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DYNAMIC ACCESS TO SHARED OPERATIONAL INFORMATION

RASMUSSEN Rolf, SLETTEN Geir

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FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
P O Box 25, NO-2027 Kjeller, Norway

FORSVARETS FORSKNINGSINSTITUTT (FFI)
Norwegian Defence Research Establishment

P O BOX 25
N0-2027 KJELLER, NORWAY

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b)	C2 Information System	b)	K2 Informasjonssystem
c)	Information Model	c)	Informasjonsmodell
d)	Common Operational Picture	d)	Felles situasjonsbilde
e)	Interoperability	e)	Interoperabilitet

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8) ABSTRACT

A model for the configuration of and access to the common operational picture at a high level of command is described, in the context of Network Centric Warfare. The main focus is on the application that gives the user of the picture access to the information infrastructure.

The model described is at a conceptual level, but can be used as a basis to identify specific requirements for systems to cover these functions.

NATO Corporate Data Model is used as basis for the examples. An object-oriented view of the model is presented. This report deals a lot with the meta data level, which would require some extensions to be captured in NCDM, or, a separate model can be created to handle metadata.

This report needs to be followed up by experiments to test the concept presented.

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CONTENTS

DYNAMIC ACCESS TO SHARED OPERATIONAL INFORMATION

1 INTRODUCTION

This report is produced under the FFI project 855 FIS/O. The task has been to describe a model for the configuration of and access to the common operational picture at a high level of command, in the context of Network Centric Warfare (NCW). A textual description is to be created, supported with diagrams in Unified Modelling Language (UML). The application constituting the gateway between the user of the picture and the information infrastructure is to be further described.

Chapter 2 gives relevant background information for this report, while Chapter 3 describes the meaning and content of Common Operational Picture. Chapter 4 describes two different strategies for Picture Compilation, recommended by this project. A concept for realising one of these is described in Chapter 5, with discussion and examples in Chapter 6. Chapter 7 gives a concluding summary.

2 BACKGROUND

In the following, some of the vital concepts used in the remainder of this report are described.

2.1 Network Centric Warfare and military operations

The new buzzword in modern warfare is Network Centric Warfare (NCW). This is a new concept that has evolved over time, in parallel with the development of technology that has made it possible to realise. The concept of NCW has been adopted by several nations. The Norwegian Defence has named their concept “network-based defence” (directly translated) (5). Another term is Network Enabled Capabilities (NEC). In this report the term NCW is used.

The traditional way of thinking in military operations has been very hierarchical. A unit at lower level will report to one and only one other unit, which is the one above in the chain of command. Even at higher levels the flow of information is very much predefined, both in content and to whom. Information between two units at lower level usually had to be sent through their superior units at a higher level. This way of doing business was to a large extent enforced by the technical solutions available, with several proprietary applications covering only a part of the command chain.

In Network Centric Warfare, the basic idea is that information created anywhere in the network should be available for anyone. The focus has shifted from sending information to a specific receiver, to making the information available to anyone that may need it. The idea is very logical, but has several technical implications that could not be solved earlier. One consequence is that all applications should work together on one common, logical network, and not on isolated subnets. This does not mean that there must be only one type of application; but they must all comply with the same standards for storing and exchange of information. Another important consequence is that the number of command levels can be reduced; each unit will be able to read the commanders intent and orders directly, and can act accordingly. The need for the units in between is therefore reduced, which was also the conclusion reached in (10) and (11).

Our work is based on a high-level model of NCW as shown in Figure 2.1, consisting of the actor-components Decision-makers, Sensors and "Effectors". They are tied together by the Information Infrastructure, or Infostructure in short.

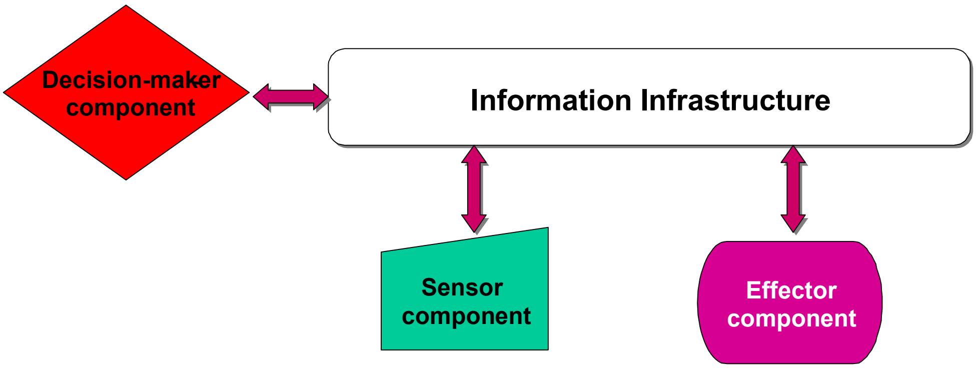

Figure 2.1 A high-level structure model of NCW

2.2 Information Exchange Requirements (IERs)

To specify the requirements for the exchange of operational information, several templates have been developed, called Information Exchange Requirements. This is a generic term used in many contexts, but has a specific meaning in the domain of military operations. Each IER covers information exchange related to one specific area. The templates give all the subjects that are deemed to be relevant in that area, but only as headings and brief descriptions. There are three collections of templates, Land (APP-9), Air (APP-8), and Maritime (APP-4), which will be replaced by APP-11 covering all services. All these IERs are focused at, for a specific situation, to send information from a unit to a predefined receiver.

Each IER is, unfortunately, developed more or less independent of the others, basically defining its own world. This means that the same piece of information needed in two different IERs very often is not structured in the same way, which causes a problem when it comes to mapping them to a data model used in a modern Command and Control Information System (CCIS). A data model will usually only use one way of representing that information, and therefore cannot satisfy all solutions at the same time.

One way to overcome the problems with the IERs, would be to 'reverse engineer', i.e. to create a new IER based on the corresponding information elements present in the data model. This would also be the same method to use to create a 'dynamic IER'; an IER created when the need occurs during runtime.

Several of the IER-templates described above have been implemented as messages in ADatP-3 (Allied Data Publication No 3). The information content is the same, but the format is stricter. The development of the messages started a long time ago, when telex or similar technology were the transfer mechanisms. The focus was at transferring the information, not at storing the information at any side. All the fields have a specification of the input type. Some fields are just free text, some are numeric, but a lot of them have a list of legal values assigned to them, of which only one can be selected.

A problem with these lists is that they are made up of values that do not logically fit together. Very often this leads to cases where it would be useful to select several values in the list, to reflect different aspects, but this is not legal. In a data model, the values may have to be split into several logical lists throughout the model, which makes it possible to select several of the values at the same time. Another problem, when it comes to using automated CCIS and databases, is the lack of unique identifiers in the messages. There was no need for keys when the development of the messages started, but in a database it is critical to have unique keys.

Information exchange based on messages is widely used today, even though there are several problems attached to the messages. However, these problems are related to the way the messages are created, not to the concept of using messages itself.

2.3 New concept for information exchange

Halaas (1) describes a concept where the process between information source and information user is considered as two parts:

1. Information Management – integration of information from different sources, generating a consistent offer
2. Information Distribution – delivering information via different channels according to user demand

This model, where producers (sources) and consumers are totally independent of each other, may be regarded as a contrast to the pair of sender and receiver given for an IER, along with the conditions under which it is sent. The model, shown in Figure 2.2, is in line with the main concept of NCW, where the information producer does not know to whom the information will be sent.

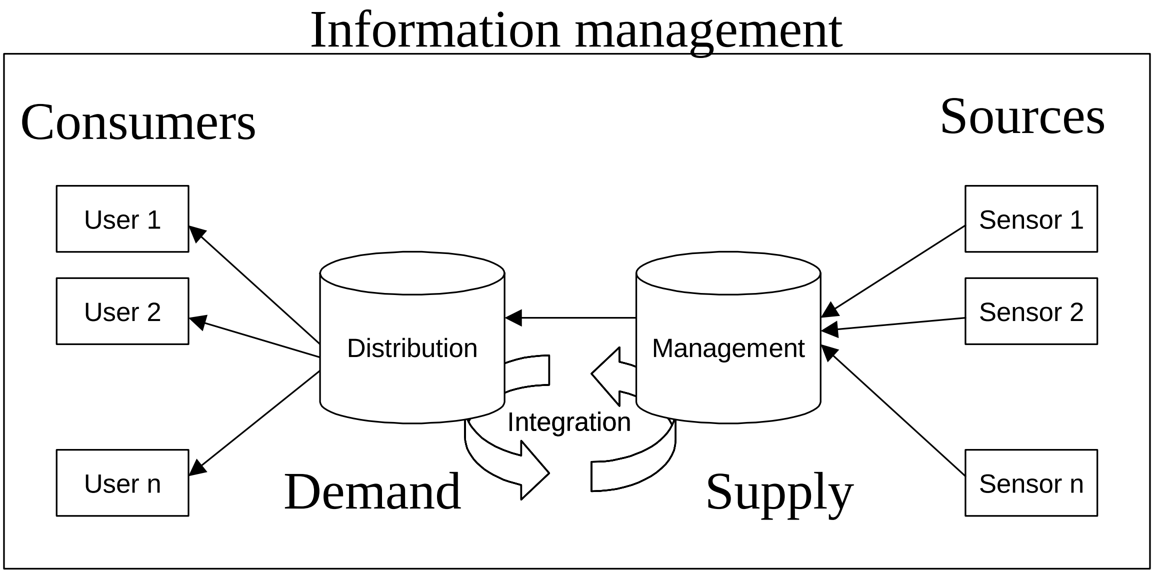

Figure 2.2 Information Management

This generalised concept of Information Management is one of the main underlying ideas for the recommended strategies for Picture Compilation that is described in chapter 4.

Halaas also presents a framework where the different elements are "boxed" together. This framework is given in Appendix 0.

2.4 NCDM – A Data Model for Interoperability

NATO Corporate Data Model (NCDM) is a model for information exchange developed by NATO Data Administration Group. It is a suite of data models, which together cover the business of NATO. To make the content of NCDM explicit, a Reference Model (RM) (4) is created. The development of the RM started in year 2000, by adopting an army based generic data model (ATCCIS – see section 2.5 below) as the basis for the NATO standard. Since then the model has been expanded with Air, Maritime, and Joint concepts. The RM is not meant to be implemented directly, different View Models, covering a subset of the RM relevant for a subject area, will be the implemented models. The ATCCIS data model (now under the custodianship of Multilateral Interoperability Programme (MIP)) is the first View Model, and represents the view for land-based operations. A high level version of the RM is shown in Figure 2.3, using UML notation. The RM is created for use in relational databases, modelled according to rules for how to make a model sound (normal forms). This figure represents a more object-oriented view of the model, where only the main classes without attributes are shown, and hiding most of the subclasses in the model. Concepts introduced for implementation reasons are also hidden. The complete relational model is about five times as big as shown here.

All the entities shown in bright yellow colour represent the main concepts in the model. These entities can exist without a relationship to any other entity. All the other entities depend upon the existence of at least one other entity.

