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Towards a persistent capability for NATO MTDS

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Towards a persistent capability for NATO MTDS

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Problem area

NATO and nations face challenges regarding training and exercises. Current and future operations are multinational in nature, the missions and the systems are becoming more complex and need detailed preparation and rapid adaptation to changing circumstances is needed. At the same time opportunities for live training and mission preparation are reduced due to available resources and limited time span between political decision making and deployment. Mission Training through Distributed Simulation (MTDS) is therefore crucial to NATO and nation's mission readiness. Despite a number of initiatives in the past to set-up a NATO MTDS capability, currently NATO does not have a standing operational MTDS capability.

Description of work

In October 2013 the NATO task group MSG-128 was set up with the objective to establish essential elements for a permanent NATO MTDS capability for air operations and validate these elements through initial operational test and evaluation. The approach of MSG128 is two-fold:

1. Define a reference architecture and concept of operations for a permanent MTDS architecture for air operations
2. Build the MTDS environment incrementally by organizing a yearly MTDS exercise

To achieve these two objectives the task group created three teams:

1. Operational – developing the concept of operations
2. Technical – defining the MTDS reference architecture and establishing standards and agreements for the technical framework
3. Implementation – developing an initial persistent MTDS capability with existing simulation assets and organizing a yearly exercise

The MSG-128 has performed a number of exercises and in this way established an initial MTDS capability with minimal changes to existing systems.

Results and conclusions

Currently seven sites are connected to the MTDS architecture that comprise an AWACS mission simulator, several fighter aircraft simulators, a Control and Reporting Centre (CRC), an Air Command and Control System (ACCS), and a simulation control centre. The architecture is based on a High Level Architecture (HLA) backbone, and uses the Combined Federated Battle Laboratories Network (CFBLNet) as a secure network infrastructure. A federation agreement document (FAD) has been created that defines and records agreements about the federation architecture, data exchange models, enumerations, communications, startup and shutdown procedures, damage models and the synthetic natural environment. A basic test plan has been developed that includes basic connectivity testing between sites and testing the simulation assets compliance with the agreements described in the FAD.

Applicability

The first test and example exercises have shown the benefit of MTDS to coalition pilots. It is important that compared to previous networking studies which have been limited to temporary networks, the MTDS infrastructure must remain a permanent capability which can be utilized on “short notice”. The developed FAD and the test plan are a first step to reduce the preparation phases for future exercises. The current architecture is a first step to a persistent NATO MTDS capability for air operations, and can gradually be extended with more simulation assets and functionality.

GENERAL NOTE

This report is based on a presentation held at the Simulation Innovation Workshop, Orlando, FL, USA, September 12, 2016.

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Summary

NATO (North Atlantic Treaty Organization) Airborne Warning And Control System (AWACS) and nations have a common need for training of air combined and joint collective tactical training. Due to reduced availability of live assets in the military air space, the general restrictions inside the airspace and the significant effort it takes to prepare and conduct live multinational exercises it is an agreed necessity to evaluate future options for conducting such training. Since most NATO nations already own simulators for their “general” pilot training in order to save costs, the goal is to achieve collective tactical training by networking these national simulator assets. This concept is referred to in NATO as Mission Training through Distributed Simulation (MTDS). Several NATO and national activities have been conducted in this area and some nations have national implementation programs for networking their national air force simulators. With these activities and programs, MTDS has achieved a level of maturity that makes it feasible for NATO to implement a persistent capability to support operational readiness training. A strong air warfare capability is one of the pillars of NATO’s defence while training of aircrew is a national responsibility, thus implementation of MTDS operations has to be a combined effort of NATO and the nations. Therefore in October 2013 the NATO task group MSG-128 “Incremental Implementation of NATO MTDS operations” was set up with the objective to establish essential elements for a permanent NATO MTDS capability and validate these elements through initial operational test and evaluation.

The approach of MSG-128 is two-fold: define a reference architecture and concept of operations (CONOPS) for a permanent MTDS architecture (focus on the longer term), and start building the MTDS environment incrementally by organizing a yearly MTDS exercise (focus on short term). The MSG-128 task group consists of three teams: OPS (Operational), TEK (Technical) and IMPL (Implementation). The OPS team focused on developing the CONOPS. This team mainly consists of active military operators. The TEK team focused on defining the MTDS reference architecture and establishing the standards, technologies and agreements for the technical framework. The IMPL team main tasks are to set up the yearly exercises and connecting simulation assets.

This paper outlines the MTDS architecture and describes the technical choices and federation agreements that have been made in setting up the MTDS exercises. The MTDS architecture will incrementally transition to a NATO ratified HLA 1516 ™ 2010 (HLA Evolved) based solution. In 2014 an initial technical interoperability exercise took place between the NATO AWACS simulator and German Eurofighter flight simulators. The NATO AWACS also provided the Computer Generated Forces. In 2015 a second training exercise was executed where the initial NATO AWACS/German Eurofighter setup was extended with Netherlands F-16 simulators and Canadian F-18 simulators. In 2017 a third training exercise will be held extending the MTDS environment with a Norwegian CRC (Control and Reporting Centre) and ground radar, and a French Rafale simulator. This exercise will use an HLA Backbone. The lessons learned from the exercises are fed back into the NATO MTDS reference architecture.


