Technical Communication through Digital Media

Abstract

In this paper technical communication through digital media is discussed. The paper has two major parts; first a development of a theoretical framework that can be used for designing and evaluation technical information in digital media, and second the evaluation of a computer program specially designed for delivering technical information. The evaluation was made with the theoretical framework and the conclusions are:

ActiView is very suitable for delivering reference and user manual style of information and its use of interactive 3D visualisations is a good help for the users.

The evaluation was made using qualitative method and consisted of interviews with the developers of the program, interviews with users, and a heuristic walkthrough of the program.

The theoretical framework was based on the uses and gratifications approach and was proved useful, and the result was a set of guidelines.

Keywords: Technical communication, 3D visualisations, ActiView, Uses and Gratifications, interactive media, information design

Innehåll

1. Introduction

1.1 Technological Trends

The industrial development over the last 200 years has given us a society where people depend on technology for most aspects of their lives, be it work, leisure or basic survival. As a result, the standard of living has risen dramatically, and a world without power plants, computers, cars, water faucets, industrialised agriculture, television, etc. would look very different.

There are two important trends in this development. The first is that the number of technological systems that surround us increases. The second trend is that the new systems get more and more complex and that high-level technology diffuses from a governmental or corporate level down to the private person. One clear example is computers. From having been a tool built and used by researchers and scientists alone, they are today used by many people both at home and at work.

With these trends in mind, one realises that a great load is put on people to constantly learn how to use new complex systems. It is therefore not surprising that one of the great challenges in the development process is to effectively communicate how to use (in a wide sense including servicing, repairing and upgrading) these systems properly. If this challenge is not met they will be unusable and worthless.

1.2 Problems

The basic problem is thus one of communication; telling the user how to use the products, and there are basically two ways of doing this:

1. Letting the product itself tell the user how it should be operated. This is the area of product semantics, and the idea is to design the product to give the user clues on how to use it (Löwgren & Stolterman 1998, Monö 1997, Norman 1998). One example is the colour codes used for computer cords where for example the green mouse cord plug goes into the green socket in the back of the computer.

2. Letting information material tell the user how to use the product. These are the good ol' manuals, on-line helps, instruction videos, help-desks, etc.

Since this is a paper in Media and Communication Studies it will only cover the second way of tackling the problem, but I would like to stress that the first is always the best. The product should always be designed so that it is easy to use, preferably without any extra information. If information material is needed, it should complement the product, never compensate a bad design.

Most products do need supplementary information of some sort, and with the growing complexity the amounts of information accompanying some systems become truly gigantic. A illustrative example of this development comes from the aeroplane industry; the complete documentation for the DC3, a plane constructed in the 1930's, was approximately 100 000 pages or ca. 500 kg of paper, whereas the documentation for a Jumbojet covers several million pages and weighs more than the actual plane (Pettersson 1998).

With these vast amounts of information another problem emerges, that of information retrieval. The user should be able to find the needed information easily at all times. Different categories of people need different kinds of information at different times and with varying frequency, which puts great demands on the structure and the ways the information is delivered.

1.3 Solution?

All the problems discussed so far emanate from the advances of technology, so it is a bit ironic that the suggested solutions are based on other complex technological systems to handle all this information. With the rapid development of computers (and what is popularly called information technology) over the last decades, new ways of presenting and handling information have emerged. This has given new hope to both information producers and overloaded users, and more and more information is now not only produced with computers, but also communicated through them.

The fundamental differences between communication through paper and screen might not seem very big at first, but they are. Some obvious benefits with the digital media such as small physical size, low distribution costs, easy updateing, etc. have been welcomed by the information producers and caused more and more technical information to be delivered on for example CD-ROM:s and the Internet.

The shift from paper-based to digital information has given the technical communicator many new possibilities to design the messages, but also puts requirements on the communicator to know how to best utilise these possibilities. In some cases the shift has been successful and the situation has improved remarkably, while in others the effect has been quite the opposite. An everyday example is computer programs; Microsoft Word 6.0 was delivered with well over 1000 pages of documentation, whereas the latest version depends almost entirely on the online help (the infamous paper clip). At the same time the number of third party computer books has risen dramatically. A search on Amazon gave 1249 books and 5 videos covering Word. This development might indicate that the benefits for the producers' have been the focus rather than the needs of the users.

1.4 The Importance of Technical Communication

From a product development perspective technical information has often been seen as an almost un-necessary addition to the actualproduct. It has quickly been put together after the product has been developed and thrown in for the sake of it. But as the systems become more and more complex developers have discovered that good technical information is as important as the actual product, and a central part of the interface between the product and the user. (Mårdsjö & Carlshamre 1999)

There are a number of direct advantages with well-communicated technical information for a number of interested parties:

The benefits for the *users* are obvious:

- They get less frustrated.
- It saves them time.
- Large sums of money can be saved if the equipment is used to its full extent and production stops are avoided.
- They learn how to use all of the functions of the system.
- They are less likely to get injured. The so-called human factor is often blamed for accidents, but many of these are due to poor user information.
- They feel they are in control of the machine instead of vice versa.

(Zetterlund 1997)

The *manufacturer* of the product also enjoys benefits when supplying quality information:

- The product is used in the correct way and service and support costs can be reduced.
- Since the users often evaluate the whole delivery, not just the physical product, the customers see a higher quality product when the technical information is good than when it is bad.
- Good technical information can (and should) be used as a marketing argument.
- Access is gained to markets where governmental regulations put demands on the supplied technical information, for example the European Union

(*ibid*)

Decision-makers are often confronted with technical information in their work and are dependent on clear, summed up and easily understandable reports to make the right decisions.

Society. It is not only for the sake of making technical artefacts understandable technical communication is needed. If we as citizens are to take part in the public debate on technical issues we must grasp the possibilities and dangers that technology offers. G H von Wright (in Mårdsjö & Carlshamre 1999, p. 6) means that active participation in many public issues has been made more difficult due to the technical complexity of them:

"It is thinkable, that the complications of the industrial and technified society are so vast, that democratic participation in the public decision-making process eventually must degenerate into an empty formality of either agreeing or objecting to incomprehensible alternatives"

1.5 Objective of Presented Work

In this paper technical communication through digital media will be discussed. The purpose is to *investigate how technical information is communicated effectively through the new digital media.* The goal is to gain understanding and insights into the process of technical communication that can be used when designing and evaluating technical information destined for digital media.

The perspective will be from a sender's (information producer's) point of view, but

with the focus on the receiver's experiences. The reason for this is that I believe that knowing your audience is central as an information producer if the information is to be effective.

The paper will strive for its purpose and goal in two steps; first the building of a theoretical framework that can be used when designing and evaluating digital technical communication, and second this framework will be applied in the evaluation of a practical case.

The practical case will show whether the framework is usable, and will also be an illustrative example of what can be done in the technical information area with the possibilities the new media have to offer. The chosen case is a computer program named ActiView developed by AeroTech Telub Information & Media AB in Växjö, Sweden. The program is especially designed for delivering technical information and presents a novel approach to this.

The reason for choosing ActiView is that it serves as a very information-rich case for this study, suitable for the purpose of this paper. The approach to information and communication in ActiView is very different from other products with similar purposes (at least as far as I know). Instead of having a view of information originating from paper based media, which usually is the case, the developers of ActiView have chosen an approach originating from the receivers' needs and the possibilities offered by computer technology. The result is a unique product.

In order to focus the work, all the things discussed above can be summed up in one specified question that we will seek the answer to:

How effectively is technical information communicated with ActiView?

To answer this the theoretical framework has to be built, and the evaluation conducted. In the process, and from the results, we will get the understanding we are longing for.

1.6 Demarcations

1.6.1 Audience

This paper is primarily written for fellow students at the Media and Communication Studies 41-60 credit level, and our teachers. I realise that there are some other people interested in reading this paper, for example the developers of ActiView, but I do not think there will be any problems understanding this paper even if one has not studied Media and Communication before.

1.6.2 Type of Information

The type of information considered in this paper is only technical information delivered through digital media. Technical information on paper will occasionally be covered in this paper, but only for the purpose of compare and contrast it with its digital counterpart. Some aspects described are probably applicable to other types of information, both technical and non-technical, but this more a bonus than an intention.

1.6.3 Perspective

This paper is written from a communications perspective and the technical aspects of communication through digital media will not be covered.

This paper is written from a sender's perspective but with a focus on the receivers. The issues covered herein are about what technical communicators can do to improve the communication. But to be able do this, the receiver has to be understood, and hence the focus is on the reader's experiences.

The theoretical framework is based on communication theories but also include theories from other disciplines, for example psychology, design studies, etc. These theories have however always been used from a communicative point of view to deepen the understanding, not to shift the focus.

1.6.4 Application

The ActiView program is a medium through which technical information is communicated. The actual content is different for different applications of ActiView, but the basic functions of the program are the same. The evaluation was made on an application describing a telescopic mast for radio equipment used by the Swedish coastal artillery. This was the only application that had been made with ActiView when I started my work, so choosing between, or comparing different applications was unfortunately out of the question.

ActiView is a program that probably will find its largest use in industrial settings. The theoretical framework and the things learned from the evaluation are however applicable to information aimed at the consumer market as well

1.7 Overview of Presented Work

The next chapter describes the ActiView-application being evaluated, and how the information is presented to the user. Chapter 3 discusses the relevant theories that are being put to use in the evaluation process. Chapter 4 describes the methods used during the evaluation and why they have been chosen. Chapter 5 then presents the results and discusses the analysis of these and chapter 6 contains concluding remarks.

2. ActiView

This chapter will give a short introduction to how ActiView is laid out and how it works. The reason for presenting this information at such an early stage is that I want to give the reader the opportunity to make his or her own reflections over ActiView when the theories are discussed in the next chapter.

The application analysed in this paper describes a telescopic mast for radio equipment, but the program works the same way regardless of the content. The screen shot in figure. 2.1 shows the main parts of ActiView (counter-clockwise from the lower left corner):

- The navigation window
- The text window
- The top row buttons
- The 3D window
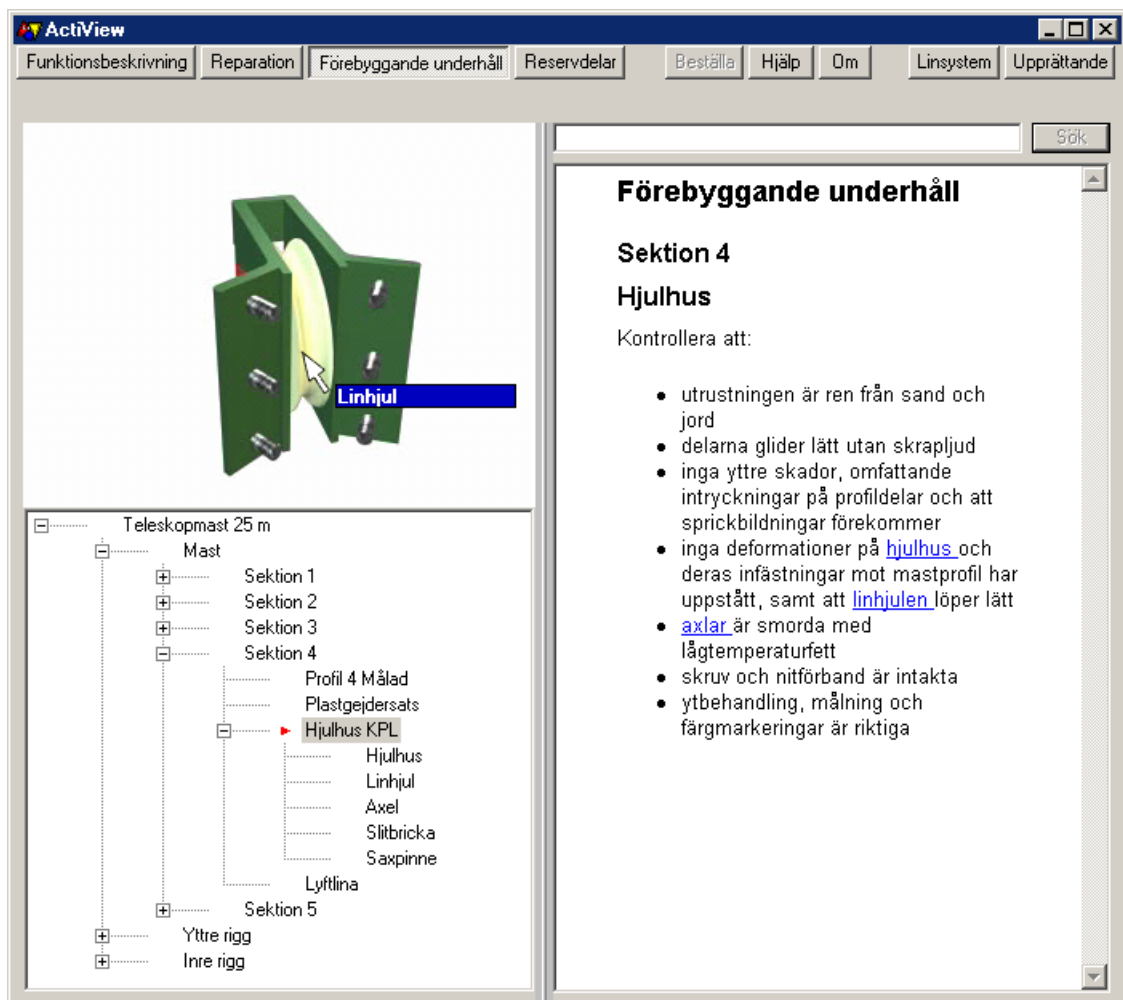
Figure 2.1 The main parts of ActiView

2.1 Navigation Window

The heart of ActiView is the navigation window with its tree structure. The individual parts of the objects or systems being described are here shown in a hierarchical structure, where the object is divided into logical subparts which are in turn further divided and so on. By clicking the "+" and "-" signs the structure is expanded or collapsed to show or hide the different parts, much like the way folders are handled in Windows Explorer. By clicking the names the parts are selected and the object, for example a bolt, is shown in the 3D window, and the corresponding text in the text window. The current object is marked by a small red arrowhead.

