NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-MSG-005**

Federation Development and Execution Process (FEDEP) Tools in Support of NATO Modelling & Simulation (M&S) Programmes

(Des outils d'aide au processus de développement et d'exécution de fédérations (FEDEP))

Work performed by the RTO NATO Modelling and Simulation Group (NMSG) Task Group MSG-005/TG-005.

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(Des outils d'aide au processus de développement et d'exécution de fédérations (FEDEP))

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Work performed by the RTO NATO Modelling and Simulation Group (NMSG) Task Group MSG-005/TG-005.

The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS Studies, Analysis and Simulation Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Federation Development and Execution Process (FEDEP) Tools in Support of NATO Modelling & Simulation (M&S) Programmes

(RTO-TR-MSG-005)

Executive Summary

MSG-005, PathFinder FEDEP Support Tools, was initiated following a NATO Industry Advisory Group (NIAG) Working Group report titled, “Follow-on NIAG Prefeasibility Studies on Common Technical Framework and Multi-National Force Rehearsal (PathFinder Experiment Definition)”. This report recommended the establishment of a new Working Group to define Initial Common Tools (ICTs) required to support Multi-National PathFinder Federations. The following nations contributed to the work of MSG-005: Canada, France, Germany, Portugal, United States, and United Kingdom.

NMSG Task Group 005 held its first meeting in February 2001. The original plan was to complete the task in two years to ensure that the report would provide timely information to the PathFinder group. As the PathFinder schedule slipped, however, MSG 005 took advantage of the additional time to expand its scope.

The Task Group recognized the value of the NIAG study and recommended the development of a product that would be broadly supportive of the development of High Level Architecture (HLA) based federations across NATO. The mission of MSG-005, in accordance with the TOR was “the identification of the availability of the most appropriate and cost-effective FEDEP support tools […] to:

- Reduce cost of simulation development;
- Improve training simulations;
- Promote reuse of national models and simulations in a multi-national federation.”

More specifically, MSG 005 was to:

- Identify the most appropriate and cost-effective PathFinder FEDEP support tools, e.g., scenario preparation, environmental data, requirement definition, configuration management;
- Determine the availability of the most appropriate and cost-effective PathFinder FEDEP support tools, whether commercial, academic, government, or military products;
- Recommend the development of new FEDEP support tools.

Liaison was established with the EUropean Co-operation for Long-term in Defence Research and Technology Programme, EUCLID RTP 11.13 (“Realizing the potential of Synthetic Environments in Europe”). This effort combined with the NIAG report and the original DMSO HLA Tools Database formed a basis for the MSG 005 study.

Task Group members considered 2 competing approaches for the development of the final product. The first was to recommend a tool set to support the PathFinder Development and Execution Process, and the second was to create a searchable collection of descriptions of available tools. The latter approach was selected since it met the requirements of the PathFinder Programme, and served the needs of broader

NATO modelling and simulation community. The tool list itself is indexed to the new IEEE 1516.3™ – 2003 standard: "IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)". In an effort to ease maintenance in the future, this tool list focuses exclusively on modelling and simulation tools, omitting general software development and support products. The list currently contains 79 tools and others should be added as they become known.

Finally, the Task Group has recommended that the tool list be made available through a web-based interface, to ease access and use. In support of this concept, a formal recommendation was made at the 8th NATO M&S Business Meeting in The Hague (in 2001) to establish a common set of web-based M&S repository services to support all of NATO.

This report details the work of the Task Group and includes the methodology and rationale for the development of the tool list. Chapter 1 is the Introduction which discusses the origin of the MSG-005 activity and scope of the report. Chapter 2 provides background information on the FEDEP and the FEDEP Tools Overlay. Chapter 3 discusses the PathFinder program and related work and Chapter 4 addresses the tools, the report methodology and an explanation of the technical approach and analysis. Conclusions and recommendations are contained in Chapter 5.

Des outils d'aide au processus de développement et d'exécution de fédérations (FEDEP)

(RTO-TR-MSG-005)

Synthèse

Le groupe MSG-005 sur les outils de soutien pour le FEDEP Pathfinder a été créé suite à la publication du rapport du groupe consultatif industriel OTAN (NIAG) intitulé « Etudes de pré-faisabilité complémentaires NIAG sur l'infrastructure technique commune de simulation et l'entraînement des forces multinationales (définition de l'expérimentation Pathfinder) ». Ce rapport a recommandé la création d'un nouveau groupe de travail, ayant pour mandat de définir les outils communs de base (ICT) demandés pour le soutien de fédérations multinationales Pathfinder. Les pays suivants ont contribué aux travaux du MSG-005 : Le Canada, la France, l'Allemagne, le Portugal, les Etats-Unis, et le Royaume-Uni.

Le groupe de travail NMSG 005 a tenu sa première réunion en février 2001. Son objectif initial était de terminer ses travaux dans un délai de deux ans, afin de pouvoir fournir un rapport en temps voulu au groupe Pathfinder. Cependant, puisque le planning Pathfinder avait glissé, le groupe a profité du temps additionnel pour développer ses activités.

Le groupe de travail a reconnu l'intérêt de l'étude NIAG et a recommandé le développement d'un produit plus général pour soutenir le développement de fédérations basées sur l'architecture de haut niveau (HLA) au sein de l'OTAN. Conformément à son TOR, le groupe MSG-005 a eu pour mandat « l'identification de la disponibilité des outils de soutien les plus appropriés et les plus rentables […] afin de :

- réduire le coût de développement des simulations ;
- améliorer les simulations d'entraînement ;
- promouvoir la re-utilisation de modèles nationaux au sein d'une fédération multinationale. »

En particulier, MSG-005 devait :

- identifier les outils de soutien au FEDEP de Pathfinder les plus appropriés et les plus rentables, par exemple, la préparation des scénarios, les données d'environnement, la définition des besoins, la gestion de la configuration etc. ;
- déterminer la disponibilité des outils de soutien au FEDEP de Pathfinder les plus appropriés et les plus rentables, qu'il s'agisse de produits commerciaux, universitaires, gouvernementaux ou militaries ;
- formuler des recommandations concernant le développement de nouveaux outils de soutien au FEDEP.

Un lien a été établi avec le Programme Européen de Coopération en Recherche et Technologie pour la Défense à Long Terme, EUCLID RTP 11.13 (« Réaliser le potentiel des SE en Europe »). Ces travaux, le rapport du NIAG et la base de données d'outils HLA du DMSO, ont constitué les bases de l'étude MSG 005.

Les membres du groupe de travail ont examiné deux approches concurrentes pour le développement du produit final, à savoir, la recommandation d'un jeu d'outils pour le soutien du processus de

développement et d'exécution de Pathfinder d'une part, et la création d'une base de données décrivant les outils disponibles d'autre part. La deuxième approche a été retenue puisqu'elle correspondait aux critères du programme Pathfinder et qu'elle répondait aux attentes des spécialistes OTAN de la modélisation et de la simulation. La liste des outils est indexée à la nouvelle norme IEEE 1516.3™ : « La pratique recommandée IEEE pour l'architecture de haut niveau (HLA) processus de développement et d'exécution de fédérations (FEDEP) ». Dans un souci de faciliter la maintenance future, cette liste est composée exclusivement d'outils spécifiques à la modélisation et la simulation, à l'exclusion de tout produit général de développement et de soutien logiciel. Aujourd'hui, la liste contient 79 outils et d'autres y seront ajoutés au fur et à mesure de leur apparition.

Enfin, le groupe de travail a recommandé la mise à disposition de la liste d'outils par l'intermédiaire d'une interface Web, afin de la rendre accessible et exploitable par le plus grand nombre de personnes. Pour promouvoir ce concept, une recommandation officielle a été faite lors de la 8ème réunion NATO M&S à la Haye (en 2001) relative à la création d'une bibliothèque M&S sur le Web pour le soutien de l'ensemble des pays membres de l'OTAN.

Ce rapport donne la description détaillée des travaux du groupe de travail, y compris la méthodologie et les objectifs adoptés lors de l'élaboration de la liste d'outils. En guise d'introduction, le chapitre 1 examine les origines de l'activité MSG-005, ainsi que le champs d'activités couvert par le rapport. Le chapitre 2 présente l'historique du FEDEP et des outils. Le chapitre 3 examine le programme Pathfinder et le travaux associés. Le chapitre 4 porte sur les outils, la méthodologie adoptée pour le rapport et commente l'approche technique et l'analyse. Le chapitre 5 contient des conclusions et des recommandations.

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Chapter 1 – INTRODUCTION

1.1 ORIGIN OF THE TECHNICAL ACTIVITY PROGRAMME

In 1996, a temporary North Atlantic Treaty Organization (NATO) working group was convened to assess the possibility of establishing a permanent Modelling and Simulation (M&S) organisation. This working group, the Steering Group for M&S (SGMS), reported to both the Conference of National Armament Directors (CNAD) and the Military Committee (MC) via the Research and Technology Organisation (RTO).

In 1998, the SGMS published two documents:

- A final report proposing a NATO M&S organisation
- A NATO M&S Master Plan (MSMP) [A.2-1]

Both documents were approved by the RTO, CNAD and MC hierarchy, and ultimately by the North Atlantic Council (NAC) in November 1998. Since then, the NATO M&S Organisation has been established under the auspices of the RTO as shown in Figure 1. The NATO M&S Organisation is composed of the NATO M&S Group (NMSG) and the M&S Coordination Office (MSCO). The NMSG is a leading committee that meets twice a year. It is supported by the MSCO, which has a permanent office that is installed in the Research and Technology Agency (RTA) in Neuilly-sur-Seine, France.

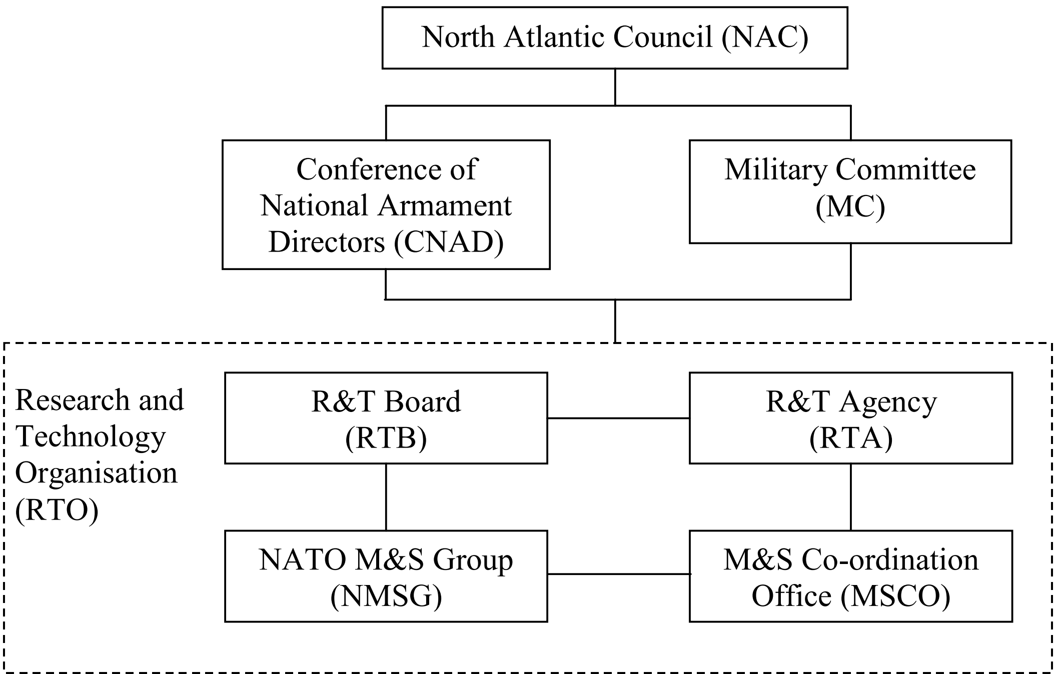

Figure 1: NATO Modelling and Simulation Organisation.

The NATO MSMP, referenced above, addressed a variety of M&S subjects. Its five objectives are shown below in Table 1. Notable among these was the subject of modelling and simulation standards under Objective 1. Both the approved MSMP and the SGMS final reports recognised the High Level Architecture (HLA) [A.3-1 to A.3-9] as the primary NATO M&S interoperability standard. Since that time, the HLA has matured and is now being recommended by the NMSG as a NATO Standard (STANAG).

Table 1: MSMP Objectives

Objective 1	Objective 2	Objective 3	Objective 4	Objective *5*
Establish a Common Technical Framework	**Provide Common Services in NATO M&S**	**Develop Simulations**	**Employ Simulations**	**Incorporate Technological Advances**
1.1 Adopt HLA	2.1 Compile M&S Information	3.1 Identify & Prioritise Requirements	4.1 Plan Employment	5.1 Monitor M&S Related Advances
1.2 Establish Data Interchange Standards	2.2 Provide M&S Education	3.2 Identify Strategies	4.2 Provide Resources	5.2 Conduct R&D
	2.3 Establish a Simulation Resource Library	3.3 Allocate Resources	4.3 Provide Databases	5.3 Share Information
	2.4 Establish a Help Desk	3.4 Execute Strategy	4.4 Operate Simulations	5.4 Implement Advances
		3.5 Provide Feedback	4.5 Conduct Impact Assessment	

Objective 3 of the MSMP led to the PathFinder initiative. It states: "the development of individual models and simulations has been occurring for decades and is relatively well understood. However, NATO has limited experience with the co-operative development of federations of diverse simulations." To address this issue, the MSMP discussed the need for a PathFinder programme to demonstrate the viability of co-operatively developed multi-national distributed federations based on the HLA.

The origin of the MSG-005 technical activity came from Objective 1, "Establish a Common Technical Framework", or more specifically, Sub-objective 1.1, which recommended the adoption of the HLA as the interoperability standard within NATO. The PathFinder programme was initiated to support this objective and specifically to provide a mechanism for HLA experimentation. A number of Technical Activity Programmes (TAPs) have been created within the NMSG to support PathFinder; MSG-005 is one of them.

In the year 2000, prior to the formation of MSG-005, a NATO Industry Advisory Group (NIAG) Working Group completed its study [A.2-2, A.2-3]. One of the products of the study was the identification of the support tools required for PathFinder. This study formed the foundation for the MSG-005 Task Group. More specifically, the MSG-005 Terms Of Reference (TOR) [A.1-1] state the mission of the Task Group as:

> The identification of the availability of the most appropriate and cost-effective FEDEP [Federation Development and Execution Process] support tools [which] will allow NMSG to recommend that NATO defines a set of standard common tools to support employment of an integrated high-level simulated mission space that can support NATO in the principal application areas of defence planning, training, exercises and support to operations to:
>
> - Reduce [the] cost for simulation development
> - Improve training simulations
> - Promote re-use of national models and simulations in a multi-national federation

As stated in the TOR, the main tasks of MSG-005 are to:

a) Identify the most appropriate and cost-effective PathFinder FEDEP support tools, e.g., scenario preparation, environmental data, requirement definition, configuration management

b) Identify the availability of [the] most appropriate and cost-effective PathFinder FEDEP support tools, whether commercial, academic, government, or military products

c) Recommend the development of new FEDEP support tools

1.2 RELATED WORKING GROUPS

Task Group MSG-005 was established to support the NATO PathFinder programme, which is described in some detail in Section 3.1 of this document. The current programme organisation is composed of a PathFinder Steering Group (PSG), which consists of senior leaders from the NMSG. The PSG meets four times a year and formed MSG-002, another NMSG Task Group. MSG-002 was in charge of specifying the future development of PathFinder according to a tailored version of the FEDEP (described in Chapter 2). This version is referred to as the PathFinder Development and Execution Process (PADEP). France was leading the nine nations that participated in MSG-002, which completed its work in June 2003.

Upon the completion of MSG-002, Germany started to lead a new PathFinder Task Group designated MSG-027. The title of this group is: “PathFinder: Integration Environment for Multi-Purpose Application of Distributed Networked Simulations”.

MSG-012 was another Task Group that had a strong link with MSG-005. Its focus was the establishment of a NATO Simulation Resources Library (SRL). MSG-005 believes that the tool database that it is developing should be made available and maintained on this resource. For this reason, MSG-012 and MSG-005 established close co-ordination.

Though not explicitly mentioned in their titles, there are other RTO Task Groups that will benefit from the output of MSG-005. MSG-001/SAS-034, “Distributed Mission Rehearsal for NATO Combined Air Operations”, which is preparing a demonstration based on an HLA federation, is a good example. In fact, more than half of the MSG Task Groups have expressed an interest in MSG-005 activities.

Outside the NMSG community, other programmes also maintain a strong interest in MSG-005. The main interest exists under the auspices of the European Co-operation for the Long Term In Defence (EUCLID) consortium. This effort is led by the Common European Priority Area (CEPA) 11 steering committee on M&S, within a Task Group identified as Research and Technology Project (RTP) 11.13, “Realising the Potential of Synthetic Environments in Europe”. Chapter 3 of this document provides more detailed information on this parallel work. Some MSG-005 Task Group members are involved in RTP 11.13 and are ensuring that close co-ordination is maintained between the two groups.

