On the Improvement of Strategic Investment Decisions and Active Decision Support Systems

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Abstract

Strategic investment decisions (SID’s) are more easily understood and controlled than most of the other activities undertaken within the framework of strategic management. Hyperknowledge support systems have been used as problem solving and decision support environments for strategic management and for strategic decision making in a number of industries in recent years. It appears that the logic of a SID is complex enough for a decision maker to benefit from the use of a hyperknowledge environment, and that a hyperknowledge support system could help a management team to control the problems with deciding, launching and following up on strategic investment projects.

1. Introduction

We have found that recent developments in knowledge-based systems technology offer an effective approach to building management support systems for strategic management (cf. Carlsson and Walden [4-6, 15-17]). The scope of strategic management is broad and the issues involved are ambitious, ambiguous and non-routine. The executives and managers involved should have the ability to break away from the cognitive constraints of their everyday activities and a capability to understand the context in which the company is operating. Also, their future strategic context should be outlined and understood, which requires a capability to conceptualize key strategic issues, their corresponding action programs and their expected consequences.

In strategic management it is often necessary to make difficult and important decisions on the basis of imprecise information and incomplete knowledge. In order to cope with the complexities involved the managers need to reduce a context of almost infinite proportions to a manageable personal conceptual framework. Knowledge-based systems have the potential to be very useful in this respect; they can be used to support the building and enhancement of competitive advantages and to help solving complex strategic problems (cf. Mockler [13]). We have found supporting evidence of this in a number of projects (in 1993-98), in which we have implemented knowledge-based support systems in the forest products, the insurance, the telecommunications, the alcoholic beverage, the plastic pipe and the forest machinery industries (cf. [9], [15-17]).

Thus, we will assume that there is a reasonable basis for assuming that knowledge-based support systems will be useful tools for handling strategic management problems.

Butler et al [2] has studied strategic investment decisions in a wide range of UK and international companies. Their perspective was one of organizational decision-making theory, which is why they found a number of factors relating to judgment, negotiation and inspiration to be of importance, i.e. more or less qualitative factors. In structured interviews with senior managers the most important attributes for judging the relevance and potential effectiveness of investments were, nevertheless, quite traditional and in the following order: (i) fit with corporate plan, (ii) (expected) internal rate of return, (iii) payback period, (iv) worst case scenarios for internal rate of return and (v) best case scenarios for internal rate of return. Their study focused on important investments, which probably did not have quite the magnitude we are considering in our case, but the attributes they found are still relevant.

The assessment of the relative merits of investment proposals is typically a decision problem built around multiple criteria (cf. Carlsson [3]). If we look at the attributes Butler et al identified from this perspective, we can find conflicts between (ii) and (iii), as well as between (iv) and (v); there would probably be a positive mutual support between (i) and (ii), or (i) and (iii); a corporate plan would emphasize either a high IRR, or a short payback period. Thus, a possible support system could in this case simply be an imple-
mentation of some useful multiple criteria decision making models.

As we will see in our giga-investment case, this is rather far from what turned out to be the actual needs of decision support.

One of the early ideals of the DSS was to find a way for human decision makers, and computer-based support systems, to tackle complex problems in interaction, in such a way that the resulting synergy produces new insight. There is not much material in the literature to suggest that this has happened, even if we would be satisfied with only a few cases. One of the reasons is that senior managers are normally not active DSS users. Instead, the DSS is used by those who are hired to get answers for the decision makers. These are, in most cases, junior analysts and staff who do not have the knowledge, experience and overview to fully utilize the potential of a DSS. Thus, the ideal use of the DSS has not become standard.

When designing a DSS it is not always remembered that it is counter-productive to give executives tools to carry out tasks they normally do not perform at all. Unless there is a very good reason for them to use their working time on new tasks, which involve the use of a DSS, they cannot take the time out of their normal (overloaded) schedule.

There is another way. SID’s are definitely among the tasks of senior managers and they have planned and budgeted time for working on them. A DSS can be helpful if it can be shown to have a few important, supportive properties: it should be useful for (i) getting a quick overview and intuitive understanding of the domain (= to provide explanations of key factors and their relationships); for (ii) helping with a comprehensive problem formulation (= to determine assumptions and to simplify reality); for (iii) relating a problem to relevant and effective problem solving methods (= to assist with proper problem-solver interaction, to advise on proper procedures), and for (iv) interpreting and explaining results. This is quite close to Mili’s description of an active DSS (similarities are indicated with the ≈ sign, cf. Mili [12]). These properties are, again, quite easy to describe and a bit harder to build and implement for actual use.