2.2 Text Window

This window shows the text corresponding to the part selected in the tree structure and shown in the 3D window. This window can also contain images, photos, animations, etc. as well as hyperlinks. These links can be to other texts but also to other views in the 3D-window, or to highlight parts of an object in the 3D window, for example clicking a link labelled "locking nut" in the text window would cause the nut to highlight in the 3D window to show its position in the object.

2.3 Top Row Buttons

The four leftmost buttons at the top of the program window switch between four different types of information in the text window; description of function, repair information, maintenance information, and spare parts information.

When the help button ("Hjälp") is clicked, instructions on how to use the program is displayed in the text window and likewise the about button ("Om") shows a short description of the application.

The greyed out button next to the "Hjälp"-button is an order-button ("Beställa"), and will in later versions give the user the possibility to order spare parts by just clicking the needed parts and this button.

Pressing the two rightmost buttons opens two new windows where information that does not fit into the tree hierarchy is shown. "Linsystem" shows how the system of cables used to raise the mast works, and "Upprättande" brings up a description of how to raise the mast, which is shown in figure 2.2. When scrolling down the text on the right side, different animations on the left side show the steps being described in the text.
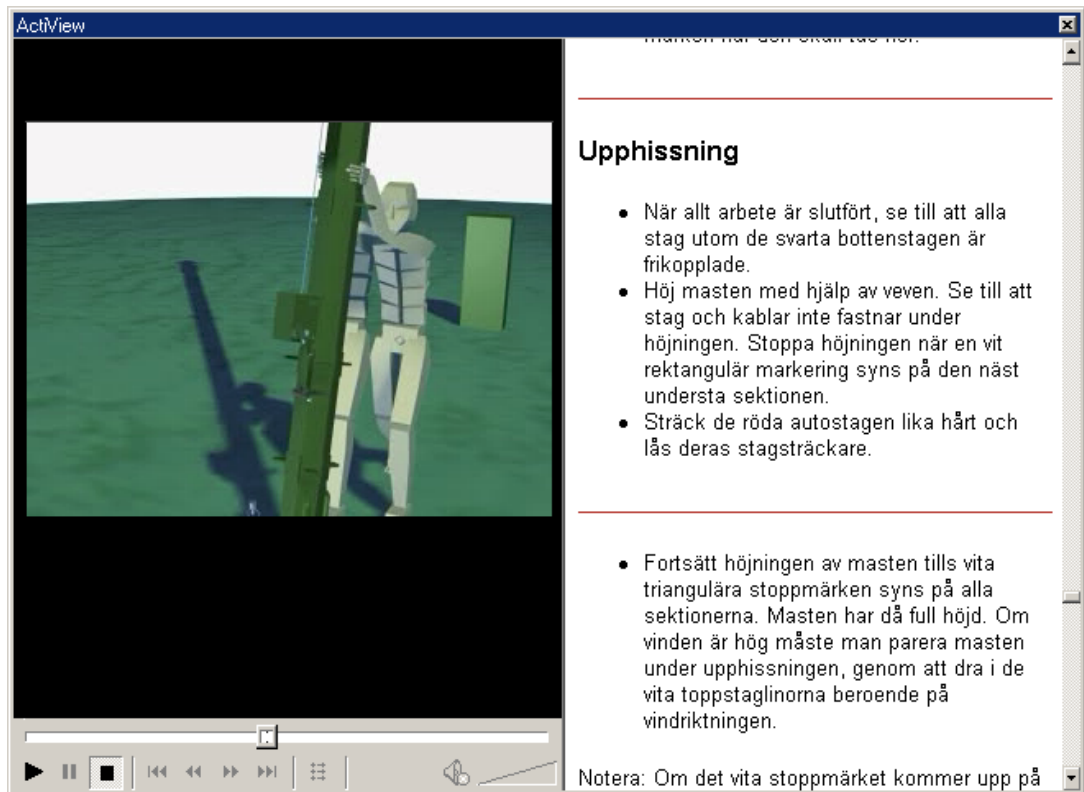
Figure 2.2 Description of how the mast is raised.

Just above the text window there is another greyed out button, "Sök". Together with the area next to it, it forms a text search function just like the ones found in most online help systems. In this application, however, it has not been implemented.

2.4 3D Window

In the 3D window three-dimensional models of the different parts and sub-parts are shown. This view offers the most interaction, and the following features are the most prominent:

- The models can be rotated by pressing the left mouse button and simultaneously dragging the mouse. This gives the user the possibility to see the objects from different angles.
- The names of the different parts of the object are shown in a blue box when the mouse pointer is placed over the part (see figure 2.1).
- If the different sub-parts are clicked the user is taken further down in the tree structure hierarchy, and the text corresponding to the part will be shown in the text window. If the sub-part is double clicked it is shown alone in the 3D window. For example in figure 2.1, clicking the mouse would display the text covering the object "Linhjul" and double clicking would cause the 3D window to show just this object.

The right mouse button gives access to up to three different functions by the use of a pop-up menu.

- The first function is to go one step up in the hierarchy and to highlight the current object in the larger structure. If continuing the example in figure 2.1; having only the "Linhjul" displayed, choosing the "go up"-option from the pop-up menu would show the whole "Hjulhus" (as in figure 2.1) but with the "Linhjul" highlighted.
- The second function is a search function that marks all the occurrences of the same object in the tree structure and highlights all these objects in the 3D and navigation windows. This enables the user to, for example, see where all the "Linhjul" in the whole system are situated.
- The third function is the ability to drag the individual parts of an object apart. Figure 2.3 shows the same object as in figure 2.1 dragged apart. The functionality is the same with the exploded view as with the normal view, i.e. the objects can be rotated, names are displayed, and clicking/double clicking the individual objects gives the same results as described above.
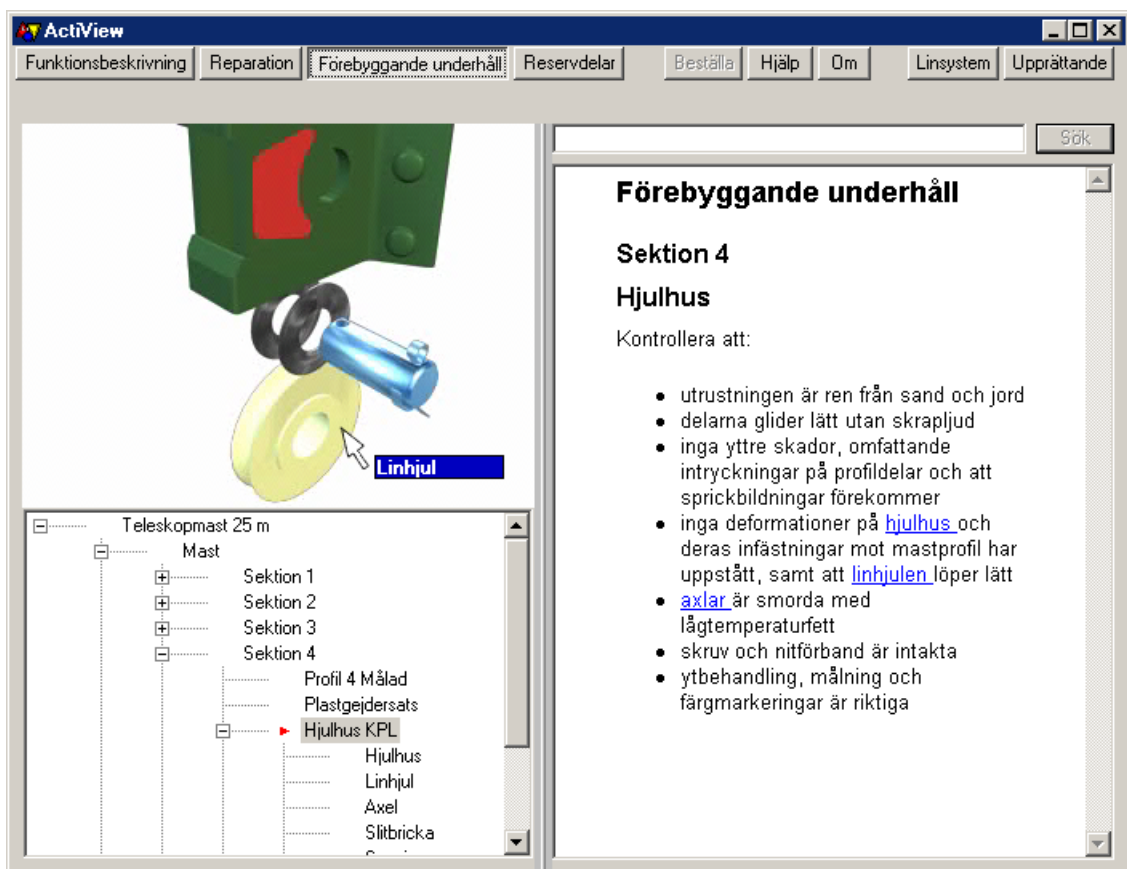

Figure 2.3 Exploded view of the object in figure 2.1.

3. Theory

3.1 Introduction

In this chapter technical communication will be discussed from a theoretical point of view. A set of theories will be collected in a framework that can be used when designing and evaluating technical information in digital media. This framework will then be used for the evaluation of ActiView in the later chapters. In chapter 4 it will be used to determine an appropriate approach to the practical parts of the evaluation and in chapter 5 it will guide the analysis of the results.

Since there are a number of disciplines that in some way connect to the topic of this paper, some elements and theories from other areas than communication studies, for example psychology and design theory, will also be included. These are however always used from a communicative point of view, to deepen the understanding of the communication process.

As a result of the discussions in this chapter, a series of themes and questions will be raised. These form the basis for the evaluation of ActiView and are stated in this chapter, in connection to the theories giving rise to them. The questions are then used to design the evaluation instruments in chapter 4.

To be able to answer this paper's main question (section 1.5), the first thing to consider is how to define "effectively communicated technical information". With the type of information covered in this paper (see section 1.6.2), the final goal with the communication, from both the communicator's and reader's perspective, is to reach a state where the reader has the knowledge to perform certain tasks (mental or physical). It can for example be to operate or repair a machine, or set the clock on the VCR. The question is just how to reach this state?

To answer that, there are three keywords that needs further discussion: *communication*, *information*, and *knowledge*.

3.2 Communication

The word "communication" stems from the Latin word *communis*, which means to have something in common (Liljestrand & Arwidsson 1989). From this I make the following definition of communication:

To communicate is to share thoughts and knowledge with others.

If the communication works well the reader's thoughts and knowledge resembles the communicator's.

The definition above is primarily meant to explain the use of the word in regard to technical communication. I am aware that the definition is too narrow to cover all that can be considered to be communication, for example subconscious communication and pointless rambling. The reason for the wording of the definition is that it is meant to be a help when reading this paper, not for it to be a universal truth.
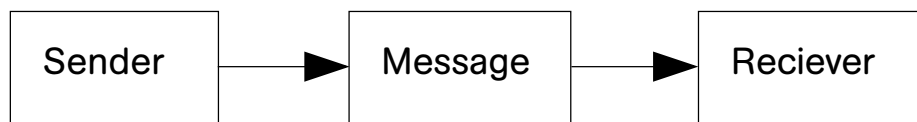
The next question is how the communication process works. What are the mechanisms behind the sharing of thoughts and knowledge? It's time to bring in the communication models.

3.3 Communication Models

A model is a helpful tool for any evaluation or analysis job. A good model helps us organise our thinking, gives us insights, and helps us discover new relationships. There are a vast number of communication models to choose from, all have their merits and disadvantages and, depending on the study, different models are appropriate. Two of these models will now be discussed.

3.3.1 Shannon and Weaver

This is the most influential of all communication models. It originates from electrical engineering but has made its way into many different disciplines. It is depicted in a slightly simplified form in figure 3.1 (McQuail 1994):

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┌─────────────┐        ┌─────────────┐        ┌─────────────┐
│   Sender    │ ────▶  │   Message   │ ────▶  │   Reciever  │
└─────────────┘        └─────────────┘        └─────────────┘
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Figure 3.1 The Shannon and Weaver communication model (simplified version)

The sender composes a message, which is sent through some sort of medium to the receiver, who reads, sees or listens to it. The message is seen as a package of information, nicely wrapped up and sent to the reader who unwraps it and is informed.

