

Opportunities for Mobile Solutions in the Process Industry

– A case study at SSAB

Claes Arnesson

MASTER OF SCIENCE PROGRAMME

Department of Business Administration and Social Science
Division of Industrial Logistics



PREFACE

This report is the product of a master's thesis work at Luleå University of Technology and it constitutes of 20 academic points. The thesis is done as an assignment at Ericsson Research AB in Luleå and the research has been conducted at Ericsson Research AB as well as SSAB Tunnpåat during the time from November 2003 until May 2004. The master's thesis is the final result of the Master of Science program Industrial and Management Engineering with logistics as major subject.

I would like to take advantage of this opportunity to thank everybody who have supported me, answered my questions and given me information while working with the master's thesis. I would also like to thank some persons exclusively. First of all, I would truly like to thank my tutors at Ericsson Research AB, Tor Björn Minde, Marika Stålnacke and especially Tommy Arngren, who have supported me with information and answers to all my questions. Even though you are constantly busy, I have always felt that I have had someone to turn to. Again, many thanks. I would also like to thank Robert Johansson at SSAB who has been a great help and a wonderful administrator of my observations at SSAB. Ola Jonsson, my dear friend and opponent, thank you for the critical review and support during the progress of this project. Finally, I would like to thank my tutor, Anders Sörqvist, at Luleå University of Technology for keeping me on the right track.

Västervik, 22/06/2004



Claes Arnesson

ABSTRACT

The process industry, and especially steelworks, is a capital-intensive industry, which implies that the equipment should be utilized as much as possible since stops are associated with very high costs. Moreover, the plants in the process industry typically are spread out over a very large area and that creates a breeding ground for an information gap between the mobile personnel and the stationary as well as between the mobile personnel and the information stored in the enterprise's computer system. The mobile technology has during recent years developed tremendously; opportunities and solutions that were not even imaginable a few years ago are now helping enterprises to be more efficient. The new technology cannot only make information available at anytime and anywhere to anyone but also make the communication faster, and thereby more efficient. This master's thesis purpose is to find opportunities for mobile solutions within the process industry and describe the specific requirements on the equipment that arises in this type of industry. Another objective is to study business opportunities with respect to mobile solutions. Observations, interviews and a questionnaire are methods used to fulfil the thesis's purpose and conclusions and recommendations are hammered out on the basis of these methods. SSAB Tunplåt AB is chosen as a research object in this report.

The communication devices that are used at SSAB are cell phones, computers, short-range radios, intercoms and ordinary telephones. These different communication systems create confusion and inefficient communication. If a Push-to-Talk solution is used the number of different communication systems needed would be far less but the same services would still be provided. Furthermore, the maintenance personnel as well as SSAB's documentation could benefit from a Smart Phone solution from which the enterprise resource planning system can be accessed.

The work tasks as well as the rough environment at SSAB create a need for an all-in-one device that can withstand heavy abuse but nevertheless fit into the pocket of the working clothes. Business opportunities with these solutions arise from a more efficient communication due to a fewer number of systems as well as from a more appropriate system. Better documentation and more efficient repairs are also benefits which can occur from a Smart Phone solution. A vibration function in the cell phones and durable hands-free headsets are important functions to make the current, as well as the future, solutions even more efficient at SSAB.

ABBREVIATIONS AND DEFINITIONS

3G	Third generation mobile telecommunications system.
802.11a	A WLAN standard
802.11b	A WLAN standard
Active time	Active time refers to the time when value is added to the final product, for example assembling of the product.
ATM	Automatic Teller Machine
Bluetooth	A technique for wireless communication.
BOF-converter	An oven where hot iron is transferred to steel by a reduction of the carbon contents.
CDMA	Code Division Multiple Access, a multiplexing technique.
CSD	Circuit Switched Data
D-AMPS	Digital American Mobile Phone System
EDGE	Enhanced Data Rates for GSM Evolution
ERP	Enterprise Resource Planning
GPRS	General Package Radio Service
GSM	Global System for Mobile Communication
HSCSD	High Speed Circuit Switched Data
Information	The work related contents that are communicated.

Instant Messaging	Instant messaging is text messages sent over a packet switched network and it can be used for communication between computers and cell phones as well as communication between cell phones.
LAN	Local Area Network
MMS	MultiMedia Service
Mobile Solution	Includes a wireless network a terminal and an enterprise computer system which supports handheld devices. A mobile solution makes it possible for the user to access the information in the enterprise and give information to the enterprise at anytime and anywhere.
Mobitex	A data network often used for pagers.
Multiplexing	The term for describing how the available frequency band is allocated. There should be as many users as possible utilising the frequency.
Passive time	The Term is used for time that occurs when the personnel are unproductive, i.e when no value is added to the product. Passive time could be time for transportation or packaging.
PDA	Personal Digital Assistance, a handheld digital organiser with various functions such as word processing ability.
PIN	Personal Identification Number
Presence	The ability to see the status of your contacts.
Process	A chain of constantly returning activities that create value for the customer.

Push-to-Talk	Voice communication over a packet switched network where the user can use an instant talk service by pushing a button, similar to a short-range radio. This service also includes group communication.
RAM	Random Access Memory
Ruggedized Device	A device tailor made for a rough environment.
SLAB	Blocks of solid steel.
Smart Phone	A mixture of a cell phone and a PDA.
SMS	Short Message Service
Tablet Computer	A computer which lacks keyboard and has a permanently exposed screen.
TDMA	Time Division Multiple Access, a multiplexing technique.
Terminal	A handheld device such as a cell phone or a PDA.
UMTS	Universal Mobile Telecommunications System
WAP	Wireless Application Protocol
WEP	Wired Equivalent Privacy, encryption method in WLAN.
WLAN	Wireless Local Area Network
VPN	Virtual Private Network, it creates a secure passage between the public internet and the enterprise's LAN.
WAG	Wireless Application Gateway, the gateway which makes it possible to present the information in an enterprise's computer system on a handheld device.

INDEX

<u>1 PROBLEM AREA</u>	1
<u>1.1 Introduction</u>	1
<u>1.2 Background</u>	2
<u>1.2.1 Ericsson Research AB</u>	3
<u>1.3 Problem Discussion</u>	3
<u>1.3.1 Research Problem</u>	4
<u>1.3.2 Problem Definition</u>	5
<u>2 THEORY</u>	6
<u>2.1 Mobile Solutions</u>	6
<u>2.1.1 Wireless Technology</u>	7
<u>2.1.2 Services</u>	15
<u>2.1.3 Security</u>	16
<u>2.2 Future Mobile Services</u>	17
<u>2.3 Practical Examples</u>	19
<u>2.3.1 BT Industries</u>	19
<u>2.3.2 Boliden</u>	20
<u>2.4 Description and Analysis of the Present Situation</u>	20
<u>2.4.1 Processes</u>	20
<u>2.4.2 Flowcharts</u>	23
<u>2.4.3 Lead Time Analysis</u>	24
<u>2.6 SWOT-analysis</u>	25
<u>3 METHODOLOGY</u>	26
<u>3.1 Project Strategy</u>	26
<u>3.2 Research Approach</u>	27
<u>3.2.1 Research Strategy</u>	28
<u>3.2.1 Literature Study</u>	28
<u>3.3 Data Collection Methods</u>	28
<u>3.3.1 Construction of the Questionnaire</u>	29
<u>3.4 Analysis Methods</u>	30
<u>3.5 The Company</u>	31
<u>3.6 The Respondents</u>	31
<u>3.6.1 Categorization</u>	32
<u>3.7 Methodology Problems</u>	34
<u>3.7.1 Reliability</u>	35
<u>3.7.2 Validity</u>	36
<u>4 SSAB TUNNPLÅT AB</u>	37
<u>4.1 The Company</u>	37
<u>4.2 The Production Process</u>	37

<u>5 DESCRIPTION OF THE PRESENT SITUATION</u>	39
<u>5.1 The Machine Keeper</u>	39
<u>5.2 The Control Room</u>	41
<u>5.3 The IT-Maintenance Personnel</u>	42
<u>5.4 The Maintenance Mechanics</u>	45
<u>5.5 The Operation Supervisor</u>	46
<u>5.6 The Production Planner</u>	47
<u>5.7 The Transportation Personnel</u>	48
<u>6 ANALYSIS</u>	50
<u>6.1 The Machine Keeper</u>	50
<u>6.2 The Control Room</u>	51
<u>6.3 The IT-Maintenance Personnel</u>	53
<u>6.4 The Maintenance Mechanics</u>	55
<u>6.5 The Operation Supervisor</u>	57
<u>6.6 The Production Planner</u>	58
<u>6.7 The Transportation Personnel</u>	58
<u>6.7 General Requirements on the Equipment</u>	60
<u>6.7.1 The Terminal</u>	60
<u>6.7.2 The Network</u>	63
<u>6.8 Business Opportunities</u>	65
<u>6.8.1 SWOT-analysis</u>	65
<u>7 CONCLUSIONS</u>	71
<u>7.1 Summary</u>	73
<u>8 RECOMMENDATIONS</u>	74
<u>8.1 Future Research</u>	74
<u>9 FULFILMENTS OF THE OBJECTIVES</u>	76
<u>REFERENCES</u>	78
<u>Literature</u>	78
<u>Interviews</u>	80
<u>Articles</u>	80
<u>Internet Sources</u>	81

APPENDIX

Appendix 1	Questionnaire Concerning Requirements on the Cell Phone
Appendix 2	Visual Categorisation of the Respondents
Appendix 3	Flowchart-The Production Process at SSAB
Appendix 4	Flowchart- The Machine Keeper's Information Flow
Appendix 5	Picture of Ericsson S868
Appendix 6	Flowchart- The IT-maintenance's Information Flow
Appendix 7	Flowchart- The Maintenance Mechanic's Information Flow

1 PROBLEM AREA

This chapter gives the reader an introduction to the topic and a background to the project as well as a problem discussion containing the purpose of the project. The chapter ends with a definition of the project.

1.1 Introduction

The international markets were, according to Bjørnland, Persson & Virum (2003), undergoing a considerable change in the competitive situation during the 80s and the 90s due to, among others, the fast development of information and communication technology. For a business to be competitive in the market nowadays, the production needs to be carried out rationally to create a competitive advantage. Krajewski & Ritzman (2002) claim that “increasing the value of a product to a customer or reducing the costs of bringing the product to the market” creates a competitive advantage for an enterprise.

New technology provides big opportunities to create competitive advantages and a company that invests in and uses new technology is likely to have a stronger financial position than those that do not. This fact is stated in various studies and it proves the great importance of adoption to new technology. An increasing information flow implies a need for newer and better solutions with managers who use information and communication technology to obtain, process and communicate information to make more effective decisions (Krajewski & Ritzman, 2002). However, the technology develops continuously and one can only dream about what the future holds. But, one thing is certain; companies that do not accept the technology development change will not survive.

Many consider telecommunication to be the most important part of information technology (Krajewski & Ritzman, 2002). Telecommunication is used for person-to-person, man-to-machine and machine-to-machine communication. These solutions are in many cases based on information transfer through cables but there has been fast development of wireless technology during the last decades. Development of wireless networks, batteries, Central Processing Units/memories, user interfaces and enterprise applications have made it possible to create mobile solutions in which the workers can communicate and transfer data from any location without using cables. The loss of cables is also especially important in rough environments and in machines with moving parts where the equipment is exposed to heavy wear. Portability is a well known concept closely related to laptops and implies devices that are easy to move.

The mobility concept goes one step further and demands seamless roaming as well. In telecommunication the term roaming describes the service in which the subscriber is allowed to use other operator's cellular networks. This means that a subscriber can travel through areas covered by other operator's networks without losing the connection, i.e. continuing the conversation.

A study of the process industry shows that companies that have made an effort to improve the flow in processes, for example information processes, are more profitable than others. Bjørnland *et al.* (2003) suggest that activities which do not add any value to the product should be eliminated or at least kept to a minimum since those activities lead to additional costs and make the process unnecessary complex, and thereby less efficient. Non-value adding activities are waiting for decisions, transportation and so forth. There are notable examples of when the unproductive, or passive, time constitutes of over 99 % of the total lead-time (Aronsson, Ekdahl & Oskarsson, 2003). Beside the increasing amount of tied-up capital the long lead-time conduct to higher error rates (Bjørnland *et al.* 2003). As the demand for shorter lead-time increases so does the demand for more efficient information exchange within organisations and it is important to improve the processes to increase profitability (Aronsson *et al.*, 2003).

A mobile solution helps the organization to be more efficient, i.e. to receive more output for less or the same amount of input, by reducing and eliminating non-value adding activities. Activities that are most likely to benefit from a mobile solution are bottlenecks caused by not having the right information, data re-entry, wait time and lack of coordination (Brans, 2003). The results are shorter total lead-time, which can imply increased number of on-time deliveries, better quality and increased profitability due to higher utilization of the resources. This leads to higher output (Bjørnland *et al.* 2003).