- The objects in the battlespace are described using OBJECT-TYPE and OBJECT, for type and individual information. Both these entities have the same subtyping as shown in grey,

specialising any object into FACILITY, FEATURE, MATERIEL, PERSON or ORGANISATION
- Any activity, performed by own, enemy or neutral objects, will be captured in ACTION
- CAPABILITY ties these three entities together, specifying what objects can do, and which requirements must be fulfilled to perform an action
- All OBJECTs can have a position and shape specified in GEOMETRY
- REPORTING-DATA and CONTEXT can be used to specify information about the other information in the model, and how it should be grouped
- ACCESS contains various kinds of addresses, ranging from physical address to telephone number and call sign
- CANDIDATE-TARGET-LIST contains lists of targets, categorised from different perspectives
- RULE-OF-ENGAGEMENT gives additional information or constraints related to the execution of one task

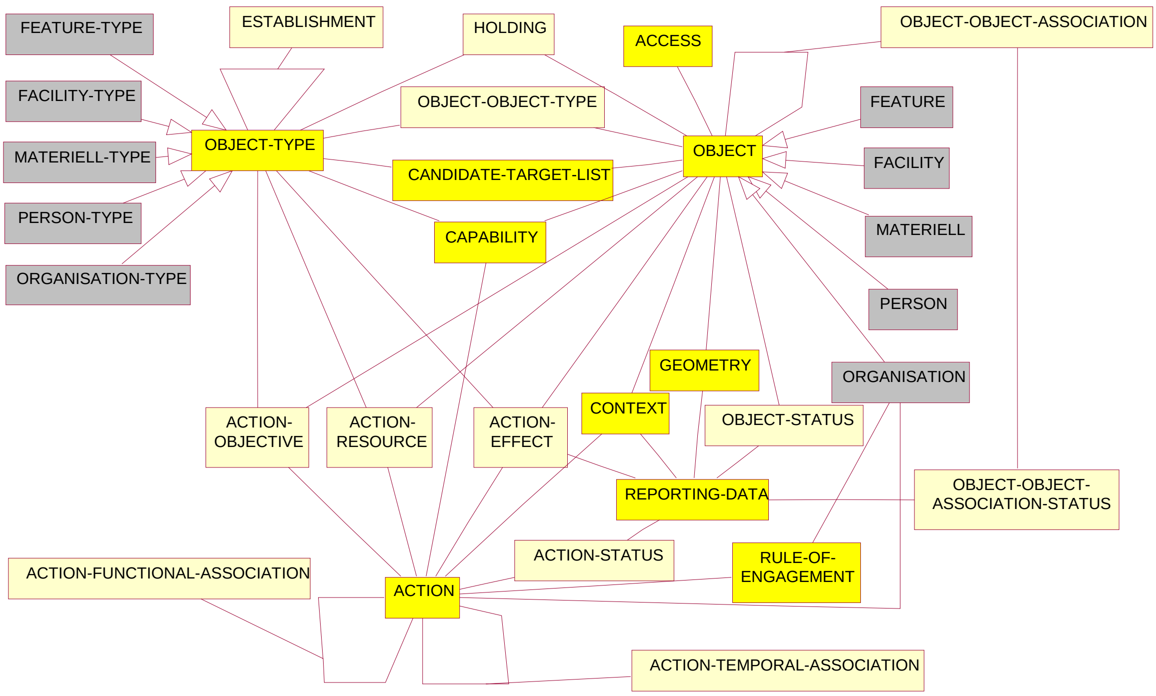

Figure 2.3 A high level view of the RM of NCDM

2.5 ATCCIS/MIP

Army Tactical Command and Control Information System was a study that ran from 1980 until 2002. The focus was to develop new concepts for information exchange, enabling automatic information exchange between computer systems. ATCCIS had two main products: a generic data model for the storage of information and a replication mechanism for the exchange of information. The two products were created to be used together, but they can also be used independently of each other.

The data model, referred to as both Generic Hub (GH) and Land C2 Information Exchange Data Model (LC2IEDM) (2), was developed from Army requirements, but using terms suitable for all services. The development of the data model from a land perspective continued in ATCCIS after it was selected as the core for NCDM in 2000.

The replication mechanism (3) was developed to move the information between databases. It was developed to overcome some problems with commercial replication mechanisms from database vendors, like the assumptions that communication is always working, and that the bandwidth is always sufficient. The ATCCIS Replication Mechanism (ARM) handles these problems, and is at the same time vendor independent. The ARM is an element of NATO C3 Technical Architecture.

In 2002, ATCCIS merged with Multilateral Interoperability Programme (MIP), a programme running since 1998. MIP was a programme already implementing the specifications developed by ATCCIS. Furthermore, in February 2004, it was decided that the Data Modelling activities of both NDAG and MIP would be merged, with MIP in charge of all further development.

3 THE COMMON OPERATIONAL PICTURE

The definition used for "Common Operational Picture" in NATO's official definition list AAP-6, is:

> "An operational picture tailored to the user's requirements, based on common data and information shared by more than one command."

This definition is not very precise, and gives room for many interpretations. In this report, the use of the term is based on the following description in the remainder of this section:

An operational picture can be viewed as a snapshot of the situation at any point in time. However, not only information shown on a screen together is relevant for the COP, also all the earlier information being used to derive this picture is relevant. Since it is a snapshot of the situation, it follows that it does not contain information about plans and orders *not yet started*. However, orders already under execution, is part of the COP.

All the information presented together as one COP, will not be stored as a picture, rather as individual information elements being valid at the same time. The time information will decide which elements should be included in the COP at any time. Some information is valid at almost any time, like maps used as a background. Other information is only valid for a certain period of time.

The users will most likely have different requirements, so they will not need the same information elements in their operational pictures. However, even though being different, the different operational pictures will still be consistent.

All information will necessarily be based upon information dated back in time, from milliseconds to minutes and maybe several hours. A COP, therefore, does not represent facts about the current situation, it is an estimate of how the current situation is, based upon the most recent information available. It is possible to establish several estimates, i.e. COPs, at one point in time, due to alternative interpretations of the information available.

Another term that has been in use lately is Common Relevant Operational Picture (CROP) (6). At first glance, this seems like it has to be the same as COP; who wants anything not relevant in the COP? The definitions are almost the same, but the description reveals that CROP is not *used* to mean the same. CROP is used to include the whole system, including software, around the COP to give the user access to the information. In essence, the system described by CROP is what this report is describing as well. However, the term CROP will not be used further in this report, since there is a mismatch between the term and the usage of it.

3.1 Situational awareness

A COP is the basis for a decision maker when trying to obtain situational awareness. A COP alone is, however, not sufficient. To obtain situational awareness, the user must also be able to understand what is presented in the COP. The goal is that every user will achieve the same situational awareness. Situational awareness is the main building block for making decisions in the NCW concept (see Figure 3.1).

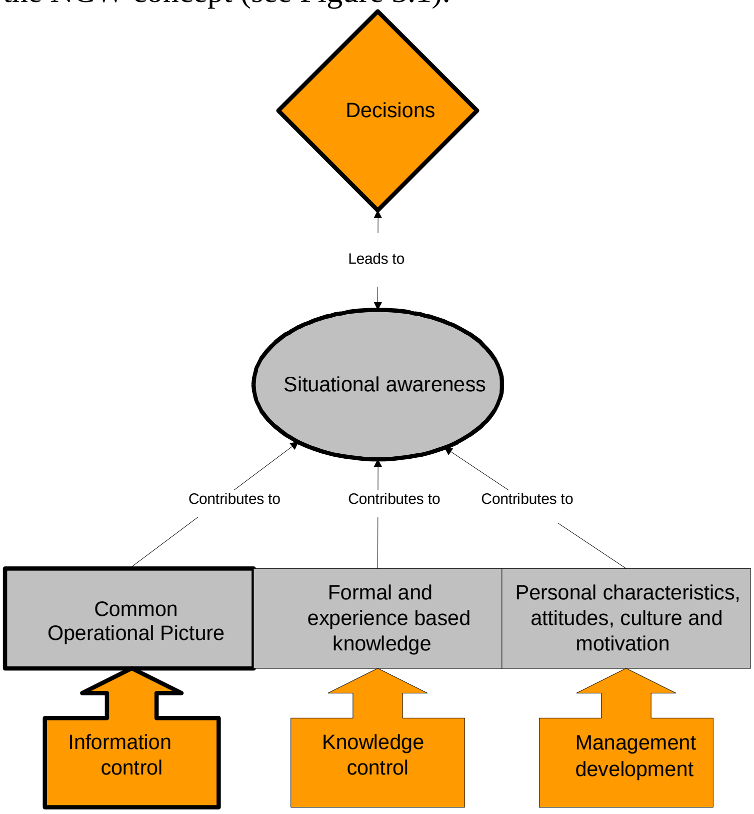

Figure 3.1 Situational awareness

3.2 An operational view of the COP

The following general types of information elements were identified to be part of the COP by a group of operational users in ATCCIS (7). Only dynamic information that needed to be exchanged was identified here, information of a more permanent nature like maps and doctrines were assumed to be present at all nodes already.

- Information about all (friendly and other) units, materiel, persons, control features, geographic features and facilities within a certain Area Of Interest (AOI), including:
    - Identifying description (e.g. name, size)
    - Reports on the type of object
    - Location reports
    - Status reports
    - Hostility reports
- For units only the following additional information applies:
    - Reports on ongoing (or formerly performed) activities
    - Reports on combat effectiveness and additional assessment remarks
- Holdings (enemy and friendly units)
- Organisational structure of all forces (Order of Battle - ORBAT)
- Linkages between organisations and facilities or control features
- Associations between facilities and features
- Information about the reports, including date/time, source and verification

A more detailed analysis of these types of information has resulted in the following results, with an additional part for static information not covered above.

3.2.1 Dynamic information

In the grouping shown in Table 3.1 below, some details may be as relevant in other groups as well, however, the total of information is important, not how it is subdivided.

Main category	**Further details**
Friendly and other units	Type of unit Strength (types and numbers) Capabilities Holdings Command relationships and associations Status of unit, its personnel and equipment Position and direction (frequency of update) Vulnerabilities
Mission	Assigned task Commander’s intent Critical impacts on mission accomplishment (medical, mobility, logistics, CIMIC, NBC threat) Rules of engagement Targets
Weather and Terrain	Effects on operations Light conditions Oceanography Risk of avalanches Mine fields Temporary bridges

	Terrain data Obstacles Control measures (points, lines, areas)
Civil considerations	Civilian institutions and organisations Attitudes and activities in the civilian society

Table 3.1 Dynamic information in the COP

3.2.2 Static information

Main category	**Further details**
Concept of operations	
Own and enemy doctrine	
Time available	Time for the enemy to react Considerations whether own forces can utilize time (like night capability)
Terrain	Features Slope Elevation Soil conditions Vegetation Trafficability/obstacles
Civilian conditions	Infrastructure

Table 3.2 Static information in the COP

3.2.3 Graphical representation of the contents

Figure 3.2 below shows how the assumed user view of information from the tables above can be illustrated at a conceptual level, using a UML class diagram. Both the dynamic and static information of the COP are included. The units have been split into own and enemy units as a clarification, due to the assumption that the two normally will have different usage.