It was first presented by Claude Shannon in the late forties as a part of his and Warren Weaver's theory of information. Shannon and Weaver's work deal with transmission of information on a mathematical level, and was meant to be used for constructing telephone systems. For this purpose it was a very useful theory, and it has also has a great impact on the development of computer technology. (Nørretranders 1991)

The theory is only meant for the purely technical aspects of communication and does not consider the meaning of the sent messages. The term "information" in Shannon and Weaver's theory has very little to do with what we normally call information. The "normal" definition of information includes order and structure, whereas Shannon's information increases with disorder. (*ibid*)

Both Shannon and Weaver tried to make it clear to the world that their theory did not deal with meaning, only the transfer, of messages. Warren Weaver said: "Information must not be confused with meaning." (in Nørretranders 1991 p.141) But nevertheless their communications model has been (mis-)used in the humanities area, and a myriad of communicators have had it in the back of their heads when designing their messages. The model presents a fairly intuitive view of communication and its focus on the concrete aspects of communication has made it popular among communicators with a background in technology. (Keith 1997)

Since the model does not deal with meaning it is not helpful in our study of communication of knowledge, unless we also consider the technology used to

communicate. The reason for bringing the model up is that the thinking it gives rise to, focus on the structure of communication rather than communicating meaning, can be seen in many technical information products. But if one knows that this is not an appropriate model, this pitfall can be avoided.

3.3.2 Semiotics

The Shannon and Weaver model has spawned a series of other models, all of which concentrate on the communication as a process where messages are transferred. A totally different view of communication is presented in semiotics, the study of signs. Here the focus is on the creation of meaning through the interpretation of signs. The "sign" is a wide concept including all things detectable with our senses that refers to something other than itself. The signs form texts when put together, for example images, sound recordings, etc. Thus all forms of information considered in this paper are thus texts made up of signs. (Fiske 1982)

The main difference compared to the process view of communication is that the focus is on how the reader interacts with the text to interpret it rather than on how it is transferred. The reader is seen as an active participant in the communication process whose preferences, interests, previous knowledge, culture, etc. influence the outcome of the process. (*ibid*)

There is no distinction between the communicator and receiver in semiotics. They are both seen as equal users of the signs; one uses them to communicate a thought, the other to reconstruct the thought. (*ibid*)

There are three main areas that are studied in semiotics:

- The sign itself. How do the signs relate to each other and to the people who use them.
- The codes or systems that these signs are organised in.
- The culture in which these signs and codes are used.

(*ibid*)

One might ask if this discussion is relevant for technical communications as well? Yes indeed, the first two points for example deal with technical jargon, computer interface design, technical drawing, etc. and the third point should be obvious to all communicators working in multinational companies.

There are a number of models describing the semiotics view. They are all fairly similar in structure and all include the following three elements:

- The sign.
- What the sign refers to.
- The user of the sign.

In 1923 Ogden and Richards proposed the model depicted in figure 3.2 (slightly modified) to describe the relationship between these elements.

Mental Representation
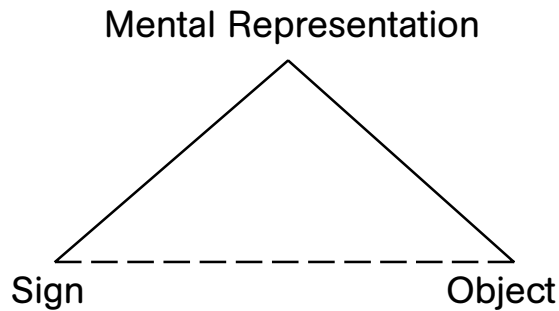
Sign   Object

Figure 3.2 Ogden and Richard's model.

The sign refers to a mental representation, which in turn is connected to an object or concept in the world that surrounds us. The connection between the sign and the object is not direct, since it needs a mind to be established. The most important element according to Ogden and Richards, is the sign. The signs we use control and structure our mental representations, which in turn control and structure our view of reality. (*ibid*)

The key point is that the message itself does not become meaningful until the reader interacts with and interprets it, and in this process creates his or her own meaning. This view of an active reader is very different from the Shannon and Weaver view, where the pre-packed knowledge package is unwrapped and all the pieces fall into place just as the sender intended.

For the communicator it is therefore crucial to know his readers and how they are likely to interpret the message. The sign, code and culture aspects must be considered before composing the message. Some examples of the many questions that can be asked are: is it better to use a picture than describing the object with words (sign), does the reader understand the technical terms used (code), etc.

3.3.3 Constructivism

A field related to both communication theory and psychology is learning theory. Here a special form of communication is studied, education. One of the many theories describing how people learn is constructivism. The constructivist view of learning has its roots in cognitive psychology, child development and semiotics. Even if it does not originate from communication studies it is still a theory describing a form of communication, and gives us further insight on how technical content is best communicated.

Just as in semiotic theory the learner/reader is seen as an active participant, central to the communication process. The basic assumption is that *knowledge is a constructed entity created by the learner through a learning process*. Knowledge can thus not be transmitted and cannot exist on its own. It has to be (re-)constructed within the mind of the learner and is therefore always subjective. The consequence of this is that knowledge never can be absolute, but is always is relativistic and fallibalist (varying and can not be taken for granted). (Wilhelmsen et al. 2000)

The construction of new knowledge is based on both the learner's previous knowledge and the new information. The learner selects and transforms the new information and tries to put it in relation to previous knowledge and cognitive structures. These cognitive structures are, for example, mental models, and will be discussed further in the next section. By constructing and testing hypotheses, exploring, discovering relationships, and applying previous knowledge to new situations, the learner increases his understanding and creates new knowledge. The reader should always be able to make a personalised reading where his interests, goals and previous knowledge direct the reading process. (van Ryneveld 2000)

The view of the instructor in constructivist theory is more as a catalyst of learning than a traditional teacher. The instructor's main task is to facilitate the learner's own creation of knowledge by presenting the material in a suitable way, and encourage the learner's process of discovery. By transforming the information into an appropriate form and, if needed, provide multiple representations, the teacher helps the learner. (*ibid*, Bruner 2000)

To summarise, the implication of the semiotic/constructivist view on technical communication is that the communicator must aim at putting together a message that is as easy as possible for the reader to interpret and create meaning out of.

In this section a first definition of knowledge has been presented and the next section will present a deeper discussion of this concept.

The discussion on communication models raises the following themes for use in the evaluation:

What is the view on the user, active reader or passive receiver?

Have the sign, code, and culture aspects been considered, i.e. how have for example conventions and terminology been used, how have media choices been made, etc.?

Does the program facilitate the readers creation of knowledge, and if so how?

Can the reader personalise the reading or is there just one fixed way of accessing the information?

What is the role of the program, teacher or "learning catalyst"?

3.4 Knowledge

3.4.1 Data, Information, and Knowledge

Before going any further the relationship between information and knowledge will be sorted out. Nathan Shedroff (1999) discusses this relationship when describing different levels of understanding. Based on his and Davenport and Laurence's (in Thurman 1999) work, I make the following distinctions:

1. *Data* are pure facts produced in for example research, surveys, and measurements. A typical piece of data is a temperature reading from a thermometer. In this stage understanding is minimal and data is only useful for producers of information in the production stage. Yet, we are all drowned in data everyday, which we are left to sort and make sense of ourselves. (Shedroff 1999)

2. The next stage is *information*. Here the data have been organised into a

meaningful form and are appropriately presented (*ibid*). A typical piece of information would be a graph showing the temperature fluctuations for Lund over a year.

3. The third level is *knowledge*. This is understanding gained through contemplation, evaluation and interpretation of information. The information is integrated with the reader and the patterns and meanings of the information are assimilated.

This definition of knowledge is the same as the constructivist one presented in the previous section. So, when the readers gain knowledge, they interpret and internalise the information we send them, and create their own personal knowledge. The communicator must therefore design the information in a way that suits the reader's information processing patterns if the communication is to be effective.

Brenda Dervin (1999) states that information design is in fact meta-design, design of design; the communicator must design the information so it is easy for the receivers to design their knowledge.

To be able to evaluate how well ActiView supports this creation of knowledge, a deeper discussion on what really is created is necessary.

3.4.2 Mental Models

The key to all knowledge, learning and intelligent thinking is the ability to form mental representations of the things, concepts, etc. that surrounds us in the world. We operate on these mental representations when thinking, solving problems, predicting outcomes, etc. instead of having to try it out in the real world. (Atkinson et al. 1993)

For example if we are about to repair a flat tyre on a bicycle we first go through a series of repair steps in our minds and "see" what happens before trying it out in real life; "If I loosen this bolt, the wheel will come of, which makes it possible to remove the tyre so that I can get to the inner tube and repair the hole. But if I do it this way instead …"

If, when we try to do our repairs, the mental model proves to be wrong we make adjustments to it so that it will help us make better predictions the next time it is used. The successful mental model is an abstraction where only the relevant aspects are represented, so that we do not have to bother with irrelevant details. Including the direction of the threading on the tyres in the mental model of the bike is probably an irrelevant detail and would only distract our thinking. But we must not make the model too simple, since this can lead to unexpected and unwanted effects, for example if you compete in down-hill mountain bike racing it would be less fortunate not to include the threading in the model. It is when the mental model includes just the right elements that new insights emerge. (Norman 1993)

The mental representations do not only include objects, but everything that we come in contact with and have a need to explain or predict the outcome of. It can be people, natural phenomena, abstract concepts, or objects (Norman 1998). Since this thesis covers technical information, the mental models of interest are of technical systems, objects, machines, computer programs, processes, etc.

We try to organise, compare, and generally make sense of the data and information that we receive from the world around us by building mental models. When we come across new information we test the models against the new information and if the model does not work satisfactory, i.e. gives the wrong answer, we modify it accordingly. The mental model does not only have to include the structure of an object. It can also tell us how a machine is operated, repaired, or whatever may be relevant. (*ibid*)

So, when we have discussed the creation of knowledge in the sections above, it is the creation of mental models we mean. We are now ready to give a first answer to the question raised in section 3.1 about how to "reach a state where the reader has the knowledge to perform certain tasks":

We supply the readers with information designed to make it easy for them to form a well working mental model of the situation in which the tasks shall be performed.

Naturally a new question arises; how do we design the information for this to happen?

The answer lies partly in the discussion in section 3.3.2 and 3.3.3. Since we all have different ways of interpreting the information, it is important to take these possible differences into account when designing the information. By thinking of the three basic concepts of semiotics; sign, code, and culture, we can tailor the messages and avoid the worst confusions.

But, if we really are to make the best of the fact that people have different preferences when constructing their mental models, we must also cater for these different styles in the information material. Some people learn best by doing, others by imagining, reasoning or theorising. If the readers can choose how the information is presented, based on their own preferences, the learning and acquisition of knowledge is much more effective. (Coe 1996)

Inner motivation is also an important aspect. If the reader finds it rewarding, for example if his understanding increases, he is more likely to continue using the information material than if he finds it boring, hard to use, or confusing (Allwood 1991). When using computers to deliver the information, a great risk for bad motivation comes with poor navigation structures. If the user cannot get an overview and easily navigate through the information, frustration and anger is usually the result.

Besides these aspects there are two more that greatly influence how easily a mental model is created; the nature of the involved thinking, and the load on the memory. These will be discussed in the next two sections.

The discussion in this section gives rise to the following questions for the evaluation:

Does ActiView deliver data or information?

How are the users' mental models formed? What is done to help them in the process?

Are individual differences catered for?

Is it rewarding and motivating to use the program?

How does the navigation structure work?

3.4.3 Experiential and Reflective Thinking

Donald Norman (1993) discusses two different modes of thinking, *experiential* and *reflective* cognition. In experiential mode we react efficiently and effortlessly to the events around us. This is the mode of expert performance. Based on the perceived data we rapidly and almost automatically know what to do. For example, when driving a car we (hopefully) use the experiential mode of cognition, we see the traffic around us, traffic signals, etc. and adjust the speed, signal turns, etc. without having to think before acting. We just react more or less instinctively without delay or apparent effort. (*ibid*)

Reflective cognition, on the other hand, is the mode of deep thought, comparison and contrast. This is slow and laborious mode that leads to new insights and ideas. This is what we normally think of as "thinking", for example solving a math problem.

These two are not the only modes of cognition, nor are they mutually exclusive. But normally one mode is dominating over the other. There is no ranking either, they are equally "good", but used for different purposes. (*ibid*)

The problem is when the information we use triggers the wrong type of thinking. If for example a timetable is poorly designed we are forced into reflective thinking to decipher it when it should be an experiential task. Norman especially points to the danger of being forced to experiencing instead of reflecting when using new technologies such as multimedia. When the perceptive richness of the new media is used to the fullest, we are experiencing, but with very little reflection over what we are experiencing. In this manner new experiences can be had, but not new ideas, concepts or insight.

When designing information it is therefore essential for the communicator to realise what kind of cognition he wants the reader to use. If the reader is to build a new mental model reflective thinking is required and the information should then support this. A flashy instruction video showing how to use a computer program may thus be less effective than a paper manual.

Likewise tasks that should be experiential, for example getting the instructions on how to start a program, should be straightforward and not require reflection.

