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DCMF –Survey of Related Research and Approaches

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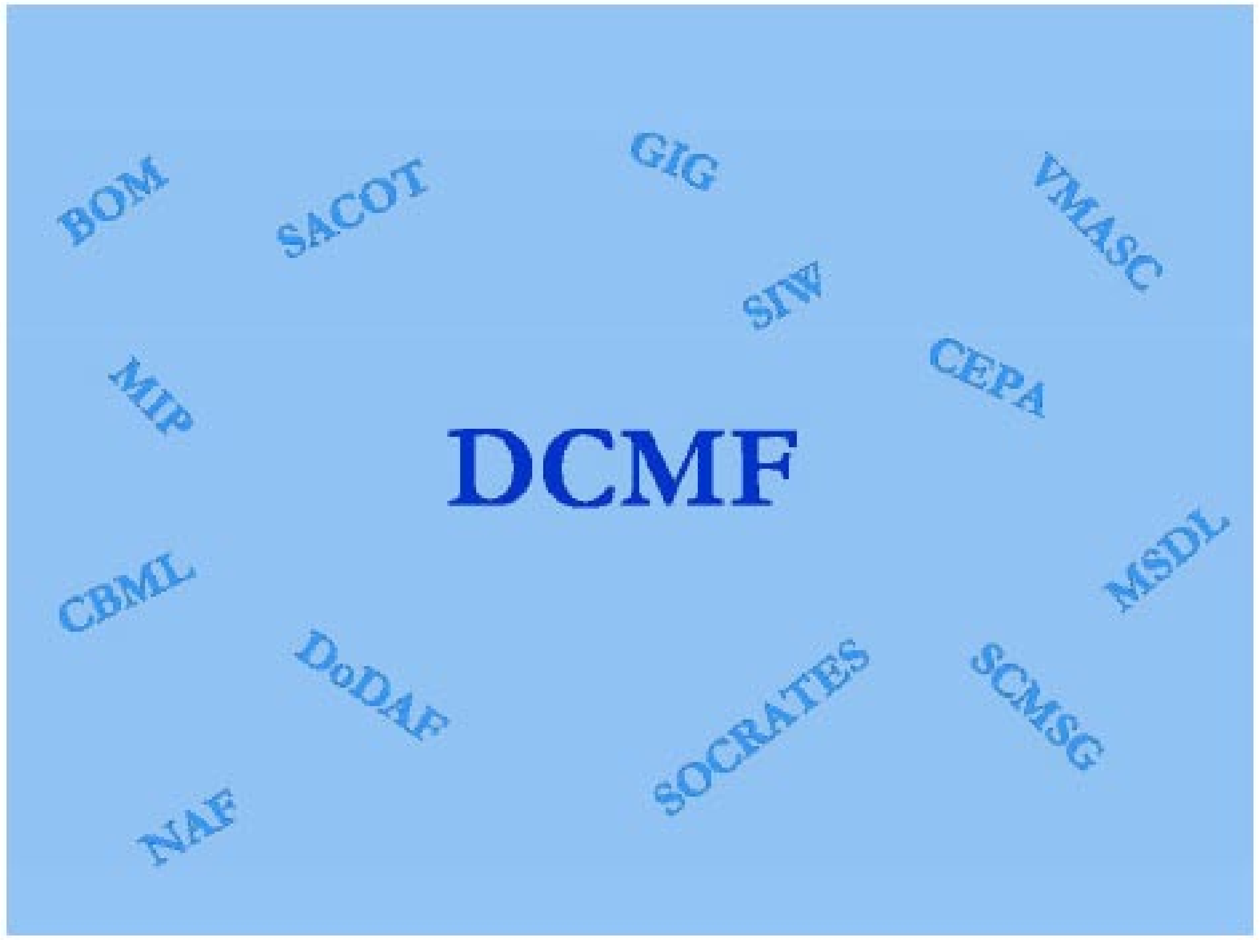

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Abstract

Defence Conceptual Modelling Framework (DCMF) is a Swedish framework, developed within an ongoing project at the Swedish Defence Research Agency, for making conceptual descriptions and models of military operations. DCMF has its origin in the CMMS concept presented by the US DMSO.

DCMF bears a more or less close resemblance to a number of other international research and approaches. In this report their most important approaches from the DCMF perspective are outlined and an overview of each approach is given.

Keywords

Conceptual Modelling, Interoperability, Reusability, Conceptual Modelling Framework, SIW, SCM-SG, BOM, MSDL, BML, C-BML, GIG, MIP, DoDAF, NAF, CEPA, SOKRATES, SACOT

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En överblick över DCMF-relaterade ansatser

Sammanfattning

Defence Conceptual Modelling Framework (DCMF) är ett svenskt ramverk utvecklat inom ett pågående FOI-projekt och avsett att stödja framtagandet av konceptuella modeller av militära operationer. DCMF har sitt ursprung i CMMS-konceptet framtaget av US DMSO.

DCMF har en mer eller mindre stark koppling till ett antal andra internationella projekt. De ur DCMF perspektiv viktigaste ansatserna presenteras översiktligt i denna rapport.

Nyckelord

Konceptuell Modellering, Interoperabilitet, Återanvändning, Modelleringsramverk, SIW, SCM-SG, BOM, MSDL, BML, C-BML, GIG, MIP, DoDAF, NAF, CEPA, SOKRATES, SACOT

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Contents

1. Introduction

The Defence Conceptual Modelling Framework (DCMF) is FOI's[1] proposal to how to deal with Conceptual Modelling issues in military business. It constitutes an important step in the implementation of the Swedish Defence's modelling and simulation plan by initiating the first study of how a common library of verified and validated conceptual models of military operations can be developed. Such a common library could create the basis for the defence's future simulation models. In the long term it could help making the simulation software easier to develop, use, reuse and maintain, and achieve both a higher quality and a higher level of interoperability at a reduced cost.

The DCMF is an ongoing project at FOI which try to create a framework, including a process for developing the conceptual models of military operations. These conceptual models are formalised descriptions of real world processes, entities, environmental factors, associated relationships and interactions constituting a particular set of missions, operations or tasks. Constructed models are supposed to be generic and applicable to as many scenarios as possible without any loss of critical knowledge. One benefit of such models is that they may serve as the same basis for all stakeholders of what is to be simulated, and thus act as a bridge between the military experts and the developers.

DCMF has its origin in an American concept called Conceptual Models of the Mission Space (CMMS), which was introduced by US DoD[2] in their Modelling and Simulation Master Plan [1] in 1995 to address the same problem. The CMMS concept, which was presented as an important component in this vision, was according to DMSO[3] an essential requirement for interoperability and reusability of knowledge in the military domain. For unknown reasons the CMMS concept was never completed and the activities in it seemed to end around 2001. However, FOI found the concept interesting and has, since 2002, done research on the concept to explore its potential.

FOI began with an extended study of all known published material about CMMS up to that point. It was early discovered that many of the specifications of the CMMS process were vague and unfinished. During the work it became more obvious that a lot of the necessary components, methodologies and tools to finish the process, were also missing. This meant that to get a clearer understanding of the concept, a basis for a common methodological framework had to be developed. FOI started a project for developing the process further and decided in 2005 to no longer call it CMMS but DCMF. An introduction to this framework has been given in a more extensive FOI methodology report [2]. That report describes the ongoing activities and the experiences of the work done so far in the project. It also presents the properties, characteristics, design and experiences of the DCMF as a method, and it should be able to serve as a foundation for anyone who wishes to understand the framework and method better, is interested to develop it further, or wants to use it.

In this report, however, we are not going through the framework and will only focus on some identified related research and other approaches which we believe may have bearing on the DCMF, and vice versa. Note that the research and approaches are what we have found and there may very well be more initiatives or other activities that have stronger bearings on our DCMF work, but here we try to present at least those we have succeeded to capture with limited

[1] FOI – Swedish Defence Research Agency
[2] US DoD – United States Department of Defense
[3] DMSO – United States Defense Modeling and Simulation Organisation

resources. We will comprehensively look at these activities, thus in some cases there will only be a single page which try to explain a work documented by thousands of pages. Therefore we also want to point out that these explanations may be insufficient and once more ask you to have in mind that this is a survey of related research and approaches which may have bearing on the DCMF, and the ambition is not to completely explain those concepts.

So we will neither give an overview nor will we discuss the current status of the DCMF project in here and for a deeper look into ongoing activities and the experiences gained in this project we refer to our simultaneously written major DCMF report [2]. The main objective of this survey is to be a complement to the DCMF report and therefore we presuppose some familiarity with terms and abbreviations that are mentioned there. However, for those who never had an opportunity to read the main documentation of the DCMF, we will in the following concluding section give a very short description of which problems the DCMF try to address.

DCMF concerns the construction of MSM's (Mission Space Models). MSM's are the final result and the kernel of both DCMF and CMMS, and are defined as simulation and implementation-independent functional descriptions of the real world processes, entities, and environmental factors associated with a particular set of missions. These descriptions would be able to serve as a frame of reference for simulation development by capturing the basic information about important entities involved in any mission and their key actions and interactions. Thus *the overall objectives* for both concepts are: to capture authorised knowledge of military operations; to manage, model and structure the obtained knowledge in an unambiguous way; and to preserve and maintain the structured knowledge for future use and reuse. And *the premier aim* of doing so is to enable semantic and substantive interoperability of the future simulation models built on these descriptions.

The other objectives of DCMF are to achieve the following additional advantages. First, to produce a disciplined procedure by which the simulation developer is systematically informed about the real world problem to be synthesised. Second, to deploy a set of information standards the simulation subject matter expert employs to communicate with and obtain feedback from the military operations subject matter expert. Third, to provide a real world, military operations basis for subsequent, simulation-specific analysis, design, and implementation, and eventually verification, validation, and accreditation. Finally, to be the means for establishing reuse opportunities in the eventual simulation implementation by identifying commonality in the relevant real world activities.

