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Paper for ITEC 2017 Presentation

Dear Mrs Taranova,

Please find attached the requested paper for my Presentation “Airforce MTDS Across Borders: Goals, Challenges and Achievements”. I hope that the fact that I took almost the maximum size of pages for my paper does not matter too much.

Thank you and best regards

Sönke Pink

Airforce MTDS Across Borders: Goals, Challenges and Achievements

The focus of this paper is to point out the possibilities and benefits but also challenges of military training with networked simulators in a multinational context.
In the introduction other important areas of networking within the training community will be touched.
The main part starts with the explanation for the improved usage of simulators and simulation in the military training and how this training "naturally" evolves towards networking. The paper then explains the work done during the NATO Modelling and Simulation Group (NMSG) 128. The focus of explanations will be put on the network infrastructure via the Combined Force Battle Lab Network (CFBL Net) and the two most important training areas Communication and Electronic Warfare.
The paper will finish with an overall evaluation of the performed work and an outlook for the near future.

Other networking areas

Prior to starting the explanation of the content of this paper in detail, three other important areas of training with simulation shall be covered as the title "networking across borders" could cover those areas as well.
The first area to consider here is the so called "Live-Virtual-Constructive" or just LVC training. This concept aims towards the combination of simulators (virtual asset) and computer generated forces or CGF (constructive asset) with live assets in a common training environment. LVC has become a major point of interest in the training community and would definitely require "networking across borders", namely the borders between simulation and live training. But this paper will limit its focus to the virtual and constructive parts of LVC as it was decided early on to omit the involvement of live assets at this point of time. The main reason behind this is that a well developed and proven environment for networking simulators and CGF tools is considered a mandatory prerequisite to involve live assets at a later stage. Live assets which support a "simulation mode" are considered as a virtual asset in this regard since the data interface to such an asset would be the same as to any "native" simulator.
The second area of consideration has to be performed on the types of simulators which are considered for networked training. The technical possibilities of today tend to cloud the question of "what should be done" to a more "what can be done" viewpoint. Thus the consideration of the area of "to be networked" simulators must not be started from a technical viewpoint but has to focus on the training goals. The main point of interest of the work explained in this paper was the networking of air force simulators to further enhance the training of pilots and pilot controllers. Thus the "to be considered" simulators were limited to "air force related" simulators. Networking with simulators e.g. from Army or Navy to perform a joined mission would only be considered once the "air force only" training has reached its internal goals and additional capacities are available. In addition to the limitation to the area of simulators the focus of the simulators was also considered. As the training focus was primarily aimed at pilots and operators, the types of simulators were limited to "operational" or "tactical" ones. These types of simulators are built for the training of the operator (or operators) of a single weapon system. An involvement of "strategic" simulators which are aimed at representing a command post and used to train the chain of command instead of the operation of a single weapon system was disregarded in the context covered within this paper. The reason for this is mainly the different "time line" of tactical and strategic simulators. Tactical simulators are focussed on real time and a typical training mission would be build around a specific mission task seldom exceeding a two hour time frame. Strategic simulators on the other hand are more aimed around the long term development of a large scale employment and are often simulated in "decision jumps" which cover multiple days.
And the third area touches the training across security borders. Not all simulators considered for networked training have by default the same security classifications. The differences can range from common security level classifications like NATO RESTRICTED and NATO SECRET to national ones which usually also contain "eyes only" classifications. Security regulations usually allow the provision from lower ranking systems to higher ranking ones but not the other way around. Such a "one way"

communication usually prohibits a reasonable training. Technical solutions are already available which allow the flagging of data coming from a device in a networked training down to single attributes. Such flagged data can then be blocked if the receiving device is below a certain classification level instead of blocking the complete data traffic. This type of networking between simulators on different security levels was not considered in this line of work. All participating simulators had to have a common security level classification.

