Abstract

This thesis was written with the purpose of designing a new storage facility at the Surgery Department of Varberg Hospital. The authors came up with the general possible solutions of the problem despite of a number of assumptions that had to be made during the early stage of the project. These solutions concern such issues as the alternative locations of the storage within the limits of the new department building, process flows within the storage, information flow enhancement, and what was of a great importance for the initiators of the thesis research subject – suggestions concerning the types of the storage equipment and physical dimensions of the new storage.

While performing the study the authors came identified a particular problem in the supply chain that connects the Surgery Department with its suppliers. The ideas of how to improve the supply chain efficiency can also be regarded as the result of the thesis. However, this area requires deeper research initiative and did not receive extensive attention in the present work.

Hospital logistics is one of the new directions of logistics development. Working with the department's material and information flows required that the authors combine the extensive knowledge of basic logistics and an indepth understanding of health care sector specifics. The working process opened a new angle of logistics knowledge for the research team and made the creation of this thesis an interesting and unique experience.

Acknowledgment

The authors would like to thank the Administration of the Surgery Department of the Varberg Hospital for the opportunity of carrying out the present research. It was of a great interest to work with this rather new area of logistics – hospital logistics.

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List of Abbreviations

AUTO ID	Auto Identification Systems
CMI	Co-Managed Inventory
COP	Computer Order Processing
CRP	Continues Replenishment Programs
EDI	Electronic Data Interchange
FIFO	First In First Out
HIBC	Health Industry Bar Code
IPSec	Internet Protocol Security
LAN	Local Area Network
LIFO	Lst In Last Out
SKU	Stock Keeping Unit
TPS	Transaction Processing System
VAN	Value Added Networks
VMI	Vendor Managed Inventory
VPM	Virtial Private Networks
UCC/EAN	Uniform Code Council/International Article Association

1. INTRODUCTION

The first chapter of the present study provides an overview of the research subject in focus. The chapter starts with presenting the thesis background and the strategic importance of the study. It provides the initial acquaintance with the problem and the structure of the research questions. The chapter also addresses the purpose of the study and problem delimitations.

1.1 Background

Hospitals are, as ever, under increasing pressure to provide high-level patient care with minimal funding. Higher patient demand for treatment and surgical procedures, coupled with increased pressure to measure the services provided, are some of the key issues driving the need for hospitals to re-engineer the logistic processes to raise service quality and save costs.

Many hospitals have already started to look at logistics best practices in other sectors, such as automotive and retail, and take lessons learnt from those industries and apply them to hospital logistics. However, in general hospital logistics still remains de-fragmented, with little visibility over ordering, stock availability and status of supply chain activity. These issues drain critical patient care resources and lead to escalating costs. Therefore, modern logistics at hospitals today must fulfill all the functional as well as the business requirements, and must render transparent the following individual performance and task areas:

- Fast and reliable supply of the requesting units
- Permanent availability without oversized inventory
- Information technology (IT)-based logistics organization
- Continuous operational procedures (without breaks at department boundaries)

1.1.1 Current Tendencies in the European Health Care Sector

Over the past few years several progressive tendencies have been observed in the health-care sector. Central logistics centers for a number of hospitals have been set up to optimize purchasing, storage and shipping of products. At the same time the importance of the Internet has grown tremendously; sourcing is conducted frequently with the help of intranet constituting the IT platform for purchasing partnerships. In the field of transportation market different models for a partnership between hospitals and logistics service companies are used nowadays to optimize storage and delivery conditions and processes. The hospitals are becoming increasingly conscious of the importance of logistics costs. For example, based on the experiences of a number of preliminary

projects in Germany, a cost-cutting potential of between 10% and 30% of the total scope of goods and logistics services can be realized.

1.1.2 Decreased efficiency within the nursing sector

Because the nursing sector in Sweden has traditionally been carried out of public regime, this industry has lived in a sort of a protected world, away from competition. Thus, at the beginning of the 1990's private entrepreneurs began to appear in the area of medical attendance.

The medical attendance is today very much debated in the media, mostly because of the inefficiency problems that are taking place, and that is often illustrated by the longer waiting time for patients.

During the 1990's the nursing sector suffered from heavy rationalization and downsizing and the consequences of these negative processes are seen today in the form of decreased healthcare efficiency. Nowadays, one of the most debated deficiencies is the long waiting time for the patients.

The authors suggest applying a logistical way of thinking as one of the ways to improve the efficiency in a hospital,. With a logistics way of thinking the authors mean that the hospital as a whole must be seen as one organization, and all the activities within the hospital should be seen as interrelated processes. Professionals working within the healthcare sector ought to reflect their daily and long-term plans through the prism of logistical point of view.

1.2 Strategic importance of the Project

Healthcare is one of the most important public sectors, and it is of a great importance that this sector delivers high quality services. In order to do so many processes within medical organizations require reorganization and optimization aiming at meeting both economic savings and population satisfaction at the same time. The task of delivering high quality services while keeping the costs down is not an easy one. However, it is achievable in practice if medical organizations start to use some of the business principles mainly applied to private organizations. One set of useful knowledge to assimilate from the private sector is how to handle logistics operations in the most efficient way since overall logistics costs account for almost 30% of the total cost in the supply chain.

The above statement said makes the present study strategic important since it will attempt to take a look at the traditional logistics activities within the hospital through the prism of the modern "logistics science".

1.3 Problem Discussion

The Varberg Hospital is one of the two biggest hospitals in province of Halland. Due to the fact that Varberg is a continuously growing town with rather large suburban area puts more pressure on the hospital infrastructure. This trend has also affected the Surgery Department as the major department unit of the hospital. The constantly increasing number of patients is causing bottlenecks on the resource side. It is the main reason why it has been decided to build an extension to the present surgery department building that would allocate additional surgery theaters to ensure that the department infrastructure can withstand steadily increasing patient flow. Along with the new surgery theaters it was decided to build a new storage area. It is important that the new storage utilizes the space as efficiently as possible in order to minimize the construction costs. Additionally the Surgery Department is heading for improving its logistics operations once the new storage is put into operation. Therefore, it has become important to take a purely logistics look at the problem, and that is why the present study was initiated.

There is one important factor that makes this study different from other similar studies within logistics. This factor is that the study concerns logistics operations within healthcare sector, and that requires additional attention that should be put in learning the healthcare sector specifics that are relevant to the logistics knowledge. This is why through close co-operation with the department personnel, the authors had to gain an extensive overview of the key activities that are performed at the department and their relations with each other. Secondly, the theoretical base is required that would provide a feedback on solving practical problems. For this purpose it is important to access latest information resources available that would ensure that the study is up-to-date and has forward thinking characteristics. The final step is to find the optimal storage design that would meet both practical and theoretical requirements.

1.3.1 Research Questions and Information Needs

In this section the research questions of the study will be represented. They consist of the dominant research problem and the sub-problems that are to solve the main problem.

1.3.1.1 Prime Problem

What would be the optimal design for a new storage facility for the Surgery Department at the Varberg Hospital?

This is the main question of the current research on how to design the new storage facility. This question deals with the majority of aspects related to warehousing as a logistics activity. The preliminary design of the storage facility including storage layout with physical dimensions, description of

storage activities, storage system and design of the information flow will be the answer to this question. In order to answer the major problem of the present research it is proper to divide the decisions that are need to be taken into three different decision levels. This division is used in order to structure the design process, to make it transparent and consequent. The methodology was supported by the article in the European Journal of Operational Research "Warehouse design and control: framework and literature review"[1].

1.3.1.2 Sub-Problems

- **What are the decisions that are to be taken at the strategic level of the design?**

To answer this sub-problem question it is necessary to collect information that would help to identify the location of the storage within the new Surgery Department, it is necessary to find out what kind of storage activities are taking place at the moment, what are the possible storage systems alternatives that would meet current and future demands of the material flow, what are the ways to enhance the existing information flow.

- **What are the decisions that are to be taken at the tactical level of the design?**

Under this question it is important to come up with the physical dimensions of the storage areas. Information that has to be entered in order to answer this question is the output from the previous question since the space dimensions depend directly on the storage processes and storage system space requirements.

- **What are the decisions that are to be taken at the operational level of the design?**

The field work in the department will determine what functions will make the daily routines of order fulfillment and pick-up processes more efficient.

1.4 Purpose

The purpose of the study is to design a new storage facility for the Surgery Department at the Varberg Hospital. The design will include not just the physical lay out of the storage space but a number of strategic, technical and operational issues as well. The new storage design will be used as a background for further decision making for the upcoming construction project. Thereby the present study can be seen as an initial study that can be used as a guideline for further studies in this field.

[1] Rouwenhorst B, et al, European Journal of Operational Research, Vol. 20, issue 13/14, 2002

1.5 Problem Delimitations

The authors will answer the thesis problems with the decisions made at strategic, tactical and operational level of the design process. These levels and the scope of the decisions related to each of them provide a major framework for the analytical part of the research. Because of the fact that the operational level decisions are characterised as purely internal department management decisions, since they depend directly on the personnel policy and the medical processes, only very limited operational process decisions will be included in the scope of the present design.

This thesis's initial step in designing the most optimal storage facility is to determine the most suitable location of the storage area within the new building. During this investigation the authors declared advantages and disadvantages for each location and the approximate size of the storage premises, but what is not taken into consideration is the construction costs of each alternative. The authors believe that these factors are more important at a later stage of the planning, while the most important at the moment is to present different alternatives for the hospital management consideration.

Current inventory level is mostly estimated from primary data collected from the interviews with the department personnel and secondary data provided to the researches. However, the numbers of articles might differ to some extent from the real number of articles that is why the authors have tried to acquire an average number. Consequently, the authors reflect on approximately current inventory levels but do not measure the exact amount of SKUs stored or the exact amount of tied-up capital this inventory level accounts for.

During the research project the authors paid a lot of attention to study the storage equipment commonly used in hospitals today. With this purpose two major study visits were planned. During these study visits and investigation of choosing the optimal type of the storage system different factors are taken into consideration. These factors are mentioned but equipment costs are not being considered. Also here, the authors believe that it is most important to give an extensive observation of advantages and disadvantages of different storage systems for the hospital management.

1.6 Definitions

In this section, the explanation of the essential definitions used in the study will be given. Some of the definitions have medical specifics and might not be evident to a reader outside the medical sector.

"Optimal design" definition has to be understood considering some limitations of the word "optimal". In the context of the paper it means the design that would meet the optimal space dimensions and ensure high accessibility to the stored items.

"Efficiency" is defined as the degree of target fulfillment and can be regarded as the benefits accomplished by the executed performance. Efficiency is mainly about doing the right things. [2]

In the present study the "material flow" definition is used in line with the direct logistical meaning of this term, however due to the specialization of the study by "material flow" is undermined the physical movement of medical products of one-time use needed to satisfy a wide range of surgery requirements. This flow does not include surgery instruments of multiple use.

A product is defined as a type of a goods. For example, latex gloves of a specific brand. The individual packages of a pair of gloves are called items or stock-keeping units, SKU's and the combination of several items of several products that are requested for a surgery is considered to be an order.

[2] Lumsden, 2003, p. 436

2. RESEARCH METHODOLOGY AND DESIGN

This chapter outlines different methodological theories and approaches that are typically used in business and marketing research. The chapter contains two design models that served as frameworks for both research and data collection processes within the study. Evaluation categories are also addressed later in the chapter. The chapter is closed by the summary of the methodological principles and data collection procedures that were used during the work on the thesis.

2.1 Introduction

It is important to make a selection of a proper research method when starting a scientific investigation. The selected methodology depends directly on the character of the study, as well as the purpose of the study and time constraints. The choice of the methodology is a complicated problem since it determines the outcome of the complete study. At the same time, it is an absolute necessity to decide upon one because the applied research methodology serves as a guideline for the researchers and is able to lead them throughout the research process.

2.2 Research Design

A research design is the basic plan that outlines the activities that are essential to undertake executing the research project. Research design provides an operational framework within which the facts are placed, processed through analyzing procedures and the valuable research output is produced.

Research design specifies the sources and types of information to be collected to answer the research questions. The research framework also guides the data collection and the data analysis processes. A good research design ensures that information gathered is consistent with the study objectives and that the data are collected by optimal in a particular case procedures.

It is the nature of the research objective that determines the characteristics of the research design. The most significant characteristic of the research design is the choice of the research approach since it determines how the information will be obtained and processed. With this regard there is no standard research design to guide the research process, since many different designs may accomplish the same objective. Conversely, different stages of the same research may require different research approaches.

Tactical research decisions on the research techniques specifications are made once the research approach has been chosen. Experiments, surveys,

observational studies, interviews are just a few common research techniques. Within this phase of the designing the researcher designs experiments, construct questioners, plans interviews and so on.[3]

2.3 Methodological Approach

One can meet different classifications of research studies in the literature on research methodology. On the basis of the research fundamental objective business research can be categorized into the following types: exploratory research, conclusive research, which can be both descriptive and casual research, and performance-monitoring (routing feedback) research. [4]

It is possible to differentiate the research methods into deductive and inductive methods. A deductive research entails the development of a conceptual and theoretical structure prior to its testing through empirical observation. The logical ordering of induction is the reverse of deduction as it involves moving from the "plane" of observation of the empirical data to the construction of explanation and theories about what has been observed. [5]

Another helpful classification distinguishes between quantitative and qualitative research. Quantitative research is a research strategy that emphasizes quantification in the collection and analysis of data. It also entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories. By contrast, qualitative research can be constructed as a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data. At the same time it has an interrelation with inductive approach, in which emphasis is placed on generation of theories.[6] From this stand point the present study can be characterized as a qualitative study what is important to take into consideration when evaluating the collected data. The evaluation criteria for qualitative research will be discussed later in the chapter.

2.3.1 The Exploratory Research Approach

Exploratory research is appropriate to any problem about which little is known. In general it is used for a variety of purposes, such as: formulating a problem and developing hypothesis; establishing priorities for further research: gathering information about the practices of carrying out research on particular conjectural statements; increasing the analyst's familiarity with the problem and clarifying concepts.[7]

[3] Aaker, Kumar, Day, 2003, p.73
[4] Kinnear&Taylor, 1996, p.126
[5] Gill&Johnson, 1997, p.28, p.33
[6] Bryman&Bell, 2003, p. 25
[7] Churchill&Iacobucci, 2002, p.95

Because knowledge is lacking when an inquiry is begun, exploratory studies are characterized by flexibility with respect to the methods used for gaining insight and developing hypotheses. Most productive techniques for conducting the explorative studies are literature search, experience surveys, focus groups, and the analysis of the selected cases. [8]

Much, but certainly not all, exploratory research provides qualitative data. Usually, exploratory research provides a better understanding of a concept or crystallization of a problem, rather than providing precise measurement.

2.3.2 Conclusive Research Approach

Conclusive research is designed to provide information for the evaluation of alternative courses of action. It can be sub-classified into descriptive research and casual research.

2.3.2.1 Descriptive Research

The major purpose of the descriptive research, as the term implies, is to describe characteristics of a business phenomena. It is appropriate when the research objectives include: portraying the characteristics of business phenomena and determining the frequency of its occurrence; determining the degree to which certain research variables are associated; and making predictions regarding the occurrence of the phenomena.[9]

The character and the purpose of descriptive research are substantially different from that of exploratory research. Unlike exploratory research, descriptive studies presuppose some previous understanding of the nature of the research problem. More than that, it requires a clear statement of the problem and specific research objectives.

It is characterized by a carefully planned and structured research design. Whereas an exploratory study is flexible, descriptive studies can be considered rigid. Descriptive studies require a clear specification of the who, what, where, why, and how of the research.[10] To find satisfactory answers to these questions, surveys, studies of primary and secondary data and simulation methods are used.

[8] Churchill&Iacobucci, 2002, p.95
[9] Kinnear&Taylor, 1996, p.131
[10] Zikmund, 1997, p.38

However, statements regarding cause-and-effect relationships are not possible with descriptive approach. Where cause-and-effect evidence is needed, causal research designs are required. [11]

2.3.2.2 Casual Research

The main objective of the casual research is to show that one variable causes or determines the values of other variables. A typical casual study deals with changing one variable and observation of the caused effect on another relevant variable. The second objective is to understand the nature of the functional relationship between the casual factors and the effect to be predicted. In spite of the fact that from the scientific research perspective a casual relationship is impossible to prove, researches seek certain types of evidence in order to help understand and predict relationships. [12]

The main sources of data for casual research are conducting surveys and business experiments.

2.3.3 Performance-Monitoring research

Performance-monitoring research provides information regarding the monitoring of a system. The purpose of the research is to signal the presence of potential problems in the systems or opportunities.
With regard to the objectives of the present study the performance-monitoring research approach will not be included into the final research design.

2.4 Data Collection

There are two general types of research data – primary and secondary. This distinction is defined by the purpose for which the data were collected. Secondary data collected for purposes other than research being conducted. Primary data, in contrast, are originated by the researcher for the purpose of the investigation at hand.[13] Since secondary data are characterized by a number of advantages over the primary data which will be discussed later in the chapter, it is recommended to start the data collection process with accessing the secondary data first (see Figure 2-2).

[11] Kinnear&Taylor, 1996, p.132
[12] Zikmund, 1997, p.40
[13] Churchill&Iacobucci, 2002, p.196

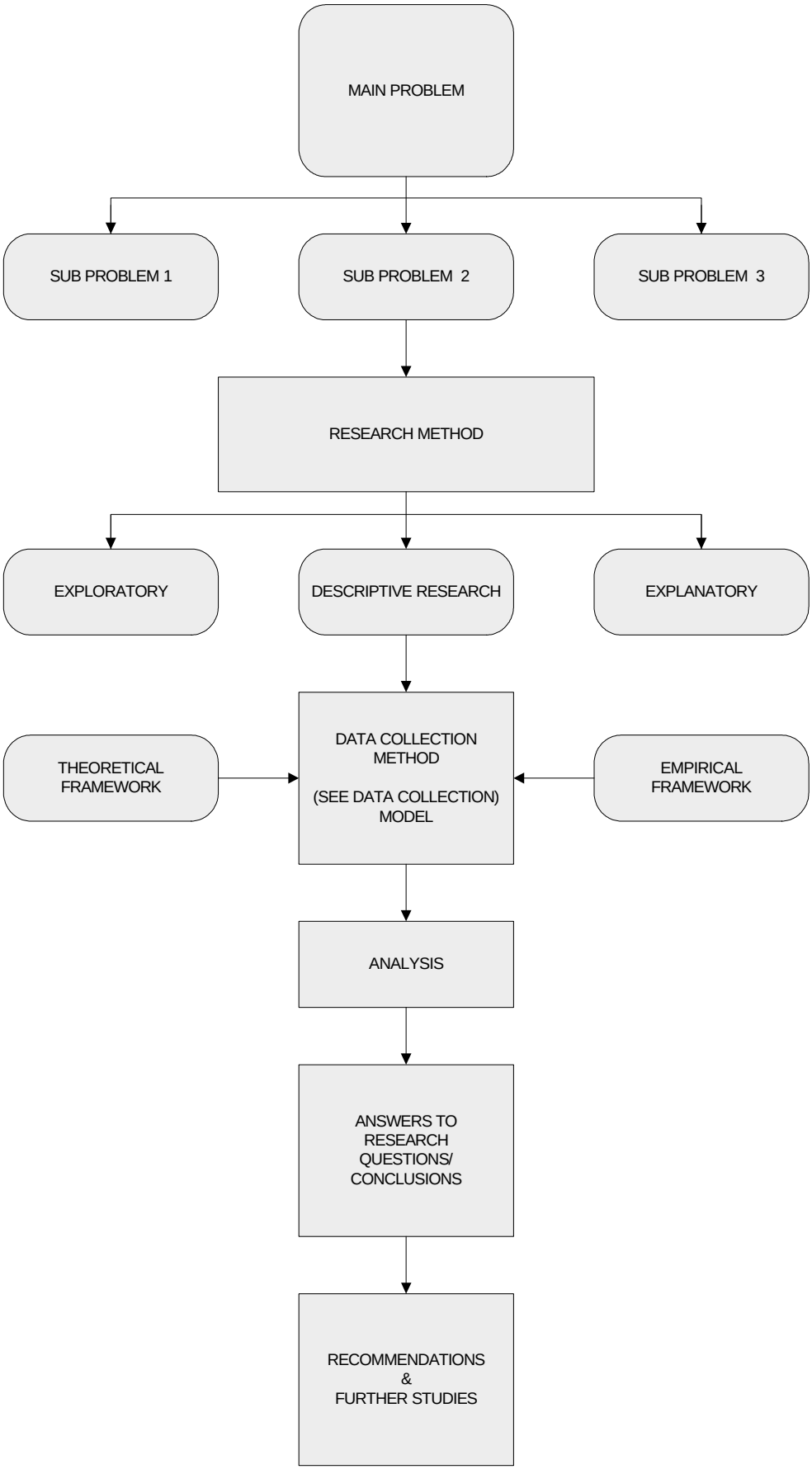

Figure 2-1: Research Model

2.4.1 Secondary Data

In the majority of cases secondary data will not solve the particular problem under study, secondary data typically will serve the following objectives: help to clarify the problem under investigation; suggest improved methods or data for investigating the problem; and provide comparative benchmark data against which primary data can be more insightfully interpreted.[14]

Secondary data can be classified as coming from internal or external sources. Internal secondary data are available within the organization while external secondary data come from the array of sources such as government publications, statistics bureaus, books, bulletins, reports, and periodicals. [15]

2.4.1.1 Internal Data

The methodology suggests that the internal secondary data should be searched first before turning to the external secondary data. Among the sources of the internal data can be a variety of internal organizational reports, shipment and warehouse records, production reports, etc.

2.4.1.2 External data

External data are created, recorded, or generated by an entity other than the researcher's organization.

Published data are by far the most popular source of information. The major published sources are various government publications, books and periodicals, journals, and publicly available reports from such private groups as foundations, publishers, trade associations, unions, and companies. Government agencies are prolific in producing data, and the most of the data published can be counted on accuracy and high quality of investigation. Books and periodicals found in a library often are considered a very essential secondary data source. [16]

Syndicated sources are services that collect standardized data to serve the needs of specific research purposes. This data are subject of sell and purchase transaction. This kind of data will not be used in the present thesis.

Internet has made it possible to conduct online computer searches for data. This source of accessing data has become increasingly popular over the last 20 years for locating both published information and data via electronic databases and search engines. Databases are typically defined by the type of information

[14] Ibid, 2002, p.199
[15] Kinnear&Taylor, 1996, p.176
[16] Zikmund, 1997, p. 151

they contain what ensures the convenience of their usage. Taking into consideration the highly specific subject of the present research internet sources of information are of high prioritization.

The most significant benefits secondary data provides are savings in cost, efforts and time in comparison to collecting primary data. In some cases secondary data can be also more accurate than primary data. However, despite many potential benefits of secondary data, they also have several limitations that come along with them. Problems of fit are very likely to occur, since secondary data were collected for another research purpose. The available data may also have a different measurement unit from what is required. Secondary data can also have poor accuracy and be outdated.[17]

2.4.2 Primary Data

The present research could not take place without the collection of primary data due to the specifications outlined in the Problem Definition part of the work. In this particular case primary data is an essential complement to the research process.

Presently, it is difficult to make any predictions about the methods of primary data collection. However, there is an absolute certainty about the adoption of such data collection methods as scientific observation, qualitative research interviews, focus groups and case histories.

2.4.2.1 Scientific Observation

Scientific observation is the systematic process of recording the behavioral patterns of people, objects, and occurrences. The researcher who is utilizing the observation method of data collection witnesses and records information as events occur or compiles evidence from records of past events. [18] Potentially two types of observation will be used in the present study: direct and participant observation.

Direct observation produces a detailed record of events. It can take place on the business meeting, sidewalk activities, on the shop floor. The observer plays a passive role of recording the events as they occur, there is no attempt to control or manipulate a situation. Direct observation is characterized by a high level of accuracy of data due to the elimination of errors associated with the recall of behavior.

[17] Aaker, Kumar, Day, 2003, p.107
[18] Zikmund, 1997, p. 263

The direct observation method has several advantages in comparison to the survey methods. It does not rely on the interviewee's willingness to provide the desired information. The potential bias caused by the interviewer and the interviewing process is sufficiently reduced. It covers the context of event in the real time situation. [19]

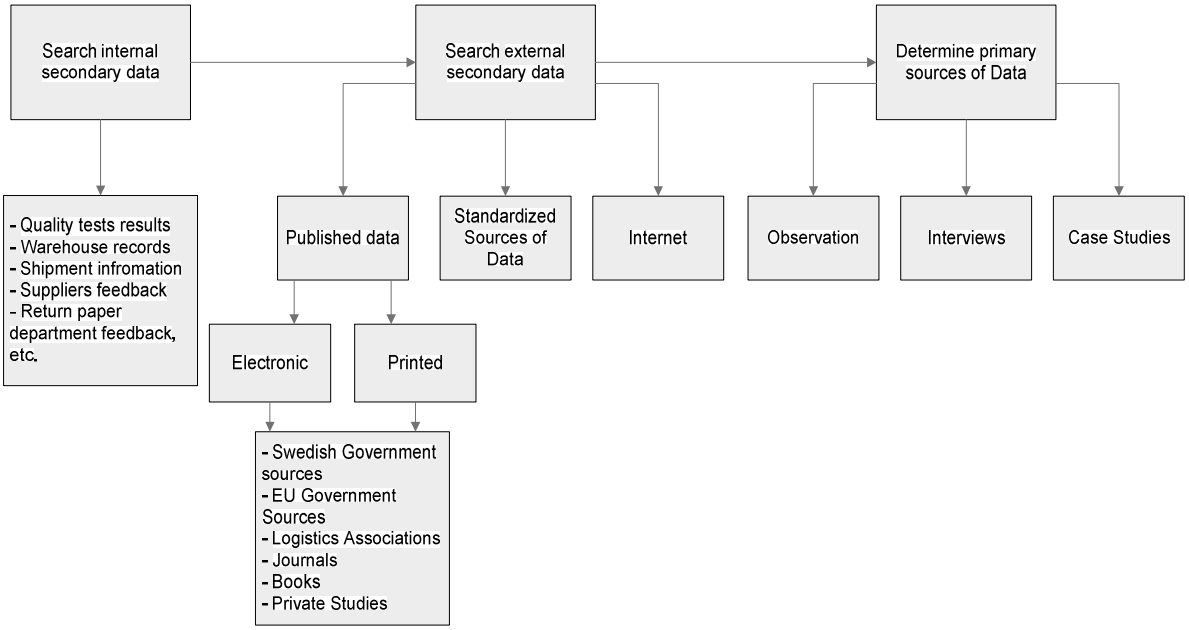

Figure 2-2: Data collection design model

Although there is no interaction with the interviewee, direct observation is not error-free. The observer may still add subjectivity to the recording and also due to improper recording effect the accuracy. Among other weaknesses of this method are: time consumption, economical costs and selectivity unless broad coverage of the phenomena.[20]

Participant observation refers to situations in which the observer gains firsthand knowledge by being in or around the activities that are being investigated. In this case the observer generally uses a combination of direct observation and interviewing. Long and involved personal interaction with the subjects of research is the prime advantage of participant observation. [21]

2.4.2.2 Qualitative research interview

The qualitative interview aims at obtaining nuanced descriptions from the different qualitative aspects about a certain phenomena from one or several persons who have a unique knowledge about the research subject. This kind of

[19] Yin, 2003, p. 86
[20] Yin, 2003, p. 86
[21] Zikmund, 1997, p. 274

interview works with words and not with numbers. Precision in description and stringency in meaning interpretation correspond in qualitative interviews to exactness in quantitative measures.

Considering the requirements of the present work the authors foresee the potential adoption of individual interviews.

Individual interviews are interviews that are conducted face-to-face with the respondent, in which the subject matter of the interview is explored in detail. There are two basic types of individual interviews: non-directive and semi-structured interviews, the difference lies in the amount of guidance provided by interviewer. [22]
In non-directive interviews the interviewee is given maximum freedom in answering the questions within the bounds of topic interests to the interviewer.

In semi-structured individual interviews the interviewer attempts to cover specific determined in advance areas. The time, exact wording, and time allocated to each question area are subjects to interviewer's guidance.

Interviews as a research method have a great deal of advantages, such as:

- interviews are targeted, they focus directly on the topic under the research
- interviews are insightful, they provide perceived casual inferences[23]
- direct interaction with the respondent, which allows further development of the question depending on the received answers
- face-to-face conversation is more suitable for using visual techniques for clarifying certain points, for example drawings
- atmosphere of trust will make the discussion more productive and open

Interviewing has certain weaknesses as well. They are as follows:

- bias due to poorly constructed questions
- response bias
- inaccuracies due to poor recall
- reflexivity – interviewee says what interviewee wants to hear
- unwillingness to provide confidential information
- time-consuming method

Already at the current stage of the research it is apparent that a significant share of information will be obtained through telephone interviews. This type of interviewing has proved to be time and cost efficient. The majority of the

[22] Aaker, Kumar, Day, 2003, p. 191
[23] Yin, 2003, p. 86

contacted organizations including the hospital are located outside the Gothenburg region, which places a high priority on conducting telephone interviews. The authors are planning to conduct telephone interviews when there will be a small number of simple questions to be answered. Here it is important that the interviewee has immediate access to necessary information, otherwise, there is a risk that answers will have more guessing character.

2.4.2.3 Focus groups

A focus-group discussion is the process of obtaining possible ideas or solutions to a certain problem from a group of respondents by discussing and brain-storming the problem. The emphasis in this method is on the results of the group interaction when focused on a series of topics introduced by the leader. Each participant in a group from five to nine people have a possibility to both express points of view in each topic discussed and to elaborate on or react to the views of other participants.

The focus group discussion offers participants more stimulation than an individual interview, people feel more comfortable to speak out in a group which results in generation of new ideas and meaningful comments.
Even though the focus group is with no doubt a very helpful way of collecting primary data, it is anticipated to be hard to organize within the present study.

2.4.2.4 Case histories

The purpose of the case study method is to obtain information from one or a few situations that are similar to the researcher's problem situation.[24] This method concerns the intense investigation of problem solving situations in which problems are relevant to the research problem. The underlining concept is to select several targeted cases where an intensive analysis will identify the possible alternatives for solving the research questions on the basis of the existing solution applied in the selected case study.

Data can be obtained through the search records and reports, observation of key variables, and interrogation of knowledgeable persons. The research focuses on developing an insight into the problem situation.

After a prior analysis of the research problem, the authors identified that several cases dealing with the hospital storage facilities projects can be selected as case histories within the research.

[24] Zikmund, 1997, p. 107

2.5 Research Evaluation

Three of the most prominent criteria for the evaluation of business research are reliability, replication and validity. [25]

2.5.1 Traditional Evaluating Criteria

2.5.1.1 Reliability

Reliability is concerned with the question of whether the results of a study are repeatable. The term is commonly used in relation to the question of whether the measures that are devised for concepts in business are consistent. Reliability is particularly an issue in connection with quantitative research. The quantitative researcher is likely to be concerned with the question of whether a measure is stable or not.

2.5.1.2 Replication

The idea of reliability is very close to another criterion of research – replication and more especially replicability. Sometimes researchers choose to replicate the findings of others. There may be a host of different reasons of doing so, such as a feeling that the original results do not match other evidence that is relevant to domain in question. In order for replication to take place, a study must be capable of replication. For the study to be replicable the researcher should describe the applied procedures in great detail.

