing in the C2 environment is the capability to prepare and input scenarios (orders) for the simulation without using any dedicated simulation control station. In fact, this problem reflects the limitations in the current operational C2 systems to prepare mission plans and submit orders to real units!
The desire to control the information flow between simulation and the C2 environment resulted in additional filtering options for the Gateway. This includes filtering on sides and object types, thus

allowing us to 'model' the peer C2 elements that the Gateway represents.

One of the operational lessons learned was that the trainees had to be aware of the fact that not all information that is displayed on the BMS has the same timestamp. For example, the position of the own vehicle (originating from the vehicle's GPS) was updated more frequently than the positions of other vehicles (transferred over the tactical data-voice radio). Especially during high speed movements, the 'own vehicle' seems to 'lead' the other vehicles of the platoon, while in fact all vehicles were close together. The evaluation concluded that BMS is an important addition to the sensors of a commander, but that it does not render all other means of observation redundant.
Secondly, the commanders in the vehicles knew exactly where they were and where their team members were, thus freeing time to focus on higher level tactical training goals.

The requirement to feed C2 systems with information from mixed sources (manned and computer generated entities) needs to be supported in the gateway. In addition, some changes may be required to the C2FW to support communication and propagation effects in the simulated environment.

THE SIMSTATION CONCEPT

Simulation interoperability is based on exchanging 'ground truth' data, while C2 data consists to a large extent of 'perceived truth' data. A human operator will use his sensors and intellect to translate the 'real world' or 'ground truth' that is presented to him into his 'perceived truth'. Different operators may have a different 'perceived truth' that (ideally) will be merged into a COP somewhere in the C2 process. However, even a 'Common' Operational Picture is still a 'perceived truth'. Obviously, the human operator and his sensors and observation process could also be modelled in a simulation. Simulations will continue to require the exchange of 'ground truth' data with other simulations to be able to operate correctly in a distributed way. However, simulation models should be extended to also expose their 'perceived truth' which is required for true interoperability with the C2 domain. Note that 'orders' also reside in the 'perceived truth' world. On the logical level, ground truth and perceived truth should never be mixed, on the implementation level they may be exchanged on the same information bus (Figure 9).

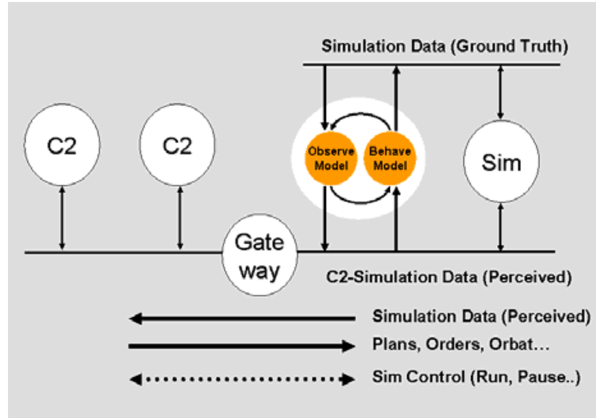

Figure 9 Interoperability of 'Perceived Truth'

The experiments described above show that both the C2 domain and simulation domain have developed widely used and accepted domain specific interoperability standards that can not be ignored. Standards like HLA meet certain requirements that are simulation specific (e.g. time-management). A complete merger of C2 and simulation datamodels (let alone interoperability protocols) is not likely to occur, nor is it realistic to expect international acceptance in the foreseeable future. The most flexible and realistic solution is to work towards alignment of datamodels and use a gateway architecture that maps between any remaining differences in datamodels and bridges the different interoperability standards. Obviously, both the C2 and the simulation architecture and datamodels need to be extended to support missing features that can bring the two domains together.

The standardisation efforts on the simulation side include the concept of a family of reusable HLA federates that use a common datamodel. The datamodel should cover all the necessary information on entity state (ground truth) and in addition also have support for C2 (e.g. perceived truth, Orbat management, COA/scenario planning) and exercise control.
Simulations need to support an interface for receiving 'orders' and mission plans or scenarios. This interface may be an extended version of the current HLA simulation data interface or could use a future Coalition Battle Management Language (C-BML) type interface for the C2 specific data. The support of external interfaces on simulations for submitting plans and orders allows not only a straightforward integration of C2 and simulation for decision support purposes, but also enables the use of the C2FW as a generic instructor station in a training environment.

Future C2 systems need new services to allow interfacing to simulation systems. The C2 system architecture needs to support different levels of C2 (e.g. staff, vehicle, combatant). In addition, the C2 system should be extended from a COP based system to a system that includes (interactive) planning features and direct control of subordinate units. Mission plans will initially be submitted to a simulation for analysis and/or rehearsal, but should then be seamlessly transferred to the real units as the current set of orders.
Simulations need to include features that allow full control through externally connected C2 systems, rather than (or in addition to) native integrated GUIs. The process of submitting a plan to the simulator, running it, observing the results, rewind, fast-forward etc should be possible from a dedicated window on the C2 system rather than through separate simulator GUIs.
Several other areas for standardisation exist in addition to interoperability of scenario data and runtime data on entities. The most important one is terrain data. C2 systems require digital maps with feature information. That same type of data is also needed for simulations, both to generate out-the-window visuals for man-in-the-loop training systems as well as for models supporting analysis or planning. Currently, several standardisation efforts exist for environmental databases. In recent years many tools have been developed to generate environmental databases from geographic information. These developments need to continue to enable faster and more reliable generation of environmental databases that are correlated for both C2 and Simulation. Where possible, C2 and Simulation systems should fully align their environmental database formats and thus avoid correlation issues.

CONCLUSION

Future C2 systems will become the information exchange hub for our future commanders who will be operating in a fully networked environment. Multiple information streams will be merged in the distributed and layered C2 system. These systems will allow commanders not only to observe the current operation (COP), but also to get a deeper understanding (situational awareness) by observing how the operation has developed into the current situation and predict how it will continue to develop in the near future (planning). Obviously, the C2 system will also be used as the control station from which lower echelons are commanded and higher echelons are informed of progress and recommendations.

The end-state should be that the command staff will receive training on the same C2 system as they use in operations by replacing the real world with a simulation. At the same time, the staff will be able to use simulation to improve the operational process through planning, decision support and mission rehearsal.

Based on this operational concept, future C2 systems will meet the requirement for interoperability with simulations. Alignment of C2 and simulation architectures and the development of suitable standards will allow effective interoperability between best-of-breed C2 and simulation applications. The results of our ongoing 'SimStation' study will influence the development direction of the C2FW and the national family of simulation systems. The C2FW is already on its way to become a useful and exciting new C2 system, which is reaching out to the HLA simulation standard. The SimStation concept is the architectural approach to enable C2-simulation operability for our future systems. The requirements for the design of the C2-simulation interoperability architecture are: flexibility, scalability, robustness and compliance to international standards. The SimStation study is currently working on the completion of the requirements definition, the initial design concept and the development of an implementation plan. The results are expected in the spring of 2007 and will be the baseline for future work.

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