The questions for the evaluation from this section are:

Does ActiView support reflective and experiential thinking?
If it does, how?

3.4.4 Memory

An understanding of the human memory is also important for our discussion since memory is the storage place for knowledge. The most spread theory on memory divides it into three separate parts: sensory registers, short-term memory and long-term memory. The sensory registers are temporary storage spaces for sensations from our senses. The information and data are filtered here before being transferred to the short-term memory for further processing. After this it is stored in long-term memory. (Coe 1996)

3.4.4.1 Short-Term Memory

Short-term memory is a "mental workspace" used for conscious thought and problem solving. Here relevant information from long-term memory as well as new information from the sensory registers is temporarily stored while being elaborated on. The capacity of short-term memory is very limited, on the average 7±2 items. The items are information units and by chunking the information into larger units the capacity can be increased. (Atkinson et al. 1993, Ellis & Hunt 1993)

Because of its limited capacity it is important not to overload the short-term memory with information. The more of the information that can be held in the surrounding (information "in the world" as Norman calls it), while still being easily accessible, the better. A well laid out information material lets the readers use the short-term memory for the central cognitive tasks and supports them with the information they need the moment they need it. A good memory support from the surroundings is especially important when reflective thinking is required by the reader. Short-term memory can then be used to hold results from the thinking instead of memorised facts, for example is it much easier to solve a math problem with the help of paper and pen than without, because then short-term memory is freed up. (Norman 1998)

3.4.4.2 Long-Term Memory

Long-term memory is the where knowledge is stored. The information processed in short-term memory is encoded into long-term memory in one of two formats, verbally or visually coded (Ellis & Hunt 1993). Long-term memory has a very large capacity and does not deteriorate with time. When we forget it is not that our memories have vanished, we just cannot retrieve them (Coe 1996).

The verbal coding of information is based on meaning, not exact wording. Long-term memory is thus good for holding knowledge, not data or information. For people to remember, it is therefore important to help them see relationships, consequences, make comparisons, etc. so they can build meaningful and logical mental models. If the task is turned into meaningless memorising, not much is remembered. The key to good memory is thus elaboration while encoding, since we then relate new information to old, put it into a context, and create knowledge. (Atkinson et al. 1993)

But for memory to be useful it is not only the encoding but also the memory retrieval that is important. The best way to make this process efficient is by organising the material as much as possible when encoding it. One effective way is to use hierarchies. Then the person does not have to search long lists in memory, but rather make decisions among a smaller set of items for each level in the hierarchy. (*ibid*)

If the communicator can help the reader to create organised and meaningful mental models by suggesting a suitable structure (for example a hierarchy) and thoughts that helps the reader discover meaning with the least amount of effort, the information material is well designed.

The second way of encoding is visually. Mental images are particularly useful when trying to improve memory. Most mnemonic techniques use mental images for encoding and retrieving (Buzan 1984). Visually encoded material generally

holds more detail and is more easily stored than verbally encoded material (Paivio in Ellis & Hunt 1993).

Our superior memory for images should be used as an asset. As a communicator one should always consider if the information can be presented visually and remember that using visual information generally helps the reader. For some tasks visual mode is clearly the most natural way of thinking, but also in highly abstract areas such as mathematics, visual analogies, etc. can lead to new insights.

When solving problems the representation is very important. Many problems can be solved much easier if the problem is presented in an optimum way, for example by using visual information. This is connected with the two modes of thinking, if the problem can be reformulated so that it is an experiential task instead of a reflective the load on the problem solver is reduced considerably. (Norman 1993)

The questions for the evaluation from this section are:

How heavy a load is put on the users short-term memory?

Is information in the world easily accessible or is memorising required?

Is the creation of meaning and knowledge supported by allowing the user to easily make comparisons, see consequences, connections, etc.?

Does ActiView support the users organisation of the information?

Is visual information used?

3.5 Uses and Gratification

The central point in the discussion so far is that the reader should be seen as an active participant in the communication process, not a passive receiver. This is the core of the Uses and Gratification approach to media usage, first described in the late fifties by Elihu Katz. According to this approach people actively use the media to fulfil their needs and to get gratifications. Different persons seek different functions in the media, for example information, status, escapism, etc., and are actively looking for the right messages to fulfil their needs. The level of activity in the search is, just like the different needs, variable and depends on both the individual and the sought function. (McQuail 1994, Sevrin & Tankard 1997)

Although this approach was derived by studying people's usage of traditional media like radio, television and newspapers, it is also very useful when studying how people use digital media, like the Internet, since here the activity of the user is more or less a requisite. (Sevrin & Tankard 1997)

Even if this approach stems from mass media research I think it is just as useful to sum up all the aspects considered above of technical communication. Just as people using mass media have a purpose, outspoken or not, so do people using technical information. Almost always this purpose involves gaining the appropriate knowledge to be able to perform a certain task.

With the Uses and Gratifications approach in the back of the head, the communicator sees the process for what it really is, and realises the central position of the reader. The communicator's job is to serve the reader with information so his purpose can be fulfilled. This approach also reminds us that the use of technical information is actually an unwanted, but nevertheless often necessary, step before

performing the task. The reader really wants to get on with the task, not waste time going through a thick manual.

It is therefore important to make the technical information as short and effective as possible. Since the reader wants to perform a task, the information should also be designed with this task in mind, and make it as simple as possible for the reader to construct the needed knowledge. The task can be practical, such as operating a microwave oven, or cognitive, such as calculating the effect produced by a microwave oven.

Practical studies have also shown that shorter manuals often are more effective than longer ones. By focusing on describing the tasks the user wanted to perform with the equipment rather than describing the equipment itself, the shorter manuals resulted in the same learning effect, but much faster. (Allwood 1991)

The two themes from this section that will be used in the evaluation are:

The evaluation will be based on the view of the active reader, as presented in the Uses and Gratification approach.

Is the information presented in a task-oriented manner?

3.6 Types of Information

In the previous sections the connection between information, knowledge, and communication was investigated. In this section information will be given a deeper treatment. Different types of information and their respective characteristics will be discussed in order to determine when to use which type.

When categorising information there are two non-correlating dimensions that are interesting to analyse, the first being the purpose of the information, and second the presentation format (text, images, etc.). These dimensions are discussed in the next two sections.

3.6.1 Information Purposes

Brenda Dervin (1999) defines information as "a tool designed by human beings to make sense of a reality assumed to be both chaotic and orderly" (p.39). Information instructs us about the world we live in, she means. This is a very broad (and good) definition, which covers most things that can be communicated, both "traditional" information material such as user manuals and newspaper articles, but also things not usually seen as information, for example fairytales and Dallas.

Fairytales, for example, often have some (slightly) hidden message, for example that it pays off in the end to be honest. Disguising this information as a fairy tale means the communicator has studied his audience and adapted the information accordingly, i.e. good information design.

Since Brenda Devin's definition is so broad, it is interesting to make finer distinctions. Based on William Keith's (1997) distinction between expressive and strategic communication, I will in this paper make the distinction between expressive and strategic information.

Expressive information is not aimed at influencing the audience, it is just meant to express ideas, feelings, etc., nothing more. Strategic information on the other

hand, serves to effect others and make an impact. The two formats of information form the extreme ends of a scale, ranging from truly expressive information to truly strategic, with mixed forms in between.

Truly expressive information is very rare, but the view of information as expressive is quite common among producers of technical information. The information is seen as an objective presentation of facts, where efforts to effect the reader are seen as inappropriate. (*ibid*)

A better approach would be to realise that technical information, even a purely "objective" presentation of facts, also is aimed at somehow affecting people; to help them learn a task, accept a proposal, understand how to repair a car, use their new mobile phones, etc. The expressive view of information often leads to flat and uninspiring presentations where the content, rather than the reader's needs, is left to dictate the structure. (*ibid*)

A typical example of expressive information is to list descriptions of what the different buttons on a TV-set does whereas strategic information would describe the tasks the user needs to perform when using the TV.

Strategic information is still too large a category to be practically interesting and is therefore further classified. Rune Pettersson (2000) proposes a taxonomy with seven different classes, of which the latter three are relevant for this paper:

- Advertising and propaganda
- Informative entertainment
- Brief messages
- Administrative documentation
- Factual information
- Instructions
- Teaching aids

A lot of information material has characteristics from more than one class. An instruction manual might for example contain sections that are instructional while other sections hold factual information, such as technical specifications. Mixing the types can lead to better presentations, if there is a purpose for doing so. If there is none, it probably will not.

When planning technical information it is very important to have a clear goal with the information, and what the reader should be able to do after having read it. Carl Martin Allwood (1991) makes the distinction between three types of manuals that serve three different functions (cf. the last three of Pettersson's categories):

- The reference manual. This is mainly meant for technicians, or other well-initiated users, and is a total documentation of all functions.
- The user manual. This is meant for intermediate users when problems are encountered.
- The instruction manual. This is meant for beginners and serves as learning material.

A common problem, Allwood says, is that manuals are written to serve more than one function, for example instruction manuals with reference material inter-

woven. This is unsuitable, and often results in unnecessarily long presentations where the sought information is hard to find. The result is that none of the functions are fulfilled properly.(*ibid*)

The questions for the evaluation from this section are:

Is the purpose of the information clear?

Is the information strategic or expressive?

Is the type of the information unambiguous?

3.6.2 Presentation Formats

In this section different presentation formats and their characteristics will be discussed. It is important to consider these characteristics when designing the information since the format to a great extent affects the way the information is processed by the reader. Not all formats are suitable for all information tasks, and what is good in one situation might be bad in another.

3.6.2.1 Text

Despite the introduction of many new media the last century, text is still the most dominant format for technical information, weather it is delivered on paper or screen. The dominance is probably due to historical as well as economic reasons. To produce and print texts has always been a cheap and easy way of delivering information.

The text-format has some positive characteristics that (I think) will guarantee its continued dominant position. Lennart Hellspong and Per Ledin (1997) discuss non-fiction texts and present a number of characteristics.

The first is stability in time. A text is not transient like for example film, the text exists as a whole the whole time and the reader can read it in a pace suitable for him. Some parts can be skimmed, others re-read, a section can be skipped, etc. The reader has good control over the reading process and can stop to reflect, compare with other parts, etc. when necessary. This is a good characteristic since it facilitates reflective thinking and creation of elaborate mental models (in accordance with the discussion in sections 3.2 and 3.3)

The second characteristic is linearity. Most printed texts have a linear structure, and are meant to be read from front to end. Some exceptions exist, like dictionaries and reference manuals. Linearity means that the author has the control over the order of the presentation, leaving little possibility for the reader to adapt it according to personal preferences.

Other disadvantages with texts are the ambiguity and limitations of language. In technical information objects or processes are often described and finding the appropriate words so the reader in a reasonably short description understands exactly what is meant is a challenge.

A similar problem is that different groups of people do not use the same words to describe things. This is obvious for different nationalities, but also for different professional groups where various jargons are used. Efficient use of jargon and specialised terminology is a great help to reduce the length of technical texts, but it is also necessary that the reader knows the specialised language. Further

problems arise when the same word has different meanings for different professional groups.

To get around some of the language related problems, and to make translations more exact, a number of multinational companies have introduced so called controlled languages. This means that there is a company dictionary with the words that are allowed to be used in technical information, and a corresponding grammar with the allowed grammatical constructions. (Allen 1999)

3.6.2.2 Hypertext

With the introduction of World Wide Web the hypertext format got its public breakthrough, but the thought of linking texts was first presented over 50 years ago. There have been examples with hypertext structures on paper, but nowadays hypertext structures are almost exclusively presented on computers.

The greatest difference compared to normal texts is that the linearity is broken. With the links, the reader has control over the order of the text and can let personal preferences and interests direct the reading.

The author's intentions are thus mixed with the reader's and the communicator must produce texts that can be read in many different ways, and that can be understood regardless of the order of the reading. Alas, a well-planned hypertext structure consists of many small, self-bearing units (Håkansson 1999).

The downsides with hypertext structures, is firstly, that the texts are read on screens. This limits the size of the texts considerably if too much scrolling is to be avoided and the limited resolution on today's computer screens also makes it uncomfortable to read longer texts.

Secondly, it is easy to get lost in a hypertext structure and it can be hard to find the needed information. It's therefore crucial that the communicator provides some sort of navigational help to give the user context and orientation. (Hollan & Benderson 1997)

3.6.2.3 Hypermedia

Hypermedia is similar to hypertext, but with links between multimedia components instead of texts. A map where clicking the different countries brings up video films describing them, is an example of hypermedia. (Rada 1995)

As with hypertext, the linearity is broken and the reader directs the reading to a large extent. The characteristics of the components in a hypermedia structure vary with the formats and are further described under the corresponding headings below.

3.6.2.4 Pictures

Ever since the Stone Age humans have communicated with pictures, which has proved to be a successful form of communication. Thousands of years later we can still interpret the cave paintings and get insights into the lives of our ancestors. In the Middle Ages people started to use pictorial information to supplement texts in order to clarify and explain what was written (Ellenius 1990).