There are a few more, interesting approaches to the active DSS. An active DSS should “take the initiative without getting specific orders” and should “respond to nonstandard requests and commands” (cf. Manheim [11]). An active DSS could be a conversational, agent-based approach to DSS in order to “enhance creativity in collaborative human-computer problem solving” (cf. Angehrn [1]). Clearly, these approaches show features we would like to have in a support system for senior managers.

Our own approach has been built around hyperknowledge, which is a cognitive metaphor introduced by Chang et al [10].

We have built and implemented hyperknowledge support systems, mainly for strategic management, since 1993. The first industry tackled was the forest products industry (the Woodstrat system), but since then hyperknowledge support systems have also been developed and implemented in the telecommunications, the plastic pipe, the insurance, the forest machinery and the alcoholic beverage industries. The approach we have used has been fairly straightforward, as is demonstrated in fig. 1.

![Figure 1. Hyperknowledge support environment for strategic management.](image-url)

A systems user can start with any module of the system and work his way through it by going from module to module. Let’s start with the market position: (i) the demand is a function of (ii) market, (iii) price and (iv) volume, which will decide the coming demand; (v) the critical success factors (CSF) will influence the demand (there is an interaction between the two modules) and also decide (vi) market share, (vii) our competitive position and (viii) the competitive position of our competitors. A similar network of interactions is played out over all the modules, which allows us to work out interactions among the concepts.

There are various modules covering key aspects of strategic management, which have been implemented with Visual Basic 5.0 and Java in a Windows NT 4.0 environment. The user interface is designed as a user-friendly platform for senior managers, which is supported with a data warehouse built in Oracle 8.0 and with Java-implemented links to external data sources. The use of external data supports the follow up and continuous assessment of the macroeconomic environment, key industrial changes and developments, competitors and their activities and significant changes in key market characteristics. The use of external data sources is supported with software agents.
The hyperknowledge support environment (= Woodstrat) shown in fig. 1 has most of the characteristics described in the Chang et al [10] paper.

There are still some unresolved problems both with developing support systems for strategic management and with the conceptual richness of hyperknowledge. We are looking for ways to develop the hyperknowledge environment to combine quantitative with qualitative assessments in analysis models. We also want to combine empirical hard facts with knowledge-based estimates and proposals in such a way that we can find a synthesis and new knowledge. We would like to combine interactive and (more or less) intuitive problem solving methods, building on learning processes, with numerical optimization methods, which would help us to tackle complex problems, in which part of the complexity is due to imprecise and incomplete information and knowledge (cf. [7]). This is still work to be done, which is being done in the IMAGINE21 research program, and some elements of which will be shown and discussed in this paper, in section 4.

The rest of this paper is structured as follows. Section 2 is a description of the corporate context and the gigabit realm. Section 3 outlines principles for decision support in SID’s, and section 4 describes some new principles for hyperknowledge, which are useful for building SID support systems. Section 5 gives a summary and conclusions on major findings.


The Metsä-Serla Group is a major Finnish forest products group, developing, manufacturing and marketing a wide range of high-quality printing papers, paperboards, chemical pulp and converted products on the European market. The turnover for 1997 was FIM 19.182 billion. Exports from Finland and sales by foreign subsidiaries represented 85 percent of the turnover. Metsä-Serla’s basic strategy is to expand and strengthen its market positions in carefully selected core businesses, which are printing papers and paperboard. In the Annual Report for 1997 CEO Jorma Vaajoki quite clearly outlines Metsä-Serla’s strategy in six points: (i) focus on key businesses, (ii) strengthening market positions, (iii) improving competitiveness and efficiency, (iv) focus on customer service locally and globally, (v) creating added value for customers, and (vi) improving the financial position of the Group. Metsä-Serla is continuously assessing its prospects for expansion and is committed to a strict and constantly enhanced environmental policy. This is a proven way to secure long term competitive ability in the forest industry. The Metsä-Serla Group’s profit after financial items was FIM 1.008 billion in 1997; the number of employees was approximately 14,000, of whom more than 44 % worked outside Finland.