1.2 Background

The idea of this project has developed from discussions between Ericsson Research AB and the other companies within the ProcessIT Innovation network, which is a union between process/manufacturing companies, Research and Development at Luleå University of Technology and IT-companies in the Luleå region. The purpose with the ProcessIT Innovation union is to increase the competitive advantage and the efficiency for the companies in the process industry. This shall be done by increasing the usage of IT-technology in the industry and by attracting the enterprises' attention to the latest findings within this field. The telecommunication companies see this cooperation as an

opportunity to increase their knowledge about the industry and to detect needs for telecommunication solutions. That is why Ericsson Research AB created this master's thesis proposal.

1.2.1 Ericsson Research AB

AWARE, Advanced Wireless Algorithm Research, is a branch of Ericsson's research organization and is located in Luleå. AWARE is operating in three areas, Wireless Access Networks, Multimedia Technologies and Service Layer Technologies. The assigner to this thesis is Service Layer Technologies which develops new mobile services and applications for enterprises as well as for consumers. There are three persons working within this field at Ericsson in Luleå, these are Tor Björn Minde, Marika Stålnacke and Tommy Arngren.

1.3 Problem Discussion

The process industry, for example breweries and refineries, is characterised by high volume production of standardized products. It is important to maximize the utilization of the process since shutdowns and start-ups are very expensive, and hence the process runs around the clock (Krajewski & Ritzman, 2002). The process industry is also characterized by many mobile workers because the process plants tend to be spread out over large areas. Consequently, there is a need for good communication and information transfer regardless of the location of the worker. According to the theory there is a gap between mobile workers and critical information. The mobile workers do not have the right information when they need it, and therefore miss opportunities and become less productive. Other personnel in the company also get affected because the mobile worker lacks the ability to report back to the company in a satisfying way. If the information is brought back to the company over a phone it just has been relocated to another person but it is still not recorded anywhere. It has been proved that mobile solutions make personnel who are travelling a lot, such as field salespeople and service engineers, more efficient (Brans 2003). If this is also true for the process industry a mobile solution could improve efficiency, which could lead to shorter lead-times, fewer breakdowns, and less administration. It would probably mean better delivery service, with better proportion of on-time deliveries and better quality as well. The delivery service is particularly important to a company and it measures the quality of the producer's logistic processes. A good product is not enough nowadays; a company must provide the customer with more value for money to be competitive (Bjørnland *et al.*, 2003).

The theory concerning mobile solutions for the industry is very modest, and thus insufficient for finding out the process industry's specific needs and requirements. However, the technology is still in its infancy and the theory will be more extensive as the technology develops. Today's mobile solutions' number one concern is general public, and as a result the solutions are not appropriate for the rough environments that the industry provides. Present industry applications are mostly customized to fit the customer's specific need since the lack of suitable standard solutions. These so-called vertical solutions are often very costly for the companies due to the large number of suppliers involved and the high costs concerning the administration of the solution. A great deal of customer integration may be required to develop a standard and to fulfil all needs.

These facts create incitements for the telecommunication companies to study the process industry's needs with respect to mobile solutions and in what way the needs affect the user-friendliness, standards and products.

1.3.1 Research Problem

The purpose of this thesis is to discover opportunities for mobile solutions in the process industry i.e. identify and describe situations where mobile solutions can provide higher efficiency. Moreover, to list general requirements on mobile solutions according to the end-user's demands and to study business opportunities related to standardized mobile solutions for the process industry.

Research Questions

To concretize the research problem and to make it easier to achieve this thesis's purpose following research questions are formed:

- What does existing mobile solutions for the industry look like?
- What can possible future services based on third generation (3G) mobile technology look like?
- Are there situations in the process industry where a mobile solution can improve the process efficiency?
- Which requirements does the process industry have on the equipment and the service when using a mobile solution?
- In what way can the end-user benefit from an adoption of a mobile solution and are there any barriers or threats associated with such solutions?

Research Objectives

The objectives of this thesis are to:

- analyse the selected personnel from an information flow, communication flow, and production flow perspective. Categorize the personnel's degree of communication, information, responsibility, and availability and compare them in relation to the personnel's mobility
- identify and analyse situations where possible improvements can be done with mobile solutions, that is, identify the process industry's needs for such solutions
- list the process industry's requirements on mobile solutions
- provide a summary over business opportunities related to standardized mobile solutions for the process industry

1.3.2 Problem Definition

This project is done by one person during a 20 week period and it includes a case study at a company within the process industry.

This thesis focuses on communication and information transfer between persons and groups and between persons and machines, e.g. servers or machines within the process. Hence, this project does not consider machine to machine (m2m) communication. The communication which is studied is solely work related and personal or informal communication is not taken into account in this study.

A maximum of seven professional roles are observed and interviewed and the most interesting roles are selected for a deeper analysis.

No cost-analysis is carried out nor is any implementation plan prepared for the mobile solutions. This thesis only discusses existing wireless technology; although a discussion of future services is presented.

2 THEORY

This chapter provides the reader with sufficient theory to assimilate the continuing part of this report. The chapter discusses existing mobile solutions and future services as well as basic theory regarding how descriptions and analysis of the present situation are conducted. It is completed with a brief explanation of a SWOT-analysis.

2.1 Mobile Solutions

A mobile solution is illustrated by Patrick Brans (2003) as magic, as if all employees within a company would have telepathic powers. What Brans describes is the employees' ability to access all information in the company from anywhere at any time and similar, give the company information from anywhere at any time (*ibid.*). This is what separates the often used term wireless from the term mobile because mobile is something that changes its location over time while wireless is something that can exist without wires. Although, a mobile service is typically provided over a wireless network (Casati & Shneyderman, 2003).

It is the past decades fast growing technology development that has made mobile solutions possible and also created a need for them. The evolution of wireless networks, of mobile devices and of user-friendly interfaces have made the solutions available to ordinary persons as well as to enterprises. Information technology has increased the productivity in many enterprises and companies nowadays use different business systems to a great extent. Enterprise resource planning and supply chain management systems allow companies to, for instance, minimise inventory. Smaller inventory increases the need for the employees to have access to the systems at any time and place, and consequently a demand for a mobile solution (Brans, 2003).

There are a number of factors that must collaborate to build an efficient mobile solution, see figure 2.1. Wireless technology is one as well as useful services presented in a way the customer understands is another.

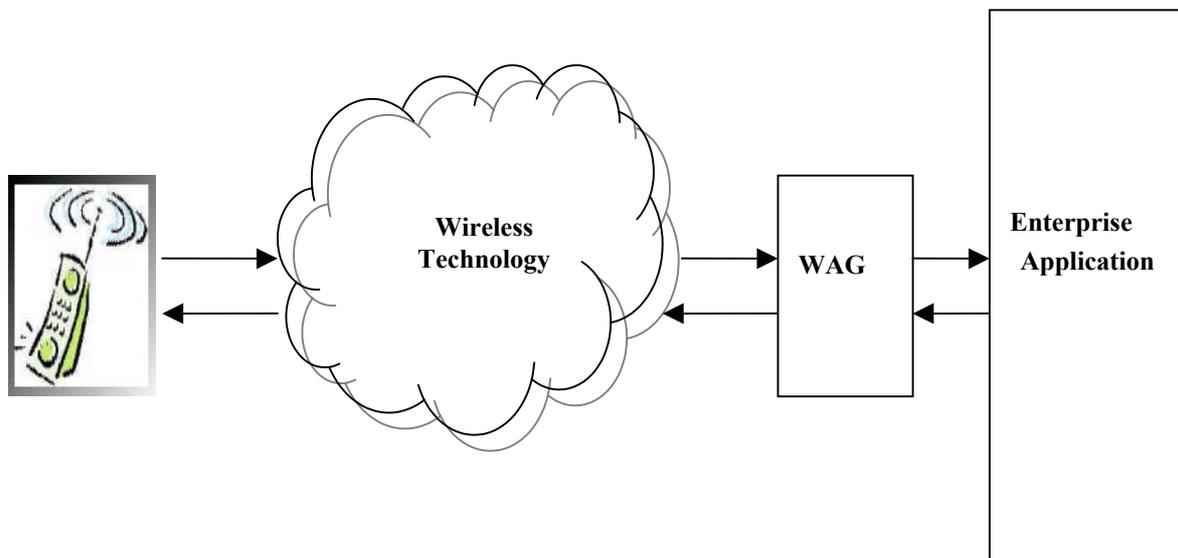


Figure 2.1. Free interpretation of Brans's (2003) description of a mobile solution

2.1.1 Wireless Technology

Wireless technology is a broad and complex area to describe. It can be divided into terminals, networks and wireless application gateways.

Terminals

There are a number of different terminals on the market and each one satisfies different needs. The most common devices are cell phones, Personal Digital Assistants (PDAs) and notebook computers but there are also Smart Phones and tablet computers available (Brans, 2003).

Cellular Phones

Almost everyone uses a cell phone these days. A cell phone is a powerful tool and, besides from voice calls, it offers basic features such as voice mail, Short Messaging Service (SMS) and calendar. There are also other features available on the more advanced phones, for example Wireless Application Protocol (WAP) that gives the user the ability to browse on the Internet. To be able to use the new data services, such as MultiMedia Services (MMS), the phone must support GPRS, EDGE or whichever technology that is used in the cellular network. More information about these techniques is to find under the Cellular Network section below. Another technique that can be used in cell phones is Bluetooth. Bluetooth gives the phone capacity to wirelessly exchange

information with other devices without to point them at one another like with infrared communication (Brans, 2003).

Something that has become more usual the past years are cell phones with cameras and it will not be long before cell phones with video cameras will penetrate the market (Tommy Änst, TietoEnator).

Personal Digital Assistants

There is an array of different PDAs, although the basic functions are the same. Typical functions are calendar, directory, and calculator etcetera. The more advanced PDAs also offer word processing, spreadsheet, time and expense applications. PDA manufacturers use different operating systems and different solutions for data input. The input methods are on-screen keyboard, ordinary keyboard or a letter recognition system in which the user draws letters on the screen with a stylus, a pen-like object. The letters are recognised by the shape of the stroke of the stylus. Most users prefer this model and it usually take less than 20 minutes to learn. Some models can be connected to a full sized keyboard if the user needs to write a lot of data. The PDAs can easily be synchronized with an ordinary personal computer too (Brans, 2003). It can be useful to connect the PDA to a computer if plenty of input needs to be done and the user can also update different functions continuously, such as the calendar. The calendar can be presented at the intranet, and thus the colleagues will not interfere when a booking already is set.

There are PDAs on the market with over 60 Mb of memory capacity and processing power over 200 MHz. Well known PDA manufacturers are Palm, Hewlett-Packard etcetera [pricerunner.se, 03-12-2003].

The add-ons to a PDA are numerous, e.g. barcode readers, cameras, global positioning system (GPS) and communication cards. The communication card could be a Bluetooth card or a card that gives the client access to a wireless network for data services (Brans, 2003).

Smart Phones

Smart Phones are a mixture of a PDA and a cell phone. A problem with the Smart Phones is that many are too big or too awkward to hold to the ear. A microphone and an earplug can reduce this problem but this solution might also be a bit inconvenient since the user needs to walk around with the earplug in the ear to be prepared for a phone call (Brans, 2003).

Manufactures of Smart Phones are companies mostly known for their cell phones, such as Sony Ericsson and Nokia but also companies who usually are recognized as PDA manufacturers, for example Palm (*ibid.*).

Tablet Computers

Tablet computers have many similarities with notebook computers, although with less hard disk space and RAM memory. The processors are also typically slower. However, a Tablet computer can withstand more abuse than a notebook. The visible differences are that a tablet computer does not have a keyboard and that the screen is permanently exposed. Data is entered either by writing directly on the screen or, likewise to the previous devices, by connecting it to a full sized keyboard (Brans, 2003).

There are other solutions though; according to the technical journal *Verkstäderna* the computer manufacturer Fujitsu Siemens has developed a notebook computer that is equipped with a screen which can be turned around, and hence it can be used as a tablet computer (Skärm ger dubbel dator, number 11, 2003).

Notebook Computers

A notebook computer is very powerful tool and it often can replace a desktop computer. Brans (2003) identifies two categories of notebooks, the ultra-thin and the desktop replacement. The ultra-thin notebook is, as the name implies, very thin; there are actually computers on the market which are less than one inch thick and weigh less than two kilograms. As an example; Dell offers a powerful notebook computer that only weighs 1.3 kilograms and is 0.8 inch thick [dell.com, 18-11-2003]. The desktop replacements are a little bit more ungainly, although more powerful than the ultra-thin ones and run at a clock speed of at least 1.7 GHz (Brans, 2003).