We are all as human beings built to be good at interpreting visual impressions. Just as with other expert behaviours, much of this interpretation is done with the experiential mode of cognition. The process is parallel, fast, data-driven, and allows us to function in the world without bumping into things and getting run over by busses. (Norman 1993)

Another reason for why pictorial information is often easier to understand, is that the used codes (se section 3.3.2) are easy to interpret. For example, on a picture of an object many of the distinct features are easy to recognise (shape, colour, etc) and the connection to the real object is strong and natural. If the same object was described in a text, the reader would have to use reflective thinking in a larger extent to first make the interpretation of the text, and then connect this to reality. Thus it is easier to know what to do having seen a picture of how to assemble a nut on a bolt than having read a description of the same task.

In many situations of technical communication it is easier for the reader to create a mental model if the information is delivered in a pictorial format. As we have seen above, reflective thinking is necessary for building more elaborate mental models. This is often facilitated by pictorial representations, since the reader does not have to reflect as much over the interpretation of the information, and can instead concentrate his mental abilities on reflection over the actual content of the information and the creation of a mental model.

A problem with pictures is that there are no clearly defined codes. When describing objects this is seldom a problem since the code is more or less self-explanatory because of the strong and natural connection to reality. But when describing processes it can be a real problem. One way of getting around this is to use multiple images and change key features, just like in comics (Tufte 1994). Nevertheless each individual picture often describes a process, for example pulling a lever.

There are some pictorial elements used for describing processes, for example arrows. But because there is no set code for what an arrow means (it can depict movement, force, attention, etc), it can confuse more than clarify.

There are two main categories of pictures, illustrations and photographs. With illustrations the communicator can control the level of detail, and by only depicting the relevant aspects the reader is lead to focus the interpretation on these. With illustrations it is also possible to add aspects depicting more abstract concepts, for example the traditional colour coding of cold water as blue and hot as red can be used in a plumbing blueprint.

Photographs, on the other hand, has the advantage of being much more accurate depictions of reality than illustrations, and are often cheaper to produce. The accurateness can be both an advantage and a disadvantage. The level of detail is often high and the reader is not helped to filter out the unimportant aspects, but on the other hand the connection to the real world is stronger.

The choice of pictures for the information should, as always, primarily be based on the purpose. It is important that the pictures visualise the content rather than just liven up the presentation. They must also be clear, use a proper code, and be integrated in the information.

3.6.2.5 Film and Animations

Film and animation are both transient formats. The individual frames are seen for a short moment before the next is shown. These formats trigger experiential thinking and are not good for reflection, comparisons, etc. since the viewer must process the information in the pace and order as set by the communicator (Norman 1993). When shown on a computer the viewer can be given more control over the order and pace of the parts of the film/animation, for example by using hypermedia links and scrollbars.

The real strength of this format is its possibilities to show processes. With static pictures the communicator has to pick out one or a few key images to represent the process, whereas the film/animation can show the whole sequence. This means that the viewer can see exactly how, and in which pace the process is carried out.

The difference between film and animation is the same as between photographs and illustrations. In animations the level of detail can be controlled to a larger extent than with film, which on the other hand has a closer connection to the real world.

3.6.2.6 3D

With the advances in computer technology new ways of visualising information have emerged. 3D-visualisations have become more and more popular and can be described as a mix between traditional illustrations and photography. The communicator can easily build a 3D-model and define aspects such as surface characteristics, lighting, etc. after which a "photo" is taken by the computer. The "photographing" is actually a calculation of how the light in the scene is reflected, diffracted, etc. and projected onto the viewing plane.

The communicator has full control over the level of realism, and which details that are included. The costs for producing technical images are also often low compared to traditional illustration and photography, since the digital blueprints used to manufacture the objects often can be reused for the 3D-models as well.

3.6.2.7 Sound

Sound is serial and transient in nature which limits is use for technical communication. The transient nature makes it hard to do any serious reflection over the content and there is no way to store the information in the surrounding in a way that allows for easy access by the listener. Sound can be helpful in connection with films or animations where a speaker can explain what happens on the screen.

3.6.2.8 Paper vs. Screen

Since the evaluation concerns communication through a computer program, a short discussion on the characteristics of computer screens, and how they differ from paper follows.

Firstly the display area is much smaller on a screen than on paper. This means that non-transient formats such as texts and images often are forced to be semi-transient, only a part is shown at a time. The "displayed" information in the reader's surrounding can therefore not be as extensive as when delivered on paper. There are two ways around this problem: A printout function, which lets the user

turn the content into paper based information; or making a good navigation structure that allows the reader fast and easy access to the different parts of the information.

Secondly, the resolution of computer screens is much lower than for print material. This together with the fact that the image flickers at 50-100 times per second and that the light is not reflected (as with paper), but directly emitted, makes reading from screens tiring. The texts should therefore be as short as possible and if the user has to read long texts, a printout function is necessary.

Thirdly, we are used to seek information with a physical form, for example books, binders, etc. When using computers none of the cues we are used to are available. We can for example estimate our position in a book by feeling how many pages the left hand holds compared to the right. Because of the abstract form of digital information it is much easier to get lost. Good navigation structure and feedback to the user is thus important. (Pettersson 1998)

In this section a number of characteristics for different formats have been presented. Based on this, the following questions will be asked in the evaluation:

Have the different formats been used in a way that supports the creation of knowledge? If so, how?

3.7 Sphere of Actions

In this chapter the central theme has been the active user creating knowledge and mental models from the supplied information. This creation process is driven by certain actions the reader performs, for example connecting, contrasting, comparing with previous knowledge, etc. If these actions are easily performed, the reader can easily create the knowledge, and vice versa.

All artefacts, cognitive or physical, have what Donald Norman calls *affordances*. These are the fundamental properties that tell us how the artefact can be used. For example a chair primarily affords ("is meant for") support, and therefore affords sitting, hanging clothes on the back, putting books on it, etc. (Norman 1998). The affordance of an artefact thus directs us to the possible actions that can be performed with it.

In the same way all the different aspects that have been discussed in this chapter are connected with different affordances and offers certain possible actions. For example different types of information afford different actions, some forms allow the reader to set the pace of the reading himself which in turn affords the action of reflective thinking, other form afford the action of viewing processes, etc. Well-designed information affords actions that lead to the creation of mental models; the different communication models afford different views on the communication process, etc.

The total set of possible actions an artefact affords is in this paper called *the sphere of actions*. As discussed above, the creation of knowledge depends on certain actions, so when evaluating ActiView what we really are interested in is the total sphere of action supported by the application.

These actions depend on the structure and the functions of the program, but also which format the information is delivered in, and the quality of the content.

3.8 Conclusion and Specified Question

With this in mind, an answer to the questions raised in section 3.1 and 3.4.2 can finally be given:

Effectively communicated technical information has a sphere of actions that facilitates the readers' creation of knowledge.

Before starting the actual evaluation work, the question that this paper aims to answer (from section 1.5) can thus be further sharpened and specified to:

What sphere of actions does ActiView have?

The evaluation will therefore be concentrated on analysing this sphere of actions and comparing it to an (maybe hypothetical) ideal sphere and also the sphere of actions supported by paper based information. If the ActiView sphere of actions is closer to the ideal it is more suitable for technical communication than printed information, see figure 3.3.
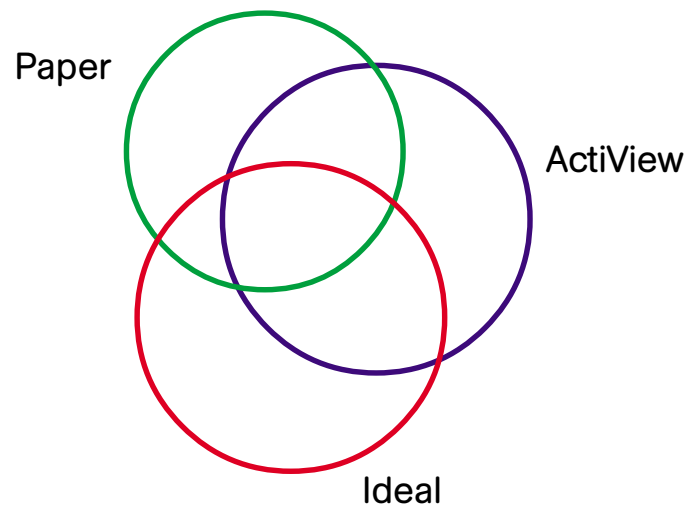
Figure 3.3 Different media have different spheres of action.

4. Methodology

In this chapter the methodology, and execution of the evaluation of ActiView is described. The evaluation is based on qualitative method, for reasons described in the section below. The plan for the analysis, and how the measurements were conducted are described in the next sections. A discussion on the reliability and validity of the evaluation rounds off this chapter.

4.1 Rationale for Choosing Qualitative Method

To be able to answer the questions raised in this paper (see sections 1.5 and 3.8), there are some requirements on the evaluation process that have to be met. The fundamental principle, upon which this evaluation is based, is that knowledge is individually created in a highly subjective process. To study this process, the individuals' experiences in their own terms are essential. To be able to capture this rich and varied data, to be flexible when new insights emerge during the evaluation, and not being constrained by pre-determined categories of analysis is thus very important.

A holistic perspective is also important since ActiView as a whole is to be understood. Not only the individual parts of the program, but also how they form a unit together with the user and his surrounding. The goal is to understand how the users perceive ActiView, interact with the program, and essentially to experience the process from the users' perspective. At the same time the developers' perspective is important to get the whole picture. The perspective should thus be shifted depending on which part of the evaluation that is being conducted.

Since ActiView is new product that has not yet been (at least academically) evaluated, the nature of this evaluation is oriented towards exploration and discovery. Being able to follow interesting leads that emerge during the data collection, and study selected issues in greater depth, is therefore essential. Inductive logic with the focus on questions, issues and patterns is thus a more efficient way of evaluation than deductive testing of pre-postulated hypotheses. The naturalistic approach to data collection (not manipulating the situation for purposes of the evaluation), in this case, gives the most accurate report on how the users and developers view the program.

One of the goals of this paper is to make some general observations applicable to other situations where technical information is delivered via digital media. By choosing ActiView, because of its novel approach to technical information, as an information-rich case and by deeply analysing this program, some more general conclusions can hopefully be drawn.

Considering all the requirements above on the evaluation, and comparing with what Michael Patton (1987), Patel & Davidson (1994), and Repstad (1993) say about methodology, it is clear that qualitative method is most suitable for this paper.

Further, it was also clear from the beginning that the number of people, other than developers, that had been using the program was very limited, less than 10 in a first estimate. Making a quantitative evaluation, for example a survey, would thus be statistically very unreliable.

4.2. Evaluation Plan

In order to get a clearer picture and to be more certain on how effective ActiView is for technical communication, data from three perspectives, the users', the developers', and mine, were collected and compared. This is called triangulation and is a way of controlling the data and increasing the validity (Patton 1987, Ely et al. 1993). The collected data were then analysed based on the themes from the theory chapter. The evaluation process progressed through five distinct stages, which are described below:

4.2.1 Literature Survey and Building of a Theoretical Base

The first thing I did was to search for relevant literature in library databases, on the web, in the reference sections of articles and books, in specialised bookstores and by requesting literature lists from various university courses. The search was conducted in a rather wide area, mainly in communication studies, but also in the fields of psychology, information design, education, human computer interaction, typography, and design theory. The goal was to find theories that could help deepen the understanding of how knowledge is communicated.

The search resulted in a number of books, articles and web pages from which, a set of useful theories were collected. By using these theories from a communications perspective the theoretical base slowly formed. This base then lay as the foundation for the data collection but was revised continuously during the rest of the evaluation as new insights emerged from the data.

4.2.2 Heuristic Walkthrough

As stated above I wanted to collect data from different perspectives and triangulate. In order to not be biased from the interviews with the developers and users, I started off with the heuristic walkthrough. This is a method similar to direct participation where the evaluator himself goes through the program, performing tasks as the users would, and at the same time reflects over the way the interaction flows.

These reflections were guided by, but not in any way restricted to, the themes and questions that emerged in the theoretical chapter. The themes and questions have been summarised in Appendix A for easy reference.

The walkthrough was conducted in three parts:

- First I gave myself the task of learning how the mast described in the application works in a general way, and how to raise it. This mainly involved the functional instructions.
- Secondly, I gave myself the more specific tasks of learning when and how to repair three different parts of the mast: lyftlina, plastgejdersats, and linhjul (a wire, some plastic covers, and a wheel). This mainly involved the maintenance, repair, and spare parts information.
- Thirdly, I just went through all the pages without any specific task or order to get an overall impression.

In this way I could test the information in terms of different functions, as described in section 3.6.1. The first walkthrough tested instruction manual aspects and the second user and reference manual aspects.

The walkthrough was conducted on a 550MHz PIII computer with a 19-inch screen and with the application running from the hard drive instead of the CD-ROM. These are probably better conditions than for the average user, but by making the application window the size of a 15-inch screen I think my experiences were similar to the users since the speed of the computer is said to be rather indifferent to this application (it has even been run on an old 486 processor).

4.2.3 Interviews With the Developers

The next I did was to interview the developers. The reason for interviewing them prior to the users, was that I wanted to understand their intentions and purposes with ActiView so that I would be able to compare these with what the users experienced and be able to ask initiated questions about this.

The development team consisted of a core of 7 persons. I choose to interview two of these, the project manager and a member of the project reference group. The reason for choosing these persons was that they had different tasks in the development process and therefore could give information on different aspects, and also to see if their views on the program differed depending on their jobs.