Background for networked training

After the excurse to explain the “left and right border” of the paper content, the background for the work of networking simulators shall be explained.
Simulation is a still growing area within the military training. The reasons for this are manifold as the following list shows:

- Cost savings are important in light of optimal utilization of defence budgets. Utilizing a simulator instead of a live asset saves on consumables like fuel and personnel like maintainers.
- Live training is often limited due to various regulations like environment protection, noise reduction or the simple unavailability of training areas. Especially weapon deployment puts high hurdles in this regard.
- Simulators allow the training of emergency situations without actually putting the trainee in danger.
- Engagement of military forces all over the world demands training “in the target environment” for optimal preparation prior to the actual deployment.
- Professional trainers are a limited resource as well and require an optimal environment to teach the trainees and evaluate their performances.

All these areas demand for the utilization of simulators. Military training which can profit very much from utilization of simulation lies in the operation of a “weapon system” like an tank or artillery unit, the radar system or weapon on a ship or the operation of a complete military aircraft. Considering the demands and costs for a single trainee the training of fighter pilots ranges on the top of the training branches which should (and already do) make intensive use of simulation in the training schedule. Modern weapon platforms get ever more sophisticated and require highly specialized training plans. But in order to avoid negative training the simulations have to be very close to “the real thing”. The first part of this demand is usually achieved by providing the trainee an accurate physical representation of the weapon system. This can range from a one to one replica of the vehicle (some modern weapon systems even allow the usage of the live asset in a simulation mode like mentioned in the introduction) to pure mock-ups which give only a generic representation of the system. But regardless of the hardware representation of the asset the software behind it must present the Human Interface as close as possible in order to achieve reasonable training. Displays for example must show the same content as in the live system in order to train the operator in their usage. A sophisticated representation of the “Ownship” already allows for the utilization of simulation for many training tasks.

Natural evolvement of training towards networking

The first area of training which is usually aimed at the familiarization of the trainee with his weapon system “only” requires a simulation of his own weapon system. These representations can start with pure part task trainers for “clicking the right buttons” to full system representations which then also give the trainee the correct dimensions of his future working environment.
As the training progresses it will naturally shift from the training how to operate the Ownship towards how and when to use it during a certain mission task. This form of training shall teach the operator on how to interact with the natural and tactical environment during the execution a mission. This is the

point when the focus of the training moves from the pure fidelity of the Ownship simulation towards networking the simulator with other training participants.
During the first phase of this advanced training the task of representing the environment usually remains with the training instructor who also guided the trainee through his initial training on the simulator. The instructor generates CGFs (constructive assets) within a specific training scenario through a synthetic environment (SE) simulation and controls them during the training execution via an Instructor/Operator Station (IOS). During this execution of the training scenario the instructor gives his CGFs (enemy, friendly and neutral forces) orders to stimulate the Ownship and usually also directly interacts with the trainee via simulated communication lines like Radio or Tactical Data Link. While instructors are usually very well versed in the optimal utilization of their IOS and SE and also have clear training schedules on how to stimulate the trainee they can only “play” the other participants within the scenario up to their own experience and the fidelity of IOS and SE. Also the SE and IOS and even the simulated communication lines would still be considered part as the local simulation especially if they have been specifically tailored to the local Ownship.
The next step of further enhancing the training is thus the networking of multiple manned simulator assets to train real live interactions with other future battlefield participants. An interim step towards this goal is usually the networking of multiple simulators (and their instructors) of the same type in order to train e.g. two or four ship engagements. The provision of manned wing men allows for a much better training of tactics and interactions regarding expected real live operations. Having multiple instructors supporting such a mission also allows for a better control of the CGFs as tasks can be specifically assigned to single instructors. Nonetheless this type of networking would still not really “across borders” because it is still within the well known environment of simulators created by one supplier and operated by the same type of personnel.
The ultimate goal of networked training should always be the networking of different kinds of simulators based on agreed standards in order to allow them a simulated environment for how they would interact in real life. This is the “networking across borders” which will be described within this paper.