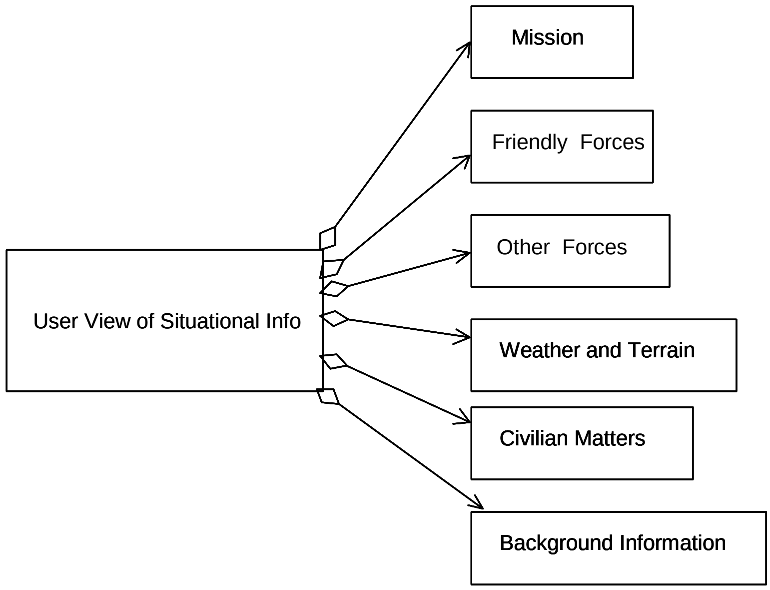

Figure 3.2 UML representation of the information in the COP

4 PICTURE COMPILATION

The whole area of collecting sensor data and combining the data from different sources into human-readable “pictures” is here called Picture Compilation.

The recommendation from FFI project 855 (8) is that the strategy for producing the COP should differ depending on the levels of operation (see Figure 4.1).

- At the lowest levels of command there will in general be a focus on “push” of information from available relevant sources (numbered 2). This will be the case when the information need is mainly predefined.
- At the highest levels the focus will to a large extent be to “pull” the right answers to whatever information need the user might have (numbered 1). This covers cases where the information need is not predefined, but can change during the operation. All users will pull their information from the same pool. This will lead to that their pictures may not be identical, depending on their needs, but all the pictures will still be consistent. This information need is what we propose to formalise into an “Information Request” that will be described later.

In real life, a combination of the two strategies will be used. Strategy 1 will be more used at the higher levels of command, where the main tasks are to assign missions and resources, perform planning and control the execution of operations. Users at these levels will to a large extent have individual information requirements. It is hard to predict their requirements, so flexibility in picture production is vital for them. The time frame will allow the users to actively search for information, creating a picture tailored to their needs. At lower levels of command the main task will be to execute a given task, with given resources. It is easier to predict the information requirements, which may be the same for several collaborating units. The shorter time frame may even make a push strategy the only possible strategy.

There is one important change compared to the situation today, for both strategies. The ownership of the sensors, effectors and picture producing nodes will no longer be tied directly to the platforms; they will be considered common resources, and utilised on an ad-hoc basis, based on the users’ needs. There must exist a set of rules for how to utilise the resources, especially how to prioritise between requirements for the same resource, but these rules will not be further investigated in this report. For the lower levels of command, there will be some pre-defined flows of information, however, these will be much easier to adjust according to changing requirements than today.

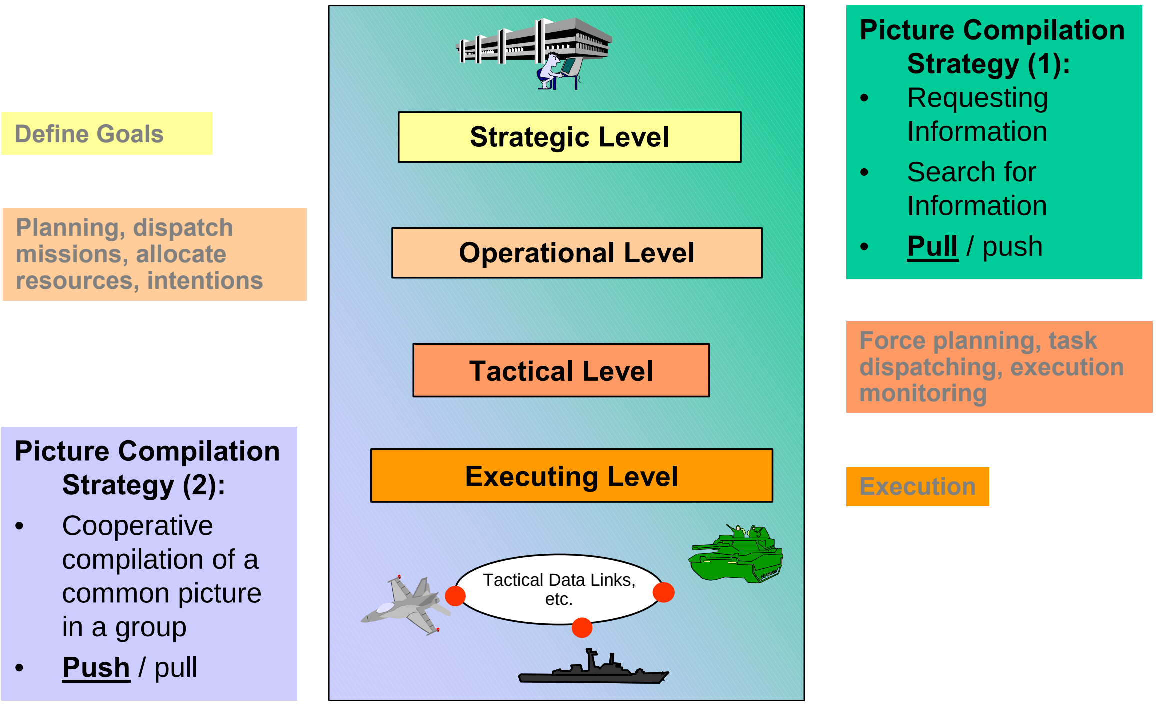

Figure 4.1 Top-down (1) and Bottom-Up (2) Strategies

4.1 Strategy 1: Pictures tailored to user needs

Strategy 1 is most widely used where the main tasks are assignment of missions and resources, planning and control of execution. The strategy is that every user of the COP will publish his information requirements in the Infostructure, and receives a COP tailored to this need. An assumption behind this is that every user at this level will have individual requirements, which may not be shared by many other users. This strategy is illustrated in Figure 4.2.

With this strategy there will not be any COP compiled for the user before he requests what he would like it to contain.[1] It is a requirement that all the different COPs presented to the users have to be consistent. This is achieved by deriving every COP from the same basis provided by the common pool of information providers. Information from different providers must be made consistent before it is added to the pool. New providers will not be added to the pool unless current provider cannot deliver the requested information, to avoid information overload.

[1] With Strategy 2 there will be picture compilation all the time, according to a pre-defined information need, see section 4.2.

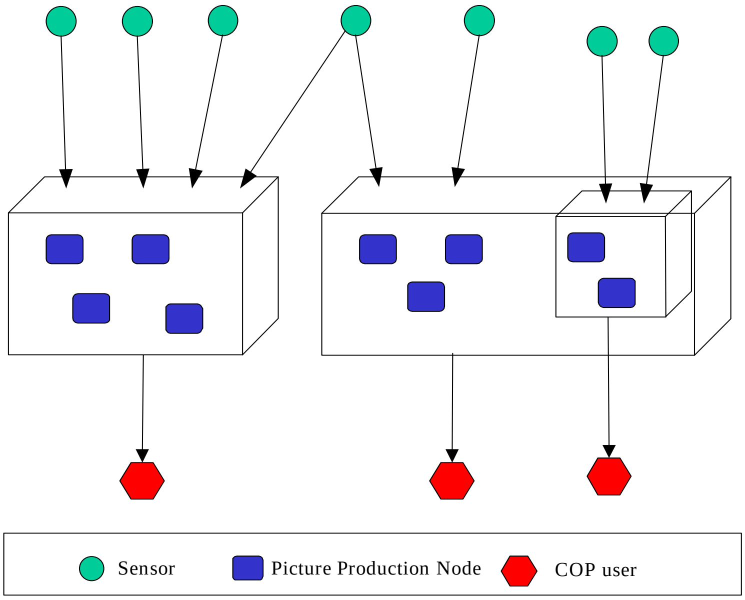

Figure 4.2 Compilation of several consistent COPs

The picture compilation is initiated by a COP user publishing his requirements on the Infostructure. The Infostructure will find the Picture Production Nodes that will fulfill parts of or the complete requirement, and ask for their collaboration in producing the picture. The Infostructure will respond to the user with a node to connect to.

The sensors are connected to the Picture producing nodes as needed, and send their information to them.

4.2 Strategy 2: Compiling one COP within a group

At the lower levels of command, there will be groups with a need for the same COP. A group has a need to be closely integrated either because they are in the same area and/or because they are executing a task together. Due to time restrictions it may not be relevant to make individual requests. Within a group everybody will have the same picture, another groups may have different pictures, but they are all consistent.

A COP can be viewed as a common database where all the available data is stored. All the users will have access to the same COP, but can modify the presentation of it by filtering the data. The filtering can be because of technical limitations, like bandwidth, or depending on the role of the user. This is illustrated in Figure 4.3.

The main difference from Figure 4.2 is that several users will receive the same picture, which they can filter upon, instead of having exactly their need covered. In addition, the information flow is to a larger degree predefined.

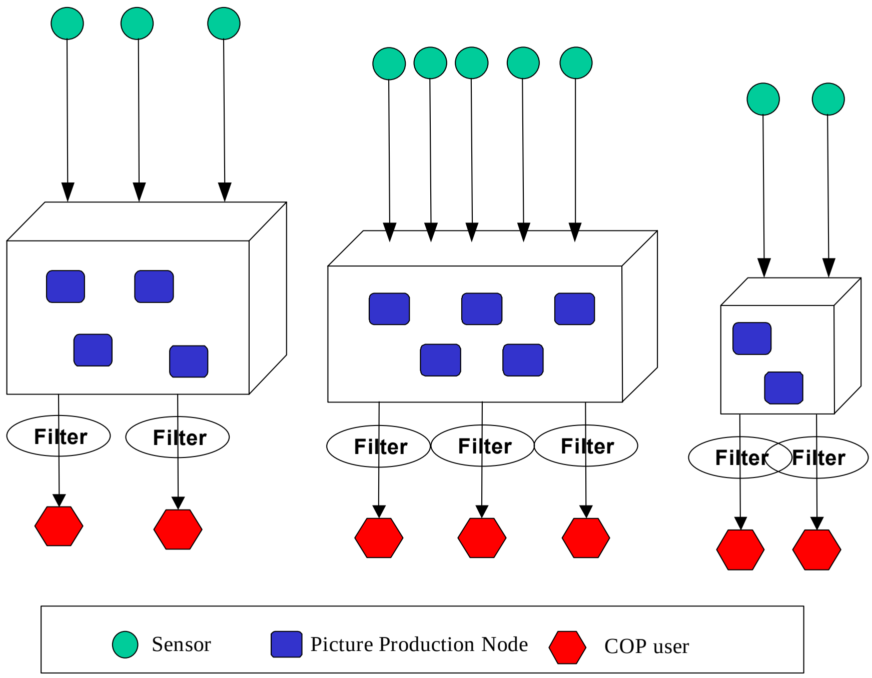

Figure 4.3 Compiling one COP for a group

Even though Strategy 2 to a larger extent is based on pre-planned information flow between the actors, there will be larger flexibility than in the traditional way. It will be possible to

- Connect new units ad-hoc
- Change the roles of the actors during the course of action
- Redirect the flow of information and the protocols used
- Connect a sensor directly to a user, when needed

4.3 UML Use Case diagram

The following diagram describes, using UML, the Picture Compilation environment at the highest level.