One of the Group’s key development projects has been the construction of the new fine paper mill in Kirkniemi, Finland. The project started in the beginning of 1995 and the new fine paper machine went into production in August 1996; the new mill is one of the largest in the world with a capacity of 350 000 t/a, and a total investment cost of FIM 2.87 billion. The Group’s sales network will be handling almost 4 million t/a of paper and paperboard after the new mill has been added – thus, even if the development project was significant, it did not dominate the Group’s operations. The Annual Report for 1997 shows, however, that the new paper mill is the most productive and the most profitable in the Group.

Extensive market research, carried out by both the Group’s own market research department, as well as by external consultants, showed that there were market opportunities for two different paper qualities:

- LWC and MWC paper qualities, with mechanical pulp included, and
- WFC paper qualities.

A closer look at potential market segments, which appeared to offer a sustainable growth at good product prices, revealed that there was a particular demand for a thin (70-115 g/m²) printing paper with good opacity characteristics. There was not much production capacity on offer for this particular paper quality, even on a global scale, as it obviously is rather difficult to produce a thin paper with good opacity characteristics. The Metsä-Serla R&D department had over the years experimented with a process in which mechanical fibers of aspen combined with tcf-based softwood pulp fibers was a key ingredient, and this process was proved to answer to the technical requirements.

Two other key factors were advanced coating know how, which had been developed in cooperation with Valmet, the producer of paper and board machines, and the pigmentation process.

The thin printing paper was positioned for the HSWO segment (heat-set offset papers for printing from reels) in which it offers its users about 20% more printing surface per ton than competing products. In strategic management terms, the new product had a significant impact in the users’ value chains offering savings in the purchase, the storing and the transportation of printing paper. The competitors did not have any clearly matching products, and will face a 3-5 year catching up struggle if they decide to enter the competition, and as the markets for electronic printing papers (= the HSWO) are taking off, Metsä-Serla is well positioned with its new paper product.

The new paper machine is 9000 mm wide, with a process speed of 1600 m/min combined with the coating machine’s...
1800 m/min. It was built by Valmet and is the most productive and cost effective of its kind in the world. The paper quality can be guaranteed to be consistently high as the production process is constantly monitored with advanced technology, including (among other control systems) several fuzzy logic control systems to make sure that the paste-like substance rushing past at 1800 m/min over a 9000 mm wide area in a 500 m long paper machine is kept to preset quality standards. This gives Metsä-Serla an edge in the fierce competition of the fine paper markets.

Told after the fact, this giga-investment project appears to have been a quick and straight forward process: (1) decide that there is a need for restructuring an existing paper mill, (2) find growing and profitable market segments for an expansion, (3) invent a new paper quality for these segments, (4) build the paper machine, (5) restructure and expand the paper mill, (6) get everything ready well ahead of schedule, (7) start up the new paper machine, and (8) make significant profits from the new paper products positioned in the discovered market segments. Ossi Kokkonen, who was responsible for the project, wants to point out that the planning, problem solving and decision making that went into the project was not at all this simple, well-informed, rational and straight forward. He found that a support system of the kind we had implemented as a prototype will (i) organize data and information, which is fragmented on many data sources, and will (ii) harmonize decision making as everybody has the same facts available.

In the following, we will work through his ideas about an ideal support system for giga-investments of the type we have described in this section.


In 1992-1994 we had developed and implemented a support system in nine strategic business units in the Metsä-Serla corporation (the Woodstrat system, cf. Walden, Kokkonen and Carlsson [5], [8], [10]). From experiences gained during the development process, it was not unexpected that the same principles we had used for the Woodstrat system also got used for the SID support system. Here we will not go into details with this system (the material is in Walden, Carlsson and Kokkonen [17]), but present a synthesis of the experience we gained and formulate this as key principles for the building of a SID support system.

Ossi Kokkonen has found that the real world structure of the SID process differs somewhat from the principles described in the literature on SID’s.

The process starts with a mapping of investment alternatives as a brainstorming process in the project team on the basis of the corporate guidelines. As soon as there is a consensus on the first set of alternatives, this set is run through a first evaluation, which should eliminate those alternatives, which will fail on one - or more – of the corporate guidelines. This is rather quickly followed by a decision, which is then justified (i) with data from external and internal sources on markets and competition, (ii) with systematic studies on productivity and profitability, and (iii) with assessments of customer value and product life cycles.

![Figure 2. SID’s – the real world process.](image)

Then it seems justified to propose that a SID support system should be built to support this sequence of processes rather than some ideal sequence, which will not be used anyway.