2.5.1.3 Validation

The most important criterion of research is validity. Validity is concerned with the integrity of the conclusions that are generated from a piece of research. There are four main types of validity typically distinguished: [26]

- *Measurement or construct validity* applies mainly to quantitative research and to the search of measures of social scientific concepts. Essentially, this type of validity deals with the question of whether a measure that is devised of a concept really does reflect that it is supposed to be denoting.

- *Internal validity* relates mainly to the issue of causality. It concerns the question of whether a conclusion that incorporates a casual relationship between two or more variables is relevant. It is used for validating whether the identified variables really do cause the variation in the relationship and not produced by something else.

[25] Bryma&Bell, 2003, p. 33
[26] Bryma&Bell, 2003, p. 33

- *External validity* deals with issue of whether the results of a study can be generalized beyond specific research context. It is in this context that the principle of how organizations and people are selected to participate in research becomes crucial. This type of validation is also important in quantitative studies for generating representative samples.

- *Ecological validity* is concerned with validation of applicability of social scientific findings with people's social setting. The notion is that business research should produce findings that must be both technical valid and reflect peoples' every day life. If research findings are ecologically invalid, they are in a sense artifacts of the social scientist's arsenal of data collection and analytical tools. The more the researcher intervenes in natural settings or creates unnatural ones, the more likely the findings will be ecologically invalid. For example, conclusions deriving from a study using questionnaire may have measurement validity and internal validity, and they may be externally valid, but the unnaturalness of the fact of having to answer a questionnaire may mean that the findings have limited ecological validity.[27]

One common feature of the above mentioned evaluation criteria is that it seems to be geared mainly to quantitative research rather than qualitative which is by far the major methodological characteristic of this thesis. Both reliability and measurement validity are essentially concern with the adequacy of measures, which are most obviously a concern in quantitative study. Internal validity is concerned with the soundness of findings that specify a casual connection, an issue that is most commonly of concern to quantitative researchers. External validity may be relevant to qualitative research, but the whole question of representativness of research subjects with which the issue is concerned has a more obvious application to the real of quantitative research with its preoccupation with sampling procedures that maximize the opportunity for generating a representative sample. Only ecological validity relates to the naturalness of the research approach and seems to have considerable relevance to both qualitative and quantitative research.

These considerations inspired the authors to search for alternative evaluating criteria that are more adjusted for the specifics of qualitative studies.

[27] Bryma&Bell, 2003, p. 34

2.5.2 Alternative Evaluating Criteria

Lincoln and Guba propose the trustworthiness as a criterion of how good a qualitative study is. Each aspect of trustworthiness has a parallel with the previous quantitative research criteria[28].

2.5.2.1 Credibility

Credibility, which parallels internal validity – how believable are the findings? The establishment of credibility of findings ensures that the research was made in accordance to the canons of good practice and submitting findings to the respondents that took part in the research for confirmation that the investigator has correctly reflected the respondent's reality.

2.5.2.2 Tranferability

Tranferability, which parallels external validity – do the findings apply to other contexts? As Guba and Lincoln put it, whether qualitative findings "hold in some other context, or even in the same context at some other time, is an empirical issue".[29]

2.5.2.3 Dependability

Dependability, which parallels reliability – are the findings likely to apply at other times? To establish the merit of research in terms of this criterion researchers should adopt an "auditing" approach. This entails that complete records are kept of the all phases of the research process – problem formulation, selection of research participants, fieldwork and interview notes, data analysis decisions, and so on. The next step is for the peers to review how proper the research procedures have been followed. But since this approach is very time consuming for the auditors it has not become popular among the business researches.

2.5.2.4 Conformability

Conformability , which parallels objectivity – has the investigator allowed his or her value to intrude to a high degree? This criterion is concerned with ensuring that, while recognizing that complete objectivity is impossible in business research, the researcher can be shown to have acted in good faith; in other words, it should be obvious that the researcher has not allowed personal values or theoretical inclinations to affect the research process and derived findings.

[28] Lincoln&Guba, 1985, p. 316
[29] Lincoln&Guba, 1985, p. 316

2.6 Method and Data Collection Techniques Used

Throughout writing the thesis the authors have gone through various stages that have required different methods and data collection techniques. Below all the used methods and applied techniques are summarized in order to characterise the present research from the methodological perceptive.

The first part of the study can be characterised as an exploratory research because of the lack of initial information and the strong need to gather it for providing a better understanding of the problem. However, in general, the study can be characterised as a qualitative study that operates mostly words in such processes as data collection and analysis. At the same time the study has an interrelation with the inductive approach for generation of theories.

Regarding the collection of data, the primary data has been a necessity due to the specifications outlined in the Problem Definition part. The primary data has been collected through scientific observation, both direct and participant, in order to obtain a combination of an observation and immediate verbal feedback on the observed topic. Also qualitative interviews have assisted the authors with accessing unique knowledge from the department personnel. Either non-directive and semi-structured individual interviews or a combination of these two, have been used. Also a significant share of data has been obtained through telephone interviews. Concerning the secondary data collection, the internal data was searched first and then the external. Internal secondary data was received from the department administration and was represented by the hospital introduction brochure, product items description, number and names of suppliers, department map and other. External data included such sources as books, course lecture materials, scientific journals and Internet.

In order to receive an intense investigation of problems that are relevant to the research problem, the case study method has been applied in form of reading reports and study visits. The authors have selected several targeted cases and places where intensive analyses have identified the possible alternatives for solving the research questions. Data from the study visits have been obtained through knowledgeable persons.

3. THEORETICAL FRAMEWORK

The aim of this chapter is to provide an overview of the theories which were used as a theoretical founding for the analytical chapter of the present paper. Each theory is outlined in a compressed version, however, containing the major ideas and points. The main focus is given to the introduction of warehousing theory and modern information systems used within logistics, and an overview of the supply chain philosophy.

3.1 Introduction

Theoretical material outlined in this chapter is meant to be used for several purposes. One of the purposes is to assist the researchers in gaining an understanding of the theoretical categories needed in order to be able to complete the research. The first stage of applying this knowledge is needed for acquiring information for the empirical chapter. Here, theoretical framework is used in order to assist the researchers to identify the directions of data collection.

Another aim of the chapter is to serve as a feedback for the potential readers of the thesis, therefore, some of the theories are given in more details than was actually required for the analysis itself.

The crucial importance this chapter has for the analysis carried out at the end of the research. Analytical statements are strictly connected to the outlined theories.

Among the theories that were put into focus are the following: inventory management; warehousing theory including warehousing processes and flows, storage principles and storage equipment; information systems applied for inventory data collection and order placement. A separate block of the chapter is devoted to the introduction of supply chain philosophy as related to this subject problems got into the focus of the researchers' attention.

3.2 Definition concepts of Logistics

Logistics is a key enabler for supply chain management, and is defined of Christopher (1998) as: "Strategically managing the procurement, movement, and storage of materials, parts and finished product inventory and the related information flow, through the organisation and its marketing channels in such a way that the current and future profitability are maximized through the cost-effective fulfilment of orders.[30]

[30] Harrison & Van Hoek, 2002, p. 7.

Regarding to this definition one can recognize the importance of well working logistics for a product or service. The degree to which the consumer is satisfied with the finished product depends crucially on the management of material flow and information flow along the supply chain. If delivery is late, or the product has parts missing, the whole supply chain is at risk from competitors who can perform the logistics task better.

Below follows an additional definition of logistics for the better understanding of the relationship.

Logistics is the work required to move and position inventory throughout a supply chain. Logistics, by itself, is a subset and occurs within the broader framework of a supply chain. Logistics is a process that creates value by timing and positioning inventory. In this way it is a combination of a firm's order management, inventory, transportation, warehousing, materials handling, and packaging as integrated throughout a facility network. Integrated logistics serves to link and synchronize the overall supply chain as a continuous process, and is essential for effective supply chain connectivity.[31]

3.3 Inventory

3.3.1 Reasons for holding inventory

Inventory represents a large share of organization's capital costs on inventory investment. Inventory also accounts for inventory service costs that include taxes and insurances; storage space costs; inventory carrying costs, such as electricity, labour, handling, storing equipment and other; inventory risk costs initiated by damage and shrinkage[32]. Nevertheless, very often inventory is an absolute necessity for the daily organization's activities. This section, however, will not cover all the reasons for holding inventories since many of them are not directly related to the research subject of the present paper.

Inventory is required if an organization is aiming to realize economies of scale in purchasing and transportation by achieving a lower per-unit price in connection with purchasing large volumes. Often purchase contracts are being negotiated based on annual volumes, and not based on the volume of individual order.

Another serious reason for holding inventories is a protection from uncertainties. Excess of a normal product stock level can result from expected

[31] Bowersox, Closs, and Cooper , 2002, p.4.
[32] Stock&Lambert, 2001, p. 199-201

price increase, uncertainty regarding the availability of a certain product or variability in lead-time.
Regardless of the reason for maintaining a product inventory, a proper inventory management is a must. Inventory managers must determine how much inventory to keep, and at what level of a stock to place an order to avoid the excess of products and shortage of storage place.

3.3.2 Types of Inventory

Inventories can be categorized into different types depending on the reason for which they are accumulated. With respect to the research objective four types of inventories are overviewed in this section: cycle stock, safety or buffer stock, speculative stock and dead stock.[33]

Cycle Stock:
Cycle Stock is inventory that results from consumption, and is required to satisfy demand under conditions of certainty – when organization can predict demanded quantities of goods and lead times with a high degree of preciseness.[34] Since the demand and lead times are known, orders are scheduled to arrive just as the last item is consumed.

Safety or Buffer Stock:
Safety or Buffer stock is held in excess of cycle stock because of uncertainty in demand and lead time. The idea is to keep a portion of average inventory in order to cover short-range variations in demand and lead times. Average hold inventory in this case equals to half of the order quantity plus safety stock. Any company that has to have safety stock due to variability in demand and/or lead times must aim at its minimum quantity. Organizations should facilitate better demand forecasting and purchase products from reliable partners that in turn use reliable transportation carries in order to reduce total inventory.

Speculative Stock:
Speculative stock refers to unnecessary inventory gained by ordering larger volumes than required by consumption trying to achieve economies of scale. It can also be caused by forecasted price increase or material shortage.

Dead Stock:
Dead stock is an accumulated set of items that have no registered demand. Dead stock requires managers' attention since it might account for serious tied-up capital and inventory carrying costs for keeping the items in storage.

[33] Stock&Lambert, 2001, p. 235
[34] Stock&Lambert, 2001, p. 232

3.3.3 Ways to Reduce Inventory Levels

It is useful to understand the potential of keeping low inventory. In many cases inventory levels can be reduced by applying some of the following procedures:[35]

- Proper inventory Planning
- Lead-time analysis of order cycle
- Delivery-time analysis. This might lead to reconsideration of carriers
- Elimination of dead stock
- Analysis of pack size and discount structure. It is possible that economies gained by ordering are not justified
- Installation of computerized order processing systems
- Measurement of fill rates by SKU
- Analysis of demand or consumption

3.3.4 Order Point

Inventory is constantly being decreased by the number of picked items and at a certain point of time it subsides a predetermined level, the Order Point (OP). The amount of inventory at this point should be enough to cover the expected demand (D) for the lead time (LT*D) and in case of possible deviation the safety stock (SS)[36]. The ordering point can, therefore, be expressed as:

OP = the expected demand during the lead-time + the safety stock = D*LT+SS.

Order Point is an important issue in inventory management. Its value has to be optimized as much as possible avoiding the creation of unnecessary inventory. Order point should be programmed into automated re-ordering system in order to avoid time consuming calculation activities for inventory managers.

3.4 Major Aspects of Warehousing

This section accumulates the important issues and definitions that concern warehousing as a logistic activity. This section is considered to be a preliminary acquaintance of the reader with the warehousing theory and terminology that will be used by the authors through out the research in part of storage design.

3.4.1 Facility Layout Objectives

The construction of a new storage facility is always a project that requires high investments. In order to meet the final goal of the project a set of objectives for the new facility must be established. These objectives are following:

[35] Stock&Lambert, 2001, p.255
[36] Lumsden, 2003, p. 182

- Maximization of storage space utilization by providing the maximum number of storage positions within the facility
- Allow an efficient product flow through all the functional areas of the storage
- Facilitate access to SKU's pick positions and ensure inventory rotation
- Reduce annual operating costs
- Improve the storage personnel productivity
- Protect the products and the storage equipment from damage
- Provide for expansion
- Provide the employees with a safety and ergonomically optimized environment
- To ensure that operations satisfy customer requirements[37]

Another issue to take into consideration when it comes to the storage design is the trade-off between maximization of storage and handling efficiencies. Maximum use of the storage area gives a low accessibility of the goods. The storage would have lowest possible capital cost with respect to equipment and facilities, but very high operating costs. On the opposite side, providing maximum accessibility of the goods that would make the picking process quick and, thus, operating costs low, would dramatically increase the capital costs since the use of the storage space capacity would be low.[38]

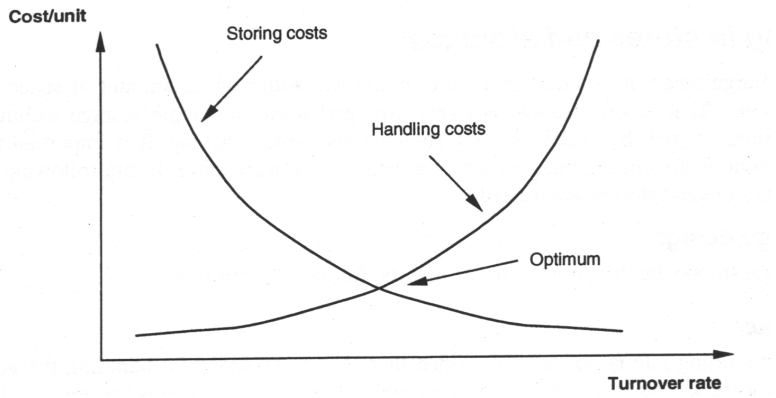

Figure 3-1: Storing and handling costs as function of turnover rate

Source: Lumsden, 2002, p. 268

3.4.2 Warehouse processes and flows

The material flow of items within a storage facility is a sequence of several distinct processes. Theses processes are the following:

[37] Mulcahy, 1994, pp. 3.3-3.4
[38] Lumsden, 2003, p.268

- The *receiving process* is the first process encountered by an arriving item. Products may arrive by truck in case if external transportation or by some mean of internal transport in case if a storage facility is a part of production process. During this process the products are unpacked, checked and transported into different storage areas.

- During the *storage process* items are transported to the storage system and are allocated to storage locations. Most often the storage area consists of two parts: the reserve area, where products are stored in the most economically efficient way in form of bulk and the forward area where products are stored in a way to ensure easy retrieval by an orderpicker. In the forward area products are often stored in smaller amounts than in a reserve area to enable fast and easy access to them. The transfer of items from the reserve storage area to the forward storage is called a *replenishment.*

- *Orderpicking* refers to the retrieval of items from their storage locations. After that picked items may be transported further for the *consolidation process*, meaning the grouping of items destined for the same order.

- *Shipping* concerns the process when picked products are checked, scanned, packed and put on transportation equipment.[39]

Depending on the various types of storage activities, the material flow processes can be structured differently. The main types of flows are linear, U-shaped, triangular and circular flow(Figure 3-2). [40]

A linear flow is described as a material flow that comes in at one end of a physical storage facility and comes out at the other end of the facility. The goods are transported the entire distance from the arriving area to the shipping area which in turn increases the distance for moving the goods. The linear pattern is suitable when there is a technical need for the warehouse entry and exit to be located at the opposite sides of a facility.

In U-shaped flow, conversely, the goods arrive and leave at the same end. In combination with ABC principle of product placement U-shaped flow decreases the transportation work.

[39] B.Rouwenhorst, European Journal of Operational Research 122, 2000, p.517
[40] Lumsden, 2003, p.270

Triangular flow makes construction of functional departments easier. Circular flow brings cost reductions from the combined sending and receiving function. It suits best when there is no need for separate docks for arriving and shipping.

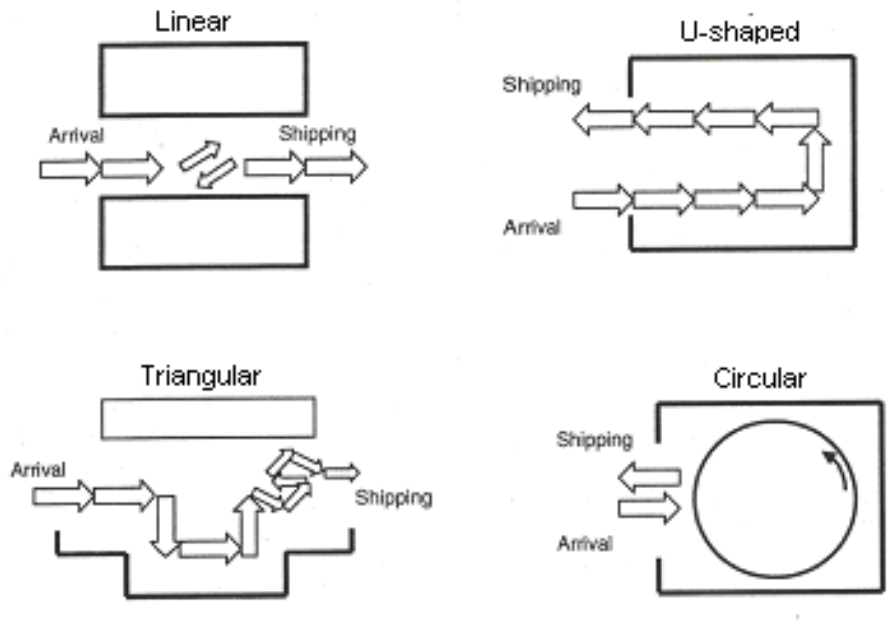

Figure 3-2: Various material flow structures

Source: Lumsden, 2002, p. 271

3.4.3 Functional Areas

A warehouse consists of several main departments or areas that correspond to their major functions or processes such as receiving, storing, order picking and shipping. The number and size of functional areas can be reduced if several functions are performed in one area.[41] For example, receiving and unpacking operations can be performed in the reserve area.

Storage is the major department in a warehouse. It is common to divide storage area into reserve and picking areas in order to facilitate storage operations. Each of two areas may in turn be portioned further into sub areas based on inventory turnover frequency and size of unit loads. For example, the picking area can be divided into sub areas for small and large items, or/and into zones for fast, medium and slow moving items.

There are different ways to locate the reserve area with relation to the picking area. The reserve area can be located nearby, not in the immediate surroundings of the picking are. For example, it can be located in a different

[41] Hassan, 2002, Facilities, Vol. 20, p.435

building or on the other side of the same building. It is common to locate the reserve area close to the picking area, however, without being accessible for the collector, which means that the picking area has to be constantly replenished from the reserve area apart from the order picking process. It is also common to combine reserve and picking area in the same physical premises. In case of shortage the order can be picked directly from the reserve area. Immediately afterwards collectors can initiate the replenishment of items that are in short supply in the picking area.[42]

3.4.4 Storage Principles

The combination of storage principles compile certain guidelines for storing a wide range of products, i.e., so called storage policies applied for both reserve and picking areas. There is no general storage policy since the product characteristics and warehousing operations vary to a great extent. However, a storage policy can be worked out based on the analysis and application of storage principles.

3.4.4.1 Principle of Product Rotation

There are two picking principles classified according to the sequence basis: FIFO (First In First Out) and LIFO (Last in Last Out). The FIFO principle is suitable for the linear flow through the storage, while LIFO is better if arrival and shipping take place at the same spot.[43] If there are requirements that a product has to be consumed within a specific period of time the FIFO principle must be used, since in this case the oldest item is picked up first. Conversely, the LIFO principle ensures that the item that arrived last is picked first. According to the LIFO principle the maximum time in storage can be beyond control, creating so called shelf warmers, i.e. items that stay in the storage for a long time.

3.4.4.2 Principle of Variable and Fixed Slot Assignment

How easy a product is to find is primary determined by the placement or slot assignment principle used. A variable-slot placement principle means that a product can be given any vacant location in the storage. A fixed-slot system assigns a product a determined permanent location within the storage as long as the product sustains volume.[44]

The advantage of variable slotting is efficient utilization of storage space since the number of empty storage locations lower for a variable storage than for a fixed. The advantage of fixed slotting is that personnel are familiar with the products location what increases the operating efficiency.

[42] Lumsden, 2003, p.287
[43] Lumsden, 2003, p.273
[44] Bowersox, 2000, p.403

3.4.4.3 Principle of Compatibility

Within storage facility products can be grouped according to their compatibility which refers to how well products may be stored together.[45] Here the main issue is the safety rules that govern the storage layout.

3.4.4.4 Principle of Complementarity

This principle refers to how often different products are picked together and therefore should be stored close to each other in order to facilitate picking process.[46] This principle is proper to use for both floating and fixed storage.[47]

3.4.4.5 Principle of Family Groups

According to this principle items are grouped on the basis of family relation. By a predetermined criterion, items are assigned to specific locations (areas) within storage. Such criteria can be: similar dimensions and weight; similar usage characteristics; special storage conditions such as warming, refrigerating or freezing; require better security, etc.[48]

3.4.4.6 Principle of Popularity

Popularity relates to the fact that products have different inventory turnover or demand rates. Another term used for this turnover rate is velocity.[49] The popularity principle is based on an ABC division of products into three groups based on Pareto' law (after Vilfredo Pareto, 1848-1933; Italian economist). The law states "that 85 percent of the wealth is held by 15 percent of people". In the warehouse industry, this law applies that 85% of the volume shipped to the customers is derived from 15% of the SKUs. Many studies have indicated that it is common that another 10% of the volume comes from 30% of SKUs and that remaining 5% come from 55% of the SKUs (Figure 3-3).[50] The notion behind this division is that the storage consists of three zones of Pareto's law. "A" storage-pick zone is allocated to the high frequency SKUs. These SKUs are relatively few in number but have a large inventory quantity per SKU. The "B" storage-pick zone allocates a larger group of medium frequency SKUs which are as well medium in number and have medium inventory quantity per SKU. The "C" storage-pick zone is allocated to the low frequency SKUs. These SKUs are large in number and have a small inventory quantity per SKU. The popularity principle stipulates that all product positions should be placed in one of the storage zone with respect to the SKU group they belong to.[51] Fast

[45] Stock & Lambert, 2001, p. 418
[46] Ibid, 2001, p. 418
[47] Lumsden, 2003, p-273
[48] Mulcahy, 1994, p.3.19
[49] Stock & Lambert, 2001, p. 418
[50] Mulcahy, 1994, p.3.14
[51] Lumsden, 2003, p. 273

moving products that account for the largest share of storage activities should be positioned nearest to the outbound end of the facility. It makes sense to store slow moving products at points farthest from outbound end. The overall work for picking is therefore reduced.

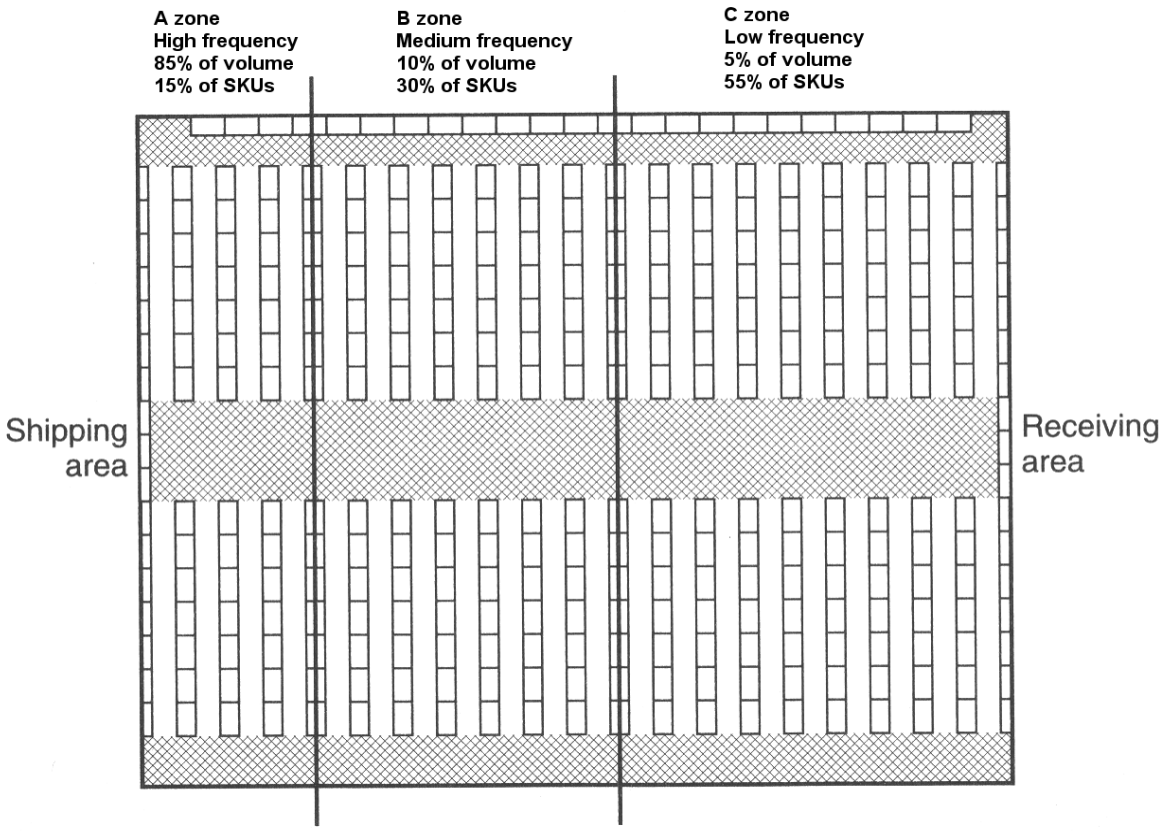

Figure 3-3: ABC Storage Zones

Source: Mulcahy, 1994, p.3.14

It is important to take into consideration that ABC product division is not an ultimate tool for optimized storage layout. To decide if this principle proves to be beneficial or not a prior investigation has to be performed. One of the investigating tools is to analyze the shape of so-called ABC curve (Figure 3-4). A flat curve, i.e. many fast moving products, means reduced possibilities to place products according to their frequency. The steep curve, i.e. too few fast moving products, means high potential in placing the products based on the turnover rate.

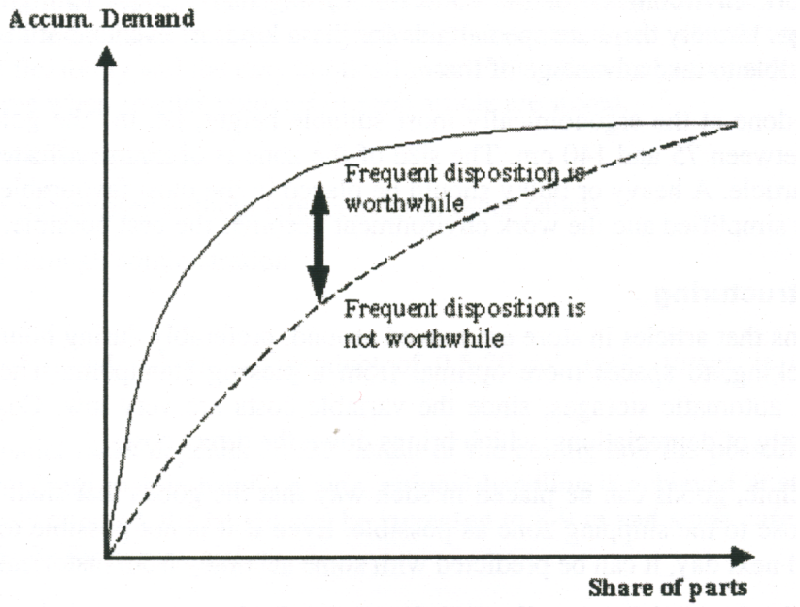

Figure 3-4: ABC division from the articles' frequency.

Source: Lumsden, 2002, p. 277

3.4.4.7 Principle of Similarity

Similarity principle is concerned with storing the products if they are ordered together at the same location is beneficial. The same applies if products are received simultaneously from the same supplier. The principle of similarity requires a serious statistical analysis of the order pattern.

3.4.4.8 Principle of Size and Height

This principle suggests that heavy and bulky articles are stored close to the outbound end of the storage facility or close to the place where they will be used. Another approach is to store heavy items close to the floor to ease the picking work. Ideally picking should be done at the ergonomically most proper height called "the golden zone" which is the height between 75 and 140 cm.

3.4.4.9 Principle of Aisle Length

The length of an aisle is an efficiency trade-off between the storage space utilization and picking speed. With long aisles principle the rack rows and aisles are arranged to flow in the long direction of the warehouse rectangle. This long aisle concept does not have a cross aisle in the middle of each rack to provide easy and quick access to other aisles; however, long aisle concept does provide grater storage density. The short aisle concept specifies that the rack shelve rows and aisles run in the short warehouse dimension or short width of a rectangle-shaped warehouse. This concept requires turning aisles at the end of each rack row. This will lead to decreased storage density and decreased space utilization as cross-aisles need space.[52]

[52] Mulcahy, 1994, p. 3.22

3.4.5 Determining the best Storage-Pick Position System

The definition of a small-item pick position is a location that contains a sufficient SKU inventory to satisfy at least one day of customer demand.[53] In most small-item facilities, the inventory is allocated to a pick position, a ready reserve storage position, or remote storage position. The ready and remote reserve positions hold inventory that does not fit into the pick position.

The decision on which type of storage-pick concept for small-items to use is based on six major factors:

- Storage-pick position type
- Material handling system
- Inventory controlled method
- Customer order requirements
- Building design
- SKU characteristics
  - SKU type (single-item, cartons) and volume
  - Dimensions (length, width, height, and weight)
  - Shape
  - Handling characteristics (security requirements, environment conditions: weather room temperature, refrigeration or warming up)

In addition to the above factors the designers must collect information on the following aspects:

- Storage-pick area size (height and floor space)
- On-hand inventory level (average and peak)
- Withdrawal characteristics (single or multi-packs)
- SKU velocity movement (ABC grouping)
- Replenishment method
- Labor productivity and availability
- Inventory rotation requirements (LIFO/FIFO)
- Degree of security and safety

[53] Mulcahy, 1994, p. 6.39

3.4.6 Types of Storage Equipment

This section gives a short overview of different storage solutions for small-item storage facility. It is often appropriate to use several methods within one storage area since each method gives unique advantages. It is extremely rare that only one storage method is used. However, there are not so many storage concepts that would meet the need of a storage facility that allocates small items and that are manually picked.

3.4.6.1 Shelving

High density shelving storage is used for storage of items that vary from very small details (approx. 1 cm3) to items that due to their weight are handled manually. Shelving is usually used for primary “picking face” in storage. The biggest advantage of shelf storage concept is that it gives a high flexibility in allocating products. Depending on the SKU characteristics shelves can be complimented by modular containers, boxes, baskets, forming closed and open cupboards (Figure 3-5).

Figure 3-5: Shelving

Low frequency products can also be stored on mobile shelves that are mounted on rails so as to reduce aisle space to minimum (Figure 3-6). Shelves are controlled manually, mechanically or by electrical engines. By moving entire sections, handling aisles can be opened in the storage block. Storage of expensive components with low frequency is an interesting application for dense storage system.