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2. SIW - Simulation Interoperability Workshop

The Simulation Interoperability Workshop (SIW) is a conference about interoperability which provides an opportunity for members of the Modelling and Simulation (M&S) community who share common interests and/or are dealing with similar problems in various organisations to exchange ideas. This is also a forum for exchange of information and technology, to share lessons learned and to identify where common standards and practices will improve interoperability and reuse. SIW is organised three times a year by the Simulation Interoperability Standards Organization (SISO). There is a SIW in the US every Spring and Fall. The so called EuroSIW is taking place in Europe during Summer time [1].

SISO focuses on facilitating simulation interoperability across government and non-government applications worldwide. One of SISO's interests aims to explore methods that support and promote reuse of simulation components and encourage agile, rapid, and efficient development and maintenance of models [1].

The SISO originated over ten years ago with the aim to enable companies, researcher and developer groups to exchange information and ideas which can support rapid development of technology. When a technology begins to stabilise then there will also be a need for standardisation. Standardisation of M&S products is the main focus for the SISO and one of the main topics of the SIW conferences. The open standardisation efforts within the organisation are considered to encourage development, distribution and use of the study results and products developed by groups in SISO [1].

Ideas that are generated during the Workshops and on the reflectors that are run by the organisation are developed further through SISO Study Groups (SG) and the Product Development Groups (PDG). The purpose of these groups is to develop standards in the M&S community which will support interoperability and reusability [1]. Examples of interesting groups within SISO concerning the DCMF are the following.

The Base Object Model (BOM) PDG is developing a specification for BOMs. The open standardisation of BOMs is essential for establishing component technology to facilitate interoperability, reusability and composability. As part of this standardisation effort, the PDG will define an XML[4] schema to identify the base elements and ontology of a BOM and provide guidance describing how BOMs can be used to generate FOMs[5] and SOMs[6] from BOM compositions [6]. For more details about BOMs and a discussion about its bearing on DCMF, see chapter 4.

The Battle Management Language (BML) is an attempt to create an unambiguous language between both human and computers. BML is considered to be particularly relevant in a network centric environment for enabling mutual understanding. A Coalition BML (C-BML) developed and applied by the all Services and by coalition members would not only allow interoperability among their C4ISR[7] systems and simulations, but also among themselves [7]. This is being studied in the C-BML SG within SISO. Read more about BML and C-BML in chapter 7.

4 XML – Extensible Markup Language
5 FOM - Federation Object Model within the High Level Architecture (HLA) concept
6 SOM - Simulation Object Model within the High Level Architecture (HLA) concept
7 C4ISR – Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance

The Military Scenario Definition Language (MSDL) is being developed by the OneSAF Objective System program [2] to provide simulations with a mechanism for loading military scenarios. The intent for MSDL is to define military scenarios that are independent of the applications generating or using the scenarios. To that end, MSDL is an XML[8] based data interchange format that enables Command and Control (C2) planning applications to exchange the military portions of scenarios within simulations and other applications [1]. MSDL is described further in chapter 5.

The Simulation Conceptual Modelling (SCM) SG is conducting a preliminary investigation on the use of conceptual modelling in M&S and related information technology domains. The study group will perform exploratory work into the establishment of best practices for simulation conceptual modelling, and establish recommendations for persistent management of the topic within SISO [1]. Chapter 3 in this report describe the SCM SG in more details.

The Verification, Validation and Accreditation (VV&A) PDG is developing a recommended practices guide outlining implementation methodologies for the VV&A of a federation. The guide will serve as the foundation for the assessment of credibility of a federation by addressing issues relating to establishing substantive interoperability, promoting reusability, and assuring composability [1]. VV&A efforts are highly relevant for the DCMF project and those issues are discussed in another report this year by our project [3].

The FOI has had several projects during the last decade which have contributed to the SISO community. Among them are HLA[9], CGF[10], VV&A and recently also the DCMF project. The SIW conferences are a very important opportunity for the DCMF project to communicate with researchers from other organisations and companies who are studying the same problems. At the Fall SIW 2005 two papers [4, 5] were presented by the DCMF project group.

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[7] Tolk, A et al. Coalition Battle Management Language. Paper 04F-SIW-103, Fall Simulation Interoperability Workshop, 2004

[8] XML – Extensible Markup Language
[9] HLA - High Level Architecture
[10] CGF - Computer Generated Forces

3. SCM-SG - Simulation Conceptual Modelling Study Group

The Simulation Conceptual Modelling Study Group (SCM-SG) was formed in order to conduct a preliminary investigation on the best practices of simulation conceptual modelling and to establish recommendations for pursuit of the topic within the scope of the Simulations Interoperability Standards Organization (SISO), if appropriate. Current member count in the group is just over 100 [1].

Within the study group an action list has been formulated [1]:

- Research the use of conceptual modelling in the M&S or related information technology domains. In doing this a data call for readily available empirical evidence should be made, with the intention of creating a set of best practices by leveraging successful and unsuccessful conceptual modelling experiences.

- Perform exploratory work into the establishment of best practices for simulation conceptual modelling. In doing this identify and evaluate prospective significance of the topic to the scope of the SISO and the interests of its members, addressing particularly the implications of conceptual modelling best practices for modelling and simulation. Also, refine existing conceptual modelling terminology, draft a taxonomy of concepts, document relevant techniques and beneficial procedures.

- Consolidate the findings of the topical committees and establish recommendations for persistent management of the topic within SISO.

The first foundation element for the work in the group is a commonly agreed definition of, or vision statement about, what a simulation conceptual model is. In the context of the SCM a simulation conceptual model is an abstraction from either the existing or a notional physical world that serves as a frame of reference for further simulation development by documenting simulation-independent views of important entities and their key actions and interactions. A simulation conceptual model describes what the simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the stakeholder's requirements. It bridges between these requirements, and simulation design [1].

The second foundation element is a commonly agreed scooping of the topics that the SCM best practices should address. The scope is divided into the sub-areas Justification, Methodology and Relationships. Justification concerns matters like identification of stakeholders, the impact conceptual models has on these stakeholders and the ability of conceptual models to address real world components. Methodology concerns matters of understanding conceptual models, issues about modelling language and reuse of models. Relationships concerns matters like the capability of conceptual models to support Validation, Verification and Accreditation (VV&A) and the application of conceptual modelling to a broader audience than the SCM [1].

The third foundational element is the establishment or definition of a common vocabulary that should be used within the SCM. This terminology is considered important when discussing SCM best practices [1].

Finally, the fourth foundational element that is required for the development of a set of recommended SCM practices is the establishment of a taxonomy of SCM concepts [1].

The communication form has, so far, been through mail where the members of the SCM-SG have shared papers and presentation material through an active mailing list. The SG also has the opportunity to meet for discussions at every SIW[11] conference (Chapter 2).

Bearing on DCMF

The work in the SCM-SG is aimed at sharing experiences about best practices in conceptual modelling. This means that a number of conceptual models formulated according to best practices are made public for parties in the SG along with explanations and rationale. Such models are related to the MSMs[12] produced by the DCMF. MSM are reusable conceptual models that can be shared and combined with other models for the purpose of performing simulations. Knowledge about what others consider a good conceptual model can be valuable when preparing MSM libraries.

The SCM-SG is also a forum for discussion. This is well in line with the objective of the DCMF project to actively seek partners, share knowledge and exploit collaboration opportunities.

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[11] SIW – Simulation Interoperability Workshop
[12] MSM – Mission Space Model

4. BOM - Base Object Model

The objective with the Base Object Model (BOM) effort is to encourage and support reuse, interoperability and composability and help enable rapid development of simulations. The BOM concept is based on the assumption that piece-parts of simulations and federations can be extracted and reused as modelling building-blocks or components. The interplay within a simulation or federation can be captured and characterised in the form of reusable patterns. These patterns of simulation interplay are sequences of events between simulation elements. The representation of the pattern is captured in the BOM [1].

Simulation models are often defined for a particular simulation application which constrains reusability and interoperability with other simulation models. Furthermore the initial activities in M&S development require a great deal of effort and a lot of collaboration which takes time and resources. There is a need for a composability infrastructure that encourages the development and reuse of components that are matched to the needs of the desired simulation or simulation space. BOMs have been developed for describing and sharing models across domains and M&S Frameworks. A BOM standard is seen as a key enabler for supporting reusability and interoperability among others. The current framework is intended to support capabilities like; Composability, Adaptability, Aggregation, Multi Resolution Model and Web Services [2, 3].

A BOM is defined as a piece part of a conceptual model composed of a group of interrelated elements, which can be used as a building block in the development and extension of a High Level Architecture (HLA) federation, individual federate, Federation Object Model (FOM) or Simulation Object Model (SOM) [2, 4]. In other references [3] it is claimed that BOMs are not exclusive to HLA federates and federations. BOMs are not restricted by the HLA constrains. Thus, it is possible for other distributed simulation architectures, than the HLA, to utilise BOMs as a mechanism for representing capabilities and building agreements among an enterprise of simulations.

The BOM technology has been developed within the SISO[13] [2] and the work has been led by personnel from SimVentions [3, 5]. There are currently efforts performed for studying whether elements of the C2IEDM[14] could be represented within a BOM.

The Open standardisation of BOMs is considered essential for establishing component technology to facilitate interoperability, reusability and composability. Furthermore, open standardisation of BOM representation encourages development, distribution and use. As part of this standardisation effort, the PDG will define an XML[15] schema to identify the base elements and ontology of a BOM and provide guidance describing how BOMs can be used to generate FOMs and SOMs from BOM compositions [2].