![Figure 3. The first SID phase: Mapping of investment alternatives.](image)

In the first SID phase the guidelines set by the corporate management, market knowledge (tacit or clearly formu-
lated), knowledge about the competition and assessments of the development of production technology are used to build an investor strategy (= corporate strategy), which can be either a full-scale document or a few points of the minutes of the first meeting of the SID project team. If the SID is built on a document, there normally are studies on (i) the market position the SBU (strategic business unit) will have, with and without the SID; (ii) the competitive position, which will show how strong the SBU will be relative to its competitors, with and without the SID; and (iii) an assessment of the productivity of the technology used by the SBU, with and without the SID.

Software modules for assessments of market position, competitive position and productivity were implemented already in the Woodstrat, and this technology is both useful and motivated for SID’s of the giga-investment type. The support system would be used to screen and initially test possible investment alternatives.

A more critical factor is to obtain enough facts about the environment and to get good estimates of prevailing trends in product demand and prices. We need material on the relative strengths of competitors and their prevailing strategies in choices of products and markets. We need to be able to follow mergers and acquisitions, and to assess what their impacts are on market positions, on logistical alliances, on production technology and on R & D. We also need to find good benchmarks on the productivity of the existing production capacity in the market, and to find some facts on the cost effectiveness of the operations. The cost effectiveness is decided by the cost development of production factors, and we need to get some factual databases on these. Then we have all the odds and ends, which form so-called “weak signals” of changes already starting or about to start, and which can cause significant changes in the markets or among groups of key customers. This material is scattered on many different data sources, which are updated with regular or irregular intervals. There are now some feasible technological solutions for handling this type of material, and we will work through them in section 4.

**Figure 4. The second SID phase: First evaluation of investment alternatives.**

The SID process quite quickly focuses on 2-3 alternatives. Ideally, the evaluation of alternatives should run through many more alternatives but the project teams working on even giga-investments seem always to be pressed for time.

As the focus is narrowed the need for data, information and knowledge becomes much more concentrated and more precise, and the role of a SID support system moves from the support of scanning and screening tasks to the support of (mostly) numerical evaluation tasks.

The investment alternatives, which are being evaluated, have passed the test of fulfilling the investor strategy. Still, there may be some need for rating them on how well they fulfill the strategy, which can be done with AHP or VISA, or some similar tool for combining qualitative and quantitative assessments (cf. [6]). A SID support system should provide a platform for using this type of tools with the data provided from its modules.

The products and services to be produced by the SID need to be evaluated in detail. We should be able to trace trends in demand and prices, as well as how well the products and services may succeed in comparison with similar offers by the competition. This requires a fairly detailed database and numerical tools for forecasting and competitive analysis. The SID support system should offer a platform for both, which is not tough in a technological sense, as a normal Windows platform will do.

The markets on which the SID products and services will be placed should be traced and evaluated. We need to get material on what markets there are in which countries, who are the (industrial) customers we are going to work with and what are their demand and business potential. We should be able to find and define market segments with specific characteristics, which we should be able to identify and pair off with either innovations produced by the SID products and services, or with core competencies found with the SBU. We should also be able to trace the (industrial) customers markets, as the first signals on growing or declining demand will come from those markets. We need to get some benchmarks on what prices we can charge and what is the overall cost competitiveness of the customers. The SID support system needs to offer possibilities for quick ad hoc calculations and graphics, which could be based on getting data through “drill down” capabilities in a data warehouse implementation.

The market and competitive positions, and the capacity and productivity of the production systems, as well as their level of production technology, will serve as background scenarios for the evaluation of the chosen investment alternatives. Scenarios on the changes and the trends of the environment will serve as drivers of the background scenarios,
which will form the basic assumptions for judging the outcomes of a SID. There is no doubt that these scenarios are critical for the success of a SID – if these basic assumptions fail (mostly they fail in a negative way) they can turn a profitable and successful investment alternative into a failure. Then there will be four essential requirements on these scenarios: (i) the facts used should be valid and stable; (ii) the assessments should be tested for sensitivity; (iii) the consequences derived should be tested for precision and validity, and their sensitivity to changes of key factors should be evaluated and tested, and (iv) the methods used for building the scenarios should be quickly adaptable to significant changes.