Canada
Duitsland
Duitsland
Nederland

Contents

Abbreviations

ACRONYM	DESCRIPTION
ACCS	Air Command and Control System
ACTAR	Air Combat Training Architecture Requirements
AI	Air Interdiction
AMSP	Allied Modelling and Simulation Publication
API	Application Programming Interface
AWACS	Airborne Warning And Control System
BOM	Base Object Model
C2	Command & Control
CAX	Computer Assisted eXercise
CFBLNet	Combined Federated Battle Laboratories Network
CMS	Collective Mission Simulation
CONOPS	Concept of Operations
CRC	Command and Reporting Centre
DCA	Defensive Counter Air
DEM	Digital Elevation Model
DIS	Distributed Interactive Simulation
DTED	Digital Terrain Elevation Data
EW	Electronic Warfare
FAD	Federation Agreement Document
FAFD	Federation Architecture and FOM Design
FEAT	Federation Engineering Agreement Template
FOM	Federation Object Model
HLA	High Level Architecture
IFF	Identification Friend or Foe
IOC	Initial Operational Capability
IT	Information Technology
JREAP	Joint Range Extension Application Protocol
M&S	Modelling & Simulation
MILS	Multiple Independent Levels of Security
MRAD	MTDS Reference Architecture Design
MS3	Modelling and Simulation Standards Subgroup
MSG	Modelling and Simulation Group
MTDS	Mission Training through Distributed Simulation
NAFAG	NATO Air Force Armaments Group
NATO	North Atlantic Treaty Organization

NETN	NATO Education and Training Network
NIAG	NATO Industry Advisory Group
NMSG	NATO Modelling and Simulation Group
NLR	Netherlands Aerospace Centre
NTP	Network Time Protocol
OCA	Offensive Counter Air
PoP	Point of Presence
QoS	Quality of Service
RIEDP	Reuse and Interoperation of Environmental Data and Processes
RPRFOM	Real-time Platform Reference Federation Object Model
RTI	Run-Time Infrastructure
SIMPLE	Standard Interface for Multiple Platform Link Evaluation
SISO	Simulation Interoperability Standards Organization
SNE	Synthetic Natural Environment
TDL	Tactical Data Link
UDP	User Datagram Protocol
VoIP	Voice over Internet Protocol
VTC	Video Tele Conferencing
WAN	Wide Area Network

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1 Background

NATO and nations face challenges regarding training and exercises: while current and future operations are multinational in nature, the missions and the systems are becoming more complex and need detailed preparation and rapid adaptation to changing circumstances. At the same time opportunities for (live) training and mission preparation are reduced due to available resources and limited time span between political decision making and deployment. NATO AWACS and nations have a common need for training of air combined and joint collective tactical training.

Simulation has become an essential tool to meet the training demands of the military forces. Improvements in technical capabilities and reduced costs have enabled more effective use of simulation tools across nations and organizations. Mission Training through Distributed Simulation (MTDS) is therefore crucial to NATO's and nation's readiness. At a time when many member nations are moving toward greater use of advanced simulation for mission training and adopting national MTDS capabilities, NATO does not currently have a collective MTDS capability to leverage these national developments. NATO has had a number of initiatives including the study SAS-013 on MTDS (2000), training demonstration exercise First WAVE (SAS-034/MSG-001, 2004) [1], the NATO SMART (2007), NATO Live, Virtual, Constructive (2010) projects, and the NIAG (NATO Industry Advisory Group) Study Group 162 on distributed simulation for air combined and joint mission training [2]. These studies have provided valuable inputs in the development of a NATO MTDS vision and concept of operations (CONOPS), however none have provided a persistent MTDS capability to support the warfighter in achieving increased Mission Readiness. In light of decreasing exercise budgets, decreasing availability of assets for live exercises and increasing difficulty in realistically simulating the complex threat environment NATO is missing a cost effective means to enhance Operational Readiness for the Forces of contributing nations to conduct future Coalition Operations.

2 MSG-128 Task Group

The NATO Modelling and Simulation Group's (NMSG) mission is to develop and exploit Modelling & Simulation (M&S) for the benefit of the Alliance and its partners. The considerations above were the motivation for the NMSG to initiate the task group MSG-128 "Incremental Implementation of NATO MTDS Operations" to establish essential elements for a persistent NATO MTDS environment and to validate these elements through initial operational test and evaluation. In October 2013 the MSG-128 started with seven NATO countries (Canada, France, Germany Netherlands, Norway, Turkey and USA), the NIAG and the NATO E-3A Component. The approach of MSG-128 is two-fold:

1. Define a reference architecture and CONOPS for a permanent MTDS architecture (focus on the longer term)
2. Start building the MTDS environment incrementally by organizing a yearly MTDS exercise (focus on short term).

To achieve these two objectives the MSG-128 task group has created three working teams: OPS (Operational), TEK (Technical) and IMPL (Implementation). The OPS team mainly consists of active military operators and its main tasks are to:

- Define training objectives
- Define operational requirements
- Develop a CONOPS for running the future MTDS Initial Operational Capability (IOC)
- Identify and document MTDS assets (especially participating assets for the initial exercises)
- Define MTDS missions and scenarios for initial exercises in the MSG-128 timeframe.