There are a variety of options to a notebook computer that can be useful for a mobile worker, one is Wireless Local Area Network (WLAN) availability, which makes it possible that without a cable gain access to the Internet and the intranet at the company. The so-called hot spots, where it is possible to browse at the Internet using WLAN, are increasing in number at airports and hotels. An option to WLAN is a Bluetooth card that makes it possible for the notebook computer to use wireless data services through a cell phone. Network cards which provide the user with access to data services on a public network is one further solution (*ibid.*).

Short-Range Radios

A short-range radio is used for voice communication in local areas and it is often used for group communication as well. Some radios have a reach up to five kilometres line of sight, that is, in open areas without obstacles between the transmitter and the receiver. If a larger area is to be covered a base station might be an option since the covering range can be extended over ten kilometres if an external station is used.

Accessories to the short-range radios are headsets and voice activation functions so that the user can work with his/her hands free. The advantages with short-range radios compared to cell phones are; no cost per call, short connection time and possibility with group communication. There are not any standard solutions for the industry concerning short-range radios but there are companies that are specialized in developing customized solutions (Bertil Åhs, 11-12-2003).

Ruggedized Devices

Many industries provide rough environments where the terminals are likely to be exposed to water, dust, and so forth. Accordingly, there is a need for devices that are able to withstand these conditions. A terminal, which is able to handle industrial environments, is called a ruggedized device. A ruggedized device is basically an ordinary terminal cased in a material proper for the environment in which the terminal is used. There are ruggedized devices for virtually any environment; a terminal can handle shocks, large temperature ranges and it can be protected against dust as well as water. However, the solutions are often customized to fit the specific requirements (Brans, 2003).

Wireless Networks

There are a number of different networks, some suited for voice communication and others with the only purpose to transfer data. To cover the entire subject is an extensive task and is not the purpose of this report.

Cellular Networks

The digital wireless standard in Europe is GSM, Global System for Mobile Communications, and it operates in the 900, 1800 and 1900 MHz bands. The latter is primarily used in the United States. GSM is the worlds largest mobile standard and it is used in over 50 different countries (Lindberg, 2002). GSM had 554.2 million subscribers year 2002 which correspond to two thirds of the total 2G market (Casati & Shneyderman, 2003).

Multiplexing is the term for the technique which is used to allocate the available frequency band. GSM networks use the multiplexing technique Time Division Multiple Access (TDMA). TDMA basically permits digital networks to handle more calls. Simplified; the method divides a frequency range in time and assigns each time slot to a user. The time slots are regularly repeated but the user gets the impression of a continuously connection (Ahtiainen *et al.*, 2001).

There are two ways to transfer data in a cellular network, either through circuit switches or packet switches. Circuit switches were originally designed for voice communication whereas packet switches concerning data. In the circuit switched data service the user dials a phone number and a special modem is used to transfer the data. This technique establishes a physical connection between the terminal and the network access server. The packet switched service on the other hand sends data in small packets. This creates a higher utilization of the available frequency since a physical connection is not required (Ahtiainen *et al.*, 2001).

Data services that are available in the GSM networks are circuit switched data (CSD), general packet radio services (GPRS), and SMS. The CSD offers data and fax services over the voice line using a modem with a data transfer rate around 9.6 kbps. The transfer can only occur once a connection is established because a voice line is used, and accordingly CSD lacks the always-on ability that the packet-switched services possess. The expression always-on refers to the ability to constantly be connected to the Internet. SMS is a widely used service in Europe wherein the user can send messages containing up to 160 characters (Lindber, 2002).

The original GSM network must be updated with a packet network overlay for the user to be able to use GPRS. With the right technique a terminal is given the opportunity to form a packet switched connection over the GSM network to an external packet data network such as the Internet. A GPRS user can be always-on since the technique does not require an actual connection. The end-user pays for the amount of data that is transferred and not for the connection time itself (Lindberg, 2002). GPRS allows a maximum data transmission rate of 57.6 kbps but the future bids well and promises transmission rates around 384 kbps (Ahtiainen *et al.*, 2001). The high rates are possible through new technologies as EDGE, Enhanced Data for GSM Evolution, and HSCSD, High Speed Circuit Switched Data. The HSCSD technique uses more time slots than ordinary GSM and the user get more capacity out of each time slot. EDGE is a

technique in which better coding is used between the terminal, the antenna and the transceiver in the base station (Ahtiainen *et al.*, 2001).

GPRS is the first step towards 3G or Universal Mobile Telecommunication System (UMTS), which is the name for the European 3G standard. 3G will make it possible for the user to exploit seamless roaming to its full extent since it will be a global standard. Consequently, the client can use the cell phone anywhere in the world and use other operators' network but only get one invoice from the ordinary operator (Lindberg, 2002). The future 3G systems will offer data transmission rates at 144 kbps, 384 kbps and up to 2Mbps. The speed depends on if the client is travelling or not, the slowest connection is for high mobility users, i.e. users that travels in vehicular speed. 384 kbps is offered to pedestrians and the highest rate is for stationary data transmission (Casati & Shneyderman, 2003).

Apart from GSM, there are a number of different standards, for example Digital Advanced Mobile Phone Service (D-AMPS), which in similarity to GSM uses TDMA as a multiplexing technique. This standard has developed to the TDMA (IS-136) and is comparable to the GSM standard. Another standard is CDMA (IS-95) in which Code Division Multiple Access (CDMA) is used as a multiplexing technique. It is argued that CDMA is the most efficient multiplexing technique and an improvement of this technique is going to be used in the future 3G networks (Brans, 2003). CDMA allows the transmitter to spread its signal over all the available frequencies. The signal is predetermined by a code and the receiver needs the same code to be able to pick out what the transmitter is sending (Lindberg, 2002).

Data Networks

There are networks where only wireless data services are offered, these networks are called data networks. Mobitex is a well-known data network system (Brans, 2003). Mobitex has been used for many years and has a long-range capability as it operates at low bandwidth with bit rates from 4.8 to 19.2 kbps. A small device called Blackberry successfully uses this technique in the United States for e-mail services (Lindberg, 2002). Mobitex has better network coverage than GSM in Sweden, although GSM is a better solution if the client is using the service indoors or is travelling between countries [ieab.se, 01-12-2003].

Bluetooth

Bluetooth is a relatively inexpensive technology which is originally created to replace cables. The technique's main area of usage is for connections between

cell phones, PDAs, hands-free headsets, and keyboards (Lindberg, 2002). Devices equipped with Bluetooth technology can create a so called piconet under which several devices are connected to each other wirelessly. A piconet can contain of maximum eight devices where one acts like a master and synchronize the other slaves (UMTS-an overview, 1999).

Bluetooth normally has a link range from ten centimetres up to ten meters but can be extended to over 100 meters by increasing the transmit power. The gross data rate that can be achieved is 1Mb/s (UMTS-an overview, 1999).

Wireless Local Area Networks

A Local Area Network in which wireless technology is utilized is called a WLAN. The network is a so-called pedestrian wireless network, which implies that the client can use the data service even if he/she is moving at a slow speed. Although, data transmission becomes more difficult the faster the client is moving.

WLANs are typically operating at low power (Brans, 2003). Nevertheless, some claim that wireless networks are too power consuming to use in combination with PDAs since the battery only last for a couple of minutes. However, there are adapters with external batteries as an additional feature to the PDAs and it can extend the time between charges to several hours (Lindberg, 2002).

There are different WLAN standards, for instance the 802.11 standards. The standard 802.11 is divided into 802.11a and 802.11b. One difference between the two is that 802.11b operates around 2.4 GHz and 802.11a operates in the 5 GHz spectrum. The 802.11b is, however, the most common and probably will remain in the near future. This standard approves theoretically transmission rates at 11 Mbit/s but in reality it is often lower. A WLAN has a short reach; the access point only covers the area within a 0.1 kilometre radius compared to the GSM base station which covers an area with a radius of approximately 20 kilometres. As a result, the cost to cover a square kilometre using WLAN is a lot higher than the cost for using GSM. An estimation of equipment and installation costs shows that the cost is approximately 800 times higher to cover one square kilometre with a WLAN than with a GSM network. One has to remember, though, that the purposes of these networks are different and seamless roaming is only possible within a WLAN network and not between networks as with cellular systems (Lindberg, 2002).

WLAN is popular among companies since it increases flexibility and can provide higher efficiency. It is widely used in hospitals and warehouses. Some reasons for using WLANs are that it can be less expensive than ordinary systems with cables or if the company wants to provide access to their network in open spaces where cables is a problem. WLAN is also useful if a company are divided into different buildings located close together but cabling between them is expensive.

Wireless Application Gateways

A handheld device differs from an ordinary desktop in many ways, and consequently different solutions needs to be used in the communication between the enterprise and the terminal. A platform therefore is required which repackage the data from the applications used by the business into a form fitted for the small devices. This kind of platform is normally referred to as Wireless Application Gateway (WAG). There are many different types of terminals and the WAG must be able to identify what kind of device the client is using to be able to form the output accordingly. Another difference compared to a fixed-line connection is that it takes longer time for a bit to get from one place to another, that is, high latency. The connections are also less stabile, use lower bandwidth, and have higher bit error rates. Handheld devices run on battery, and hence the WAG must be able to handle situations when the battery runs out as well. Furthermore, neither Internet nor the business applications are designed to interface with handheld devices. A handheld device typically uses less power and has a smaller screen than the ordinary desktop and it is the WAG's job, together with a protocol gateway, to overcome these difficulties. The protocol gateway transforms the wireless data protocols to Internet protocols and is most often connected to the operator's network.

A wireless application gateway can use different kinds of exchange models, four examples of exchange models are: prefetch and aggregate, on-demand, push, and synchronize. In the prefetch and aggregate model data are loaded regularly onto the WAG from the back-end applications, that is, the enterprise's computer system. When the terminal sends a request it goes to the WAG which sends the reply without any interaction with the back-end applications. Users who require short response times can chose this model. The on-demand model works in a similar way as the previous one with the exception that the WAG collects data from the enterprise's computer system if needed. If data is sent to the terminal without a request it is called a push model since data is pushed from the WAG. This model is very useful for people who need to be noticed when they receive new information, such as an e-mail. The e-mail can be pushed directly to the client's terminal so that he/she can read it. However,

there is a problem with attachments and the best way to handle an attachment is to read it at a full-sized computer.

In some cases, when real time-access is not crucial, it might be better to provide an offline access. In an offline access solution, data are stored on the device and synchronised with the enterprise's computer system, for instance every night. The synchronization is done where there is high and reliable bandwidth or over a fixed-line and preferably from both directions, i.e. the back-end application is updated with new information from the terminal and vice versa. Accordingly, the WAG must be able to monitor and adapt to the bandwidth. For example, if the bandwidth is low it might reduce the complexity of the graphical presentation. Occasionally it is better to have the applications running entirely on the server side and very little on the terminal. The terminal is a so-called thin client. This works best if the wireless data service is very good and stable. The alternative is a thick client where most of the applications run on the terminal, as described above.

A Terminal is often used by one person only, and therefore some WAGs offer the possibility of personalization. The WAG does not just consider the type of terminal and browser used but who is using the terminal as well. Some gateways also offer a technique with voice interface, which makes it possible to access the application from an ordinary cell phone. A number of people claim that this is the future since talking is the most natural form of communication for humans (Brans, 2003).

2.1.2 Services

Services that are offered for an enterprise today are obviously different depending on which terminal, network and WAG that is utilized. According to Brans (2003) the data networks are very popular for pagers and for sending and receiving e-mails due to the extensive coverage area. A WLAN has completely different types of services because of its high bandwidth and small coverage area. Thus, the technology is mainly used as private networks by companies. The terminals used are often notebooks and the high bandwidth makes it almost similar to a fixed-line connection where the user is able to manage all enterprise applications. However, a major concern is the difficulty of voice communication over WLAN. There are companies that supply voice communication but it has not reached any breakthrough yet (Lindberg, 2002).

The services provided by the telecommunication operators are numerous, from the ability to have group conversations to continuously connection to the company's LAN [telia.se, 02-12-2003]. 3G services are now starting to be

available to customers, and hence the demand for data services will probably increase, both from the general public but also from enterprises that see business opportunities in using it. In fact, the operator 3 claims that the data services are the most appealing to the companies (3's customerservice, 08-12-2003).

2.1.3 Security

An important aspect an enterprise has to consider when choosing a mobile solution is the security. Different solutions can be equipped with different security features and in some cases it is possible to add better security. Not just unwanted access to the network has to be regarded but also preventing people from stealing the terminals. Terminals can in many cases contain valuable information and, even worse, give access to the company's enterprise applications. There are ways to prevent this; biometrics, for instance, such as fingerprint identifications. However, this technique is costly and some people take it as an invasion of privacy. A more common method is passwords or two-factor authentication, which is one thing the user has and one thing he/she knows. A good example is the Automatic Teller Machines (ATM) where the user needs a card and a PIN (Personal Identification Number) code. There are also one-time passwords; the client gets an unpredictable value from the server and encrypts it by using a private key. Then, the code is sent back to the server for verification. This method is frequently used for Internet transactions by many banks (Brans, 2003).