1.3 PARTICIPATING NATIONS

The nations and one organisation participating in MSG-005 are:

- Canada
- France
- Germany
- Portugal
- United Kingdom (UK)

- United States (US) (chair)
- NATO MSCO

Note: Poland expressed an interest in participating but was unable to send a representative to the meetings.

1.4 SCOPE OF THE REPORT

The main deliverables of the MSG-005 Task Group are:

- this report, and
- a list of tools and related information in eXtensible Mark-up Language (XML) format.

The scope of the report is as follows:

- Chapter 2 describes the history of the HLA Federation Development and Execution Process and the development of software tools to support it.
- Chapter 3 gives an overview of the PathFinder programme and previous work related to the selection of software tools for this programme and EUCLID RTP 11.13.
- Chapter 4 presents the methodology that was used to develop the list of tools, an overview of the database schema, and an analysis of the tools in the database.
- Chapter 5 completes the report with conclusions and recommendations.

Due to the volume of information, this report does not list all of the information in the database; however, Annex E describes the database structure and Annex F lists all of the tools with some key information that was extracted from the database.

Chapter 2 – FEDEP

2.1 FEDEP HISTORY

When the initial definition of the HLA was first made public in March 1995, a number of new concepts were introduced. One of these was the notion of a "federation", which was defined as a set of "federates" (software applications) capable of exchanging information based on an agreed upon interchange document known as a Federation Object Model (FOM). The data is exchanged through a communication layer known as the Run-Time Infrastructure (RTI). For more detailed information concerning the HLA, see References A.3-1 to A.3-9.

During 1995-1996, a number of participating organisations were identified to build prototype HLA federations. Although the three components of the HLA provided the required "pieces" for building a federation, there was no process guidance by which federations could be developed. In fact, each application developer was forced to define their own practices and procedures for HLA federation development and execution. This resulted in a large amount of trial-and-error experimentation and high levels of consumed resources. In addition, the prototype federations reported that the lack of process guidance would likely be a persistent barrier to HLA acceptance and cross-domain interoperability and collaboration.

Throughout the HLA prototyping period, there were a wide variety of approaches to HLA federation development. These approaches and development concepts were shared among the different domains via the HLA Object Model Template (OMT) Working Group. These discussions led to several instances of group consensus on "best practices" for various aspects of federation development. During the final briefings of the HLA prototype federations, a unanimous recommendation was reached to establish a common process view for HLA federation development and execution.

Initially, the HLA OMT Working Group provided the forum for sharing federation development practices and approaches, and in September 1996, the first release of the HLA Federation Development and Execution Process (FEDEP) took place. Version 1.0 of the FEDEP was based on experiences within the prototype federations and incorporated the best practices, as they were understood at that time.

In November 1997, a Concept of Operations (ConOps) was established to mature and evolve the FEDEP in a structured fashion. The Simulation Interoperability Standards Organization (SISO) Simulation Interoperability Workshops (SIWs) were a key element of this strategy. The Federation Development Process (PROC) Forum was established by SISO to provide an open forum for exchanging ideas, concepts, and practical experiences regarding the process of federation development. In the Call For Papers (CFP) for each subsequent SIW, the PROC Forum sought out papers that contributed to this charter. As these papers were presented, suggestions for FEDEP modifications and enhancements were discussed and documented. The HLA Architecture Management Group (AMG) later reviewed those suggestions. The approved changes were implemented in a new FEDEP release and the process was repeated for later versions. This first cycle of changes implemented minor changes to the FEDEP diagram and resulted in FEDEP Version 1.1.

In July 1998, the review cycle included improvements to the process description regarding roles and products. It also addressed the topic of federation re-use and resulted in FEDEP Version 1.2. The December 1998 review cycle improved the graphical representation and Version 1.3 was released.

FEDEP Version 1.4, released during June of 1999, incorporated an executive summary and partitioned federation design and development into two steps. The final version of the first FEDEP generation, Version 1.5 [A.3-1], was created in December 1999 and contained only minor editorial changes.

With this release, the FEDEP had undergone five full cycles of the ConOps. In releases 1.1 to 1.4, feedback on the FEDEP document was heavy and resulted in a number of significant improvements. However, FEDEP Version 1.5 (Figure 2) implemented only minor editorial changes with no new changes proposed for the sixth development cycle; a planned Version 1.6 release was deferred as a result. The PROC Forum believed that this decrease in change requests provided direct evidence that the process model description had stabilized. Additional information on the development of the FEDEP can be found on the PROC Forum area of the SISO archives at http://www.sisostds.org/.

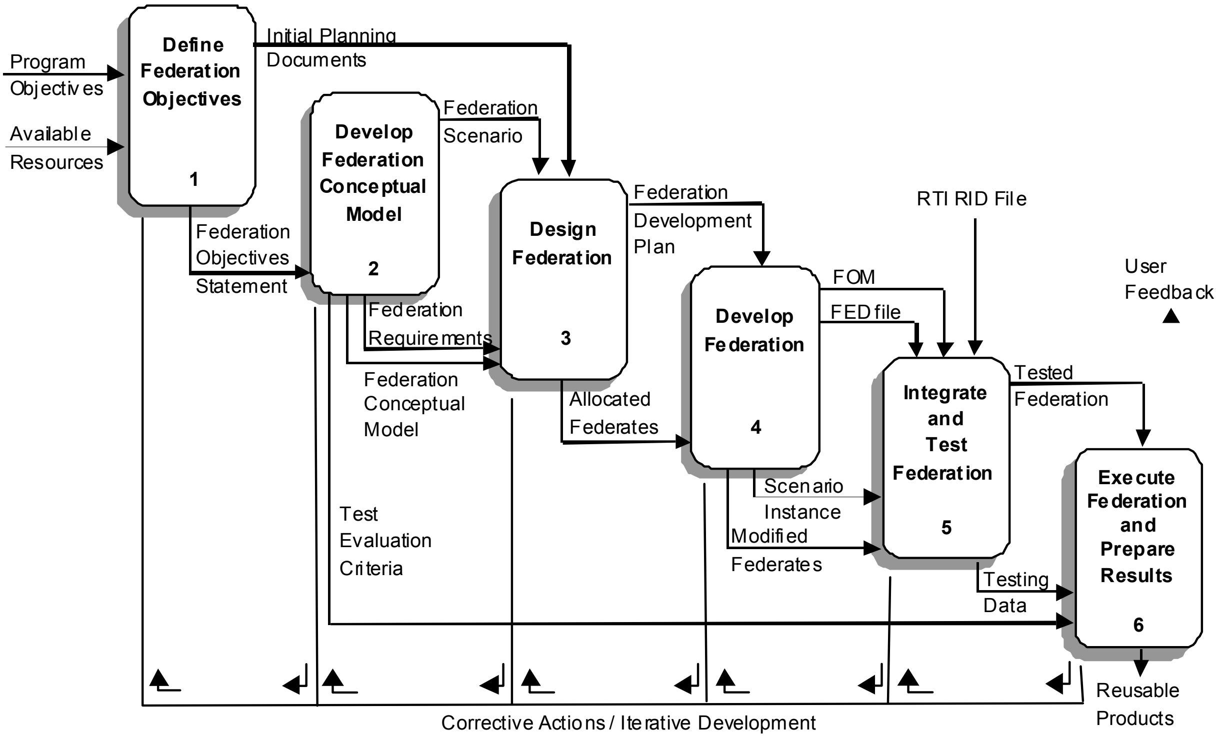

Figure 2: Six-Step FEDEP Version 1.5 (December 1999).

2.2 THE CURRENT FEDEP VERSION

With the Institute of Electrical and Electronic Engineers (IEEE) society approval of the HLA 1516 series of specifications, the PROC Forum recommended to the SISO Standards Activity Committee (SAC) that a supporting process model was still needed by the HLA user community for requirements development, conceptual modelling, scenario development, federation development and execution. These activities were considered critical to the successful development of an HLA federation but were clearly outside of the scope of the HLA specifications.

Including the FEDEP as part of the IEEE 1516 series of documents would help to fulfil the need for a process model. The M&S community also believed that the FEDEP would improve and mature with the wider community involvement brought on by the IEEE standardisation process, as did the HLA.

Today, the current version of the FEDEP (Figure 3) embodies many of the comments and contributions from NATO and the broader European communities. The NATO PathFinder programme and EUCLID RTP 11.13, as well as significant individual contributions, have broadened and matured the FEDEP to the point that it was accepted as an IEEE standard in March 2003 [A.3-9].

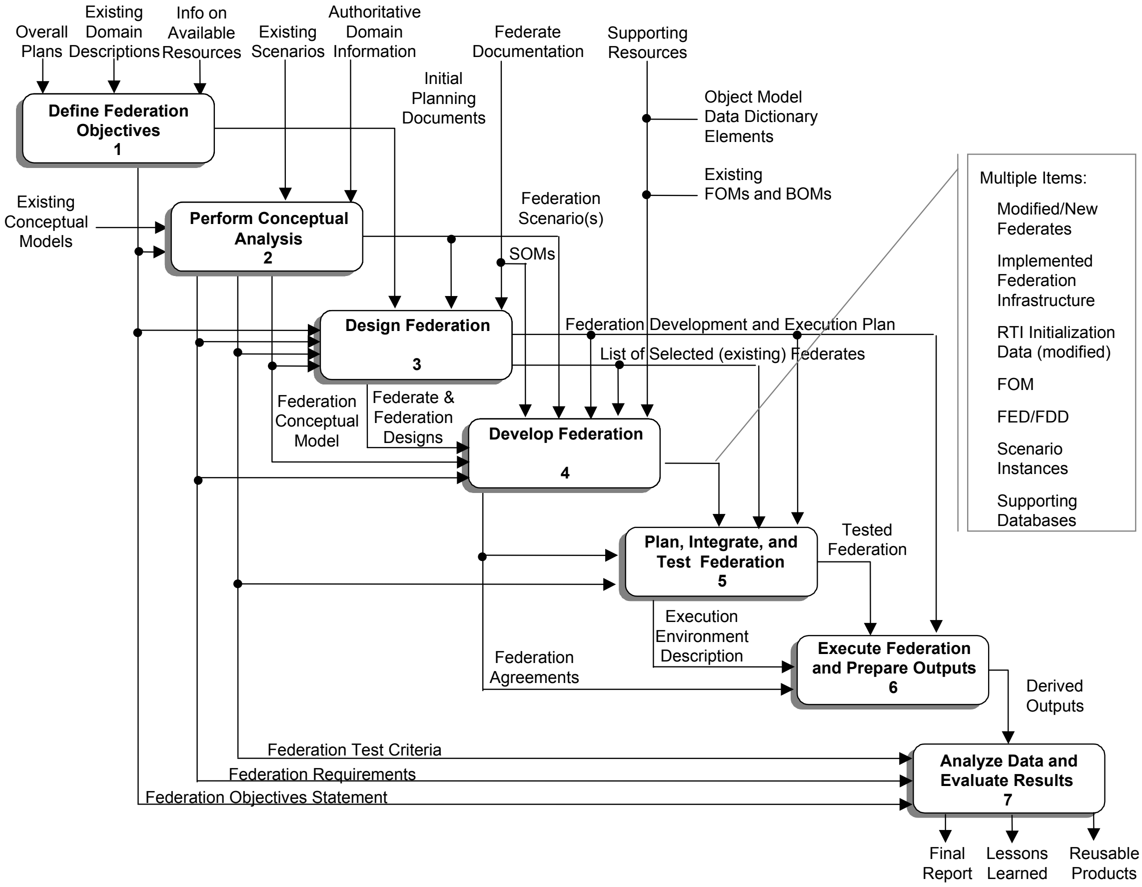

Figure 3: Seven-Step FEDEP (3 June 2002).

2.3 TOOLS TO SUPPORT THE FEDEP

During the early development of the HLA, it became apparent that a set of tools was required to support early technology adopters. The challenges were how to determine which tools to build in order to provide the greatest benefit, and how to ensure that commercial vendors would have an opportunity to compete in this endeavour. The answer lay, in part, in the development of the HLA Tools Architecture (Figure 4).

The architecture was created as an overlay to the FEDEP in an effort to show the relationship of the tools to the FEDEP. This approach demonstrated the notional types of tools that were available to support each phase of development and their relationship to the process and tools in the later phases. The architecture not only depicts the tools and supporting repositories but also the flow of data from one phase of the FEDEP, and corresponding set of tools, to another using a set of standardised Data Interchange Formats (DIFs).

The architecture itself is divided from left to right by the phases of the FEDEP.

The tools shown in the architecture are of two major types. The boxes represent end-user tools and the cylinders depict library resources that can be shared by all HLA users.

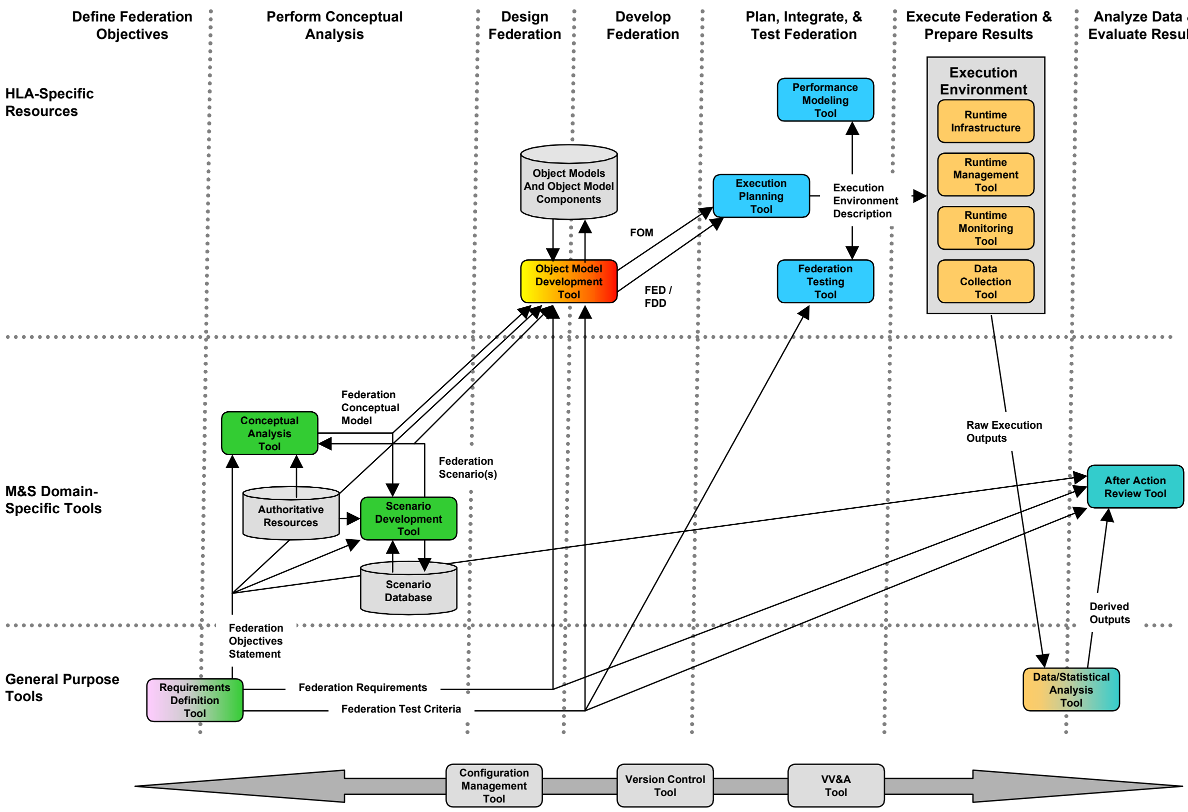

Figure 4: HLA Tools Architecture: Mapping Tools on the FEDEP.

On the left-hand side of the chart, the architecture is divided horizontally into three categories:

- General-purpose tools not specific to the M&S domain
- M&S-specific tools
- HLA-specific tools and repositories

The HLA developed tools can further be divided into three groups:

- Object model tools
- Federation development tools
- Federation run-time tools

As previously discussed, the tools are connected within the architecture by a set of standardised Data Interchange Formats. These DIFs provide a specification of the semantics and structure of data to be interchanged between multiple data-producers and multiple data-consumers. Also note that the DIFs were produced in co-operation with commercial tool vendors. This ensured that their tools were interchangeable with those being developed by the US Department of Defense (DoD) Defense Modeling and Simulation Office (DMSO).

The HLA DIFs support the interchange of tools within the architecture without any resulting loss of data. For example, Object Modelling Development Tools (OMDTs) from multiple vendors may be used by the various members of an HLA federation. The tools can all be initialised by extracting Simulation Object Models (SOMs) or Federation Object Models (FOMs) from the Object Model Resource Repository. Each of the different OMDTs will output data in standardized formats that can also be used by other tools later in the federation development cycle. This approach allows users to choose among the available tools knowing that they are interchangeable with the DMSO-sponsored tools.