This type of equipment requires sufficient investments and can only be justified economically for special purposes, primary used for arrangements in a totally mechanical picking design. Before a storage concept of this kind can be considered, the prior investigation should clearly show that the degree of

filling would be constantly high, even though only one product is kept in stock on each bar track.[54]

Figure 3-6: Compact Storage

3.4.6.2 Box Racking Storage

Racking can be used as the "picking face" for items which are too big or heavy for shelve accommodation or for reserve stocks for replenishing shelves (Figure 3-7). Reserve stocks themselves can be sub-divided into two classes – those which consist of separate cases and bulk storage.[55]

Figure 3-7: Box Racking

[54] Lumsden, 2003, p. 283
[55] Burton, 1973, p.72§

3.4.6.3 Carousel Storage

Horizontal carousel has an endless chain that is attached to a top and bottom drive. Several carousels can be put one by one in a row and serve several picking stations (Figure 3-8). Advantages are that it reduces aisle space, reduces order-picker walking time, and is an excellent method for handling small items. Carousel is a computerized system where items are located and taken out by a computerized system. The computer orders the right storage compartment to a picking station.

Figure 3-8: Carousel storage

The disadvantages of the carousel method in comparison to other methods is that it limits pick position, limits items quantity in the pick position, slow-moving, and requires a replenishment cycle.[56]

3.4.6.4 General Rule of Thumb

A great support in determining the most optimal concept design for small-item storage is existing best warehousing practices that dictate the SKU location within the facility storage. One of them is the *General Rule of Thumb for Case SKUs*. A general rule of thumb for small-item cases storage-pick position criteria is illustrated in Figure 3-9.

General Rule of Thumb for Small SKUs. If the SKUs are very small parts that have the size of 2.5 * 2.5 * 7, 5 cm and smaller, then the storage-pick position criteria are as listed in Figure 3-10.[57]

[56] Mulcahy, 1994, p. 6.29
[57] Mulcahy, 1994, p. 6.40

Case movement	Storage-pick concept
0-1 case	Shelving
1.1-3 cases	1,5-m box rack
3.1-5 cases	3-m box rack
5.1-10 cases	6-m box rack

* Case dimensions are 27, 5 cm width * 25 cm length * 27,5 m height and 11,4 kg weight, and movement is cases per day.

Figure 3-9: General rule of thumb for storage-pick position for case SKUs

Product movement	Storage-pick concept
0-4 items	5 cm *4 5 cm * 12,5 cm bin
4.1-8 items	10 cm *45 cm * 12,5 cm bin
8.1-12 items	15 cm * 45* 12,5 cm bin
12.1-14 items	20 cm * 45 cm * 12,5 cm bin
14.1-18 items	25 cm * 45 cm * 12,5 cm bin
18.1-24 items	30 cm * 45 cm * 12,5 cm bin
24.1-144 items	Shelving
3.1-10 cases	Box rack

Figure 3-10: General rule of thumb for storage-pick position for small SKUs
Source: Mulcahy, 1994, p. 6.40

3.4.6.5 Safety hygienic regulations

In Swedish law there are several safety hygienic regulations written for a surgery department to follow. Some of these regulations concern the storage area and what needs to be thought of when planning the area. Below, we clarify the regulations for three areas that will affect the subject of this study.

Area for unpacking goods

A surgery department must hold a specific room exterior the enter zone for unpacking the bulk incoming goods.[58]

[58] Arbetsgrupp BOV (Byggenskap och Vårdhygien), 2003, p. 52

Area for receiving goods
A surgery department should have an enter zone which allows hygienic wagons with incoming un-bulk goods to enter. These packages should be taken care of by the personnel and be either further transported to storage space or just be reloaded. This area should contain device for hand disinfection.[59]

Storage Area for Sterilized Goods
Storage area for sterilized bulk goods should keep a stable temperature above zero degrees Celsius, be dry and secure for bugs and other noxious animals.[60]

Storage area for un-bulk goods should, as storage for other packages for sterilized material, keep normal room temperature and humidity. The storage room should also be dustless and is not allowed to be a passing-through room. The room should contain device for hand disinfection.

Sterilized products should be stored inaccessible form un-sterilized products. In departments where smaller quantities of sterilized products are stored there should be a particular room or cupboard for this purpose.[61]

3.5 Design of Storage Facility

Typically, a design runs from a functional description, through a technical specification, to equipment selection, determination of a layout, and selection of planning and control policies. Alternatively, these decisions may be situated at a strategic, tactical or operational level of the design process. These levels and the scope of the decisions related to each of them will be given particular attention in this section of the current chapter, since they provide a major framework for the analytical part of the research. The analysis will follow the stages that are determined by the design process levels: level of strategic decisions, level of tactical and operational decisions.

Up to now, no overall accepted systematic procedure exists to design warehouses. Therefore, there is a clear need for research that can support design activities in one particular case.

3.5.1 Strategic Level

Strategic level concerns decisions that have a long term impact, mostly decisions that concern high investments. The four main decision groups at this level are location of the storage facility, design of the process flow, decisions concerning the selection of the types of storage and information system.

[59]Arbetsgrupp BOV (Byggenskap och Vårdhygien), 2003, p. 52
[60]Ibid, p. 29
[61]Arbetsgrupp BOV (Byggenskap och Vårdhygien), 2003, p.30

Location of the storage facility refers to the physical position of the warehouse. It concerns both the geographical location and the location within the site where a certain activity that requires this storage is positioned. Location of the warehouse has a very strategic character since it influences the product, vehicle and people flows to a great extent.

The process flow design defines the required processes. As was mentioned before the basic processes are receiving, storage, orderpicking and shipment. Process flow design output is the decision upon which processes will not be involved in a process flow and which process can be added additionally, for instance, a sorting process may be needed in order to sort orders.

The selection of the storage system concerns technical capabilities. The storage pick position (storage unit), the storage system and the pick equipment have to be suitable for the products and suitable for picking, and should not conflict with each other. The output of this design problem specifies which combinations of systems are technically capable of handling the products and meeting performance constraints.

Although, the range of systems is a limited number of alternatives that must fulfil performance requirements in particular: throughput, response times and storage capacity.

Both process flow design and storage system selection have to be based upon economic considerations:

- The warehouse investment costs are mainly determined by the number of recourses used.
- The warehouse storage capacity is mainly determined by the type and dimensions of the storage system. The storage policy is of minor importance (variable and fixed SKU position, family groups, etc.).
- The maximum warehouse throughput is partly determined by the type and dimensions of the recourses. A large number of other factors may also influence the maximum throughput: the separate reserve area decision, the storage policy, the batch policy, the routing policy and assignment policies (personnel, equipment, etc.).
- The warehouse response time is influenced by a number of organizational decisions, such as, for example, the storing policy.

3.5.2 Tactical Level

On the tactical design level, a number of medium term decisions are to be made, based on the outcomes of the strategic decisions. In general tactical decisions concern the dimensions of recourses (storage system sizes but also a number of employees), the determination of a layout and a number of organizational issues. Clusters of problems that arise at the tactical level and should be treated simultaneously include:

- Determining the size of the picking zones, replenishment policies and batch policies, the selection of a storage concept (variable, fixed, family group based, etc.)
- Determining the dimensions of the storage systems, including the forward and reserve areas
- Determining the number of material handling equipment
- Establishing a layout of the overall system
- Determining the number of personnel

3.5.3 Operational Level

At the operational level, processes have to be carried out within the constraints set by the strategic and tactical decisions. The main decisions at this level concern assignment and control of problems regarding people and equipment. Decisions concerning the storage process at the operational level are:

- The assignment of replenishment tasks to personnel, and
- The allocation of incoming products to free storage locations, according to the storage concept determined at the tactical level.

Concerning the orderpicking process, decisions are related to:

- Batch information or order sequencing, in line with the batch sizes determined at the tactical level
- The assignment of picking tasks to order pickers
- The sequencing of picks per order
- The selection of a dwell point for idle orderpicking equipment, and
- The assignment of products delivery schedule

It is necessary to emphasize the strong hierarchical relationships between decisions made at the strategic, tactical and operational level. During the design process the decisions should follow the order outlined above in this section.

3.6 Supply Chain Philosophy

In this part of the paper we will focus on an organisational analysis from the intra and inter organisational point of view, aiming at the better understanding of the potential benefits when applying the logistic way of thinking. The authors start with a description of the initial level of the logistics way of thinking – an organisation level or in other words the process oriented approach within an organization. Further on it will lead to a better understanding of the importance of the supply chain management and its essentials.

3.6.1 The Process Oriented Approach

When different parts of the organisation are integrated and cooperate with the aim of creating the most value for the customer, external or internal, the organisation is said to be process oriented. The roots of this approach lead to the moment of the actual establishment of the organization. According to Ljungberg, the construction of the organisation has to be purpose oriented if successful and efficient achievement of its goals is prioritized.[62]

For that reason one of the most important concerns for management is to produce prerequisites for the whole organisation to reach its goals. Below the traditional function oriented organization approach is discussed and it is compared with the process orientated approach.

In the traditional hierarchical or function oriented organizations, the specialised departments take care of their own parts of responsibility inside the organisation, without integration between the departments. Thus, a series of handling over between the areas of responsibility are made before the final task is completed. This kind of organizational structure is built on the assumption that generally speaking human beings are not skilled enough to perform advanced tasks, and that might limit the organisation's ability to obtain the human's initiative, strength, ability and capacity. This way of organising might lead to sub-optimisations, internal hierarchic disputes, lack of customer focus, bureaucracy, slow decision-making and difficulties to adapt the organisation to external changes.

The functional oriented organisation is sometimes illustrated with the brick walls in between the different functions or departments. In this kind of an organisation the internal view is vertical, and cooperation between the different subparts would require abnormal crossings of boundaries.

[62] Ljungberg & Larsson, 2002, p. 180

The essential cooperation between the parts which is created for the survival of the organisation is only based on the assumptions and illusions about “the other side of the brick wall”, and comments shown in Figure 3-11 below are typical.[63]

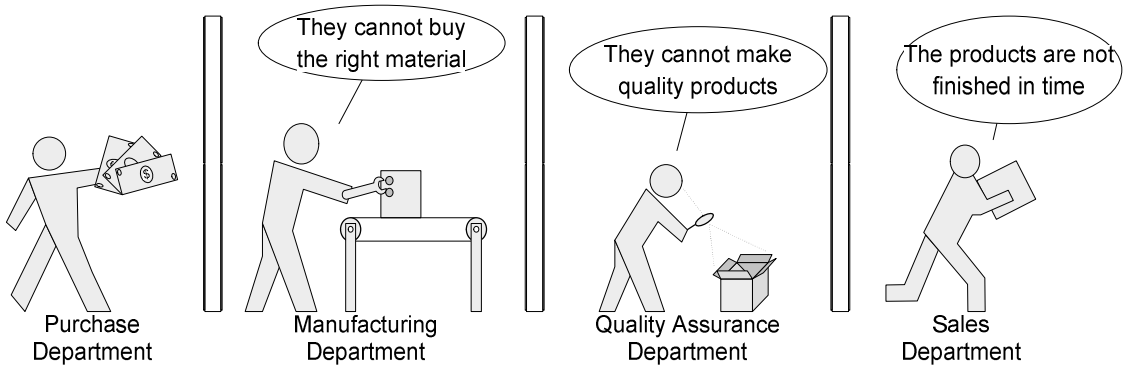

Figure 3-11: Typical attitudes within a Function Oriented Organisation

The figure above is able to illustrate two kinds of scenarios. One is within the organisation where the departments do not co-operate. To illustrate this in a hospital case would mean that achieving an efficient patient flow through each department is seen to be more important than an efficient patient flow through the whole hospital. The second scenario of this figure will lead to the discussion about supply chain management, and since this concept is generally more complicated, it will be explained in the following section.

3.6.2 The Supply Chain Management

process has by this point of the discussion been limited within the scale of an organisation. The cooperation between departments and information delegation between several organisations will give us an even bigger perspective on the problem. The following discussion will cover the reasons behind the necessity of cooperation between organisations, in other words the incentives of joining into the supply chain.

The discussion starts with focusing on the second scenario outlined in the figure above. Apart from the organization perspective the figure is also able to illustrate that the described processes can be seen from a supply chain perspective. That would mean that various activities illustrated in the figure are performed by different companies which complete their activity before handling it over to the next company in the chain. The problem in this case is that companies do not see the output of the whole chain as the ultimate goal, instead they trace their individual output goals.

If the supply chain concept was reflected through the hospital case that would signify that the companies in the material supply chain do not realize that the output is to satisfy the needs of the patients in both the most economical and time efficient way, and not just closing the transactions at a certain price. The notion is that every firm within the supply chain is conscious about its input to the overall output result produced by the chain. Although, this sophisticated level of supply chain philosophy, is not easy to achieve, and requires a great deal of chain coordination, the discussion about which will follow later in this section.

The next step in the discussion is to consider some of those instruments that are in the toolbox of the supply chain management, and these are: market distribution mechanism, channel coordination and tiering the suppliers. Discussion will end with outlining the goals of supply chain management.

3.6.2.1 Market Distribution Mechanism

Channel of distribution is necessary to support and structure the supply chain. It can be defined as a network of organisations and institutions that, in combination, perform all the functions required to link producers with end customers. Specialization in these functions by organisations creates the need for a process to resolve the problems of efficient and effective exchange between those organisations. These problems relate to time, place, quantity and assortment requirements.[64]

The discrepancy in space refers to the fact that the location of production activities and the location of consumption are seldom the same. Discrepancy in time refers to the difference in timing between production and consumption. Discrepancy in quantity and assortment refers to the fact that manufacturing firms typically specialize in producing large quantities of a variety of items.

These basic problems of exchange are resolved by the overall market distribution process, through the mechanism typically referred to as the channel of distribution.

Market distribution mechanism must emerge to resolve these problems and create efficiency by minimizing the transactions required to meet customer demand. In fact, market distribution can be thought from the conceptual point of view as two separate structures: one to fulfill the buying and selling activities required and another to fulfill the logistics activities.[65]

[64] Bowersox, 2002, p.94
[65] Bowersox, 2002, p. 95

When different channel members specialise in various functions it requires to have a well working channel coordination to achieve a smooth cooperation within the chain. The description of channel coordination is following next in the discussion.

3.6.2.2 Channel Coordination

A channel is said to be coordinated when the separate members of the channel are brought together to set up the goals of the channel, rather than their own independent goals. Channel coordination is not a one-time achievement, but an ongoing process of analysis and response to the market, the competition, and the abilities of the members in the market. [66]

The core for channel coordination is logistics because it ties all the links of the chain together. Supply chain management integrates goods, resources, information and financial flows among companies from the point of production to the point of consumption with the goal of maximizing consumption satisfaction and minimizing company costs.[67]

A good coordination among operations, marketing, purchasing and all other activities within the supply chain cannot be overestimated. Failing to recognize that can negatively affect operations.

3.6.2.2.1 Reasons for Channel Coordination

Now, significant elements of channel coordination theory are reviewed to highlight why interaction between companies in a channel is important.

If a channel is coordinated the specialisation idea can be accomplished. The logic of specialization is based on economies of scale and economies of scope which are the fundamental drivers of economic efficiency. Specialisation means that the individual companies within a coordinated chain should focus only on the activities they are good at. The result of this is that each activity is performed by an expert in the most efficient way.

One example of such an expert is a first-tier supplier, that buys specific assortments adjusted to the customer's needs it serves. A first-tier supplier is an expert in offering the most suitable assortment and stores it on behalf of the customer.

Another objective which is real to achieve if the channel is coordinated is the assortment objective. The process of building an assortment can be as well

[66] Coughlan, et al., 2001, p. 38
[67] Lumsden, 2002, p. 90

illustrated on the same first-tier supplier example since it is the closest link to the chain customer. The process consists of various activities.

One activity in building the assortment concerns the allocation which refers to breaking down a homogenous group of products into constantly decreasing lot sizes unless the lot size matches the required volume. Allocation is also known as the process of bulk breaking.

Another activity concerns the customization which refers to regrouping the products into an assortment of items for resale that would exclusively meet requirements of the specific customer. In this case the first-tier supplier works on behalf of its customer when executing purchasing from the second-tier suppliers since first-tier suppler has a very good knowledge of product characteristics demanded by the customer.

The last activity in the assortment concerns dispersion which refers to shipping the customized assortment to customers when and where specified by the customer.[68]

3.6.2.3 Tiering of the Suppliers

To tier the suppliers refers to the process of giving some suppliers the encouragement to assume greater responsibility than other suppliers. The supplier that works closest to the customer gets the most responsibility and is called the first-tier supplier. By close is meant that this supplier is located closest to the customer in the supply chain and with whom the customer communicates directly. This primary supplier is responsible for structuring the rest of the supply network and maintains fine contacts with the second-tier suppliers. The second-tier suppliers are then responsible for the contacts with the third-tier suppliers and so on.

The outcome of tiering suppliers is sort of a network that consists of all the suppliers that deliver various products to the customer. The number of network tiers usually depends on the degree of specialisation within the business. The hospital example is helpful to understand this pattern.

Suppose one of the departments within a hospital needs a very special product. The purchasing of this product can be performed directly from the supplier who gets this product from the producer. However, it has been proved that using its first-tier supplier that in turn has bought the product from the second-tier supplier is the most efficient way. The second-tier supplier might be some

[68] Bowersox, 2002, p. 97

kind of a wholesaling company for that product that accumulates the total assortment group of this specific product. The pattern can be continued down to the actual manufacture of the product and then even further down in the same manner to the level of raw material tier-suppliers. Figures 3-12 and 3-13 below show the difference on the outlook of the non-tiered and tired supply chain networks.

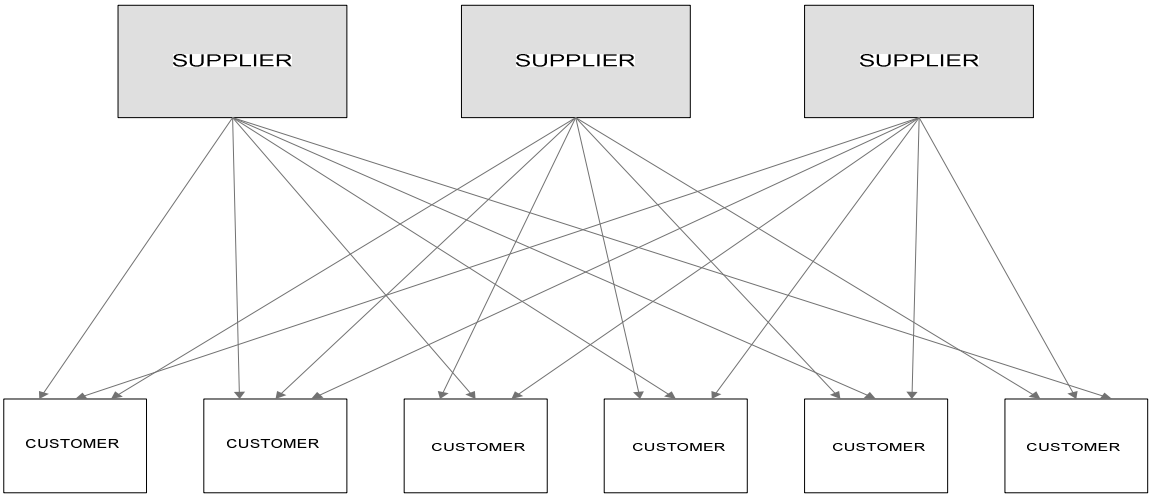

Figure 3-12: None-tiered network

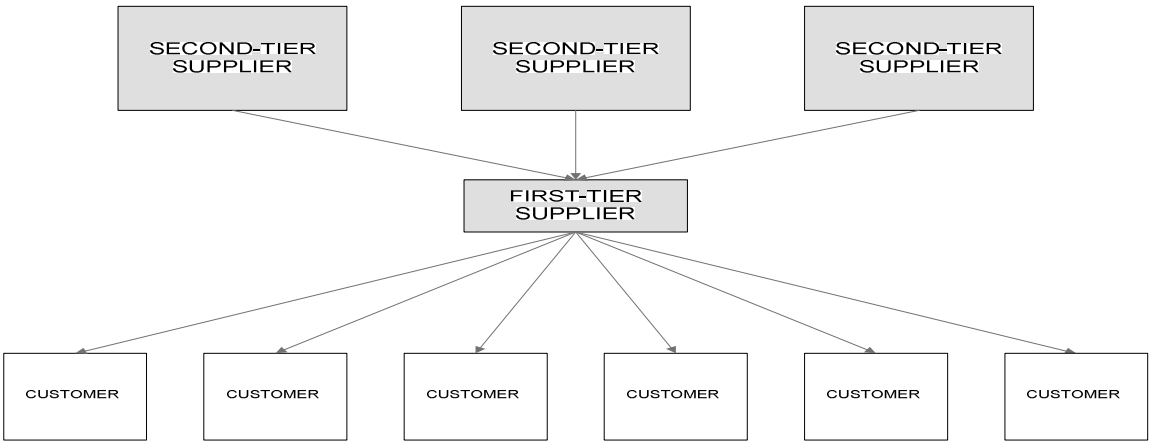

Figure 3-13: Tiered network

The first-tier supplier, shown in Figure 3-13, is referred to as a specialist within the market who purchases the output of each second-tier supplier. The products are delivered to one location (concentration) where the first-tier supplier breaks the bulk (allocation) and customizes quantities (customization) according to each customer's specific requirement. These customized assortments are then transported to the individual customer's locations (dispersion).[69]

[69] Bowersox, 2002, p. 97

When using the first-tier supplier, the total number of transactions is reduced. On the Figure 3-13, only three transactions are required from second-tier suppliers to the first-tier supplier, and only six from the first-tier supplier to the customer. Compare this number of transactions to Figure 3-12 where as many as 18 transactions are used. The savings in order placement, processing, and fulfillment costs can be substantial. Furthermore, the costs of transportation is substantially reduced because there are only 9 transportation movements, each of large quantity, rather than 18 individual small quantity shipments.

The first-tier supplier is usually an external company but it can also be an internal part within the organisation. This situation is usually the case within public owned organisations such as county governments.

3.6.2.3.1 Reasons for Tiering the Suppliers

The reasons for tiering the suppliers are the following:

- More efficient purchasing activity which will reduce the transactions cost
- Economies of scale and scope might be achieved in the purchasing activity
- The first-tier supplier is a specialist and can spend a lot of time focusing on trends in the market
- Special price reductions and sales are easier found[70]

3.6.2.3.2 How to tier the Suppliers

The key question to ask when organizing the suppliers is which principle to apply concerning how many suppliers to use in parallel. The main alternatives are single sourcing and multiple sourcing.

Single sourcing means that the company only uses one supplier for an article even if there are multiple companies in the market. Multiple sourcing means that the company uses multiple suppliers simultaneously in parallel. This model has, in the past, been the most dominant supply chain strategy. The main purpose to use multiple suppliers in parallel is that they compete with each other and by that improve the negotiation position when price is set.[71]

The first managerial issue in the process of tiering the suppliers is then to consider which partners are needed in the network and the question to use single or multiple sourcing. Here, it is important to review the existing network to check if suppliers' service activities duplicate or if some of the suppliers

[70] Mattson, 2000, p.250-253
[71] Mattson 2000, p. 244-247

offer the same product assortments. Should that be so the number of suppliers might be reduced.

The next step to take is to find out which of the remaining suppliers have the most resources and capability needed to represent the requirements of the purchasing company. It might be very difficult to decide which supplier should get the primary position, but in some cases circumstances make this decision uncomplicated. In cases when there is an internal unit within the organization, which has both knowledge and resources to perform the functions of the first-tier supplier, the decision becomes very obvious.[72]

The third step to take is to create a co-operation among various suppliers in the network. At this stage the purchasing company improves the relationship with the first-tier supplier, the first-tier with the second-tier suppliers and so on. The analysis of the relationship involves the need for trust and commitment as well as the simultaneous occurrence of conflict and co-operation. These aspects of the atmosphere are no less important when we deal with network efficiency.[73]

Another managerial issue is concerned with the information exchange in the network. To establish an efficient communication structure is a prerequisite for a functioning network. Part of this communication structure is about building formal structures for the exchange of information with for example EDI systems. But also informal exchange of information is essential for the future development of the network because it provides opportunities for identifying new combinations of actors, activities and resources. [74]

3.6.3 The Goal of Supply Chain Management

After the above discussion concerning different aspects of the supply chain management it is proper to give an overview of what a good coordinated supply chain might generally result in.

The ultimate goal of the supply chain is to create value for the customers. The logistics executive is faced with the challenge of managing logistics inputs to create services for the customer that do not create gaps, that meet the requirements of the customer, and that agree with the perceptions of the customer. If this occurs, quality is achieved and value is created. [75]

The customer's perception of service quality is basically the same as the customer's attitude. A customer's attitude is developed over time and is not

[72] Gadde, 2001, p. 171
[73] Ibid, p. 171
[74] Gadde, 2001, p. 173
[75] Coyle, 1999, p. 15

necessarily changed by a single transaction. Attitude is needed to be developed and managed among the customers because it is attitude that directs repurchase decisions. A good customer attitude will allow the service provider to grow and be profitable, while a negative attitude will dramatically slow growth and reduce profits. Positive attitude is achieved by continuous and reliable delivery of quality services, what is in other words the main goal of supply chain management. [76]

3.6.4 Channel Problems Analysis

In this part a certain algorithm isclarified that will later be used for the analysis of the current supply channel. This way of analyzing has been learnt by the authors from lectures of Professor Adel El-Ansary, a co-author of the book "Marketing Channels".[77]

The algorithm divides the channel into three parts to be able to analyse each part separately. The objective to use this algorithm is to obtain assistance through the analyses. Once a problem in a channel is discovered for its elimination it is important to understand what causes the problem. The three parts that are used and described below are: channel management, channel strategy and channel structure.

3.6.4.1 Channel Management

The goal of a channel implementation is to achieve channel coordination, which can be achieved by using power to manage conflicts. First, there is a need to identify power sources and channel conflicts.[78] A channel member's power is its ability to control the decision variables in the marketing strategy of another member in a given channel at a different level of distribution.[79] Channel conflict is generated when a channel member's actions prevent the channel from achieving its goals. Given the interdependence of all channel members, any single member's actions have an influence on the total success of the channel effort, and can harm the total channel performance. Channel conflict can stem from differences between channel member's goals and objectives (goal conflict), from disagreements over the domain of action and responsibility in the channel (domain conflict), and from differences in perceptions of the marketplace (perceptual conflict). These conflicts directly cause a channel member to fail to perform the flows that the optimal channel design specifies for them, and thus inhibit total channel performance. The channel management problem is twofold. First, the channel manager needs to be able to identify the sources of channel conflict, and in particular, to

[76] Coyle, 1999, p. 19
[77] Coughlan, Anderson, Stern, El-Ansary, 2001, p. 98
[78] Ibid, p. 110
[79] Ibid, p. 36

differentiate between poor channel design and poor performance due to channel conflict. Second, the channel manager must decide upon the action to take in order to manage and reduce the channel conflicts that have been identified.[80]

Often one channel member can be considered the "channel captain". This is an organization that takes the keenest interest in the work of the channel for this product or service, and that acts as a prime mover in establishing and maintaining channel links.[81]

3.6.4.2 Channel Strategy

The channel strategy is the method used in the channel for various activities. It is important that the plans for the activities are rather similar or a least aiming for the same outcome.

3.6.4.3 Channel Structure

The design of the channel structure involves two main elements. First, the channel designer must decide who are to be the members of the channel and also the exact identity of the channel partner to use at each level of the channel.[82]

The other main element of the channel structure is the decision of how many of each type of channel member will be in the channel. This is the channel intensity decision. The channel structure decisions upon type, identity, and intensity of channel members all should be made with the minimization of channel flow costs in mind.[83]

3.7 Information Systems

Logistical operations today are overwhelmed with the vast amount of data available to them. When processing data it has becoming more and more common to use information systems that use available raw data and portray meaningful information to the managers. The term information, however, is often confused with the term data.

Data consists of raw facts, such as inventory item article numbers and order volumes, while information is a collection of facts organized in such a way that they have additional value beyond of the facts themselves.[84]

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[80] Coughlan, Anderson, Stern, El-Ansary, 2001, p. 37
[81] Ibid, p. 12
[82] Coughlan, Anderson, Stern, El-Ansary, 2001, p. 33
[83] Ibid, p. 34
[84] Stair&Reynolds, 2003, p. 5

The most common types of information systems used in organizations are electronic commerce systems, transaction processing systems, management information systems, and decision support systems.[85] This section will deal with the description of technical characteristics and possible applications of transaction processing systems.

3.7.1 What Is An Information System?

An information system is a set of interrelated components that collect (input), manipulate (process), and disseminate (output) data and information, and provide feedback to meet an objective.[86]

Input is the activity that concerns gathering and capturing raw data. Input can take many forms. A bar code scanning is one of them. By scanning the bar codes located on products different data on products circulation can be downloaded into the system.

Processing refers to converting data into useful outputs. Processing involves calculations, making comparisons and taking alternative actions, and storing data for future use. This way the system calculates the order point from the data gathered about product consumption.

Output involves producing useful information in form of documents and reports. In case of automated re-ordering system the output is an order list.

In information systems feedback is output used to communicate errors or problems that happened during the input or the processing of data. For instance, if the maximum order quantity equals to 100 units, and accidentally 150 units were ordered, the system would determine that 150 is out of range and provide feedback, an error report. The feedback is used to correct the input data.

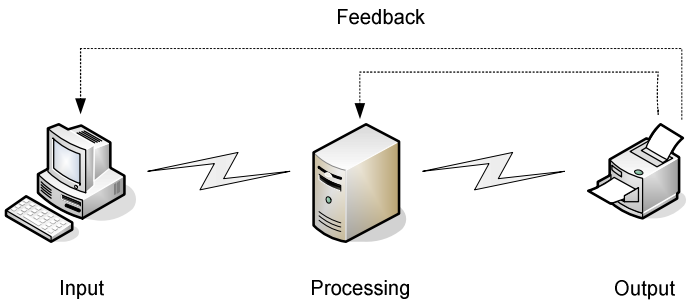

Figure 3-14: Components of information system

Source: Stair&Reynolds, 2003, p. 13

[85] Stair&Reynolds, 2003, p. 18
[86] Ibid, 2003, p. 13

3.7.2 Order processing system

A transaction processing system (TPS) is an organized set of people, procedures, software, databases, devices used to record transactions and standardized communications. At the most basic level, TPS initiate and record organization's individual logistics activities and functions. One of the most commonly used TPSs is an Order Processing System.

The primary function of the order processing system is to provide a communication network that links the customer and the supplier.[87]

No other logistics functions have benefited more than order entry and processing. Currently, there are still many traditional ways to communicated orders by telephone, fax and e-mail. However, electronic method such as end-to-end computer system is the trend that gains speed all the time. This fact does not surprise because electronic methods are more consistent and fast, in the long run more cost efficient and offer a wide range of functions that come along with the main ordering functions (ordering functions will be discussed later in the chapter). Electronic end-to-end system can accumulate useful statistics information about the actual consumption, finance information for cash-flow planning and even information for production scheduling, if the system tires customers, distributors and manufactures together.