The IMPL team mainly consists of national simulation experts and technical staff from the participating simulator sites. The main tasks of the IMPL team are:

- Develop and implement the architecture for the initial exercises using existing assets and tools (quick wins)
- Conduct initial exercises (including integration testing)
- Define and implement security requirements and a secure NATO network (initial exercises are running NATO SECRET)
- Assess the initial exercises (employment of MTDS, performance and limitations of architecture of initial exercises) and document the lessons learned (e.g. regarding IT security)
- Contribute to the MTDS CONOPS by return of experience on the initial exercises and recommendations for future MTDS IOC implementation.

The TEK team consists of mainly experts and specialists in the field of distributed simulation and simulation architectures and has some overlap with the IMPL team. The focus of the TEK team is long-term and its main tasks are:

- Develop the recommended reference architecture for MTDS IOC (MSG-128 follow-on: 2017-2020) including a road map
- Conduct unclassified technical evaluations if required
- Describe a transition path from the initial exercise architecture to the recommended architecture. Contribute to initial exercises
- Recommend required standards for MTDS in liaison with the Simulation Interoperability Standards Organization (SISO) and NMSG Modelling and Simulation Standards Subgroup (MS3)
- Contribute to MTDS CONOPS with technical requirements.

Aside of these three teams there is a fourth team incorporated in the MSG-128 task group. This is the Air Combat Training Architecture Requirements (ACTAR) team. The ACTAR team originates from a NATO Air Force Armaments

Group (NAFAG) study (2011-2014) which focused on the architectural requirements derived from operational needs of the live air combat platforms to be integrated within MTDS architectures. The scope of work for the ACTAR team is:

- Identify data formats/protocols standards for the live part of MTDS exercises
- Develop architectural requirements for integration of live components (connected flying platforms) in the MTDS architecture
- Propose a live instrumentation experiment for MSG-128 follow-on (connection of live elements to a ground network).

3 MTDS Reference Architecture

The MTDS Reference Architecture Design (MRAD) is addressing the technical and procedural interoperability standards that are important in meeting the MTDS needs of the Alliance. The purpose of the MRAD is to describe to the stakeholders of the system how the system is designed. The capabilities and key characteristics of the future system are included as well as the interactions of the system users. The MRAD focuses mainly on technical interoperability issues in distributed simulation. It is not a complete guide on how to design a distributed simulation to support MTDS but will provide key architecture and design patterns, and proposed solutions. As a reference document, the MRAD is not intended to replace design and agreements documents authored to support each particular instance of federation development and use. The reference architecture is a blueprint for specific MTDS instantiations (i.e. exercises). A specific exercise will typically tailor the reference architecture as needed to meet technical or other constraints. The resulting target architecture should be as close as possible to the reference architecture. Improvements or extensions that are developed for specific target implementations should be incrementally merged into the reference architecture when these are considered sufficiently general and mature.

The MRAD will capture the results of the experiments and the evolution of the reference architecture to support implementation and operational requirements.

3.1 General approach

The NMSG has established the Modelling and Simulation Standards Subgroup (MS3) as the permanent body responsible for M&S standards. The AMSP-01 M&S Standards Profile [3] is maintained by MS3 and it is a document that contains a validated general overview of relevant and recommended NATO M&S interoperability standards. The AMSP-03 [4] is a specific profile or guideline for NATO and multinational Computer Assisted Exercises (CAX). The document recommends specific procedures and technical standards for CAX. AMSP-03 refers to existing standards, procedures etc. where applicable. These referred standards are typically included in the AMSP-01 profile.

The MSG-128 TEK team will build on these recommendations and reuse existing standards wherever possible. The team will specify and recommend MRAD standards for the general AMSP-01 profile. The technical core of the AMSP-03 standards consists of the Federation Architecture and FOM Design (FAFD) and the NATO Education and Training Network (NETN) reference FOM [5]. The MRAD will build on the NETN FAFD and extend areas that are currently not covered or recommend improvements or extensions to existing standards where needed to address the needs of the air domain. The MRAD recommendations may be considered an 'MTDS profile' in a similar way as the AMSP-03 is a CAX profile. The task group will submit the MRAD recommendations to the NMSG which will become its formal custodian.

3.2 Standards implementation policy

The NMSG is NATO's delegated tasking authority for M&S standards. Consequently, NATO is required to apply the procedures and recommended standards for distributed multinational MTDS in NATO context. Nations are encouraged to use the standards nationally or in other multi-national events. Specific MTDS standards (e.g. data models) will also be included in the NMSG M&S Standards Profile AMSP-01 [3] and will be recommended for consideration in other contexts.

In general, the AMSP-01 profile will refer to the latest version of a standard (e.g. HLA). The MRAD profile is aimed at operational use of MTDS systems in NATO and multi-national exercises and will therefore include recommendations for the use of specific standards and identify the version of these standards in a separate appendix. This could mean that MRAD in comparison with AMSP-01 refers to an earlier version of an M&S standard to address the reality of existing legacy tools. The MRAD profile will generally prefer validated/proven processes and technology, where AMSP-01 also provides recommendations regarding interoperability innovations (i.e. emerging standards).