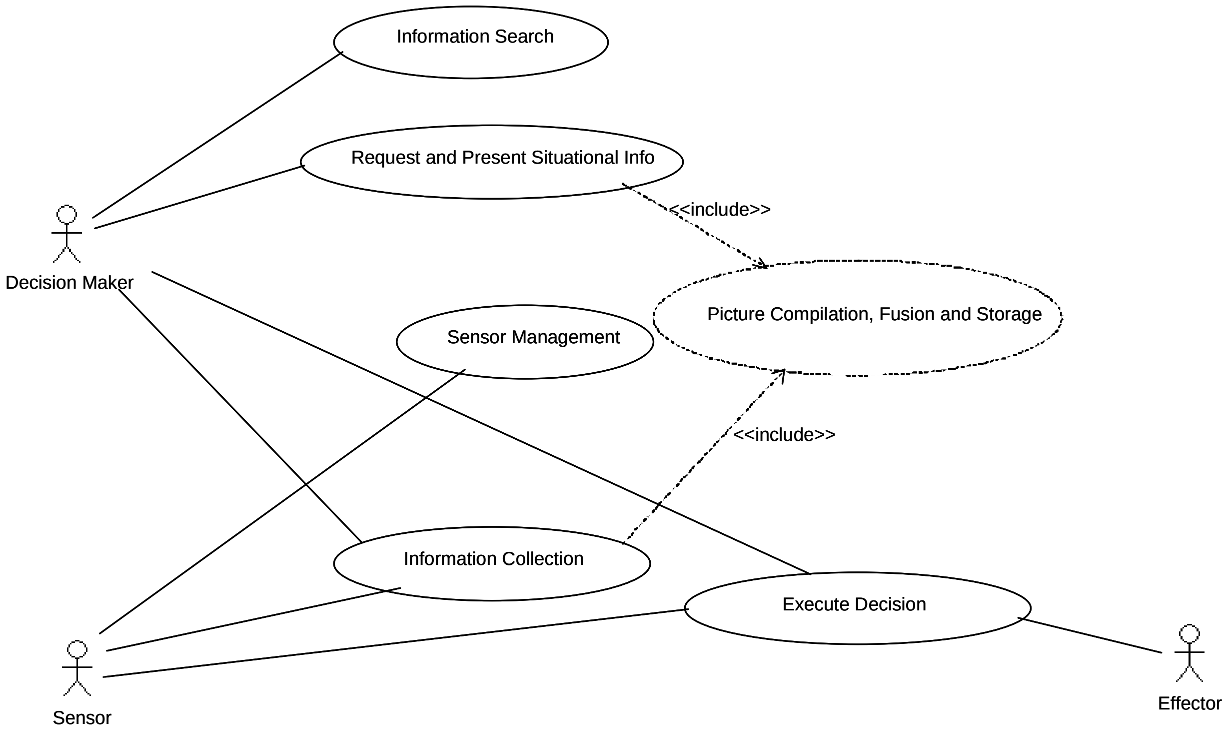

Figure 4.4 UML Use Case representation of Picture Compilation environment

This Use Case diagram identifies the main functional areas involved in Picture Compilation and usage. The Use Cases are primarily thought of as “users interacting with the Infostructure”, but may also be regarded as an example of a technology-independent “business process view” of Picture Compilation. The Use Cases are briefly described in the following table.

High level Use Cases (may be compared to business processes)

1.	Information Search	Covers all kinds of (unstructured and more intelligent) search for information – may be compared to Internet's "search engines". It is there to support any need of information that goes beyond the pre-planned contents of the COP.
2.	Request and Present Situational Info	The decision maker requests and gets delivered a well-structured collection of relevant information – a COP. This is the context of the "Information Request" concept described in this report.
3.	Sensor Management	Managing the sensors as resources – covering all aspects from fine-tuning and physically moving to agreements on "who has the rights to allocate this sensor for the next time period". Note that the assumed actor "Resource Manager" is not present in this picture, due to the fact that the details of Sensor Management are outside the scope of this study.
4.	Information Collection	This is the interface of the sensors to the Infostructure. Properties must include configuration of the network of a number of decentralised "collection nodes" (assumed to be a part of the Picture Production Nodes in this report), and information delivery further in to the compilation process. Optional elements may be logging and (temporal) local storage of information.
5.	Execute Decision	This is when the action begins – a decision is to be executed. This involves the use of an effector, and may well require capabilities like real-time processing and "sensor-to-shooter" communication
6.	Picture Compilation, Fusion and Storage	This is the most important process – assumed to be running "in the background", but being able to adapt to the requirements indicated by the users. The "pictures" that are delivered are the (logical) data about all the relevant contents of the COP (see separate description). The Picture Compilation process includes Data Fusion and the necessary storage mechanisms. It is assumed to consist of several decentralised processes that are able to coordinate themselves and cooperate with their environment at any time.

The main flow of activities and information in the context of Picture Compilation is between sensor and decision maker. This report will be focusing on the Use Case labelled "Request and Present Situational Info", elaborating the contents of the "Request" part.

5 THE "INFORMATION REQUEST" CONCEPT

In this chapter a more detailed description of the core concept of the top-down strategy for picture production, namely the "Information Request" Concept, is given.

5.1 Terms

The main terms used in this chapter are shown in Figure 5.1 below. In the context of Picture Compilation this may be regarded as one (out of many) first-level exploration of the NCW structure model in Figure 2.1. Note that the actors at this stage are pictured as related to the Infostructure as a whole.

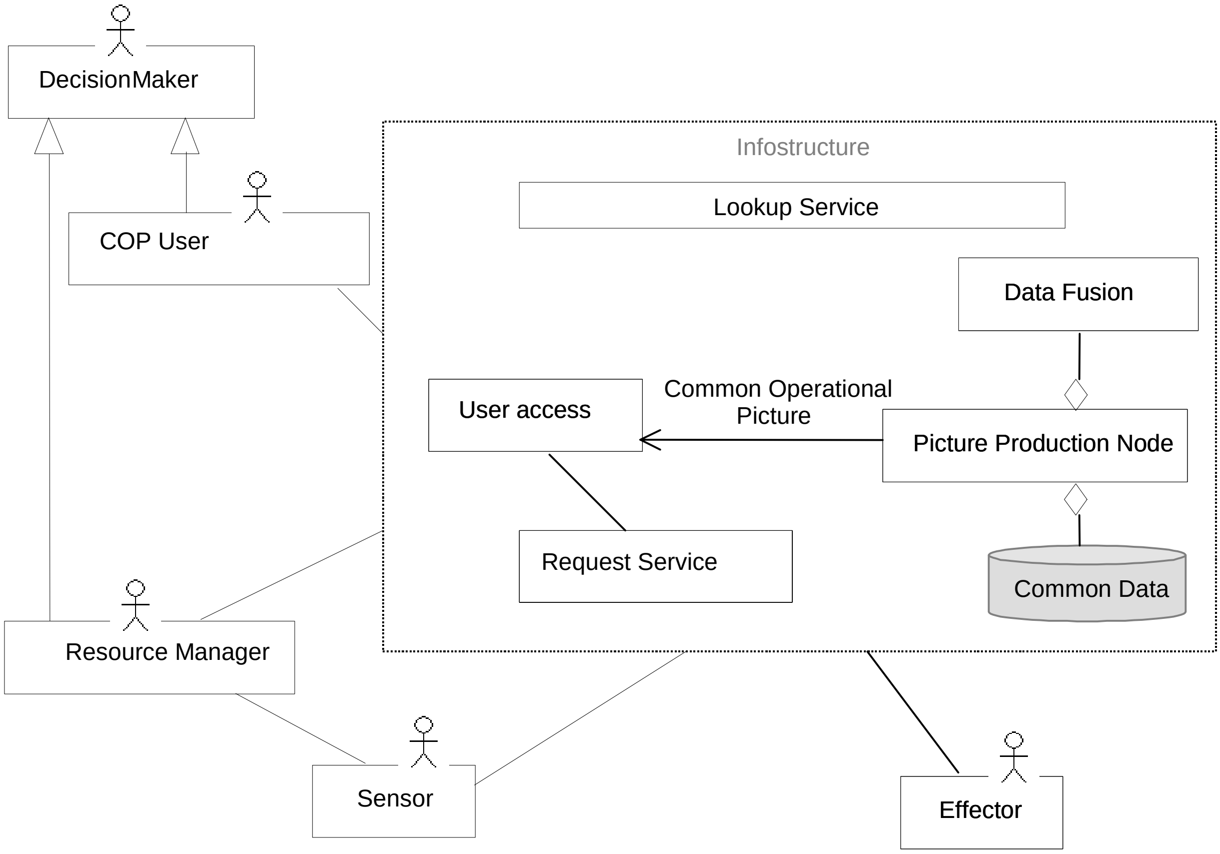

Figure 5.1 Terms used in this chapter

Actors

Decision Maker	This actor models what traditionally is considered the human part of the scenario described – the person who acts upon the received information by making decisions.
• COP User	This is the main user of the COP – i.e. the Decision Maker in the context of access to the compiled picture.
• Resource Manager	This is another sub-class of Decision Maker, being responsible for resources (i.e. Sensors, Production Nodes) in the context of Picture Compilation.
Sensor	Sensors are in charge of supplying the information to build upon. There are several different types of sensors. Some of them may be “managed” – physically moved or technically tuned – according to changing requirements from the picture compilation process. Note that the actor Decision Maker may be considered to take the role of a Sensor when supplying input to the picture compilation process.
Effector	The properties of the effectors have not been focused in this work.

Components inside the Infostructure:

User Access	Handling the user interface, and interacting with the other components on behalf of the user
Lookup Service	The directory that holds access information to all relevant components and services (a kind of "telephone directory") – also known as Directory Service
Request Service	Holding knowledge about ongoing Picture Compilation activities, and information requests from users
Common Operational Picture	Here used to describe all variants of "situational info", tailored to each user's need, that can be delivered from the Picture Production Node
Picture Production Node	This is where sensor information is collected and assembled, resulting in a COP
Data Fusion	Specialised part of Picture Production, where data from several sources is combined and analysed
Common Data	This is the store of all collected information, from which all the user tailored COPs will be extracted

5.2 Introduction

This concept is introduced by describing a four-step scenario as follows:

- Given a Decision Maker in need of information to update his situational awareness. The first step is that the decision maker specifies an information request. This request is sent to an "automated information assistant" - an invisible application in the Infostructure. The assistant will get the list of available services, and compare it with the request. Depending upon the results of the analysis, there are two different courses of action:
- If the request can be satisfied, it will, providing the requestor is allowed to access this type of information, be sent to the Picture Production Node. The requestor will then be added as a new subscriber to its picture.
- However, if the assistant cannot find any service that will satisfy the request, it will be forwarded to the Resource Manager, who will decide what will happen with the request.
- If there are currently no sensors available that can fulfil the request, it will be put on hold, and maybe satisfied sometime later. In the remaining cases, there are sensors that can satisfy the request, but they are not assigned to this task right now. When idle, this is easy to solve, the problem arises when they are already busy. The manager then has to prioritise, alternatively, if not authorised to, raise the conflict to a higher level. If the request is not prioritised, it will be put on hold until the sensors may become available later.