The DIFs also ensure that data produced during one phase of federation development can be automatically transferred to another and used by a tool in that phase. Again, using the OMDT as an example, the output of the OMDT from any vendor can be used to automatically populate the Federation Execution Planners' Workbook (FEPW) files, eliminating the need to recreate the information in the FEPW.

In short, the tool architecture identifies the types of tools that are required and used during federation development and execution. It ensures that as long as a tool uses the standardised DIFs, the tool will be interchangeable with others of the same kind, and that the data produced can be used in subsequent phases of federation development and execution.

Chapter 3 – RELATED WORK

3.1 PATHFINDER

3.1.1 Background

In the past, NATO has relied on the principle that training by individual nations should meet the readiness requirements of the Alliance. Today, however, NATO faces new challenges in Europe. One challenge is the new NATO structure with new nations becoming incorporated into the Alliance. Another is the increasing number of Crisis Response Operations (CROs) involving the deployment of multi-national forces engaged in new and complex scenarios.

The difficulties of this new situation have prompted the development of an overarching *NATO Training, Exercise, and Evaluation Policy* (Military Committee document MC 458). Parallel developments, such as the Partnership for Peace (PfP) Training and Education Enhancement Programme (TEEP), MC 94/4 *NATO Military Exercise Policy*, ACE (Allied Command Europe) Command and Staff Training Programme (ACSTP), and Joint Analysis Lessons Learned Centre (JALLC), have already demanded an increasing training involvement by NATO.

The ability to practice NATO staff procedures under realistic conditions and in a cost-effective manner requires a technological leap ahead. Specifically, it requires the employment of Computer Assisted Exercises (CAXs) that are seamlessly connected to the NATO Communication Information System (CIS).

One of the objectives of the PathFinder programme is to address these issues by providing a training capability supported by modelling and simulation. PathFinder deals with the integration and employment of multi-national models and Decision Support Tools (DSTs) for the Combined-Joint Task Force (CJTF) Headquarters (HQ) and lower component commands.

PathFinder is a follow-on programme of the Distributed Multi-National Defence Simulation (DiMuNDS) 2000 feasibility demonstration. The DiMuNDS project was a highly successful pre-PathFinder experimental federation. It established the technical viability of combining multi-national simulations using the HLA for the purpose of providing training and exercise support in a CJTF operational context. This programme culminated with a demonstration of its technical capabilities at the NATO M&S Conference in October 2000. The PathFinder programme, building on this success, will provide a technological leap ahead for NATO and PfP nations. Eight nations, as well as the main NATO organisations, now actively support PathFinder.

3.1.2 Description

The vision of the PathFinder programme is to provide the technical capability for federations of national models and DSTs to be integrated and linked to NATO and National Command, Control, Communications and Intelligence (C3I) systems. These federations will be linked for the purposes of exercising and training the CJTF HQ staff and component commands in the conduct of Crisis Response Operations.

The PathFinder programme is now assessing a number of promising national models with Non-Article 5 CRO capabilities for possible integration. The identification and selection of the best and most appropriate models is part of the initial phase of the programme. For several years, NATO agencies and NATO Technical Activity Programmes have been studying and developing the concept of the CAX. They have been using national models linked via tailored software architectures. While the work has been very extensive, the success and utility of these programmes has not been leveraged outside of the individual working groups. PathFinder offers a solution to this problem (Figure 5).

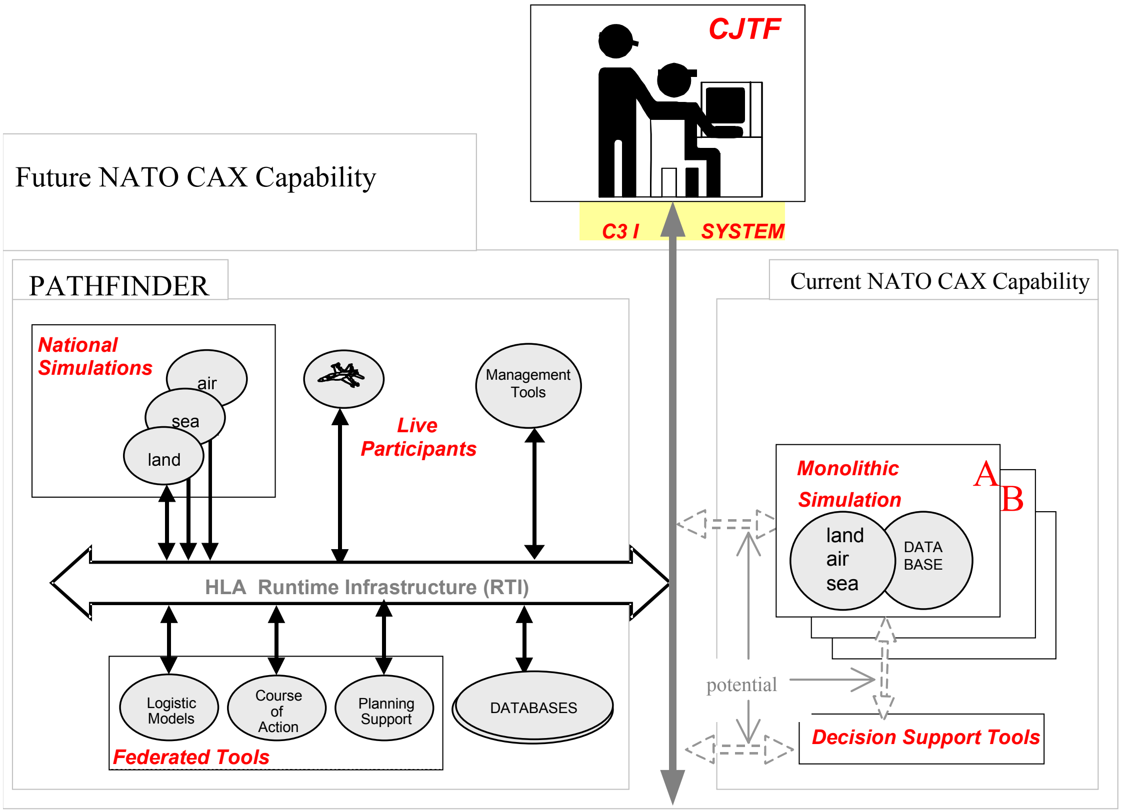

Figure 5: Pathfinder Vision Integrated into the Future NATO CAX Capability.

Other important by-products of this multi-national linkage of national simulations will be the interoperability of national simulations and CISs, and the standardisation of tools and services. Additional by-products will be the creation of common databases and the development of secure communication networks.

The use of federations composed of different national models may also offer enhanced detail, fidelity and realism (capabilities sought by Operational Commands) over that of the monolithic simulations that are employed today. Federations are capable of providing greater fidelity in each of the Air, Land and Maritime domains, and they also offer the possibility of dynamically linking families of models with different levels of resolution. This more flexible, multi-resolution approach enhances the training value of the models and the ability to validate and improve NATO doctrine.

3.1.3 Type of Capability

PathFinder is not a dedicated HLA federation. It is a programme to acquire and enhance the capability to assemble simulation environments consisting of distributed national or NATO agency simulations, DSTs and NATO CISs, to form flexible federations adapted to meet specific requirements. In so doing, PathFinder will converge with future NATO CAX capabilities to help deal with the development of CAXs and DSTs.

3.1.4 Concept

The PathFinder capability will not only support training but also the capability to provide operational support to NATO commanders. PathFinder implies the use of three functional networks:

- **Operational CIS:** This is the operational CIS that NATO commanders employ in the conduct of any NATO operation. The operational commander interfaces with this network, receiving information on operational progress and inputting commands and actions to influence the course of the operation.
- **Exercise Control Network:** This is the network through which the Exercise Control element communicates with the response cells. It is outside of the exercise command and control system.
- **Simulation Wide Area Network (WAN)/Local Area Network (LAN):** This network is the backbone of the CAX. It is used to exchange data between simulation federates. Additionally, response cells provided by nations or NATO communicate with component response cells and common-resource management personnel using this network.

The PathFinder concept relies on the HLA standards and the national skills and experience now prevalent in the field of distributed simulation. Building a high-fidelity flexible simulation composed of dissimilar simulations is possible today using this architecture. The “federation of models” approach is believed to facilitate the transparency, flexibility and validation of the simulation environment. In the near future, war-gaming federations will be an important part of CIS, operations planning, and doctrine development. The opportunity to train at different levels is provided with the development of appropriate federations. Additionally, the employment of nationally federated models in operational support roles will facilitate the development of doctrine and tactics.

In order for all of this to work, a commonality of data standards and consistency of independent databases will also be required. Working towards this goal is important to the overall outcome of the PathFinder programme.

3.1.5 Summary

The vision of the PathFinder programme is to provide HLA federations consisting of national models and DSTs that can be linked to operational C3I systems to exercise and train the CJTF HQ and Component Commanders. The PathFinder programme will also provide dynamic support and will represent a major technological leap forward for the CJTF HQ training in the conduct of Crisis Response Operations.

Typically, nations have observed a significant increase in training and exercise effectiveness and a ten-fold reduction in cost when employing CAX compared to conducting live exercises at the CJTF HQ level.

Important by-products of this multi-national linkage of national simulations will be:

- The interoperability of national simulations
- The standardisation of tools and services
- The creation of consistent databases
- The improvement of the international community of simulation developers

The feasibility phase of PathFinder is currently underway. It is being funded by national contributions.

3.2 SYNOPSIS OF RELATED WORK

3.2.1 NIAG Report

Chapter 7 of the NIAG report [A.2-3] identifies “Initial Common Tools” (ICTs) for use by countries participating in the PathFinder programme. The tools consist of applications such as Commercial Off-The-Shelf (COTS) products, required services such as “email” and “security”, and some data-type specifications such as Digital Terrain Elevation Data (DTED). Very few COTS products are listed and specific tools for services such as "Network Devices" are not listed at all.

To assess the ICTs, 30 criteria are listed in Table 7.1 of Reference A.2-3 under the following seven categories (the bracketed numbers indicate the number of criteria in each):

- Availability (3)
- Usefulness (2)
- Platform Support (3)
- Credibility and Reliability (3)
- Usability (7)
- Documentation (7)
- Capability to Evolve (5)

Since the assessments of individual ICTs are not presented in the NIAG report, it is difficult to assess the effort that went into the evaluations.

Table 7.2 in Reference A.2-3 lists 32 ICTs under 7 tool requirement categories. The table indicates whether the ICT is HLA specific, which step of the PADEP (PathFinder Development and Execution Process) requires it, and if it currently exists as a commercial, government, or military tool (as opposed to one that needs to be developed). The categories and the number of ICTs in each are:

- Federation Development Tools (13)
- Scenario Generation Tools (3)
- Federation Control and Feedback Tools (5)
- After Action Review (AAR) Tools (2)
- Federation Support Tools (4)
- Response Cells Support Tools (2)
- Data Sets (3)

Each of the categories is further broken down and the requirements, existing tools, importance, and recommendations for each are briefly discussed. The report makes numerous recommendations to evaluate the ICTs. Some are very specific ("Use the Object Model Library (OML)") while others are very general ("Define a unique, widely spread tool for all team members").

Few COTS or Government-Off-The-Shelf (GOTS) tools are listed in the various categories and individual evaluations are not presented. Thus, a more extensive review is required, as well as explicit analyses of the tool capabilities. This report addresses these issues.

Another key issue addressed in the NIAG report is interoperability. Unfortunately, this issue is not a property of any one tool and cannot be addressed at this time. Once candidate tools are selected, their ability to interoperate must be studied in detail. Interoperation should, in the simplest case, support the same file formats and versions, complement each other, and, for the sake of cost effectiveness, have minimum overlapping capabilities. Several commercial products listed in the MSG-005 tool list embody these features in tool suites.

3.2.2 EUCLID RTP 11.13

The EUCLID RTP 11.13 programme "Realising the Potential of Synthetic Environments in Europe" is a multi-national effort under the authority of the Western Europe Armament Group (WEAG). The objective of EUCLID RTP 11.13 is to mitigate the obstacles that prevent networked simulations from being exploited in Europe, by developing a process for the production, execution and evaluation of networked simulations, including an integrated set of prototype software tools to support the process. The aim is to reduce the cost and timescales associated with developing networked simulation environments for collective training, mission rehearsal and simulation-based acquisition applications. Key to this aim is the development of software required to set up a European repository of simulation assets.

The EUCLID RTP 11.13 programme is jointly funded by 23 commercial organisations and 13 member-nations of the WEAG. The programme is overseen by representatives of the national ministries of defence of those countries involved, in the form of a Management Group (MG) led by the UK. EUCLID RTP 11.13 is a three-year effort initiated in November 2000 and scheduled to end in October 2003. The programme has a budget in excess of 17-million Euros.

Among the many Work Elements (WEs) of RTP 11.13, WE 1.2, "Review of Application Tools", has an objective similar to that of MSG-005. Its aim is "to identify and evaluate the applicability of tools that will support the generation and utilisation of SEs [synthetic environments]". The focus of the work is to ensure that managers are aware of what SE tools are already available so that time and money is not wasted duplicating their functionality in new software.

Since the focus of RTP 11.13 is not the same as that of PathFinder, WE 1.2 spent a limited amount of time on the analysis of existing tools. Therefore, only a top-level review was performed to identify the part(s) of the networked simulation lifecycle that a tool supports.

The types and numbers of tools reviewed were:

- Scenario generation tools (7)
- HLA support tools (22)
- AAR tools (such as data loggers) (3)
- Requirements analysis tools (3)
- Requirements management tools (1)
- Computer-generated forces (2)
- Execution support tools (network analysis, voice, and two-dimensional (2D) or three-dimensional (3D) visualisation tools) (10)

Information about the tools was collected using a questionnaire that was sent out to the nations participating in the EUCLID programme. The results were entered into a Microsoft® Access© database, which can be accessed, searched and sorted via a web browser.

The EUCLID RTP 11.13 Management Group has agreed that the deliverables of WE 1.2 can be shared with NATO MSG-005. Thus, the WE 1.2 database was selected as one source of information for the Task Group.

Chapter 4 – TOOLS

4.1 ASSUMPTIONS

The catalogue of tools established by the MSG-005 Task Group provides information that is necessary for users and developers of HLA federations, but it is by no means exhaustive.

MSG-005 considered including general-purpose applications and software development tools in the database but eventually decided to exclude them. The Task Group felt that the software development community is generally aware of such tools and would not be inclined to look for information on them in the MSG-005 database. In addition, listing all such tools would have expanded the list to an unmanageable size and made future database maintenance much more difficult.

Some tool characteristics were also excluded from the database in order to minimise the difficulty and recurring cost of database maintenance. Typically, product information that varies with the size and scope of the project, such as product cost, was omitted. Contact information was included so that fluctuating product information can be easily determined.

Schedule and budget constraints for PathFinder and MSG-005 precluded addressing all of the tool requirements that were identified in the NIAG report. For example, new tools must be developed to satisfy some of the requirements but creating new applications was beyond the scope of the MSG-005 TAP.

4.2 METHODOLOGY

The results presented in this report are based on lessons learned and previous tool surveys that support the set-up and execution of HLA federations. More specifically, two sources of information have been used as the basis for this study (Figure 6):

- The HLA Bulletin Board
- The tool list developed by the EUCLID RTP 11.13 consortium[1]

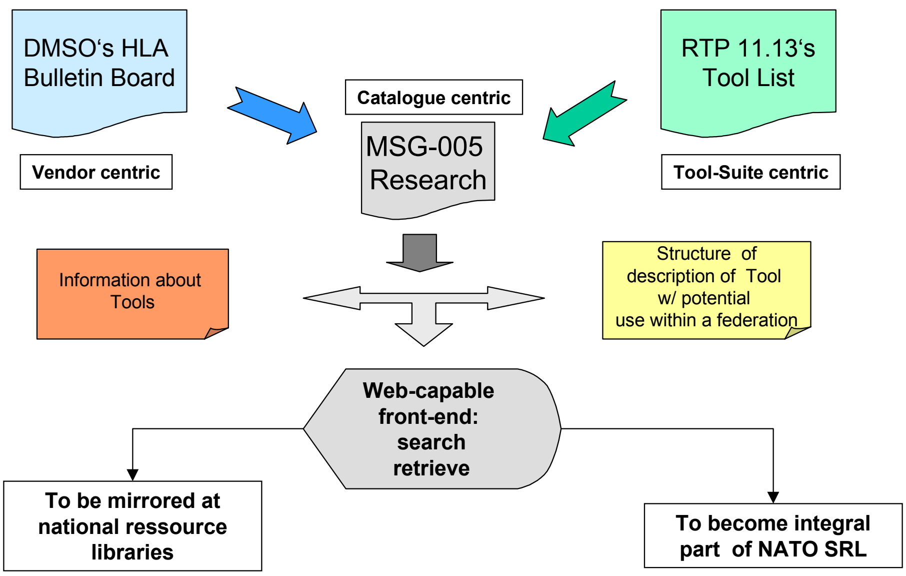

Figure 6: Schematic Sketch of the Exploited Methodology.