Bearing on DCMF

The DCMF is somehow addressing the same issues as BOM such as creating processes and tools for developing piece parts of conceptual models which can be used for designing and implementing simulation models in the military mission space.

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[13] SISO – Simulation Interoperability Standard Organisation
[14] C2IEDM – Command and Control Information Exchange Data Model
[15] XML – Extensible Markup Language

The main parts in a BOM are very similar to the main parts within the DCMF Knowledge Meta Meta Model, namely objects, activities, states and rules. Both structures are striving to support interoperability and standardisation by using XML as the representation language.

The DCMF and the BOM has somehow different focus in the Knowledge Management Process, which is good. While DCMF concentrates on the early phases such as acquiring and analysing knowledge, the focus of the BOM is on the composability of knowledge component in order to create a conceptual model.

The BOM tool might most probably be interesting to study further for the DCMF. For example to what extent the tool supports an automatic process for knowledge management and developing reusable conceptual models.

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5. MSDL - Military Scenario Definition Language

Military Scenario Definition Language (MSDL) is an automated tool developed and proposed to describe military scenarios in an XML grammar to provide simulations with a mechanism for loading military scenarios [3]. Furthermore MSDL is proposed to provide ability to create military scenarios that can be shared between simulations and C4I devices [1, 2]. The intent is to define scenarios which are independent of the application.

It is considered critical for distributed simulations that all federates, components and services are initialised by a common interoperable data source. One of the most time consuming and human intensive processes in a simulation enterprise is the initialisation of the simulation environment itself. If this process could be automated it would reduce costs and also reduce the need for human intervention [3]. It would also improve the scenario consistency between federated simulations [2].

Simulation scenario definitions and associated scenario development tools have been non-standard and closely coupled to the simulations they support. The MSDL effort is proposed as a possible solution on this problem. Therefore Simulation Interoperability Standard Organization (SISO) has organised a Study Group (SG) for MSDL in order to find a standard for reusing military scenarios among simulations [1]. A standardisation of scenario description would enable different services but also joint communities to leverage significant scenarios between multiple exercise and course of action development activities [2].

A related activity to the MSDL SG is the C-BML (Chapter 7) effort within SISO. There are efforts to identify the scope and coordination points between C-BML and MSDL. There is obviously an overlap between the interests of those two concepts [6]. C-BML focuses on data interchange between Command and Control systems and Modelling and Simulation systems while MSDL is focused on simulation initialisation. A commonality between the two concepts is that both C-BML and MSDL are leveraging the 5W concept (Who, What, When, Where and Why) to support the identification, description and storage of entities, activities and relationships in the military domain [3].

MSDL is currently used to initialise systems as the OneSAF Testbed Baseline (OTB) [5] and the OneSAF Objective Systems (OOS) [4]. In addition, the Modeling Architecture for Research and Experimentation (MATREX) program is contributing to the MSDL standard development and plan to use it for the initialisation of the scenarios [3]. The MATREX team is working with federate development team to understand their scenario initialisation data requirements. These requirements will then be translated into MSDL extensions that the MSDL development team can include in their development cycle. When the language reaches a sufficient level of maturity, all initialisation tools will be able to read/write data in the MSDL format to express and initialise scenarios in the MATREX environment [3].

MSDL is an evolving standard and there are still issues to be solved before MSDL will be a practical solution for simulation initialisation [3].

Bearing on DCMF

The Knowledge Meta Meta Model (KM3) in DCMF aims to describe military scenarios for storage, reusability and composability which is also the aim for the MSDL effort. The automatisation is also a common issue. Both concepts try to develop a process which automatically builds conceptual models for use and reuse in modelling and simulation.

Furthermore both concepts are currently work in progress and an exchange of ideas and results would be of great interest. For the DCMF it would be interesting to initiate collaborations and/or discussions with the MSDL group. This would be feasible since the group is active within SISO and continuously participating in the SIW[16] (Chapter 2).

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[16] SIW – Simulation Interoperability Workshop

6. The Interoperability War

This section is a bit different than the others in this report. That is because it is largely connected to the views and visions of one particular researcher - Andreas Tolk. Tolk is very productive and influential mainly in the modelling and simulation domain. The following text represents some of his views on the current state and the future of interoperability within his domain. The main reference is [3], but additional information comes from [1, 2].

Tolk has identified a number of problems concerning the state of interoperability today and in the future. There is no lack of conferences where interoperability researchers in the modelling and simulation domain express their interests using words like modularity, composability, interoperability, reference data models, and architecture frameworks. Despite those words Tolk finds that the solutions presented are not too interoperable among each other. The result is a situation where the architecture is moving from proprietary stove-pipe systems to standard-driven stove-pipe systems. They still remain systems with little or no possibility to interoperate. Tolk calls this fight about whose standards that will dominate "the Interoperability War".

Tolk proposes a solution for this problem in [3]. The general way to solve the problem is not to force users to accept new standards if this is not absolutely necessary. If they have no problem with how their currently used standard supports them today then they should keep it. What is needed is to address the interoperability problems by creating common meta-models and create mappings between systems providing solutions, through the use of those meta-models. He does so by suggesting a layered framework, conceptually similar to the ISO/OSI [4] network protocol stack, that addresses the lack of interoperability bridges between standards. The suggested new layers are built on top of current network layers.

Tolk envisions the future of modelling and simulation as based on a service oriented architecture (SOA). Within this architecture, in which interconnected heterogeneous systems form a computing grid, simulations are performed by services that are discovered, composed and executed. The full potential of a SOA lies in the possibility to compose services and orchestrate their execution, thereby enabling new functionality from compositions to fulfil the often changing user requests "on the fly". This environment not only reflects the target architecture for future parallel and distributed simulations; it also equals the IT environment for future military IT systems supporting Joint Command and Control (JC2) or the Global Information Grid (GIG) (Chapter 8).

When discussing interoperability between heterogeneous systems the importance of a standardisation between data elements is stressed. This standardisation is often referred to as a common language or a common ontology. Tolk exemplifies by using the Command and Control Information Exchange Data Model (C2IEDM) as this language. However, it is not so important which data model is used as a reference, just that some unambiguously defined data model is used.

Concerning meta-modelling, the path taken by the Object Management Group (OMG) is considered promising. OMG has developed a framework for meta-modelling known as the Model Driven Architecture (MDA), which can form the base for constructing Platform Independent Models (PIMs) that can be made interoperable through suitable mappings. The PIMs are converted to Platform Specific Models (PSMs) using standardised transformation rules. The PIM defines the necessary functionality, while the PSM specifies how this functionality is realised on a specific platform.

Bearing on DCMF

Tolk argues that it is important paying attention to the format in which the information is stored and exchanged. This is addressed in two ways in the DCMF; a) through the creation of the KM3[17] and b) the investigation of ontologies.

The C2IEDM was chosen in the DCMF to take the role of an ontology (in Tolk's terms). Tolk argues that this particular data model is a good choice for this end.

Tolk envisions a distributed architecture where one of the tools used to facilitate interoperability is the MDA, in order to understand how ideas from it can be applied and how other actors in the architecture is positioned with respect to this concept. The DCMF project has looked into the MDA framework but not in sufficient depth. Future research involves studying it generally, but concentrate on the parts called Meta Object Facility (MOF) and Common Warehouse Model (CWM) as they seems most relevant for the DCMF. Finally, Tolk repeatedly returns to the use of common open standards and using industry support when addressing interoperability problems.

The views of Tolk seems well in-line with the goals of DCMF. The DCMF aims to produce reusable conceptual models that can be used in distributed simulations. We will therefore carefully investigate the proposed architecture solutions as well as the suggested methods for producing conceptual models to find out where they could strengthen the DCMF.

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7. BML - Battle Management Language

BML is an attempt to create an unambiguous language for command and control of forces and equipment conducting military operations. This would support communications within an organisation but also with other organisation and provide a shared operational picture and situational awareness [1].

Current simulation systems lack a standard methodology for representing Command and Control (C2) Information that can interoperate with other simulations or C2 Information System (C2IS). Many advanced simulations have representations of internal command and control but they are not supporting interoperability with other systems. Another problem is that orders and directives in C2 communication do not really flow as data but as 'free text' elements which demands a human brain to interpret and act on the information. Since communication of C2IS for military forces is moving towards more digitised systems there has been a growing need for solutions that make it possible for machines, and not only humans, to exchange and parse information [1].

There are several earlier attempts for solving this interoperability problem before BML, for example Eagle BML which is very structured but is difficult to use and is specific to a single simulation and therefore not offer any interoperability. In 2001 SIMCI OIPT[18] presented BML as a concept for addressing these issues [2].

BML is described with the following three views [1]:

- A Doctrine view – BML must be aligned to doctrine.
- A Representation view – BML must model the missions in a way that can be parsed and processed by underlying technology systems, both for Modelling and Simulation as well as for C2IS. Currently the BML developers use an extended version of the Command and Control Information Exchange Data Model (C2IEDM).
- A Protocol view – There must be protocols specified to enable information exchange between the participating systems. For the protocol view BML uses the web-based standards such as web-services and grid-services.

Furthermore the following four principles are fundamental for BML [1].

1. BML must be unambiguous.
2. BML must use the existing C4ISR[19] data representations when possible.
3. BML must allow all components to communicate information pertaining to themselves, their mission and their environment in order to create situational awareness and a shared, common operational picture.
4. BML must not constrain the full expression of a commander's intent.