The settings were the respondents own offices in Växjö, which provided a relaxed environment for them. The interviews were approximately one hour long and the respondents did not seem to loose concentration even at the end. I used an interview guide with broad questions and themes, which would give me both the overview and details needed to answer the questions in this paper. The questions partly concerned the origin of the program, how it was developed, purposes and intentions, etc., and partly the questions and themes derived in the theoretical section. The questions were not formulated before the actual interview. Instead I had written them as keywords, and depending on the situation formulated different question around these. The same keyword could also be repeted under different themes if it was considered relevant under more than one theme. The interview guide can be found in Appendix B.

Since the interviews were quite long and I wanted to be fully concentrated, they were recorded, which the respondents had no objections to. By comparing the behaviour and responses to questions I got before and after the interview with the ones I got during the interview, I drew the conclusion that they felt comfortable with the situation and gave me all the support they could.

One might think that the respondents would be reserved towards an outsider evaluating their work, but I felt that they welcomed the opportunity to get an evaluation of ActiView, and opinions from a different perspective than their own. Thus I am convinced that they were not trying affect my view or to portray the program, their work, etc. in an incorrect way.

4.2.4 Interviews with Users

After the interviews with the developers the turn came to the users. When I started working on this paper I realised that a problem would be to find users since the program was so new. In my initial contact with AeroTech Telub in Växjö I was informed that there was a group of users on the coastal artillery base KA2 in Karlskrona. But, unfortunately this group was laid off when the base was closed down a short time after I started working. Hoping that eventually more people

would start using the program I continued working with the literature survey and the other measurements.

4.2.4.1 Semi-User

While waiting for more real users to emerge I contacted a "semi-user" also working at AeroTech Telub, whom I interviewed. The reason I call him a semi-user is that he has a background as a colonel in the coastal artillery and knows the conditions under which the programs is to be used, what it is to be used for, what information material is used today, and primarily, has also tried ActiView. He has not been part of the development team but taken an interest to the program.

The reason for interviewing him was that his extensive knowledge of how the military organisation works, and of how technology and information is used there, made him able to give me insights on both how ActiView would work out in practise, and a more managerial perspective on how it would fit into the organisation and its way of operating.

The interview was conducted at his office in Hässleholm, was also approximately one hour long, and recorded. Just like the developers, he was very helpful and supportive. As with the developers, this interview was open but guided by certain themes and open-ended questions/keywords around which the conversation circled. The interview guide can be found in Appendix C.

4.2.4.2 Users

Eventually I was told that there was a group on the coastal artillery base in Gothenburg, KA4, that was going to be trained to use the telescopic mast with the ActiView application two month later. With restored faith I continued working, but it turned out the information about the training course had passed many persons before reaching me, and was quite exaggerated. When I finally (after three weeks of man-hunting and numerous phone calls) talked to the two officers responsible for the course it turned out that they were not going to use ActiView since they had not had any training themselves in using the program, and hardly had any computers, and definitely none for the soldiers to use.

When I told the reference group member I had previously interviewed about this he called the two officers and offered them to go to Gothenburg and train them in using ActiView and show them how it could be used in the training of the soldiers. The result was that he spent a day showing the program to officers and holding two introductory lessons about the mast with the use of ActiView. During the lessons one computer with a projector was used but afterwards the soldiers were also given the chance to try ActiView themselves.

Since I realised that this was the closest I would get to find something resembling real users I went along to observe during the lessons and to make two group interviews with the soldiers afterwards. In total there were 22 soldiers being trained and they were done so in two groups. After each lesson I made a short group interview with them, approximately 20 minutes long.

The reason for making the interviews as group interviews was primarily that the soldiers were on a tight schedule, which did not give me much time. Instead of making two interviews with just one person each time I made the judgement that

a group discussion would give me more information, and that they would be open about their opinions since the discussion would not cover anything of a personal or sensitive nature.

The interviews were conducted in the same classroom as the lessons had been held and in conjunction with these. This also allowed for the soldiers to reason about things they saw on the projected screen. Both discussions were directed by an interview guide with some themes and open-ended questions/keywords, which can be found in Appendix D. Many of the respondents were obviously interested in computers in general, and also the novel way of presenting information with ActiView, which made the discussions lively and interesting with many opinions. Since the groups were quite large I could not record the interviews and instead I took notes.

4.2.5 Analysis

The analysis was made continuously during the evaluation process. In this way insights and ideas gained from the heuristic walkthrough could be used in the interviews, etc. It was also an advantage since the interviews then were fresh in my memory when analysing them.

The basis for the analysis was the resulting texts from the measurements: a protocol from the heuristic walkthrough and printouts of the interviews. I then read and reread these texts a number of times while trying to find patterns, themes and categories that the material could be organised into.

These themes, categories, and patterns were then compared with the theories from the literature survey to find possible explanations and to direct further literature searches. The analysis of the data thus lead to modifications to the theoretical framework, which in turn enabled me to ask more specific questions in the later interviews and make better interpretations of the material.

In practice most of the organising work was made with the help of a computer and a word processing program (Microsoft Word). Quotations from the interviews and the protocol were cut out and incorporated into different files covering different themes and categories. Making this in a computer environment was a great help since being able to electronically copying, pasting and moving the quotations made the process very flexible.

The result was an organisation of the data in concepts that could be understood from the theoretical framework, and a theoretical framework based on the collected data, usable in other similar situations.

4.3 Validity and Reliability

Since this is a qualitative evaluation, some might ask if the terms reliability and validity have any relevance at all. These terms require that there is some objective "truth" that the evaluation is aiming to find and with the focus on subjectiveness in qualitative method, this might seem as a contradiction: how can we estimate how close we are to the "truth" if there is no objective truth?

I agree that the truth is not out there. But I also think that there are some inter-subjective agreements that are shared by most people. The reason can be that we

share the same cultural background or have biological similarities because we are human beings, and therefore make similar interpretations of some experiences. For example, most students tend to agree on a lecturer's quality, and most people experience pain in the same way.

Patton (1987) also sees objectivity as an unattainable concept and suggests the use of the term neutrality instead. He means that all measurements are subjective but by accepting this and trying to take this into account in the analysis, a balanced (but nevertheless subjective) picture emerges. He writes:

"The practical solution may be to replace the traditional search for truth with a search for useful and balanced information, and to replace the mandate to be objective with a mandate to be fair and conscientious in taking account of multiple perspectives, multiple interests, and multiple possibilities." (p.167)

The term generalisation is often used when discussing objectiveness in quantitative research, but I agree with Patton when he says that extrapolation is a better term to use when using qualitative method. This, he means, signals that modest speculations are made about similar situations rather than postulating "objective" truths. Extrapolations are logical and thoughtful statements based on information-rich samples that can be used as guidelines and learnings under conditions resembling the original one.

So, if this paper is to be more than just a journalistic description of how things are at the moment, there must be an attempt to explain why things are as they are in a neutral way, and there must also be possibilities to extrapolate this new knowledge to other similar cases. Otherwise the evaluation has little value to anybody but the developers of ActiView. Specifically, the goal is to make some statements that can be extrapolated to other situations where technical information is delivered via digital media (se section 1.5).

But for these extrapolations to have any value we must be assured that I have been as neutral as possible during the evaluation and put together balanced and useful information. If I have not made any major errors we may conclude that the produced information is (probably) close to some inter-subjective agreement. From this perspective the terms validity and reliability have relevance: have I measured the right things and how much have random factors affected the results?

As I see it the two factors that have affected this evaluation mostly are:

Evaluator characteristics

Since qualitative method is based on subjectivity and use the evaluator as an instrument, his personal characteristics, experience, previous knowledge, etc. affect the measurements. It is therefore important to be self reflective and try to eliminate as much as possible of this influence on the data (Ely et al.1991).

In my case the fact that I am interested in technical communication and, believe it or not, enjoy reading manuals might have affected how energetically I read the information while making the first two parts of the heuristic walkthroughs and the time I was willing to spend doing so. To avoid this effect, I tried to see the information as a necessary but unwanted step to pass, and read as I think a normal user would.

Lack of users

The main problem was of course the lack of real users. The soldiers being trained with ActiView had very little direct contact with the program and I could only get their first impressions of it. The best thing would have been if they had been given the opportunity to use the program the entire week their training on the mast continued, and if I could have interviewed them afterwards as well. However I was surprised at the amount of information that the two short group interviews gave. Here the interest shown by the soldiers made a big difference.

The first impressions by the soldiers had then to be completed with the impressions after longer use I got from the heuristic walkthrough and from the interview with the semi-user. By comparing my own first impressions of ActiView with the soldiers' I found them quite similar, which might suggest that my own long-use impressions could be similar to real users'. However, having the users impressions as well would have been better since I do not have the same characteristics as the average user.

As said above the use of three different measurements allowed me to triangulate and compare the data to control the validity. The differences were small which leads me to believe that this evaluation is valid and reliable, but should be seen for what it is, an explorative evaluation with the aim to explain some aspects of technical communications. Further studies of ActiView, and especially the users, would further deepen the understanding and are strongly recommended.

5 Results and Discussion

In this section the results obtained in the evaluation will be reported and discussed from the theoretical point of view presented in chapter 3. During the discussion certain conclusions that can be extrapolated and used in similar situations are reached. These will, just as the themes in chapter 3, be stated in conjunction with the corresponding discussion.

5.1 Physical Aspects

In section 3.7 the concept *sphere of actions* was discussed. This concept does not only include the cognitive actions possible, but also for example physical restrictions and characteristics. These can be just as important, and a holistic view were all aspects are considered and weighed together is recommended.

In this evaluation the fact that a computer is needed for the CD-ROM to be used is such an example. Since nobody at the military headquarters had bothered to check if there were any computers the information users could access before ordering the CD-ROMs, the situation is that the information cannot currently be used.

The actual delivery of the program is also important. The mast-application was just sent to the officers at KA4 through mail and they were not introduced to, or shown how to use it. The result was that the CDs were put aside and more or less forgotten about. The fact that the ActiView application is delivered in a normal CD-case is probably a part of this problem. This makes its physical size less impressive than many other software products, that often ship in rather large paper boxes, and makes it easier for the application to be buried in papers, other CDs etc.

But more importantly, the officers were never presented to the application and how they could be helped by it. They were also under the impression that they needed training to be able to use the program (a very common mental model regarding computer software), and hence never even tried it.

With information on paper the user can flick through the pages and in a few seconds get a first impression of it. With a CD-ROM on the other hand, it first has to be installed on a computer and does not allow for quick flicking through its content. It is therefore important to tell the user why he should go through the trouble of installing the software and take part of the information. Otherwise the risk is that the information ends up on the bottom of a desk drawer. In this case a simple two-minute phone call from the responsible persons at the military headquarter would have sufficed to explain the benefits of using ActiView and how easy it is to use.

The first general conclusion to be drawn from this discussion is:

The entire sphere of actions must be considered when designing information. The physical aspects of the information delivery and the introduction to the information are just as important as the actual content.

5.2 Personalised Reading

In sections 3.3 and 3.5 the concept of the active reader was discussed. ActiView encourages, and requires, the reader to be very active. The hypermedia structure of the information means it has no intrinsic order. The user can thus read the information in his own preferred order, and has good opportunities to let personal preferences direct the reading to a way of learning that suits him.

By selecting the information himself, the user indirectly chooses which level of detail he wishes. This makes the product accessible to both novice and expert users of the telescopic mast, and also means that the information can be used for a number of different purposes. One user might need a quick repetition of the necessary steps for repairing a part of the mast, whereas another user needs detailed instructions on every step to learn how to perform the repair. Letting the user control the information depth means he can work in an optimum way, not having to waste time on reading unnecessary information or getting frustrated by too little information.

The presentation formats used in ActiView gives the reader good control over the pace of the reading. The main part of the information is presented as either static images and text, or interactive 3D models. The 3D models can be rotated and exploded when the user drags the mouse and can be seen as semi-static. All these formats give the readers the possibility to examine the information in his own pace. Parts of the texts can be re-read or skimmed, images and 3D models can be examined as closely as desired without having to consider the time factor, as with for example video.

Sometimes animations are used in the application to show how certain important processes progress in time, for example to show how the mast is raised. This overcomes the problems of showing the accomplishment of the process, but using a time-based format takes away the control over the pace from the user. In the mast application this has been done in a way to optimise the user control. To allow the user to stop and reflect over the information being shown, the animations are split up into parts showing just one stage of the process at a time. The reader thus has the possibility to watch the different animation bits in any order and as many times as needed, without having to sit through the entire animation. Further the animation clips are played in the standard Windows media player, which also enables the user to go through the animations frame by frame by dragging a slider. This feature is however not described in the help page for ActiView and is therefore probably missed by many.

Users reported they appreciated the possibilities to control the reading and to be able to go into detail where they wanted. They also said that the addition of sound would be good. The ability to watch the animations while hearing a speaker explaining what is seen would be an advantage compared to having to read text while the animations are running, as has to be done now. But if implemented, the ability to turn the sound off would also be valuable to minimise irritation.