The overall picture of the components in the "Request Service" Concept is shown in Figure 5.2 – as a kind of UML Collaboration diagram. The "assistant" from the previous scenario is divided into three components: a User Access component, collaborating with a Lookup Service and a Request Service as described below.

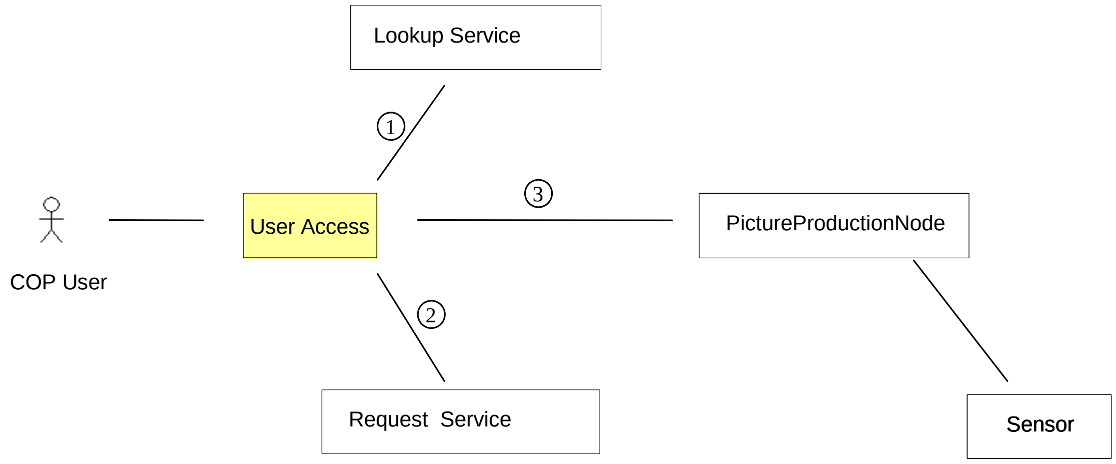

Figure 5.2 UML Collaboration Diagram of Information Request

This diagram is based on the following assumed activities:

- There is a highly interactive dialogue between the User and the Infostructure. This part of the Infostructure is the User Access component.
- First thing (1) for User Access is to locate other components to work together with. The Lookup Service holds a description of all components and services that are currently accessible for the component to communicate with.
- Given that the user need is an Information Request, the next thing (2) is to transfer a formalised description of the request to the Request Service. This service will evaluate the request compared to ongoing and potential Picture Production capabilities.
- As an integral part of the Request Service, there exists some kind of resource allocation manager (presumably an actor external to the Infostructure). The rules and mechanisms for resource management are not the focus for this work – they are just "assumed" to be there.
- The approved request is handed over (3) to the Picture Production component, and information is delivered in return. The delivery may well come as a kind of subscription, with information delivered regularly at predefined points of time.

The "story" described here is also expressed in the following UML Sequence Diagram.

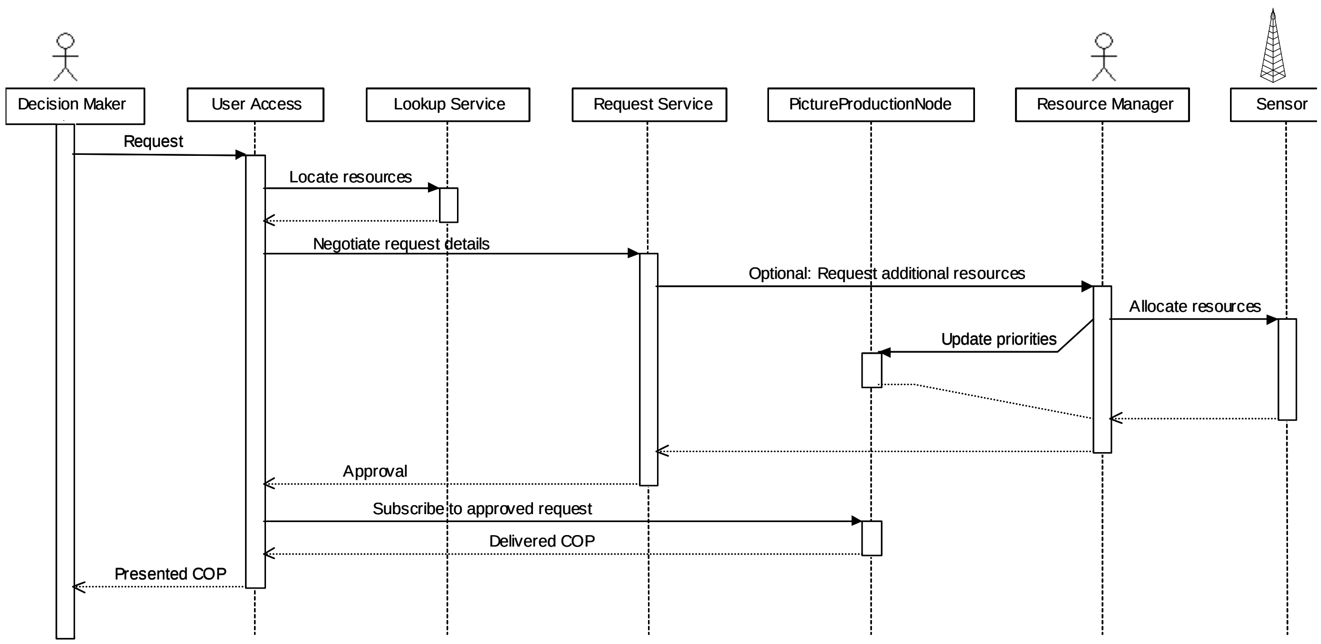

Figure 5.3 UML Sequence Diagram “Request information”

5.3 The User Access Component

The previous section aimed at giving the overall picture of “Information Request”. Now the focus will be on the component named User Access.

The aim of this diagram is to describe what the Infostructure offers to the User in a Use Case manner. It shows an “exploded” but non-exhaustive view of the high-level Use Case from Figure 4.4 labelled “Request and Present Situational Info”. All the arrowed lines shown are of stereotype <<include>>.

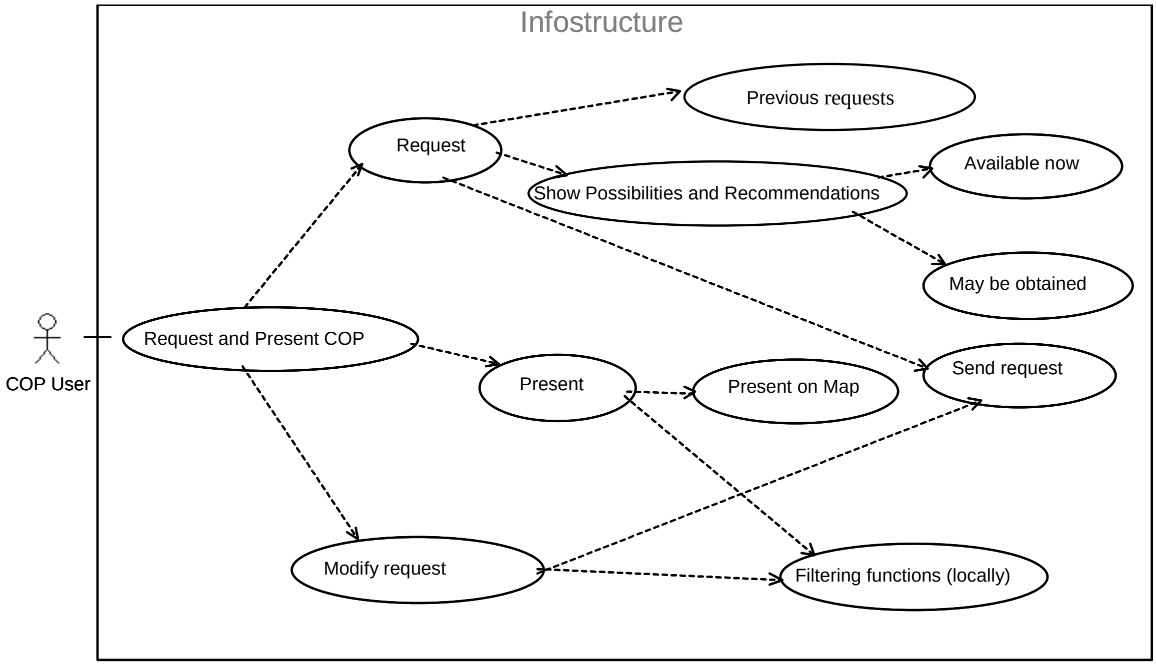

Figure 5.4 UML Use Case – Elements in Requesting Structured Information

The purpose of this diagram is to bring across an idea of a de-composition of the user interaction. Starting from the top it shows the importance of the User being able to continue previous work – that is, the system should recognize the User and “remember” what he was doing. The other point highlighted under “Request” is the ability to show possibilities for the User to select from. These may include future possibilities that may be obtained – for a given production cost and/or waiting time. Several other de-compositions are possible – the ones shown are to give an illustration of the idea.

Another moment is the potentially highly interactive properties of the user interaction. Typically, the user may

1. Specify an initial request
2. Get the (preliminary) results presented
3. Define modifications to the request

…and then continue looping through points 2 and 3 above until satisfied.

If sufficient precision is achieved in the initial request, interaction time will be saved.

The purpose of the “Request” part of the functionality inside the User Access Component is to assist the User in creating a request for the information the User wants. The request should be created in a format that can be used for automatic information search in the next stage.

The request specification will always contain a part specifying the wanted information content. In addition, it may also include certain properties of the services that must be fulfilled as well. A normal approach would probably be to start by defining your own area of interest, for which you are interested in available services, to avoid having a too long list to choose from. The list can be further reduced by specifying specific types of sensors, specific data formats, level of aggregation and so on.

At the data level, the application can create the requirement using following elements:

- Existing IERs. An Information Exchange Request specifies a predefined collection of information, with the corresponding mapping to the data model (NCDM compliant). IERs in this group can be traditional IERs like in APP-9, or re-designed IERs created from the data model.
- Requests created earlier. All requests should be saved for later use, to further refine it later, or just as a basis for another new query.
- Subject areas from the data model. The data model can be split into several subject areas, each covering a small number of elements that logically should be grouped together.
- Free text specifications. If the requested information cannot be covered by any of the above, a textual description of the requested information can be given, for instance specific words to search for. Since this cannot be tied directly to a data model, this part can be used both to initiate other searches, as well as filtering the result from the data model (see below).
- All available services. This would require that the request application is also capable of retrieving information from a lookup service. The benefit of this would

be twofold; the requestor would know that this is a requirement that can be satisfied (provided availability), and the time needed to make the request would be very short.

The requested information specified above can be further detailed by specifying additional filters. A filter will further restrict the already defined selection from the data model to the information that has certain values, or lies within certain limits. These filters can specify information like:

- Geographic area. Only information located within an area of interest may be relevant to this query. The relevant area can be specified using a Geographic Information System.
- Time. Only information given after a certain time may be relevant.
- Type information. This may be type of unit (headquarters, artillery...), materiel (tank, gun...), rank of personnel etc. Filtering on this information may be done by restricting the selection only to objects having certain values specified in their attributes.
- Hostility. Only own, enemy, or neutral units.
- Context. This can be information in one of several alternative plans, units involved in one action, current situation etc.
- Functional area. The basic functions have been divided into the areas C^2, firepower, mobility, protection, reconnaissance/surveillance and logistics.
- Domain. Land, air, surface, under water, space.
- Movement. Objects moving with a certain speed or direction.