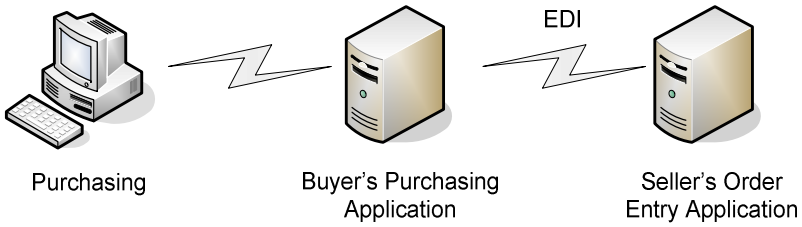

Figure 3-15: Electronic Data Interchange System

Source: Stair&Reynolds, 2003, p. 13

3.7.2.1 Inventory Control System

For each item picked during the picking process, data on stock level and quantity picked is passed to the inventory control system. In this way, the computerized inventory records are updated to reflect the exact quantity on hand for each SKU. It allows personnel that are responsible for inventory control receive current information about the SKUs stock levels.

Once items have been picked from the picking positions and the data has been input to the system, different documents and reports are initiated by the

[87] Stock&Lamber, 2001, p.151

inventory control application. Normally this report contains item description, number of items on hand and number of items that have to be ordered because their stock level has reached the determined order point. In this case the data from this report is used as an input to order processing system and is sent via EDI transaction directly from a buyer's purchasing application over a wide area network to the supplier's order entry application.

In addition, the inventory control system can generate a number of other valuable informative reports. For example, it can summarize all inventory items picked during a certain period of time, most frequently ordered items, prices for ordered items, etc.

Real time inventory control systems are using auto identification (ID) systems such as bar coding and electronic scanning to collect the data on item pick-up or arrival to the storage area. Coupled with EDI, auto ID provide a powerful tool for providing accurate information with high speed between the organizations in a supply chain.

3.7.2.1.1 Bar-codes

A bar code is a pattern that consists of spaces and bars arranged according to a certain principle. Once the scanner is passed over the bar code, light waves are reflected off of the code and read by the scanner. These waves are converted to a frequency and assigned a "0" or "1" (binary code) based on weather light was reflected from the space on the bar code or absorbed by the bar. The particular symbology standard specifies possible sizes of bars and spaces. In some cases, the standard may specify the distances from one bar to the next and from one space to the next. In all cases, these sizes and distances are expressed in terms of multiples of the smallest dimensional unit, called a module. The module is the smallest width and/or length of a space, bar or dot in the barcode symbol. Each character of encoded data is represented by set of bars and spaces of varying width. The standard specifies how many bars and spaces encode a character. Typically the total number of space and bar modules encoding a character is fixed for a given code type. Sometimes, the name of barcode reflects these numbers, as in Code 39 which is described later on. Bars and spaces at the beginning and at the end of the barcode symbol, called start/stop characters, are added to identify a barcode of a specific type.[88]

The most common codes in logistics are Code 39, Code 128, Interleaved 2 of 5, and PDF 417.

[88] http://www.inliteresearch.com/homepage/technology/b_standards.html, downloaded on 22.10.04

Code 39 was developed because of the raised necessity to encode both numeric and alphabetic data. Code 39 uses five bars and four spaces. Two bars and one space are wide and the remaining six spaces and bars are narrow. The three wide elements out of the nine total is where the name Code 39 comes from.[89]This code is typically used in non-food industries for identification, inventory and tracking purposes.

Code 128 evolved when the need for more informative bar coding standard that have a wider character selection. Code 128 offers 3 major advantages, they are:[90]

- Complete: It is one of the most complete, alphanumeric, one-dimensional symbologies available today.
- Compact: Code 128 is one of the most compact linear bar code symbologies what is important when label size on small items is an issue (see the comparison with Code 39, Figure 3-16).
- Reliable: Code 128 symbols use two independent self-checking features which improve printing and scanning reliability.

Figure 3-16: Comparison of symbol length between Code 128 and Code 39

* The figure shows a 15 alphanumeric data string using the same narrow bar/space "X" dimension.

Source:
http://www.inliteresearch.com/homepage/technology/b_standards.html

It is projected that over 90% of all shipments in the medical, retail, apparel and wholesale drug industry will use Code 128 symbology to track expiration dating, lot numbers, and production dates.

Due to the fact that the present paper is devoted to the healthcare sector the structure and the existing standards for Code 128 will be given in more detail.

[89] Transportation, 2000, p. 408
[90] http://www.ean-int.org/index.html?http://www.ean-int.org/intro.html&2, downloaded on 22.10.04

3.7.2.1.2 Code 128 Standards

There are two different standards, HIBC (The Health Industry Bar Code) controlled by the Health Industry Business Communication Council (HIBCC) and UCC/EAN code standard controlled by HIBCC's affiliate international organizations, the Uniform Code Council and the International Article Numbering Association.[91] Both code standards are in substantial use in the medical industry and give the adequate functionality (see Appendix 5 for more application areas of bar codes). For the suppliers the decision on which bar code standard to use is based on many factors, such as functionality, customer preferences, use in related trades and future developments. For the European manufacturer of medical products, this will normally lead to choosing EAN standard. However, it is recommended that hospitals and healthcare logistics organizations arrange for handling both code standards.[92] It is also important to mention that UCC/EAN identification is the basis for the small item package identification system.

3.7.2.1.3 UCC/EAN-128 code structure

UCC/EAN-128 bar codes always contain a special non-data character known as function 1 (FNC 1), which follows the start character of the bar code. It enables scanners and processing software to auto-discriminate between UCC/EAN-128 and other bar code symbologies, and subsequently only process relevant data. The UCC/EAN-128 bar code is made up as follows (Figure 3-17):

- a light margin
- a start character A, B or C
- a FNC 1 character
- Data (Application Identifier + data field)
- a symbol check character
- a stop character
- a light margin

[91] The Health Industry Bar Code Supplier Labeling Standard, http://www.hibcc.org/autoidupn/docs/SupplierStandard.pdf, downloaded 23.10.04

[92] EUCOMED Position on Bar Coding for Medical Devices, http://www.eucomed.be, downloaded 23.10.04

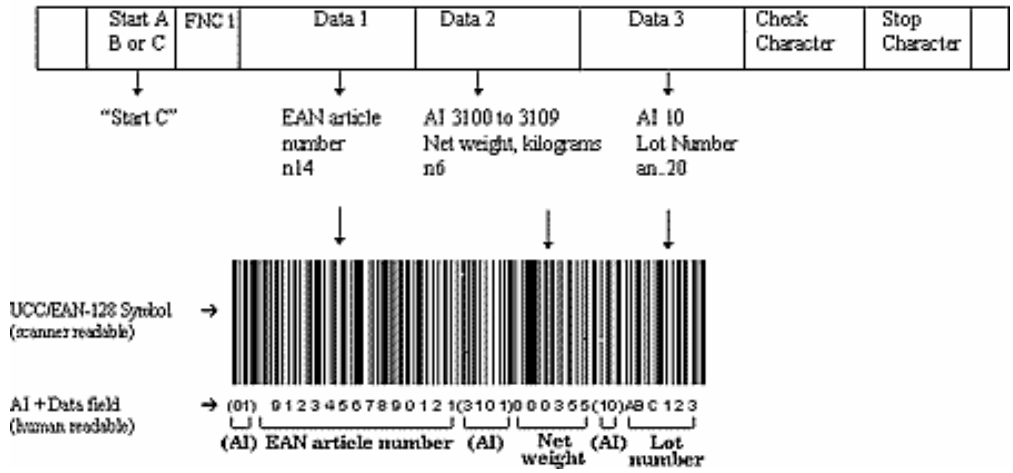

Figure 3-17: Example of UCC/EAN 128 Code

Source: http://www.eucomed.be

3.7.2.1.4 Scanners

Another key component of Auto ID technology is the scanning process, which represents the eyes of a bar code system. A scanner optically captures bar code data and converts it to usable information. Most popular type of a scanning device is a handheld laser guns that ensure flexibility and convenience in their implementation. Auto ID technology is widely used in material handling sphere. Through the use of bar codes and scan guns the responsible personnel in the warehouse can have a better control of product movement, item storage location and inventory replenishment.[93] It is obviously important, though, that scanning is done with high extent of accuracy, which would require:

- Educating the staff
- Maintenance of scanning equipment
- Correct product information files
- Barcode printing quality
- Appropriate location of the barcode

Modern scanning devices today vary in their sizes, shapes and level of complexity. It can be a simple laser gun (Figure 3-18) when command communication is performed through barcode commands scanning and scanning data extraction is done by connecting the gun to the keyboard.

[93] Bowersox, 2002, p.216-219

Figure 3-18: Laser scanning

Another category of scanning guns can have the built-in keyboard that allows data input into the device while data extraction is done through the terminals that transmits data into the computer inventory system (Figure 3-19).

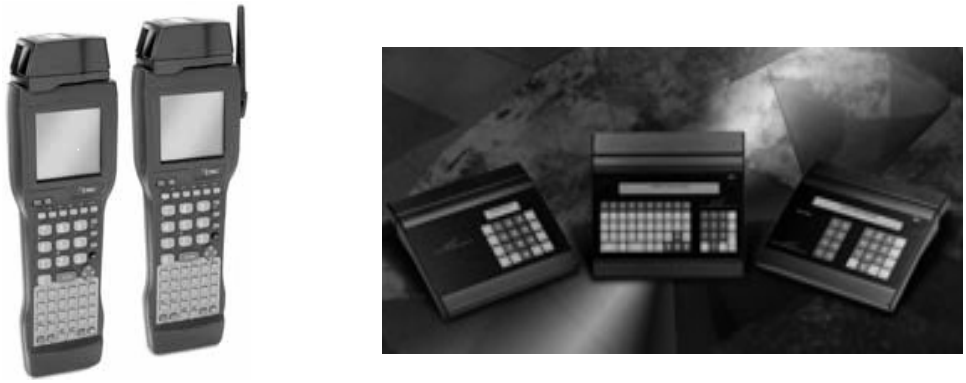

Figure 3-19: Scanners with terminals

It also becomes rather common to use hand-computers with built-in scanning device and wireless data transmission device (Figure 3-20).

Figure 3-20: Hand-computer

3.7.2.1.5 Electronic Data Interchange

Electronic data interchange can be defined as the interorganisational exchange of business documentation in structured, machine-processable form, or in other words it is the communication between two computers.[94]

EDI transmits business documents electronically in standard form avoiding traditional communication such as telephone, fax and e-mail. EDI transmission allows the receiving side to process the received document directly, often with sophisticated systems without any human intervention in the process. A very common application of EDI is order processing system, when orders are placed directly into the seller's order entry application.

3.7.2.1.6 Types of EDI Systems

The main types of EDI systems are proprietary systems, value-added networks (VANs) and Virtual Private Networks (VPN).[95] A proprietary system is an EDI system that is owned and maintained by a single large company that buys materials from a number of supplies or sells its products to many customers. Normally this company is the strongest link in the supply chain and has power and recourses to initiate EDI project and encourage its business partners to become a part of the EDI network.

VANs which are as well known as third party networks or many-to-many systems. With VAN in use, all the EDI messages from different organizations that have incompatible EDI message standards go through a third-party firm, which redirects messages to a proper receiver after having translated them according to the EDI standard supported by the receiver. In this case business partners do not have to worry about the system compatibility.

One of the major trends in EDI is using Virtual Private Networks. Virtual Private Network usually refers to a network in which some of the parts are connected using the public Internet, but the data sent across the Internet is encrypted, so the entire network is virtually private. A typical example would be a company network where there are two offices in different cities. Using the Internet the two offices merge their networks into one network, but encrypt traffic that uses the Internet link.[96]

This solution has the lowest investments since EDI over the Internet is virtually free. It requires only a software purchase and systems setup

[94] Stock&Lambert, 2001, p.158
[95] Stock&Lambert, 2001, p. 159
[96] http://computer.howstuffworks.com/vpn.htm, downloaded 18.01.05

investments. Experts say that it is just a matter of time when before the Internet solution will completely replace other solutions.[97]

A well-designed VPN can greatly benefit a company. For example, it can:

- Extend geographic connectivity
- Improve security
- Reduce operational costs versus traditional proprietary systems
- Reduce transit time and transportation costs for remote users
- Improve productivity
- Simplify network topology
- Provide global networking opportunities
- Provide telecommuter support
- Provide broadband networking compatibility
- Provide faster ROI (return on investment) than traditional proprietary systems

Through the use of dedicated equipment and large-scale encryption, a company can connect multiple fixed sites over the Internet. VPN uses several methods for keeping your connection and data secure. The major methods are firewalls and encryption.

A firewall provides a strong barrier between your private network and the Internet. Firewalls are set to restrict the number of open ports, what type of packets are passed through and which protocols are allowed through.

Encryption is the process of taking all the data that one computer is sending to another and encoding it into a form that only the other computer will be able to decode. Most computer encryption systems belong in one of two categories: symmetric-key encryption and public-key encryption.

In symmetric-key encryption, each computer has a secret key (code) that it can use to encrypt a packet of information before it is sent over the network to another computer. Symmetric-key encryption is essentially the same as a secret code that each of the two computers must know in order to decode the information. The code provides the key to decoding the message. The sending computer encrypts the document with a symmetric key, then encrypts the

[97] Newton D. Swain, 1996, p.12

symmetric key with the public key of the receiving computer. The receiving computer uses its private key to decode the symmetric key. It then uses the symmetric key to decode the document.

Public-key encryption uses a combination of a private key and a public key. The private key is known only to your computer, while the public key is given by your computer to any computer that wants to communicate securely with it. To decode an encrypted message, a computer must use the public key, provided by the originating computer, and its own private key.

Depending on the type of VPN certain components will be needed to build a VPN. These might include:

- Dedicated hardware such as a VPN concentrator or secure Private Internet Exchange firewall
- Dedicated VPN server for dial-up services
- Router
- Switch
- VPN network and policy-management center

Because there is no widely accepted standard for implementing a VPN, many companies have developed turn-key solutions on their own.

3.7.2.1.7 VPN Protocols

Most VPNs rely on tunneling to create a private network that reaches across the Internet. Essentially, tunneling is the process of placing an entire packet within another packet and sending it over a network. The protocol of the outer packet is understood by the network and both points, called tunnel interfaces, where the packet enters and exits the network.

Tunneling requires three different protocols:

- Carrier protocol - The protocol used by the network that the information is traveling over
- Encapsulating protocol - The protocol (IPSec, PPTP, L2TP, SOCKS v.5) that is wrapped around the original data
- Passenger protocol - The original data being carried

Tunneling has amazing implications for VPNs. For example, it is possible to place a packet that uses a protocol not supported on the Internet inside an IP packet and send it safely over the Internet.

The protocol which seems destined to become the de facto standard for VPNs is IPSec (Internet Protocol Security). IPSec is a set of authentication and encryption protocols, developed by the Internet Engineering Task Force (IETF) and designed to address the lack of security for IP-based networks.[98]

The IPSec protocol typically works on the edges of a security domain. Basically, IPSec encapsulates a packet by wrapping another packet around it. It then encrypts the entire packet. This encrypted stream of traffic forms a secure tunnel across an otherwise unsecured network.

The majority of VPN vendors are implementing IPSec in their solutions. The comprehensive nature of the protocol make it ideal for site-to-site VPNs, although there are still interoperability issues that exist across different vendor's implementations. IPSec is a bi-directional protocol, which means that extranet configurations must be carefully designed and implemented. When setting up an extranet VPN, it may not be needed to give all the business partners access to the entire network or allow them to access yet another partner through the network.

PPTP is a tunneling protocol which provides remote users encrypted, multi-protocol access to a corporate network over the Internet. Unlike IPSec, PPTP was not originally designed to provide LAN-to-LAN tunneling.

PPTP is built in to NT 4.0, and the client is a free add-on to Windows95. Microsoft's implementation of PPTP has been found to have several problems that make it vulnerable to attacks, and it also lacks scalability in that it only supports 255 concurrent connections per server. The low cost and integration with NT and Windows 95, however, makes PPTP a viable remote access solution where multi-protocol access is needed, heavy-duty encryption and authentication is not needed, and a Microsoft-only solution is appropriate.

PPTP can support only one tunnel at a time for each user. However, its proposed successor, L2TP (a hybrid of PPTP and another protocol, L2F) can support multiple, simultaneous tunnels for each user. L2TP will be incorporated in Windows 2000 and can support IPSec for data encryption and integrity.

SOCKS version 5 is a circuit-level proxy protocol that was originally designed to facilitate authenticated firewall traversal. It provides a secure, proxy architecture with extremely granular access control, making it an excellent choice for extranet configurations.

SOCKS v5 supports a broad range of authentication, encryption, tunneling and key management schemes, as well as a number of features not possible with

[98] http://compnetworking.about.com/od/vpn/l/aa010701d.htm, downloaded 20.01.05

IPSec, PPTP or other VPN technologies. When SOCKS is used in conjunction with other VPN technologies, it's possible to have a more complete security solution than any individual technology could provide. A user may, for example, incorporate IPSec and SOCKS together. IPSec could be used to secure the underlying network transport, while SOCKS could be used to enforce user-level and application-level access control.

3.7.3 Benefits of Order Processing System

Order Processing System that utilizes bar-coding, scanning and EDI technologies offers a wide range of benefits for both a single organization and a whole supply chain. These benefits include:[99,100]

- Reduced stock holdings through accurate data on product day to day demand and order cycle time
- Improved channel relationships by avoiding commercial disputes between the buyer and the seller
- Eliminates stock-out situations
- Ensures the un-interrupted flow of deliveries
- Increased productivity through faster and accurate order transmission and reduced redundancy
- Reduces operating costs of issuing purchase orders through reduced labor and material costs associated with data entry, filing, printing, mailing, and handling paper-based transactions; reduced telephone and fax costs

3.7.4 Continuous Replenishment Programs

Computer assisted order processing system gives additional functional possibilities when it comes to the replenishment methods, such as Vendor Managed Inventory (VMI) and Co-Managed Inventory (CMI). Both methods are known as continues replenishment techniques. The classification of these techniques into two groups is made on the basis of which party has the responsibility for the management of the inventory, and secondly, taking into account the extent to which the partners are sharing information.[101] However, both models apply the cross-company supply chain integration approach where the supplier becomes somewhat of a process owner and carried out activities traditionally belonging to the purchasing process in the customer's company. This approach eliminates a number of activities that the buying company otherwise would have to perform.[102] The main purpose of CRP system implementation as well as in case of COP is to decrease stock levels and

[99] Computer Assisted Ordering, pp.3-4, http://www.ean-int.org/Doc/EDI0001.pdf , downloaded 23.10.04
[100] Bowersox, 2002, p.206
[101] Continues Replenishment, p.4, http://www.ean-int.org/Doc/EDI0002.pdf , downloaded 23.10.04
[102] Stig-Arne Mattson, 2004, p. 337

improve product availability within the replenishment chain, from the point of manufacturing to the point of use.[103]

3.7.4.1 Vendor Managed Inventory Model

When the supplier has the full responsibility to replenish buyer's inventory, consumption and inventory information must be transmitted by the buyer to the seller as often as the replenishment is executed. This information is used by the supplier's replenishment system as historical data for future requirement calculations and adjustments for the future consumption.

The next step is to process the given information in the supplier's continues replenishment system. Based on current and forecasted future demand for products the system generates automatically the required order quantities. The order information is then transmitted to the buyer to update the buyer's order processing system (see Figure 3-23 for the information transmissions scheme).[104]

3.7.4.2 Co-Managed Inventory

The main difference of CMI from VMI is that the generated order quantities generated by CRP system have to be revised and confirmed by the buyer. In this way the buyer maintains the responsibility for the inventory replenishment and can vary the order quantities depending on the current conditions. CMI is a rather convenient model since the buyer is not fully involved in inventory control but at the same time can adjust the amount of ordered products (see Figure 3-23 for the information transmissions scheme).

[103] Continues Replenishment, p.5, http://www.ean-int.org/Doc/EDI0002.pdf , downloaded 23.10.04
[104] Continues Replenishment, EAN International, pp.34-35, http://www.ean-int.org/Doc/EDI0002.pdf , downloaded 23.10.04

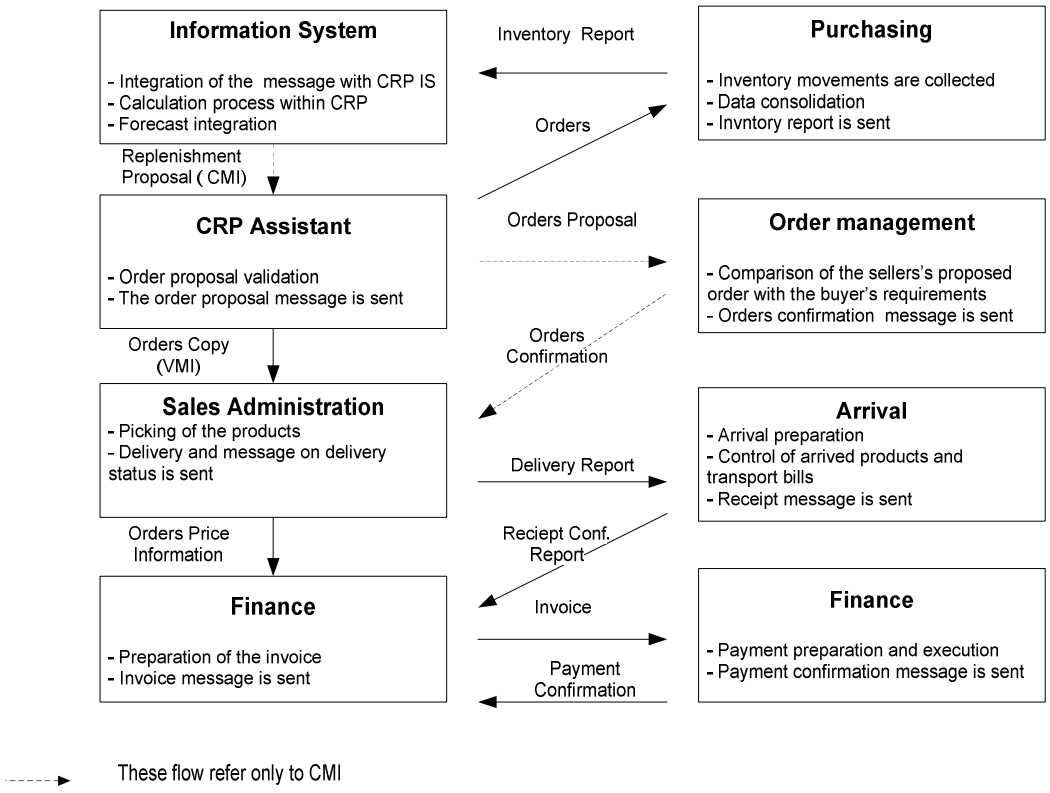

Figure 3-21: Information transmissions of Continues Replenishment Program

Source: Continues Replenishment, http://www.ean-int.org/Doc/EDI0002.pdf

4. EMPIRICAL FRAMEWORK

In this chapter, a short description of Varberg Hospital and its Surgery Department will be given. This is followed by a layout map over the department and the storage areas. Further the current material and information flow will be explained, with the support of flow diagrams.

4.1 Introduction

In this chapter, all collected information from brochures, interviews and observations has been put together. The information gathered from the interview answers will not be specified per each interview but will be grouped and divided into different topics. However, the interview questions can be found in Appendix 3.

4.2 Background of the Hospital

On the west coast of Sweden, in the county of Halland, the City of Varberg is located. Within the walking distance from the city centre one finds Varberg Hospital. The hospital accounts for 2000 employees and operates approximately 400 treatment sites. The hospital has a large number of divisions that specialize in diagnostics, care and treatment within rehabilitation, psychiatry, surgery that covers such areas as orthopedics, gynecology, laparoscopy, trauma and medicine. Varberg Hospital was opened in 1972 but since then it has been going through continuous improvements and developments, which is also conveyed in its mission statement: “Varberg Hospital – slightly better in all ways.”

4.2.1 The Surgery Department and its Mission

The Surgery Department at Varberg Hospital is divided into two sub-departments: the surgery and the anesthesia division. These two divisions share the same physical premises, however located in oppositely located corridors within the departments premises. More detailed description of the department lay out is given in Section 4.3 below.

Approximately sixty persons work during a normal working day in the whole department. Eighty nurses and thirty doctors are employed. Except from the permanent employees there are an additional number of other personnel. They include two cleaning attendants, six students per semester and finally one product representative. Together, all these personnel have a common mission to follow, and that is to perform surgeries on patients. Today the capacity of the surgery department is between thirty to thirty-five surgeries per day.

4.2.2 Last Years Developments

The following part describes in brief, the most important developments of the hospital during the latest years.

In the year of 1994 a logistic study of the patient flow was performed which resulted in a big reorganization of the personnel. Since then the personnel work in teams. The nurses working in the theatres are all certificated nurses which make the process more efficient. A certificated nurse is a nurse which has a nurse education from college level and is registered at the Ministry of Social Affairs. This is not yet very common in Sweden, and the hospital management consider themselves rather advanced in this regard. The result of this development is that they perform more surgeries and, of course, use more materials in comparison with before the adjustment.

During 2003 there was another project carried out that dealt with a so called presurgical centre, which has lead to major improvements for both patients and staff, as well as for the security and working environment.

4.3 Description of the Surgery Department

In this part of the present chapter, the surgery department will be described in detail. Finally, the ideas of possible improvements are summarized based on the interviews with the department personnel.

As mentioned before the surgery department is divided into surgery and anesthesia sub-departments. These two departments are located on each side of the seven surgery theatres that have the central position inside of the department as shown below. For a larger and clearer vision, see Appendix 1. The surgery part is to the right from the department entrance by the surgery theatre number seven. The anesthesia part is to the left from the department entrance.

Each of seven surgery theatres consists of three separate rooms: an arrival room where patients enter the theatre, a departure room, and the surgery room when the surgery itself takes place. Not all the hospital can afford this kind of theatre design since the department space is always a trade of between actual surgery facilities and all the other facilities required for allocating supporting activities such as storage, sreralization center, washing sites for the surgery stuff and stuff offices.

The department storage areas are very much spread out all over the department. Figure 4-1 provides an overview of the storage areas location within the department. The two following section will cover the description of areas where the department logistics functions are taking place.

4.3.1.1 Unpacking Area

The unpacking area where the incoming goods are unpacked is located in the corridor within the department next to the gate (Figure 4-1). It is through this gate the porters and the nurses enter with the boxes taken from the basement storage or from the hospitals central goods reception.

The unpacking activity takes place in the middle of the corridor, between theatre one and the restrooms. When the unpacking is done, the material is most often transported to the bigger storage, a so called buffer storage, but once in a while the material can be put straight into the picking storages. According to the nurses responsible for these activities different nurses are acting in different ways regarding this matter.

4.3.1.2 Storage Areas in the Surgery Department

Figure 4-1 below depicts the picking storage areas that are marked by the red numbers and two other bigger storages, the material buffer and the basement storage which are placed further down on the picture.

The present storage principle is a fixed position for each product, and the majority of the products are stored according to family grouping, for instance orthopedic screws are located in one place and laparoscopy equipment in other.

The knowledge of where the different items are stored can be found in the information system in use, called the SterilAgent which provides information to the nurses about the location of a certain product. The information is called destination address, and it will show the location and a picture of the items. Not all the items have a picture, but the reason for this is that this kind of system is pretty new and is in process of being completed. This system is more described in more detail later on in the chapter.

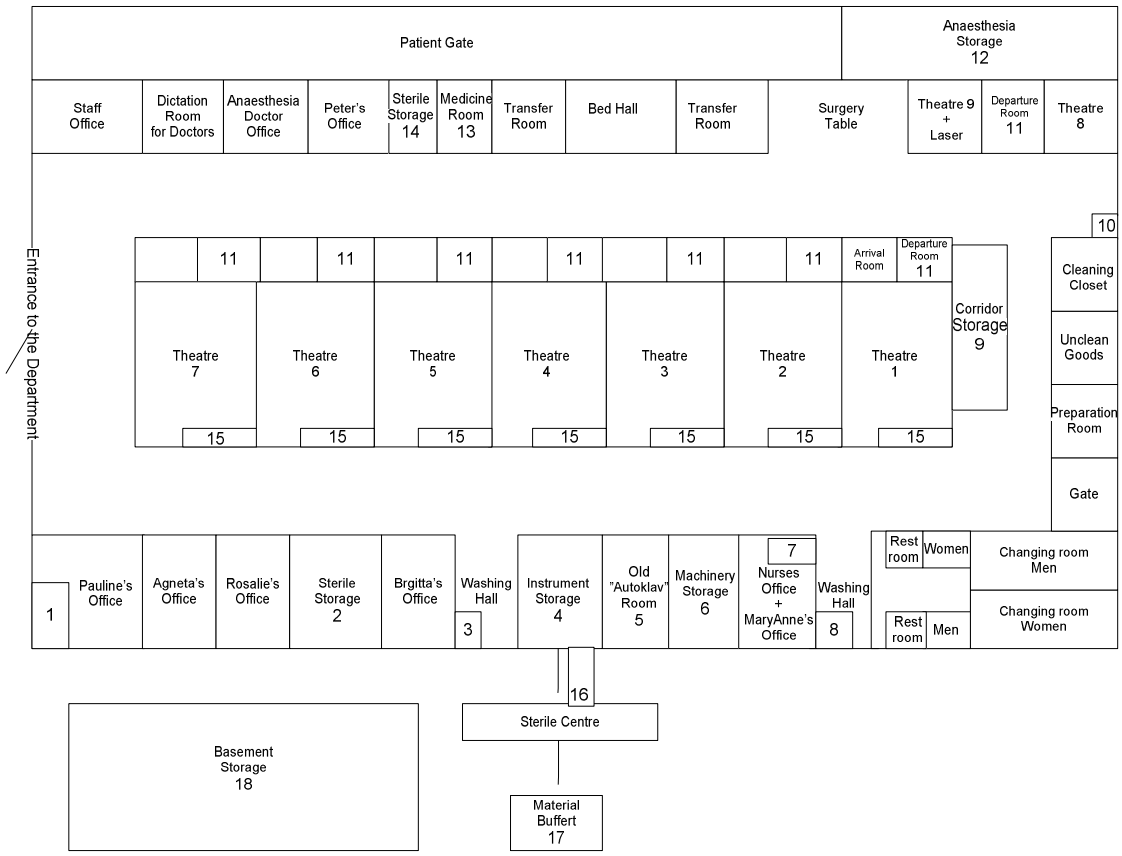

Figure 4-1: Surgery Department

4.3.1.2.1 Description of Each Storage Area Related to the Surgery Department

The different storage areas, as they are today, are explained below. One can follow the numbers in the figure above. The descriptions include the material stored in each of them, and also an explanation of the logic behind the location.

1. Roughly all the laparoscopy material is stored here since the surgeries made in theatre seven are mostly laparoscopy.
2. A big part of the sterilized materials are stored here, even if not all the sterilized materials can fit into this room.
3. Bandage of different kinds.
4. This storage is the instrument storage. It is big and all the different instruments can be stored in this room. The instrument and the sterilized storages are located close to each other for the reason that theses kinds of items are placed on the trolleys outside the theatres.
5. Different screws and small items used in surgeries are stored in the cupboards in this room. The screws are used in the orthopedic surgeries which are the two closest theatres to this storage, theatre number three and four.
6. Different kinds of plasters.