[1] See http://www.euclid1113.com/deliverables/reports/WE1.2/default.htm.

MSG-005 considered two competing ways of using this information. The first was to create a searchable collection of available tools. Such a catalogue would contain a brief tool description along with information on its availability and potential use. The catalogue would only provide information on tools that were expected to be of interest to federation developers; it would not give recommendations for or against a specific tool.

The second option was to recommend a set of tools to support the PADEP.[2] Similar to the efforts of EUCLID RTP 11.13, such a tool set would directly support the PathFinder programme and cover all steps of the FEDEP/PADEP. It would consist of a selection of currently available tools or new tools built especially for PathFinder.

Although the heading of this TAP suggests the second option would be chosen, MSG-005 decided to pursue the first for the following reasons:

- The requirements definition phase of PathFinder is being developed independently of this TAP and has not been finalised for use by MSG-005. Therefore, identifying tools against evolving requirements was considered too risky.
- A dedicated tool set suited for PathFinder would have been inflexible. The first option, however, was open to any federated simulation environment and would serve a broader section of the M&S community.
- The development of a tool set is a major undertaking as the experiences from EUCLID RTP 11.13 demonstrated. When MSG-005 started, PathFinder had an ambitious timeline and the development of a specific tool set could have delayed the programme.

To summarize, the MSG-005 Task Group decided to concentrate on tools specific to the development of any HLA federation, not just PathFinder. Nevertheless, two co-ordination meetings occurred with the PathFinder programme to ensure their requirements were being met.

General-purpose software development tools were excluded because of the assumptions discussed above. The database does not contain product marketing or commercial details because the Task Group had no desire to provide extensive commercial information or to promote specific tools. Instead, Point of Contact (POC) information has been provided for those desiring additional information.

4.3 TOOL LIST DATABASE

The database was to be based on the DMSO and EUCLID tool lists enriched by the investigations and contributions of the MSG-005 Task Group members. However, upon initial investigation of the DMSO and EUCLID tool lists, the MSG-005 Task Group discovered that the level of detail was inadequate for its purposes. Therefore, a spreadsheet was created to store more detailed information.

At first, use of Microsoft® Excel© or Access© for storing and retrieving tool information looked quite promising. Unfortunately, refining the data structures became complex. Eventually, XML was chosen to develop the database because it offered a more flexible and effective solution. Figure 7 shows the XML editor used to develop the tool list database.

[2] See Section 1.2 and Chapter 3.

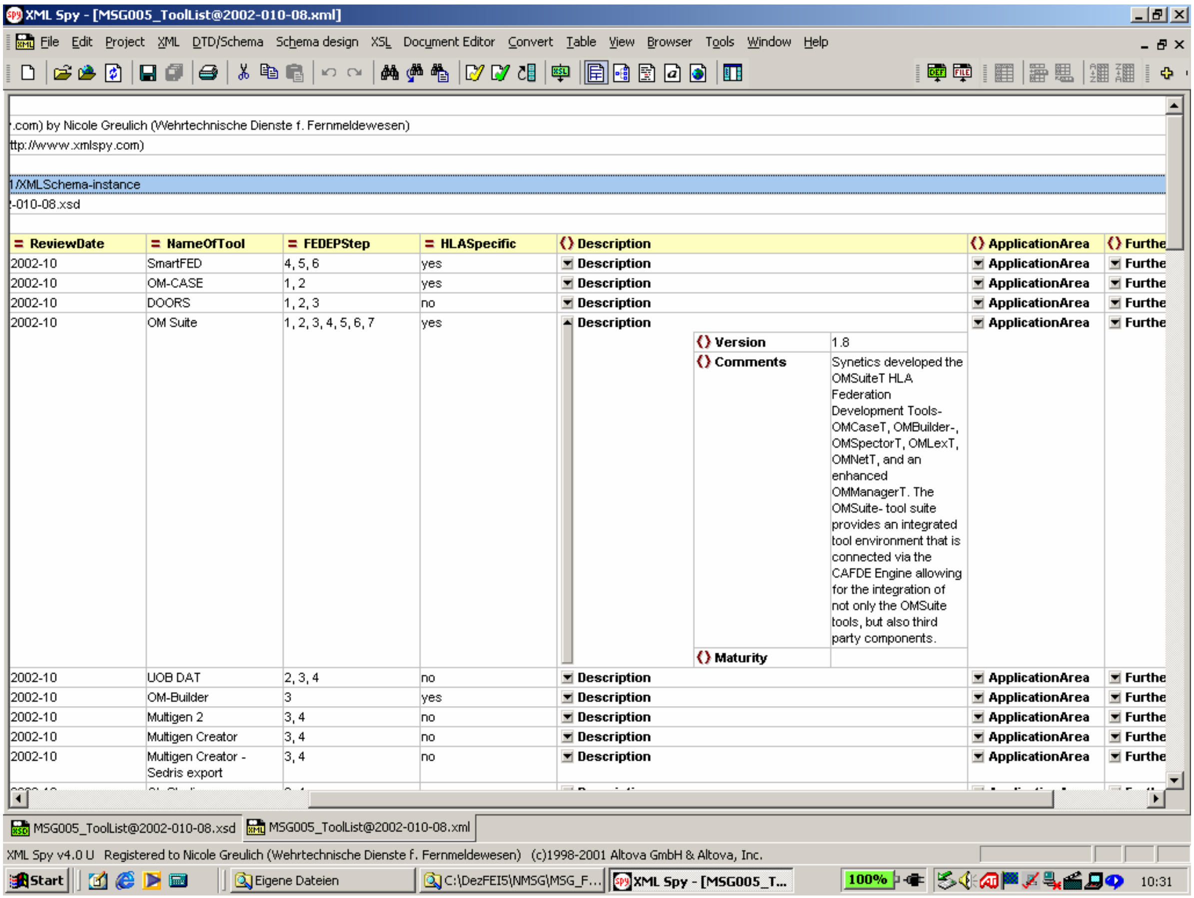

Figure 7: Screen-Shot of the Tool List within the Database Development Software.

Additionally, XML made the use of Hyper Text Mark-up Language (HTML) possible for output pages, making a web-like interface feasible. The ease of using an Internet browser to search the database solidified the decision. That said, other output formats, such as Adobe® Portable Document Format (PDF), can still be produced without affecting the data set.

A spiral development process was used to produce the database. After a draft definition of the logical structure, Task Group members were assigned responsibility for tools and provided a list of background information corresponding to the database elements. The logical structure, in terms of a Document Type Definition (DTD) or schema, is explained further in Section 4.4 and Annex E. From this, an XML extract was generated and entered into the data file. The logical structure and tool information were revised three times prior to finalisation of the data set.

4.4 THE XML SCHEMA

The basic philosophy behind XML is the separation of structure, content and presentation style. An XML project like the FEDEP tool list consists of three parts:

- **The XML Schema Definition:** In this file (extension ".xsd"), the logical structure of the data is contained in XML syntax. Alternatively, a Document Type Definition (DTD) file (extension ".dtd") can be used, which contains the equivalent information in Backus-Naur Form.
- **The XML file:** This file contains the tool information delineated by XML tags, as defined in the XML Style Definition (XSD)/DTD schema file.

- **The eXtensible Stylesheet Language (XSL) file:** This file defines the rules that specify how to create a formatted output from the XML and the DTD/XSD files. Usually, the XSL file contains the style information to produce an HTML page. However, the more sophisticated concept of XSL Transformation (XSLT) allows for outputs other than HTML, such as PDF. It is important to emphasize that the combination of HTML and JavaScript allows the programming of user-specific retrieval functions, such as sorting on keywords.

Figure 8 depicts the top-level view of the database. The tool list consists of any number of tools, each of which is characterized by a Description, its Application Area (where this tool can be of benefit), and Further Information (vendor information, POC, etc.) For a detailed description of the database schema, refer to Annex E.

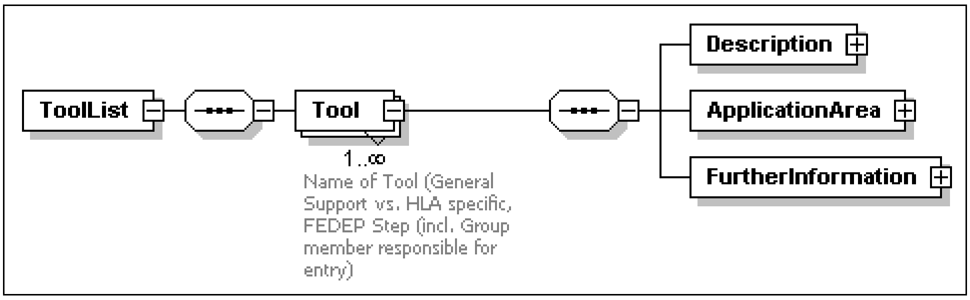

Figure 8: A FEDEP Support Tool is an Element of the Tool List and is Characterised by a Description, Application Area Data and Further Information.

4.5 DATABASE USE

4.5.1 Providing Database Access to Federation Developers

Since the tool list is represented in XML, the format is not easily readable or searchable without a Graphical User Interface (GUI). The database development software that was used to create the tool list provides one, and it can be used to search the tool list; however, the development software is expensive and is intended for database creation rather than end-user access. The database tool also requires end-users to have local access to the database, making centralized updates impossible; it also prevents database developers from having control over end-user access to the raw data. Thus, expecting every person that is interested in searching the tool list to purchase the database development software is not a realistic solution.

A much better approach is to have the XML database hosted on a web site and to provide end-users access to it via a web-based GUI. The GUI would simply be downloaded from the same web site whenever someone visited to search for tool information. The database could also be updated remotely by providing database developers with password-protected access.

Unfortunately, the schedule and resources available to MSG-005 did not permit the development of a GUI or the hosting of the database on a web site. It is a substantial undertaking and requires careful planning. For instance, the GUI should be developed in conjunction with the hosting of the database for several reasons. The GUI may need to consider: the graphic standards used by the hosting site (to ensure a consistent “look and feel”); password protection and firewall systems in place; the software tools used by support staff at the hosting site; etc.

The future NATO Simulation Resources Library would be an ideal site to host the tool list when the library is implemented. Related information will be available on the same site and the software required to support other library functions will probably be more than adequate for supporting the tool database. In the meantime, nations are being polled to develop the GUI and host the tool list on their own web sites as a Voluntary National Contribution (VNC).

Wherever the tool list is eventually hosted, the Task Group recommends that access to it be unlimited. The data is neither classified nor company confidential since it is publicly available.

4.5.2 Presentation Proposal and Services

Assuming that a GUI will be developed at some point, the Task Group recommends the following:

- The GUI should provide the following search criteria as a minimum:
  - The name of a tool
  - The name of the developer/vendor/provider company/organisation responsible for a tool
  - The main functional area to which a tool may apply (its category of use)
  - The FEDEP step(s) to which a tool may apply
  - The availability of a tool (GOTS, COTS, freeware, shareware, etc.)

  As the list is not expected to grow to more than 200 entries,[3] it appears unnecessary to enable a search or sort on all of the entry fields.
- A single generic tool page should be created that dynamically loads tool information from the XML database. Each tool property should be placed in a data field next to an appropriate label.
- Generic tool pages should contain field names that are also links to popup annotations. These annotations will provide additional data describing what each term means and provide illustrative examples.
- Tool pages should contain an e-mail link to a point of contact for the tool to facilitate requests for additional information.
- By selecting a company or organisation name, a complete list of their tools is presented.
- By selecting a FEDEP step, a list of all tools that support the step is presented.
- By selecting a category of tools, a list of all tools in that category is presented.
- After selecting a specific tool, a convenient means is available to find alternative tools from the same category and which support the same FEDEP step.

4.5.3 Update/Maintenance of the Tool Database

Regardless of which organisation maintains the tool list, MSG-005 suggests that it provide a means of enabling vendors to change their tool information. Vendors should not be able to upload new information directly; instead, they should submit requested changes to a decision authority that reviews and validates them. The decision authority should ensure that all changes are factual and not subjective. For example, the authority should reject overt marketing information that a company wishes to add.

4.6 DATABASE ANALYSIS

One of the objectives of the Task Group was to evaluate how well the tools in the database meet the needs of federation developers. Since the Task Group wished to make its results broadly applicable rather than to focus on the needs of a particular federation, it decided to analyse the tools based on:

[3] By mid-2003, the list contains less than 100 tools.

- their applicability to the seven steps of the IEEE 1516.3© version of the FEDEP (see Reference A.3-9), and
- their coverage of eight "application areas", each of which may overlap several FEDEP steps or be a special case within one of the steps.

These analyses are described separately below.

4.6.1 Tool List Categorised by IEEE FEDEP Step(s)

Each entry in the tool database contains the FEDEP step(s) to which the tool applies. By searching the database and counting the number of tools that are applicable to each step, the steps that are well supported by tools, and those that are not, become apparent.

The Task Group performed such an analysis in February 2003 and reported the results at the SISO Spring 2003 SIW [A.4-1]. At the time, the database contained 79 tools. Figure 9 presents the results based on the different combinations of steps that the tools supported. For instance, only 1 tool supported Steps 1 through 3, 11 supported Steps 3 and 4, etc. Clearly, the vast majority of tools are applicable to more than one step, the only exception being 3 tools that only support Step 4. The largest group (containing 26 tools) supported Steps 4 through 6, which suggests that these steps probably have similar tool requirements.

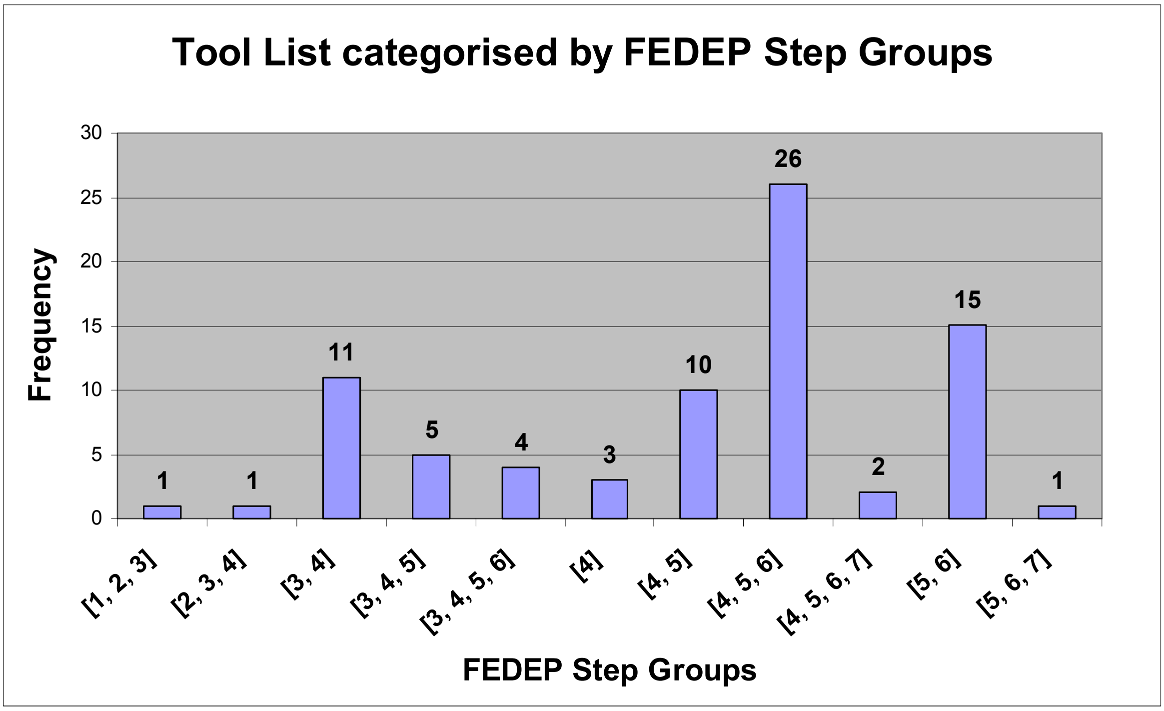

Figure 9: Tool List Categorised by Groups of IEEE 1516.3© FEDEP Steps.

Figure 10 presents the results of the analysis in the form of a "radar diagram". Experience has shown that this type of diagram is the best for depicting the relative level of tool support for the various FEDEP steps.

The radar diagram has an axis emanating from its centre for each FEDEP step, and each axis is labelled with the step number in square brackets. A point is plotted along each axis to indicate how many tools are applicable to the step, the distance from the centre indicating how many. Each point is also labelled with the number of tools (in bold font). The concentric rings provide a scale; the number of tools that each ring represents is shown beside the axis corresponding to FEDEP Step 1. Note that the value for the outermost ring (80) is slightly more than the number of tools in the database (79). Points on adjacent axes are joined by lines, which result in the polygon shown. The position of the polygon (or to be more precise, the positions of its vertices) relative to the centre of the diagram indicates any bias of the tools towards particular FEDEP steps.