In general, all elements of the data model, from entities through attributes to single domain values, can be used as parts of a filter specification. Even free text can be used as a filter for information from the data model, for instance, to find information about one specific unit. In Chapter 6, some examples show how the request application can assist the user in creating the request. In Appendix C, a table shows examples of how some of the information above can be mapped to the data model.

5.4 Interfaces between the components

The previous section covered some aspects of the interface between the User and the ”system”, represented by the User Access Component. Now the focus is to consider how the User Access is supposed to cooperate with the other involved components inside the Infostructure:

- Lookup Service
- Request Service
- Picture Production Node

This is done by describing the contents of the interaction – that is the interface – assumed between the components. But first, some initial considerations about metadata.

Metadata is “data about data”, describing the contents of the data. Metadata is used to add a level of abstraction, to tell something about the data in addition to the content itself. This is very useful to identify properties of the data you want, without specifying the real data content. A trivial example is the traditional library card that describes author, title, genre, etc of a book. These data are the metadata describing the book, necessary to order or borrow a book, whilst the words inside the book are the real data of interest to the reader. The modern equivalent is searching the Internet for digitised music: Enter artist and/or title, and receive a list of relevant files. They may be of several formats (qualities) and have different prices. By filtering on these elements, the search result may be narrowed to match the user need.

The military domain of Picture Compilation is a lot more complex. Imagine an expansion of the Internet example to search for not only music but also movies and different kinds of software. The metadata that was easy to define for music needs quite advanced modifications to cover the other types too. In fact, the definition of a proper set of metadata requires knowledge of the classification (taxonomy) that describes how the different entity types are related.

Keep the simple example of metadata for books and music in mind when considering the elements pointed out as core interface contents in the following. The core interface elements are the information basis for the interaction between the components in order to satisfy the user need.

5.4.1 Lookup service

An important element in the information infrastructure, to achieve the required flexibility to connect to all picture producing services in NCW, is a Lookup service (a similar name may be directory service). All the actors are listed there, to make it possible for them to find each other.

The purpose of the Lookup service is to maintain a list of all active services among sensors and picture producing nodes, and some selected features associated to them. All own platforms can be included here. This service can be used to establish the connection to a node that is producing the requested information. Table 5.1 below (based on (8)) illustrates the core information that will be relevant to maintain in the Lookup service:

Information element	**Description**
Name	A name of the service, indicating what kind of information is provided, e.g. "COP 6th Division"
Provider	The node producing this information
Content	Textual description of the information (COP, track...), and what types of objects can be found
Format	Format of the information provided, e.g. video, replication, messaging...
Update interval	How often can new information be expected
Area of coverage	The maximum area expected to be covered by this service (the current position of any of the sensors is not included)
Addressing	How to connect to the provider (IP, URL, frequency, protocol etc)

Table 5.1 General information about existing services

Additional information may be Source of information, Timestamp, Required bandwidth, Security classification and Access restrictions.

For providers being a sensor, some additional information may be relevant:

Information element	**Description**
Type of sensor	Active/passive...
Type of data produced	Image, track, classification...
Sensor quality	Resolution of image…
Domain	Land, sea, surface, underwater, space
Mobility	Stationary/mobile, speed of movement
Reporting to	Which picture producing node is this sensor sending information to
Platform	To which platform is the sensor attached, if any

Table 5.2 Sensor specific information about existing services

The Lookup service should support the following operations:

- The registration of any service that participates in the Picture Compilation process (e.g. sensor, picture producing node, platform)
- Lookup in registered information – when any component or service needs to locate a service to cooperate with

It is important to keep the information flow to maintain this service on a realistic level; therefore the meta data should not be too dynamic. This leads to an example assumption that the position of a sensor will not be updated in real time in the service specification; it is more likely that the area in which it will operate, will be specified. Alternatively, a position with a direction and speed of movement at a given time will make it possible to make an estimate of the current position.

5.4.2 Request service

The most fundamental purpose of the Request service is to keep a log of all the requests being put into the system, whether yet fulfilled or not. When a service becomes available that can satisfy a request not fulfilled, a message should be sent to the originator of it. This service can be used to make it easier to specify a new request, by reusing or modifying an existing one, or merging several of them.

A full-scale Request service should also have the ability to

- Assist the user interaction with "knowledge" about ongoing Picture Production services
- Interact with a (background) Resource Allocation Manager to initiate or modify sensor activity
- "Approve" the negotiated request on behalf of the Picture Production Nodes (PPNs) involved, and by that authorising the User Access to initiate a delivery (subscription) from the PPNs

Further elaborated, the Request service may be viewed as "the instance in the Infostructure that is able to translate from expression of the user need over to Picture Compilation services (resources) that may satisfy the need". That is an extremely complex task, into which the technological possibilities of knowledge systems and formal representation of semantics (semantic web) may be exploited in the future. In this report the ambitions are held on a basic level, describing the core information elements to build on. The examples given in section 6.4 may give the reader some more ideas of possible ways to develop this service.

Core information elements of the Request service are:

Information element	**Description**
Request name	A unique description of the requested information
Request specification	The requested information – described in a formalised way. This represents the information the user asks for, all the other fields contain only additional information *about* the request. An example of how this may be done is shown in Table 6.1.
Requestor	Who created the request
DTG	Timing information to include the times when the request was filed, effected, cancelled etc
Status of request	State of processing: Service provided; tasked, but still in queue; awaiting prioritising; request cannot be fulfilled with current resources
Priority of request	The priority given to the request, needed when several requests are in queue or resources need to be re-allocated to fulfil the request
Assigned to	When request serviced: Which node is responsible for delivering the information requested

Table 5.3 Information about a request

5.4.3 Picture Production Node

The basic collaboration between User Access and (each of) the Picture Production Nodes, can be described as

1. User Access subscribes according to an approved request
2. Picture Production Node delivers

The contents of the approved request may be derived from the Request service interface description. Note that a unique identification of the request will be of substantial value.

The delivery may be described from several viewpoints:

- The contents are similar to what's in a Common Operational Picture
- The formats may be among the numerous relevant ways of exchanging this kind of information:
    - The Tactical Data Link formats (Link-1, -11B, -14, -16, etc)
    - OTH-GOLD (Over-The-Horizon GOLD)
    - ADatP-3 (formatted messages)
    - METOC (Meteorological and Oceanographic Information)
    - MIP Data Exchange Mechanism (replication)
    - Other formats may be defined in the future

- The physical delivery can be thought of as an electronic transmission, although a messenger carrying CD-ROMs is imaginable as a possible delivery mechanism in certain situations…

This interface is easily described on a high level. Nevertheless an actual implementation will involve great complexity.

6 DISCUSSION

6.1 NCDM suitability

The task specification stated that NCDM was to be considered during the work. NCDM is a model that is basically created to store *data* that needs to be exchanged, for which it is very capable. This is more or less talking about 'facts'. However, when we talk about information requests, we have a lot of data *about* data, i.e. metadata, which the model does not handle to this extent. However, the model can be expanded to support metadata as well, with a few additions. Another solution would be to create a separate data model to store the necessary metadata. In the area of picture compilation, we need to talk about data fusion and different hypothesis, analysing other data. The results of these processes can be stored in the data model, but the processes performed by applications or humans are not directly supported. The same is the case with tracks; assisting in determining whether something belongs to a track or not is left at application level, but the result can be stored.

This has led to that we do not refer to any data model when we talk about information requests at a general level. NCDM is only used as a basis in some of the examples showing content of an information request.

Actually, the Reference Model of NCDM is not meant to be implemented itself; all implementations are supposed to be based on a View Model of NCDM. The only current View Model is LC2IEDM, which means that examples will apply to LC2IEDM as well as NCDM.

6.2 UML suitability and experiences

This report has used UML for diagrams. Basic knowledge of UML is widespread, and many of the diagramming rules are easily interpreted. Nevertheless, the options of defining "dialects" using specialized graphical symbols sometimes create confusion and discussions.

The diagrams used in this report are on a high level of abstraction, and using basic diagram notation. The traditional rectangle has been used both for classes and components. The "matchstick man" has been used to distinguish actors outside the Infostructure from those (classes and components) inside.

For the purpose of this work, UML has been the best choice of diagramming language.

6.3 Implementing a Lookup Service as Middleware

The Lookup service has been described as a logical component – perhaps best imagined as a centralised register where all the information is found. But the important requirements of operational systems being decentralised, and especially the need to avoid any "single point of failure", makes the central register a too simple solution when it comes to actual implementations.

FFI has done some experimental work on implementing a Demonstrator where the Lookup service is completely decentralised – using the middleware tool JXTA (9) as basis. This work is described in (12).

6.4 Examples

6.4.1 A minimalistic Request Service

The most basic form of a Request Service would be to allow the user to only choose among existing services. The available services could be presented to the user like shown in Figure 6.1. Some selected attributes relevant to a service are shown, including area of coverage, frequency of update, and format of delivered data. Each service has a checkbox for selection. A geographic area may also be specified to restrict the information from the selected services.

List of available services

	Name	Area	Type of data	Update freq.	Format	Producer
√	COP 6th Division	59 N 10 Ø 60 N 11 Ø	Aggregated	15 minutes	Replication	6th Division
	Enemy artillery	59.6 N 9 Ø 59.8 N 9.6 Ø	Analysed	1 minute	Replication	Arthur
	Maritime tracks	57 N 9 Ø 59 N 10 Ø	Tracks	10 minutes	OTH Gold	Navy
	RAP	57 N 9 Ø 59 N 10 Ø	Aggregated	15 minutes	Link 16	Måkerøy
	RMP	57 N 9 Ø 59 N 10 Ø	Aggregated	15 minutes	OTH Gold	Navy
	Radar plot	58 N 9.5 Ø 10 km radius	Raw	5 seconds	Bitmap	Måkerøy
	Sound	59.6 N 10 Ø 200 m radius	Raw	1 minute	Replication	Ground sensor
	Targets	59.8 N 10.1 Ø 10 km radius	Analysed	1 hour	Replication	Forward observer

Figure 6.1 Examples of available services

6.4.2 Contracts and TIC's

During the ATCCIS work, the concept of Tactical Information Composite (TIC) was introduced. A TIC is a subset of the Data Model, as small as possible, but still recognised by operational expertise as having operational meaning. A total of 32 TICs were identified within the Data Model. These TICs were used as building blocks to create a smaller number of replication contracts, grouping together subject areas that would normally be requested in the same operational context. Some of the TICs are present in more than one contract. The complete correlation between the 9 contracts and the 32 TICs is shown in Appendix C. One of the contracts defined is Common Operational Picture (COP), and the mapping to TICs and further to the main concepts of NCDM is also shown in the appendix.

Using the concepts of contracts and TICs, it is possible to create a list of subject areas (contracts) and sub-areas (TICs) for the user to select from, when specifying an information request. An example of how this might be presented to the user is shown in Figure 6.2. Here it is possible to select all elements of a contract at a high level, or it is possible to expand the contract into all sub-areas, to select just a few of these.