The first principle means that terms used in BML must be rooted in defined and documented vocabulary for example manuals or glossaries. The demand for using existing data representations makes it easier for underlying Information Technology Systems to exchange information and parse the results. The third principle is a cornerstone for BML in order to digitise the concept. Finally, the desired results of BML are executable descriptions of missions [1].

Since the first presentation of BML there have been several projects working on evaluating and developing the concept. Among them are Defense Modelling and Simulation Office (DMSO)

[18] SIMCI OIPT – The United States Army's Simulation to C4I Overarching Integrated Product Team

[19] C4ISR – Command, Control, Communications, Computers Intelligence, Surveillance and Reconnaissance

and Simulation Interoperability Standards Organisation (SISO). The first prototype implemented in 2003 by DMSO called the U.S Army BML proof of Principle had the objective of prove the feasibility of the BML solution. That prototype has been further developed during 2004 for more interoperability by applying the data model C2IEDM (Chapter 9 and Appendix A) for the representation view and web-based open standards for the protocol view. The implementation with web-service is called Extensible BML (XBML) [3].

The first two prototypes of BML were developed with U.S Army in focus. But since the scope of BML is joint forces as well as allied forces the prototype implemented as a web-service, XBML, has been studied and evaluated for use in U.S Air Force and the U.S Joint Forces Command [1].

C-BML - Coalition Battle Management Language

Future military operations most probably will be joint in nature. To support joint operations it is considered important that BML allows interoperability among C2IS and Modelling and Simulation (M&S) as well as among C2IS themselves. Therefore a study group was established at the 2004 Fall Simulation Interoperability Workshop (SIW) dealing with issues of a Coalition Battle Management Language (C-BML). The C-BML group is sponsored by SISO and the ultimate objective is to prepare the way for C-BML to become a SISO standard [4].

The initial tasks for the Study Group (SG) were to conduct a paper survey comprising international contributions and to develop a plan of how those efforts could be used for the development of a C-BML Standard [4].

The SG submitted a report at 2005 Fall SIW which comprises a literature survey and a compilation of current work with C-BML from 18 organisations and study groups from different western countries [5]. There is also a plan and a recommendation formulated for the continuing development of C-BML which is based on the mentioned surveys and also meetings and discussions with international experts [5].

For the future development of C-BML the SG recommends the development to be conducted in cooperation with other standardisation efforts such as BOM (Chapter 4) and MSDL (Chapter 5). There is still important to keep those tasks separated since the focus differs in some aspects. For example the MSDL focuses on simulation initialisation instead of M&S/C2 data interchange, which is the focus of C-BML. The C-BML Standard is proposed to evolve over time structured in three phases each delivering a new version of C-BML [5].

Bearing on DCMF

C-BML is among other an interesting attempt to support unambiguously communication between humans and machines. Furthermore it strives to support semantic and conceptual interoperability between systems in the domains Modelling and Simulation and Command and Control. Both unambiguously communication and interoperability solutions are goals for the DCMF too. Therefore the C-BML is a very interesting work for the DCMF to follow.

Another part in C-BML which is highly relevant for the DCMF is the effort to structure an ontology for battle management. This effort has also similarities with the SOKRATES (chapter 14), and C-BML and researcher from the SOKRATES has actually initiated collaboration in the field of battle management ontologies. Even here we believe that we can make use of their outcomes and perhaps also contribute to their work.

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8. GIG - Global Information Grid

The Global Information Grid (GIG) is a vision put forward by the US DoD[20] in 1999 to achieve "information superiority". A published memorandum that concerns the GIG defines it as:

> "The globally interconnected, end-to-end set of information capabilities, associated processes and personnel for collecting, processing, storing, disseminating and managing information on demand to war fighters, policy makers, and support personnel. The GIG includes all owned and leased communications and computing systems and services, software (including applications), data, security services and other associated services necessary to achieve Information Superiority".[1].

Furthermore, from the same memorandum we find that "… *The GIG provides interfaces to coalition, allied, and non-DoD users and systems.*" [1]. That is, no information producers and consumers are a priori excluded from the Grid.

The premises underlying the idea are that information superiority is achieved when no war fighter is lost because of missing or inaccurate information. Or, in other words, all necessary information is available for a war fighter to win. The right information is available for the war fighter wherever he is, whatever he does, and whichever system he uses. To this end, technically interoperable and conceptually composable services relevant to the full range of application domains are brought together in a distributed, heterogeneous, information technology.

It should be pointed out that one of the main challenges with the introduction of the GIG is within a change in the information policy. The GIG mandates that information will be posted immediately and will be available to every potential user without excess processing. The rationale behind this change of policy is two-fold. First, even raw, potentially incomplete data can support users in a time-constrained environment, and in fact, the knowledge gained balances the risk inherent in not waiting for the processed information. Second, data distributors may not be aware of all potential users of their data. The unidentified user would never be reached by the traditional data distributions paradigm of pushing data from the provider to the user.

Traditionally, the approach for dissemination of information in a heterogeneous system environment has been to focus on data administration and use this to construct interoperable system solutions. That approach meant to standardise and control data elements, definitions, and structures, requiring consensus among and across organisations. Data administration was intended to promote interoperability through standardisation of data elements, minimise duplication of data elements, and reduce the need for data element translation. The shift in policy from data centricity to consumer centricity represents indeed a real paradigm shift.

The way to achieve the envisioned goals of the GIG is first of all to describe its organisation as a service oriented architecture (SOA). In this architecture interest groups will be formed that exchange information in pursuit of their shared goals, interests, missions, or business processes and who therefore have shared vocabularies for the information they exchange and have responsibility for data and meta-data that is kept in their repositories.

All in all, the GIG is the globally interconnected, end-to-end set of information capabilities, associated processes, and personnel for collecting, processing, storing, disseminating, and managing information on demand to war fighters, defence policymakers, and support personnel.

[20] US DoD – The United States Department of Defense

Net centricity, by securely interconnecting people and systems independent of time or location, supports a substantially improved military situational awareness, better access to business information, and dramatically shortened decision cycles. Users are empowered to better protect assets, more effectively exploit information, more efficiently use resources and create extended, collaborative communities to focus on the mission. The documentation about the GIG includes policy documents (e.g. [5, 6]), vision statements (e.g. [3]), and research documents (e.g. [2,4]).

Bearing on DCMF

The GIG vision puts some emphasis on the notions of shared vocabularies and data repositories. This is well in line with research done in the DCMF on ontologies and also perhaps, the KM3[21]. The work done in the GIG could well be investigated to find out the rationale for the decisions taken in this respect.

The GIG also focuses on the importance of meta-data and use of meta-data as a means for maintaining heterogeneous data repositories. This is one idea that the DCMF will pursue in future research. That is, how to maintain potentially inconsistent data stores but still keep them useful.

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[21] KM3 – Knowledge Meta Meta Model

9. MIP - Multilateral Interoperability Programme

The successful execution of fast moving operations needs an accelerated decision-action cycle, increased tempo of operations, and the ability to conduct operations within combined joint formations. Commanders require timely and accurate information. Also, supporting command and control (C2) systems need to pass information within and across national and language boundaries. Moreover, tactical C2 information must be provided to the operational and strategic levels of command including other governmental departments. Additionally, forces must interact with non-governmental organizations, including international aid organisations.

The Multilateral Interoperability Programme (MIP) [1] was established by the Project Managers of the Army Command and Control Information Systems (C2IS) of Canada, France, Germany, Italy, the United Kingdom and the United States of America in April in 1998 in Calgary, Canada.

The aim of the MIP is to achieve international interoperability of Command and Control Information Systems (C2IS) at all levels from corps to battalion or lowest appropriate level in order to support multinational (including NATO) combined and joint operations and the advancement of digitisation in the international area. The MIP solution enables C2IS to C2IS information exchange and allows users to decide what information is exchanged, to whom it flows and when.

The core of the MIP solution is the Joint C3 Information Exchange Data Model (JC3IEDM) [2]. It is a product of the analysis of a wide spectrum of allied information exchange requirements. It models the information that combined and joint component commanders need to exchange.

The purpose of the MIP is to provide the following:

- A description of the common data in the JC3IEDM that contains the relevant data, abstracted in a well structured normalised way that unambiguously reflects their semantic meaning.
- A base document that can be used as a reference for future amendments to the model.
- A core upon which nations can base their own modelling efforts of chosen areas and onto which specialised area models can be attached or "hung".
- A basic document that nations can use to present and validate functional data model views with their own specialist organisations.
- A specification of the physical schema required for database implementation.

In 2002 the Army Tactical Command and Control Systems (ATCCIS) programme merged with MIP. ATTCIS was founded in 1980 to see if interoperability could be obtained at reduced cost and developed according to technical standards prescribed by NATO and agreed by Nations. The programme sought to identify the minimum set of specifications, to be included within national C2 systems that would allow interoperability between them. Since information exchange requirements change over time, there is a need to design a flexible generic model that could adopt over time to changing information needs and serve as a basis or hub for new systems. For these reasons the data model was initially known as the Generic Hub Data Model. The name was changed to Land C2 Information Exchange Data Model (LC2IEDM) in 1999 and an updated version was released in 2002. Development continued to include considerably more joint content. In 2003 a new version named C2 Information Exchange Data Model (C2IEDM) was released.

In 2004 the NATO Data Administration Group, NDAG, and the MIP data modelling group merged to form the (MIP) Data Modelling Working Group, DMWG. The immediate result of this merge was to combine the C2IEDM and the NATO Corporate Data Model to produce the Joint Command Control and Consultation Information Exchange Data Model (JC3IEDM).

There are three models that are presented in the JC3IEDM namely the conceptual, logical and physical.