5.3 Type of Information

In section 3.6 the purposes and types of different information are discussed. An analysis of the information types suitable for ActiView is important to know when other delivery media are more suitable.

The actual text content of the mast application is the same as in a paper manual describing the mast. The reason the texts were not rewritten is that the production budget did not allow for this. Texts written for paper are often not usable in a hypertext structure since they often rely on linearity. In this application it still works reasonably well since the paper manual texts were written for reference purposes, and reference manuals are not based on linearity.

Reference and user manuals (see section 3.6.1) are not meant to be read from cover to cover, instead the user looks up relevant information when needed. Instruction manuals, on the other hand, are structured to be read from start to end and laid out for the user to learn how to use a system. This also gives us a clue to which kind of information ActiView is suitable for.

ActiView is very suitable for reference and user material since the user then has some previous knowledge about the system and knows what information he is looking for, for example a description on how to repair a certain part or the serial number of a spare part. The navigation structure of ActiView (more on this below) makes it very easy and fast to find the desired information and makes it much easier for the user to do perform his task.

Users requiring instruction material on the other hand have very little previous knowledge about the system and need help to know which information they should read. What they need is linear material with a pre-set order that gives them a basic understanding of the system. An example is the tutorials found in some well designed on-line helps today (for example in Macromedia's products) that give the novice user a first introduction to the programs. After completing these tutorials the user has a basic knowledge of the program and can use the reference and user information in the help systems to learn more about topics that interest him.

Since one of the basic characteristics in ActiView is the break of linearity and that the user should have control over the order, instruction-type information is hard to present in a natural way. The analysed application mainly contains reference and user material but also some instruction material, most notably the instructions on how to raise the mast.

The way this has been solved is to put this information in a separate window accessible via a button in the top right corner of the ActiView window (see figures 2.1 and 2.2). The new window opens on top of the original and contains a long text describing how the mast is set up, and a series of animations next to the text that change automatically as the text is scrolled down. This is a recapitulation back to linearity, scrolling and pacification of the user.

A better solution in my view would be to have an "instructions-mode" accessible through a button similar to the ones changing between the function, repair, maintenance and spare parts modes. By pressing this new instructions button the structure in the navigations tree could change to show the contents of an instructions manual (instead of reflecting the structure of the object), for example chapter 1 Introduction, chapter 2 Safety, etc. where clicking the chapter names would bring up sub-headings etc.

In this way the normal three windows would suffice, the text window showing the texts, the 3D window could show the animations and the user would be given some of the control back over the order by using the navigation tree instead of having to scroll long texts. To make sure that the readers find this information the application could start in instructions mode the first time it is started. The first page could then give an introduction to the application, how to use it and what information that can be found where.

But still, a normal paper manual gives stronger cues to be read from front to end than this proposed addition to the program. It is also much more comfortable to read long texts on paper and therefore the best solution might be to give the user an instructions manual on paper and reference and user manual as an ActiView application.

The lesson learned from the discussion in this and the previous section is that:

It is important to consider the type of information and the purpose of it when designing the medium.

Information technology should used in a way to help the user and give him as much control as possible over the reading, but still give him the support he needs.

5.4 Navigation

As pointed out in section 3.6.2.2 the abstract and non-linear nature of hypertext structures makes it easy to get lost. With paper based information this is seldom the case since this usually is a linear structure with a number of cues to show where we are in the material. We might for example remember the page number, that the information was right after the section describing the safety aspects, or that the information we are looking for was in the red binder, on a right page towards the end (which we realise by feeling that there are more pages in the left hand than in the right).

Since ActiView is based on a hypermedia structure it is thus important to provide the user with other cues that show the current position in the material and how it relates to the other parts. The user should also be able to navigate around the information without effort, in other words by using experiential instead of reflective thinking.

The answer to these demands is the navigation tree in the lower left window. It works in a way similar to Windows Explorer and is described in section 2.1. The tree structure is a good example of how the users' existing mental models can be used to simplify the learning of a new program.

The users reported that they got a good overview of the information and their current position in it. They also found the tree easy to use since they were familiar with Windows Explorer, and that information retrieval was much faster and easier than using paper manuals.

The hierarchical structure is also a great help to the user when encoding the information into long-term memory. The user does not have to make this structure himself but can adopt a logical and ready-made hierarchy.

The learning from this section is that:

A well working, unambiguous navigation system that does not require the readers to use reflective thinking is crucial.

5.5 Information Density

The function of the navigation tree structure is twofold since it also gives the user an overview of the structure of the object being described. Letting the same structure serve two information purposes is a good example of what Edward Tufte (1994, 1997) calls high-density information. The higher the information density the better he claims, referring to the fact that the user's control over the way he or she interacts with and interprets the information increases with density.

Tufte points to cartography as an example of an area where information density is both important and often very high.

Since the resolution on computer screens at present is quite low, approximately 75 dots per inch compared to at least 300 dots per inch for printed material, the information can never reach the same density on a screen as on a printed page if it is just statically displayed. But by letting the information be dynamic and inter-active, the same area can be used to display different views of the information and serve different purposes, which increases the density.

The twofold function of the navigation tree is one example of increase in informa-tion density. The possibility to expand and contract the different parts of the tree, and only show the parts interesting to the reader, is another. The third important increase in information density is through the interactive 3D-models. Here the user can rotate the objects, take them apart and make searches and thus gets a lot of information from a small area on the screen.

The keyword when considering information density is user control. In the examples above the user has full control over both the pace and order in which he accesses the information. Showing the user an animation is not high information density, even though a lot of different information is displayed on a small area, since the user is not in control.

Another way of increasing the information density, Tufte says (*ibid*), is by putting the information in different layers, as is done to a great extent in for example maps. The layering technique has in a way been used in ActiView to separate the information about function, repairs, maintenance and spare parts. The four buttons on the top of the screen makes switching between these "layers" easy, and is an effective way of hiding information but yet having it close at hand.

As it is now information of different types is hidden, another similar possibility would be to have filters hiding all information for different *parts* of the object. For example a mechanic serving a car might want a 10 000 km-filter that, when activated, only shows the parts that need attention. A 50 000 km-filter would then show other parts when activated and so on.

A similar possibility would be to have a button controlling the level of detail in the text, say an expert/novice switch determining the extent of the text. This would further increase the personalisation of the reading.

The thing to remember from this section is thus:

Well-designed information has high information density.

5.6 Presentation Formats

Section 3.6.2 presented the characteristics of a number of different presentation formats. Here the way these formats have been used in ActiView and the implications of this will be discussed with a focus on the process of creating knowledge.

5.6.1 3D-Visualisations

The use of interactive 3D is one of the major strengths of ActiView. The image quality and the level of detail are high enough to make the connections between the information and the real world both strong and natural. The user can rotate the objects to examine them from different angles and even dismantle them to see how they fit together. These actions make the creation of mental models much easier for the user compared to using paper-based information.

Using a visual format also helps the encoding of the information into long-term memory as discussed in section 3.4.4. Another advantage with the 3D-visualisations is that irrelevant details are left out and important details are automatically highlighted, making it easier for the reader to focus their attention.

The right format for the information is of course important. When describing objects, three dimensional models means the reader uses experiential thinking when interpreting the image and can use his cognitive abilities to reflect over how to complete necessary tasks instead of having to use reflective thinking in the interpretation stage as well, which would be the case if the object was described in a text instead.

Users reported that using ActiView gave them a clear overview of the mast and its operation even before seeing it in real life. They also stated that it was a very time-efficient way of getting the information, indicating that the building of a mental model of the mast was fast and easy using ActiView.

The direct navigation in the 3D-objects was appreciated and made the interaction fast, users reported. Having the names of the parts shown when pointing at them was also very helpful for learning the terminology of the mast.

5.6.2 Animations

In the mast application there are a number of 3D-animations. As described above the user still has good control over the order and pace of what is shown even though it is a time-based format. The animations are designed to show just the relevant aspects and are stripped of unnecessary detail which makes them much more effective than, for example, video clips. In the mast application all animations show the important objects in detail and the rest, for example persons and the ground, are highly simplified.

The animations are used with restriction, which is applaudable. It is easy to fall for the temptation of producing flashy 3D animations more for the sake of impressing than informing. This is the danger of overusing the experiential cognition that Donald Norman discusses (1993). But the animations in the mast application are used only to describe processes where other formats would be insufficient.

5.6.3 Images

There are a number of photos in the application that have been reused for economical reasons from the previous paper manual describing the mast. The photos are black and white, and of rather low quality, and not very pleasing to the eye.

The actual content of the would probably be better communicated with a illustration where the unnecessary details were left out. As it is now, there is a lot of unnecessary data in the images.

5.6.4 Texts

The texts in ActiView are all hypertexts, which makes cross-references and connections in the material easily accessible to the user, and further strengthens the possibilities for a personalised reading.

The texts are all task oriented and the information is strategic in its nature (see section 3.6.1), i.e. the readers are told what to do in a direct and natural manner. The texts are also well integrated with the content in the 3D window and often links in the text cause parts of the 3D models to highlight.

The evaluated application did not have a text search-function, which of course is a drawback. Later versions however, will have this feature. Having a good search function is very important, especially when the amount of information is large.

From this section we learn that:

Visualising information is an effective way of helping the user build mental models

5.7 Memory

The role of memory in communication was discussed in section 3.4.4. The load put on short-term memory in the communication process affects the efficiency greatly. The more information the user can keep "in the world", as Donald Norman expresses it (1993), the more of the cognitive abilities can be focused on the central tasks at hand. Information in the world can for example be notes on a piece of paper, or a timetable. The important thing is that the information in the world is easy to access the instant it is needed. The grocery list is useless if it is still on the kitchen table when you enter the store.

With ActiView the user's short-term memory is helped a lot. When building mental models, comparing and contrasting information, etc. the navigation structure and the top row buttons lets the user keep most of the information in the world and at close range. Instead of memorising the necessary information the user can concentrate on the communication process and create his knowledge, assured that the needed information is close at hand.

Presently the number and types of windows in ActiView are fixed. As it is now the information is shown in one 3D-window and one text/image-window. If the user instead could decide what type of information these windows would show, comparisons between two 3D-objects or two pieces of text would be possible. One should also consider the option of having the user decide how many different windows he or she wants to see. A person having a 21" monitor might want to see (and has the space) to see three 3D-windows and two text-windows instead of the standard ones.

Giving the user the opportunity to choose the layout of the information on the screen in this way means the user has control over what and how much information he wishes to have direct access to "in the world". This in turn facilitates comparisons, discovery, seeing of connections, etc. and is thus very helpful when creating mental models.

When the information is on paper the reader can decide what information is displayed by spreading the pages on a large desk or on the floor. The relatively small screens available on today's computers do not allow such actions and therefore all the possibilities to control what is shown are welcome.

The general conclusion from this section is:

If information is close at hand in the world the reader does not have to load his short-term memory, and can focus his cognitive power on understanding rather than memorising.

5.8 Screen vs. Paper

Presently printouts cannot be made from ActiView, but it would be a welcome addition for a number of reasons:

First, the resolution on printed paper is much better than on a screen. Making high-quality printouts would make it easier to study detailed blueprints, photos, etc.

Secondly, the size of a computer screen, especially on portable computers, is very limited. Spreading blueprints, notes, diagrams, etc. on a desk gives the reader good possibilities to compare and draw conclusions on all the information before him. When the same information is presented on a computer screen, the user has to switch a number of windows on and off, click to zoom in and out, etc. Printouts can therefore be valuable to take some of the information off the screen and make it easier to get an overview. Some documents are also too large to be displayed properly on a screen, for example larger blueprints. If it was possible to print them out on a plotter when needed, it would be helpful.

Third, it might not be possible to access a computer where the information is needed. The information might for example be needed under rough conditions such as rain, in dusty environments, etc. where a computer cannot be used. Another example might be, as in the studied case, that the only computer available is stationary and the information is needed elsewhere. A printout would probably have helped the soldiers when they later tried to raise the mast themselves.

Fourth, sometimes only a small, and maybe condensed, part of the information is needed as a reminder. For example a list telling a mechanic which steps should be done, and in what order, when servicing a car. In these situations the user will probably not appreciate having to carry a laptop around when a piece of paper would do.

The risk with printouts, and the reason they have not yet been implemented, is that people might save them and refer to them the next time they need the same information. This way they will be unaware of updates in the information.

The lesson here is:

Printed paper has certain advantages and a printout function is therefore good to have.

5.9 Usability

When considering the implementation of new functions, these have to be weighted against how much harder it would be for a new user to use the program. The philosophy from the developers' side has been to make ActiView as easy as possible to use and not to crowd it with functions. For example the entire user manual for ActiView is fitted within one screen (without scrolling) and the user only has to use the mouse to interact with the program.

This is an admirable, and unusual philosophy, when comparing with other software developers that seem to take pride in packing as many functions as possible into the programs, often requiring obscure combinations of key presses or searching in endless menus to perform certain tasks.

A solution to the problem of keeping the simplicity of ActiView, but still being able to implement new functions, could be to let the users to log on as normal or expert users when starting the program, and hide these extra functions from the normal users (as is already done on some websites). This way the user would not only read the information in a personalised way, but also use personalised functions to process the information.