7. Different kinds of medicals.
8. Different kinds of cleaning liquids.
9. This storage contains materials that mostly are used for the urology/surgical surgeries made in theatre one and two.
10. Unclean used material.
11. This storage contains the used material which just left the surgery theatre. The surgery nurse sorts those materials in paper, hard plastics, glass and trash. The used material is only placed in this storage until the porters get it.
12. This storage contains most of the materials which are used in the anesthesia part except from the sterilized and medicines.
13. Contains the medicines for the anesthesia part.
14. Contains the sterilized materials for the anesthesia part.
15. All the storages under number fifteen are the built-in storages that are directly accessed from the theatres. These storages contain collected materials for the surgeries made in each theatre. There is a list placed in each of the wall cupboards which include the quantity of the materials that should be placed in these storages.
16. Contains orthopedic products.
17. The buffer storage contains the bulky boxes of material that cannot fit into the picking storages. From this storage items are moved to the picking storage as soon as there is some vacant place there.
18. The basement storage contains products supplied by the companies Mölnlycke Health Care and 3M. However, in the near future Mölnlycke products will be dropped by the surgery department and only 3M products will be stored in this storage. The basement storage is a bulk storage which is approximately 45 square meters, but only approximately 20% of the space is utilized.

4.3.2 Ideas of improvements of the Storing and Unpacking Areas

When the interviewees were asked if they could think of any improvements that they thought were necessary at the storage and unpacking areas some things were mentioned.

Regarding the storage areas some ideas were mentioned. The core idea concerned the direction towards less storage areas. Today the personnel believe that there are too many small storage areas spread around the department. Basically the products are placed and rotated depending on where there is some extra space. There is logic for what is stored where but nevertheless it is a pretty unclear structure. Once the product location is learned it works all right to pick up products, but it is not an efficient way of learning for new or inexperienced personnel. For that reason less but bigger

storage areas with some logical storing structure were mentioned as a desired change for the future.

Every day the surgery nurses collect items required for the next day's surgery needs. This is usually happening in the afternoons or alternatively when nurses have some spare time. The activity is done most often by one nurse from each theatre, and the collected items are placed into the built-in storages (number fifteen on the Figure 4-1) for each theatre. In order to collect all the needed items a nurse is usually forced to visit many of the forward storages within the surgery department. This activity, therefore, is rather time consuming, however, it is done in a trouble-free way because the surgery nurses have a lot of experience and knowledge about locations. Nevertheless, to have less storage areas more close to each other is one of the major issues when launching the construction project.

The buffer storage is the biggest of the storage areas located inside of the department, but even though the personnel consider it as being too small. This area is used for storing the bigger boxes, and from here the SKUs are taken to fill up the forward storages. The personnel would wish this area to be bigger because in this case more of the items could be stored in the buffer, and the big boxes in the picking storages could be avoided.

For safety reasons mentioned in the Theoretical Framework chapter sterilized and non-sterilized products should not be stored together, however this is the case in a few storage areas because of limited space. This issue was mentioned for more safety and hygienic reasons rather then for the reason of the improved efficiency.

According to the personnel responsible for the receiving and unpacking the boxes at the gate there is a strong necessity to have a shorter distance between the gate and the buffer where the received products are moved. Often boxes which are to be moved are rather heavy and rigid to lift. These lifts that are made completely manually are both time-consuming and negative for the personnel's health. Another issue mentioned concerning this transportation is that it has to pass through the sterilization centre, what obviously does not follow the hygienic regulations. Hence, the ideas for potential improvement are to have a shorter distance of moving the boxes to their storage locations, and not have to pass through the sterilization centre.

Another issue in relation to the unpacking was also mentioned by the personnel. The activity of actual unpacking the big bulky boxes is currently taking place in the corridor inside the surgery department. This is a rather

unclean job and it takes place only a few meters from the doors of the first theatre, and this is of course does not stand the critics in the light of safety and hygienic regulations. According to the rules this activity should not take place within the surgery department, however as the situation is today it is a necessity caused by the lack of space resources. Another issue with this regard is that space is pretty narrow and the personnel mentions that it is hard to pass through when the unpacking activity is taking place. Hence, a bigger space isolated from the department itself is desired by the personnel.

4.3.3 The Suppliers of the Materials

Information regarding the suppliers of the materials in this part of the study is gathered from the interviews conducted with personnel of the surgery department at the hospital, with the personnel working in the Pharmacy division located in the hospital and with the central storage personnel. We start by describing the Pharmacy and then continue with the central storage in Halmstad. Lastly, the co-operation with the external suppliers will be discussed.

4.3.3.1 Pharmacy

The Pharmacy is the one and only provider of all registered medicine in Sweden, and the well known drugstore both for individuals and hospitals. The Pharmacy which the surgery department orders from is located in the basement of the hospital and is the medicine provider for the hospital only.

The orders from the surgery department go via the proprietary EDI system WebbABest which the Pharmacy offers with their big customers. A couple of nurses at the surgery department have access to this system, where they are able to read annotations to all the medicine supplied by the Pharmacy and easily do the ordering. This EDI system was established in the end of 2002 and is working very well. The nurses we have spoken to say that this is an easy and fast way of ordering once one knows what to order. The frequencies of orders are approximately three times per week and the orders are transported in small open boxes by the hospital porters.

4.3.3.2 The central storage in Halmstad

The central storage located in Halmstad was established by the Halland County Council a couple of years ago following the overall reform of joining the logistics activities for several hospitals in one logistics centre. Before the reform the hospital utilized its own central for the hospital storage facility, managed by the hospital administration. It was found that the opinions about this change are rather contradictionary and hard to judge without the actual costs reduction analysis. However, it is known that specifically the surgery department had to increase the number of the external suppliers due to the fact

that the central storage was found incapable of carrying the product assortment required by the Department. Another complication related to the issue is that the central storage carries out only those assortment positions that are at the same time demanded by at least two other departments within the hospital.

The orders should be made before 10.00 am on Fridays, the packing is done on Monday, and transportation is on Tuesday morning. If there is a need for a fast delivery in one day this is possible to a fee of 100 kronor. In case the total price of the order is lesser than 250 kronor an extra administration fee of 75 kronor is added.

291 different product articles have been ordered by the surgery department from the central storage during 2004.

4.3.3.3 The external suppliers

Currently there are 92 external suppliers registered for the surgery department, but around 30 are used frequently. They are represented by both world scale international companies and small local suppliers. The number of the suppliers varies from year to year as well as the companies themselves which mostly depends on the changes in the demand pattern determined by the surgeons. The medical developments have an ongoing character and that results in the fact that the demand on some older medical products is decreasing while it is growing for newer product substitutes.

As was found out from the interviews the major reason for having such an extensive number of the external suppliers, apart from the problems associated with establishing the central storage in Halmstad, is that some products account for substantial investments which the central storage can not afford to carry. This problem will be addressed later on in the research.

The number of items ordered from these suppliers account for 2 416 SKUs.

4.3.4 Mapping of the Material Flow

In this section the material flow will be discussed with the assistance of Figure 4-2 which is a diagram that shows the different processes and direction of the flow. The processes are explained in detail below the figure, followed by an explanation of the equipment and personnel involved in this material flow. Lastly, this section will describe the different ideas concerning the improvements mentioned by the personnel regarding the material flow.

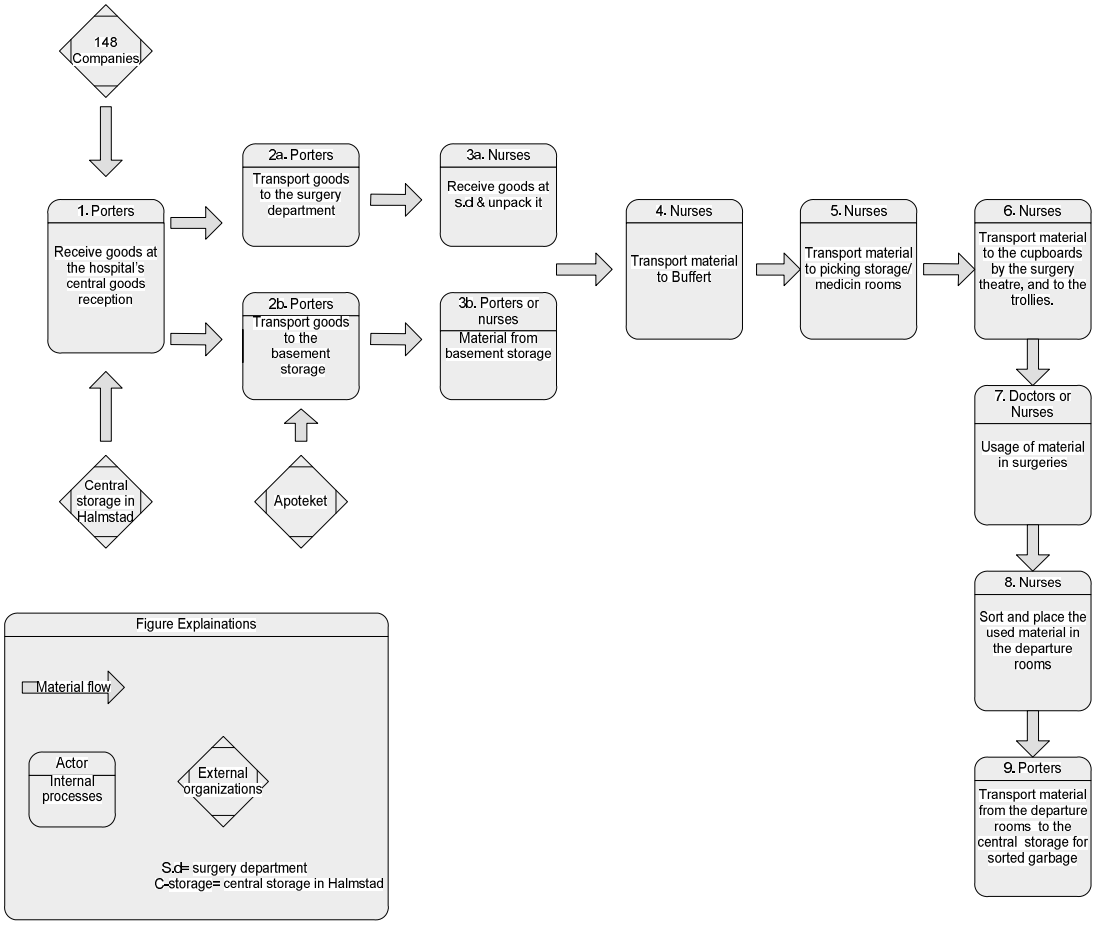

Figure 4-2: Material Flow

1. All the goods arriving at Varberg Hospital enter via the central goods reception. The porter receives the goods and most often the goods are marked with a label that indicate to which department they need to be delivered.
2. Some of the delivered boxes containing surgery products should be transported straight up to the surgery department (2a). Some boxes should be moved to the basement storage that is devoted to big bulky boxes (2b).
3. When the boxes get to the surgery department it is the responsibility of the nurses to unpack it. The unpacking is done in the corridor within the operations department next to the gate where the boxes are received (3a). When the boxes from the basement storage are needed, the nurses either call the porters to bring it up or they go themselves to get it (3b).
4. When the boxes are unpacked some products are transported to the buffer storage, and some are transported to the near storages.
5. When the picking storages need to be filled up, the nurses get items from the Buffer storage.

6. Every day the cupboards inside the walls of the operating theatres are filled up. Also the trolleys that stand outside the theatres are filled up every day for the next day's needs.
7. The materials are being used by doctors and nurses in the surgery theatres.
8. After the usage the materials are sorted and put in the departure rooms.
9. The sorted materials are eventually transported to the central storage for the disposed materials.

4.4 Information Flow

In this part of the empirical chapter the present information flow will be discussed.

Figure 4-3 shows the structure of the information flow that supports inventory control and the ordering process within the surgery department. The different processes schematically depicted in the picture are explained in more detail below:

1. Each of the cupboards located in the picking storage areas has a list which states all the articles for the products stored inside of this cupboard. These lists contain the article numbers of products which are placed in that specific cupboard. Every product has its own row on the list what results is that the lists can be very comprehensive. Each time a nurse takes an item from a cupboard she/he has to note the amount of items that were taken on the list. These lists only contain those products that are ordered from external suppliers. Once a week two nurses collect these lists from the cupboards (a). The total consumption of items is then manually calculated.

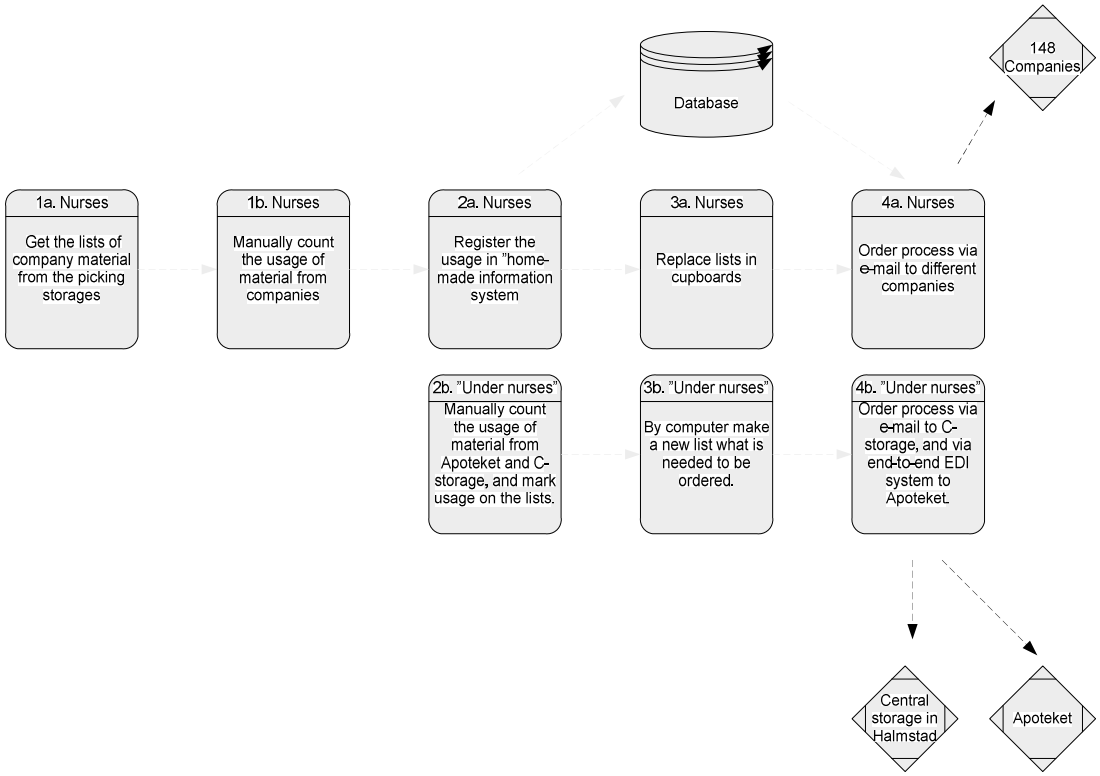

Figure 4-3: Information Flow

2. The consumption quantity is registered in the "home-made" information system called Steril Agent 2000. The consumption data is stored in the database. Steril Agent 2000 processes the input data and when the inventory level of one of the products reaches the reorder point, the nurses get the notice from the system that states the required order quantity (a). The consumption of the materials supplied both from the Pharmacy and the central storage in Halmstad is also counted manually by nurses. However, the order to the central storage in Halmstad is not executed automatically by Steril Agent software. It is done with the help of a prewritten list in the Steril Agent which contains all the products that can be possibly ordered from the central storage, and the task of a nurse is just to mark those positions that are necessary to order. Once a week this list is printed and used for marking the consumption. In this case the lists are not in use and the consumption is estimated by sight which means that the nurses order when they believe it is time. This is a completely manual process which is purely based on common sense (b).

3. The lists for the products supplied externally are now rewritten and replaced in the cupboards (3a). With help of the Steril Agent the nurses make new lists of the materials that are to be ordered from the central storage as well (3b).

4. Two nurses in charge of the ordering process from the external suppliers get the order information from the Steril Agent as explained in step 2a above. This information tells them what required order quantities are for each product. Steril Agent then divides this long list of orders according to the assortment data supplied by the companies so that one order list for each supplier is created. These lists are then attached as PDF format files and sent by e-mail to each of the suppliers (4a).

   There are only a few nurses that have responsibility of ordering material from the Pharmacy, because they are the only ones that have access to the EDI system called WebbAbest that connects the Pharmacy with the hospital. In this system it is only needed to mark which kind of medicals are needed and in what quantities (4b).

There is also another type of a list used for inventory control in the other two bigger storages. The list used in the basement storage is used every time a box or boxes are taken from there up to the department. However, this list is physically located in the surgery department in order to have an easier access when the list is checked to find out the inventory level.

The procedure of marking the list in the buffer storage is the same. In both storages the inventory control of checking the lists is done once a week.

4.4.1 Ideas of improvements for the Information Flow

When the interviewees were asked if they could think of any improvements that they thought were necessary for the information flow a few things were mentioned. According to feedback on the present information flow gathered from the interviews there are issues that concern the list system for keeping track of the inventory level. The lists are sometimes very long because many items are placed in that cupboard, and to find an item in that list can be very time consuming and sometimes even stressful. Either the nurse who picks the items forgets to mark the consumption in the list or he/she thinks it is too time consuming. It leads to the fact that once in a while the level of inventory stated on the lists does not match the reality. This is a big problem because these lists are the bases for the order quantities from the suppliers. Therefore, a more accurate and less time consuming process is desired.

Also a desire for the suppliers to use the same information system is mentioned. The ordering process could have been made in a much faster and accurate way. Today none of the 92 external suppliers has an information system in use connected to the hospitals surgery department. All the orders therefore have to be sent as attachments via e-mails to these companies. The ordering process supported by e-mail communication is considered by the

personnel to be pretty efficient and accurate way of exchanging order information, and therefore, is not perceived as a serious problem. At the same time there are already enough of examples of computerized order processing system applied in the healthcare sector, and there is a great deal of potential improvements offered by these systems that hospitals can not afford to overlook. This desire of getting an improved order process with the supplier has been working on for a while and it seems like one of the biggest supplier is interested in this investment and improvement. Also an initial investigating project of having the computer order processing system that would connect the surgery department and the central storage is in progress.

5. ANALYSIS AND DESIGN ALTERNATIVES

The chapter starts with a discussion of the assumptions that are important to take into consideration before the analysis takes place. Further on the overview of the evaluating parameters is represented. The core of the chapter is the actual decisions made at strategic, tactical and operational levels, which provide the answers to the research questions. The chapter is closed with the analysis of the changes in the system parameters that are likely to emerge from the new storage design.

5.1 Introduction

This chapter is based on the knowledge extracted from both theoretical and empirical chapters of the present study which was further analysed not only from purely theoretical logistics perspective but from the practical hospital perspective as well. The practical side included the considerations and feedback received during the co-operation with the department personnel. Therefore, storage design which is the outcome of the present chapter is a certain compromise between theory and practice.

In order to follow up on how effective the proposed storage design is nine parameters were developed. The purpose was to have a relevant measure tool that would help to analyse the possible improvements in the system once the new storage facility is implemented in reality. These parameters are what the authors believe are the most important areas that are requiring improvement.

5.2 Assumptions

It is important to take into the consideration that the research subject was initiated by the hospital administration's decision about the construction of a completely new building as an extension of the present building that allocates the surgery department. The new building will occupy the vacant space of the hospital's internal yard and will allocate the surgery theaters while the existing premises will be converted into the Intensive Care Recovery Center. Since this project is only at the very initial stage of its formulation and development a number of assumptions are to be made when designing the storage area, especially in part of the physical size and location of the storage space within the new building. These assumptions are as follows:

- No previous calculation of the building total space has been made
- No lay out plans for the surgery theatres location exist
- No decision on surgery theaters specialization has been made

On the other hand there are enough of already known facts and considerations that provide a sufficient background for the potential storage layout design to take place. These factors include the following:

- Most probably the storage area will be located in the new building due to the fact that the majority of the surgery theaters will be located there, and it is the idea that nurses cover short distances accessing the storage area.
- The inventory of the anesthesia department will be joined together with the inventory carried by the surgery department, what will ensure total products stock integration.
- The potential location of the storage inside of the building will be determined in accordance with common logistics consideration in part of suitable and efficient flow pattern.
- The actual lay-out of the storage will be designed based on logistics warehousing principles, that do take into consideration issues such as safety regulations established for storage of medical products, possible grouping of the products and accessibility.
- The authors were given freedom to come up with up-to-date development ideas that the new material flow would benefit from to a certain extend, these developments can concern such areas as storage and inventory control systems.

5.3 Performance Parameters

The parameters and their descriptions are represented below in Table 5-1. The first parameter discussed concerns the hygienic safety regulations that are described in the theoretical chapter. The safety regulations state how storage and product handling activities should be carried out to follow the quality safety regulations applied to healthcare. The authors prioritize this parameter as the most important because the hospital shall provide the most quality and safety healthcare possible.

The space utilization concerns the space usage efficiency in the storage areas. Here the authors look at the optimization of the space used for storage. The storage space concerns with how well filled the storage system is, and the authors look at air-filled space over and between the shelve rows and empty places on the shelves. Empty gaps on the shelves usually occurs when the area between the shelves and the size of the boxes stored are not matched well, and the air between the top of the box and the next shelve is too large to be efficient. This is an important factor mostly from the economic point of view because space costs money, and therefore it is important to use it in the most efficient way.

The orderpicking time concerns the time needed to pick the items. This factor can be influenced by various factors but the authors mainly focus on the organisation of the storage system. The distance to the storage system, the distance between the storage places and also if the storage places are spread out are issues to look at. Distance factor is of a major importance and it lays behind the reason why to optimize the processes at the department. Time spent on patient care should be maximized and the time spent on picking items should be minimized.

The visibility concerns the efforts needed to see and find the items quickly. This factor takes into consideration both the inventory control issue which focuses on the control of what items are in the storage, and for how long they have been stored, and the picking issue focuses on how easy it is to find the items in the picking process. This factor is important because it can influence the orderpicking time a lot, and again time for product handling should be minimized.

Regular product flows concern the product flow routines within the Surgery Department. The authors mainly look at the unavoidable at the moment interference of the product flow with other flows, such as patient and personnel flows. Also, the authors look at the movements of the products and if they are optimized. This is an important factor because it influences the time and effort used for moving products without causing inconvenience to non-product related activities within the department.

Number of items concerns the number of items stored for every SKU. Certainly, these numbers differ a lot between different SKUs but the authors have tried to acquire an average number. This is also an important factor from the economical point of view because of the tied-up capital aspect. Also if items are stored a long time, the expired date can run out and the trends and technology changes which leads to that the value of the items decreases.

The floor space concerns the physical floor space that is occupied by the storage areas. In other words it includes space that cannot be used for any other purpose than storage. Space criterion is affected both by the number of items stored and the space utilization, and can only be improved if one of these factors is changed. This factor is important because space in the Surgery Department should be optimized, and the best locations should be used for the most important activities.

The clerical work relates to the time needed for order related processes. Included are all the activities regarding the input data to the inventory control system when products are received, the input data when the inventory control is made, and the activities for placing an order. This factor is important also because the processes should be optimized in order to maximize the time for patient care and minimize the time needed for inventory handling and ordering.

The daily routines concern knowing what day and time the products are going to be received. These routines should be reliable so that every week the arrival schedule is the same. This factor is important because in case of working routines the personnel's schedules and activities are easier and more efficiently planned.

Now when the parameters are known, the current status of each parameter can be given.

Parameters	Description	Current status
Product Flow		
1. Hygienic Safety	Hygienic safety is discussed in theoretical chapter.	Violation of hygienic safety regulations in part of mixing sterile and none-sterile products, and unpacking directly within the facilities of the surgery department.
2. Space Utilization	Space occupied by stored products.	Space utilization is not optimized. Storage system contains a lot of air-gaps and empty spaces.
3. Orderpicking Efficiency		
3.1. Orderpicking Time	Time consumption for orderpicking.	Storage areas are widely spread within outside the department which results in longer orderpicking times.
3.2. Visibility	Concerns both knowledge about the product storage location and accessing the products visually.	Product location is learned by experience and sometimes low visual product accessibility which results in longer inventorisation and picking times.

4. Regular Product Flows	Concerns the consistency of physical products flows within the department.	Physical flows are constantly interacting with human flows. Unnecessary movements of bulk in between the storage areas.
Information Flow		
1. Inventory		
1.1 Number of Articles	Number of items stored within one SKU.	Current inventory levels sufficiently exceed two weeks which results in high tied-up capital.
1.2 Floor Space	Physical floor space of current storage areas.	Currently occupied space is 176 square meters.
2. Administrative Work		
2.1 Clerical Work	Concerns with all the activities related to order processes.	Large share of manual administration including telephone calls, faxing and production of paper documentation.
2.2 Daily Routines	Possibilities to plan working daily schedules.	Lack of delivery routines. Packages may arrive throughout the day.

Table 5-1: Evaluating Parameters

5.4 Design Process

5.4.1 Storage Functional Areas

It is often in this chapter that the following names of the storage areas are used: unpacking area, reserve area, forward area and picking area. In order not to confuse the reader it is necessary to mention that each of the areas has its name after the main function performed in these premises as described in Section 3.4.3 Functional areas. As a matter of fact, presently the department operates the same functional areas, except for the unpacking area. Therefore, what will be called a reserve area in the new lay-out are currently the facilities known as the Buffer Storage, and the Basement Storage. However, these two rooms will be joined into one reserve area. The forward area in the new design will be split into two parts for sterile and none-sterile products. Currently, forward storages are found allover the department. By the picking storage area is meant

all the built-in storages in the surgery theaters. The same meaning and functionality of this storage area will also be kept in the new design.

5.4.2 Strategic Level Decisions

In this section the strategic decisions will be addressed. Firstly, the possible location of the storage area is analysed outlining advantages and disadvantages of each location; secondly, the process flow will be viewed in terms of the sub-processes that compile it; thirdly the decision on the type of the storage system will be represented and justified, and finally, the improvements regarding the information flow suggested.

5.4.2.1 Location of the Storage Area

The initial step in designing the storage area is to determine the most suitable location of the storage area within the new building. Obviously, at this stage of the complete construction project this task is easy and difficult at the same time. Easy because all the location possibilities are open, and difficult because the location of the surgery theaters are the key factor that would determine the final location of the storage. Therefore, this section will only outline the basic considerations concerning the location proposal. The most proper location of the storage area should ensure the most efficient pattern of the product movements. Here, the question that has to be analysed is what exactly an efficient pattern is with regard to the department needs. Should the pattern prioritize the shortest walking distances from the surgery theaters, and the quickest access to the products storage positions or should the objective of achieving the regular and convenient movements of products be prioritized instead. Three simple graphical models on the figures below were constructed to recreate the flow pattern for three location scenarios.

5.4.2.1.1 Alternative 1

Alternative 1 assumes that the storage area is placed in the middle of the Surgery Department and surrounded by the surgery theaters.

Advantages of this solution are:

- Walking distances for the nurses who pick up products for the theaters are minimized
- Access is simplified since all the products are located at one place

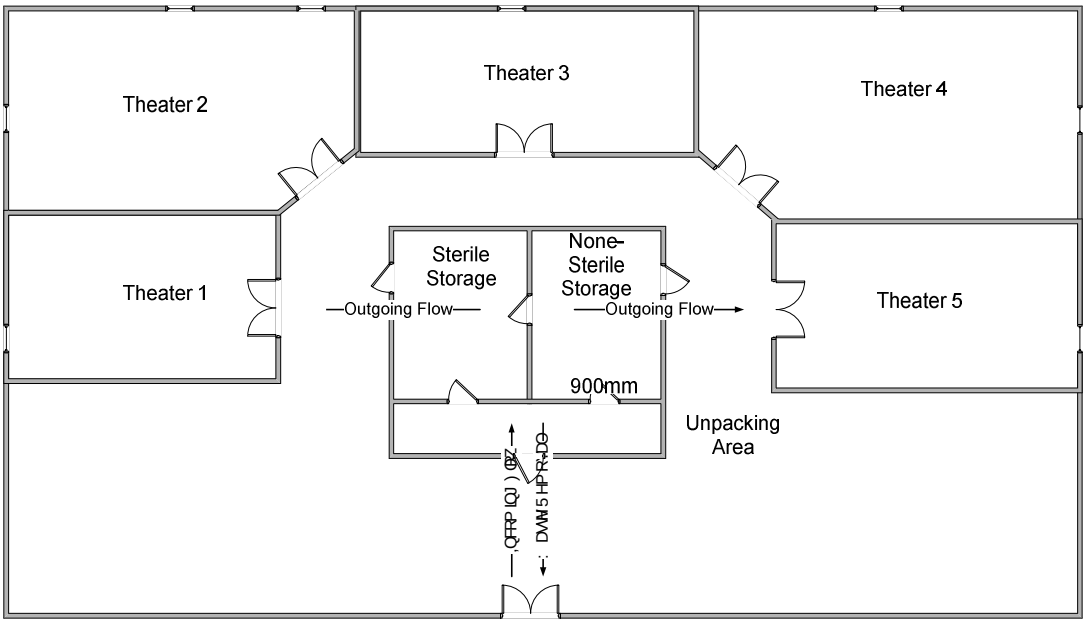

Figure 5-1: Central location

Disadvantages of this solution are:

- The incoming products flow goes through the department which creates a number of problems, such as: crossing the people flow within the building; unpacking will be taking place either at the entrance gate to the department or will require additional unpacking area inside of the storage which, in turn, will take usable space from the other department facilities, for instance surgery theaters.
- The disposal of carton boxes will have to be done through the entrance gates.
- Violation of hygienic regulations, since product and patient flow mixes.
- These lay-out questions of whether the inventory of the sterile and non-sterile products can be placed at one location since the central position of the storage limits the possibilities of zoning it into isolated areas.

5.4.2.1.2 Alternative 2

Alternative two suggests that the storage area is placed in a way that it is attached by one of its walls to the external wall of the building at the place where there is the best access for the porters who deliver products to the department.