3.3 MTDS interoperability needs

The MRAD needs are derived from the MSG-128 MTDS CONOPS document. MTDS connectivity should be flexible in the sense that nations and organizations that have access to the MTDS infrastructure will be able to perform realistic exercises (e.g. sensor and weapons behaviour, data links, radio) or experiments in different configurations using their own assets located at their base stations. In some cases all nations may want to join a specific event, in other cases, a (small) numbers of nations may use MTDS for a particular training exercise or mission preparation event. MTDS is intended to become a permanent (persistent) NATO capability. The preparation time to set up a particular event should be minimised as a result of the permanent character. The MRAD will provide interoperability services between several applications in a typical MTDS event:

- National or NATO simulators (including simulated radio and data links), possibly with hardware in the loop for training purposes.
- National or NATO Command & Control (C2) systems, mainly consisting of operationally deployed systems.
- Video Tele Conferencing (VTC) for exercise mission briefings, mission planning and after action review.
- VTC for technical briefings, technical planning and technical after action review.
- Voice over Internet Protocol (VoIP) for technical management and control (before, during and after the exercise)
- Network remote management, control and monitoring
- Network time synchronization (e.g. utilizing the Network Time Protocol – NTP).

In addition classified data storage and data exchange for planning, results, documentation etc. should be accessible from all sites.

3.4 MTDS security concepts

As in many of the national and NATO simulators classified data are used, MTDS should be able to handle NATO SECRET data. Nations or organizations that are not involved in a particular event taking place on the infrastructure should not have access to the data related to that event. As also future participation of NATO ‘Partner for Peace’ nations is foreseen, a future goal will be to support multi-level security in one shared environment. This certainly implies that adequate security measures need to be developed and validated. A multi-level security capability is envisaged as the target objective. However, this can only be achieved in a phased approach from “system-high” towards Multiple Independent Levels of Security (MILS).

While a lot of technical concepts, standards and tools are already available to support the interoperability of classified simulators, security still puts limitations on their usage in a multinational distributed network. Every program and its provided services have to be accredited by national and NATO security experts. Unfortunately the whole area of exchange of simulation data (exchange of data packets and not files, run-time necessity, permanent data-flow) is not always explicitly covered by Information Technology (IT) security regulations. Thus the early involvement of IT security experts and their willingness to understand the specific MTDS needs is very important. Security regulations which are not applicable must be adapted to allow the progress of MTDS.

The NATO task group MSG-080 investigated current practices and technologies to better understand the challenges in the development of future Collective Mission Simulation (CMS) environments [6].

3.5 MRAD simulation interoperability architecture

NATO Standardization Agreement (STANAG) 4603 [7] mandates the use of IEEE 1516-2010™ standards [8][9][10] on High Level Architecture (HLA Evolved) for new M&S systems. Therefore the MTDS simulation interoperability will be based on HLA Evolved, using a federation object model (FOM) based on the NETN reference FOM and FAFD design patterns. The NETN FOM will be extended based on MSG-128 recommendations. The MRAD Federation is an HLA Evolved Federation that complies with the MRAD recommendation.

Any MRAD federation will be supported by a Run-Time Infrastructure (RTI) implementing the HLA services. The RTI provides a standard interface (application programming interface - API) to the federated systems. MRAD will not make any recommendations with respect to specific RTI implementations but will assume a complete and certified HLA RTI implementation will be part of any MRAD federation design. In many MRAD federations there will be a need to mix different simulation infrastructure implementations and to support other distributed simulation standards. The MRAD allows non-HLA (e.g. Distributed Interactive Simulation (DIS)) or legacy HLA (e.g. HLA 1.3) federates to participate in federations using appropriate bridging and/or adaptor technologies. Any bridging required in order to integrate federates to HLA Evolved or the selected RTI shall be the responsibility of the integrating federate (see Figure 3.1.).

An adaptor is used to modify the way an individual system interacts with the simulation infrastructure. The adaptor can be implemented as:

- an integrated and configurable part of a system (e.g. a plugin “HLA” module of a simulation system)
- a separate component but tightly coupled through interfaces with the system (e.g. an HLA Wrapper)
- a part of the simulation infrastructure providing an alternate API for system integration (e.g. HLA 1.3 and HLA 1516™-2000 APIs provided by an HLA Evolved RTI implementation).

A bridge is used to integrate multiple federations or federations running different versions of HLA, DIS or other simulation architectures. The difference between an adaptor and a bridge is that the latter allows multiple systems to use the same integration component. In some cases multiple MRAD based federations may exist and information between them exchanged using bridges (federation of federations). This approach may for example be used to address specific security requirements (e.g. filtering of data).