1. The Conceptual Model represents the high level view of the information in terms of generalised concepts such as actions, organisations, material, personnel, features, facilities, locations and the like. This model is of interest to senior commanders wishing to verify the scope of the information structure.

2. The Logical Data Model represents all of the information and is based upon breaking down the high level concepts into specific information that is regularly used. For example, a tank is an armoured fighting vehicle that is a piece of materiel. This breakdown follows human reasoning patterns and allows command and control systems to generalise by recognising, for instance, that tanks are equipment. A logical data model specifies the way data is structured with an entity-attribute-relationship diagram and supporting documentation. This model should be of interest to staff officers to ensure that the operational information content is complete.

3. The Physical Data Model provides the detailed specifications that are necessary to generate a physical schema that defines the structure of a database. It is of primary concern to C2IS system developers building JC3IEDM-compliant systems.

Foundational elements

Basic concept in data specification is an entity, i.e. any distinguishable person, place, thing, event or concept about which information is to be kept. Properties or characteristics of an entity are referred to as attributes. The entire structure is generated from 15 independent entities that is, entities whose identification does not depend on any other entity. These 15 independent entities and a short explanation of them are gathered in a table in Appendix A.

Bearing on DCMF

The JC3IEDM was chosen as the starting point for the middle layer of the multiple layered DCMF-Ontology (DCMF-O) frameworks within the DCMF Project. The DCMF-O is a central knowledge representation and analysis core from which knowledge components for building MSMs may be generated. Given that the theme for the MSMs are military operations and their procedural and behavioural aspects. Thus DCMF-O is thought to capture and model the semantics of the military operations domain. As such all information contained in the JC3IEDM model is of interest for the DCMF. The main objectives of the JC3IEDM are well in line with the original CMMS concept and therefore with the DCMF project itself. Though, the proposed application of the common data model is different. In case of JC3IEDM, it is a part of the MIP solution and is intended to facilitate data level interoperability between co-operating national or international C2IS systems. On the other hand, the DCMF project is at a much higher level of semantic and conceptual modelling and interoperability. Nevertheless, we found that the JC3IEDM is an accepted and consensus approved model of the basic entities involved in the military domain. Therefore, the DCMF Project has been taking a close look at the model and proposes to make those adaptations and modifications as will be required for complete representation of MSMs.

Reference

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10. DoDAF - The DoD Architecture Framework

In response to increasing needs for joint and multinational military operations, the US DoD[22] became increasingly aware of the need for a standard architectural approach to ensure that its systems can communicate and interoperate. Beginning in 1995, the US DoD developed guidance on architecture development. The C4ISR[23] Architecture Framework, Version 1.0 was published in 1996. Version 2 of the framework was published in 1997. After experience with these versions and in recognition of the need to strengthen adoption, the US DoD began work on a new version. On August 30, 2003 the DoD Architecture Framework (DoDAF) [2], Version 1.0 was released [1].

DoDAF defines a framework for both war fighting operations and business operations and processes. The framework is intended to ensure that architectural descriptions can be compared and related across organisational boundaries, including joint and multinational boundaries. The DoDAF consists of three different perspectives or views as they are called, namely Operational, Systems and Technical Standards View (see Figure 10-1).

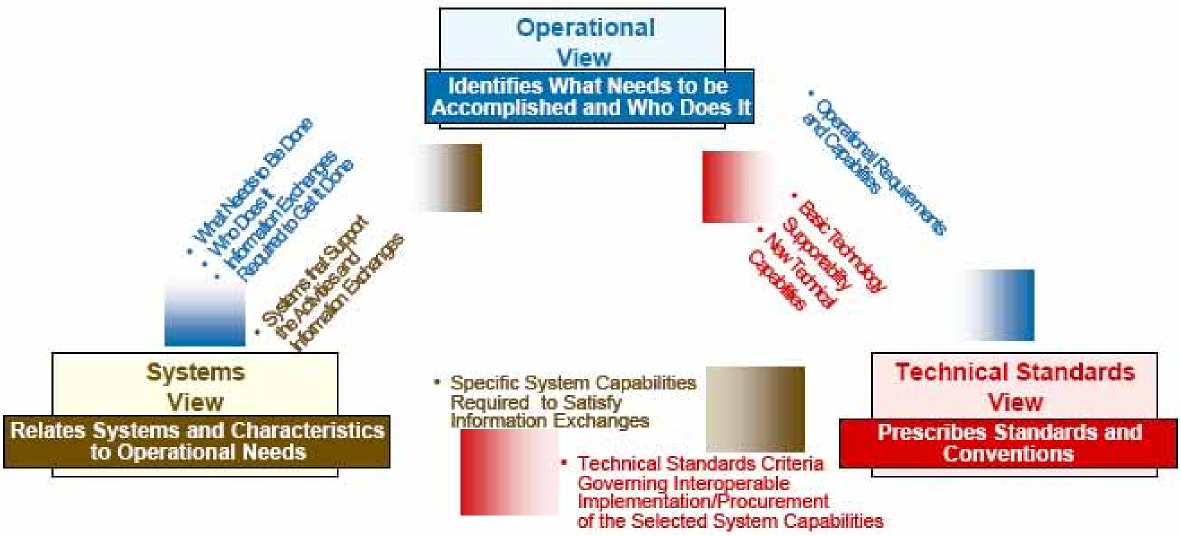

Fig 10-1: The three views constituents of DoDAF [2]

Each view is composed of sets of architecture data elements that are depicted via graphical, tabular, or textual products. The DoDAF comprises of 26 different architecture products grouped under these three different Views.

The Operational View is a description of the tasks and activities, operational elements, and information exchanges required to accomplish DoD missions. DoD missions include both war fighting missions and business processes. The Operational View contains graphical and textual products that comprise:

- An identification of the operational nodes and elements, assigned tasks and activities, and information flows required between nodes.
- The types of information exchanged.
- The frequency of information exchanges.

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[22] US DoD – United States Department of Defence
[23] C4ISR - Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance

- Which kind of tasks and activities are supported by the information exchanges.
- The nature of information exchanges.

The Systems View is a set of graphical and textual products that describes systems and interconnections providing for, or supporting, DoD functions. DoD functions include both war fighting and business functions. The Systems View associates the system resources to the Operational View. These system resources support the operational activities and facilitate the exchange of information among operational nodes.

The Technical Standards View is the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements. Its purpose is to ensure that a system satisfies a specified set of operational requirements. The Technical Standards View provides the technical systems implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed. It includes a collection of the technical standards, implementation conventions, standards options, rules, and criteria organised into profiles that govern systems and system elements for a given architecture.

Bearing on DCMF

The DoDAF has certain aspects which has a direct bearing on the DCMF goals and objectives. Prominently among them being, the Operational View, which has similar goals and objectives as the DCMF. Several of its instruments like the High-Level Operational Concept Graphic, Organisational Relationships Chart and Operational Activity Sequence, may provide useful input to our project. The repository which has been used by the DoDAF may also be worth investigating further, to see if parts of the data model may be integrated or used in our current DCMF knowledge base.

While the DoDAF provides direction on how to describe the architectures compatible for interoperability, supporting joint operations, it does not provide guidance on how to implement or construct a specific architecture.

This framework covers the military domain and is used mainly by the US DoD. This has been the major reason, why we in the DCMF project chose not to proceed further with our analysis of the DoDAF in the current cycle of the project. However, as we have pointed out, there are several features in the DoDAF which can be used as input to our DCMF.

References

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11. NAF - The NATO C3 Systems Architecture Framework

For a long time NATO has realised that future military information systems need to interoperate with each other more closely. Unforeseen contingencies and an increasing level of international conflicts in the near times have only further strengthened this need. In 1996 the US DoD introduced its DoDAF (Chapter 10) specifications for similar objectives as has been discussed earlier. As a combined effort NATO refined the three views (operational, technical and system architectural) of the DoDAF and incorporated them into the NATO policy for C3 Interoperability.

As described in [3] NATO has an interoperability framework that can be divided into three distinct categories:

1. Policy: The NATO Policy for C3 interoperability represents the policy layer. It is a policy that addresses all overarching and essential C3 interoperability issues, identifies each of the respective authorities and associated responsibilities, links existing interoperability documents, defines the relationship with the NATO Standardization Organization, and other relevant organisations.
2. Execution: The NATO Interoperability Management Plan and the five year Rolling Interoperability Program comprise this layer.
3. Products: The NIE[24] comprises this layer. In the following paragraphs we give a brief overview of some of its main features.

The NATO C3 Systems Architecture Framework (NAF) is a framework for enabling interoperability among disparate systems. The NATO Interoperability Environment (NIE) places the NAF at the bottom layer of the hierarchy together with NATO C3 Technical Architecture (NC3TA) [1].

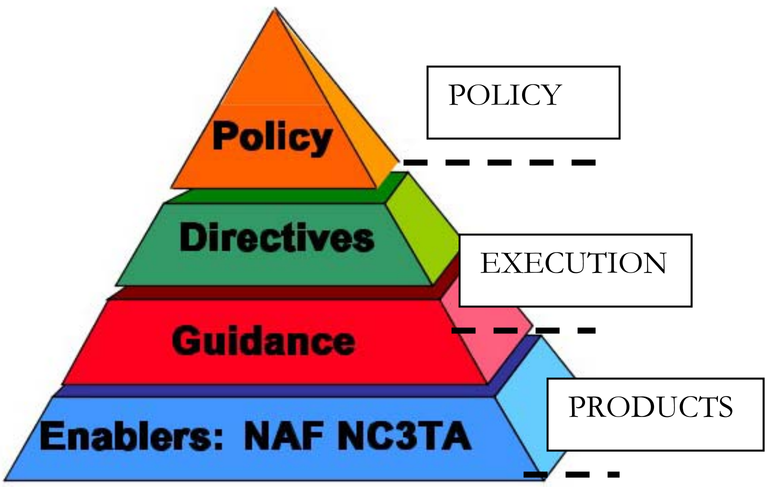

Figure 11-1 The NATO Interoperability Environment (NIE) is a four layer hierarchical structure comprising Policy, Direction, Guidance and Enablers.