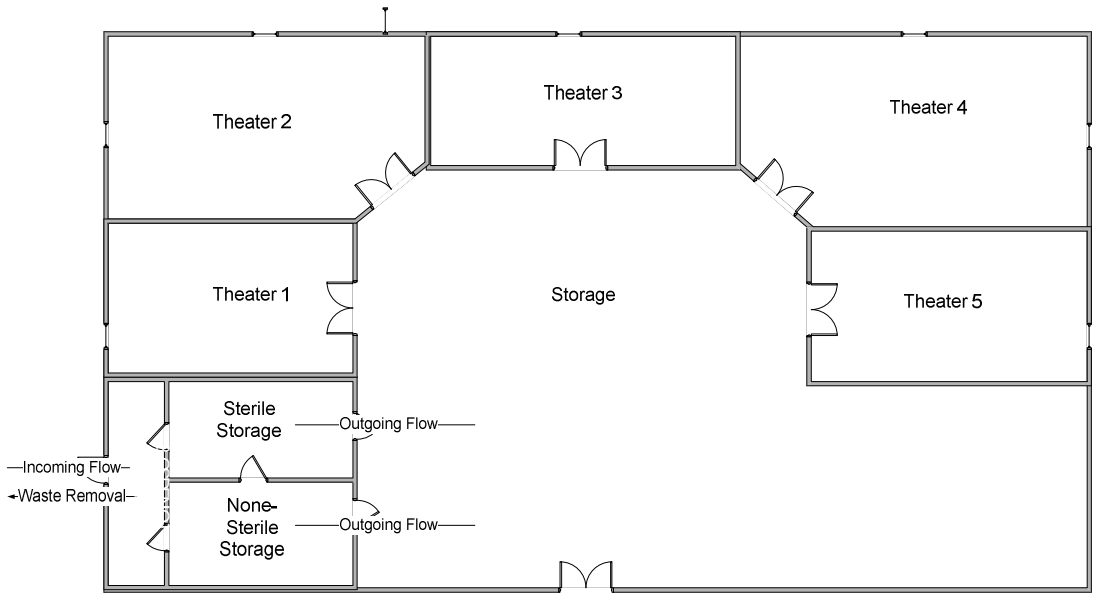

Figure 5-2: Side Location

The main advantage of this solution over the previous one is that the incoming product flow is completely isolated from all other flows within the department. Thus, among the related advantages are:

- Unpacking is done at the entrance to the storage area, the waste is removed simultaneously or can be collected for a period of time within the unpacking area and removed once per week.
  The nurses that pick up items enter the picking storage and do not disturb the unpacking activities that can take place at the same time. In this way the sorting of the incoming products and picking are two physically isolated processes that do not interact in any way.
- Total follow up on the hygienic regulations, no boxes are either unpacked nor moved through the department on the way to the storage.
- Non-central location provides more possibilities for larger space utilization since it does not take high-valued strategically central space.

This solution has one feasible disadvantage, the walking distances for the nurses will be longer than in the case of the central location. The key factor here is how large the new building is going to be, with the relatively small size of the department the walking distances are negligible.

5.4.2.1.3 Alternative 3

In case there is an identified potential in terms of the product flow efficiency the storage area can be split into several sub-areas. Should there be a necessity that surgery teams that are specialized in different surgery types require

specialized mini-storages close to the theaters, the third alternative is then to be chosen. According to the alternative three, there is a major central storage adjusted to one of the external walls that will allocate all the basic products that are in use of complete department without certain specialization. In parallel to this common storage there is one or even several mini-storages located in the central part of the building that have narrow specialization and carry out only certain product families, for instance, only orthopedic or laparoscopic items.

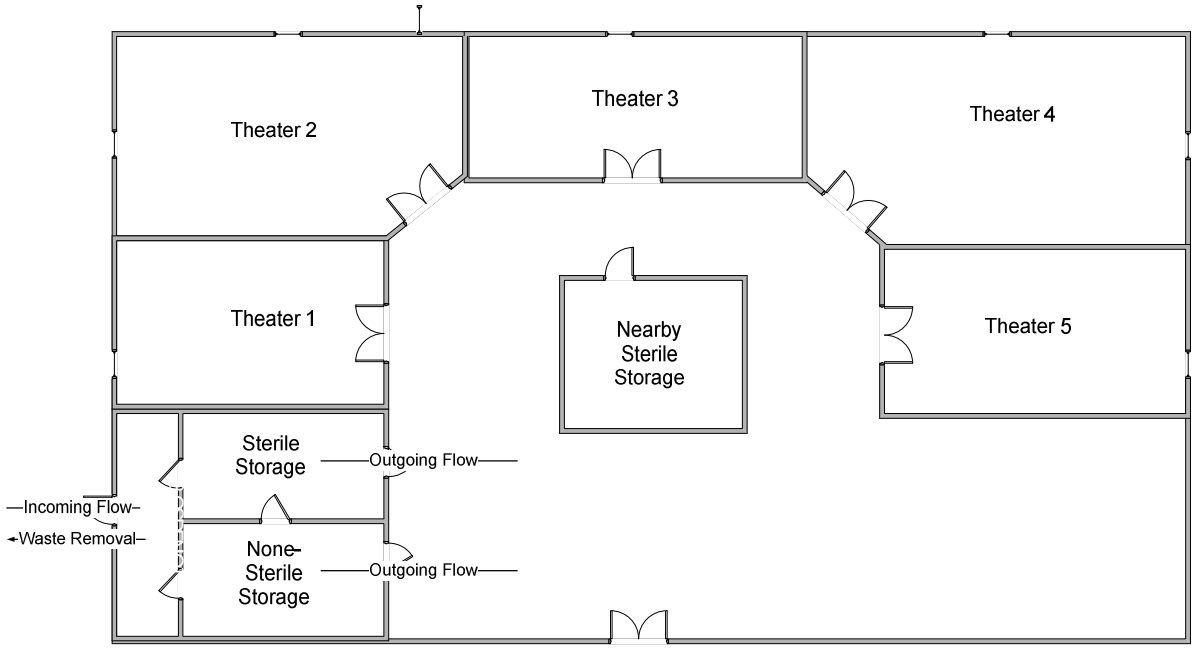

Figure 5-3: Combined storage location

Advantages of this solution are:

- Better accessibility of the items since they are located in the proximity to the specialized surgery theaters.
- Increased visibly since the surgery team nurses can decide on the item allocation that meet their specific requirements.
- Items with narrow specialization and low picking frequency will not be mixed together with items used by all the theaters.
- Often items with narrow specialization are ordered from external suppliers and it is possible that order process for these items will remain manual, therefore, under certain circumstances it would be better to store such items separately from other products in order to avoid confusion during the computerized order process.

Disadvantages:

- One of the main disadvantages is the complicated replenishment policy needed in this case. The replenishment is needed in the forward storage area, centrally located storage area and picking areas.
- The design process will take longer time while all the problems concerning family grouping are solved.
- Personnel might find it difficult at the beginning to understand the logic behind the product allocation what will cause confusion when looking for an item in one storage area or another.
- Centrally located space can be used for purposes other than storage.

5.4.2.2 Storage System

Choosing the optimal type of the storage system the following factors were taken into consideration:

- High construction investments
- Limited space recourses since the total space of the new building is limited by the size of the internal yard
- Picking process is carried out manually and, therefore, only the storage system that ensures the access to the items from the level of the average human height is usable
- Storage system should have the optimal relation between storage capacity and occupied floor space

5.4.2.2.1 Forward area storage system

During the research project the authors paid a lot of attention to studying the storage equipment commonly used in the hospitals. With this purpose in mind two major hospitals in the City of Gothenburg were visited. The study visits to Sahlgrenska Hospital and Öster Hospital showed that the current trend with regard to hospital storage equipment is moving towards replacing traditional shelving system with a dense or compact storage system. The fact that a dense storage system has a much higher performance level than the traditional shelving system was mentioned several times during both interviews with the nursing personnel responsible for the storage activities. Among the improvements that were mentioned by both teams are:

- Very high floor space utilization
- Very good visibility of the stored items due to the high flexibility provided by a wide range of shelf accessories, which can allocate items that vary largely in its dimensions
- No physical force or efforts are required to move the sliding cupboards and access their content

There are also other considerations that make the choice of the dense storage system justified in the particular case of the Surgery Department at Varberg Hospital. The fact is that the storing activity carried out at the department meets all three of the requirements applied to the dense storage system. They are:

- Picking process at the department is done only mechanically (manually).
- The fill-rate of the items is constantly high and does not have strong divisions.
- All of the items stored at the department are relatively slow movers when compared to the warehouses when items can be accessed hundreds of times during the day or in some cases during the night as well. In case of the hospital departments in general only a very limited amount of pickings and fillings are executed during the day.

When all the above information was analyzed and put together the dense storage system was chosen to equip the storage area.

5.4.2.2.2 Reserve area storage system

The undertaken research of potential improvements in the material and information flows showed that there will be still some amount of products delivered in bulky boxes. These boxes are used as a sort of reserve storage, and items from them are picked to replenish the forward area. It is possible that some of the boxes will be laying in stock for a relatively long time. Therefore, the storage system should have an alternative way that would provide conditions for storing such a bulk. It is suggested to equip the unpacking area with a basic box racking system, which would be able to allocate boxes with large dimensions that would complicate the usage of the dense system. It is also important to have a certain number of open shelves inside of sterile and non-sterile areas, since it is rather obvious that both boxes and different stored items can have rather odd sizes and configurations.

Another alternative way is to keep the boxes in the unpacking area directly on the floor or pallets. This will provide faster handling of boxes but will lead to increased space requirements since a floor stacking storage system is far not the most efficient storage system from the point of cubic volume utilization.

5.4.2.2.3 Picking storage system

During observations of the activities regarding the replenishment and usage of the items in the picking storage, the authors realized that there is a need for a change of the picking storage size and system storage system in use. After

discussing with the personnel in order to understand their whishes and thoughts, there are two things that can improve the activities with this regard.

The first change would be to increase the current picking storage. Today, too few items are fitted into the storages and this leads to the fact that the replenishment must be very regular or there will be an issue of running out of items. One reason why these storages need to be larger is because of a hygienic regulation rule changed a few years ago. The change implies that the items within a so-called department package cannot be split, but the whole package has to be stored in the picking storage. This means that larger boxes take up a lot of space and lesser number of SKUs can be stored inside of the cupboards.

The second change would be to add another type of picking storage that is mobile. There should be a space for inserting a moveable cupboard in the wall between the theatres and the corridor which could be taken out, and placed into another surgery theater picking storage if needed. This space should be protected with sliding doors so that the items in the cupboards are safely stored. The items stored in these cupboards should be specific items for certain surgeries, items that are strongly related to the type of surgery that is being performed.

- The Fixed Picking Storage

The fixed storages should all contain the same products. There was an ABC analysis of the products used in the surgery theaters conducted among the four surgery teams. One of the teams ABC grouping of products is given in Appendix 4. The ABC product analysis done by all the surgery teams resulted in almost identical frequency grouping. The A products are the ones which should be stored in the fixed storages.

- The Mobile Picking Storage

The mobile storages are recommended to contain specific items for certain surgeries. These items are not yet analysed by the personnel but the suggestion to do that has been put as a further recommendation for future studies and analysis.

5.4.2.3 Design of Process Flow

The processes required for realizing the material flow within the Surgery Department are explained below (Figure 5-4). The explanation holds the assumption that the new storage area is equipped with a new information system that we refer to during the process flow. The processes are divided into four main processes: receiving, storage, orderpicking and shipping followed by

explaining the activities that take place under each process. Those four processes are the ones the researchers believe add most value to the material flow in the activities being considered in the surgery department.

5.4.2.3.1 The recieving process

The receiving process includes three handling activities needed for a smooth flow. The products arrive at the Surgery Department in large quantities on trolleys, which are the internal mean of transportation. The activity of unloading is the first handling activity, which should be made in the unpacking part within the storage area. The boxes are manually placed on top of each other on the floor. The unloading activity should occur directly after receiving the products with the intention that the trolleys can be taken outside as fast as possible. The trolleys are quite big and occupy a lot of space if placed within the storage.

The second handling activity is the unpacking, which refers to the activity of removing the large bulk boxes of the products. This process is completed manually within the unpacking area in order to follow the hygienic safety regulations. In the case of unpacking sterilized products it should be done in the sluice that is located between the unpacking/reserve area and the forward area. This sluice is a small room with doors at both ends. The doors are closed while extracting the products from.

The unpacking and the reserve area is planned to be in the same premises. Only the products that need to be filled up in the forward area should be unpacked, otherwise the products stay as bulk as long as possible in the reserve area to obtain the most economically efficient storage. The intent for the Surgery Department is to have as little bulk inventory as possible, and aim for a just-in-time philosophy with no need to store bulk inventory. However, the reality is different and in some cases the bulky inventory is a must for a smooth flow.

The third handling activity includes the checking and scanning of the products received. The products need to be checked to see that nothing has broken during the transportation. Following this, the products are scanned and counted and the information on the Bill of Lading is compared to the products received. If any mistakes have occurred these will be informed to the supplier. The correct number of products received is then placed as an input into the inventory control system.

5.4.2.3.2 The storage process

The product movements within the storage start when the bulk products have been unpacked and are to be moved to either the sterilized or non-sterilized part of the forward area. The process of transportation to storage system is done when there is a need for more products in the forward area. The transportation of products between the unpacking/reserve area and the forward area is done by hand or with a small internal transportation mode, like an easy-to-use trolley. If a lot of products are to go to the forward area, the trolley is an efficient way to save unnecessary movements.

There is a difference in the way the movement for the sterilized and non-sterilized products are handled. The non-sterilized products can be unpacked in the same area as the unpacking/reserve area and moved to the forward area, while the sterilized products have to be unpacked in a sluice with closed doors.

When the products have been transported to the storage system, the products are to be allocated to their fixed storage location. In case the personnel doing this allocation do not know where the items are to be placed they can achieve help from a search technique in the inventory control system.

5.4.2.3.3 Orderpicking Process

Orderpicking refers to the retrieval of items from their storage locations. Below are described four points that are the fundamentals for an easy retrieving activity:

- **The right products:** The products stored should be the ones that are in use intermittently. If a decision is made not to use a product anymore, this specific product should be taken away from the storage.

- **At the right place:** The products have one fixed place in the storage area. In this way no confusion needed for the orderpicker. If the orderpicker is new or has little experience, there should be a search technique to use in the inventory control system.

- **In the right quantity:** The products should be stored in smaller packages, so that no unpacking activity needs to be done when doing the orderpicking. The products should be stored as they are to be used in one surgery. The idea is that the orderpicker can take a package without thinking of how many is needed for one surgery, this way time is saved in the orderpicking process.

- **At the right time:** The orderpicker should always be able to pick the products from where it should be placed, and no running between various storages should be needed at the orderpicking process.

The orderpicking process at the Surgery Department occurs at two different times and locations. The first time is when the orders are picked from the sterilized or non-sterilized forward area in the storage, and the second when the orders are picked from the picking storages and the trolleys placed in the surgery theatres.

The first picking process can include two dissimilar functions. One function is a consolidation activity, when several orders are grouped on one trolley for the same theatre. One order in the Surgery Department exists of the items needed for one specific surgery. Every day there is one responsible orderpicker for each theatre who is responsible for consolidating the orders needed for one theatre the following day. The orderpicker brings a trolley into the forward area on which the consolidated orders can be placed. The products are then shipped; the shipping process is explained after the second picking process below.

The second function in the first picking process is a replenishment activity. The products are to be picked from the forward area to be allocated to the picking storage. The products here are also placed and transported on a trolley to limit unnecessary transportation. The picking storage, in which the products are to be placed, refers to the storages that are built in the theatres walls. In this way the products are easy to retrieve when the surgery is in progress.

The second picking process occurs when the surgery takes place. The patient, as a customer, requires specific items that the sergeants demand at this moment. For this second orderpicking process the four points explained above are of a major importance. If the right items are not easy to retrieve from the theatre this might cause problems in the surgery activity.

5.4.2.3.4 Shipping process

The shipping concerns the process when the picked products are checked, scanned and put on transportation equipment. In the Surgery Department this process will occur in between the first and the second picking process. When the item has been picked from the shelve in the forward area it is checked and scanned by the orderpicker. The checking activity is just to make sure that the item is O.K. for usage, for example to see that the best before date has not expired.

The transportation mode for the consolidation activity is a trolley with various layers. The items that are going to the same theatre are placed on one trolley where each layer of the trolley contains items for each surgery. The trolley is then transported and placed outside the theatres, and the next day placed inside so that the products are easy the retrieve when needed. The transportation mode for the replenishment is also a trolley, but the different layers are not a need. The products from the trolley are placed in the picking storages. The products are now located in the right place for the second picking process to occur. The below Figure 5-5 explains and makes the process flow more clear for the reader.

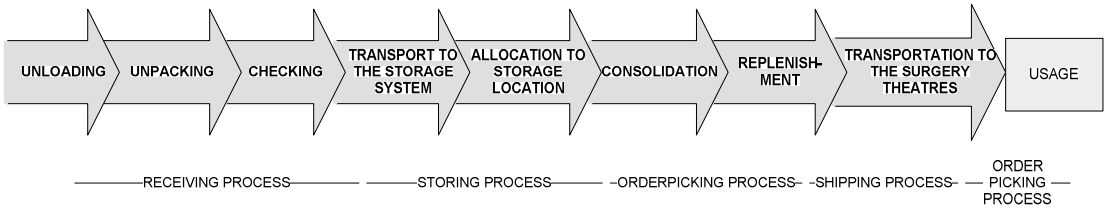

Figure 5-4: Process Flow

5.4.2.4 Information system development

The information system is an important part of the new storage design. As was mentioned in the empirical chapter in part of information flow, the Surgery Department has newly developed an off-shelve solution SterileAgent for keeping track of the SKUs and information about suppliers. According to one of the developers Lars-Gunnar Andersson, this solution can serve as a basement for building more advanced inventory control system. At the moment the present solution is capable of generating order quantities based on the programmed reorder point and order batch size. However, the consumption data has to be fed into the system manually. Obviously, the collection of consumption data is also executed manually through the use of the product list placed in the cupboards.

The authors see several ways that would lead to the improved information flow not just within the department but throughout the supply chain.

5.4.2.4.1 Data collection

The consumption data collection process should utilize hand-scanners each time the item is picked up by the surgery nurses. Each SKU has a fixed location within the forward storage area. The location is identified by the bar-code stripe of a certain standard that is chosen for the supply chain. In practice that would mean that when a nurse is ready to execute daily orderpicking activity she/he should take a hand-scanner and scan the bar-codes of the items that are being picked up from the shelves. This data is saved either on the

scanner until the moment the scanner is plugged to the terminal, that in turn is connected to a computer, or is transmitted to the computer via wireless technology directly during the orderpicking process. In the second case the scanner has a built-in wireless port.

In order for the inventory control system to calculate the order quantity the delivery data has to be fed into the system when the products arrive to the storage. This is done during the unpacking and replenishment of the forward area also with the help of a scanner. In this way the system can operate with both arrival and consumption data, and having programmed the re-order point, normal inventory level and order batch sizes, the system will generate order quantities for each required SKU.

Bar-code standard is an important issue that concerns not only the chosen common standard but defines also who will have the responsibility of printing the new bar- codes and updating the old ones when the product is changed. In the studied cases of Gothenburg and Stockholm hospitals this is the responsibility of the central distribution centres.

5.4.2.4.2 Order Placement

The order placement process within the department needs to be simplified and that is when the computer assisted order processing system can be used. Considering the comments made by the department personnel the authors realized that the department would like to stay in control of the order quantities delivered by the central storage. Therefore, the proposed alternative is to apply a Co-managed Inventory System. The theoretical part gives a schematic description of the activities that compile the electronic order placement process. The major benefit of the department in this case is that the personnel will not be fully involved in inventory control activity but will still be able to adjust the quantities of the ordered products depending on the consumption situation within the department. In this case the central storage will send the order quantities proposal for confirmation by the Department personnel in charge of the purchasing.

The most appropriate solution for exchanging electronic information with the suppliers is VPN (Virtual Private Networks) technology. Schematically, the network environment between the Surgery Department and, for example, the central storage will look as on the Figure 5-5 below:

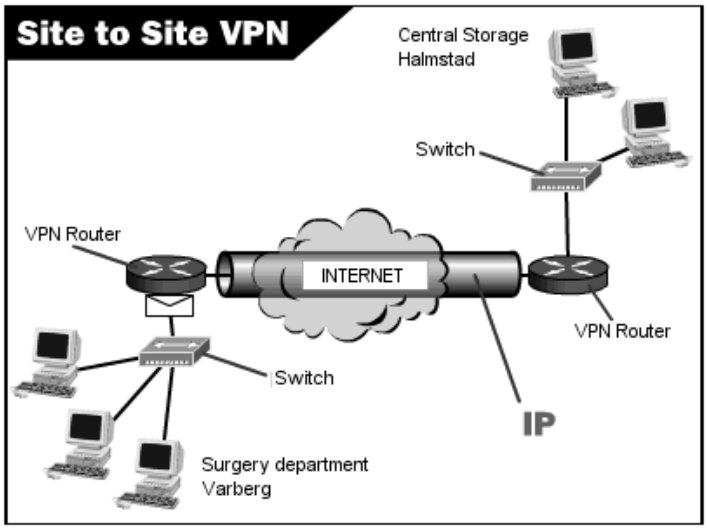

Figure 5-5: VPN site-to-site location

The technical side of how VPN works was explained in the Theoretical Chapter and therefore, will not be discussed here one more time. It is nevertheless important to mention that utilizing VPN technology is the most easy and less expensive solution for the Surgery Department.

5.4.3 Tactical Level Decisions: Dimensions of the storage areas

5.4.3.1 Forward Area Dimensions

The dimensions of the forward area are partly based on the previously made calculations of the shelf-meters that are required to allocate the existing amount of stock. The calculation was performed by Seija Torstensson, the sales person from Constructor Sverige AB with regard to how to determine the type and the size of the storage system. It was calculated that the existing amount of stock will be allocated on about 800 shelf-meters that are 40 cm in width and 1 meter in length. This number contains both sterile and non-sterile products, however, the task is to split this number into two family groups: sterile products and non-sterile products, since according to the hygiene regulations described in the theoretical chapter these groups demand separate storage areas and are not allowed to be mixed. The previous calculation did not take into consideration the amount of bulk stock kept in the storage located in the basement of the hospital. The task was then to recalculate the stock of sterile products in order to determine the required dimensions of the sterile storage area. Additionally, the task included the calculation of all the bulk inventory accumulated in all possible storage locations in order to determine the dimensions of the unpacking/reserve area. The total amount of inventory was transformed into shelf-meters since this is the measure that allows for further space calculations. The results of inventory calculation are presented in the table below (Table 5-2).

Present products location	Sterile Products Storage	Reserve Storage
Sterile storage	78, 5	2,5
Pauline's office	39	3
Anastasia department storage	17	24
Buffer Storage	4	63
Orthopedic products	52	
Corridor Storage	26,3	7
Basement storage		64
Total shelf-meters:	**138,3**	**163,5**

Table 5-2: Calculation of Sterile and Bulk Inventory

5.4.3.2 The calculation of the inventory level of non-sterile products in shelf-meters is done below:

800 shelf-meters (total) -138, 3 shelf-meters (sterile) -2, 5-3-24-63-7 shelf-meters (reserve) = 562, 2 shelf-meters (none-sterile).

The above calculation did not take into consideration the amount of shelf-meters accumulated in the basement storage since it was disregarded in the previously executed calculation resulted in 800 shelf-meters.
From both site visits to two of the major hospitals in the Gothenburg area, Sahlgrenska and Östra hospitals, and a discussion with compact storage expert Seja Torstensson, it was found that the most commonly used sections of the compact storage within the hospitals have the following dimensions:

- Height 2, 3 meters
- Length 1 m
- Depth 40 cm

Depending on the size of the stored products the section can be equipped by the different number of shelves that can be up to 20 shelves per section. The compact storage double unit contains two sections accessible from different aisles and has the total depth of 80 cm. In the same time the section can be organized in rows next to each other forming aisles of several meters.

5.4.3.2.1 Sterile and Non-Sterile Forward Areas Dimensions

In both of the forward areas the average number of shelf-meters located on 1 square meter of floor space was taken as 14 when each side of the unit

allocates 7 shelves. This number of shelves was taken as 7 per side taking into considerations the average size of the stored products. This algorithm was used for calculating the number of required double compact storage units.

Product Groups	Shelve meters	Number of double units	Required floor Space (sq.m.)
Sterile Products	140	10	15
None-Sterile Products	562	40	45

Table 5-3: Storage system and floor space dimensions

Following the received numbers it was suggested to organize the storage system inside of the sterile forward area in five rows which gives a total of 10 double one-meter sections. Each row consists of two such sections. In order to access the items inside of the rows the space of 80 cm was added to the required length of the room.

As far as the storage system in the non-sterile forward area is concerned, it was estimated that the present inventory level will require 40 one-meter double storage sections. The area is divided by the major aisle into two storage blocks, each containing 5 rows of four sections. The same amount of space was added to allow for the access.

5.4.3.3 Unpacking and Reserve Area Dimension

Addressing the size of the unpacking area three factors should be taken into the consideration:

- The dimension of space required for the actual unpacking procedure
- The dimensions of reserve area based on the average number of bulk inventory (boxes) stored
- The dimensions of the sluice required for unpacking the boxes containing sterile products

The bulk located in the basement storage accounts for approximately 60 shelf-meters (Table 5-2). These products are to be stored in the unpacking/reserve area on pallets since the size and the weight of the boxes makes it inappropriate to use box racks in this case. One euro-size pallet allocates

around 6 shelf-meters, and therefore, 10 pallets are considered to be enough for the current inventory level.

The accumulated bulk inventory within the department, excluding the basement storage, accounts for 100 shelve meters. These products are to be stored in the unpacking/reserve area on box-racks. One box-rack for the middle-sized boxes allocates in average four shelf-meters, and therefore around 25 sections of box-racks are needed.

The actual unpacking procedure will take place in the empty area by the entrance of the unpacking part. This area, shown on the layout below, has the size of approximately four square meters. The calculation is done to ensure enough of space for moving the trolleys and large-scale boxes. The dimension of the sluice is 3.75 square meters, which is considered to be enough for the unpacking procedure.

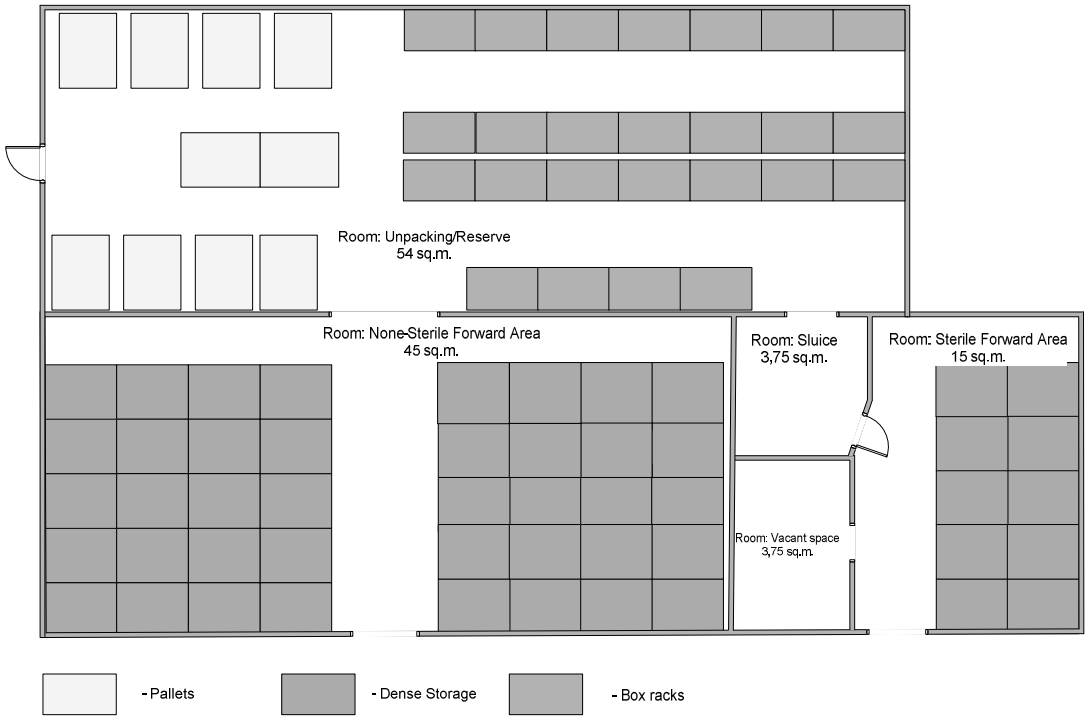

Figure 5-6: New storage lay-out and storage system design

5.4.4 Operational Level Decisions

As was stated in the theoretical chapter, the decisions that are to be made at this level mainly concern the operation side of a warehouse, and covers such operating issues as assignment of replenishment tasks to personnel, allocation

of incoming products to free storage locations, regulations concerning orderpicking process in part of order sequencing, assignment of picking tasks to order pickers, sequencing of picks per order; assignment of product delivery schedule. Obviously the above mentioned decisions can be characterised as purely internal department management decsisons since they depend directly on the personnel policy and the medical processes, and therefore, were not included in the scope of the present design.

However, the authors found it important to include some questions concerning the replenishment process into the design scope since the smooth replenishment is vital for the new storage layout and the processes within it to function well .

5.4.4.1 Replenishment

The replenishment activity occurs twice within the storage. The four fundamental points discussed in the section of order picking process are the reasons why the authors want to point out the importance of high-quality replenishment activity.

First time replenishment takes place when the products from the reserve/unpacking area are replenished to the forward area. As mentioned before, the large bulk products on the pallets or the smaller bulk products on the racks are only stored in the reserve/unpacking area if they are not needed in the forward area. Hence, this first replenishment activity can occur as soon as the products are received in the unpacking part, or after the products have been stored in the reserve part. The personnel in charge of the forward area should make sure, on the daily basis, that the forward area is filled up in order for an efficient retrieving activity in the forward area to occur.

Second time the replenishment takes place when the products from the forward area are replenished to the picking area. How often this replenishment activity has to occur depends on the amount of items used from each theatre’s picking storage. The information gathered from the personnel declares that the items stored in the picking storages can quickly run out if the surgery schedules get tight. Considering this the authors find the second replenishment of a great importance. If needed the replenishment of the picking storages should be executed several times a day in order to make sure that the storage allocates all the necessary items in proper quantity. In this way surgery nurses will not have to leave from the surgery theatres to the sterile storage during the ongoing surgery as it happens at the moment. Improved replenishment policy has to aim at improving the security and quality of the surgery activities.

5.4.5 Expectations of the New Storage Design Implementation

The expected results that are realistic to achieve having implemented the proposed design are summarized in the Table 5-4.

Parameters	Expected Result
Product Flow	
1. Hygienic Safety	The hygienic safety will be improved.
2. Space Utilization	Higher degree of space utilization which will lead to less floor space needed.
3. Orderpicking Efficiency	
3.1. Orderpicking Time	Less time needed for orderpicking.
3.2. Visibility	Better product visibility also accounts for shorter replenishment, stocktaking and picking times.
4. Regular Product Flows	Human flow does not get interrupted by product flow. The majority of products are assigned their movement routes.
Information Flow	
1. Inventory	
1.1 Number of Articles	Due to the better information flow it is possible to decrease the number of stored articles by 30%.
1.2 Floor Space	Eventually less floor space will be needed and not more. New lay-out design requires 120 square meters.
2. Administrative Work	
2.1 Clerical Work	The computer assisted program will be running the order routines using electronic data interchange instead of using telephones, faxes and e-mails.
2.2 Daily Routines	Deliveries are scheduled during the week and only emergency packages are the allowed exceptions.

Table 5-4: Expected results of the new storage design

5.4.6 Long Perspective Results

The expected results that are briefly stated in the above table are somewhat of direct consequences that can be shown in a rather short-term perspective after the initiated changes. However, the authors believe that the optimal design for the new storage facility will in a longer perspective also lead to more essential and superior improvements and results. Those superior results are what the authors call the long-term results and they are described more detailed below:

Quality of medical services improved. When the hygienic safety improves it will result in a better hygienic situation.

The improved regularity in the product flow will lead to fewer flows crossing each other. In a long-term perspective this will result in improved quality of the medical services performed.

More time for the patients. When the visibility and the orderpicking time in the products flow, and the decreased clerical work in the information flow decrease it will release personnel time that was previously required for these functions. It is an important outcome since the main idea behind the healthcare sector is taking care of patients and not the product flow. More time spent on the patients is very closely related to the result of quality services described above, because more time will lead to better care.