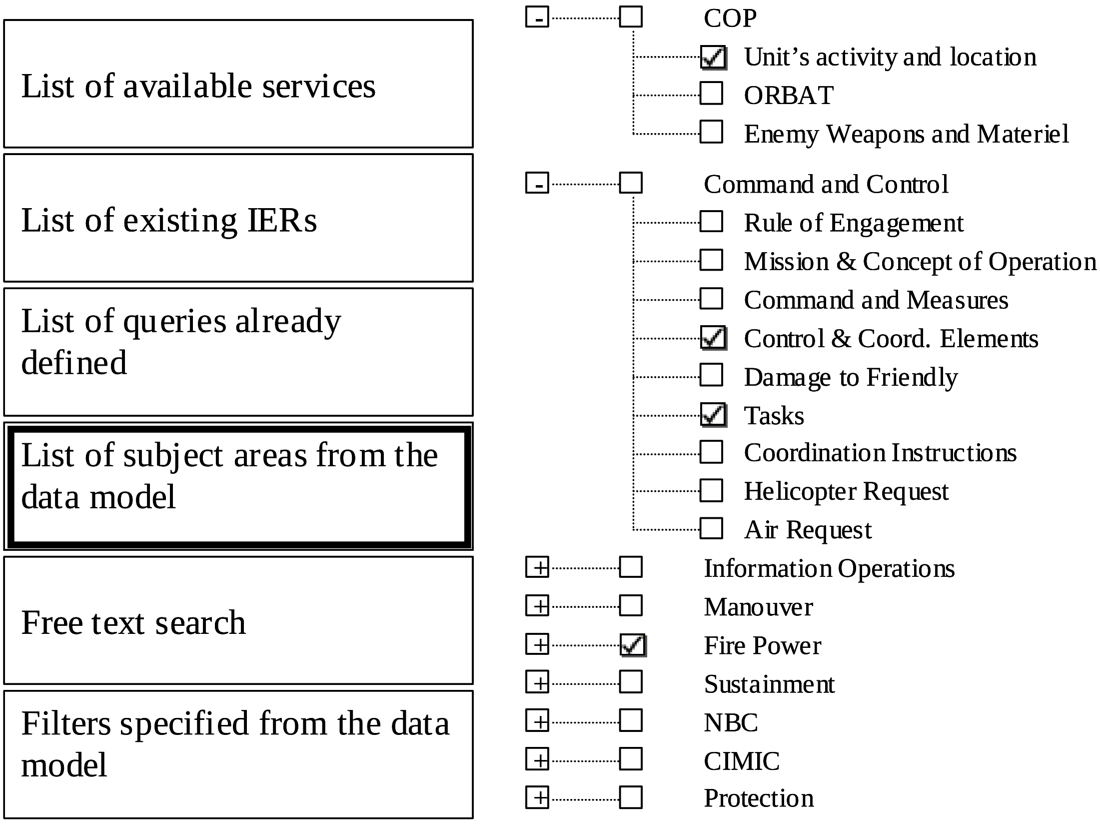

Figure 6.2 Example of subject areas to select from

After specifying the main content of the information request, it is possible to specify filters to restrict the information to only that relevant for the user. For a geographic area, a GIS can be used in specifying it. In Figure 6.3, only a smaller area is selected within the whole area that is available.

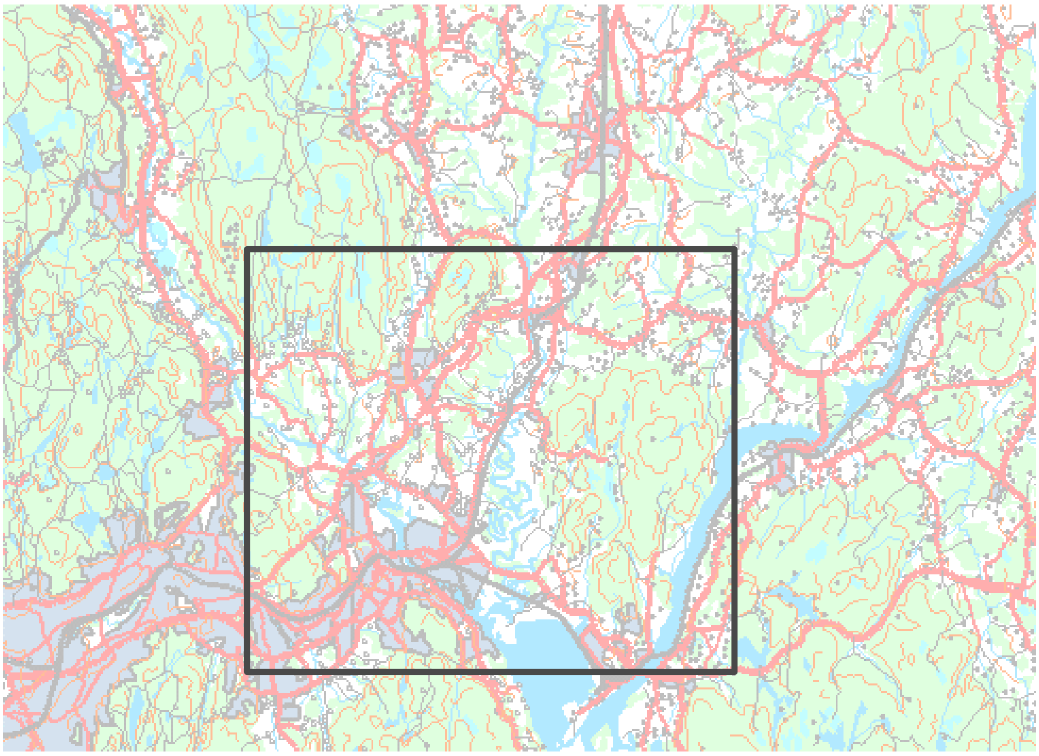

Figure 6.3 Specifying a filter area using a GIS

Figure 6.4 shows an example of what the graphical representation of the requested information from Figures 6.2 and 6.3 above in the earlier example may look like. The figure shows administrative borders between own units, forward line of own troops, one artillery battalion, one forward observer, and two targets.

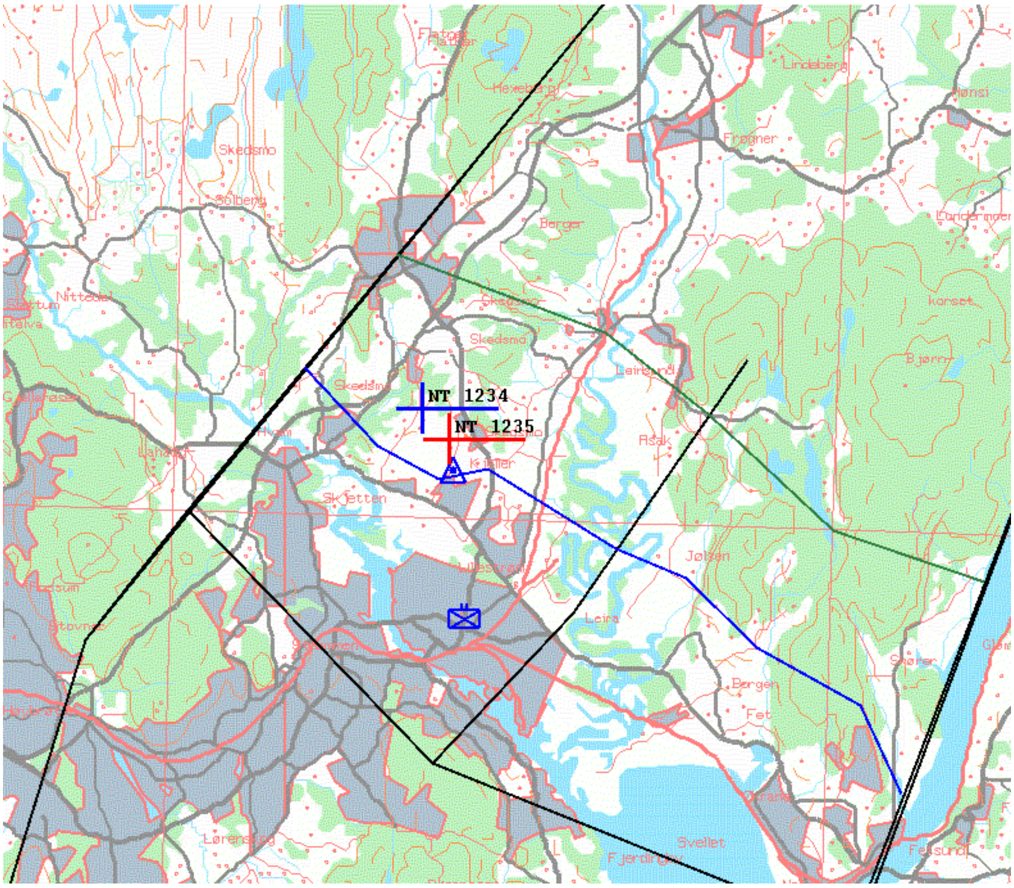

Figure 6.4 Example of graphical representation of information

6.4.3 An idea of a request formalism

An ideal goal would be to be able to express an information request in a formal way – as a kind of statement in a Structured Query Language (SQL). Such formalism will not be defined here, but the results may look something like this:

SELECT (what we want to know)	• Identification (position, status) • Structural description • Changes only • All data about • History / Prognosis • **Degree of Sensor Coverage**
FROM (user-related information-objects)	• Own Forces • Enemy Forces • Weather/Terrain • Civilian Matters • Mission • **Events**
WHERE (conditions)	• Within current Mission • Geographic Area • Level of detail • Time perspective • Specific Objects

Table 6.1 Outline of an SQL-like formalism

Note that the desired precision level is significantly less detailed than what we are used to in SQL. Not even working with object models and "OQL" (Object Query Language) will be sufficiently high-level. Especially in the SELECT part this approach is more like a set of standards than the SQL-like database fields.

6.4.4 Example component models

The concepts and diagrams described so far have all been from a "logical" point of view. When it comes to implementation of physical components, it may well happen that several logical components will be combined into the same physical component. It is even possible to imagine pieces of each logical component present in a "physical peer component". Such a peer component will have "a bit of everything" capabilities. Combined with collaboration capabilities (imagine each logical part communicating with the similar logical part in its peer), these physical peers will come forward as collaborating "agents".

To exemplify some of this, diagrams of the component “User Access Node (UAN)” are shown in Figure 6.5 below. This is a high-level, “white box” view of the imagined software contents of this component.