Data transfer between the device and the enterprise should be encrypted to prevent eavesdropping. To do this there are different methods to use depending on which network technique that is being utilized. The WLANs are using the most questioned method when it comes to this. Lindberg (2002) argues that WEP, Wired Equivalent Privacy, which is an encryption method in the 802.11 standard, is too weak and he gives an example of scientists at AT&T who managed to break into a network in only 15 minutes. On the other hand, this is a claim that Jaclyn Easton (2002) does not agree upon. She feels that WLAN, which uses this technique, is as safe as a fixed-line network. Bluetooth has the similar security level as WLAN but is less debated (Lindberg, 2002).

A firewall is a good idea to secure a local area network. Firewalls prevent unwanted intrusion from people on the outside. A firewall monitors the traffic between the company's private network and the Internet and, besides from preventing intrusion, it can avoid the employees to browse certain pages. To get pass the firewall the user should be authenticated by the enterprise, i.e. identified when logging on to the VPN, Virtual Private Network. A VPNs job

is to, by authentication and cryptography techniques, let people work anywhere but still have the company's enterprise system available just as safe as if the person was at the company. This is done with a technique called tunnelling in which a passage is created from the public Internet to the enterprise's LAN.

As seen, there are a number of ways to secure a mobile solution all depending on how critical the data are and the first thing a business has to consider is the security level required. A too high as well as a too low security level could mean high extra costs for the enterprise (Brans, 2003).

There is another side of security as well, that is how reliable the mobile solutions are. For example, if a company is depending on a mobile solution for the production to work, the solution needs to be extremely reliable or a backup solution might be required. A redundant system cost at least twice as much as a nonredundant which is important to have in mind when deciding how high availability the mobile solution must have. Moreover, fluctuations in the bandwidth as well as time for recharging the batteries in the terminal must be considered before implementing a solution (*ibid.*).

2.2 Future Mobile Services

It is hard to predict the future; however, some trends are already starting to develop and most likely some of tomorrow's services will be based on them. Lindberg (2002) argues that future mobile solutions might include seamless roaming between wireless local area networks and other techniques, such as a GSM network. The client will use the WLAN in the corporate area but if he/she travels out of its reach the GSM network automatically will take over, the change will be transparent to the user. The connection will remain but the data transfer will be slower and most likely more costly as the user enters the cellular network.

Other services that are offered are, for example, a positioning service in which the user can see where his/her co-workers are at the moment and it can also help the user to find a specific place, such as a customer's location. The positioning service could be used to provide traffic information for the area where the client currently is travelling as well. Bank services are other useful services that can be offered by the network operators. The client can check his/her account, pay bills or get the latest information from the stock market. The users are obviously able to get the latest news or sport results sent to the cell phone from the operators as well [tre.se, 02-12-2003]. Other multimedia services such as listening to music, sending pictures and streaming of video

clips are also available. Streaming means that the user does not need to download the video clip to watch it, and as result he/she is able to watch clips in real time. Cell phones might actually replace the television in the future. Many of these services are starting to be available to some users, especially in the major cities.

Apart from the previous person to machine services, interesting person to person services are: real time video conversation, presence and Push-to-talk services. Real time video conversation already is starting to come in a small scale but it will surely grow more popular as better phones and higher data transmission rates become available to the general public [tre.se, 02-12-2003]. The authors of *UMTS—an overview* (1999) believe that videoconferences will be a part of the future services. Casati & Shneyderman (2003) say that in the next-generation services the user will subscribe to communities, e.g. a virtual community including family members. The idea with these communities is to exchange pictures, messages, video clips and voice communication within the group. Membership of a community results in that the phone number will not be the only identity by which the user is known. The interface will be icon-based and the user will be informed when the other members are on-line. The other members will also be able to signal their availability; if they are busy, at lunch or available etcetera. If a call or message is placed when the other user is not accessible it will be stored in the user's mailbox until he/she is available.

Another service which will be available within the community is the Push-to-Talk service and as the name implies the client talks by pushing a button similar to two-way radio communications. Moreover, the user will be able to have communication with an entire group or just between two persons and in addition with the presence service, wherein it is possible to see if the persons in a group are on-line, it is very useful. The company Nextel already offers this service and claims that it is far cheaper than an ordinary call [Nextel.com, 05-12-2003]. Verizon, USA's largest mobile operator, is another company that just started to offer this type of service. The service costs about 160 SEK a month but requires a special phone [Nyteknik.se, 01-12-2003]. Verizon offers the ability to store 150 Push-to-Talk contacts in the cell phone and a contact group can constitute of a maximum of 20 members. It is possible to use 50 groups that the user set up in a contact manager on the Internet. If a regular voice call is received during a Push-to-Talk session it goes directly to the voice mail but the user does not notice if a Push-to-Talk call is received during an ordinary voice call. However, the caller will get a message that the user is unavailable.

There are different ways to contact other persons with Push-to-Talk; either by an alert in which an alert tone will notify the receiver that someone needs to talk to him/her or a barge call where the Push-to-Talk button is pressed and the caller starts to talk [verizon.com, 06-02-2004]. Nextel have a vibracall alert function in which a vibration is used instead of a sound to alert the receiver [Nextel.com, 01-03-2004].

Businesses are able to sign up for special offers, wherein the network operator provide the customer with different solutions, for instance a fixed number of minutes for ordinary calls but unlimited number of minutes for Push-to-Talk calls. The monthly fee depends on the number minutes the customer chooses to include for free in the subscription (*ibid.*).

Instant messaging is using a similar technique as the Push-to-Talk service but for text messages and the service includes presence too so that the user is able to see the status of his/her friends. It is comparable to the ICQ or the MSN Messenger service that is offered over the Internet. Nextel have a comparable service in which the client is able communicate in real time with his/her friends, either with their cell phone or with their PC [Nextel.com, 05-12-2003]. Some services that are available for GSM will grow stronger when the available bandwidth increases (Casati & Shneyderman, 2003).

2.3 Practical Examples

Mobile solutions such as cell phone solutions are common within the industry. However, solutions involving PDAs and Smart Phones are not widespread but some enterprises have adopted this technology.

2.3.1 BT Industries

BT Industries is a forklift truck manufacturer that has adopted a mobile solution. BT's service technicians are equipped with ruggedized Smart Phones from where they get their assignments. The technician normally connects to the enterprise resource planning program four times a day to get specific information about what is to be done, e.g. special agreements, which type of forklift truck it concerns and its repair history. Obviously, they get information about the customer and location as well. If an emergency problem arises the technician receives an SMS with an alert. After the repair the customer signs the terminal's screen and instantly receives an invoice either by fax or by e-mail.

BT Industries has estimated the pay-off time to a year for this investment and BT calculates to save about 24 million SEK per year when the solution is used to its full extent. The savings are due to shorter lead times, less administration and better planning. Other benefits that come from the mobile solution are a more uniform reporting, improved work environment and a higher status to the technician profession. One risk that BT Industries predicted was that the new technique would not be accepted. This turned out to be wrong; the service technicians felt pride and higher status as the paper and pen were replaced. Still, some drawbacks have been noticed; it is hard to define each supplier's area of responsibility and some of the personal interaction between the technicians and service management has disappeared. The implementation process also required longer time than expected [Nyteknik.se, 01-12-2003].

2.3.2 Boliden

Boliden is another company that has adopted a mobile solution. Their operators are equipped with PDAs which make it possible for them to access information about the process from anyplace. This information was previously reachable only from certain terminals around the factory but with the PDA the operators are able to get all the necessary information from anywhere. The operators are also able to access the intranet. The advantage with this solution is that waiting and monitoring times have decreased and the machine operators do not need to go the unnecessary trips to check the machine's terminal anymore. The operators are also better updated about the company's activities, which create a more unified feeling (Världstvåa, 2003).

2.4 Description and Analysis of the Present Situation

It is important to get a correct description of the present situation to be able to do an accurate analysis. There are numerous of methods and theories to describe and analyse the present situation.

2.4.1 Processes

Larsson & Ljungberg (2001) state that a process can be defined in many ways. One definition is; a chain of constantly returning activities that create value to the customer. Words that are similar in every definition are input, activities and output but the justification of the process depends on if it creates any customer value (*ibid.*).

Process Identification

An enterprise needs to understand and identify its processes in order to manage and develop the organisation. In an enterprise it is important to identify three

kinds of processes; the main process, the support process, and the management process. The main process is the one that describes the purpose of the organisation, for example SSAB's main process is to make steel. The support processes exist to support the main process and are not absolutely crucial for the organisation's success, e.g. maintenance of the machines in the main process. The management processes are the processes that coordinate and control the organisation. A process often constitutes of other process, see figure 2.2 (Egnell, 1994).

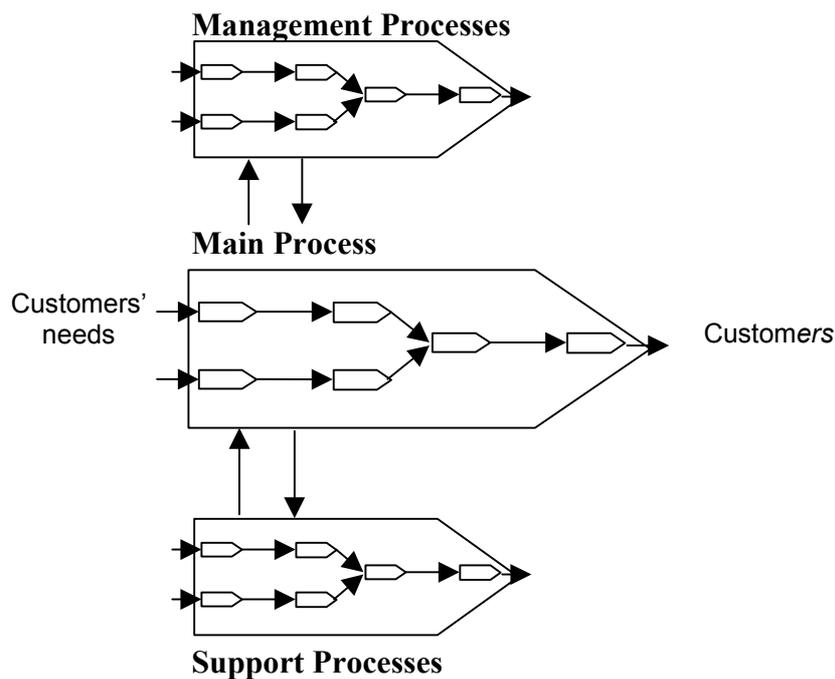


Figure 2.2. Illustration of the processes in an organization, free interpretation of Egnell (1994).

Process Improvements

Efficiency within a process is to create appropriate products with as few resources as possible. The resources can, for instance, be personnel, money or time (Larsson & Ljungberg, 2001).

Process improvements are concerning elimination of the unnecessary activities by, for example, decreasing the operation and transportation times (Segerstedt, 1999).

Krajewski & Ritzman (2002) argue that in order to improve a process one has to systematically study activities and flows in the process. It is absolutely crucial to understand the process to be able to improve it. The persons with the greatest knowledge about the process and how to improve it are therefore usually the people who work with it every day. Key tools for analyzing a process are process charts and flowcharts, see section 2.4.2. Process charts are used to inform about all activities within a process and to categorize them depending on the type of activity. The categories are often operation, transportation, inspection, delay and storage. Important factors for measuring performance also need to be identified when improving a process. There could be six factors that are of importance: throughput time, cost, errors, safety, on-time deliveries, and total elapsed time (*ibid.*).

Egnell (1994) identifies typical high potential areas to analyse when to improve a process. Some of these are:

- *Minimization of unnecessary administrative routines*
In many organisations there are unnecessary administrative routines.
- *Minimization of activities that do not create value*
Keeping inventory, transportation and controls are all examples of activities that do not create any value to the customer but still add to the total costs. As a result, minimizing or eliminating these activities will make the process more efficient.
- *Eliminate repeatable activities*
If different persons do similar activities in different stages of the process, the enterprise should try to eliminate or consolidate these activities.
- *Simplify the process*
Activities within the process should be easy to perform, learn and understand.
- *Standardize work duty and activities*
Standardization is crucial when improving a process and it is important to current and future employees so that they are able to perform their work as efficient as possible.
- *Decrease the throughput time*
By focusing on improvement of activities the total throughput time of the process can be decreased.
- *Automate and/or mechanize*
New technology and especially information technology can improve many activities and processes.
- *Maintain and increase the utilization of the equipment that is used in the process*

If the equipment in the process is in good condition the process becomes more reliable.

Brans (2003) says that some activities are more likely to be improved with a mobile solution. These are bottlenecks caused by lack of information, data re-entry, wait time, and lacks of coordination. Bottlenecks can occur from somebody waiting for information or time that arises from extra trips to acquire information. Data re-entry is probably common in the industry and takes place when data is not typed into the system immediately, for example if somebody writes the data on paper before he/she types it on a computer (*ibid.*). Stig-Arne Mattsson (2002) means that two percent of the manual registrations that are typed into computers become wrong. Wait times refers to time when an employee is waiting for something to happen and has nothing useful to do. The last area comes about when activities needs to be coordinated but the persons involved are unable to do so (Brans, 2003).