More patients taken care of. The outcome explained above means that the released time would give the patients better care. Also, the released time will result in the fact that more patients can be taken care of on the daily basis. This will create a possibility to decrease very much debated long queues and the long waiting time for the surgery patients.

Better working environment for the personnel. Also, the regularity and the daily routines will help the personnel to improve their schedule planning, and limit the unnecessary movements and manual box transportation.

Less tied-up capital in inventory. The possibility to decrease the number of stored articles because of a better information flow will lead to the fact that less capital is tied-up in the form of inventory. A large amount of inventory tied-up capital is a big risk in the healthcare sector. Constant product progress questions if the already existing inventory is ever going to be consumed at all.

Less construction costs. Regarding the new storage that is to be built, factors such as better space utilization and decreased number of articles stored, leads

to less floor space needed. Considering less floor space the construction costs of the new storage will be lower.

5.5 Supply Chain Problems Analyses

During the study the authors were paying certain attention to the supply chain management since it has a lot of influence on both the product and information flows. The supply chain includes the external suppliers, the central storage and the end-users at the Surgery Department both at Halmstad Hospital and Varberg Hospital. It was important to find out the internal relationships between the channel members, the degree of cooperation and information exchange between them. The authors, in this way, want to clarify the picture of the partners' relationship along the complete medical chain organisation in Halland County Council. It was important to find out the internal relationships between the channel members, the degree of cooperation and information exchange between them. The executed study showed that the existing chain structure can not be considered a supply chain since it does not meet the supply chain definition given in the theoretical framework of the present work. The authors identified a number of problems in the system that causes obstacles in optimizing product and information flows.

5.5.1 State of Nature

By state of nature is considered the environment in which the "supply chain" exists (Figure 5-7). There is nothing that can be done to change the parameters of this environment. They are considered to be fixed, and therefore, are called state of nature. In the present case the fact that the hospital is a public enterprise, and is controlled by the local government with low economic incentives is a state of nature. It means that in order to change the performance of the chain it is only possible to improve the variable characteristics of the chain. In order to improve the system parameters first the problems in the chain have to be identified.

5.5.2 Supply Chain Problems

The problems were split into three channel problem groups such as channel management problems, channel strategy problems, and channel structure.

5.5.2.1 Channel Management

5.5.2.1.1 Communication problem

Various surgeons have different demands for products used for the same activities. These various demands and requests are communicated to the person in charge of ordering. The medical side which consists of the surgeons, and the administrative side which consists of persons in charge of ordering, do not communicate with each other well enough and do not discuss the details of

order placement of non-standardized materials that account for extensive costs. The result is that it is almost impossible to keep track of the number of SKUs ordered and the overall order costs.

Communication problems arise also at the linkage with the Central storage. Central storage does not receive statistics about the order frequency of SKUs. The central storage has the resources to store items that are used frequently, but it is difficult when the incorrect statistics are received. Central storage could enlarge the offered product assortment if the current needs of the hospital could be discussed on a constant basis with the administration of the central storage. The result is that the central storage neither fulfils its functions that it was initially planed for, nor utilizes its storage potential to 100%.

5.5.2.1.2 Order Processing Speed

It is faster and easier to order directly from the external companies instead of placing orders with the Purchasing Department. The result is that the Surgery Department saves time but has no economic incentive to order via the Purchasing Department.

5.5.2.1.3 Channel Power

There is no organisation in the chain that would be powerful enough to lead the development of the “supply chain”. It results in the fact that chain members are disintegrated and are not given a common development direction.

5.5.2.2 Channel Strategy

5.5.2.2.1 Lack of Common Goals

5.5.2.2.2 Even though the central storage was designed to be the essential part of the supply chain that would be responsible for smooth and reliable supply of the majority of items there are no common goals set for both the hospital and the central storage. The management teams of the hospital, surgery department and central storage do not put enough of attention and efforts into aligning their separate goals in relation with their functions. In the same time the common goal should be the overall cost saving through out the chain.

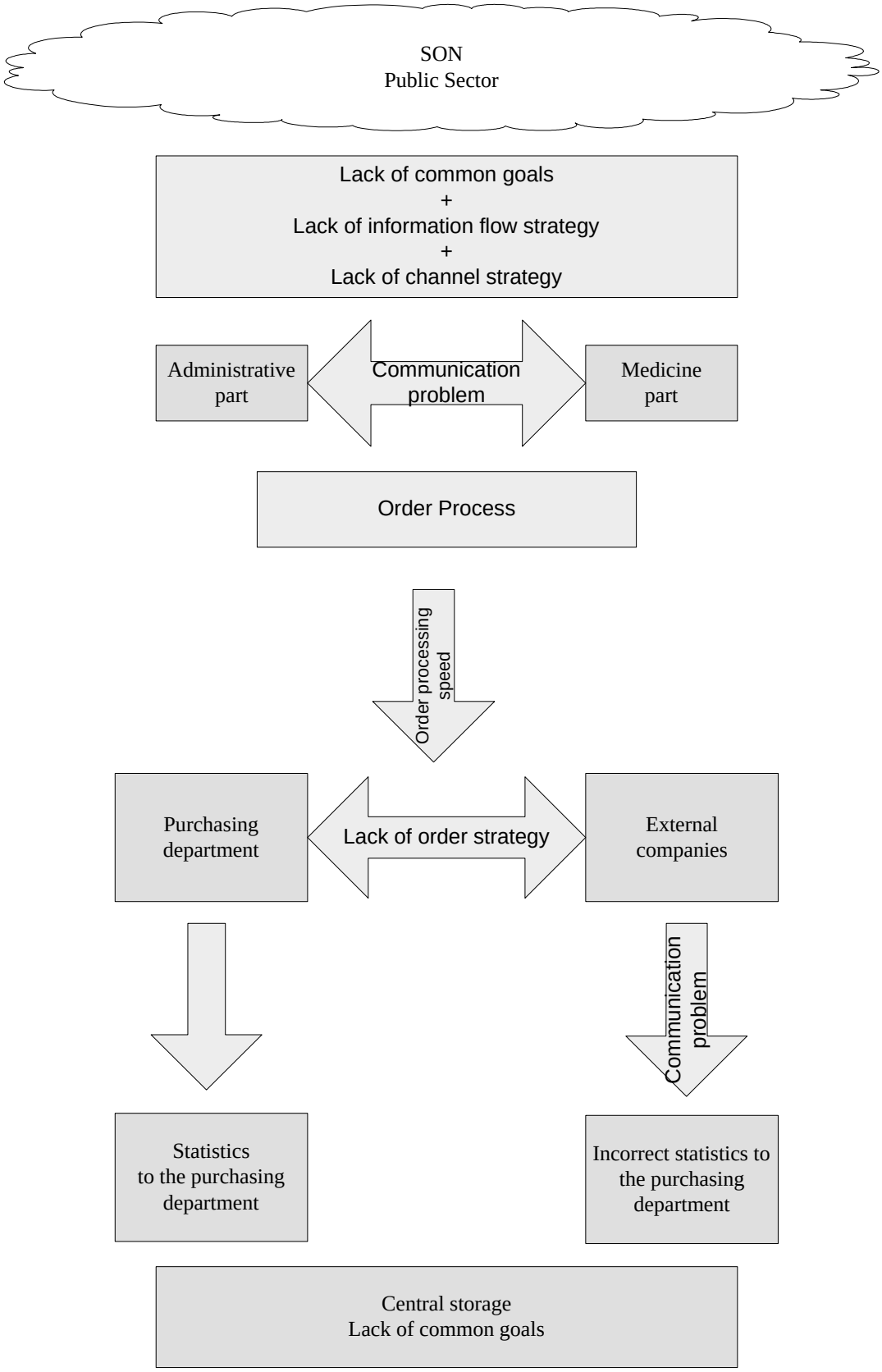

Figure 5-7: Supply chain problems

5.5.2.2.3 Order Strategy

There is no firm order strategy or policy applied at the moment. The items ordered from the external suppliers are not standardised to a reasonable extent. It results in the fact that some SKUs transform into the obsolete inventory that is practically never utilized. Additionally, it leads to the wider order assortment that is needed in reality.

5.5.2.2.4 Information Flow Strategy

In relation to the problem concerning the lack of the power in the chain, the information flow strategy problem arises. All of the members utilize their own internal information systems. There are no actions undertaken by any of the members to implement a common information system. It is important to mention that even such important link as “hospital-central storage” uses electronic mail system at the most.

5.5.2.3 Channel Structure

5.5.2.3.1 Channel Members

The number of the channel members is too far from being characterised as optimal. At the moment the number of external suppliers exceeds 90 companies. It can especially be regarded as a large number when the existence of the central storage is taken into consideration. Administration of order placing and delivery control requires a great deal of clerical work from the department medical personnel since no administration positions were created for executing order placement and inventory control activities.

5.5.3 Areas of improvement

After the identified problems were addressed some of the improvement directions can be discussed.

It can be beneficial to revise the material assortment aiming at standardisation of items in use.

Revision of the suppliers. It is important to check if the suppliers carry out the same SKU positions, and if so the SKUs can be consolidated at one supplier who can offer better assortment range.

Central storage order assortment has to be reconsidered. Frequently used items have to be ordered from the central storage and not directly placing an order with one of the external suppliers.

Investigating possibilities that would allow increasing the order placement speed with the hospital purchasing department.

Investigating possibilities that would allow improving communications along the supply chain.

6. CONCLUSIONS

6.1 Conclusions

The study starts with the discussion of the new global trends within the healthcare sector. More hospitals nowadays are aiming at providing high-level patient care with minimal funding, and that is the main driving force for the hospitals' administration to re-engineer their logistic processes. Therefore, the strategic importance of the thesis was to investigate the possibility of changing some of the traditional logistics processes within a hospital to logistics practices that are currently more common within the private sector.

The purpose of the study was to come up with a design for a new storage facility for the Surgery Department at Varberg Hospital. It was planned that the design would attempt to re-engineer current product handling activities at the department and not simply suggest the physical dimensions and lay-out of the new storage area. Under the level of strategic decisions it was planned to put a certain focus on the information technology issue as well what can be regarded as not a typical design issue according to the commonly used definition of a warehouse design. However, it is important to remind that this thesis puts a broader perspective on the warehouse design process and its stages. The final outcome of the research would be a draft of both a new storage lay-out proposal and a suggested set of warehousing processes which could be used as a background for further decision making for the upcoming construction project. Therefore, the present study had the status of a pre-study for further studies within the construction project at the hospital.

It is important to state that the study dealt only with the product flow within the department, and these are the materials that are used during the surgeries. The product assortment accounts for about 2 700 SKUs. The present study did not investigate the instrument flow within the Surgery Department even though it is another major flow that ensures the department efficiency in general. However, there are different sets of general safety regulations and internal department rules and considerations applied to the instrument flow, and this area would demand a separate research initiatives.

In order for this study to be scientifically consistent a research design was made that provided a major guideline for the research steps, type of information needed and potential sources of accessing this information. Primary data was collected through scientific observation and qualitative interviews which were both non-directive and semi-structured individual interviews or telephone interviews depending on a particular situation the

authors were dealing with. Internal secondary data was received from the department administration and was represented by the hospital description brochure, product items description, number and names of suppliers, department map and other. External data included such sources as books, course lecture materials, scientific journals and Internet. In order to access information on commonly used logistics practices case history methodology in form of investigating relevant projects carried out at other Swedish hospitals. In general, this study can be characterised as a qualitative and inductive study.

Regarding the structure and the content of the theoretical chapter the authors would like to emphasize the practical importance of all the theories and outlines for the actual analysis. It was especially important to review theoretical sources regarding warehouse theory including warehouse processes and types of storage equipment with their advantages and disadvantages. Information systems overview was also an important part to ensure the better understanding of possible information solution within the inventory control. A rather big part of the theoretical chapter refers to supply chain philosophy. It was outlined in the study mostly for the surgery department administration. After the authors had determined some problems in the current supply chain it was requested to overview those in the paper as well. Absence of the relevant theory could cause some misunderstanding between the parties.

Here, it is useful to open here a short discussion about the final results of the present study outlined in the end of the analytical chapter. From one perspective the final outcome of the conducted research is the new design of the storage facility. A more detailed the design process will be discussed later on in this chapter when answers to the research questions are given. From the other perspective the identified improvements which are expected to follow after the design is implemented can also be regarded as research results. The authors would also like to mention that the analysis made for the supply chain and identified areas of improvements can be regarded as side-results of the thesis which thus represent important findings for the future improvements.

6.2 Answer to the research questions

This section is devoted to summarizing the answers to the research questions stated in the very beginning of the thesis. The authors believe that this is a convenient way of reminding the reader the initial problems that initiated the present research.

6.2.1 Main Question

What would be the optimal design for a new storage facility for the Surgery Department at Varberg Hospital?

The answer to the main research question is indeed the set of answers given to each sub-question listed below. Only when having made all the necessary decisions can an optimal storage design be identified.

6.2.1.1 Sub-questions

What are the decisions that are to be taken at the strategic level of the design?

The first decision to make under this level was to decide on the location of the storage facility within the new building. As it was mentioned in the analysis a number of assumptions were taken into consideration regarding this matter. However, after the discussion with the department chief personnel two possible locations were named as equally optimal. Here the opinions among the personnel were split. The purely administrative personnel and the authors agreed that Alternative 2 with the corner location of the storage offers better operational advantages than Alternative 3 that suggests the existence of a smaller storage area in the center of the building apart from the main storage in the corner. In case of Alternative 2 only two replenishments are required: from the reserve area to forward area and from the forward area to picking area within the theaters. Alternative 3 was supported by the surgery nursing personnel since it offers better flexibility for them during the surgery process. In case some of the items within the theaters finish they can be quickly obtained in a near storage.

Storage system is designed to consist of four different types, such as: movable cupboards equipping the picking areas; compact storage system for the forward area; pallets and box-racks for the reserve area.

The process flow will include the following processes: receiving, storing, orderpicking and shipping process.

With relation to the information system it was decided to develop the current inventory control system SterilAgent even further. One step of the development should be done in part of implementing scanning and bar-code technique for improving inventory control activity. Another important development stage is the usage of the current internal system as end-to-end system. The first step here is to connect the central storage in Halmstad, and at

the later implementation stage, connection of the major external suppliers to the system. The new system is likely to utilize Virtual Private Networks technology.

What are the decisions that are to be taken at the tactical level of the design?

The decisions undertaken to answer these sub-questions resulted in determining the space dimensions for the storage areas that compile the storage functional areas. The dimensions are given in the analytical chapter but the total required space accounts for about 120 square meters.

What are the decisions that are to be taken at the operational level of the design?

It was mentioned in the analytical chapter that the authors faced limited possibilities to undertake the decisions at this design level due to the character of these decisions. Nevertheless, the authors gave several recommendations concerning the replenishment activities within the new storage. High importance was given to a proper replenishment activity within the forward and especially picking areas. Having proper smoothly scheduled replenishment activities within the surgery departments will make possible that Alternative 2 is used instead of Alternative 3.

The research conducted for the Surgery Department operates the empirical data relevant to particularly this department. Nevertheless, the present study can be used for solving any other similar problems faced by the other departments of Varberg Hospital or even by the other hospitals. Theoretical background of the research and problem solving model used in the paper can be further developed and adjusted to various problem solving within the hospital logistics in part of warehouse design, material and information flow improvements.

7. RECOMMENDATIONS AND FURTHER STUDIES

7.1 Recommendations

The suggestions given in the analytical chapter contain the majority of the recommendations that are likely to take into consideration once the new storage facility is planned. Additionally, in this section of the paper, some side suggestions will be given. The given suggestions are not graded according to their importance or classified in accordance with their implementation area.

Location of the Storage Facility within the New Building
The authors of the thesis did not come up with the final selection of one of the three location alternatives due to the fact that this is strictly internal matter of the department project team, however, having outlined advantages and disadvantages of each of the alternatives, the authors would like to recommend the avoidance of any potential locations that would cause the interference of material and human flows.

Package Withdrawal
In case the new building had a basement floor it would be interesting to plan for a pipe system that would transport used packaging materials from the unpacking area to the ground floor for further collection and withdrawal from the territory of the hospital. Such a system would help to keep order in the reserve area and ensure more useable space.

Marking and Signs
The doors of the sliding sections should have the lists of the items that they contain. Different sections should have different colours of the lists for better visibility and convenience of the old and new personnel.

Item Allocation
Item allocation should utilize storage principles, primary such principles as product family groups, complementarity and popularity. Different principles can be applied to different sections depending on the collegial agreement of the medical personnel of the department.

ABC Zoning
It was found out that a number of items have a higher rotation frequency than others. Therefore, it could be beneficial to conduct a more detailed ABC analysis of all the products and place at least A-products closer to the storage entrance.

Standardization Policy
Newly ordered expensive products have to seek approval of the purchasing department. The general trend within the Swedish hospitals is to use more standardized surgery materials that would ensure cost savings.

Mobile Storage Content
As it was mentioned in the Analytical Chapter the convenience of material control within the picking storages can be improved by implementing the Mobile Sections within the theaters. The authors' recommendation is to carry execute an analysis of the products that should be included into the mobile cupboards assortment.

7.2 Further Studies

The present study can be regarded as the initial investigation due to the fact that there were a lot of assumptions made, and very little information available about the new building functions and lay-out. The authors regard their work as a guideline for those members of the department who will be responsible for all of the projects related to the new building lay-out design.

The future development of the construction project would obviously cover the areas that were left outside the frames of the present research, and stated in the Problem Delimitations paragraph, in the opening chapter. Nevertheless, there is a block of problems earlier mentioned in the Analytical Chapter that strongly require further investigation. This area deals with the Supply Chain Management that unites the department with its suppliers. The researchers believe that the hospital administration should initiate a new research project that would aim at finding the ways to solve the identified supply chain problems, and focus the research on the outlined areas of potential improvements. The draft of the research proposal is represented in Appendix 6. It is vital to seek for the benefits hidden in the supply chain optimization and co-ordination since only the organizations internal efficiency has proved itself not to be enough.

7.3 Closing Words

Having finished this thesis we would like to take the opportunity to once again thank everybody who was involved with the research process. We very much appreciate this great contribution and help.

The research team experienced certain problems with the thesis subject selection and was forced to change the project completely in the later stages.

That is why the quick feedback and support of the university supervisor was of a great value and appreciation.

Also, more time for the current research would be highly desirable since there is a lot of potential to broaden up the analytical framework. Nevertheless, the answers to the research questions were found, and the authors would like to think that their work will be not just of a purely academic value but of a practical value as well.

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Interview Sources

Agneta Knese, Division Manager, Varbergs Hospital

Annelie Lewinbäck, Nurse, Varbergs Hospital

Anita Johansson, Nurse, Östra Hospital

Bo Christensson, Sales Manager, IAB AB

Christina Ekroth, Nurse, Sahlgrenska Hospital

Eivor Blomqvist, Surgery Nurse, Varbergs Hospital

Göran Nilsson, Head Manager, Halmstad Central Storage

Jill Johansson, Nurse, Varbergs Hospital

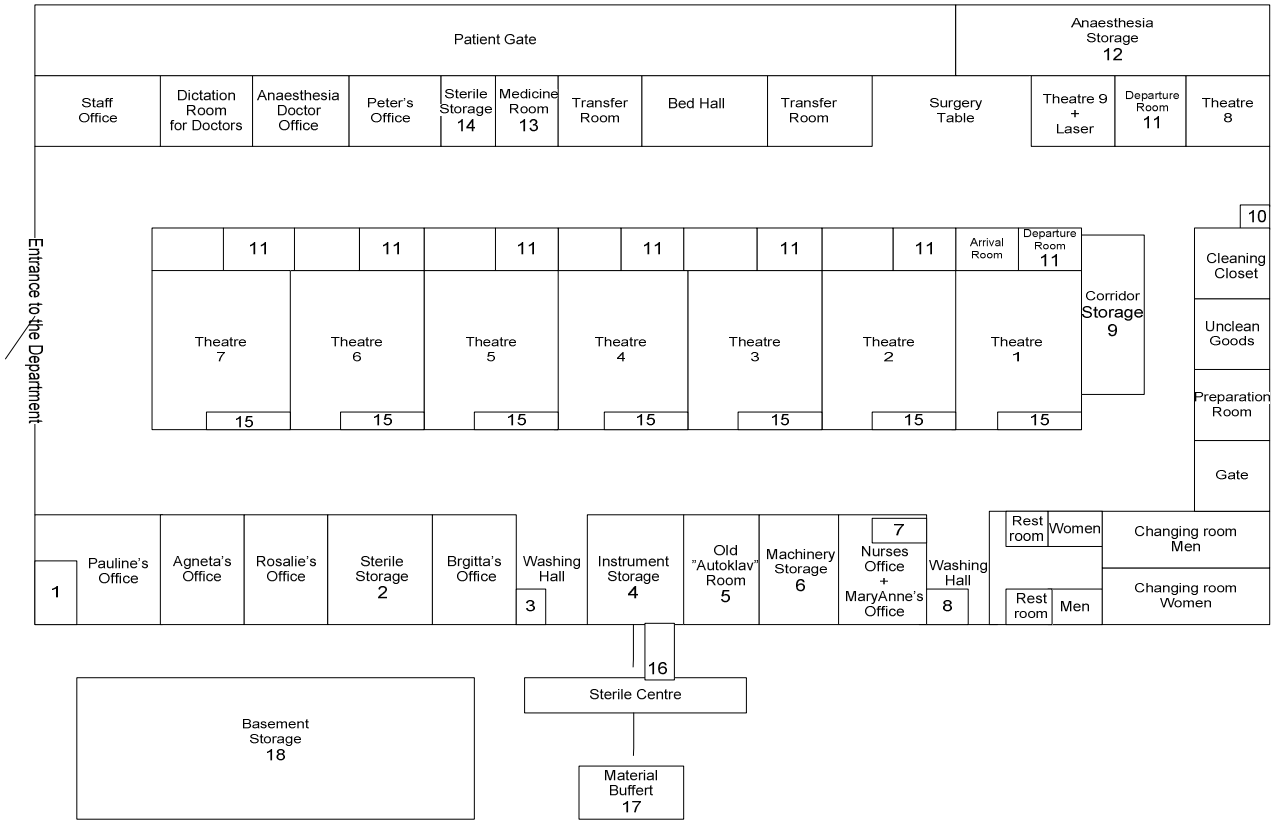
Lars-Gunnar Andersson, Varbergs Hospital

Pauline Matsson, Department Administrator, Varbergs Hospital

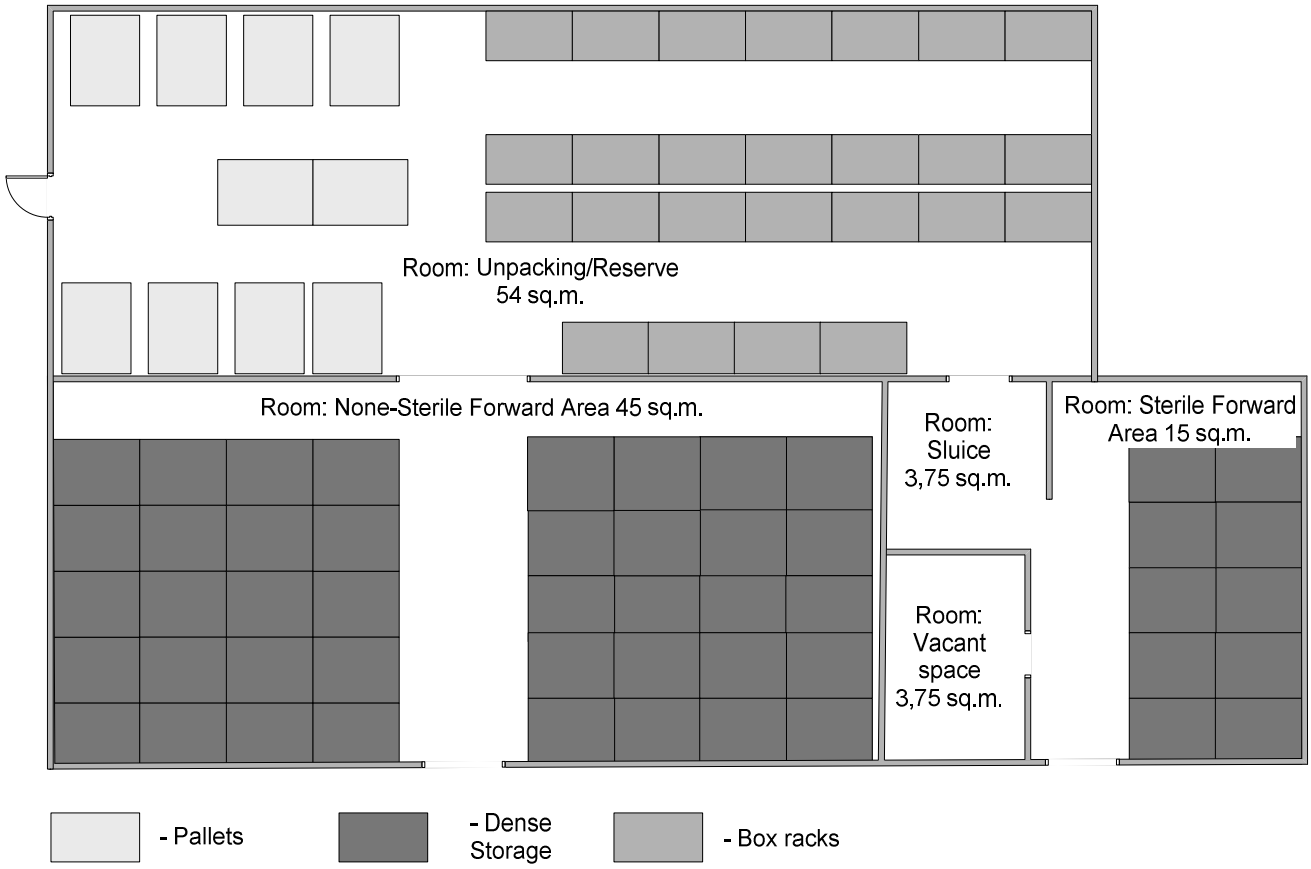
Rosalie Hammarsten, Division Manager, Varbergs Hospital

Seija Torstensson, Sales Manager, Consult & Compact Storage

APPENDIX 1: SURGERY DEPARTMENT LAY-OUT PLAN



APPENDIX 2: STORAGE LAY-OUT AND STORAGE SYSTEMS



APPENDIX 3: INTERVIEWS

Sahlgrenska Hospital 20th of October 2004

Interview with Christina Ekroth - a medical nurse at the central surgery department at Sahlgrenska Hospital.

Major Question:

- How are the storages arranged at the central surgery department?

Sub-questions:

- What types of storage equipment are used?
- What are the material flows within the department?
- How is the order process working?
- What kind of inventory control system is used?
- How is the central storage in the county of Västra Götaland working? Any pros and cons of having this system?
- Any future plans for the department, in regard to ordering process, inventory control or material flows?

Seija Torstensson 12th of November 2004

Interview with Seija Torstensson - an expert in compact storage systems.

Major Question:

- With regard to knowing how much space is needed for the dense storage, how to convert shelve meters into square meters? Is there a formula we can follow?

Sub questions: system

- What methods to follow when planning for compact storage?
- How does the compact storage work?
- What are the different sizes of compact storages, different sizes of the shelves?
- What kind of products/boxes can be stored in the compact storages?
- What is the approximate price of the compact storage system?

Central Storage 16th of November 2004

Inteview with Göran Nilsson – the head manager at the central storage in Halmstad.

Major Question:

- With regard to the product supply for the hospitals in the county of Halland, what are the major tasks for the central storage?

Sub-questions:

- Describe the history of the central storage, and why it was decided to be a central storage in the county of Halland?
- How many items are stored, and how are these decided to be stored? Is there any minimum level of orders before the central storage starts to carry a product?

- Do the various hospitals in the county of Halland have the chance to communicate their desires concerning what items are stored in the central storage? If yes, what is the procedure?

- How many items are ordered from the surgery department at the Varberg Hospital?

- Describe the relationships with the suppliers?

- Describe the relationships with the customers (the various hospitals in the county of Halland)?

- Describe the information system in use? Is it an end-to-end system that connects suppliers and customers?

- What are the future plans for the information system?

- Describe the future plans for the central storage, with regard to developments and activities?

APPENDIX 4: FREQUENCY ANALYSIS.