[24] NIE – NATO Interoperability Environment

The NIE is a four layer hierarchical structure (Figure 11-1) and provides the basis for the technical development and evolution of C3 systems. The enablers, such as the NAF and the NC3TA provide support for design and implementation.

The terms architecture and architecture description are defined as follows:

> An architecture is "the structure of components, their relationships and the principles and guidelines governing their design and evolution over time" [2]. From this, an architecture description is "a collection of products to document an architecture".

The NAF relies on the concept of architecture views and in particular of operational, system and technical views, to describe a system comprehensively:

- **An Architecture View** is "a representation of a whole system from a particular viewpoint (i.e. from the perspective of a related set of concerns)".
- **The Operational View** is "a description of the tasks and activities, organisational and operational elements, and information flows required to accomplish or support an operation".
- **The System View** is "a description, including graphics, of systems and interconnections providing for, or supporting, system functions".
- **The Technical View** is "the minimal set of rules governing the arrangement, interaction, and interdependence of systems parts or elements, whose purpose is to ensure that a conformant system satisfies a specified set of requirements".

As seen above the classification of the types or perspectives is quite similar to that described in the DoDAF (Chapter 10). However, the NC3TA aims at providing a more in depth and complete description. In addition the NAF describes functional views (or aspects) that complement and cut across the three main architectural views. The operational, system and technical views form the minimum set of standard views for describing C3 architectures.

The NC3TA provides the principal source of procedures, architectural concepts, data (standards and products), and their relationships, from which the views may be constructed. It could be considered as the minimal set of rules required to ensure that the selected system elements collectively conform to meet the requirements established. The NC3TA contains and describes the capabilities and attributes of all procedures, standards and products necessary to meet operational needs.

The NC3TA is an enabler which, in broad terms defines the minimum set of rules, standards, interfaces, guidelines and procedures that are necessary to ensure:

- Interoperability within NATO Systems
- Effective implementation of NATO CIS[25]
- Nation to Nation Systems Interoperability

NC3TA is unique in that it is comprised of a five-volume set that consists of the following:

- **Volume 1–Management**: This volume provides the management framework for the development, as well as the configuration control of the NC3TA. It includes the general management procedures for the application of the NC3TA in NATO C3 systems development.

[25] CIS – Communication and Information System

- **Volume 2–Architectural Models and Description**: This volume principally supports a NATO technical framework to provide a common basis for the establishment of the architecture for NATO information system projects. It also offers a vision of the use of emerging off-the-shelf technologies.
- **Volume 3–Base Standards and Profiles**: This volume contains all of the current open system and communication standards applicable to NATO information systems, as well as guidance for their use.
- **Volume 4–NATO C3 Common Standards Profile (NCSP)**: This volume mandates the subset of standards that are critical to interoperability. It provides the link between degrees of interoperability as described in the NATO policy for interoperability of C3 systems, and standards selection.
- **Volume 5–NATO C3 Common Operating Environment (NCOE)**: This volume is the NCSP standards-based computing and communication infrastructure.

NC3TA is developed by the NATO Open Systems Working Group which is supported by members from most NATO Nations as well as the non-NATO members Australia and New Zealand. Thus the NC3TA is a living standard expected to fulfil the issues of interoperability much similar to the objectives of the MIP programme or the DoDAF.

Bearing on DCMF

Sweden being a member of the EU and also a partner country to NATO, there is an obvious motivation for the DCMF to conform to the NC3TA framework. As the NC3TA is based on the DoDAF (Chapter 10) principles, we have included an extensive summary of the salient features of DoDAF in this document. This does not reflect that DoDAF is more advantageous or that NAF is less compatible. Although based on the DoD C4ISR Architectural Framework (DoDAF), the NAF is comparatively different from its US counterpart by including specific NATO directives, templates, precepts and tenets.

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12. CEPA 6. Workshop on Semantic Interoperability

Research takes many forms and is reported in many ways. The main form is literature but other forms of reports, often informal and up-to-date, can be found by participating in conferences and workshops arranged by communities with common research interests. Semantic interoperability is one research area interesting for the DCMF project as it focuses on the problems of interoperability among disparate systems.

A technical workshop with focus on semantic interoperability took place in 29th and 30th of November at the Defence Academy in Shrivenham, UK. Participating were representatives mostly from governmental organisations but also from commercial enterprises. The workshop was arranged by the CEPA6[26] and the aims of the workshop were to understand the need for Semantic Interoperability and discuss the main issues. What had to be identified, concerning semantic interoperability, were (a) what is reality and what is hype, (b) research gaps, technical as well as social and organisational, (c) work currently being done and, finally (d) areas for collaboration and discovery of potential partners.

Those issues were further explored in group discussions on the specific topic: *What are the critical technical areas that must be addressed in order to progress and help with the realisation of Semantic Interoperability in Defence?*
One of the common opinions when summing up the discussions was that trust and security are basic condition for achieving semantic interoperability. It is necessary that both people and organisations from political to operational level are certain that the systems involved are reliable and robust. The actors will not be motivated to participate in and progress work on semantic interoperability otherwise. Other critical areas identified were lack of robust ontologies and management of ontologies, for example; changes in ontologies, version control, merging and mapping of ontologies. There is also a lack of standards within the area and the standards available are not always up to date. Another problem is the conflicts within existing systems with different data structures and different semantic processes.

Solutions for the critical areas that were proposed at the discussions were:

- Define a baseline for what is the current use of ontologies in defence. Identify the problems, not only technical but also get an understanding of the socio-technical problems. Furthermore, investigate the semantic variations between various defence collaborations and the semantic incompatibilities in both national and international systems. There are obviously a number of efforts being done on semantic interoperability and ontology development for defence systems. Those efforts need to be coordinated. Some efforts are not even called "ontologies" although they practically can be considered to be ontology development.

- Develop guidelines for creating ontologies. This requires defining evaluation criteria in order to examine different approaches for ontology development, what are the advantages and disadvantages with those approaches.

- Evaluate standards and find the best fit for the defence. Standards are often developed within business and not always appropriate for defence organisations.

[26] CEPA – Common European Priority Areas within Western European Armament Group (WEAG). CEPA6 is dealing with *Advanced Information Processing and Communication.*

- Develop a semantic interoperability demonstrator for Command and Control to experiment and demonstrate solutions.

- Interoperability requires willingness to share and willingness to share requires trust between systems. Trust can be achieved by rules.

- Integration of RDF[27] with compression algorithm for better bandwidth utilisation, where compression can be used.

Another result of the discussions was that semantic interoperability can support net-centric operations. Most of the participants meant that a common ontology structure on a generic level is necessary for semantic interoperability and support of net-centric operations. Furthermore, there is also a need for an automated information process. Some participants stated that it is not possible to enforce a single consistent model and that a common backbone is unfeasible. It was also considered necessary to go beyond or above the semantic interoperability level and strive for a pragmatic interoperability level.

Most of the presentations were on a high level of abstraction, dealing with definitions and technologies available along with associated problems and challenges. However, there were also presentations of more specific projects.

In conclusion, a common point of view was that there are a lot of problems and challenges ahead to progress the work on achieving semantic interoperability within defence organisations but that the work is important and worth pursuing.

Bearing on DCMF

Most of the presentations were relevant for the DCMF project as they concern similar or related problems as those of the DCMF. Noticeable was that such a large number of both governmental and non-governmental organisations were participating. There is a clear opportunity for increased international co-operation with partners in the community, something that is well in-line with the explicit goals of the DCMF. Although this was the last CEPA series of meetings arranged within the WEAG[28] there will most probably be some continuation within the new organisation EDA[29]. There were also representatives from EDA at the workshop.

References

[1] Mojtahed, V. et al. DCMF – Defence Conceptual Modelling Framework. FOI-R--1754--SE. November 2005

[27] RDF – Resoruce Description Framework
[28] WEAG – Western European Armament Group
[29] EDA – European Defence Agency

13. SOKRATES

SOKRATES is a system under development which automatically process military information and visualise the information as the common operational picture and shared situational awareness. The SOKRATES system can be integrated into existing C2 Information systems in order to speed up the C2 process as well as reduce the amount of information which has to be processed by the command individuals themselves [2].

Natural language is still commonly being used when exchanging military messages and orders. One of the reasons for this is the challenge to adequately express what happens on a battlefield in strictly specified formats. Furthermore there is a psychological advantage in using natural language for military reports. The gap between sender and addressee is felt to be narrower and the communication is more personal if the sender reports by the means of natural language [1]

One of the main issues which SOKRATES is dealing with is interoperability concerning coalition operations. Coalition operations, which are a topic of current interest in most defence research projects, require that the forces and systems involved are able to share information and have access to the same operational picture in order to collaborate [2].

SOKRATES is proposed to be a step toward an ontology for battlefield communication as a support for military leaders considering exchanges of messages and orders. Since 2004, SOKRATES runs as a prototype, but is and will be continuously extended and upgraded to match more advanced requirements according to [3].