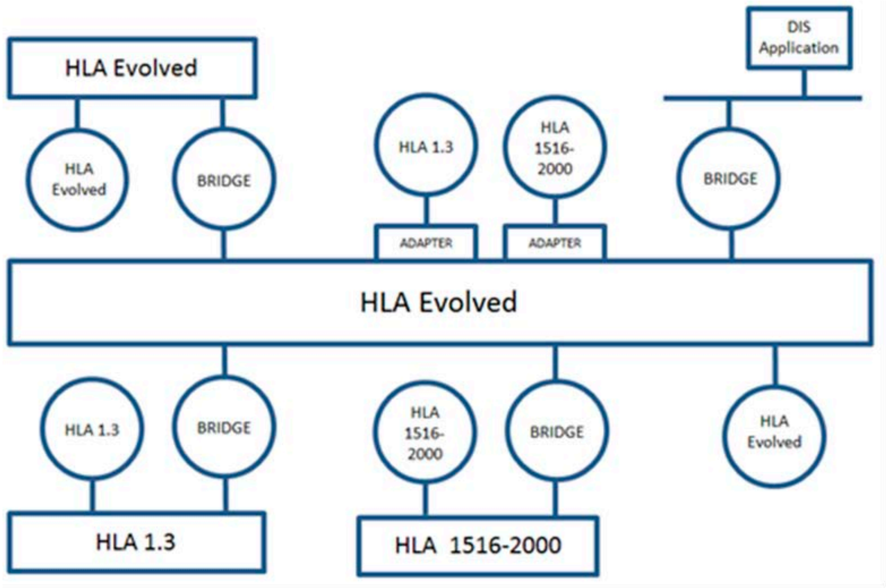

Figure 3.1. Bridges and adapters (from [5])

MRAD federations use HLA Evolved as the core simulation architecture. However, in the design of a federation, requirements may motivate the use of hierarchical federations, and integration of other simulation architectures. Some of these reasons are listed below.

- Possibility of making software changes, relinking etc. (e.g. no availability of source code to make adjustments)
- Use of different RTI implementations or versions (e.g. no/minimal change of already verified federations)
- Need to filter data (e.g. reduce load on a set of systems or prevent data leakage)
- Need to translate data (e.g. using different FOMs).

Most adaptor and bridging solutions modify/reduce the services provided by HLA Evolved. This may have little or no impact on the overall interoperability of the system, but the fundamental design guideline of MRAD is to allow systems to integrate using as many of the HLA Evolved services and MRAD design patterns as possible. Designs with bridges and adaptors that limit the use of HLA Evolved services and MRAD design patterns should be avoided.

3.6 MRAD simulation data exchange model

In MSG-128 the TEK team is responsible for the overall structure and harmonization of the MRAD FOM. The MRAD FOM is a set of HLA Evolved FOM Modules based on the NETN FOM. The MRAD FOM modules are recommended for use when implementing MTDS. The NETN modules include both references to standard FOMs and FOM modules as well as NETN modules developed and refined in earlier NMSG task groups (see Figure 3.2.). The specific MRAD modules will be defined by MSG-128. The modules have inter-dependencies and have been designed to maximize re-use and interoperability both with respect to legacy systems, existing standards and requirements for new patterns of simulation interoperability. The MRAD FOM is the complete set of MRAD modules, NETN modules and all other modules they depend on (e.g. RPR (Real-time Platform Reference) FOM modules). An MRAD Federation defines the modules that are relevant and each simulation system only loads the modules it requires.

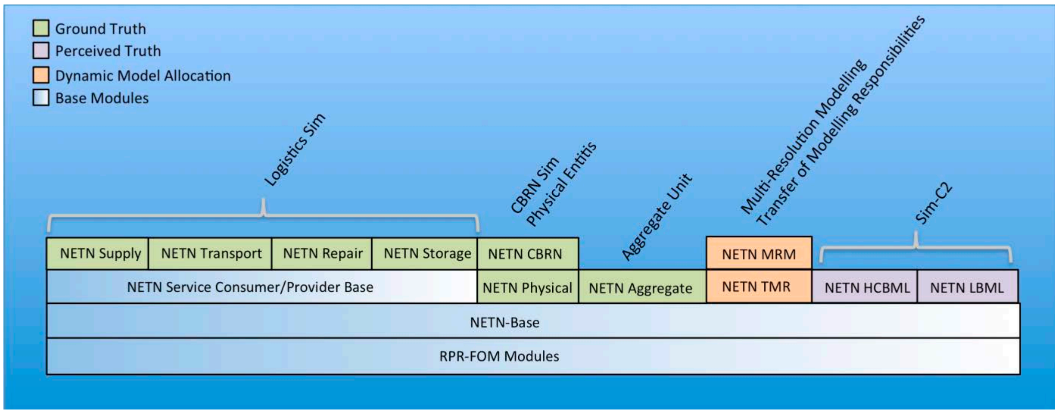

Figure 3.2. NETN FOM

3.7 Network infrastructure

MRAD relies on the existence of a network infrastructure providing local and wide-area connectivity based on standard Internet Protocols (IP). Implementation of the network infrastructure may differ for different federations based on performance and security requirements, network availability, and cost considerations. Network infrastructure services providers, such as the Combined Federated Battle Laboratories Network (CFBLNet), manage the network and can provide guarantees with respect to quality of service (QoS) and network security. Conversely, an internet connection combined with technologies for encryption may provide an appropriate level of connectivity and security for some cases.

The proposed solution from a user perspective will be to provide a number of physically separated networks that are dedicated to a certain type of information flow. For example a network dedicated to (HLA based) simulation data and networks reserved for VoIP, VTC etc. The functionally separated networks would in fact be logical channels that all share the same network infrastructure on the Wide Area Network (WAN) between nations or sites. Network configuration control would allow a flexible allocation of WAN bandwidth to specific data channels. This method would provide maximum bandwidth to the simulation channel during an exercise, while reallocating this WAN bandwidth to VTC channels during briefing and debriefing sessions.

CFBLNet is a network built and maintained by its members. The network consists of sites, national Points of Presence (PoPs), infrastructure, services and knowledge management. The national PoP is the connection from the national Wide Area network (WAN) to the international part of the CFBLNet WAN. The CFBLNet is already available to many NATO nations and partners for both training and experimentation.