Frequency Analysis for the Items Stored in the Picking Storage:

Sjukhuset i Varberg
Centraloperation

KUNDUPPGIFTER

Kundnamn		Kundnummer
CENTRALOPERATION, SJUKHUSET I VARBERG		**42039**
Rekvdatum	Ansvarig rekvirent	Telefon

REKVISITION

Artnr	Antal	Enhet	Namn		Artnr	Antal	Enhet	Namn	
20233		ST	ABORTKYRETTE 8 MM	36 ST	20166	A	PAR	HANDSKAR OP BIOGEL 7.5	50 PAR
20232		ST	ABORTKYRETTE 10 MM	36 ST	20167	A	PAR	HANDSKAR OP BIOGEL 8.0	50 PAR
20237		ST	ABORTSLANG	30 ST	20168	A	PAR	HANDSKAR OP BIOGEL 8.5	50 PAR
70275		ST	AGGREGAT BAXTER (LAP.SCOPI)	50 ST/FP	70122	A	PAR	HANDSKAR UNDERSÖKNING LARGE	100 PAR
20301	A	ST	AGGREGAT CYSTOFLOW	20 ST	70121	C	PAR	HANDSKAR UNDERSÖKNING MEDIUM	100 PAR
63201	A	ST	AGGREGAT TURP	12 ST	70123		ST	HÄFTA PLÅSTER BAND-AID	100 ST
20022		ST	BLÄSSKÖLJNINGSSET KOMBISET	10 ST	20116		ST	KANYL INJ. HJÄRTA 0,9 X 120	25 ST
20182		ST	CYSTODRAPE	25 ST	20117		ST	KANYL INJ. HJÄRTA 0,9 X 150	20 ST
20313	A	ST	DRÄNAGE UNOVAC BÄLG NR 14	10 ST	70134	A	ST	KANYL INJEKT. BLÅ 0,6 X 25 M	100 ST
20314	A	ST	DRÄNAGE UNOVAC BÄLG NR 18	10 ST	70133		ST	KANYL INJEKT. GRÅ NR 20 0,4	100 ST
70104	A	ST	FÖRBAND ABS. ZETUVIT 10 X 10	25 ST	70136		ST	KANYL INJEKT. GRÖN 0,8 X 50	100 ST
70103	A	ST	FÖRBAND ABS. ZETUVIT 10 X 25	25 ST	70139		ST	KANYL INJEKT. GRÖN 2,1 X 80	100 ST
70105	A	ST	FÖRBAND ABS. ZETUVIT 15 X 20	25 ST	70138		ST	KANYL INJEKT. ROSA 1,2 X 50	100 ST
70355	B	ST	FÖRBAND AQUASEL 5 X 5 CM	10 ST	70141		ST	KANYL LUMBAL SVART 0,73 X 75	25 ST
19722	A	ST	FÖRBAND AQUASEL 15 X 15 CM	5 ST	70158	A	ST	KATETER FOLEY 2-VÄG NR 12	10 ST
70161	C	ST	FÖRBAND CAVILON	25 ST	70156		ST	KATETER FOLEY 2-VÄG NR 14	10 ST
20253	A	ST	FÖRBAND DUODERM 5 X 10 CM X	10 ST	70160		ST	KATETER FOLEY 2-VÄG NR 16	10 st
20254	A	ST	FÖRBAND DUODERM 5 X 20 CM X	10 ST	20064		ST	KATETER FOLEY 2-VÄG NR 18	10 ST
70110		ST	FÖRBAND DUODERM 10 X 10 CM	5 ST	20063		ST	KATETER FOLEY 2-VÄG NR 20	10 st
60116	A	ST	FÖRBAND MELOLIN 5 X 5 CM	100 ST	70204		ST	KATETER LOFRIC TAPPN NR 12 2	25 ST
60117	A	ST	FÖRBAND MELOLIN 10 X 10 CM	100 ST	70171		ST	KATETER LOFRIC TAPPN NR 12 4	25 ST
19666	C	ST	FÖRBAND MEPILEX ABS. 10 X 10	5 ST	70172		ST	KATETER LOFRIC TAPPN NR 14 4	25 ST
19662	A	FP	FÖRBAND OPSITE/ABSORB. 6.5	100 ST	20068		ST	KATETER LUBRISIL FOLEY 2V/12	10 ST
19705		ST	FÖRBAND SILIKON MEPITEL 7,5	10 ST	70154		ST	KATETER LUBRISIL FOLEY 2V/14	10 ST
20169	A	PAR	HANDSKAR BIOGEL INDICAT 6.0	25 PAR	70155		ST	KATETER LUBRISIL FOLEY 2V/16	10 ST
20170	A	PAR	HANDSKAR BIOGEL INDICAT 6.5	25 PAR	70166		ST	KATETER NELATON TAPPN NR 6	100 ST
20171	A	PAR	HANDSKAR BIOGEL INDICAT 7.0	25 PAR	70175		ST	KATETER NELATON TAPPN NR 8	100 ST
20172	A	PAR	HANDSKAR BIOGEL INDICAT 7.5	25 PAR	70168		ST	KATETER NELATON TAPPN NR 10	100 ST
20173	A	PAR	HANDSKAR BIOGEL INDICAT 8.0	25 PAR	70169		ST	KATETER NELATON TAPPN NR 12	100 ST
20174	A	PAR	HANDSKAR BIOGEL INDICAT 8.5	25 PAR	20229		ST	KATETER NELATON TAPPN NR 14	100 ST
20163	A	PAR	HANDSKAR OP BIOGEL 6.0	50 PAR	20230		ST	KATETER NELATON TAPPN NR 16	100 ST
20164	A	PAR	HANDSKAR OP BIOGEL 6.5	50 PAR	70271		ST	KATETERISERINGSSET	15 ST
20165	A	PAR	HANDSKAR OP BIOGEL 7.0	50 PAR	70373	A	ST	KATETERKLÄMMA	10 ST

REKVISITION

Artnr	Antal	Enhet	Namn		Artnr	Antal	Enhet	Namn	
20123		ST	KATETERPROPP	100 ST	63214		ST	SUGSLANG KK 6.0 X 8.0 MM X 3	25 ST
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63181		ST	KNIV OP ENGÅNGS NR 11	20 ST	70267		ST	SUTURTEJP STERISTRIP 1540 3	50 ST
63182		ST	KNIV OP ENGÅNGS NR 15	20 ST	70268		ST	SUTURTEJP STERISTRIP 1541 6	50 ST
70218		ST	KNIVBLAD OP ENGÅNGS NR 10	100 ST	60106		ST	SUTURTEJP STERISTRIP 1546 6	50 ST
70219		ST	KNIVBLAD OP ENGÅNGS NR 11	100 ST	70269		ST	SUTURTEJP STERISTRIP 1547 12	50 ST
70220		ST	KNIVBLAD OP ENGÅNGS NR 15	100 ST	70230		ST	TREVÄGSKRAN M. 10 CM SLANG	100 ST
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70222		ST	KOMPRESS 5 X 5 CM	120 ST					
70223		ST	KOMPRESS 7 X 10 CM	120 ST					
20235		ST	KOMPRESS KRULL 10 X 10 CM	120 ST					
60130		ST	OP-DUK BRUN RTG-TRÅD 30 X 45	55 ST					
20161		ST	OP-DUK GRÅ RTG-TRÅD 45 X 70	22 ST					
60131		ST	OP-DUK KLINIDRAPE 50 X 50 CM	50 ST					
20321		ST	OP-DUK LILA RTG-TRÅD 10 X 60	125 ST					
20177		ST	OP-DUK STERIDR. 1000 30 X 45	10 ST					
20176		ST	OP-DUK STERIDR. 1020 40 X 40	10 ST					
20162		ST	OP-DUK SVART RTG-TRÅ 45 X 70	150 ST					
20180		ST	OP-TORK BLÅ RTG.TRÅD NR 3	150 ST					
60138		ST	OP-TORK ORANGE RTG.TRÅD NR 0	200 ST					
20181		TF	OP-TORK SVART RTG.TRÅD NR 5	75 ST					
70299		ST	PLEURATAPPNINGSSET	25 ST					
70253		ST	SPRUTA 2 ML	100 ST					
70254		ST	SPRUTA 5 ML	100 ST					
70255		ST	SPRUTA 10 ML	100 ST					
70256		ST	SPRUTA 20 ML	60 ST					
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60147		ST	SPRUTA 60 ML LUERLOCK	60 ST					
20218		ST	SPRUTA 60 ML LUERTIP	60 ST					
63211		ST	SUG RECTOSCOPI	25 ST					
63212		ST	SUG RISSLER	25 ST					
20234		ST	SUG VÅLLFORS	35 ST					

REKVISITION

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70606		FP	BATTERI 1,5 V PC1500 LR6	1 FP	70527	C	ST	BURKLOCK PLAST PREPARAT 170	1680 ST
60747		FP	BATTERI 1,5 V PC2400 LR03	1 FP	70528	C	ST	BURKLOCK PLAST PREPARAT 500	460 ST
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70310	C	ST	BINDA ELASTISK REHNAGARD 6	10 ST	70823		ST	CIDEX STERILVÄTSKA	1 ST
70312	C	ST	BINDA ELASTISK REHNAGARD 10	10 ST	71560		ST	DATOR FÄRGPATR. FÄRG F.DESKJ	1 ST
20016	C	ST	BINDA ELASTISK REHNAGARD 15	10 ST	20077		ST	DATOR FÄRGPATR. SVART 45 (BI	1 ST
20013	C	ST	BINDA ELASTISK SELEFIX 6 CM	20 ST	19710		ST	DATOR TONER HP LASER(ROSALIE	1 ST
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70305	C	ST	BINDA ELASTISK SELEFIX 10 CM	20 ST	19650		ST	DATOR TONER KYOC.TK20 (AGNET	1 ST
20096		ST	BINDA GIPS CELLONA 6 CM	10 ST	70658		ST	DESINFEKTION DAX HAND 600 ML	1 ST
20097		ST	BINDA GIPS CELLONA 8 CM	10 ST	70880		ST	DESINFEKTION DAX YT PLUS 1 L	1 ST (12/F
20092		ST	BINDA GIPS CELLONA 10 CM	10 ST	70663		ST	DISKDUK BLÅ NONVOWEN 32 X 40	50 ST
20093		ST	BINDA GIPS CELLONA 12 CM	10 ST	20041		ST	DISKMEDEL ETD DESINFEKTION B	1 ST
20094		ST	BINDA GIPS SELONA 15 CM	10 ST	20141		ST	DISKMEDEL ETD VIT	1 ST
20095		ST	BINDA GIPS SELONA 20 CM	10 ST	70667		ST	DISKMEDEL MASKIN PULVER KÖK	1 ST
70612	A	ST	BINDA SANITET	20 ST	70665		ST	DISKMEDEL MASKIN SPOL SUMA S	2 ST
20323		ST	BLANKETT INTERNREKVISITION	50 ST	70857		ST	DISKMEDEL SUMATOX DIP SKÖLJ	1 ST
71142		ST	BLANKETT LEDIGHETSANSÖK. GRÖ	1 ST	70784		ST	DISKMEDEL TASKI	1 ST
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20285		ST	BLANKETT REMISS MIKROBIOLOGI	1 ST	60749		RULLE	ETIKETT GUL RISKAVFALL BIOLO	1 RULLE
20277		ST	BLANKETT TJÄNSTG. MÅNADSANST	50 ST	70890		RULLE	ETIKETT GUL SMITTFARLIG LITE	1 RULLE
70914		ST	BLOCK LINJERAT A4	1 ST	60716		RULLE	ETIKETT RISKAVFALL STICK/SKÄ	1 RULLE
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70917		ST	BLOCK LINJERAT A6	1 ST	60718		ST	ETIKETT VIT RISKTVÄTT	1 RULLE
70911		ST	BLOCK NOTIS GRÅ	12 ST	60540		ST	FLASKA BLODODL. AEOROB GRÖN	1 ST
70624		ST	BORSTE DISK RÖD	1 ST	60541		ST	FLASKA BLODODL. ANAEROB ORA	1 ST
70626		ST	BORSTE NAGEL BRED AUTOKLAVER	10 ST	70895	C	ST	FLASKA PLAST PREPARAT 150 ML	200 ST
20028		ST	BURK PLAST KANYL 6500 ML	1 ST	70452		ST	FÖRBAND COLLAR CUFF 5 CM X 6	1 ST
70508	C	ST	BURK PLAST PREPARAT 1500 ML	180 ST	70675	A	ST	FÖRKLÄDE PLAST 85 X 160 CM	100 ST
70506	C	ST	BURK PLAST PREPARAT 170 ML	1680 ST	70938		ST	GEM METALL 30 MM	100 ST

REKVISITION

Artnr	Antal	Enhet	Namn		Artnr	Antal	Enhet	Namn	
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70707		ST	HANDKRÄM ATRIX 200 ML	6 ST/FP	70406		ST	MÖSSA OP BASKER ANNIE	150 ST
70719		ST	HANDKRÄM NATUSAN 200 ML	1 ST	63003		ST	MÖSSA OP KOLUMBUS (MISS)	100 ST
19681		ST	HANDSKAR NITRIL X-LARGE	100 ST	63004		ST	MÖSSA OP RONDO EXTRA SVETTBA	100 st
19659		ST	HANDSKAR NITRIL LARGE	100 ST	19652	A	ST	MÖSSA OP TOP	100 ST
19658		ST	HANDSKAR NITRIL MEDIUM	100 ST	70744	B	ST	NAGELFIL/PETARE	100 ST
19657		ST	HANDSKAR NITRIL SMALL	100 ST	71017		ST	PAPPER DATA HÅL A4	2500 ST
70347		ST	HANDSKAR PLAST SOFTLINE	100 ST	71016		ST	PAPPER DATA OHÅLAT A4	2500 ST
60616		ST	HINK PLAST 3 L EXIT	1 ST	70703		ST	PAPPER HANDDUK SAGA	3000 ST
70363		ST	HÄFTA HYPAFIX 5 CM	1 ST	20270		ST	PAPPER M-TORK PLUS	6 ST
70364	A	ST	HÄFTA HYPAFIX 10 CM	1 ST	70746		ST	PAPPER NÄSDUK	100 ST
70365	A	ST	HÄFTA HYPAFIX 15 CM	1 ST	70748		RL	PAPPER TOALETT	64 RL
70360		ST	HÄFTA PAPPER MIKROPOR 1,25 C	24 ST	70720	C	ST	PAPPER TORKRULLE KATRIN	1 ST
70361	B	ST	HÄFTA PAPPER MIKROPOR 2,5 CM	12 ST	71536		ST	PENNA BLYERTS NR 3	12 ST
70362	B	ST	HÄFTA PAPPER MIKROPOR 5,0 CM	6 ST	71026		ST	PENNA KULSPETS BLÅ	1 ST
70357		ST	HÄFTA SILKE DURAPOR 1,25 CM	24 ST	71028		ST	PENNA KULSPETS RÖD	1 ST
70358	A	ST	HÄFTA SILKE DURAPOR 2,5 CM	12 ST	20151	B	ST	PENNA MÄRK PERMANENT BLÅ	1 ST
70359	B	ST	HÄFTA SILKE DURAPOR 5,0 CM	6 ST	71035	B	ST	PENNA MÄRK PERMANENT RÖD	1 ST
70947		ST	HÄFTKLAMMER 26/6	5000 ST	71037	B	ST	PENNA MÄRK PERMANENT SVART	1 ST
70300		ST	KAFFEFILTER MELITTA 1 X 6	200 ST	71046		ST	PENNA STIFT BLYERTS 0,7 MM	1 ST
70817	B	ST	KARTONG RISKAVFALL 38 L	25 ST	71030		ST	PENNA WHITEBOARD BLÅ	1 ST
71507		ST	KARTONG TRANPORTBURK	1 ST	71031		ST	PENNA WHITEBOARD GRÖN	1 ST
70922		ST	KASETT DIKTERING	10 ST	71032		ST	PENNA WHITEBOARD RÖD	1 ST
70376		ST	KOMPRESS 7,5 X 7,5 CM (OST	120 ST	71033		ST	PENNA WHITEBOARD SVART	1 ST
70343		ST	KOMPRESS 30 X 30 CM	500 ST	71040		FP	PENNA ÖVERSTRYKNING 5-FÄRG	1 FP
70730		RULLE	KUDDSKYDD 60X 80 CM BLÅ	1 RULLE	71011		ST	PLASTFICKA HÅLAD A4	100 ST
70969		ST	LIM KONTOR	1 ST	71531		ST	PLASTMAPP OHÅLAD A4	100 ST
19693		ST	LIM STIFT	1 ST	70677		ST	PUMP TVÅL	1 ST
70733		ST	LUFTRENARE SPRAY	1 ST	70732	C	ST	PÅSE ISTÄRNING	10 ST
20159		ST	MAPP OFFERT BLÅ	1 ST	20757	C	RULLE	PÅSE PLAST FRYS 1 L	1 RULLE
63027	B	FP	MUNSKYDD ANTIFOG SURGINE	50 ST	20758	C	RULLE	PÅSE PLAST FRYS 2 L	1 RULLE
63023	B	ST	MUNSKYDD M. KNYTBAND (F.D.MU	50 ST	70759	C	RULLE	PÅSE PLAST FRYS 3 L	1 RULLE

REKVISITION

Artnr	Antal	Enhet	Namn		Artnr	Antal	Enhet	Namn	
70760	C	RULLE	PÅSE PLAST FRYS 5 L	1 RULLE	70465	B	ST	VADD POLSTER 10 CM	48 ST
70761	C	ST	PÅSE PLAST PAPPERSKORG	100 ST	70466	B	ST	VADD POLSTER 15 CM	36 ST
60129	B	ST	RAKAPPARAT KLIPPHUVUD	40 ST	70470	A	ST	ÖRONPINNE BOMULL	100 ST
60771		ST	RAKHYVEL	200 ST					
70919		FP	RESERV STIFT BLYERTS 0,7 MM	1 ST					
70561		ST	RÖR PLAST 16 X 99 MM VÄVNAD/	100 ST					
60549		ST	RÖR TRP MEDIUM SVART LOCK	1 ST					
70805		ST	SKOSKYDD	100 st					
70845		ST	SUGRÖR	200 st					
70813		ST	SÄCK PAPPER 30 L	1 ST					
70814		ST	SÄCK PAPPER 125 L	1 ST					
70820	A	ST	SÄCK PLAST GRÅ 160 L	250 ST					
70819		ST	SÄCK PLAST SVART 125 L	25 ST					
70815	B	ST	SÄCK PLAST VIT 40 L	50 ST					
71073		RL	TEJP BRUN	6 RL					
20127		RULLE	TEJP TRANSPARANT 15 MM X 66	1 RULLE					
20128		RL	TEJP TRANSPARANT 19 MM X 33	1 RL					
70950		ST	TIPEX KORRIGERINGSLACK	1 ST					
70435	C	ST	TORK PLATT NR 3	500 ST/FP					
70436	C	ST	TORK RUND NR 3	250 ST/FP					
20203	C	ST	TORK TVÄTT NR 5	100 ST/FP					
20083		RULLE	TUBBANDAGE G 12 CM X 10 M	1 RULLE					
20086		RULLE	TUBBANDAGE J 17,5 CM X 10 M	1 RULLE					
70441		RULLE	TUBGAS 4.0 CM 34	1 RULLE					
70442		RULLE	TUBGAS 6.0 CM 56	1 RULLE					
70443		RULLE	TUBGAS 8.0 CM 78	1 RULLE					
70863		ST	TVÅ FLYTANDE BAD/DUSCH 500 M	1 ST					
70871		ST	TVÅL DAX 600 ML	1 ST					
70713		ST	TVÄTTLOTION DAX 300 ML	1 ST					
70460	A	ST	URINPÅSE HÄNGARE	1 ST					
70079	A	ST	URINPÅSE TÖMBAR 90 CM X 2000	15 ST					
70463		RULLE	VADD FET	1 RULLE					
70464	B	ST	VADD POLSTER 6 CM	96 ST					

FÖRRÅDSPLATS: 8030 KÄLLARFFÖRRÅD

ARTNR	ANT	NAMN	FP STL	LEV ARTNR	-	+
310464	12 TF	ASSBORDSPÅSE	75 ST/TF	610600 UTGÅ	A	
310342	0 LF	ASSBORDSPÅSE 3M	80 ST/LFP	9035E	A	
310016	1 LF	AXELSET 3M	20 ST/LFP	9196	B	
310139	0 TF	BUKDUK 30 X 30 CM BRUN NONW.		187705 UTGÅ		
310166	2 TF	BUKDUK 30 X 40 CM BRUN NONW.TU	6 FP/TF	185460		
310353	2 LF	DIATERMIPÅSE 18 X 30 CM 3M	40 ST/LFP	1018		
310355	0 LF	DIATERMIPÅSE 33 X 38 CM 3M	200 ST/LFP	9097	A	
310474	0 TF	DIATERMIPÅSE 40 X 35 CM	120 ST/TF	707035 UTGÅ		
310349	0 LF	DIATERMIPÅSE LAP.SCOPI 3M	40 ST/LFP	1018L		
310358	1 LF	DUK ABSORBERANDE 70 X 50 CM 3M	200 ST/LFP	9095E	A	
310476	4 TF	DUK PERINEAL	138 ST/TF	706200-40		
310087	0 TF	EXTREMITETSET	10 ST/TF	697400 UTGÅ		
310193	3 LF	EXTREMITETSET 3M	10 ST/LFP	9004	B	
310357	2 LF	HANDDUK SJÄLVHÄFT 75 X 75 3M	160 ST/L.F	9084	A	
310343	0 LF	HÅLDUK 150 X 228 CM 3M	20 ST/LFP	9050	B	
310023	10 TF	HÅLDUK 200 X 280 CM	28 ST/TF	708880 UTGÅ	B	
310174	7 TF	KAMERASKYDD 17 X 240 CM	60 ST/TF	70 58 30	A	
310344	0 LF	KAMERASKYDD 250 X 13 CM 3M	200 ST/LFP	1100E UTGÅ		
310229	3 TF	LAKAN COLLUM LITET 240 X 330 CM	20 ST/TF	82 60 20 UTGÅ		
310345	4 LF	LAKAN COLLUM LITET 320 X 213 CM	12 ST/LFP	1017P001	B	
310212	0 TF	LAKAN GYN VAGINAL	12 ST/TF	925984	B	
310123	3 TF	LAKAN HAND/FOT	2O ST/TF	825600-10 UTGÅ		
310176	5 TF	LAKAN INSTRUMENTBORD 150 X 190	44 ST/TF	808000-22	A	
310153	3 TF	LAKAN LAP.SCOPI BARRIER	12 ST/TF	695-00	B	
310346	3 LF	LAKAN MÄRGSPIK IOBAN 3M	5 ST/LFP	6619	B	
310230	1 TF	LAKAN MÄRGSPIK MÖLNLYCKE	20 ST/TF	82 60 10 UTGÅ		
310466	0 TF	LAKAN OP 150 X 175 CM	30 ST/TF	777400 UTGÅ		
310348	4 LF	LAKAN OP 150 X 250 CM 3M	50 ST/LFP	9088	B	
310450	9 TF	LAKAN SLITS 200 X 260 CM (RESER	24 ST/TF	779400	B	
310247	1 LF	LAKAN SLITS 3M 228 X 260 CM	30 ST/LFP	9045	B	
310269	3 LF	LAKAN TURP (3M)	28 ST/L.FP	1081	A	
310187	1 TF	LAKAN TVT	12 ST/TF	905020	B	
310135	2 LF	LAKAN X-BAND	5 ST/LFP	1194	C	
310462	3 TF	OP-TAPE X 1 (9 X 49 CM)	400 ST/TF	381030 UTGÅ		
310261	2 LF	OP-TAPE X 1 3M	500 ST/LFP	9099	A	
310130	1 TF	OP-TAPE X 2 (9 X 49 CM)	480 ST/TF	38 10 40 UTGÅ		
310010	1 TF	PÅSE DISLOCATION	80 ST/TF	84541230		

FÖRRÅDSPLATS: 8030 KÄLLARFFÖRRÅD

ARTNR	ANT	NAMN	FP STL	LEV ARTNR	-	+
310017	1 TF	PÅSE FOT MÖLNLYCKE	540 ST/TF	691005	B	
310231	5 TF	PÅSE LAPAROSCOPI MÖLNLYCKE	30 ST/TF	705860 UTGÅ		
310458	3 TF	ROCK LARGE 135 CM (SPECIAL)	44 ST/TF	865402 UTGÅ		
310018	2 TF	ROCK SKYDD GUL MEDIUM	108 ST/TF	616401	A	
310350	3 LF	ROCK SMS LARGE 3M	28 ST/LFP	7696C L		
310351	2 LF	ROCK SMS X-LARGE 3M	28 ST/LFP	7697C XL		
310233	3 LF	ROCK STANDARD LARGE 3M	28 ST/L.FP	7692	A	
310253	2 LF	ROCK STANDARD X-LARGE 3M	28 ST/L.FP	7693	A	
310215	2 TF	ROCK UROLOGI	48 ST/TF	6275000	A	
310460	0 TF	ROCK XL 150 CM (SPECIAL)	44 ST/TF	865602 UTGÅ		
310074	0 LF	SLANGHÅLLARE 3M	400 ST/L.F	1115 UTGÅ		
310309	2 TF	SLANGHÅLLARE/KARDBORREBAND	200 ST/TF	708131	A	
310228	2 TF	STRUMPA LARGE 32 X 120 CM	40 ST/TF	61 12 05 UTGÅ		
310352	4 LF	STRUMPA LARGE 36 X 122 CM 3M	20 ST/LFP	9110		
310224	11 LF	UNIVERSALSET 3M	14 ST/LFP	9000	B	
310454	1 TF	UNIVERSALSET MÖLNLYCKE (RESERV)	12 ST/TF	699054	B	
310161	1 TF	ÄRMSKYDD MÖLNLYCKE	180 ST/TF	623501	A	

APPENDIX5: BARCODE SYMBOLOGIES SUPPORTED BY CLEARIMAGE BARCODE RECOGNITION PRODUCTS

Symbology Synonyms	Symbology Features	Supporting Organization Applications
Interleaved 2/5 ***ITF*** ***ITF14*** 	Numeric (0-9) Variable Length Optional check digit High Density	**IATA** (International Air Transport Association) Luggage Tag **ITF-14** or **SCC-14** (Shipping Container Code) **HIBC - Health Industry Barcode** **USPS** special services **OPC** (Optical Product Code Council) **German Post** Identcode and Leitcode **CIP HR** (Pharma France)
Industrial 2/5 ***Code 25*** ***Code 2/5*** ***Code 2 of 5*** 	Numeric (0-9) Variable Length	
Matrix 2/5 	Numeric (0-9) Variable Length	
Datalogic 2/5 	Numeric (0-9) Variable Length	
Airline 2/5 ***Code 2/5*** ***Code 2 of 5*** 	Numeric (0-9) Variable Length Modified Industrial 2/5	**IATA** (International Air Transport Association) Ticket Coupon

CODABA ***NW-7 (in Japan)*** ***USD-4, Rationalized Codabar*** 	Numeric (0-9) and 6 special char ($-:/.+) Variable length	**America Blood Centers** (ABC Codabar) **Ameritech Library Services**

Code 39 ***USD-3*** ***Code 3 of 9*** 	Numeric (0-9) Capital Letters (A-Z) 7 special char (space-+.$/%) 128 ASCII characters Variable length Optional check digit	**CIP** (Club Inter Pharmaceutique in France) or French Pharmacode **ODETTE** - European Auto Industry **LOGMARS** **PZN** (Pharma Zentral Nummer) or German Pharmacode HIBC - Health Industry Barcode **GSA** - General Services Administration **AIAG** - Automotive Industry Action Group **DoD** MIL-STD-1189 LOGMARS **DoD** MIL-STD-129P
Code 32 ***Pharmacode*** 	Numeric (0-9) Fixed length Check digit	Italian Pharmacode
Code 93 	128 ASCII Characters Variable length Check digits High Density	
Code 128 	128 ASCII Characters Control characters Numeric mode (00-99) Variable length Check digits High Density	HIBC - Health Industry Barcode USPS Delivery Confirmation American Association of Blood Banks(ISBT 128) SISAC- Serials Industry Systems Advisory Committee)
UCC 128 	128 ASCII Characters Control characters Numeric mode (00-99)	**UCC** (Uniform Code Council) **EAN** (European Article Numbering System)

	Variable length Check digits High Density	**FDA** (Food and Drug Administration)
UPC-A 	Numeric (0-9) Fixed length Check digit	**UPC** (Uniform Product Code) **NHRIC** (National Health Related Items Code) **NDC** (US National Drug Code)
UPC-E 	Numeric (0-9) Fixed length Check digit	**UPC** (Uniform Product Code)
EAN-13 ***JAN-13*** 	Numeric (0-9) Fixed length Check digit	**EAN** (European Article Numbering System) **Bookland ISBN** (International Standard Book Numbers) **ISSN** (International Standard Serial Numbering) **Spanish Pharmacode** **JAN** (Japan Article Number)
EAN-8 ***JAN-8*** 	Numeric (0-9) Fixed length Check digit	**EAN** (European Article Numbering System)
Addon-2 ***UPC/EAN P2*** 	Numeric (0-9) Fixed length Check digit	Supplements UPC/EAN barcodes
Addon-5 ***UPC/EAN P5*** 	Numeric (0-9) Fixed length Check digit	Supplements UPC/EAN barcodes
Patch Code 	Limited Types: 1,2,3,4,6,T 1 character long, does not encode data, but acts as a signal	Used only for batch separation and scanner control
PostNet / Planet	Numeric (0-9) Fixed length (5,9 or 11ch)	US Postal Service, and most other

	Check digit	postal authorities. Contact Inlite to decode Country Specific variants
PDF417 	Multiple modes to represent text, numeric and binary data. Variable length Flexible Geometry & Module size High capacity User Selectable ECC Level	DoD MIL-STD-129P AAMVA (American Assoc of Motor Vehicle Administrators) drivers' license cards
DataMatrix 	Multiple modes to represent text, numeric and binary data. Variable length Very High capacity Fixed ECC Level Very high density	German Post Stampit Pharmaceutical industry for unit dose packaging Automotive Industry (AIAG) NASA Electronic Industry Association

APPENDIX 6: PRELIMINARY RESEARCH PROPOSAL

Title: Preliminary Research Proposal. Authors: Anna Bengtsson, Arina Paskhina

PRELIMINARY RESEARCH PROPOSAL

1. BACKGROUND OF THE RESEARCH PROPOSAL

During the study at the surgery department the authors were paying a certain attention to the supply chain management since it has a lot of influence on both the product and information flows. It was important to find out the internal relationships between the channel members, the degree of cooperation and information exchange between them. The executed study showed that the existing chain structure can not be considered a complete supply chain since it does not meet the main supply chain criterion – the high degree of its integration.

2. PURPOSE

The main purpose of the proposed research is to identify the potential solutions aimed at improving the key activities related to the material management both within the

3. STATE OF NATURE

By state of nature is considered the environment in which the “supply chain” exists. There is nothing that can be done to change the parameters of this environment. They are considered to be fixed, and, therefore, are called state of nature. In the present case the fact that the hospital is a public enterprise and is controlled by the local government with low economic incentives is a state of nature. It means that in order to change the performance of the chain only the variable characteristics of the chain are possible to improve. In order to improve the system parameters first the problems in the chain have to be identified.

4. SUPPLY CHAIN PROBLEMS

4.1 Channel Management

Various surgeons have different demands for products used for the same activities. These various demands and requests are communicated to the person in charge of ordering. The medical side which consists of the surgeons and the administrative side which consists of persons in charge of ordering do not communicate with each other well enough and do not discuss the details of order placement of none-standardized materials that account for extensive costs. The result is that it is almost impossible to keep track of the number of SKUs ordered and the overall order costs.

Communication problem arises as well at the linkage with the Central storage. Central storage does not receive statistics about the order frequency of SKUs. The central storage has the resources to store items that are used frequently, but it is difficult when the incorrect statistics is received. Central storage could enlarge the offered product assortment if the current needs of the hospital could be discussed on

4.1.2 Order Processing Speed

It is faster and easier to order directly from the external companies instead of placing orders with the purchasing department. The result is that the surgery department saves time but has no economic incentive to order via the purchasing department.

M BB

4.1.3 Channel Power

There is no organisation in the chain that would be powerful enough to lead the development of the “supply chain”. It results in the fact that chain members are disintegrated and are not given the common development direction.

4.2 Channel Strategy

4.2.1 Lack of Common Goals

Even though the central storage was designed to be the essential part of the supply chain which would be responsible for smooth and reliable supply of the majority of items there are no common goals set for both the hospital and the central storage. The management teams of the hospital, surgery department and central storage do not put enough of attention and efforts into aligning their separate goals in relation with their functions. In the same time the common goal should be the overall cost saving through out the chain.

4.2.2 Order Strategy

There is no firm order strategy or policy applied at the moment. The items ordered from the external suppliers are not standardised to a reasonable extend. It results in the fact that some SKUs transform into the obsolete inventory that is practically never utilized. Additionally it leads to the wider order assortment that is needed in reality.

4.2.3 Information Flow

In relation to the problem concerning the lack of the power in the chain the information flow strategy problem arises. All of the members utilize their own internal information systems. There are no actions undertaken by any of the members to implement a common information system. It is important to mention that even such important link as “hospital-central storage” uses electronic mail system at the most.

4.3 Channel Structure

4.3.1 Channel members

The number of the channel members is too far from being characterised as optimal. At the moment the number of external suppliers is exceeding 90 companies. It is especially can be regarded as a large number when the existence of the central storage is taken into consideration. Administration of order placing and delivery control requires a great deal of clerical work from the department medical personnel since no administration positions were created for executing order placement and inventory control activities.

5. AREAS OF IMPROVEMENT

After the identified problems were addressed some of the improvement directions can be discussed.

It can be beneficial to revise the material assortment aiming at standardisation of items in use.

Revision of the suppliers. It is important to check if the suppliers carry out the same SKU positions and if so the SKUs can be consolidated at one supplier who can offer better assortment range.

Central storage order assortment has to be reconsidered. Frequently used items have to be ordered from the central storage and not directly placing an order with one of the external suppliers.

Investigating possibilities that would allow increasing the order placement speed with the hospital purchasing department.

Investigating possibilities that would allow improving communications along the supply chain.