As seen in the Figure 10, the available tools indicate a strong bias towards FEDEP Steps 4, 5 and 6, that is, development through execution. This strong support is not too surprising considering that the activities involved in these steps (develop, integrate, execute, etc.) involve relatively well-defined software and hardware development functions. The software development area is also one in which it is usually quite easy to market specialized software tools. Some tools may even have their origins in tools that were created by software developers to support their own federation development activities.

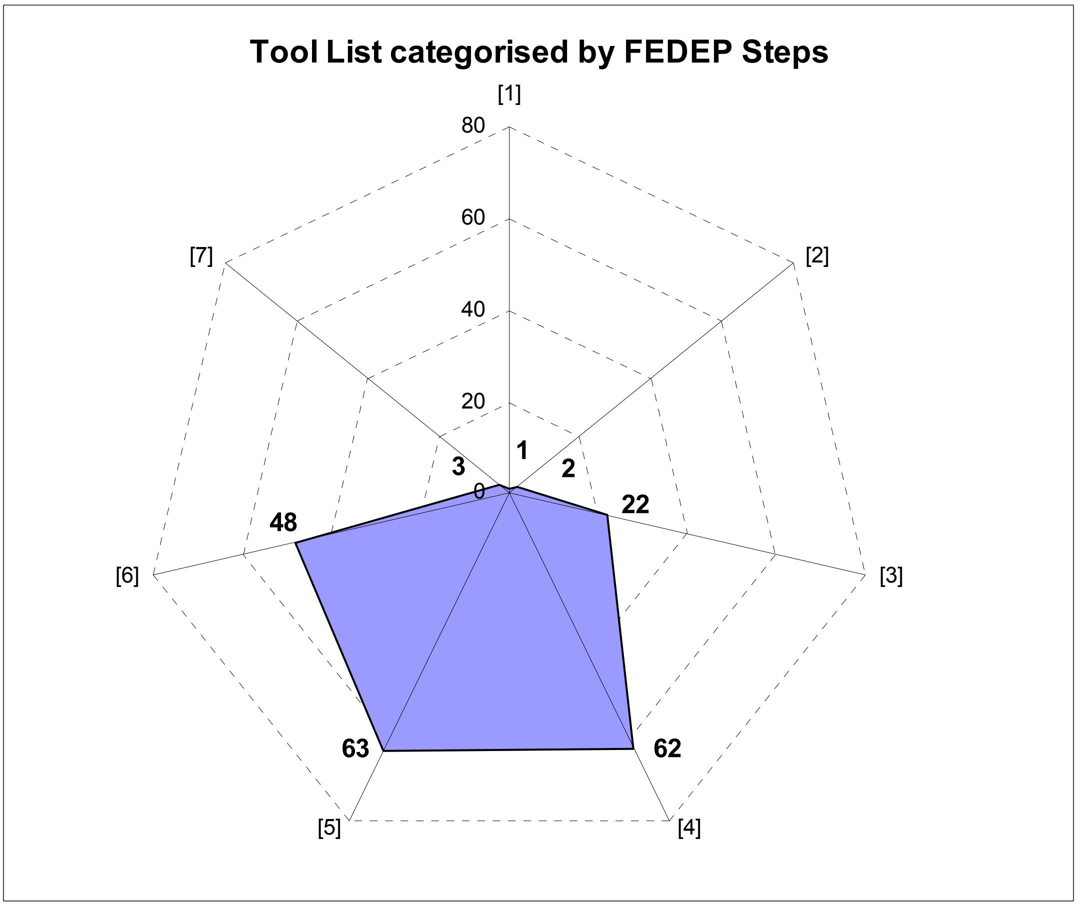

Figure 10: Number of Tools Available for Each of the Seven IEEE 1516.3© FEDEP Steps.

Unlike the support for Steps 4 to 6, Steps 1, 2 and 7 (*Define Federation Objectives*, *Perform Conceptual Analysis*, and *Analyze Data and Evaluate Results*, respectively) are barely supported by tools at all, with no more than 3 tools available for each one. The lack of support is surprising but weak support could have been expected at least for Steps 1 and 2: both involve relatively "soft" activities (defining objectives and performing conceptual analysis) which are less well-defined than those associated with Steps 4 to 6. Thus, tool requirements are more vague which discourages their development. Step 1 and 2 activities are also relatively independent of HLA considerations (compared to federation development and execution) and may be adequately handled by general-purpose requirements capture tools.

Lack of support for Step 7 (data analysis) is more surprising than for Steps 1 and 2 because data analysis is likely to require standard mathematical and database query functions, all of which are well-defined. One possible explanation is Step 7 activities, such as those for Steps 1 and 2, are relatively independent of HLA considerations and general-purpose analysis tools may again be proving adequate. Another possible reason for the lack of tools explicitly supporting Step 7 may be that this step did not exist in the former versions of the FEDEP (including US DoD Version 1.5); it was only identified during the development of the recent IEEE version.

Step 3, federation design, is supported by 22 tools. While not as many as for Steps 4 to 6, the number is considered adequate because federation design is not likely to require as many tools as federation development, integration, and execution.

4.6.2 Tool List Categorised by Application Area

The above analysis evaluated tool availability based on the FEDEP steps. While valuable to people who are working on a particular step, it ignores overlapping requirements that are shared by multiple steps and does not take into consideration how well a tool supports each step.

To offer an alternative perspective on HLA tools, tool support for eight different application areas was analysed. Each area represents a categorisation of tools with little or no regard for the FEDEP steps; in fact, each application area may overlap several FEDEP steps or be a specialised area within one of the steps.

The application areas, derived from the NIAG Report [A.2-2], are as follows:

- **FedDev:** A tool in this category can be used during FEDEP Steps 4 or 5 to create software or data that is eventually used during federation execution, or to provide support functions such as managing software requirements and/or test and integration. A tool that produces software or databases that are used during federation execution also supports the FedEx category (described below).
- **NatEnvGen:** Tools in this category can be used to create or edit synthetic natural environments such as terrain data, visual models, etc. Assuming that the resulting synthetic natural environments are used during FEDEP Steps 4 to 6, a tool that supports the NatEnvGen category also supports the FedDev (Steps 4 and 5) and FedEx (Step 6) categories; it may also support other categories such as AAR (Step 7).
- **ScenDev:** A tool that supports the ScenDev category can be used to help develop an exercise scenario, such as providing planning tools for force deployment and testing entity interactions (Steps 2 to 5). A tool that supports the NatEnvGen category but only creates natural environments or visual equipment models is not considered supportive of the ScenDev category.
- **FedEx:** A tool in this category is used, or produces software or databases that are used, during federation testing and execution (Steps 5 and 6). For instance, RTI software supports this category.
- **Viewers:** In this category, the tool provides a 2D or 3D view of exercise synthetic environments, such as terrain and equipment visual models. The tool must be usable during one or more of FEDEP Steps 4 to 7. Tools that incorporate 2D or 3D viewers to manipulate data off-line (such as equipment visual-model editors) are not considered supportive of this category.
- **AAR:** This category indicates that the tool is designed to support After Action Review activities, including data collection during federation test and execution (Steps 5 to 7). In the case of a general-purpose tool, it is likely to be used, or can produce software or databases to be used, during AAR.

- **CCIS_IF:** In this category, the tool is designed to support interfacing simulations to Command and Control Information Systems (CCIS) (Steps 4 to 6). In the case of a general-purpose tool, it is likely to be used, or can produce software or databases to be used, to help interface simulations to CCIS.
- **VV:** Tools in this category are designed to support verification and/or validation (V&V) activities (Steps 1 to 7). In the case of a general-purpose tool, it is likely to be used, or can produce software or databases, for V&V activities.

Before evaluating the tool availability in these application areas, the Task Group decided to take into consideration the degree of support for each area since support can vary dramatically from one tool to the next. As a result, the following four support ratings were used: none, minimal, partial, and substantial. Admittedly, each tool rating is very subjective but this approach was considered substantially better than a binary yes/no rating. Unfortunately, a quantitative rating based on a thorough analysis of each tool was simply not feasible given the time available and the number of tools to be rated.

In June 2003, the Task group rated how much support each of the 79 tools in the database provided to the application areas. Table 2 presents the results.

The value of the subjective rating becomes evident when the fifth and sixth (that is, the third- and second-last) columns are compared. The number of tools that provide substantial coverage (in the fifth column) is usually much less than half the number that provides minimal or more support (in the sixth). This difference is very significant and it would not be evident if a binary scale had been used. For instance, with a binary scale, the table would have indicated that 41 tools were available for VV activities. The fact that only 2 provided substantial support would have been less evident.

Figure 11 provides a graphical view of the Table 2 results. It indicates the percentage of the total number of tools in the database that provide the different levels of support for each application area.

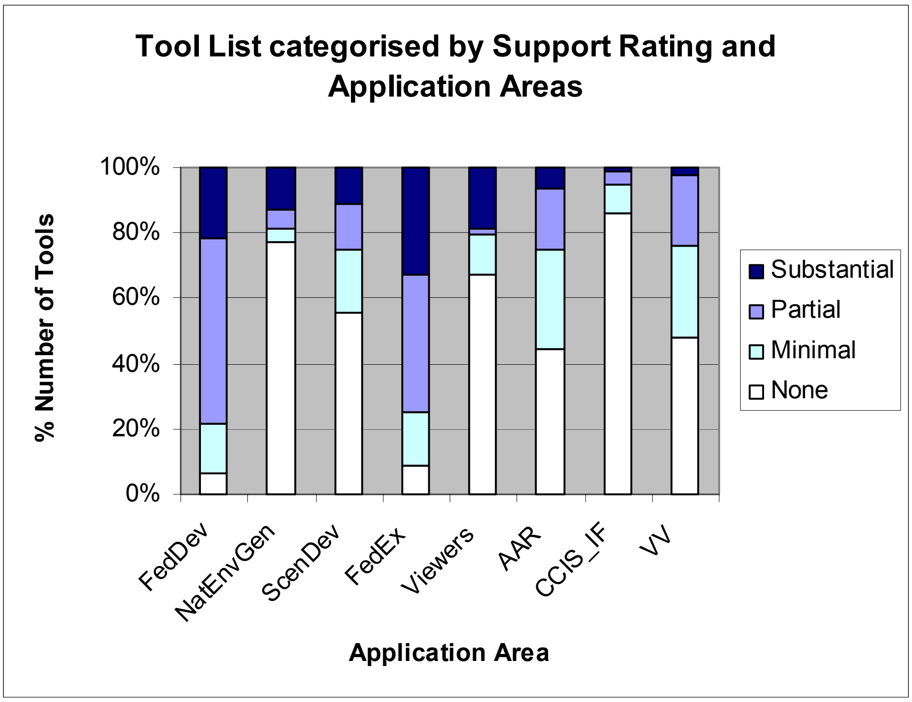

Figure 11: Tool List Categorised by Application Area.

Table 2: Tool List Categorised by Application Area and Support Rating

Application Area	Number of Tools for Each Level of Support					
	None	Minimal	Partial	Substantial	Minimal or More	Partial or More
FedDev	5	12	45	17	74	62
NatEnvGen	61	3	5	10	18	15
ScenDev	44	15	11	9	35	20
FedEx	7	13	33	26	72	59
Viewers	53	10	1	15	26	16
AAR	35	24	15	5	44	20
CCIS_IF	68	7	3	1	11	4
VV	38	22	17	2	41	19

Regarding which application areas are well covered, federation development and execution have the most support with approximately 60 tools each providing at least partial or substantial support (as seen in the rightmost column of Table 2). Both areas are well supported just by those tools providing substantial support, that is, federation development by 17 and execution by 26.

Natural environment generation and scenario development are also well supported with 15 and 20 tools, respectively, providing partial or substantial support. Given the number of Geographic Information Systems (GIS) and related applications available in the marketplace, presumably many more tools are available for natural environment generation.

The viewer category is also well supported, with 15 tools providing substantial support. Relatively few tools in this category provide minimal or partial support, indicating that tools that support this category are specifically designed for it.

The distribution of tool support for AAR and VV is similar. Both have more than 40 tools providing minimal or better support, but only a handful provides substantial support. Since the majority of the 40-plus tools provide only minimal or partial support in both areas, the support may be more by accident than design. As an example, several stealth viewers were rated as providing partial support for AAR and VV because they do not provide any features that are specifically designed for these areas.

The CCIS_IF area is the least well-supported area. Only 11 tools are available even when those with minimal support are included; in fact, only 1 provided substantial support. One explanation is CCIS_IF is probably the most specialised area of the eight and so customised software solutions, rather than an off-the-shelf tool, are required to handle the complex problems that arise. Thus, tool support can be expected to be minimal.

Overall, the first five application areas appear to be well supported; the last three are not. The lack of tools for the CCIS_IF area is understandable given how specialised it is; however, the lack of tools providing substantial support for AAR and VV is somewhat surprising. One possible explanation is that general-purpose tools are being used and proving adequate. Unfortunately, this cannot be determined from the database.

Chapter 5 – CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

MSG-005 Task Group has successfully accomplished its mission to identify tools that support the various steps of the IEEE 1516.3© FEDEP. To date, a total of 79 tools have been identified and catalogued in the MSG-005 database. The largest number of these tools support FEDEP Steps 4, 5, and 6 (*Develop Federation*; *Plan, Integrate and Test Federation*; and *Execute Federation and Prepare Outputs*; respectively), while no more than three tools support Steps 1, 2 and 7 (*Define Federation Objectives*, *Perform Conceptual Analysis*, and *Analyze Data and Evaluate Results*, respectively). The Task Group anticipates an improvement in this situation with the availability of additional tools from the EUCLID RTP 11.13 programme, which will demonstrate its capabilities in November 2003.

The lack of availability of tools should not be viewed as a negative, however. This project represents the first time that an analysis of available tools has taken place, and it has pointed out deficiencies and possible opportunities for further tool developments. With the information contained in this single source, federation managers will be able to rapidly identify tools, their capabilities and the sources for additional information.

5.2 RECOMMENDATIONS

Generating a database of tools that support the FEDEP is only the first step in creating and maintaining a viable product for the NATO Modelling and Simulation community. The issues of dissemination and maintenance need to be addressed. The information contained in this report is dynamic and will require periodic update if the product is to remain valuable. In addition, there may be vendors that were not available to the Task Group that will want to contribute tool information to the database in the future. Therefore, the MSG-005 Task Group recommends that:

1) The NMSG implement the recommendations made by this Task Group in November 2001 to request funding support from the RTA to create a web-based capability to access and maintain the tool database.

2) As an interim solution, the NMSG permit the hosting and support of the tool database on a web site through Voluntary National Contributions (VNC).

3) The NMSG create a follow on Task Group responsible for meeting on an annual or semi-annual basis to review and update the information contained in the FEDEP tool database.

4) The follow-on Task Group publish an addendum to this report and update the FEDEP tool database when the RTP 11.13 tools become available.

5) The NMSG approve this report, implement the recommendations and provide the necessary oversight.