The BlackBone (= Black Backbone) provides a common, closed, unclassified IP routed network layer implementation using a mixture of both ATM and IP bearer networks. Its primary purpose is to transport encrypted traffic throughout the network. Enclaves are the cryptographic protected networks on top of the CFBLNet BlackBone. Each enclave has a classification and a marking indicating security level and the countries allowed connecting. Specific applications that use an Enclave to exchange data are known as ‘Initiatives’. The MTDS Initiative will provide a dedicated persistent enclave on CFBLNet.

Figure 3.3. shows the top-level design of the MDTS enclave on top of the CFBLNet BlackBone. Each nation will be connected to the CFBLNet through its national access point or PoP. The PoP will either connect to a national asset located at that site or will provide the interface to the national network infrastructure which connects national assets.

Nations often use an isolated part of their national defence network infrastructure to form distributed education and training capability able to support training. The isolation is primarily required to avoid disruption of operational systems and capabilities and provide a controlled sandbox for the distributed education and training capability. National simulations/networks can use different standards and techniques, but have to be compliant to MRAD when connecting to the MTDS Backbone.

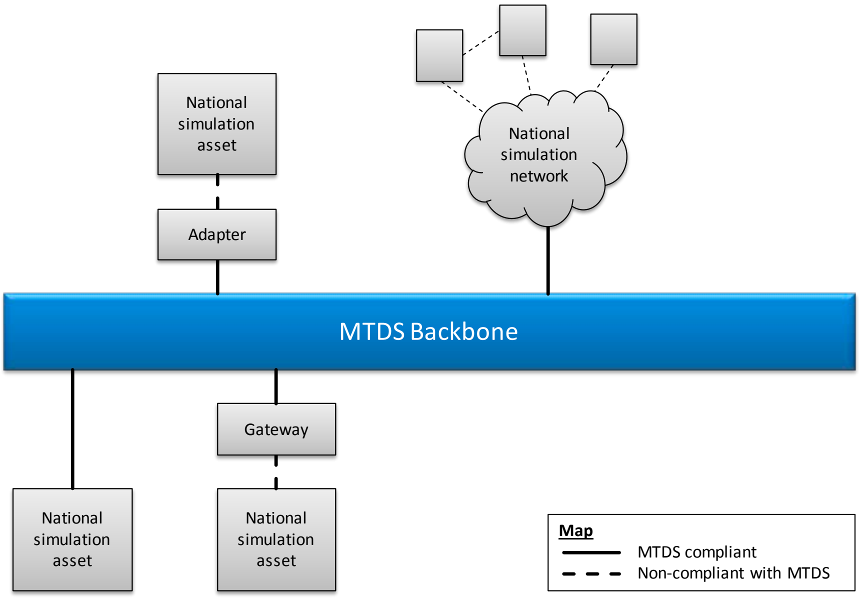

Figure 3.3. Simplified network representation

4 Experiments Towards an Initial NATO MTDS Capability

The initial operational capability of MTDS will be implemented in phases. Testing and incremental implementation is expected to take several years. Experimentation and initial training will be conducted between 2014 and 2017. Additional sites and new applications will be added during these years.

The two first exercises were conducted in October 2014 and July 2015 and involved four and five sites respectively. These two first exercises were using DIS in order to establish an initial capability with minimal changes to existing systems. Exercise 3 is planned primo 2017 and will employ an HLA based architecture.

4.1 Exercise 3 overview

Exercise 3 is planned as a four day event where each day has its own scenario and training goals. The operations that will be exercised span from Defensive Counter Air (DCA) to Offensive Counter Air/Air Interdiction (OCA/AI) with air-to-ground targets. The virtual exercise area is a 500x500 km^2 area in Norway with smaller high resolution target areas.

Participating sites are as follows:

- NATO E-3A Component, Geilenkirchen (E-3A)
- Volkel Air Base, Netherlands (F-16)
- German Air Force Simulation Control Centre, Cologne (technical support)
- Airbus Defence & Space, Manching (Eurofighter Typhoon)
- Centre de définition, d'expérimentation et de validation du SCCOA (CDEVS), Mont de Marsan (Rafale and Air Command and Control System (ACCS))
- Canadian Forces Aerospace Warfare Center, Trenton (F-18)
- Norwegian Defence Research Establishment (FFI), Kjeller (Control and Reporting Centre).

An overview over the participating systems and the overall systems architecture is shown in Figure 4.1.