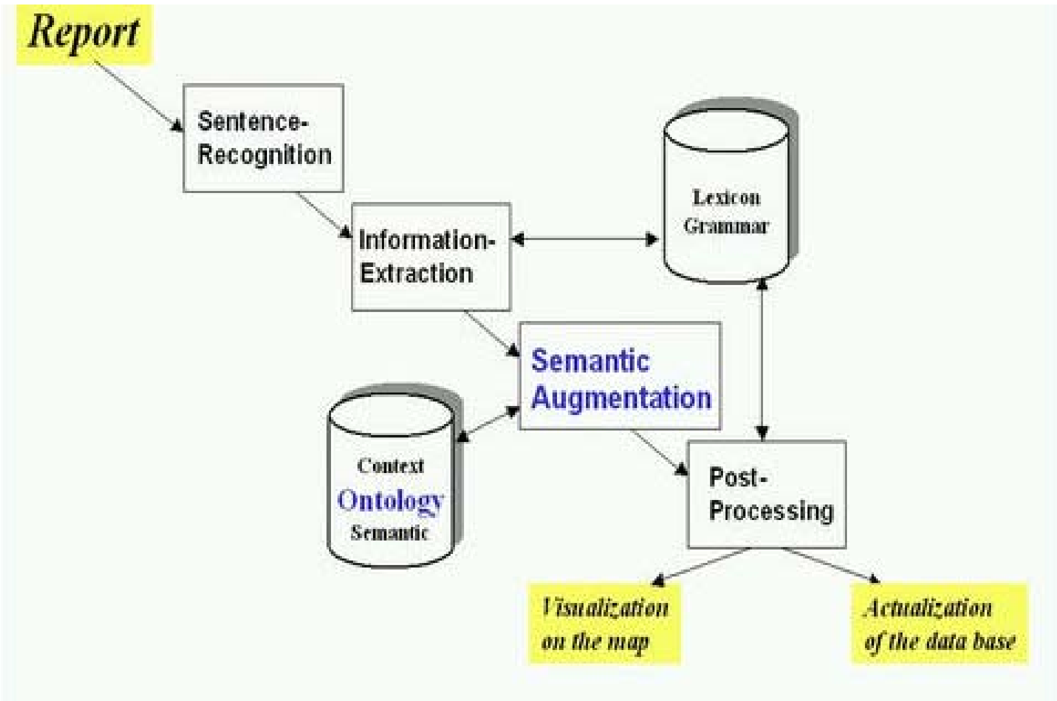

Figure 14-1: The figure illustrates the SOKRATES process initiated with a report in natural language. The report is analysed and formalised and can then be visualised within the common operational picture [3].

There are three processing steps described when analysing a report with SOKRATES [3] (Figure 14-1). Firstly, an incoming report is analysed by means of Information Extraction. The result of this analysis is a formal representation of the report's content. Secondly, the matrix is augmented semantically. This augmentation is a necessary precondition for the third processing step, the post-processing. Post-processing means that the report's content is inserted into the underlying data base and is visualised within the common operational picture as well.

The meaning extracted from the reports by SOKRATES might then complement the information provided by GPS or other sensors [2]. It will add to the common picture of the battle space and to increase the situational awareness for commanders, staffs and soldiers even further.

Semantic augmentation requires knowledge to be exploited, general knowledge (e.g., about time) as well as specific knowledge (e.g., about military operations). Thus, the SOKRATES system includes an ontology where the needed knowledge is represented, explicitly. The formal representation used in the SOKRATES system as well as its ontology component is grounded on the C2IEDM[30]. While C-BML[31] uses a fixed frame system namely the 5Ws[32], in contrast, the formal representation of SOKRATES is "lexical driven". The SOKRATES developers themselves states that the pros and cons of these differences as compared to C-BML need to be identified and assessed [3].

The SOKRATES has a great potential in supporting battlefield communication contributing to these aspects in several ways [2]. First, the system transforms natural language reports into C2IEDM entries which enable sharing the reports information. Second, the information is transformed into a map representation using standardised military symbols (e.g. APP-6A[33]) which supports a common operational picture and shared situational awareness. Furthermore, the system supports augmentation of the information which enhances its quality.

Bearing on DCMF

DCMF and SOKRATES try to solve different problems but using quite similar processes and methodologies. DCMF strives to produce conceptual models which can be used for creating simulation models while SOKRATES analyses military reports written in natural language. In spite of the different focus there are several similarities between DCMF and SOKRATES and therefore it might be interesting to share experiences between the two projects.

Some of the similarities between the DCMF and SOKRATES are that both are working with analysing natural language and represent the knowledge in order to be processable by machines. Both SOKRATES and DCMF are using an ontology structure and a common data model for achieving interoperability and both projects have studied and used C2IEDM and 5Ws.

A contact has recently been initiated with the researchers working with SOKRATES which expressed an interest in our current work. Discussions and co-operation with the SOKRATES group would certainly be valuable for the DCMF project.

References

[1] Schade, U. Towards an Ontology for Army Battle C2 Systems. http://www.dodccrp.org/events/2003/8th_ICCRTS/pdf/003.pdf . Accessed 2006-02-02

[2] Schade, U. Automatic Report Processing. http://www.dodccrp.org/events/2004/ICCRTS_Denmark/CD/papers/060.pdf Accessed 2006-02-02

30 C2IEDM –Command and Control Information Exchange Data Model
31 C-BML – Coalition Battle Management Language
32 5Ws – Who, What, Where, When and Why
33 APP-6a is the NATO standard for military map marking symbols.

[3] A description of SOKRATES on the homepage of FGAN. http://www.fgan.de/fkie/fkie_c41_f13_en.html. Accessed 2005-12-12.

14. SACOT

Military Command and Control are faced with growing issues of information overload and thereby need more advanced techniques for extracting, and processing knowledge and information from a variety of intelligence sources. The fundamental question for the SACOT[34] project is 'how to best capture and model the knowledge objects?' The Defence Research and Development Canada (DRDC) started the SACOT project for the above goals in 2004. SACOT is a knowledge engineering research project currently engaged in investigating, developing and validating innovative natural language processing techniques for building ontologies. [2]

The SACOT project proposes a methodology for knowledge extraction using natural language processing, involving the subject matter experts (SME) and the knowledge engineers for building up ontologies (figure 15-1) [1].

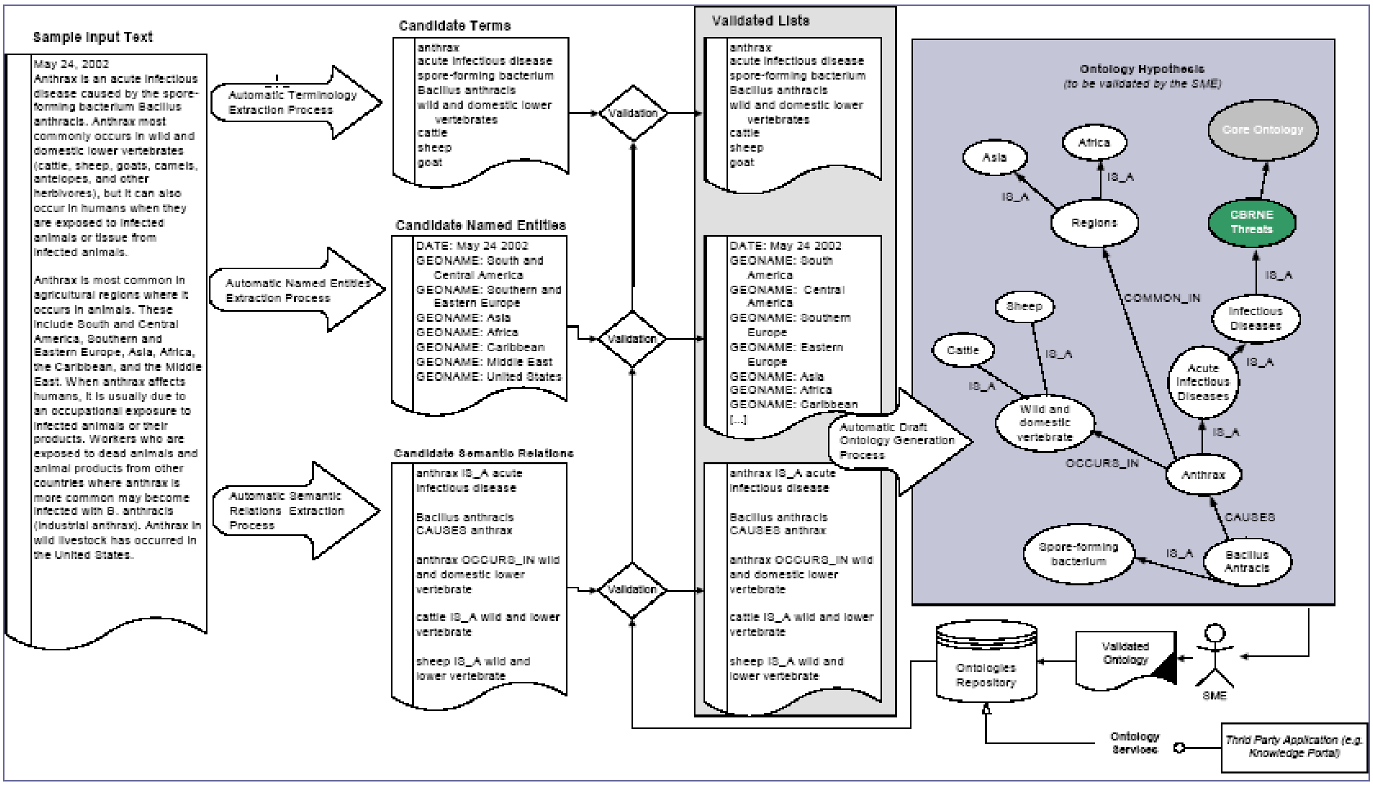

Figure 15-1: The SACOT process in brief

The SACOT ontology engineering process is proposed as a five step process enlisting:

1. Source Identification: In this step information is collected from all sources, including subject matter experts (SME).
2. Extraction Process: Domain specific knowledge is extracted by using three different processes from electronic versions of the collected information in the previous step.
3. Draft Ontologies Generation: Knowledge objects extracted from the previous step are compiled into draft ontology. For additional reference, core ontologies like WORDNET [7] or other domain ontologies are also used.