Networked Training within NMSG 128

After the lengthy introduction on the reasons why the training community wants to perform the networked training the benefits and challenges on such a task will be further elaborated on the experiences made during the NMSG 128 which was established in 2014 and shall finish at the end of 2017. In this multinational community the statement “networking across borders” got an even more obvious aspect as the partners within Europe and Canada networked not only their different kind of simulators but did that across their country borders within the CFBL Net. During the NMSG128 the approach to networking simulators was also not limited to the “can” or “shall” viewpoint. Actually the demand was that national simulators “must” be networked in the future to guarantee that especially operational air C2 units like AWACS and Military Air Traffic Controller operators can keep their quality of training. The reason for this is that certain training tasks require interaction with other live participants in order to be qualified as “ready for operation”. Usually these interactions would be trained in live flying exercises but due to the reduced live flying hours of many military units the available training time is no longer sufficient to support a dedicated CRC or C2 training.
As the main focus of interaction between the operational C2 and CRC with pilots is communication (Radio and Tactical Data Link) and does not require actual physical interaction, a potential utilization of simulators for a combined training is obvious. Technology and standards for networking simulators also continuously improve. E.g. the advances of HLA Evolved within available COTS tools and the improvement of the RPR FOM and the SISO DIS Enumerations allow for better networking of simulators. At the same time many NATO countries improve their access to the CFBL Net from existing training facilities and thus create the physical prerequisites for networking simulators.
The feasibility to perform such a networked training and the benefits of it has already been proven in many studies and evaluations. Thus the aim of the NMSG128 was not to provide another paper which purely states why the networking of simulators should be nationally and internationally advanced but to take the first steps towards a permanent establishment of a training community between NATO

partners. In the time between 2014 and 2017 5 exercises were performed between the participants of the group in addition to several conferences where experiences were discussed and the results of the NMSG were combined into results. The exercises were always accompanied by additional test periods because it became clear early on that the networking of the different kind of national legacy simulators would not be a “plug and play” task. These tests will partially have to be performed prior to every future exercise in order to verify functionalities and especially every time a new simulator is inserted into the training network.
Some of the to be utilized simulators were using the legacy DIS wire standard for transferring simulation data and even lacked mandatory functionalities for the networked training like simulated radios or TDL interfaces. As proposed within the results of the NIAG study 183 to which the NMSG 128 is considered a “Follow On” it was the ultimate goal to utilize a HLA networking instead of DIS for future networking exercises. During the first exercises a mixed DIS and HLA setup had to be implemented but during the advances of the exercises all participants were gradually able to utilize HLA connections for the simulation data as their “entry points” to the exercises. Also all simulators were gradually enhanced to provide the necessary means for Radio and TDL communication trough the introduction of COTS tools and the enhancement of functionalities.

CFBL Network: The physical connection

The first element which has to be established prior to conducting a networked exercise would always be the basic availability of the underlying network infrastructure. Permanent physical connections to the CFBL Net for the simulators within the training units can be established over the national military networks via NATO SECRET lines encrypted with Hardware Encryptors like SINA Boxes. The different lines within a nation are joined at the nations Point of Presence (PoP). From the nations PoPs the CFBL Network Operations Centre (NOC) takes over and provides the overall network functionalities. The CFBL Network can then be requested for the execution of networked simulator training via a so called CIIP. Within this document the users can request a certain bandwidth of the available network and also ask for the provision of additional network services. During the different exercises of the NMSG 128 the usage of the available services has improved to a level which provides a very well developed environment to support the training with simulators. Initially limited to a teleconference via VoIP phones in the very first exercise the last exercises have been briefed and debriefed with a video conference. Also the utilization of the CFBL Net chat service in order to provide the means to enhance the pure spoken communication via the VoIP phones was identified as very beneficial. And finally the common usage of a CFBL Net NTP service by all participants to guarantee a common time base and avoid timing errors between the simulators was identified as mandatory.