Annex A – REFERENCES

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Annex C – LIST OF ACRONYMS

Acronym	Meaning
AAR	After Action Review
ACE	Allied Command Europe
ACSTP	ACE Command and Staff Training Programme
AMG	HLA Architecture Management Group
CAX	Computer Assisted Exercise
CCIS	Command, Control and Intelligence System (C2I Systems)
CEPA	Common European Priority Area (EUCLID)
CFP	Call For papers
CGF	Computer Generated Forces
CIS	Communication Information System
CJTF	Combined-Joint Task Force
CNAD	Conference of National Armament Directors
ConOps	Concept of Operations
COTS	Commercial-Off-The-Shelf
CRO	Crisis Response Operations
C2I	Command, Control and Intelligence
C3I	Command, Control, Communications & Intelligence
DIF	Data Interchange Format
DiMuNDS	Distributed Multi-National Defence Simulation
DMSO	Defense Modeling & Simulation Office (US DoD)
DoD	U.S. Department of Defense
DST	Decision Support Tool
DTD	Document Type Definition (XML)
DTED	Digital Terrain Elevation Data
EUCLID	European Co-operation for the Long term In Defence
FDD	FOM Document Data
FED	Federation Execution Data
FEDEP	Federation Development and Execution Process (HLA)

FEPW	Federation Execution Planners' Workbook
FOM	Federation Object Model (HLA)
GIS	Geographic Information System
GOTS	Government-Off-The-Shelf
GUI	Graphical User Interface
HLA	High Level Architecture (US DoD Standard 1.3 (1998) and IEEE Standard 1516 (2000 to 2003))
HQ	Headquarters
HTML	Hyper Text Mark-up Language
ICT	Initial Common Tools
IEEE	Institute of Electrical and Electronic Engineers
JALLC	Joint Analysis Lessons Learned Centre
LAN	Local Area Network
MC	NATO Military Committee
MG	Management Group (EUCLID)
MSCO	Modelling & Simulation Co-ordination Office (NATO)
MSIAC	Modeling and Simulation Information Analysis Center (U.S.)
MSMP	Modelling and Simulation Master Plan (NATO and US DoD)
M&S	Modelling & Simulation
NAC	North Atlantic Council
NATO	North Atlantic Treaty Organization
NFDT	National Federate Development Team (PADEP)
NIAG	NATO Industry Advisory Group
NMSG	NATO Modelling and Simulation Group
OMDT	Object Model Development Tool
OML	Object Model Library
OMT	Object Model Template

PADEP	PathFinder Development and Execution Process
PDF	Portable Document Format (Adobe®)
PfP	Partnership (or Partners) for Peace
POC	Point Of Contact
POW	Programme Of Work
PROC	Federation Development Process Forum of SISO
PSG	Pathfinder Steering Group
RID	RTI Initialisation Data
RTA	Research and Technology Agency (NATO)
RTB	Research and Technology Board (NATO)
RTI	Run-Time Infrastructure (HLA)
RTO	Research and Technology Organisation (NATO)
RTP	Research and Technology Project (EUCLID)
R&D	Research and Development
SAC	Standards Activity Committee (SISO)
SE	Synthetic Environment
SEDEP	Synthetic Environment Development and Execution Process (EUCLID RTP 11.13)
SGMS	Steering Group for M&S (NATO)
SISO	Simulation Interoperability Standards Organization
SIW	Simulation Interoperability Workshop (SISO)
SOM	Simulation Object Model (HLA)
SRL	Simulation Resources Library (SRL)
STANAG	Standardisation Agreement (NATO)
TAP	Technical Activity Programme (RTO)
TEEP	The PfP Training and Education Enhancement Programme
TG	Task Group (RTO)
TOR	Terms Of Reference (RTO)
UK	United Kingdom
US	United States of America
VNC	Voluntary National Contribution
VV&A	Verification, Validation, and Accreditation
V&V	Verification and/or Validation

WAN	Wide Area Network
WE	Working Element (EUCLID RTP 11.13)
WEAG	Western Europe Armament Group
XML	eXtensible Mark-up Language
XSD	XML Style Definition
XSL	eXtensible Stylesheet Language (XML)
XSLT	XSL Transformation (XML)
2D	Two-dimensional
3D	Three-dimensional

Annex D – PADEP and SEDEP

D.1 PATHFINDER DEVELOPMENT AND EXECUTION PROCESS (PADEP)

The PathFinder Development and Execution Process (PADEP) is the result of tailoring the Federation Development and Execution Process (FEDEP) Version 1.5 (described in Chapter 2 and Reference A.3-1) to meet the particular needs of the PathFinder programme.

The PADEP, as described in Appendix B of the NIAG Phase 2 Report [A.2-2], was further extended in the NIAG final report [A.2-3]. For example, federation management issues are described, step-by-step, in Chapter 5 and the PathFinder task list is summarised in the annex.

The PADEP consists of six major steps. The documents to be generated in the PADEP and their interconnections are shown in Figure D1.

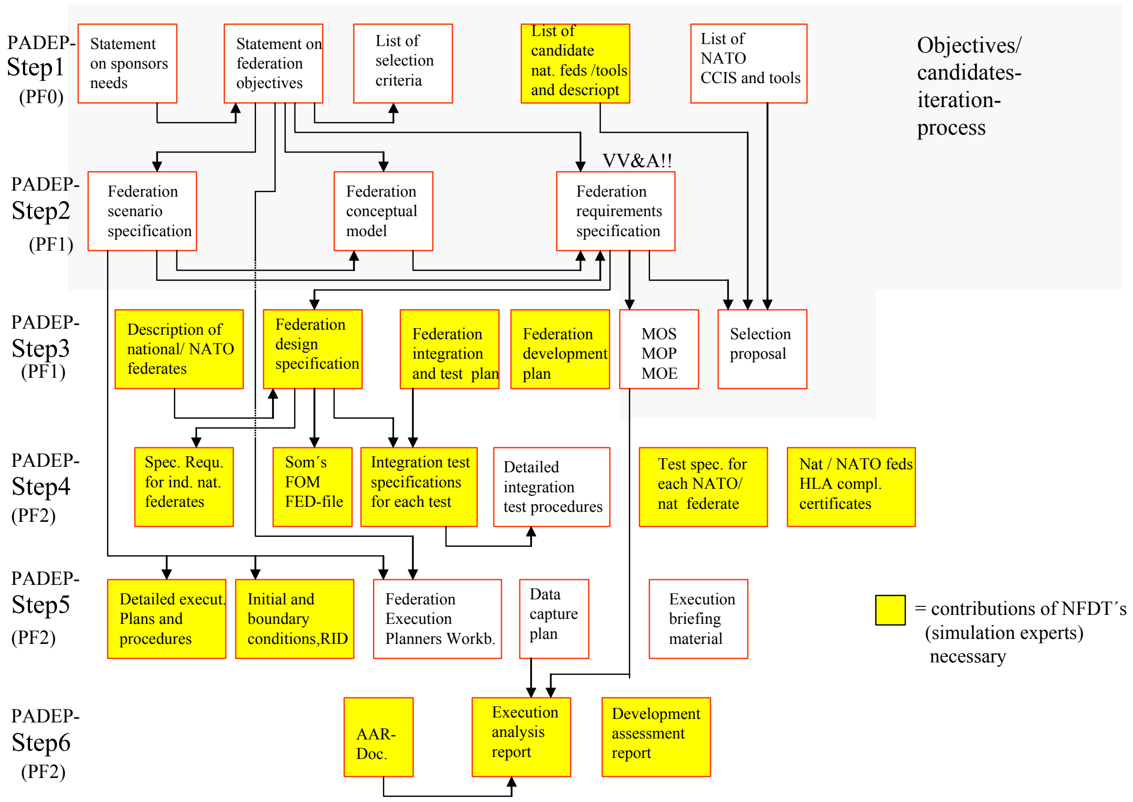


Figure D1: PADEP – Documents and their Interconnections.

D.2 SYNTHETIC ENVIRONMENT DEVELOPMENT AND EXPLOITATION PROCESS (SEDEP)

D.2.1 Introduction

The Synthetic Environment Development & Exploitation Process (SEDEP) originated as part of a major European research initiative, European Co-operation for the Long-term In Defence (EUCLID) Research and Technology Project (RTP) 11.13. EUCLID RTP 11.13 was established to identify and overcome obstacles which prevent SEs being exploited within and across European nations. This was achieved by developing a common process (that is, the SEDEP) underpinned with an integrated software tool suite to reduce the cost and timescale of specifying and developing SE applications. The SEDEP is based on the Federation and Development and Execution Process (FEDEP), which has been extended and enhanced to satisfy the wider needs of the SE community.

For the purpose of the SEDEP, the term "Synthetic Environment" means the integration of models, simulations, people and real equipment into a common representation of the world and is synonymous with the FEDEP term "federation". The term "SE" is more commonly used by the users of simulations, whilst the term "federation" is used more by the developer community. In the following description, the more appropriate term is used according to the context in which it is used.

The purpose of the SEDEP is to:

- Encourage use of SE technology to benefit different application domains, such as equipment acquisition, training, etc.
- Provide guidance to developers and users to help them plan and perform the different activities necessary to produce the required products and results.
- Promote good practice for developing SEs on time and within budget.
- Promote re-use of products (federations, federates, components, etc.) and results.
- Provide a framework for a tool set to reduce the cost and time for creating and utilising SEs.

D.2.2 SEDEP Overview

The SEDEP contains eight steps as shown in Figure D2, with each step consisting of a number of activities. In addition, each step has its own feedback loops and multiple internal iterations may be performed without interfacing to other steps. The interfaces between steps are more formal and occur less frequently than between activities within a step.

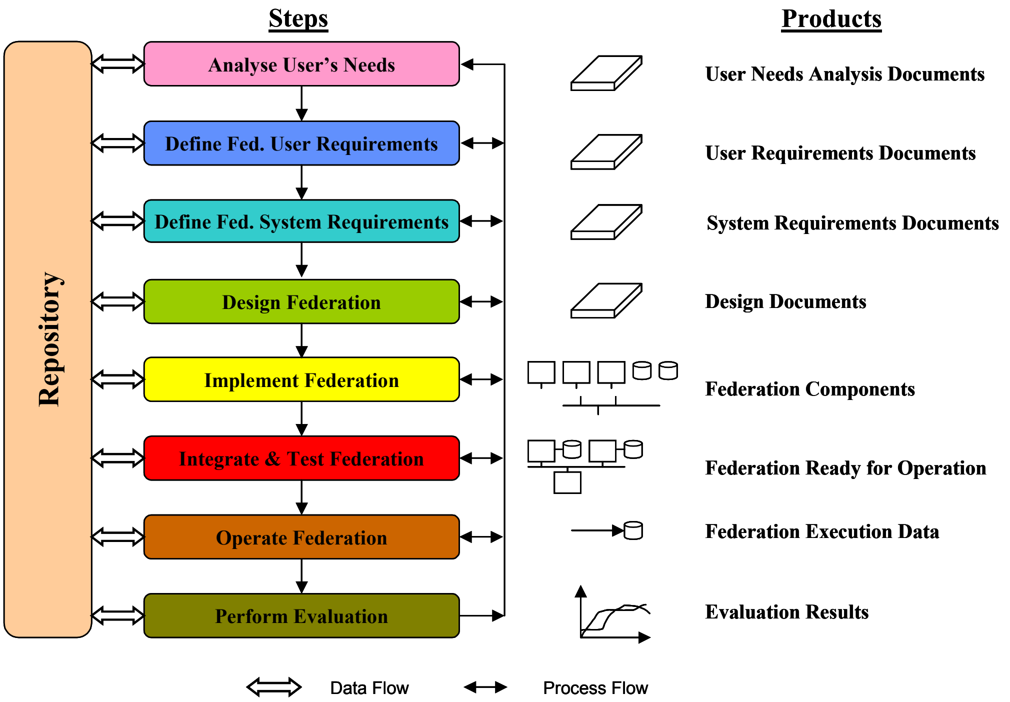


Figure D2: SEDEP Steps and Products.

Two complementary representations ("views") are used to describe the SEDEP:

- **Steps Representation**: In this view, the various activities are organised into sequential steps along the whole process. Each one covers a specific phase of the SE lifecycle.
- **Overlays Representation**: In this view, the different activities of the process are thematically organised into overlays. Each one covers a specific theme or aspect of the SE, which requires a specific technical environment and/or special expertise.

A software tool suite, including a repository, underpins the SEDEP process. The Repository Software Architecture serves two purposes, that is, to store information about existing SE assets (such as simulation systems, databases, etc.) to promote re-use, and to store data generated by a SEDEP step/activity so that it is available as input to other steps/activities.

An important aspect of the SEDEP is that it may be used iteratively. This means that it may be initiated several times for a particular SE project and that successive iterations build on the information already available. The SEDEP is tailored for each iteration to meet the requirements of the objective of the iteration. This means that for some iterations, some activities are performed to a low level of detail or even not performed at all. An important aspect of the tailoring is the specification of the particular tools used to support the different activities.

Although the steps are shown as sequential, in practice, the steps may run concurrently with one step starting before the proceeding one has finished. Feedback loops are used where it may be necessary to revisit an earlier step as a result of actions performed in later ones.

The SEDEP steps are:

- **Step 0: Analyse User's Needs.** The aim of this step is to define and analyse user needs in order to understand what results the SE should provide and the purpose of the current SEDEP iteration. This information enables the SE systems engineer to plan how the SEDEP iteration should be performed. The project planning not only includes traditional project management planning activities but also tailoring the process to satisfy the requirements of the SEDEP iteration. An important outcome of the analysis is to determine the scope of re-use, which can dramatically reduce the cost of the SE by identifying relevant existing SE knowledge and assets.
- **Step 1: Define Federation User Requirements.** The purpose of this step is to turn the loosely defined user needs into a complete and unambiguous specification of the user's requirements for the federation. The specification contains three elements: atomic user requirement statements, the scenario(s) to be run on the federation, and the evaluation objectives of the user.
- **Step 2: Define Federation System Requirements.** The purpose of this step is to translate the user requirements into the requirements for an SE that will provide an appropriate representation of the real world for solving the problem under investigation. The federation system requirements consist of three elements: a conceptual model, which provides an implementation independent representation of the federation; atomic system requirement statements; and the evaluation definition, which specifies the criteria, methods, algorithms and data definitions to be used in the evaluation step to analyse and evaluate the execution outputs.
- **Step 3: Design Federation.** The purpose of this step is to identify, evaluate, and select all the federation participants (federates), and to allocate required functionalities and subsets of the scenario pertinent to the federates. Where no suitable federates can be found, existing ones are adapted or new ones designed to provide the desired functionality. In addition to the design documents, detailed test plans are produced for verifying and validating the operation of the federation. This step also defines activities for designing the databases and the network and computer infrastructure required to support the federation.

- **Step 4: Implement Federation.** The purpose of this step is to produce the Federation Object Model (FOM), which describes the interactions betweens the participants and, when necessary, to build and/or modify federates. Once all of the federation elements have been implemented, unit testing is performed so that they are ready for integration and system testing.
- **Step 5: Integrate & Test Federation.** The purpose of this step is to integrate the federation elements with the run-time infrastructure and to ensure that the federation is ready for operation. This includes testing the interactions between federates, ensuring that the network is reliable and can handle the expected traffic, verifying the federation against the system requirements, and validating the federation against the user requirements.
- **Step 6: Operate Federation.** The purpose of this step is to prepare the federation for operation and to run the federation scenario(s). Preparation activities include training the federation instructors, operators, and technicians and rehearsing the federation executions to identify unforeseen problems.
- **Step 7: Perform Evaluation.** The purpose of this step is to post-process the outputs acquired during the federation execution, analyse them, and evaluate the results. The conclusions are then fed back to the user to decide if the problem has been solved or whether further federation runs are required.

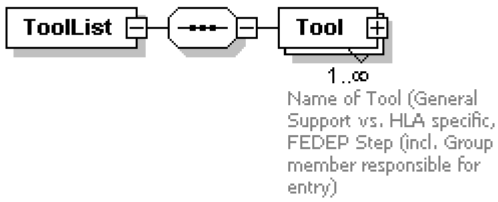
Annex E – DATABASE SCHEMA

This annex serves as a guideline for the manager of the tool list who wants to update information on tools or integrate the database into a web site or some other software application.

E.1 OVERALL STRUCTURE

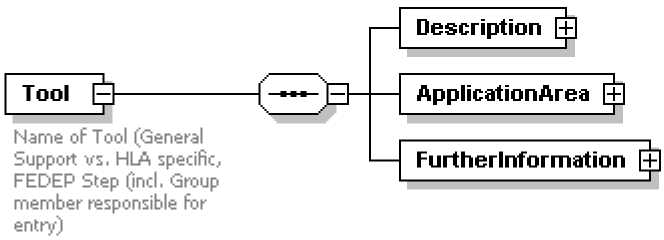
The overall structure of the tool list is tree-like: the root element, ToolList, contains any number of Tool descriptions, each of which is characterised by a number of attributes.

Element ToolList

diagram	
children	Tool

Furthermore, each Tool item contains three more elements, that is, a Description, an ApplicationArea and FurtherInformation. As the picture below shows, each Tool also has some management data (date of tool review and the name of reviewer) and information on whether the tool is HLA-specific and which FEDEP steps the tool supports.

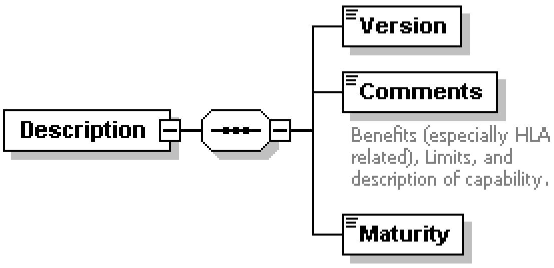
Element ToolList/Tool

diagram					
children	Description ApplicationArea FurtherInformation				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	ReviewedBy GroupMember	xs:string	required		
	ReviewDate	xs:gYear Month	optional		
	NameOfTool	xs:string	required		
	FEDEPStep	xs:string	optional		
	HLASpecific	xs:NM TOKEN	required		
annotation	documentation	Name of Tool (General Support vs. HLA specific, FEDEP step (incl. Group member responsible for entry)			

E.2 ELEMENT: Description

The Description element contains three fields: the Version field specifies the version of the tool that was reviewed, the Comment field contains user review comments, and the Maturity field indicates the maturity of the tool, such as the number of licenses in use or how long the tool has been commercially available.