An enterprise that lets its external service personnel use mobile solutions can benefit from it since the personnel are able to fix equipment faster, order parts faster, access problem history and technical documents, make fewer trips to the office, and coordinate more effectively with colleagues. Metrics that can be used when following up on service workers are, for instance, first-time fix rate, time to repair, dispatch time and revenue per engineer. First-time fix rate can increase since the maintenance personnel have problem history and technical documents easily available and do not need unnecessary trips to obtain it. The time to repair would also decrease with a mobile solution because with the right information the problem could be located and fixed faster than before. If the customer can see if a service engineer is busy with a job or near their location it would be easier to contact the one most appropriate for the job, and therefore decrease the dispatch time. All of these metrics are focusing on decreasing the unproductive time and to get the customer's equipment up and running as fast as possible. The revenue metric, however, focuses on the number of jobs the service engineer can perform under a given time since the more jobs the larger revenue (Brans, 2003).

2.4.2 Flowcharts

A flowchart can be done in a number of ways, it is important to describe the present flow without considering how the perfect flow should be. A flowchart can describe the flow of material, information, and equipment etcetera through a process. Only when a true flowchart has been made up improvements can be noticed (Krajewski & Ritzman, 2002). To get a thorough understanding of the

present situation a flowchart is a good start after identifying the type of process that is examined.

Aronsson *et al.* (2003) mean that it is possible to design a flowchart with rather simple techniques and the authors suggest symbols that are commonly used, see figure 2.3. A flowchart can be an overall picture of the organization or describe a specific part of it in detail and a good method is to start big and then refine gradually. It is a very time consuming job to carefully describe an entire organization, and therefore, if the time sets boundaries, it is recommended to focus on areas where the benefits are likely to have the most effect (*ibid.*).

When analyzing a flow there are a number of important measures that can be of interest to find improvable areas. Some measures are abstract while others are more tangible, for example lead-time, on-time deliveries, customer complaints, and service level (Aronsson *et al.*, 2003).

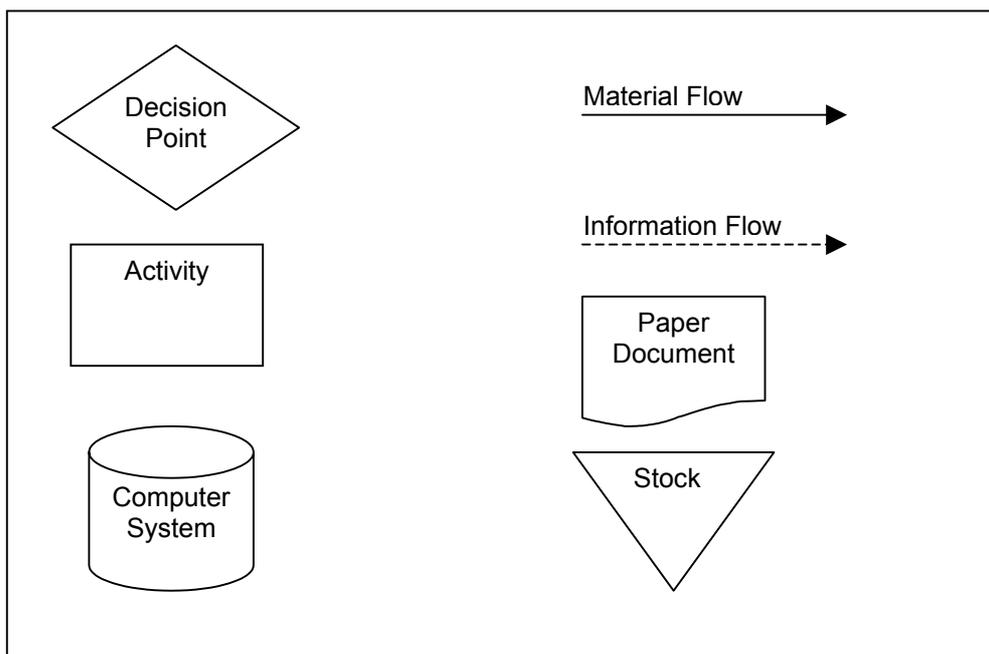


Figure 2.3. Symbols commonly used in a flowchart (Aronsson *et al.*,2003)

2.4.3 Lead Time Analysis

Time has become more important to companies nowadays when the demand for flexibility and differentiation has made it more costly and even impossible to keep stock which meets the customers' demands. The reason that time is used as metrics is because it is much more concrete than, for example, costs. Obviously, as the focus on time reduction increases it makes new and higher

demands on the information exchange within a supply chain (Aronsson *et al.*, 2003).

Lead-time analysis refers to the method used for analysing a material or an information flow to reduce the total throughput time in the flow. There are not any concept solutions but each situation requires a custom made solution. However, there are ways to attack the problem. One is to talk to persons with great knowledge about the practical solutions, either within the own or in another organisation. Another way is to study literature to find general principles of how lead times can be reduced, for instance, by improving the ability to process information (*ibid.*).

Active versus Passive Time

Aronsson *et al.* (2003) divide the total time in a flow into passive and active time. The active time is, as described in chapter one, when some activity is performed which is adding value to the product. Passive time is naturally the opposite, when products are in stock or when mails are in the inbox waiting to get handled. The best way to reduce the total time in a flow is to focus on the passive time since it usually takes up most of the total time, and therefore has the biggest potential (*ibid.*).

2.6 SWOT-analysis

SWOT-analysis is a method to assess the internal and external changes that have taken place in an organisation. The analysis is carried out at enterprise level and requires a compilation of the strengths and the weaknesses the company possesses and the opportunities and the threats it will be facing in the future. This is done to identify the key issues and the options available (Doyle, 2002). Dwyer *et al.* (2002) mean that the strengths and weaknesses arise from the firm itself while opportunities and threats are deduced from factors in the firm's environment; it might be access to growth markets or new regulations affecting the firm.

A good SWOT-analysis is performed in an honest way, otherwise there is a risk that the analysis will be useless and do more damage than good. Another important factor when doing a good analysis is to focus broad to be able to find opportunities and threats in, for example, markets outside from those that the enterprise currently is operating in. It is also recommended to examine different levels of the firm, such as key products, divisions, and countries. An analysis should also look ahead to find future trends, and hence a multiple time horizon is essential when conducting a SWOT-analysis. The final characteristic of a

good SWOT-analysis is that several individuals are involved since the analysis is built on perceptions and it is important to get different views (Dwyer *et al.*, 2002).

3 METHODOLOGY

This chapter describes the research strategy, which data collection methods that are used as well as the analysis methods. It also gives the reader a motivation to why the company and the respondents are chosen. Specific methodology problems are presented at the end.

3.1 Project Strategy

Before the project started a project specification was formed in order to guarantee that the parties involved had a unanimous view of the project. The project identification was made together with the tutors at Ericsson Research AB, Tommy Arngren, Tor Björn Minde, and Marika Stålnacke, and at Luleå University of Technology (LTU), Anders Sörqvist. The project specification was readjusted two times before the interested parties could agree. The project course can be seen in figure 3.1.

Thereafter a literature study was conducted to gain knowledge and familiarity with the subject before the fieldwork could start. The literature study also gave valuable information when deciding the personnel who should be subject for the observations. After the two observation sessions at SSAB Tunnpå AB a midterm presentation was carried out for the tutors at Ericsson Research AB. The findings, so far, were presented and constituted of the needs for a mobile solution. Requirements on the equipment and the business opportunities were still undergoing an analysis, and were therefore not included in the presentation. The presentation was closed with information about the future plan of the project.

The criticism from the tutors was mainly concerning the personnel chosen, or more correct the personnel not chosen. The tutors had a wish that, apart from the personnel already observed, transportation personnel and entrepreneurs working at SSAB Tunnpå AB should also be involved in the study. The critic was noted and measures were taken to meet the wishes, and thus transportation personnel were observed. The entrepreneurs caused more problems and due to the far progress in the project in addition with problems to administrate the observation this group was not studied. Some other ideas and tips were also aired during the presentation, which lasted for approximately one hours and a half.

Report writing has been conducted successively during the progress of the project and the written report was, together with the final oral presentations, the completion of the project.

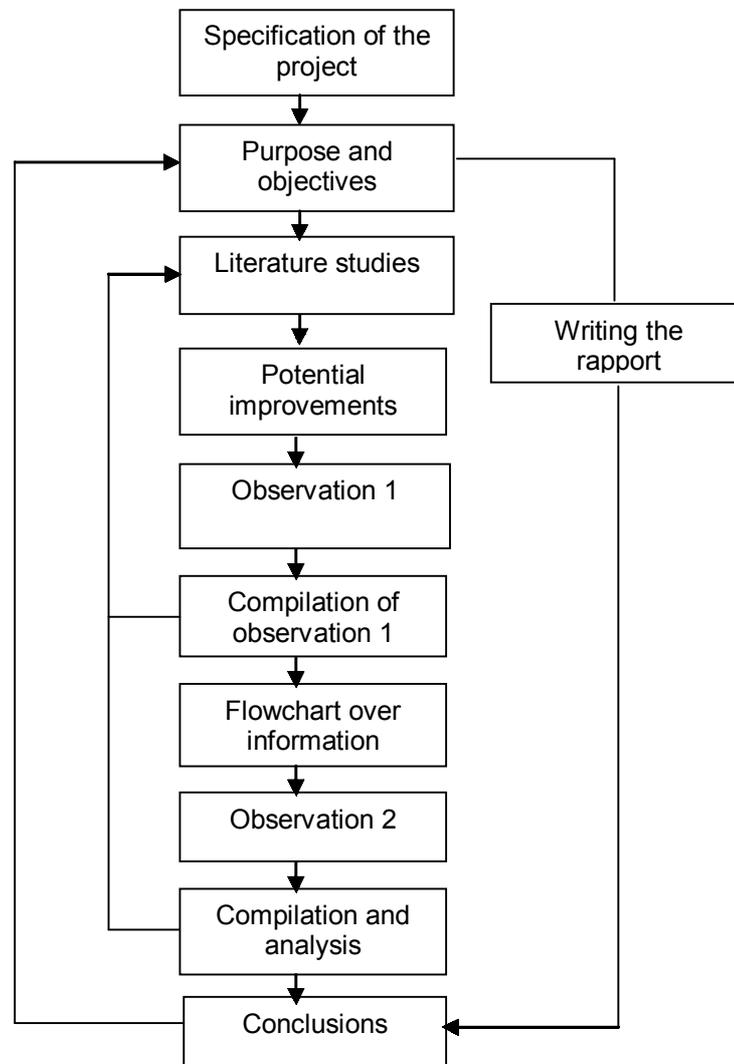


Figure 3.1. Project course

3.2 Research Approach

There are two different approaches to solve a research problem; these are the deductive and the inductive approach. The deductive approach uses the existing literature to develop a conceptual framework in which the collected data are tested. The other approach goes the opposite direction; theories are drawn up

according to the data collected (Lewis, Saunders & Thornhill, 2000). The approach that was chosen in this project was the deductive model since the purpose was to find a need for an existing solution although it involved a fragment of induction since the observations and questionnaire could serve as a foundation for new solutions.

3.2.1 Research Strategy

A case study was conducted in order to get a more thorough understanding of what the needs of mobile solutions in the process industry look like and the requirements on the solutions. Lewis *et al.* (2000) mean that a case study is useful for research when detailed information about the problem and processes is required and the study can be used to explore existing theory. Data collection methods that can be used in a case study are: questionnaires, interviews, observations and documentary analysis. The negative aspect with a case study is that it is hard to generalize the results. To be able to make generalizations extensive and germane theory is required (*ibid.*).

3.2.1 Literature Study

Literature studies have, more or less, been carried out continuously during the progress of this project to create an understanding of the problem. However, it was more extensive during the initial state to build the basis for the observations. The literature studied consisted of books, research reports, and newspaper articles as well as information from the Internet. The library at LTU and the database LUCIA has been widely used and words that have been exploited are: information exchange, mobile solution, logistics measures, wireless communication, and so forth.

Literature, in form of books and reports, provided by Ericsson Research AB were also studied as well as literature already possessed. This has, altogether, been sufficient to carry out and fulfil the project's purpose.

3.3 Data Collection Methods

If the research's purpose is to study people's behaviour or daily work observations are a natural method. Lewis *et al.* (2000) describe several types of observations where participant observation is one. The observer can take different kinds of roles in participant observation, two extremes are: complete participant or complete observer. A role between these is observer as participant in which the researcher reveals the identity and purpose of the research. An advantage with this model is that the researcher can totally concentrate on observing and taking notes since he/she does not need to

participate in the work (*ibid.*). Hence, the observation method used in this project is the observer as participant.