The main benefit: Exchange communication data

As mentioned before the available communication (spoken voice and tactical data links) between the different manned players is initially the most important improvement of networked training compared to stand alone utilization of a simulator. Thus this area was the primary focus of work during the NMSG 128. The implementation of COTS Radio Tools to allow simulated Radio communication was already performed during the first exercise for simulators who were lacking this functionality.
Even though the focus was on establishing a HLA Federation to exchange the simulation data, radio communication was initially kept to the DIS standard and TDL data had to be exchanged via different standards. The reason to keep Radio data within the DIS standard usually derives from two facts. The first one is that Radio data can only take little benefit from the translation from DIS to HLA. One of the main benefits to change from DIS to HLA is that the permanently exchanged data between networked participants can be reduced through the data distribution management of HLA. Participants subscribe to attributes and objects and only receive updates from the publishers if values change. This is extremely helpful for e.g. entities which would only update their spatial attributes (position, angles and speed) and not e.g. their appearance or name. The main content of Radio data, the encoded voice, is not exchanged via attributes in HLA objects but via parameters of HLA interactions. And HLA interac-

tions cannot be “split up” the same way as objects can be as they are not established permanently within the federation but are only “one time” events. Radio data must thus be seen as a “one to one” data translation and the potential savings on permanently exchanged data packets is limited to their transmitter objects and thus almost null.
Nonetheless successful tests during the last NMSG 128 exercise have proven the possibility of incorporating the Radio data into the HLA stream. The incorporation was possible once the utilized COTS DIS-HLA Gateways had been enhanced to better support this translation. But instabilities of the network connections forced the participants to revert back to DIS traffic for Radio data as DIS connections are not affected by short network disconnects. Unlike a HLA federation DIS data streams do not require a permanent network connection.
The situation for TDL data in a training environment of networked simulators is somewhat more complicated as its standard is not as clearly defined as the one for a simulated radio. While there are “placeholders” within DIS and HLA to exchange TDL information via these standards (initially as radio binary signals but now also as native TDL interactions in HLA based on the SISO-J FOM enhancement) their utilization is not yet “standardized”. One of the reasons for this “lack” of standardization is the existence of the SIMPLE Standard which is based on a dedicated NATO STANAG. The SIMPLE standard was specifically developed to allow the combination of live TDL systems with simulated ones. It was thus a form LVC environment for TDL which evolved in parallel to the networking of simulators via DIS or HLA and as such has been implemented as the TDL interface in several legacy simulators. Until a common format for TDL has been officially agreed within the evolving networking community a support of multiple standards for TDL data within a common exercise must be expected. Luckily current tools which simulate the central hubs of a live TDL network already support multiple TDL interfaces at the same time and thus can act as gateways between assets utilizing different standards.

The main challenge: electronic warfare data

The area which poses the greatest challenge and thus requires dedicated evaluation in networking especially of fighter jet simulators is the electronic warfare or EW. This area encompasses the electromagnetic detection of other entities with sensors (mainly radar systems but also optical sensors like Infra-Red Search and Track (IRST)) and the defence against being detected by their sensors. The Identification Friend Foe (IFF) is also part of this area due to its classification as a sensor and its typical close coupling to the radar sensors. And since sensors are not only attached to the jets themselves but also to their weapons the EW also affects all the weapon deployment and weapon effect calculations. The reason why this area requires such in depth evaluation is because all EW functionalities are based on interaction with another entity. The own sensors have to be stimulated by another entity, its sensors and countermeasures and vice versa.
The simulation of sensors and defensive aids (detecting enemy detections and utilizing counter measures against those detections) and their interaction with the tactical environment usually ranges among the most complex areas within a fighter jet simulator. Customer demands that the simulated sensor detections and the automatic or triggered reactions of defensive aids systems have to reflect the reality “as close as possible” require complex algorithms and calculations. And in those complexities lies the main danger for EW simulations in the networking across borders. As mentioned above the sensor and defensive aids calculations are dependent on inputs from the stimulating entity. As long as a simulator is only considered for Stand Alone training or at most a networking with simulators of the same type developers might be tempted (or forced) to “tweak” the sensors and weapons to work optimal regarding customer requirements and cost reductions. As long as all interactions between entities are under the authorities of the developers they can be modified for optimal support of the calculations.
But once the simulator leaves the “safe zone” of purely its own responsibility to network with other simulators all interactions have to be based on the agreed exchange standards. This affects the provision of the own data and the evaluation of the foreign data. A very vivid way to view this situation is to consider the simulators as human beings initially speaking different languages. When they agree to work together they swap to a common language with an agreed dictionary to translate from their na-