Element ToolList/Tool/Description

diagram	
children	Version Comments Maturity

Element ToolList/Tool/Description/Version

diagram	
type	xs:string

Element ToolList/Tool/Description/Comments

diagram					
type	extension of xs:string				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	UserInterface	xs:string	optional		
	RealtimeTool	xs:boolean	optional		
annotation	documentation	**Benefits (especially HLA related), Limits, and description of capability.**			

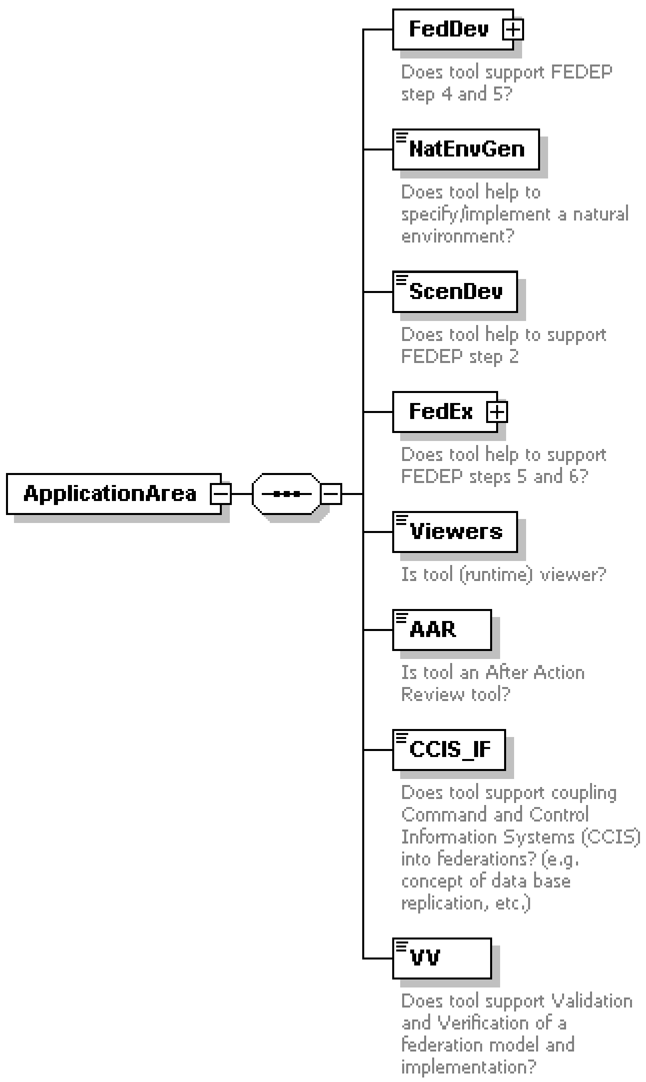
Element ToolList/Tool/Description/Maturity

Diagram	
type	xs:string

E.3 ELEMENT: ApplicationArea

The ApplicationArea element contains information related to the application area of the tool. (The application areas are described in Section 4.6.2 of the report.) The following eight subsections describe the database elements related to each one.

Element ToolList/Tool/ApplicationArea

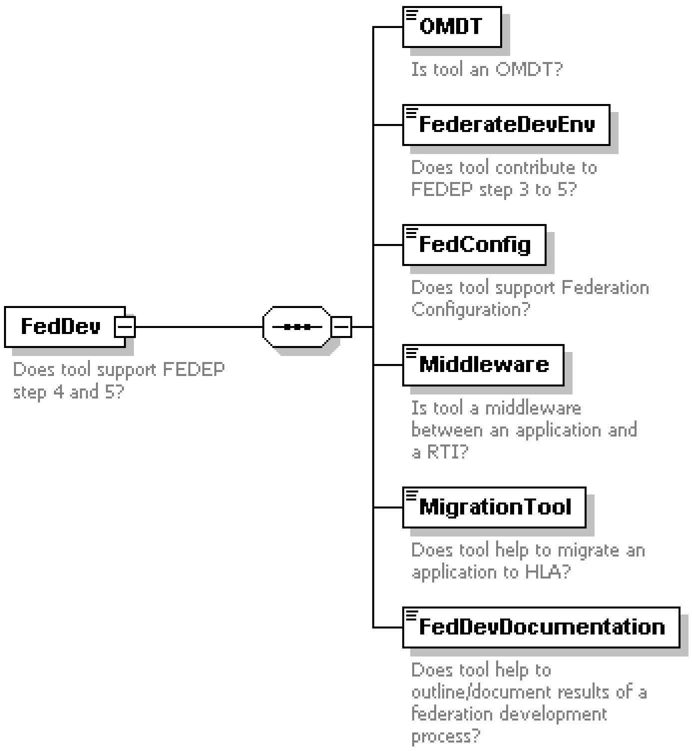
diagram	
children	FedDev NatEnvGen ScenDev FedEx Viewers AAR CCIS_IF VV

E.3.1 Element: FedDev

The FedDev leaf captures information related to the Steps 4 and 5 of the FEDEP. A tool in the FedDev application area, as described in Section 4.6.2, can be used to create software or data that is eventually used during federation execution, or to provide support functions such as managing software requirements and/or test and integration.

The FedDev element contains six leaf elements, each of which contains reviewer comments on whether the tool is used as an OMDT, to contribute to configuring and/or documenting a federation, etc. Additional service layers that help applications deal with an RTI are captured in the Middleware field.

Element ToolList/Tool/ApplicationArea/FedDev

diagram		
children	OMDT FederateDevEnv FedConfig Middleware MigrationTool FedDevDocumentation	
annotation	documentation	**Does the tool support FEDEP step 4 and 5?**

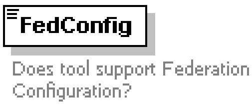
Element ToolList/Tool/ApplicationArea/FedDev/OMDT

diagram		
type	xs:boolean	
annotation	documentation	**Is the tool an Object Model Development Tool?**

Element ToolList/Tool/ApplicationArea/FedDev/FederateDevEnv

diagram		
type	xs:boolean	
annotation	documentation	**Is the tool a support to design, develop and test a federate?**

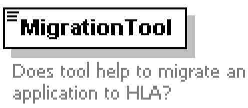
Element ToolList/Tool/ApplicationArea/FedDev/FedConfig

diagram		
type	xs:boolean	
annotation	documentation	**Does tool support Federation Configuration?**

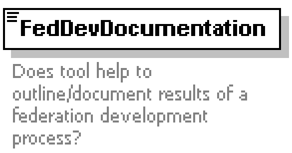
Element ToolList/Tool/ApplicationArea/FedDev/Middleware

diagram		
type	xs:string	
annotation	documentation	**Is the tool a middleware between an application and a RTI?**

Element ToolList/Tool/ApplicationArea/FedDev/MigrationTool

diagram		
type	restriction of xs:boolean	
annotation	documentation	**Does the tool help to migrate an application to HLA?**

Element ToolList/Tool/ApplicationArea/FedDev/FedDevDocumentation

diagram		
type	xs:boolean	
annotation	documentation	**Does tool help to outline/document results of a federation development process?**

E.3.2 Leaf: NatEnvGen

The NatEnvGen leaf contains reviewer comments on how the tool can be used to create or edit synthetic natural environments, such as terrain data, visual models, etc.

Element ToolList/Tool/ApplicationArea/NatEnvGen

diagram		
type	xs:string	
annotation	documentation	**Does the tool help to specify/implement a synthetic natural environment?**

E.3.3 Leaf: ScenDev

The ScenDev leaf contains reviewer comments on how the tool can be used to help develop an exercise scenario, such as providing planning tools for force deployment and testing entity interactions (in FEDEP Step 2).

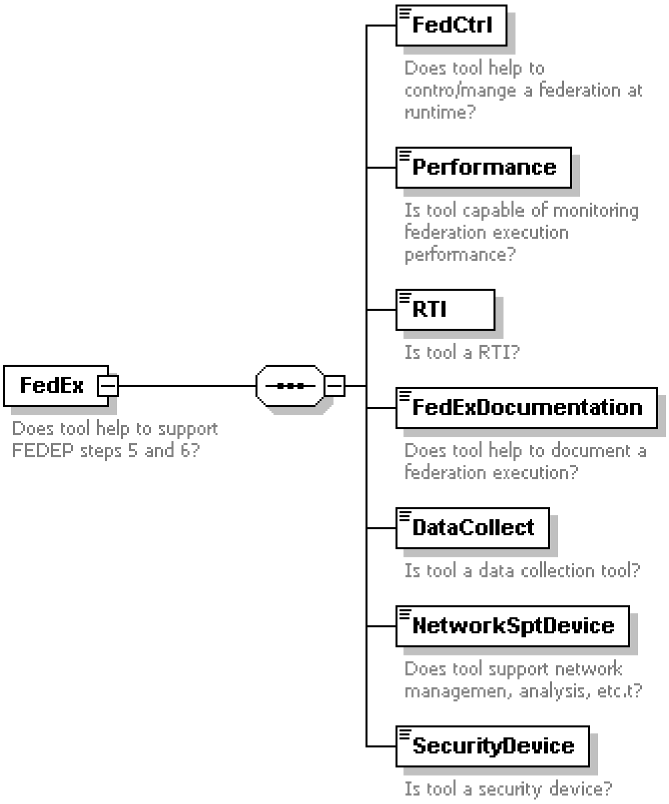
Element ToolList/Tool/ApplicationArea/ScenDev

diagram		
type	xs:string	
annotation	documentation	**Does tool help to support FEDEP step 2 to 5?**

E.3.4 Element: FedEx

The FedEx element contains seven leaf elements. They are used to describe how the tool can be used, or can produce software or databases to be used, during federation testing and execution (FEDEP Steps 5 and 6). Here, issues like controlling a federation, collection of data, documentation and general support are addressed. Security issues are also covered here.

Element ToolList/Tool/ApplicationArea/FedEx

diagram		
children	FedCtrl Performance RTI FedExDocumentation DataCollect NetworkSptDevice SecurityDevice	
annotation	documentation	**Does tool help to support FEDEP steps 5 and 6?**

Element ToolList/Tool/ApplicationArea/FedEx/FedCtrl

diagram		
type	xs:string	
annotation	documentation	**Does tool help to control/mange a federation at runtime?**

Element ToolList/Tool/ApplicationArea/FedEx/Performance

diagram	Performance Is tool capable of monitoring federation execution performance?	
type	xs:string	
annotation	documentation	**Is tool capable of monitoring federation execution performance?**

Element ToolList/Tool/ApplicationArea/FedEx/RTI

diagram	RTI Is tool a RTI?	
type	xs:string	
annotation	documentation	**Is the tool a RTI?**

Element ToolList/Tool/ApplicationArea/FedEx/FedExDocumentation

diagram	FedExDocumentation Does tool help to document a federation execution?	
type	xs:string	
annotation	documentation	**Does tool help to document a federation execution?**

Element ToolList/Tool/ApplicationArea/FedEx/DataCollect

diagram	DataCollect Is tool a data collection tool?	
type	xs:string	
annotation	documentation	**Is tool a data collection tool?**

Element ToolList/Tool/ApplicationArea/FedEx/NetworkSptDevice

diagram	NetworkSptDevice Does tool support network managemen, analysis, etc.t?	
type	xs:string	
annotation	documentation	**Does tool support network management, analysis, etc.?**

Element ToolList/Tool/ApplicationArea/FedEx/SecurityDevice

diagram		
type	xs:string	
annotation	documentation	**Is tool a security device?**

E.3.5 Leaf: Viewers

The Viewer leaf is used to describe the capabilities of the tool to provide a 2D or 3D view of exercise synthetic environments during simulation execution (FEDEP Steps 4 to 7).

Element ToolList/Tool/ApplicationArea/Viewers

diagram					
type	extension of xs:string				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	ThreeDim	xs:boolean	optional	false	
	TwoDim	xs:boolean	optional	false	
annotation	documentation	**Is the tool a (runtime) viewer?**			

E.3.6 Leaf: AAR

The AAR leaf contains reviewer comments on the use of the tool for After Action Review (AAR) activities, including data collection during federation test and execution (FEDEP Steps 5 to 7). In the case of a general-purpose tool, the comments would refer to the ability of the tool to produce software or databases to be used during AAR activities.

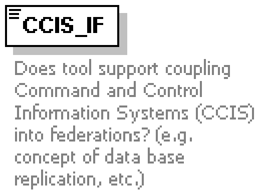
Element ToolList/Tool/ApplicationArea/AAR

diagram		
type	xs:string	
annotation	documentation	**Is tool an After Action Review tool?**

E.3.7 Leaf: CCIS_IF

The CCIS_IF leaf describes the use of the tool for interfacing simulations to CCIS (during FEDEP Steps 4 to 6), or in the case of a general-purpose tool, the ability of the tool to produce software or databases to be used to help interface simulations to CCIS.

Element ToolList/Tool/ApplicationArea/CCIS_IF

diagram		
type	xs:string	
annotation	documentation	**Does tool support coupling Command and Control Information Systems (CCIS) into federations? (e.g. concept of data base replication, etc.)**

E.3.8 Leaf: VV

The VV leaf contains reviewer comments on the use of the tool for verification and/or validation activities (FEDEP Steps 1 to 7). In the case of a general-purpose tool, the comments would refer to the ability of the tool to produce software or databases to be used during V&V activities.

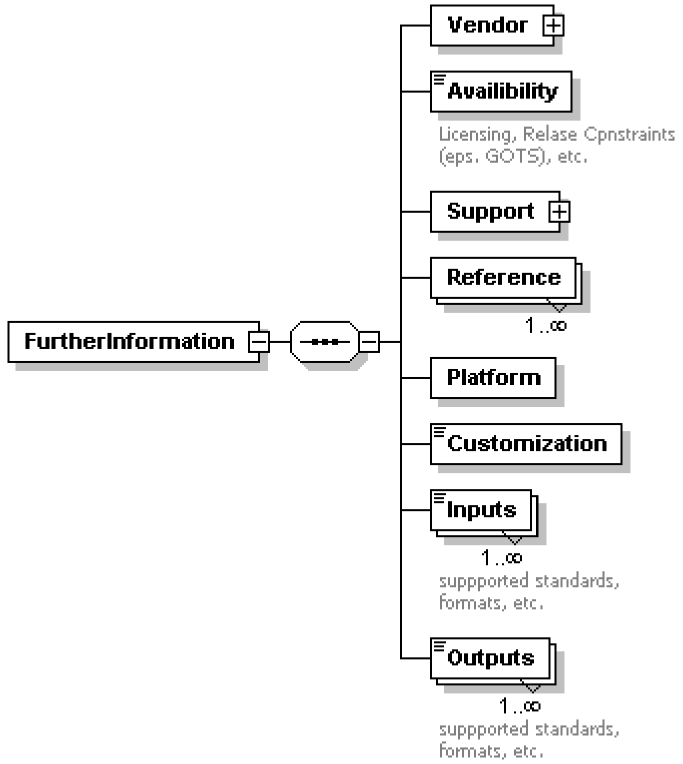
Element ToolList/Tool/ApplicationArea/VV

diagram		
type	xs:string	
annotation	documentation	**Does tool support Validation and Verification of a federation model and implementation?**

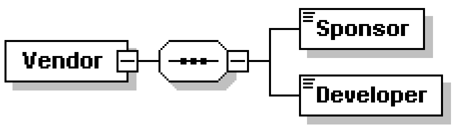
E.4 ELEMENT: FurtherInformation

The FurtherInformation element captures information that is not directly related to the application of the tool. It contains eight more elements, which provide contact and reference information, platform requirements, tool availability and support information, and supported input and output standards. The Customization field contains reviewer comments on the ability to customise the tool, which often involves the dynamic linking of user-provided software or the customisation of configuration files.

Element ToolList/Tool/FurtherInformation

diagram	
children	Vendor Availibility Support Reference Platform Customization Inputs Outputs

Element ToolList/Tool/FurtherInformation/Vendor

diagram	
children	Sponsor Developer

Element ToolList/Tool/FurtherInformation/Vendor/Sponsor

diagram					
type	extension of xs:string				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	NameOfSponsor	xs:string	optional		
	ContactInformation OfSponsor	xs:string	optional		

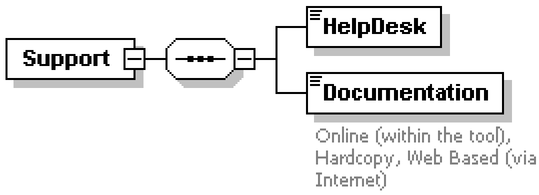
Element ToolList/Tool/FurtherInformation/Vendor/Developer

diagram					
type	extension of xs:string				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	NameOfDeveloper	xs:string	optional		
	ContactInformationOfDeveloper	xs:string	optional		

Element ToolList/Tool/FurtherInformation/Availibility

diagram		
type	xs:string	
annotation	documentation	**Licensing, Release Constraints (e.g. GOTS), etc.**

Element ToolList/Tool/FurtherInformation/Support

diagram	
children	HelpDesk Documentation

Element ToolList/Tool/FurtherInformation/Support/HelpDesk

diagram	
type	xs:string

Element ToolList/Tool/FurtherInformation/Support/Documentation

diagram		
type	restriction of xs:string	
annotation	documentation	**Online (within the tool), Hardcopy, Web Based (via Internet)**

Element ToolList/Tool/FurtherInformation/Reference

diagram	Reference				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	Name	xs:string	optional		
	Program	xs:string	optional		
	ContactInformation	xs:string	optional		

Element ToolList/Tool/FurtherInformation/Platform

diagram	Platform				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	OS	xs:string	optional		
	Memory	xs:string	optional		
	Compiler	xs:string	optional		
	OtherSWRequired	xs:string	optional		
	Hardware	xs:string	optional		

Element ToolList/Tool/FurtherInformation/Customization

diagram	Customization
type	xs:string

Element ToolList/Tool/FurtherInformation/Inputs

diagram	Inputs suppported standards, formats, etc.				
type	extension of xs:string				
attributes	**Name**	**Type**	**Use**	**Default**	**Fixed**
	InputDependencies	xs:string	required	none	
annotation	documentation	**Supported standards, formats, etc.**			

Element ToolList/Tool/FurtherInformation/Outputs

diagram	Outputs suppported standards, formats, etc.	
type	xs:string	
annotation	documentation	**Supported standards, formats, etc.**

Annex F – TOOL LIST SUMMARY

The table below serves as a quick reader's guide to the information provided by the tool list (as it is, July 2003).