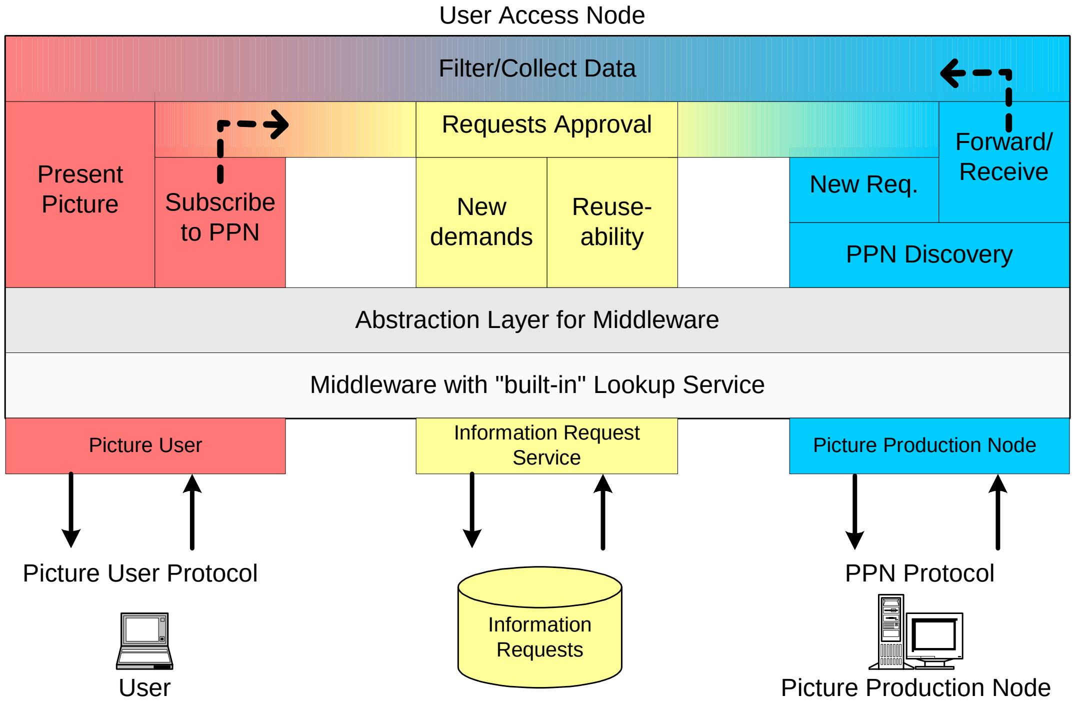

Figure 6.5 User Access Component – inside view

This figure shows the UAN communicating with Users, Information Request Services (IRSs) and PPNs. Compared to Figure 5.2 the communication line (1) against the Lookup Service is in the component view assumed to be a part of Middleware, e.g. in a JXTA implementation.

The assumed sequence of activities – as indicated by the added broken arrows in the corners – is that the user intends to make a subscription to a PPN, gets the request approved by the IRS, and receives filtered data from the PPN through the UAN.

7 CONCLUDING SUMMARY

In this report, a model for the configuration of and access to the common operational picture at a high level of command has been described, in the context of Network Centric Warfare. The main focus has been on the application that gives the user of the picture access to the information infrastructure.

The model described is still at a conceptual level, but can be used as a basis to identify specific requirements for systems to cover these functions.

NATO Corporate Data Model has been used as the basis model for the examples given. NCDM is a relational data model, and is very detailed. At this high level, a more object-oriented view of the model hiding a lot of the details is more suited. However, a mapping to the details of the relational model can always be created. This report deals a lot with the metadata level, which would require some extensions to be captured in NCDM. Another solution would be to create a separate data model only for metadata.

This report needs to be followed up by further work. The high level concept outlined needs to be further developed and tested. It may be suitable to establish experiments with prototypes based on the ideas presented.

APPENDIX

A TECHNOLOGIES IN INFORMATION MANAGEMENT

The reference model shown in Figure A.1 below illustrates possible use of technology to support the main processes Management and Distribution described in Figure 2.2.

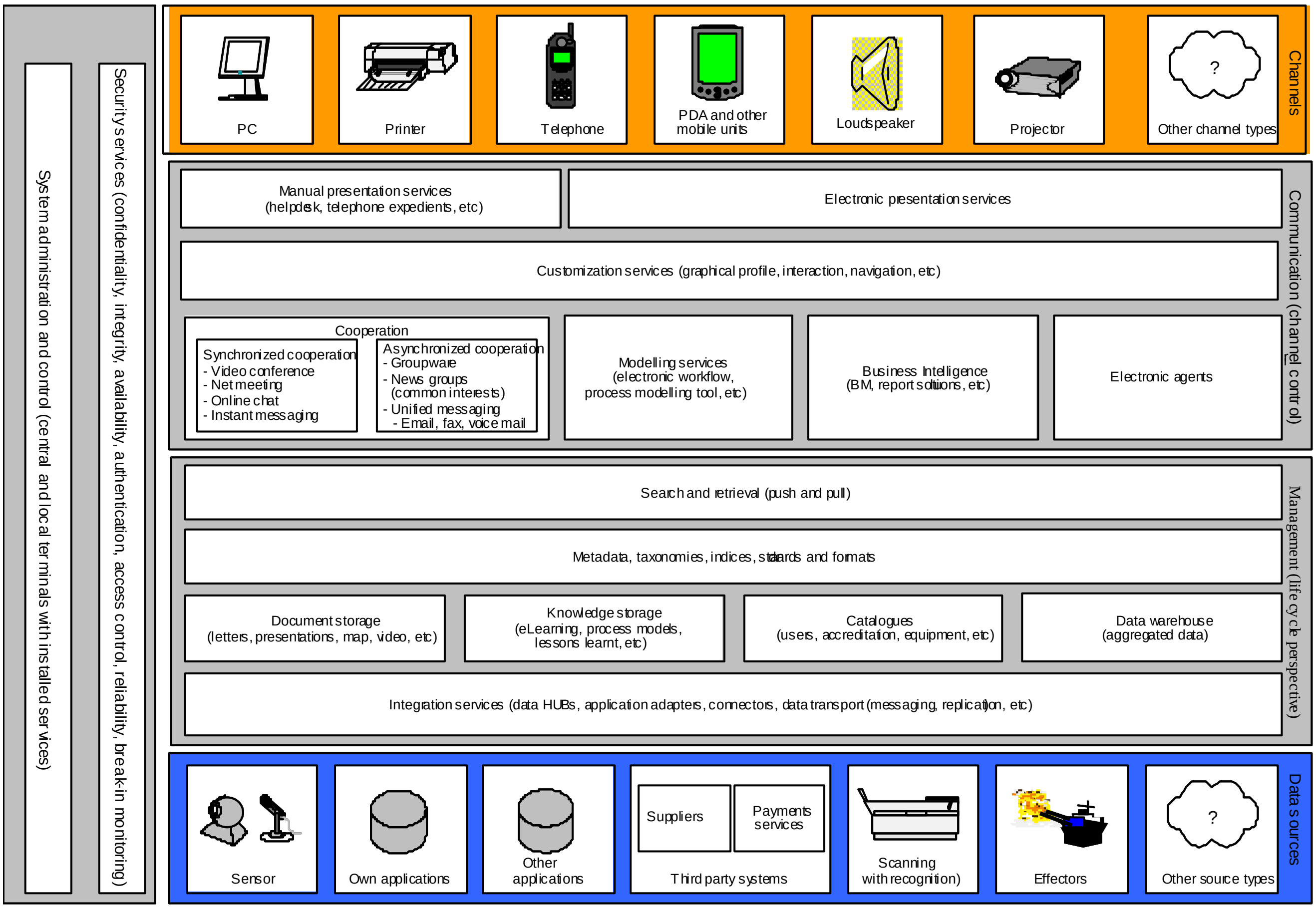

Figure A.1 A reference model of technologies (from (1))

Information consumers use the various channels on the top level of the figure to get access to information. The distribution of information to the channels is done by communication mechanisms. Included here are technology elements like presentation and customization services, agents, etc.

Information management consists of elements like search and retrieval, metadata, taxonomies and storage. As an interface to the various data sources, the figure refers to a number of integration services. Security and system administration are pervasive elements that must be considered in every part of the model.

In the context of information management and knowledge management, the main focus should be on the elements in the middle of the figure.

B CONTRACTS AND TICS USED IN ATCCIS

Table B.1 below shows the complete overview of proposed ATCCIS replication contracts and Tactical Information Composites (TICs).

	Contract Number	#1	#2	#3	#4	#5	#6	#7	#8	#9	
TIC No	TIC Name / Contract name	Command and Control	Information Operations	Manœuvre	Fire Power	Protection	Sustainement	Civil and Military Cooperation (CIMIC)	Common Operational Picture (COP)	NBC	
#1	Rule of Engagement	1									1
#2	Unit's activity & location			1					1		2
#3	Mission & Concept of Operation	1									1
#4	Service Support						1				1
#5	Command and Measures	1									1
#6	ORBAT		1						1		2
#7	Control & Coord. Elements	1		1							2
#8	Enemy Weapons and Materiels		1						1		2
#9	Intelligence Request		1								1
#10	Damage to Friendly	1									1
#11	Casualty Evacuation Request						1				1
#12	Logistic Situation						1				1
#13	Artillery Fire Units & Weapons				1						1
#14	Fire Plan Status				1						1
#15	FirePlan Targets				1						1
#16	Fire Mission Command				1						1
#17	Tasks	1									1
#18	Coordination Instructions	1									1
#19	Unit's Situation of Personnels			1							1
#20	Obstacle					1					1
#21	Reserved Demolition Order					1					1
#22	Scatterable Minefield					1					1
#23	Refugees / Displayed Persons							1			1
#24	Humanitarian Aid Assistance / Infrastructure Repair							1			1
#25	Medical Situation						1				1
#26	Helicopter Request	1									1
#27	Helicopter Landing Site				1						1
#28	Air Request	1									1
#29	Air Defence Situation				1						1
#30	NBC									1	1
#31	Electronic Warfare		1								1
#32	Communications		1								1
		9	5	3	6	3	4	2	3	1	

Table B.1 The combination of contracts and TICs from ATCCIS

The contract Common Operational Picture (COP) is made up of three TICs, which in total cover the information content as outlined earlier in the report. Table B.2 below shows the mapping from the COP contract through TICs to the main subject areas in NCDM. A similar mapping has been created for every TIC.

Category (TIC)	NCDM Subject Area
Unit's activity and location	ACTION REPORTING-DATA GEOMETRY ORGANISATION OBJECT-STATUS
ORBAT	HOLDING ORGANISATION REPORTING-DATA OBJECT-OBJECT-ASSOCIATION
Enemy Weapons and Materiel	FACILITY GEOMETRY HOLDING ORGANISATION REPORTING-DATA

Table B.2 Mapping of COP into TICs and main concepts of NCDM

C MAPPING OF INFORMATION ELEMENTS TO NCDM

Table C.3 shows how different information elements, the building blocks of any of the TICs above, can be mapped to NCDM.

Request element	**Example**	**Main concept in NCDM**	**Further detail in NCDM**
Location	Lat 60 Long 10	GEOMETRY	latitude/longitude
Area of coverage	Includes (60,11 to 61,12)	GEOMETRY	latitude/longitude for all corners
Area of interest	Within (60,11 to 61,12)	GEOMETRY	latitude/longitude for all corners
Type of unit	Headquarter	ORGANISATION	category=`headquarters`
Hostility	Enemy unit	OBJECT-STATUS	hostility =`hostile`
Time	After 301230Z	REPORTING-DATA	effective date and time
Context	Plan for tomorrow	CONTEXT ACTION	The planned position and operations in this context
Functional area	Fire power	OBJECT	Status of all units or materiel with primary function to deliver fire
Domain	Land	ORGANISATION GEOMETRY	Service code of units, or location for any object
Movement	Heading north	GEOMETRY	Bearing of an object
Holding	Holding of unit	ORGANISATION OBJECT-TYPE HOLDING	Operational quantity
Capability	Capability of unit	ORGANISATION CAPABILITY	Type of capability, and quantity of this
Target	List planned targets	CANDIDATE-TARGET-LIST	Targets in one or more specific list(s)
	Targets of action	ACTION ACTION-OBJECTIVE	Objectives identified as targets for this action
Size	Size of unit	ORGANISATION ORGANISATION-TYPE	size of unit

Table C.3 Examples of mapping to the data model

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