tive to the common language. Regarding the networking of simulators the common language would e.g. be the HLA Evolved Federation via a specific RTI and the dictionary the RPR FOM.
The graphical image of two people trying to work out a complex situation between them using a common language can also be taken to point towards the main problems arising in this form of communication. The first problem could be that either side might not “have learned” certain parts of the dictionary and thus would neither be able to understand the partner nor provide him the necessary information if the communication gets more complex. The second problem is that the communication does not end with the provision and acceptance of information but that each participant also has to understand how the partner would use the information. A typical statement in this regard is “truth is not what A says but what B understands”. The third issue could be that the initially greed dictionary might not even provide the means to explain e.g. a very specific technical problem between the two participants. And as multiple people have to use the dictionary it cannot just be modified between two participants but amendments have to be agreed within the whole community.
A complete evaluation of the EW in simulation and specifically in the networked simulation would exceed the context of this document. Nonetheless the problematic situation shall be explained at a simple example. Some information which is necessary for sensor calculations can be considered very generic like an entities position and entity type which can be used to calculate a “Line of Sight” and a basic detectability based on the size of an entity type. This data would be available from all sides and could be used for basic radar detections. But as soon as one of the participants would e.g. require Radar Cross Section (RCS) information due to a more sophisticated Radar simulation, problems can arise. These problems can range from “just” different results on both sides and thus an issue to “fair fight” conditions to a complete inability of one side to detect the other one if RCS data cannot be provided.
The issue of Radar Cross Sections (RCS) also hints at an area which is not yet fully covered by the simulation standards. A RCS might be considered as information the target provides in order to specify its detectability. But as the RCS is dependent on impact angle of the radar beam onto the target object its calculation must be based on the current angular orientation of both emitter and target and has to be performed on the receiving side. How RCS shall be handled in the future would require a common understanding by developers for Radar simulations and the designers of the data exchange standards.

Results and outlook

After the explanation of the work done during the NMSG 128 and the further focus on the most important areas the summary on the evaluation of networking across borders for simulators leads to the following points:
Successes:

- Establishment of permanent connections to the CFBL Network at multiple training locations,
- Provision of advanced supporting services within the CFBL-Net (VoIP, Video Conferencing, Chat and NTP),
- Improvement of the capabilities of the networking RTI to better support a distributed federation setup,
- Verification and improvement of COTS DIS to HLA Gateways in order to support a HLA Evolved Federation,
- Integration and combination of multiple COTS DIS Radio tools for simulated Radio communication in DIS and HLA,
- Verification of the capabilities of multi standard TDL tools to support a common TDL network despite using different standards,

- Improvement of the networked simulators and COTS tools to better support the common training tasks.

Remaining issues:

- Improve the robustness of the network connections in order to handle disconnects and automatic reconnects.
- Reduce bandwidth consumption by all participants through:
  - optimal planning of data provision to the federation from each simulator,
  - implementation of HLA functionalities for data reduction like data distribution management.
- Further improve the simulator capabilities and standard definitions in the complex area of electronic warfare and its affected areas like weapon engagement and Defensive Aids.

Despite the remaining issues especially regarding the stability of the network the successes have proven the readiness and the existing benefits of performing networked training across borders within the CFBL Net. Improvement of simulators and standards to support the more complex training tasks will be an evolving process once the training becomes more frequent and developers receive more detailed inputs on the actual demands.