This type of scenarios have been implemented already in the Woodstrat support system. In terms of technology they are not hard to build. A good Windows platform is sufficient, and most of the functional links needed to link the various scenarios can be done with Excel and Excel add-on software. It is always useful to have some tools for driving the simulations, and add-on graphics for quick representations of ad hoc scenarios save time. The scenario environments can be tailored to user needs with some support routines in either Visual Basic 5.0 or Java.

Data is a problem for the scenarios. Mostly we need to draw upon external data sources, many of which have been produced for commercial use at rather stiff prices. Then it is not attractive to stay linked up to them for longer periods of time and it is not worthwhile to try to work interactively with them. Software agents have proved to be useful as tools for collecting data from these external sources, quite often over the Internet, and for storing this data in some intelligent way in a data warehouse. If we have some tools for filtering and retrieving data from the data warehouse, quite often as a background operation, we get a setup, which will be very effective for data driven scenarios. An added bonus with the software agents and the data warehouse is that this construct will work as effectively in an intranet and with internal data sources.

The final phase of the SID process is the justification of the investment decisions.

Figure 5. The third SID phase: Justification of investment decision.

In real life a SID will have to be defended and justified many times to various stakeholder groups. Normally these groups will not appreciate the details and the (often) quite complex reasoning being used in the evaluation of investment alternatives. Thus, we need another type of SID support for this phase, but we should be able to use the same support systems platform as in the previous two phases.

The scenario part can be the same as in the previous phase, as we need to be able to show and justify the basic assumptions underlying the SID. Possibly, we could build a user support for more animation-like presentations of the scenarios, and we need not keep the links to external data sources (unless key parameters change often) as we can run the scenarios from the data warehouse.

Another straightforward part of the setup is the evaluation of estimated profitability of the SID over its lifetime. This is a simulated income statement driven by the scenarios and with assumptions on currency fluctuations, interest rates and changes in prices of labor, raw materials, energy, transportation, etc. It is standard practice to allow this pro forma income statement to drive changes in equity and the overall capital structure of the SBU, which then can be measured in terms of ROCE and similar key ratios. The income statement is also made to run cash flow scenarios and various key ratios on the financial risks with the SID. Not surprisingly, all this can be done with Excel and the only requirement of the SID support system is that it provides a good platform for feeding scenario data into the Excel application. Then, there would be much use for an effective user interface, which allows the user to quickly switch between scenarios, to print good reports and to produce good graphical representations of the consequences of the chosen scenarios.

Stakeholders may be interested in aspects like customer value and product life cycle assessments of the SID, i.e. they would want to understand how the products and services produced by the SID will/may increase the business potential or the cost effectiveness or the productivity of (industrial) customers. They may also want to be able to find out the possible life cycle changes in demand of the products and services in order to be able to fit these into similar scenarios for supporting or replacing products. This type of modeling is difficult both in theoretical and technical terms, the causal relations used are not well understood and the data to formulate them is hard to find and use. The SID support platform should support the use of advanced modeling tools, which could be used to describe life cycle processes as simulated phase changes on the basis of imprecise and uncertain input, and approximate reasoning to trace the
impact of product and service characteristics on (industrial) customer value (cf. [7], [9]).

In the next section we will then show some new technology for a SID support system, which will allow us to support the type of reasoning we have described.


The hyperknowledge platform we used in Woodstrat was built in Visual Basic and used Access for the supporting database (cf. Carlsson-Walden [4-6], [9], [15-16]). Later versions of the platform were done in Delphi and used MS SQL 6.5 as the database, but after a while it became apparent that the support system we get in this way is both too complex for senior managers to use, and that the adaptation of the system to changing environments became cumbersome. These problems were mostly due to the MS SQL. It also turned out that the design was too time consuming to build for fast prototyping.

Thus we have turned to Java and data warehousing, and we have in some applications used Oracle 8.0 as both supporting database and as a platform for the data warehouse. The design of the user interface resembles the PointCast® platform, which is a very effective and user-productive interface.

There are some modifications we have introduced as part of a project on fragmentation of working time with six small high-tech companies – we found out that badly designed Windows user environments account for a significant portion of the nonproductive use of working time we traced in the companies. People who try to be highly productive spend many hours per working day with their PC applications and we found out that we with less than a dozen fairly simple modifications could save them 15-45 min of nonproductive fighting with inflexible applications.