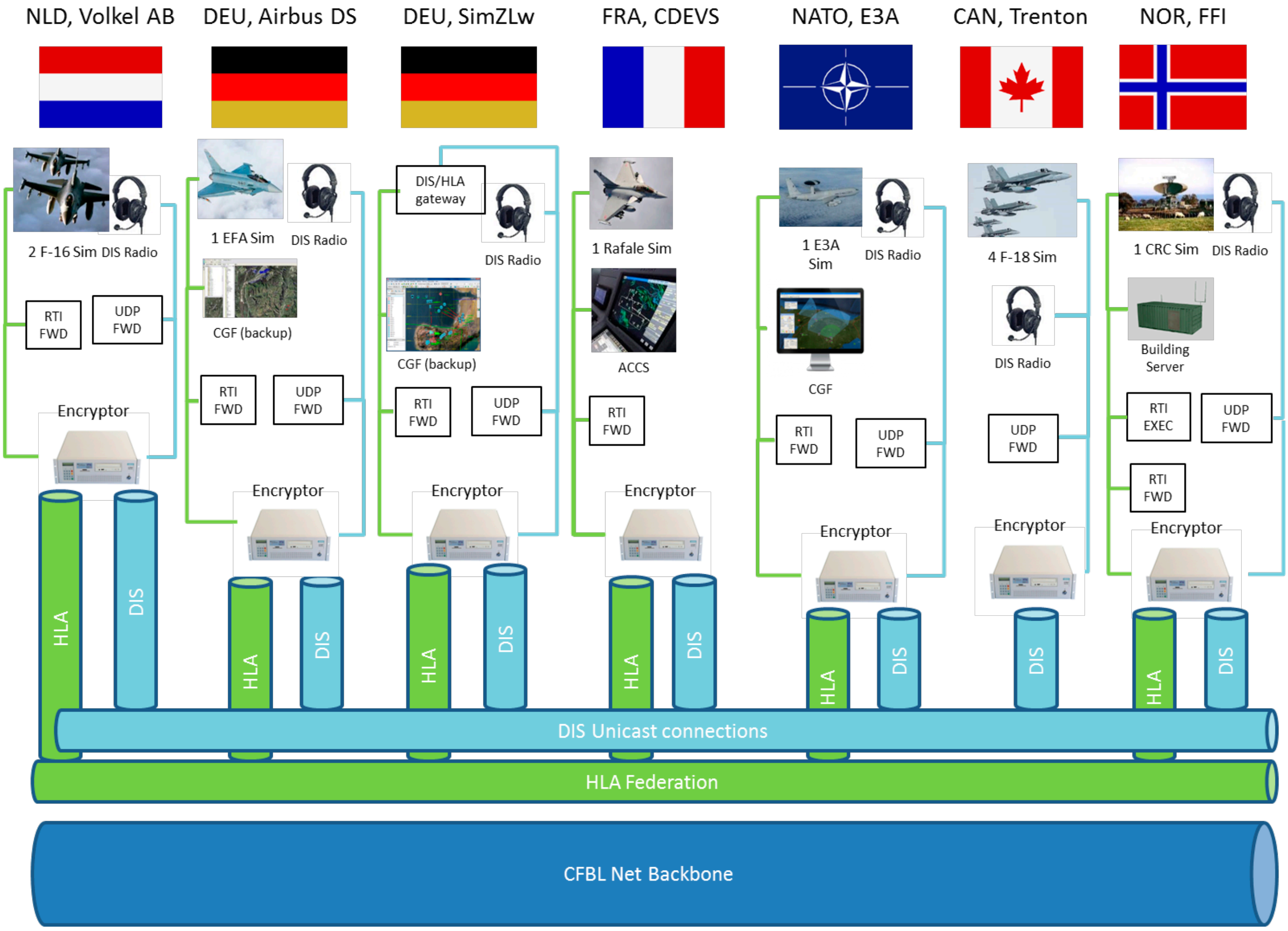

Figure 4.1. Exercise 3 planned architecture

4.2 Federation design

The design and integration of a system distributed across nations and which have classified elements is a challenging task. In order to minimize integration time and create a reference for future MTDS members a common Federation Agreement Document (FAD) has been identified as a crucial artifact for successful MTDS implementation. A FAD template has been created based on previous examples and the Federation Engineering Agreement Template (FEAT) [11]. The current FAD reflects a basic MTDS capability with focus on air-to-air operations with a limited air-to-ground capability.

The FAD main topics are as follows:

- Federation architecture and member applications overview
- Data exchange models including tactical data link (TDL)
- Interest matrix with publish/subscribe responsibilities for each federate
- Enumerations for entities and emitters
- Time representation and dead reckoning
- Simulated radio communications
- Federation states including startup and shutdown procedures
- RTI agreements including RTI services and RTI configuration

- Modelling responsibility
- Common damage models
- Synthetic Natural Environment agreements.

As discussed in chapter 3.5 the interoperability Backbone is based on HLA 1516™-2010. The Real-time Platform Reference FOM (RPR FOM) v2.0 [12], which is the core of the NETN FOM, is used as data exchange model together with the SISO Link 16 Base Object Model (BOM) [13]. Due to missing HLA capability of the existing radio simulation tools at all sites DIS is currently used for radio voice communication simulation. It is desirable to transfer voice communication to the HLA federation in the future in order to simplify the MTDS architecture and to simplify After Action Review as voice currently has to be logged by a separate tool.

Link 16 is a fundamental capability for air operations training, while at the same time being the single most complex subsystem. Link 16 simulation requires both correct implementation of J-Messages and in addition to the tactical data link functionality for track management and C2. Even though the SISO Link 16 BOM was the obvious choice for Link 16 simulation a lot of gateways are needed in order to make all systems interoperate. In addition to the SISO Link 16 BOM numerous other protocols are being used by the participating simulators: Standard Interface for Multiple Platform Link Evaluation (SIMPLE) [14], Link 16 over DIS (SISO J), Joint Range Extension Application Protocol (JREAP) [15] and J-Messages over the RPR FOM RawBinaryRadioSignal Interaction. Thus, Link 16 simulation requires special attention in the future development of NATO MTDS in order to reduce the integration effort prior to MTDS exercises.