According to Lewis *et al.* (2000) there are two types of collected data, either quantitative or qualitative. Quantitative data can be the product from all of the research strategies and it is simply data containing numbers. Qualitative data is based on words, and the researcher use semi-structured or unstructured interviews to get the sufficient information about the area that is explored (*ibid.*). The data collected from SSAB Tunnpå AB was mostly qualitative, and it was a product from interviews, observations and questionnaires. An interview, according to Newman *et al.* (1995), is a rapid way of collecting data and the data are available immediately after the interview. Since qualitative data were needed in this project the interviews were designed as semi-structured as well as unstructured. In semi-structured interviews the researcher has a list of topics as basis for the questions. In unstructured interviews, on the other hand, neither topics nor questions are formed. The interviewees are given the opportunity to talk freely about events and the interviewer can probe answer to get a richer understanding (Lewis *et al.*, 2000). The interviews have been face-to-face interviews in connection to the observations. Group interviews as well as a phone interview have been conducted too.

Dahmström (2000) lists different benefits with phone interviews and the author argues that a phone interview is fast, cheap and that unclear matters concerning the questions can be solved. The interviewer also has the opportunity to probe answers. The phone interview was performed because of the distance between the interviewer and the interviewee in addition with the benefits mentioned above.

The second stage in the observation's process was to verify the work order for the most interesting roles and to get a deeper understanding as well as to get more information about the requirements on the equipment. This was done by a questionnaire, in accordance with Lewis *et al.* (2000) findings, which say that it is good to have done observations before a questionnaire since the researcher has a richer understanding about the processes examined. The second observation in addition with the questionnaire also gave answers to questions that arose during progress of the project. The questionnaire was used as a data collection method in order to obtain a more extensive data material as a base to find out the requirements on the equipment.

3.3.1 Construction of the Questionnaire

Dahmström (2000) argues that one of the benefits with questionnaires is that many people can be examined. Thus, the questionnaire was constructed in order to get a broader data sample about the physical requirements on the equipment, and principally the terminal since that is the equipment the personnel in the process have contact with. In addition with the broader data sample, requirements also concern the attitudes a user has towards the equipment and the questionnaire was formed to get information about these. Lewis *et al.* (2000) say, “attitudes are best thought of as a thing that the respondent possesses, rather than things a respondent does” and the authors claim that attitudes are a variable that is excellent to collect with questionnaires. The questions were both of multiple-choice type and a few with open answers, see appendix 1. The first questions were constructed to explore the person’s existing terminal and his/her attitude towards it. The first section of the questionnaire was followed by a section which aimed to understand the importance of certain features of the terminal. In these questions the respondents were supposed to mark their answers on a five point numeric scale, since Lewis *et al.* (2000) mean that a self-administrated questionnaire should not have more than five response categories. The questionnaire was containing 18 questions altogether and it was written in Swedish since it was essential that the respondents truly understood the questions in order to give reliable answers.

The sample size was chosen based on the population working day or day-shift during the weeks that the visits at SSAB Tunnpå AB took place. Lewis *et al.* (2000) mean that a self-administrated questionnaire can have a low response rate. To minimize this risk the respondents was observed during the accomplishment of the questionnaire. The monitoring was also done in order to explain the questionnaire if something was incoherent. Moreover, self-delivery secure that the right person has answered the questionnaire which increase the response rate further. It also reduces the risk that the respondent has been affected by others when doing the questionnaire, which improves the answers’ reliability (Lewis *et al.*, 2000).

3.4 Analysis Methods

A method that has been frequently used to describe the process as well as the general flow of information between the employees is the flowchart. The information flow and how the information was communicated as well as the mobility factor were considered to be important factors when evaluating the need for a mobile solution. Other characteristics that were interesting were responsibility and availability. To get a lot of various data, personnel with

different degree of mentioned characteristics were selected for the study. This was done in order to try to find a pattern in the need for a mobile solution, if even people with low mobility could have a need. Another reason was that people with diverse characteristics could have different types of needs, and accordingly needs for different solutions. Moreover, the characteristics will make it easier for other enterprises within the process industry to identify personnel to whom increased efficiency is likely to arise from a mobile solution. Except from these criteria the personnel were selected from positions where SSAB Tunnpå AB would benefit the most of more efficient work, for example with less time wasted. It was both personnel in the main process but also in the support processes as well as in the management processes.

A flowchart has been designed whenever it has been meaningful to describe and visualize the work order. The flowchart has then been used to confirm the work order with the personnel to get a unanimous picture and to guarantee the information and communication flow's correctness.

3.5 The Company

SSAB Tunnpå AB, from now on referred to as SSAB, is a company typically for the process industry; the plant is spread out over a large area and the production carries on around the clock. The process is also very technology intensive, which make SSAB used to work with cutting edge technology. SSAB was chosen since SSAB is a member of the ProcessIT Innovations network, and thus familiar with wireless technology. Consequently, Ericsson Research AB and SSAB already had an established contact and SSAB had a brief knowledge about the project. Moreover, SSAB has a plant in Luleå, which made visits more convenient.

3.6 The Respondents

According to the theory illustrated in chapter 2, much of the potential with a mobile solution is for the mobile personnel but a solution might also increase the efficiency for personnel handling a lot of information and communicate a lot since it can reduce administration work and facilitate faster decisions. The factors that have been considered in this report were passive time and administration work. The observed personnel were selected on the basis of the mentioned factors in consultation with representatives for SSAB. The characteristics of the process industry were also considered, and as a result the personnel's work task focus either on increasing the reliability of the production process or decreasing the throughput time. SSAB missed its target

with 80 000 tonne, approximately representing 200,000,000 SEK, last year because of unplanned disturbances within the process, and consequently faster repairs and less disturbances and stops in the process would lead to increased revenue (Robert Johansson, 27-01-2004). SSAB always produce to order and the order book allows full production. The loss due to stops is therefore directly affecting the company's revenue since there are no buffers to cover for the lost production

Maintenance personnel supports the production process and their work focus on increasing the reliability of the process as well as minimizing the downtime if something in the process breaks down. An unexpected break down costs, according to SSAB, about 100-1000 times more than if the problem would have been prevented and fixed at an earlier stage (Stålboken, 2002). These costs could be reduced if the process was restored faster, that is, if the repairs were done faster. Personnel within the main process were chosen since more efficient work, i.e. less time wasted, would decrease the throughput time in the process and reduce the disturbances in the process. If management processes become more efficient it will mean that decisions can be taken faster since supervisors have the responsibility for the personnel and the output.

The observations were principally carried out in two stages; in the first stage the control room personnel, who are operating in the main process, were observed as well as the machine keeper and two different maintenance groups who are working to support the process. A supervisor and a production planner, representing the managing processes, were also observed. The second stage included primarily further interviews with the personnel handling the support processes, but also a questionnaire to the personnel in the main and the support processes to obtain a throughout picture over their view on the terminal. The second observations were used to confirm the compilation of the first visits and a general flowchart over the information had been done to easier get a unanimous view of the processes. Some additional information was also required to get a full understanding of the processes as well as of the personnel's preferences concerning the cell phones.

After the part time presentation, i.e. after the two observation phases, transportation personnel were observed. A lot of background information concerning SSAB had already been collected from the previous observations, which made one observation sufficient for the transportation personnel.

3.6.1 Categorization

Categorizations of the respondents have been done from the above-mentioned categories and diagrams have been drawn to visualize the result graphically in line with the objectives, see appendix 2.

Mobility was considered as very high if the personnel's normal working area included the entire plant; the IT-maintenance and the transportation personnel fulfilled this criterion. In the next level of mobility were personnel whose working area comprised a certain department at SSAB, i.e. personnel who are serving a special section, chosen. Mechanics, supervisors and machine keepers were included in this group. The group with least mobility included the control room personnel and the production planners. These roles were, more or less, immobile and spent their working hours in an office or a room to monitor the process.

It was rather tricky to categorize the degree of communication and information since these factors are virtually the same; communication is defined as transfer of information by Swedish Academy's dictionary (1998). Table 3.1 shows which different communication devices that are used at SSAB. PROST is the production-planning program and the (X)-symbol represents rarely used but available if needed. X implies that the equipment was frequently used.

	Phone	Cell Phone	Computer (e-mail, work order)	Computer (PROST)	Short-range radio	Intercom
Machine keeper	(X)	X	X		X	
Maintenance	(X)	X	X		(X)	
Control Room	X	X	X	X	X	X
Transportation		X	(X)		X	
Production Planner	X	X	X	X		X
Operation Supervisor	X	X	X	X		

Table 3.1 Man over the communication devices at SSAB

From the table above it can be seen that many different devices are used at SSAB. The categorization of the communication was not done after the number of devices the personnel were using but of how frequently they were communicating. Still, the number of devices and the frequency of the communication were closely related. The production planners and the control room workers were therefore regarded to have a high degree of communication while the IT-maintenance personnel were considered to have a low degree. The others were fitted in-between these groups. The reason for this was that the IT-maintenance workers only were communicating when a job needed to be done or during jobs and since they only handled emergencies this were relatively rare. The middle group on the other hand works continuously even if they answer to emergency calls as well. This means that they need more information, and therefore communicate more. The group with the highest degree of communication's major work task is to receive and communicate information, for example via the production planning system (PROST), in order for the production to function.

As said before communication and information are interconnected, and consequently the information factor was divided in to the same groups as the communication. However, each and everyone can seek information for themselves, for example during inspection rounds. Even though this was taken into consideration the groups were unchanged.

Responsibility characteristic was easy to categorize since the only person with higher formal reasonability was the supervisor.

The last category, availability was referring to how available the person needed to be and the category was considered with respect to disturbances in the production process. The personnel in the main process must be available in order for the process to run satisfactory, which gave them a high degree of availability. The maintenance personnel and the machine keepers supported the process and answered to emergency alerts that regarded problems which could disturb the production process. This fact put them in the same group as the previous. The same goes for the supervisors, who had reasonability for the shift-team and to see to that the right resources were available for the production to work all right. The transportation personnel support the process but there would not be any major disturbances if they were not constantly available. Hence, they were considered to be in a lower availability group.

3.7 Methodology Problems

Specific methodology problems that have been present during the research were problems to get in touch with the respondents. The most convenient way of communication and the suggested way by the respondents were via e-mail. The phone is not often personal and many of the personnel are working “five-shift”, i.e. weekends as well as night and day shifts, which made it hard to get in contact with the right persons via the phone. It was sometimes necessary to send charts and other figures through e-mail as well. However, the reply rates were very low.

The nature of the work among the respondents has made it hard to follow the work order and much of the results are based on interviews since the personnel observed often were passive due to lack of work. A mobile solution is adopted to make the work more efficient and eliminate the unproductive time. A risk when basing a great deal of the results on interviews can be that the respondents withhold and change information since they might feel that a mobile solution can involve more work and put higher pressure on them.

The midterm presentation was conducted rather late in the project process which made the time for major adjustments relatively short. It would have been more desirable to have a presentation immediately after the first observation session because the data collection would be in a more logical order. The late presentation also resulted in an incomplete observation session of the transportation personnel and eliminated the possibility to study the entrepreneurs due to the time limit.

Another problem occurred during the observation of the transportation personnel since the vehicles have small cabins and only one seat it was very hard to write during the ride. The strange position of the body made longer observations tough, and therefore less time was spent with the transportation personnel. To use a tape recorder was not an option since the cabin of the vehicle was very noisy.

3.7.1 Reliability

Reliability is, according to Dahmström (2000), concerned with how well the research methodology is able to get the same results at repeated investigations on the same elements. The reliability is considered high if the variations with respect to randomness are low. Lewis *et al.* (2000) mean that there are four threats to reliability. The first of these is subject error in which, for example, the weekday for the observation might affect the results. People tend to be more positive on a Friday than a Monday (*ibid.*). All interviews and observations

were conducted on days in the middle of the week and over the shift relief which imply that the last two to three hours of the morning shift and the first three hours of the afternoon shift were observed. This reduces the subject error since the time has been “neutral” for the observations.

The reliability could also be affected by subject bias. This bias is caused since people say what they think their bosses want them to say (Lewis *et al.*, 2000). In this research the assigner has been an external company and the researcher a student and that, together with the purpose of the research, has been carefully explained before the observations. The respondents have also been able to be anonymous and this would, altogether, be a guarantee for that they have given their true opinion. There is always a risk with unstructured or semi-structured interviews since it is easy for the researcher to ask leading questions. The researcher was well aware of this danger and tried to avoid it.

The last two threats are observer errors and observer bias. These two risks were reduced since fair copies of the notes were written down immediately after the visits which decreases the risk of interpreting the notes wrong. The second observations were also used to confirm the interpretation from the first observations and flowcharts had been made up to clarify the results even further. Lewis *et al.* (2000) suggest that a tape recorder can be used to increase the reliability of the research. This was considered as an option but the noisy environment at SSAB frustrated the plans.