Much of the functionality of this user interface has been made possible with the data warehouse application we have designed and built for the users. We have called this design INDY, which is an acronym for an intelligent dynamic data warehouse. We use Oracle 8.0 as a platform, and software agents for data storing and retrieval. In this way it has been possible to include the intelligence already in the links we have in the user interface. The overall design of the INDY is shown in fig. 6.

The Data Access Client of INDY is running a family of software agents, the functionality of which is shown in fig. 8. Agent 1 is working with selected data sources on the Internet – there is one version of this agent which accesses and retrieves news items from Reuters Business briefing – and stores retrieved data in DB1. This data is combined with material from other data sources (of which scanner data in the form of pictures was almost impossible to store on Oracle 8.0) and is organized and distributed for various applications with the INDY. Agent 2 is extracting data from internal data sources; Agent 3 is extracting market data from DB1 and is organizing it in a DB2 for market analysis and reporting; Agent 4 extracts product data from DB1 and organizes it in DB3 for further product analysis. DB1 is designed to serve as a database (or a data warehouse) for a DSS application.

Figure 6. The INDY data warehouse application.

The software agents are built to find data according to given search profiles and keywords, they can judge if the material is new or already stored with INDY, and they have some learning properties, so that a user can get “relevant material” from data sources he has “learned to trust” during the process. The software agents have been built in Java by IAMSR and there are already a number of applications in active use – the most promising of these provides a major company in the alcoholic beverage industry with material for industry foresight, i.e. keeping trace of legislation, structural changes in consumer habits, changes in distribution networks and logistics, and of the changes in strategic alliances among its competitors (cf. fig. 7).

These enhancements of the original hyperknowledge support system we had built and implemented as the Woodstrat system are aimed at making the system more user productive with a faster, better structured and better designed user interface. It is clear that the system will be more effective for the scenario building and evaluation phase than the previous system. It is also much more effective for handling large amounts of data and in saving significant amounts of working time normally spent on updating scenarios from a large number of data sources – the use of software agents proved to be a very effective innovation.

It is also the case that the modeling environment can be enhanced with the new data and user platforms now made available. A SID support system should be strong on fore-
casting and on a fast analysis of the consequences of a number of alternative numerical scenarios. In recent years there has also been some advances in modern modeling technology, which allows the use of approximate reasoning on the basis of incomplete and spotty data, and fast, on-line optimization from data in spreadsheet format. The use of artificial neural nets (ANN), fuzzy filtering and fuzzy logic, genetic algorithms, simulation, animation, etc. are becoming more and more standard for modeling complex phenomena, as the software to enable this modeling is becoming available as Windows applications.

Figure 7. Software agents for data access, retrieval and storing.

There is, of course, the problem that the users should be able to find their way with these tools and that they could make some sense of the results. The enhancements to the hyperknowledge platform we are developing will have the following elements (cf. fig. 8):

Figure 8. Enhanced hyperknowledge platform.

The first prototype of this platform is done with Java in Windows NT 4.0, with Oracle 8.0 and standard software packages for the enhanced features.

5. Summary and Conclusions.

We found initially that we could assume that strategic investment decisions (SID’s) are more easily understood and controlled than most of the other activities undertaken within the framework of strategic management. The reasons are simple: (i) the decisions get the undivided attention of senior management; (ii) the financial risks undertaken are significant; (iii) the information and knowledge needed is often quite well understood, and the resources to get it will be available; (iv) the quality of the information and knowledge may be decisive for the success of the investment (and even for the future of the company), and – as a consequence - (v) there is a need to be able to follow up and reason through the fairly complex internal logic of a SID.

Hyperknowledge support systems have been used as problem solving and decision support environments for strategic management and for strategic decision making in a number of industries in recent years. It appears that the logic of a SID is complex enough for a decision maker to benefit from the use of a hyperknowledge environment, and that a hyperknowledge support system could help a management team to control the problems with deciding, launching and following up on strategic investment projects.

Here we have worked through a giga-investment project, the extension of the Korkniemi paper mill with a new paper machine, and were able to show the type of elements we can have in a SID. We showed the structure and the use of a hyperknowledge environment (a prototype was implemented for the actual project) to support senior management in handling SID issues. We showed some benefits with hyperknowledge support and some potential problems, which have become apparent as experience with hyperknowledge has been collected over the last few years. The development of hyperknowledge support environments is now in the fourth generation, and we showed some innovations and enhancements, which will simplify and make more productive the support offered to decision makers.

6. References.