The description of the various tools originates either from personal experiences or user interviews. Only in some rare cases was third-party information included. In such cases, publicly available sources (such as Internet sites) were used; however, special care was taken to ensure that no purely commercial statements and/or advertising were included in the table.

It should be stressed that although a comment is by its very nature subjective, the statements given within the table reflect no qualifying ranking in the sense of "tool X is excellent/good/poor". Instead, the table indicates the FEDEP steps where the tool is likely to be useful.

Name of Tool	Supports FEDEP Steps	Description/Comment
BAMBOO	4, 5	Enable applications, regardless of their environmental platform(s) or programming language(s), to be dynamically reconfigurable (take on new functionality at runtime).
Calytrix SIMplicity	4, 5, 6	SIMplicity is an integrated development environment (IDE) that enables developers and scientists to rapidly assemble component-based HLA simulations from new and pre-existing components in a visual environment. SIMplicity assists the developer throughout the development life cycle, from design to development, deployment and execution. SIMplicity uses a template-driven code generation process to create all of the simulation entities for the targeted platform specific simulation model (PSM).
CERTI	4, 5, 6	Experimental RTI developed by the French ONERA institute.
DART	3, 4	Regenerates and optimizes existing visual terrain databases for new platforms; can create new versions based on how new sensors would "see" the terrain.
DCT	4, 5, 6, 7	AAR DMSO tool.
DEVS	4, 5, 6	Discrete Event System Specification (DEVS) is a framework for understanding and supporting the activities of modeling and simulation, based on generic dynamic systems concepts.
DIS Network voice	5, 6	Provides a simulated radio model with shared or individual radio access for operators located on dispersed network nodes.
DIS WAN gateway	5, 6	Support execution
DOORS	1, 2, 3	Requirement Management Tool
Equater	4, 5	Scenario Generation
FedDirector	4, 5, 6	Part of HLA Lab Works, provides the means to monitor and control the federation execution.
FedProxy	4, 5	Part of the HLA Lab Works suite, can debug federate's HLA interface, perform tests of the RTI & network, and even provide a stand-in for missing federates. Part of HLA Lab Works Suite Tests HLA interface.

FEPW	4, 5	HLA support DMSO tools
FLSIM/HELISIM	4, 5	Reconfigurable fixed or rotary wing high-fidelity aero-model which can integrate with any technology which HLA enables a simulation.
FMT	5, 6	HLA support DMSO tools
FVT	5, 6	HLA support DMSO tools
GERTICO	4, 5, 6	Modular RTI based on CORBA.
GL Studio	3, 4	One tool in the category of rapid application development.
HFC SDK 1.3	4, 5	The HFC-SDK 1.0 included the HLA Foundation Class (HFC) Framework, the OMLib Library, the HFC Automation Tool (HAT) on Windows only, and an HFC rework of the HelloWorld sample federate included with the DMSO RTI1.3v6. The HFC provides an application framework for HLA federates in much the same way the Microsoft Foundation Class (MFC) library provides a framework for Windows applications. OMLib offers the ability to dynamically read in and manipulate HLA object model data from OMT-DIF files. The HAT automates the process of mapping HLA object model content to C++ source code (providing traceability) through specialization of HFC components. HFC SDK 1.3 is the current update to HFC-SDK 1.0 and enables development of HLA federates to collaborate with the DMSO RTI 1.3v6.
HLA Control	4, 5, 6	It has all the functionality of the standard HLA FEPW, plus full life-cycle federation management capabilities. It makes it fast and easy to plan your federation, determine if performance requirements are satisfied and even identify and correct run time inaccuracies.
HLA Exercise explorer	5, 6	A fully functional HLA Manager Federate designed to aid in the development of HLA Federates and Federations. The Exercise Explorer provides the developer with critical information about the current running state of an HLA Federation Execution including run time information on each Execution Member.
HLA Integration Framework	5, 6	The framework software provides ready-made use of many HLA functions and simpler interfaces to the RTI.
HLA Results	4, 5, 6, 7	Is a comprehensive data management system with all the features needed to collect, store and understand federation data.
HP Openview Network Node Manager	5, 6	Local area and wide area network management tool.
Ibis Model Editor	3, 4, 5, 6	Ibis Model Editor is a CAFDE-compliant software package designed to create HLA-compliant models. Model Editor is still in a beta, not final, stage. As such it may not be as refined as a final product would be. Trial copies may be downloaded for evaluation purposes only.
Ibis RTI Adapter	3, 4, 5, 6	Ibis RTI Adapter is an ActiveX component that exposes DoD’s HLA (High Level Architecture) RTI (Run Time Infrastructure) to COM/ActiveX applications.

Interdaptor	4, 5, 6	Provides a customizable out of the box solution to you simulation interoperability needs. Provides true interoperability between HLA, DIS, and customized interfaces or protocols; achieves cost-effective HLA compliance; and allows interoperability between legacy and other systems.
Intersim	5, 6	InterSIM software enables simulations and instrumented systems to be networked together in the same synthetic environment according to DIS IEEE 1278.1-1995 or HLA standards. HLA RTI specs 1.1 with DMSO RTI 1.0.
ITEMS	4, 5, 6	ITEMS provides simulation and CGF capabilities; see also STRIVE.
Liteflite	3, 4	LiteFlite TM Re-Configurable Simulation Toolkit Is Low-Cost, PC-Based Solution Providing Photo-Realistic Geo-Specific Dynamic Environments.
MAK Data Logger	4, 5, 6	The MAK Data Logger is a system for capturing and relaying simulation data.
MAK Gateway	5, 6	The MAK Gateway translates DIS PDUs into RTI service invocations, and vice versa, in real-time.
MAK PVD	4, 5, 6	Provides Multiple Map Views, Controls Stealth, Calculates Line-Of - Sight, Displays Contours and Grid Lines, Language Independent, Extensible Through Plug-In Interface, FOM-Agile Through VR-Link's FOM-Mapper Architecture.
MAK Real-time RTI	5, 6	No RTI executive or other central server is necessary to use the MAK RTI, making initialization quick and easy. It can be configured to use point-to-point, broadcast, or multicast communications for maximum flexibility across different network architectures. Optimized for realtime simulations.
MAK Stealth	4, 5, 6	Used for 3D visualization, situation awareness, debugging a simulation, or after-action review.
MAK VR Forces	4, 5, 6	CGF Mäk tools. Not a tool to support process but a possible federate.
ModIOS 2D PVD	4, 5, 6	The Plan View Display (PVD) is one application in the ModIOS tool suite. It provides a 2D view of the simulation and configurable icons. Designed for DIS and included HLA gateway.
ModIOS 3D Stealth Viewer	4, 5, 6	The Stealth Viewer is one application in the ModIOS tool suite. It provides a 3D display of the battlefield from various points of view (cockpit, independent, etc.) Supports smoothing of entity positions, special effects such as explosions, and atmospheric effects. Designed for DIS and included HLA gateway.
ModIOS AAR	5, 6, 7	The After Action Review (AAR) is one application in the ModIOS tool suite. It provides a data logging and replay facility, automatic generation of performance reports, and remote control of the 2D PVD and 3D Stealth Viewer. Designed for DIS and included HLA gateway.
ModIOS Exercise Controller	5, 6	The Exercise Controller is one application in the ModIOS tool suite. It provides configurable control of simulation applications, including 2D and 3D displays, computer-generated forces, etc. It is used to start, resume, stop and freeze simulations, generate reports, create and remove entities, etc. Designed for DIS and included HLA gateway.

ModIOS logger/player	4, 5, 6	The Logger/Player is one application in the ModIOS tool suite. It provides a data logging and replay facility. Designed for DIS and included HLA gateway.
ModISE	4, 5, 6	Framework that facilitates composition of and interoperability among interactive simulation applications. It includes a web-based model repository, a GUI and a run-time Interoperability engine. ModISE stands for Modular Interoperable Synthetic Environment.
ModSAF	4, 5, 6	CGF, Not a tool to support process but a possible federate. Retired software that is being replaced by OneSAF Test Bed version 1.0.
Multigen 2	3, 4	Graphics development
Multigen Creator	3, 4	Creator is a comprehensive toolset for the rapid generation of optimized object models, high fidelity terrain and synthetic environments for use in realtime 3D visual simulation, simulation based training, and urban simulation.
Multigen Creator - Sedris export	3, 4	MultiGen SEDRIS Exporter is a plug-in for Creator that provides interoperation technology for the defense training and simulation community. The SEDRIS Exporter is a flexible, user-guided SEDRIS database production solution that supports STRICOM and DMSO’s Synthetic Interoperability Strategy in an easy-to-manage procedural workflow. The SEDRIS Exporter translates industry standard 3D OpenFlight files into the SEDRIS Transmittal Format (.stf), making this an invaluable tool for any project with SEDRIS data requirements.
OMDT	3, 4, 5	HLA support DMSO tools.
OMDT Pro	3, 4, 5	Editor for creation and modification of SOMs and FOMs.
Omni	4, 5	Part of the HLA Lab Works suite, used to Integrate simulations OMni is a set of related software components and applications that together give simulations the ability to establish a Federation Object Model (FOM) independent interface to the HLA Runtime Infrastructure (RTI). Part of the HLA Tool Suite Middleware used to integrate FOMs.
OneSAF Testbed	4, 5, 6	CGF.
pRTI	5, 6	Pitch’s portable Runtime Infrastructure (pRTI) is a platform independent software that provides HLA services used by federates to co-ordinate their operations and data exchange during an HLA federation execution. pRTI implements all services documented in the HLA Interface Specification v1.3.
pRTI for IEEE 1516	5, 6	The product implements the entire 1516 standard. First commercial IEEE 1516 RTI.
PSI-SA	3, 4, 5	User friendly API to RTI. Stresses the modelling aspect.
RAL Wrapper	4, 5	RTI Abstraction Layer for C++ developed simulation. Facilitate design, allow automatic generation of code and execution.
RealDB	3, 4	Realistic up-to-date models. Canadian, Russian, and U.N. army equipment visual models, 3 levels of detail plus damage states.
S2Focus	4, 5, 6	Provides exercise management tools, including a Mission Planner, Recorder, Manager, Viewer, and Analyzer.

SAIDA	4, 5, 6	Security extensions to the RTI prototype (CERTI) developed at ONERA (Office National d'Etudes et de Recherches Aerospatiales). These extensions are aimed at guaranteeing secure interoperation of simulations belonging to various mutually suspicious organizations. It is an UK/F cooperation.
Sedris tools	3, 4	A synthetic environment data interchange programme.
Sequoia Integrator for HLA	4, 5	The Integrator provides the means to rapidly integrate new or existing simulation systems into HLA environments. SEQUOIA Integrator for HLA v1.0 is currently available on Windows NT© for use with RTI1.3NG-V3.
SGT	3, 4	Scenario generation HLA lab works.
Simplex 3	4, 5, 6	The main design concept behind the HLA-interface of Simplex 3 is to hide all HLA-functionality from the model developer. It should be noted, that this approach leaves the entire model description of Simplex 3 models unchanged, no matter if they act as stand-alone models or federates in the sense of HLA. With that kind of an HLA interface the entire interoperability issue is part of the simulation system itself, and thus not part of the simulation model. One the one hand this facilitates the re-use of existing models, and on the other hand the developer of new models does not need to have additional knowledge for building HLA-compliant models.
Simulation Support Environment DUCTOR	3, 4, 5, 6	DUCTOR is an architecture which allow to develop operational simulations running stand-alone or as an HLA federate. It is OO (UML based) and promotes re-use of scenarios, specific behaviours and platforms.
Simulation Support Environment ESCADRE	3, 4, 5, 6	Encapsulate and hide low level HLA interface functionality, providing high level services for HLA interoperability. Provide an OO methodology and a tool set to design, implement and run stand-alone simulations and HLA federates.
Skopeo Animation System	4	In order to run in a distributed environment, Skopeo was extended for HLA. This extension uses the Beta release of the Java RTI API from DMSO. Skopeo once was developed as Proof Animation (R) compatible 2D animation tool for post-run trace-file based animation. It is written in Java and runs stand-alone or as applet in any java-capable web browser. In a second step, Skopeo was enhanced for 3D animation using VRML2.0 if an appropriate browser plug-in can be found. Additionally CORBA mechanisms are used for communication between the Skopeo Applet and the Skopeo server.
SLX Simulation Environment	4, 5	HLA interface provided SLX is a very fast discrete event simulation tool for the Windows 95/98/NT operating systems. It is a simulation language oriented tool. The SLX user is provided with an easy-to-use interface to the RTI and the possibility of "doing" distributed simulation based on HLA without having to deal with the lowest API-level of HLA.
SmartFED	4, 5, 6	HLA support
SMOC	5, 6	SMOC is a standard interface to HLA for developers of models and simulations. Serves as a DIS/HLA gateway to avoid expensive modifications to DIS-compliant systems.

SPEEDES	4, 5, 6	Simulation Engine used for JSIMS.
STAGE	4, 5, 6	Complex tactical scenario generator product which can integrate with any technology which HLA enables a simulation; can participate in HLA federations, when jointly used with the ModIOS Network Complex tactical scenario generator product which can integrate with any technology which HLA enables a simulation; can participate in HLA federations, when jointly used with the ModIOS Network Interface from Motorola.
STRIVE	4, 5, 6	Synthetic Tactical Real-time Interactive Virtual Environment (STRIVE) is a COTS simulation development environment. Reduces development through existing libraries of models. Many aspects of the software can be modified or replaced with user-defined software. It also has a CGF capability. Although quite new, Strive is expected to be a major COTS software product of CAE. It can run as a federate and provides a framework for creating the same.
Telestra HLA	4, 5, 6	Supports execution, Remote HLA Management, Radio Simulation and Communications.
Terra Vista/Terra Vista Pro Builder	3, 4	Used to create visual terrain databases in OpenFlight or TerraPage formats. ProBuilder version intended for "power users". Both versions are extensible.
TerraTools	3, 4	Terrain DB Construction Tool.
UOB DAT	2, 3, 4	MSIAC Web Page; Support Exercises Composition.
VAPS	4	Rapid prototyping of complex human computer interfaces; generates C-Code which can be HLA enabled using any HLA integrator product.
VEGA	3, 4, 5	Vega Prime is a software environment for the creation and deployment of realtime visual simulation, virtual reality, sensor and general visualization applications. Vega Prime combines advanced simulation functionality with easy-to-use tools to create an infrastructure to build, edit and run sophisticated applications.
Visual OMT	3, 4, 5	Visual OMTT is a project-based multiple-document (MDI) application supporting Simulation Object Models, Federation Object Models and Data Dictionary documents. Object-model elements can be copied within and between documents by drag and drop.
VR Link	4	With MAK's VR-Link networking toolkit you can easily and quickly network simulators and virtual reality applications together, using the HLA.
yaRTI	5, 6	yaRTI is an HLA RTI implemented in Ada95, using the Distributed Systems Annex features.

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Federation Development and Execution Process (FEDEP)	M&S Tools	Software reuse
HLA (High Level Architecture)	Requirements	Standardization

14. Abstract

This report details the work and activities undertaken by the NATO MSG-005 technical activity programme "***Federation Development and Execution Process (FEDEP) Tools in Support of NATO Modelling & Simulation (M&S) Programmes***". Specifically, it provides the methodology and rational used to develop a database of tools that support the creation of HLA federations in NATO.

The nations involved in this study were Canada, France, Germany, Portugal, United Kingdom, and the United States.

The HLA Tool database was compiled in a web-accessible format. The web interface was created by Germany and Canada has volunteered to host the database until a permanent NATO M&S repository can be created.

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