The developers of ActiView have also followed all Windows standards in terms of look, feel and functions of the interface. Buttons, scrollbars, mouse clicking, etc. all work the way one would expect if familiar with the standard Windows interface. By building on the users existing mental models of Windows programs in this way, the users can spend their energy on the actual content rather than first having to reflect over how the program works. This was appreciated by the users, who said they felt at home with the program more or less immediately.

The conclusion here can be summed up in Mies van der Rohes classic motto:

"Less is more"

5.10 Summary

ActiView has a sphere of actions that makes it a very useful medium for communicating technical information, especially user and reference material. The different presentation formats have been used in a good way. The used formats give the reader the control over both the pace, order and content of the reading, which gives them the possibilities to use reflective cognition and supports their own creation of knowledge.

The interactive 3D visualisations let the readers use experiential cognition for the interpretation of the object structure, and their reflective abilities for the deeper understanding of how the system works. From a semiotics perspective the signs and codes are much easier to understand when using 3D than text. Instead of using words (one form of signs) to describe an object, the reader directly sees how the described object looks in an image (another form of sign) that has a much closer and more natural connection (code) to the real object.

The building of mental models is greatly facilitated by the 3D visualisations. The direct and natural connection to the real objects makes this process very efficient. Letting the users virtually handle the objects gives them a easy, fast and direct way to experience them, see how they fit together, reflect over their working, etc.,

without having to go through the trouble of taking the real object apart, which might be practically impossible. One user said that he learned much more when sitting in a warm class room using ActiView than standing outdoors in the cold and rain watching the real mast and focusing on keeping his hands and feet warm.

The interactive visualisations together with the non-linearity of the hypermedia structure means that the individual preferences can direct the reading instead of the authors' preferences. This gives the program the role of a supportive learning catalyst rather than an authoritative teacher and makes it more motivating and rewarding to use. The users all said they felt motivated by being in control and enjoyed using the program.

They also said they found the program easy to use and the information easy to find. The navigation tree works very well and shows the user his position in the material clearly. Its close ties to Windows Explorer makes it easy for users familiar with Windows to directly understand the navigation system.

The well working navigation system also means that the readers can keep most of the information they need in the world instead of memorising it. This means they can use their short-term memory for the most relevant facts and concentrate their reflective thinking on the real tasks at hand. The hierarchical structure also helps the readers encode the information into long-term memory, as does the emphasis on visual information.

Based on this evaluation the following suggestions are given:

- Add a printout function
- Add a speaker voice to the animations, but make it possible to switch the sound off.
- Add the possibility for experienced users to see more windows.

5.11 Evaluation of the Theoretical Framework

The purpose of this paper was partly to find usable theories from communication studies and some other areas and to develop a theoretical framework that can be used when designing and evaluating technical communication through digital media. An evaluation of this framework is of course of interest to know if it is usable in other similar situations.

The base of the framework was compiled before the evaluation of ActiView started, and then continuously revised during the evaluation process. The framework has worked well for me during this evaluation and I think it could be usable for other similar situations. The theories that do not have their origins in communication science gave me new perspectives on the process of communication and many new valuable insights. The mix of theories has let me see some of the deeper lying aspects of technical communication. For example by mixing the theories of experiential and reflective thinking, uses and gratifications, and semiotics it became clear why the users were so fond of the 3D visualisations.

Some hard-core Media and Communication Studies advocates might claim this paper lies outside the realms of the area. To this critique I would like to answer that I have had a strong focus on communication at all times, but borrowed tools from other disciplines to strengthen the understanding, not to shift the focus. A little interdisciplinary peeking never hurt anyone.

5.12 Further Studies

As said in section 4, this is to be seen as a first explorative evaluation. Further studies are recommended, especially since the users interviewed for this paper hardly can be seen as experienced. When new applications based on ActiView have been developed and used for a while, new interviews with "real" users should be made.

Comparisons between different types of users and applications of ActiView, for example mechanics and electric engineers, could also give interesting information.

Another interesting and important aspect that has not been covered in this paper is the effects on an organisational level that can be seen when switching to digital technical information. In this evaluation the fact that there were no computers available for the users is one such organisational effect; for the CD:s to be usable substantial investments have to be made. Other effects might be changes in how the information is produced, stored, updated, distributed, etc. within the organisations. How does this affect the total communication process and the involved stakeholders? Are there any interests against the changes?

In this evaluation I have used a communications perspective and used theories describing communication between humans via media. Another perspective that could give interesting results is the media perspective. By using the medium (ActiView) as the starting point instead of the human mind insights in how we might be affected by the new ways of communicating could be learned. Does it change the way we think and perceive problems? With these questions in mind this section will be rounded off with a quote from media-guru Marshall McLuhan:

"First we shape our tools, then our tools shape us."

6. Conclusions

In this paper I have discussed technical communication through digital media. The ever increasing number of complex technical systems requires more and more information for people to be able to use them properly. With the development of information technology (or rather data technology if the definitions in section 3.4.1 are used), technical information through digital media have become very popular.

The purpose of this paper has been to investigate this new form of technical communication. This has been done in two steps, first by building a theoretical framework that can be used to bring some understanding into how the new possibilities offered are best utilised, and second this framework has been used to evaluate a new program, ActiView, which is especially designed to deliver technical information.

The theoretical framework is based on a communications perspective and the uses and gratifications approach. This is completed with some helpful theories from other disciplines, for example psychology and design studies, to form the view of technical communication used in the evaluation. The central theme is that reader is seen as an active agent creating his own knowledge in a process where the building of mental models is central. For the user to be able to complete this process he must be able to perform some (both cognitive and physical) actions, for example make comparisons, see connections, have access to a computer, etc. The interesting thing to consider when designing or evaluating technical information is thus which actions that are possible, required, etc., i.e. the sphere of actions.

In the evaluation the sphere of actions of ActiView was investigated. The program was developed by AeroTech Telub Information & Media AB in Växjö, Sweden and is designed to utilise the new possibilities of digital technology, especially 3D visualisations, to make the process of technical communication more efficient.

Since creation of knowledge is a highly subjective process, qualitative method was used for the evaluation. Based on themes that emerged during the work with the theory a heuristic walkthrough of the program and interviews with the developers and users were conducted. The main problem with the evaluation was the lack of real users. Because the program is so new, only one application had been made when my work started and it had not really been used before the evaluation started. The information gained from these interviews are nevertheless considered to be quite reliable since they show the same results as from the other interviews and the walkthrough.

The conclusions of the evaluation are that the use of interactive 3D is a great advantage to the readers since it allows them to easily create mental models of the objects being described. The hypermedia structure gives the reader control over both the order and the pace of the reading, and lets him personalise the reading to fit personal needs and interests. Together with the well working navigation tree, this further helps the reader creating his own knowledge.

ActiView is very suitable for reference and user information, but not so much for instruction manual information because this type of information requires linearity and a set order, which are things ActiView tries to break free from.

The addition of a printout function, speaker voices to the animations, and the possibility for the reader to decide how many windows and of which type that are displayed are recommended.

The theoretical framework was useful in the evaluation and the theories borrowed from other disciplines gave me many new insights into the process of technical communication. The following general conclusions or guidelines were reached from the work in this paper:

- *The entire sphere of actions must be considered when designing information.*
- *It is important to consider the type of information and the purpose of it when designing the medium.*
- *Information technology should used in a way to help the user and give him as much control as possible over the reading, but still give him the support he needs.*
- *A well working, unambiguous navigation system that does not require the readers to use reflective thinking is crucial.*
- *Well-designed information has high information density.*
- *Visualising information is an effective way of helping the user build mental models.*
- *If information is close at hand in the world the reader does not have to load his short-term memory, and can focus his cognitive power on understanding rather than memorising.*
- *Printed paper has certain advantages and a printout function might therefore be good to have.*
- *Less is often more.*

Further investigations and evaluations of ActiView are also recommended, especially interviews with long-term users of the program (when they emerge). Evaluations of how the use of digital technical information affects organisational patterns and how the use of the new media affect the human cognition would also be interesting.

Digital technical information is definitely here to stay. The benefits in terms of easy distribution, low production costs, easy updating, etc. makes it very attractive to producers. But I hope the focus will shift from these benefits to a user-centred view where the benefits for the reader and the ways he can be helped to create knowledge are at the centre. With ActiView I think an important and big step in the right direction has been taken.

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Appendix A – Themes and questions

What is the view on the user, active reader or passive receiver?

Have the sign, code, and culture aspects been considered, i.e. how have for example conventions and terminology been used, how have media choices been made, etc.?

Does the program facilitate the readers creation of knowledge, and if so how?

Can the reader personalise the reading or is there just one fixed way of accessing the information?

What is the role of the program, teacher or "learning catalyst"?

Does ActiView deliver data or information?

How are the users mental models formed? What is done to help them in the process?

Are individual differences catered for?

Is it rewarding and motivating to use the program?

How is the navigation structure?

Does ActiView support reflective and experiential thinking?

If it does, how?

How heavy a load is put on the users short-term memory?

Is information in the world easily accessible or is memorising required?

Is the creation of meaning and knowledge supported by allowing the user to easily make comparisons, see consequences, connections, etc.?

Does ActiView support the users organisation of the information?

Is visual information used?

The evaluation will be based on the view of the active reader, as presented in the Uses and Gratification approach.

Is the information presented in a task-oriented manner?

Is the purpose with the information clear?

Is the information strategic or expressive?

Is the information type unambiguous?

Have the different formats been used in a way that supports the creation of knowledge?

If so, how?

What sphere of actions does ActiView have?

Appendix B – Interview guide, developers

Background data
        name, occupation, relation to ActiView

Background of ActiView
        Could you describe the background of ActiView?
        Was it a new idea or an adoption of a previous one?
        How would you describe the philosophy behind ActiView?
        How does AV compare with other products you have made?
        Are there similar programs from other companies?
        How would you describe the possible future and further development of AV? Other similar products?

Differences between information from paper manuals and ActiView
        Which are the main purposes for using technical information?
        Could you describe how paper manuals are commonly used?
        Could you describe how you would use ActiView?
        In which ways can information be distributed with AV that is not possible with other media?
        What limitations are there to AV?

Follow-up questions on:
        Types of information (service, user, instruction, reference)
        How does this affect the program? Structure?
        Differences
        Individualising information
        Ways of accessing information
        Ways of thinking about technical systems
        Good/bad things with paper manuals
        Good/bad things with ActiView
        Updating information, by users?
        Volume of information
        Having to use a computer to access the information
        Screen vs. paper

Testing
        Usability testing, if, when, how, results?
        Reactions from users?

Different information formats
        What is behind the choice of presentation formats? Strategies?
        Why three windows? Other layouts? Multiple windows?
        Ways of reading
        Ways of accessing information
        Having to use a computer to access the information
        3D models:
        understanding
        problem solving and thinking
        Photos
        No video, why?
        Hypertext
        Linearity
        How must the information be modified to suit AV?

Cognition
        Ways of accessing information
        Ways of thinking about technical systems
        understanding

Navigating the information, usability and memory
      Computer illiteracy (Age)
      Help function/manual/training
      Navigation
      Tree structure, why? Other possibilities?
      Suitable structuring of the information?
      Instructional and introductional information, how should it be communicated?
      Level of detail?
      Interface issues
      Left out functions?
      Search function?
      Notes by the users?
      Connecting users/ Internet?

Appendix C – Interview guide, semi-user

Background data
 name, occupation, relation to ActiView

Differences between information from paper manuals and ActiView
 Which are the main purposes for using technical information in the
 military?
 Could you describe how paper manuals are commonly used in the
 military?
 Could you describe how you would use ActiView for the same purposes?

Follow-up questions on:
 Differences
 Ways of accessing information
 Ways of thinking about technical systems
 Good/bad things with paper manuals
 Good/bad things with ActiView
 Handling blueprints
 Updating information
 Volume of information
 Having to use a computer to access the information
 Using computers under rough conditions
 Screen vs. paper

Different information formats
 Ways of reading
 Ways of accessing information
 Handling blueprints
 Having to use a computer to access the information
 Describing objects vs. processes
 3D models:
 visualisation
 sense of presence
 understanding
 problem solving and thinking
 Comparisons with photos, video
 Hypertext
 Linearity
 Hypermedia:
 Pointing and clicking in the 3D models

Cognition
 Ways of accessing information
 Ways of thinking about technical systems
 understanding

Navigating the information, usability and memory
 Navigation
 Tree structure
 Suitable structuring of the information?
 Easy to use the program?
 Computer illiteracy (Age)
 Interface issues: easy to learn/understand
 Help function/manual
 Multiple windows
 Notes

Appendix D – Interview guide, users

Differences between information from paper manuals and ActiView
      Differences
      Ways of accessing information
      Good/bad things with ActiView
      Screen vs. paper

Different information formats
      Ways of reading
      Having to use a computer to access the information
      3D models:
      visualisation
      sense of presence
      understanding
      problem solving and thinking
      Comparisons with photos, video
      Hypertext
      Linearity
      Hypermedia:
      Pointing and clicking in the 3D models

Cognition
      Ways of accessing information
      Ways of thinking about technical systems
      understanding

Navigating the information, usability and memory
      Navigation
      Tree structure
      Suitable structuring of the information?
      Easy to use the program?
      Interface issues: easy to learn/understand