3.7.2 Validity

Dahmström (2000) mean that validity is the term used to describe how well the study measure the event the researcher wants to measure, i.e. to what extent the research questions are measured or described. The variable measured or described should, in other words, be relevant measure for the requested characteristics. The reliability is also of great importance since high reliability is a condition for high validity.

The respondents were informed of the research’s purpose a couple of days before the observation and they could always ask questions anytime during the observation. The purpose was to study the daily routines, which was the reason why not any topics of the interview were sent in advance. As mentioned before the respondents were observed when they carried out the questionnaire in order to increase their motivation as well as explain if anything felt obscure. The questionnaire was also tested on university students and a tutor at Ericsson Research AB before it was handed out at SSAB to make sure the questions

could be understood easily. This secures the quality of the questionnaire and increases the validity even further.

.

4 SSAB TUNNPLÅT AB

This chapter gives the reader a brief description of the company SSAB Tunnplåt AB and of the material flow in the production process.

4.1 The Company

SSAB Tunnplåt AB is a member in the SSAB group and was formed in 1988 through a merger between the steelworks in Luleå and Borlänge. SSAB Tunnplåt AB is the biggest manufacturer of steel sheets in Scandinavia with an annual turnover of over 10 billion SEK (2002) [ssabtunnplat.com, 08-01-2004]. The company has around 4400 employees altogether and 1400 of these are stationed in Luleå. The plant in Luleå produces 2.1 million tonnes of steel each year, although it is a small steelwork compared to the competitors around the world (Robert Johansson, 27-01-2004). The small size brings advantages in form of short lead-times and the customers are able to order small batches of special kinds of steel. This result in great knowledge of many different types of steel, something that SSAB's larger competitors often lack. SSAB is best known for its high strength steels.

The steelwork in Luleå sells all steel it produces to the rolling mill in Borlänge which rolls the steel to strips. The rolling mill's demand is greater than what the steelwork in Luleå can produce, and therefore is a lot of steel bought from SSAB's steelwork in Oxelösund as well. The strategy used is to let Luleå produce as much as possible while the steelwork in Oxelösund handles changes in the demand.

4.2 The Production Process

The following section gives a brief description of the production process, see appendix 3, in order to better understand the remaining part of the report.

The production process starts when coal is imported to Luleå from all over the world, e.g. Australia, Canada and the USA. SSAB keeps a huge amount of coal in stock during the winter which is due to the ice since many ships are not classified for travelling through ice. The coal is heated up to 1000 °C for 18 hours and then becomes coke. The coke is used in the blast furnace, together with iron ore and limestone, and after eight hours the hot iron is drawn into a torpedo car, which basically is a wagon used to transport the hot iron. The blast furnace is tapped about ten times every twenty-four hours. After the torpedo car the hot metal is tapped into a ladle. The volume of metal that goes into the ladle

is called a heat. This is the first activity within the steelwork building. Then, the hot iron is desulphurized by an injection of calcium carbide into the heat. The personnel know how much sulphur that needs to be reduced to match the customer's demand. These activities take about an hour. The hot iron and scrap are mixed together in a BOF-converter and oxygen as well as alloys are added to reduce the carbon content and the iron becomes steel. This is a preadjustment before the steel enters the next station and adds another hour to the total process time.

There are hundreds of different steel grades and to meet a specific customer's demand the steel has to be further refined by the insertion of different alloys and oxygen. The temperature of the steel is also adjusted. This station is called the CAS-OB station. Some of the steel does not go through this activity but is instead treated under vacuum at the RH station to remove carbon. This activity removes the carbon to extremely low proportions which makes the steel very soft. This type of steel is used by, for instance, car manufacturers. The last activity before loading and transportation is to cast the liquid steel into steel semis, or so called SLABS. The liquid steel is tapped into a tundish, a big tub, before it is transferred to the mould. Great care has to be taken so that steel to different customers is separated. The steel strand is then cooled and solidified before it is cut into SLABS. The last activities take one hour each, and thus the entire process, from the blast furnace to finished SLABS, takes approximately twelve hours. When the steel has cooled down it is transported to the rolling mill in Borlänge (Stålboken, 2002).

The lead-time from order to delivery of the finished strip is about 16-18 days of which about five days are in the plant in Luleå.

5 DESCRIPTION OF THE PRESENT SITUATION

This chapter provides the reader with a compilation of the information collected and describes the respondent's daily work, communication and need for information as well as their opinions; everything is based on the observations and the interviews.

5.1 The Machine Keeper

The shift-working machine keeper's duty is to support the main process by watching over the flow of gas and water from the BOF-converters and the desulphurization station, see appendix 4. To do so, the machine keeper needs to do real time analyses of different measurements and graphs from the support processes. The analysis is done once every hour in the control room or wherever there is a computer with the accurate computer program. It is a rather extensive material to study, about 50 pages with different graphs and usually more than one graph on each page and it takes approximately five to ten minutes for an experienced machine keeper to go through the information.

If any value in the processes changes outside the preset limitations an alarm goes off. Then, the personnel in the control room contact the machine keeper to fix the problem, and as a consequence the machine keeper needs to be available at all times. A problem is that the control system is too sensitive and alerts the personnel too often. Nevertheless, if the divergence from normal values in the control system is extremely large the process shuts down automatically. Although, some processes are monitored physical at inspection rounds.

An important task in the machine keeper's duty is to analyze the values over time to detect deflections and fix it before a problem arises. The machine keepers are normally working with emergency problems but at the weekly stop, which is a four-hour stop for maintenance, they perform planned repairs as well. They can also do some planned repairs if the production stops due to a problem in another part of the process. However, the day-working machine keepers mainly perform the planned repairs, which imply contact with external entrepreneurs and to order spare parts.

Apart from monitoring the gas flow, the machine keeper needs to make physical controls of the processes to see that everything is running without problems and to empty the ooze and the powder from the desulphurization station and the BOF-converters. This is normally done every third to fourth hour but a disturbance somewhere within these processes requires a closer

interval between the inspections. There are machine keepers who are more careful and take the rounds once every hour. The round goes in the steelwork building and to the adjacent filter building and it takes about 20 minutes altogether for one round. When the container with ooze or powder is full the machine keeper contacts the transport personnel by cell phone.

The work environment for the machine keeper is extremely dusty and he/she is also affected of large changes in temperature as well as damp since the work involves water and gas.

There are two machine keepers at each shift and one of them uses a cell phone while the other uses a short-range radio. The short-range radio works best within the steelworks building whereas the cell phone works best in the filter building. The machine keepers have divided their work between themselves, half the shift one of them is inside and uses the short-range radio and the other half the person uses the cell phone. The cell phone is used when the machine keeper has responsibility for the filter building and the station that is producing ooze. The machine keepers are, however, working in pairs if a repair is needed. A communication problem can occur if one of the machine keepers detect a problem since they uses different communication systems. If the machine keeper needs to contact the colleague, he/she contacts someone with access to a both phone and a short-range radio so that person can pass the message on to the other machine keeper. Alternatively, the machine keeper must find another communication device, for instance the ordinary phone in the lunchroom. Additional short-range radios are also stored in the lunchroom which the machine keepers are using when they are working in pairs. The machine keeper who is using the short-range radio needs to go through the same procedure when he/she needs to contact a repairer as well since they only uses cell phones.

The machine keeper records when containers have been emptied and if there has been any occasions out of the ordinary in a logbook at the end of each shift. The information written in the logbook is taken from memory and usually comprises of a couple of sentences so that the personnel at the next shift get notified about problems that occurred during the previous shift. The personnel then plan the shift on the basis of this information. However, no information about how the problems were solved is given. The machine keepers normally inform each other between the shifts as well or send e-mail to the personnel who take over. The machine keepers ask for a different logbook where they can give more extensive descriptions about the problems, and some persons would also like to document certain problems with a camera.

The machine keepers use an ordinary cell phone, which is an Ericsson S868 with GSM-technology, see appendix 5. The phone works well but it regularly needs maintenance due to the rough environment. A common problem for everybody who is using cell phones is that the loudspeaker stops functioning due to metal dust, which gets stuck on the speaker's magnet. The network operator is TeliaSonera and one service is that the personnel can call internal calls with a five digits long number, that is, the last five digits in the cell phone number. All blue-collar workers are using the same type of cell phone and are subscribed to the same network operator. The subscription includes internal calls, which are free of charge. For this service SSAB is paying a fix cost but the costs for calling to external phones are variable. The subscriptions include, apart from this service, the usual services known to private consumers, such as SMS availability. The cell phone is used every shift, and therefore the machine keepers have extra batteries which are always charged. The machine keepers often miss calls on the cell phone as well as the short-range radio since they work in noisy environments. This is considered to be a problem but no measures have been taken to solve it.

The communication with the machine keeper is mostly of the system-to-man kind, since a very large part of the job is to monitor different flows. The other communications is man-to-man via the cell phone, short-range radio and the computer.

5.2 The Control Room

There are normally two persons working in the control room, one that has responsibility for monitoring the BOF-converter process and the other supports the BOF-converter process by weighing the correct amount of alloys and testing the steel manually. This operator is only in the control room during short periods of time. The person who is monitoring the process also sees to that the steel gets the right quality. The operator can see the steel recipe on a computer screen and it gives information about, for instance, which alloys and the amount that is required and what temperature the steel should have. Oxygen is also blown into the steel by the operator to reduce the content of carbon. The operator has six computer screens, three that monitor the process in real time and three containing information about the production plan, alloys and metal scrap. When an order of metal scrap is placed by the control room operator it instantly appears on the screen in the tractor so that the driver knows how much and what type of scrap he/she shall bring to the crane operator. The control room always place orders for approximately the next twelve ladles.

The BOF-converter process is also monitored by a number of video cameras that show the process to the control room operator in real time. But, the operator usually monitors when the slag is scraped out from the BOF-converter on sight, which means that the control room might be unmanned for couple of minutes during this activity.

The control room operators usually communicate with the other BOF-converter, desulphurization station and the tractor driver. The conversations are short, typically five to ten seconds and normally concern problems like delays or other things out of the ordinary. If the process runs without problems, i.e. according to the production plan, everybody knows what to do. This fact makes it almost impossible to draw a general communication flow since it depends on the problem. Verbal communication is done over short-range radio, telephone, cell phone and intercom. The intercom and the short-range radio are by far the most used, followed by the ordinary phone. The cell phone was never used during the observations. The people that the control room operators talk to are usually inside of a rather noise-free environment, and therefore the quality of the conversation is good. The tractor driver, however, operates over a large area and sometimes out of range of the short-range radio, as a result he/she needs to be contacted on his/her cell phone. The control room operators considered this as a problem. Another problem that the operators feel is when people do not answer when they are contacted. This problem is mainly due to noisy environments at SSAB.

The communication with the computers is often system-to-man because the control room personnel must monitor the process and perform their work accordingly. Man-to-system communication via the computers is also common and information about the recipe and the production plan is processed. Moreover, the control room gives information via the computer to the tractor driver and to the personnel handling the alloys.

5.3 The IT-Maintenance Personnel

The IT-maintenance worker's main purpose is to answer to emergency calls concerning control systems and different instruments. There are other maintenance personnel handling mechanical problems and others who take care of electrical problems at the entire SSAB as well. The maintenance personnel, whose only duty is to solve emergencies, are working shift in order to always be available. On the contrary, there are maintenance personnel stationed at each department who are handling planned repairs, and are hence working day time.

This organisation structure is quite new and is different to the previous structure where all the maintenance personnel were placed at different departments, like the coke plant or the steel work for example. The centralization represents many new areas to learn for the maintenance personnel, both concerning the equipment but also the locations. Nowadays it is the person who is most familiar with the location that takes care of the problem, that is, the person who has been stationed at the place earlier. The shift-teams are created to represent a wide range of knowledge, i.e. personnel who have been placed at different locations.

Two persons work with IT-maintenance duties on each shift because of safety regulations. If more than one problem arises at the same time the most serious problem is prioritised without taking notice of the people the problem bother and since the IT-maintenance workers receive three to ten emergency calls per eight-hour shift on a normal day this happens occasionally.

When problems with a control system or with an instrument occur the personnel concerned call one of the IT-maintenance personnel on his/her cell phone and explain the problem, see the flow chart in appendix 6 for details. If needed the maintenance staff can connect to the process from the computer in the field workshop where they are stationed. Although, they rarely do that since they rather solve the problem at sight. If a computer is needed when the IT-maintenance personnel are out in the field working it is possible for them to use one of the computers in the process. The IT-maintenance personnel do therefore not feel that they need a notebook computer and they do not believe that they are required to take unnecessary trips in order to obtain information. The information the maintenance personnel need is wiring diagrams of machines etcetera and these are located in each department. The diagrams are not stored digitally. Other information are drawings of the control system, these are normally to find in the computer but are seldom updated. Other information that the repairers use is the repair history of the machines. This documentation gives information about problems that the machines have had in the past and how the problems were fixed. This documentation is important for both the machine owner and the maintenance personnel since they get information about how problems have been solved before. The maintenance personnel use the repair history more or less daily.