Another challenging topic was to implement a Common Synthetic Natural Environment (SNE) in all systems. Realizing that all participating systems have their own processes and tools for creating SNE databases, a source data set was created and shared among the nations. The data set included elevation models, imagery, vector data and models of selected targets/buildings. The exchange formats used includes Digital Terrain Elevation Data (DTED), Digital Elevation Model (DEM) for high resolution areas, GeoTIFF for imagery, the Shapefile vector format and OpenFlight. For the high resolution areas a required feature set was developed together with a reference database in order to promote database correlation. Future exercises should consider using the Missionland dataset developed by MSG-071 [16]. This dataset is freely available for nations, but it should be tested if a fictitious virtual area can be used in legacy training simulators and C2 systems. For future exercises with air-to-ground operations also a common database verification and validation process should be developed to ensure database correlation in high resolution areas. The work conducted by SISO Reuse and Interoperation of Environmental Data and Processes (RIEDP) product development group is of great interest.

4.3 Federation integration and test

Completion of local setup and tests of the participating simulators and site and network accreditations are prerequisites before federation integration. The first step is to agree upon on a common HLA RTI implementation. Due to the planned use of HLA Evolved each site has to be able to adapt to the selected version of the RTI, preferably without changing the simulation asset. The RTI at each site must be set up and configured according to the agreed MTDS configuration and one site has to provide the RTI Executive which is the central point for hosting the HLA federation. After the configuration of the RTI the simulation assets themselves have to be configured according to the federation design agreements. This includes the federation name, the federate name and the FOM. A Federation Test Plan has been developed for systematic and efficient testing of all systems. This test plan includes basic connectivity tests between sites, in addition to testing the simulation assets compliance with the agreements described in the FAD.

For the third MSG-128 exercise the integration tests focus on three areas:

1. Position and entity data

   The provided update rates and dead reckoning attributes from all assets should be tested. In this exercise for the fast jet simulators an update rate of at least 1 Hz and a correctly populated dead reckoning attribute are required for correct display of movement of the networked entities at all sites. In addition to the correct movement of the entities a correct entity type specification according to the SISO enumerations [17] is also necessary for correct identification of remote entities.
2. Electronic Warfare (EW) data

   This covers the detection and identification of other players via sensors, the engagement of threats with weapons and defensive measurements against enemy sensors and weapons. Tests have to verify that the necessary entity attributes are correctly populated (e.g. Radar Cross Sections for radar and heat emissions for IR detections). In addition the own sensor detections and active jamming have to be correctly transmitted via Sensor/Jammer Beam attributes in order for the other players to correctly trigger their defensive aids systems and calculate the effect on the own sensors and weapons. This is a complex area and in some parts not completely covered by the existing FOM (e.g. active IFF interrogations or aircraft to weapon communication). That makes tests in this area quite complex.
3. Communication

   The communication between the players is handled via voice radio simulation and tactical data links. In the MSG-128 setup we have so far used DIS for voice communications, as this is a well-proven solution. Due to this choice the use of UDP Forwarders between the participants were required as the CFBLNet only supports single-cast communication. The radio voice communication tests are thus not only related to the correct setup of DIS (e.g. regarding frequencies and crypto) but also to the preparation of the UDP connections. As described in chapter 4.2 the participating systems use several different standards to implement exchange of TDL information. In order to simplify setup and tests one site is chosen as the central TDL site with the responsibility to translate to and from the other formats. TDL tests include the default exchange of TDL position information between participants and their usage in the ownship sensor displays, and the exchange of TDL commands (e.g. engagements) and other status reports (e.g. own detections).

5 Concluding Remarks and Next Steps

The first tests and example exercises have shown the benefit of MTDS to coalition pilots. Even exercises with limited interoperability between the simulation assets (e.g. no tactical data link but simulated radio voice communications) have provided some insights to the future potential. It is important that compared to previous networking studies which have been limited to temporary networks, the MTDS infrastructure must remain a permanent capability which can be utilized on “short notice”. National assets must remain connected to the CFBLNet and periodically receive their accreditation to make this possible.

The time consuming necessary test phases prior to an actual exercise which had to be conducted during the MSG-128 study have shown the need for a structured interoperability testing process between simulators. Support by dedicated (automated) tools could be helpful to save time and reduce errors in the test phases. While the goal for future exercises should be to reduce the preparation phases to a minimum, tests will always be required and are as important as the real exercises in order to avoid dissatisfaction or worse even negative training for the trainees.
In order to avoid delay for future MTDS exercises, periodical time slots for test phases must be planned as well. These test phases should be used to verify the status and test new functionalities of already “accredited” MTDS simulators and the introduction of new simulators via an agreed “acceptance” procedure. The acceptance procedure must be conducted by a NATO body (e.g. E-3A Component) or an accepted partner and should follow strict test plans.

M&S interoperability is a primary concern of NATO and efforts have to be maintained to improve the current standards and make progress towards meeting the MTDS needs. The formal relationship between NMSG and SISO is very beneficial in maintaining a close cooperation with the international M&S community and will be continued and increased where possible. The MSG-128 NETN FOM modules will be discussed in the SISO RPR FOM product development group.

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