34 SACOT - Semi Automatic Construction of Ontologies from Text

4. Draft Ontology Validation: In this step SMEs validate the ontology, and the process is observed by an electronic agent as well, so that this human monitored validation can thereafter be translated into rules which facilitate automatic ontology drafting in the next iteration.
5. Ontology Maintenance: Knowledge engineers use versioning tools for maintenance so that the ontology can be used as reference ontology in the next extraction cycle.

We do not go into specific details of these phases, but they may be referred to in their publication [1].

The SACOT framework has proposed a set of tools to aid in the corpus building a terminology and relation extraction process. Notable among them and of particular interest to the DCMF project are the semi automatic knowledge extraction processes:

1. Terminology Extraction: SACOT's terminology extraction process adopts the methods proposed by Drouin [5] which in short builds a list of often repeated candidate terms and indexes them with the frequency at which they occur. Those terms with high weighted average are then lifted up to the next level.
2. Named Entities Extraction: Named entities like URLs[35], addresses, emails etc can be extracted using tools like the GATE[36] open source software.
3. Semantic Relations Extraction: SACOT framework exploits several previously established research in the realm of semantic or taxonomic relationships extraction procedures, including a compilation of 150 semantic markers in a work on semantic retrieval of information [6].

Bearing on DCMF

We can see that the SACOT project has a great potential considering techniques for natural language processing. That is, the terminology extraction and concept identification using methods as proposed by the SACOT project could also be used in the knowledge acquisition and knowledge representation phases of DCMF project. So far, we have looked at SPO[37], 5Ws, KADS [3, 4] and other such processing and extraction mechanisms and tools [3]. The proposed methodology of SACOT may very well be another such mechanism which should be looked at closer in the next phase. Given that the objectives of the SACOT project are similar to those of DCMF project, it is natural that there are possibilities for future collaboration and exchange of ideas between the two projects.

References

[1] Auger, A. Capturing and Modelling Domain Knowledge using Natural Language Processing Techniques. The SACOT Project, DRDC, Canada. Published at 10th International Command and Control Research and Technology Symposium: The Future of C2

[2] Auger. A. Applying Natural Language Processing Techniques to Domain Knowledge Capture. DRDC- Valcartier, Proceedings of 2005 International Conference of Intelligence Analysis, 2-6 May 2005, Mclean, VA. https://analysis.mitre.org/proceedings/Final_Papers_Files/359_Camera_Ready_Paper.pdf

[3] Mojtahed, V. et al. DCMF – Defence Conceptual Modelling Framework. FOI-R--1754--SE. November 2005

[4] Mojtahed, V. & Garcia Lozano, M. Kunskapsrepresentation (KR) och Kunskapsmodellering (KM) i CMMS-konceptet. FOI-R—1433—SE. 2004 *Abstract available in English*

35 URL – Uniform Resource Locators
36 GATE - General Arcitecture for Text Engineering. (http://gate.ac.uk)
37 SPO - Subject Predicate Object

[5] Drouin, P. Detection of domain specific terminology using Corpora comparison. *Proceedings of the Fourth International Conference on 'Language Resources and Comparison(LREC) , Lisbon, Portugal, 2004*.

[6] Auger, Alain. 1997. PhD thesis : strategies de reperage des enonces d'interetdefinitore dans les bases de donnees textuelles. (In french)

[7] WordNet is described at http://wordnet.princeton.edu/. Accessed 2006-03-01

Acronyms

5W's	Who What When Where Why
ATCCIS	Army Tactical Command and Control Systems
BML	Battle Management Language
BOM	Base Object Model
C2	Command and Control
C2IEDM	Command Control Information Exchange Data Model
C2IS	C2 Information System
C3	Command, Control and Communications
C4I	Command Control Communications Computers Intelligence
C4ISI	C4I Simulation Interface
C4ISR	C4I Surveillance and Reconnaissance
CAPES	Combined Arms Planning and Execution System
C-BML	Coalition Battle Management Language
CEPA	Common European Priority Areas
CGF	Computer Generated Forces
CIS	Communications and Information Systems
CWM	Common Warehouse Model
DCMF	Defence Conceptual Model Framework
DMSO	Defense Modelling and Simulation Office
DMWG	Data Modelling Working Group
DoDAF	Department of Defense Architecture Framework
DRDC	Defence Research and Development Canada
EDA	European Defence Agency
FOI	Swedish Defence Research Agency
FOM	Federation Object Model
GATE	General Architecture for Text Engineering
GIG	Global Information Grid
HLA	High Level Architecture
HTTP	Hyper Text Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
JC3IEDM	Joint Command Control Communication Information Exchange Data Model
KM3	Knowledge Meta Meta Model

LC2IEDM	Land Command Control Information Exchange Data Model
M&S	Modelling and Simulation
MDA	Model Driven Architecture
MIP	Multilateral Interoperability Programme
MOF	Meta Object Facility
MSDB	Multi Source Data Base
MSDL	Military Scenario Definition Language
MSM	Mission Space Models
NAF	NATO C3 Systems Architecture Framework
NATO	North Atlantic Treaty Organisation
NCSP	NATO C3 Common Standards Profile
NCOE	NATO C3 Common Operating Environment
NC3TA	NATO C3 Technical Framework
NDAG	NATO Data Administration Group
NIE	NATO Interoperability Environment
OMG	Object Management Group
OTB	OneSAF Testbed Baseline
PDG	Product Development Group
PIM	Platform Independent Model
PSM	Platform Specific Model
RDF	Resource Description Framework
SACOT	Semi Automatic Construction of Ontologies from Text
SCM	Simulation Conceptual Modelling
SG	Study Group
SISO	Simulation Interoperability Standard Organization
SIW	Simulation Interoperability Workshop
SME	Subject Matter Expert
SOA	Service Oriented Architecture
SOM	Simulation Object Model
SPO	Subject Predicate Object
URL	Uniform Resource Locator
US DoD	US Department of Defense
WEAG	Western European Armament Group
VV&A	Verification, Validation & Accreditation

XBML	XML Battle Management Language
XML	Extensible Markup Language

Appendix A – The independent entities of the JC3IEDM

Entity Name[20]	Entity Definition	Role in the Model
ACTION	An activity, or the occurrence of an activity, that may utilise resources and may be focused against an objective. Examples are operation order, operation plan, movement order, movement plan, fire order, fire plan, fire mission, close air support mission, logistics request, event (e.g., incoming unknown aircraft), or incident (e.g., enemy attack).	Dynamics (How, what, when something is to be done, is being done, or has been done.)
ADDRESS	Precise information on the basis of which a physical or electronic destination may be accessed.	Provides means to record postal and electronic addresses.
AFFILIATION	A specification of a country, nationality, ethnic group, functional group, exercise group, or religion to which membership or allegiance may be ascribed.	Provides means to assign affiliations to type or item objects.
CANDIDATE-TARGET-LIST	A list of selected battlespace objects or types that have potential value for destruction or exploitation, nominated by competent authority for consideration in planning battlespace activities.	Information to support ACTION.
CAPABILITY	The potential ability to do work, perform a function or mission, achieve an objective, or provide a service.	Indication of expected capability for types and actual capability for items
CONTEXT	A reference to one or more REPORTING-DATAs.	Packaging of information.
RELATIVE-COORDINATE-SYSTEM	A rectangular frame of reference defined by an origin, x and y axes in the horizontal plane, and a z-axis. The vertical z-axis is normal to the xy-plane with positive direction determined from the right-hand rule when the x-axis is rotated toward the y-axis.	Support to LOCATION for specifying relative geometry.
GROUP-CHARACTERISTIC	A reference to a set of characteristics that may be used for identifying a distinct collection of objects. Examples of characteristics include age group, disease, gender, language, and triage classification.	Supports the counting of types of persons according to selected characteristics.
LOCATION	A specification of position and geometry with respect to a specified horizontal frame of reference and a vertical distance measured from a specified datum. Examples are point, sequence of points, polygonal line, circle, rectangle, ellipse, fan area, polygonal area, sphere, block of space, and cone. LOCATION specifies both location and dimensionality.	Geopositioning of objects and creation of shapes (Where)
OBJECT-ITEM	An individually identified object that has military or civilian significance. Examples are a specific person, a specific item of materiel, a specific geographic feature, a specific coordination measure, or a specific unit.	Identifying individual things. (Who and What)
OBJECT-TYPE	An individually identified class of objects that has military or civilian significance. Examples are a type of person (e.g., by rank), a type of materiel (e.g., self-propelled howitzer), a type of facility (e.g., airfield), a type of feature (e.g., restricted fire area), or a type of organisation (e.g., armoured division).	Identifying classes of things. (Who and What)
REFERENCE	A description of the source from which information, that may have military or civilian significance, is coming.	Pointing to external information in support of REPORTING-DATA.
REPORTING-DATA	The specification of source, quality and timing that applies to reported data.	Support for the reporting function.
RULE-OF-ENGAGEMENT	A specification of mandatory guidance for the way a given activity is to be executed.	Support to ACTION.
VERTICAL-DISTANCE	A specification of the altitude or height of a point or a level as measured with respect to a specified reference datum in the direction normal to the plane that is tangent to the WGS84 ellipsoid of revolution.	Support to LOCATION in specifying elevation or height.