A problem that often occurs when the maintenance personnel are out working is missed calls due to noisy environments. The cellular network coverage is good all around the plant but there are special places, such as the relay interlocking plants, where the communication devices do not work.

The IT-maintenance personnel write notes in a logbook, i.e. a work order is created, at the field workshop after a job has been accomplished. Normally a few sentences based on what can be remembered from the jobs. When the personnel are occupied with lots of work they write a memorandum with details about the problem before typing the information into the computer. If a problem is left unfinished or with a temporary solution more information is required by the staff at the next shift, and accordingly more information is typed into the logbook. The personnel also write an e-mail to the concerned personnel at the next shift with sufficient information about the problem. The information given in the logbook is which machine the problem concerned, how much time it demanded, how it was solved, and if any spare parts were needed. The accountancy department uses the information about the time and spare parts as drivers of cost when they make the internal bills. The work order is created when the problem is solved, except if any spare parts are needed.

SSAB stores spare parts in a central warehouse between the coke plant and the steelwork but the maintenance personnel also have a small stock with the most frequent used parts. All spare parts are registered in a database in which it is possible to see specific data such as current stock etcetera. The machine numbers are often used when seeking for spare parts to a machine but the numbers are usually very hard to find. The repairers request a manual to find the right parts more easily. When a part needs to be changed, the maintenance workers check whether the part is available at the warehouse or not. If the part is available a work order is created, which act as an order to the warehouse. The order is placed to the warehouse via the computer system and then the people at the warehouse pick the order. The part is either collected by the maintenance personnel or delivered to them by the central warehouse staff. It is the machine owner's responsibility to order parts from external companies when the parts are not stored at SSAB.

The IT-maintenance personnel mainly use cell phones to perform their work except when talking to the crane drivers since they use short-range radio. The short-range radio has 23 channels where each represents a different location or group of workers, for instance the transportation personnel. The cell phone is not personal, and hence used around the clock which implies that there must be fully charged batteries available. Therefore, extra batteries are stored at the repairers' office. If a phone should brake down it is always possible to get another one from the sentry box. The cell phone used is Ericsson S868 and the personnel are fairly satisfied with it. A problem with the phone is that it does not have built-in vibrator. Vibrators as add-ons have been used with good

results but it could not handle the rough environment and broke down. Another request is hands-free headsets.

5.4 The Maintenance Mechanics

The day-working mechanics are responsible for planning and performing routine maintenance. Emergency calls can occur even though this is the shift-working maintenance personnel's responsibility but if the shift-working mechanics are occupied with work the day-working personnel cover for them. The mechanics are occasionally forced to hire external personnel if there are certain tasks they can not perform, such as special welding or if they are too busy. In these cases they are obligated to contact the operation supervisor who approves and orders the job.

An important part of the mechanics' job is to go rounds in the steelwork building to detect and take care of problems before the production process is disturbed. The rounds follow a predetermined schedule, the F-round, which gives specific information about what shall be examined and an estimation of how much time it requires, see appendix 7 for further details on the information flow.

There are two day-working mechanics with responsibility for one BOF-converter each. However, they usually work together because of safety reasons and since it is easier to do the work together. The mechanics also have a close relation to the machine keepers who call their attention to problems, write work orders and inform them if something extra ordinary has happen during the night. The information is given through the computer or over the cell phone. Occasionally, the machine keepers help the mechanics with repairs. The mechanics are often notified of problems over their cell phones. This especially concerns emergency disturbances, and the mechanics therefore need to be available at all times. The mechanics make a judgment to whether a problem is serious enough to stop the process or if it can be solved during a planned stop or a stop due to other circumstances. It is, however, the machine owner who has to approve the stop.

Drawings over a machine are sometimes required to be able to solve a certain problem; these are stored digitally in a computer and printed out when needed. The mechanics often ask the design engineers to print the drawing because they can find it faster and also print it in larger format than A4, which is the biggest format that the mechanics' printer can handle. The mechanics believe an A4 size is too small to be able to discern details from the drawing.

The work order describes the problem in various details depending on the problem and the person who wrote it. The order sometimes gives detailed instructions of what actions to take to fix the problem but other times it only gives a phone number to the person who reported it. The mechanics normally know by experience how to solve a certain problem. After a problem is solved the mechanics write a report, which contains information about the job. The report considers information such as the time and the spare parts required and how the problem was solved. This is a rather new routine and the mechanics admit that they do not give all this information as often as they are supposed to when they report the completion of the order.

The central warehouse has all the most frequently used spare parts but when special parts are needed the mechanics are obligated to contact the machine owner to order the parts, even though it would be faster to call the supplier directly. The parts stored in SSAB's warehouse can be found in a database, as described in the IT-maintenance section.

More or less all communications, apart from direct communications, are done via the cell phones and the computers. The cell phone is personal and it is used in the work between 7.00 am to 4.00 pm. The cell phone communication is mostly between the mechanics and with persons at the mechanic's workshop who wants a status report. Remaining communication is typically with persons who want to report a problem and with external companies currently working at SSAB. The mechanics use the cell phone to communicate with each other if the noise makes it impossible with direct communication. Such situations could occur when they are working with the same problem but apart from each other. They do not use a short-range radio since it is too inconvenient to bring both a cell phone and a short-range radio. Another reason is that not everyone at the steelwork needs to hear the conversation. The communication via the computers is information about problems, e-mails and the F-round, as well as reports to the system when a work order is completed.

5.5 The Operation Supervisor

The operation supervisor has the responsibility for the production, the quality and the staffing in the production process from that the hot iron gets into the steelwork until the moulding station. The supervisor makes a judgment if there are sufficient resources available based on the production plan, e.g. staff with the right competence. If any resources are missing, the supervisor face the decision to either find the missing resource or, as the worst alternative, close

down a sequence of the process. The operation supervisor plans stops and coordinates the repairs and maintenance work that shall be done during the stops. The maintenance personnel are then reporting to the supervisor when the activities are completed before the process can be restarted. The operation supervisor also has the right to shut down the production process if a serious problem occurs.

Most of the calls to the supervisor are from someone in the shift-team when problems occur or when something needs to be bought from an external supplier. However, there are not many calls because each individual in the team is encouraged to take a big responsibility, and accordingly does not call without good reasons. During normal circumstances most of the communication is done through the production-planning program (PROST) where the personnel continuously get updated of what to do. Maintenance personnel also call about problems and to notify the supervisor that a repair has been carried out.

The cell phone used is an Ericsson S868 and it is personal. Hands-free headset is not used since the plug often breaks where it attaches to the phone. Apart from the cell phone the fix phone connection is used when the supervisor is at the office.

The operation supervisor is a machine owner, which implies that he/she has the responsibility for at least one machine. This means that the supervisor needs to develop the machine and see to that it is working at all times. It involves ordering spare parts that is not stored at the central warehouse, approve all repairs with a cost over 50 000 SEK, and make decisions about the daily operations.

The supervisor is placed in the “steel office”, which is a building close to the steelwork building, but a large part of the work is pursued out in the production process preserving the social contact with the shift-team.

5.6 The Production Planner

The production planner plan in what order different steel grades shall be processed considering the rolling mill in Borlänge’s demands. The productions planner’s main duty is to plan one shift ahead and “fend off” the own shift, that is, if a problem with the original production plan occurs the planner needs to redesign it. It can, for example, mean a reallocation of a steel grade between the two BOF-converters. For that reason the production planner needs to be available at all times.

The production planner mostly uses the intercom and that is the only reason to be at the office; otherwise the job could be performed anywhere. In case of a change in the production plan the planner communicates with all affected personnel, for instance people handling the ladles, BOF-converter, CAS-OB, RH and the moulding station. All of these can be reached with the intercom. Everybody can see the production plan on the computer screen but they still need to be reminded when something changes. The only person without this opportunity is the walking crane driver who needs to memorize the production plan at every visit in a control room. However, this person gets information from the control rooms via the short-range radio if needed.

5.7 The Transportation Personnel

There are many different types of transportation vehicles at SSAB, for example the so-called “loop truck”. The “loop trucks”, i.e. dumper trucks specially manufactured to transport certain containers, are driven both by day and shift-working personnel. The day-working driver’s main duty is to transport scrap from trains or ships to the scrap storage but the day-working personnel support the shift-working if there is time as well. The support can be to transport ooze to the revision plant, which is operated by BDX and located in the centre of SSAB. BDX is a transportation entrepreneur very frequently hired by SSAB. The main difference between the two groups is that the shift-working team operates to support a certain department while the day-working personnel operate all over SSAB.

More or less every transport is weighed on a scale and reported to the sentry box. When the vehicle has driven up on the scale the sentry box is called on the short-range radio and the driver leaves a message involving identification number, what is transported and the final destination. The personnel in the sentry box type the information into the computer system in addition with the weight, which is reported to them automatically. Work orders are reported completed at the end of each day, or sometimes weekly, from a computer in the lunchroom.

Most of the communication is done with the short-range radio, which is mounted in the vehicle. The conversation is often short and involves information about the transports, for example if a container has been filled or if there is an empty container to pick up. Hence, most of the communication done over the short-range radio is with tractors and other transportation vehicles. Group communication seldom occurs.

Supervisors use the cell phone to contact the vehicles since they do not use a short-range radio and the cell phone is also used for more urgent messages, for instance if someone, who normally does not use transportation service, wants a container to be transported. The day-working “loop truck” driver receives approximately two calls a day on the cell phone. The hands-free headsets used with the cell phone are of two types, either via a speaker in the ear or one permanently mounted in the vehicles.

The coverage of the short-range radio is considered good and it is only in the outskirts of the plant where disturbances in the radio transmission can occur. However, the many entrepreneurs at SSAB often use bad short-range radios, which can make the quality of the transmission poor.

The problems felt among the transportation personnel are often due to noise since it can be rather noisy in the cabin of the vehicle, and therefore hearing protectors are usually worn. The quality of the communication is poor, especially for the people they talk to because of the noise. A request, and a way to improve the quality, is to have a system which fade the ordinary radio and the short-range radio when a call is placed on the cell phone and vice versa for the short-range radio. The wire to the earplug on the hands-free headset often breaks and it would also be good if an alert was heard in the ear microphone when a call is received. As the majority of the communication is done over the short-range radio the radio channel can occasionally be occupied with small talk when someone needs to say something important. The situations described above are the same for many of the vehicles operating at SSAB.

6 ANALYSIS

This chapter presents an analysis of the information given in chapter five. The results are then compared with the theory in chapter two. The chapter starts with descriptions about situations subjects to possible improvements, and it is followed by general requirements on the equipment. The last part presents a SWOT-analysis.

6.1 The Machine Keeper

The mobile solution the machine keepers currently is using is likewise many ordinary consumers a cell phone with GSM technology. This solution works fairly well, it could however be improved further. Brans (2003) describes ruggedized devices which can handle the toughest environments. The environment the machine keepers work in is very tough since they constantly are exposed to water, gas, large temperature changes and dust, which often arise from the hot iron. It is not unusual the cell phones are exposed to shocks caused by drops either. A ruggedized cell phone would withstand these kinds of trouble and according to Brans (2003) it would operate as an ordinary cell phone. Another feature that would be useful for the machine keepers is a vibrator on the cell phone, which would help them to notice calls in noisy environments, and thereby decrease the number of missed calls. The machine keeper needs to be available at all times and a missed call can, in the worst case, mean that the production process breaks down. A hands-free headset, preferably wireless, would also be practical so the machine keeper can answer and continue working even during a phone call. As seen in chapter 2 there are wireless hands-free devices with Bluetooth technology that would be appropriate for this.

The machine keepers often work in pairs and sometimes with the mechanics as well as other maintenance personnel, to make their communication easier Push-to-Talk would be a desirable solution. It is inconvenient to use both a short-range radio and a cell phone, and therefore an all-in-one solution would definitely be useful. Furthermore, this solution would also eliminate the extra calls or trips required when the machine keepers need to contact each other or repair personnel at the inspection rounds. The shift-team and personnel who supports the main process, e.g. mechanics, could be subscribed to a community as Casati & Shneyderman (2003) describe. This would make the information exchange within the group easier and faster. More about this solution later in this chapter.

A machine keeper is obligated to be available at all times to support the main process and to fix problems in the support systems before the main process is affected. Today, the machine keeper must rely on the personnel in the control room to alert him/her if an alarm goes off in a support process. This can be a risky solution since there is an extra person involved. Egnell (1994) argues that unnecessary administrative routines should be kept to a minimum and Brans (2003) claims that a mobile solution makes coordination of activities easier. A possible way to eliminate a person from this process is to use a push exchange model. In such a model data are pushed to the terminal without a request (Brans, 2003). When an alarm goes off a SMS could be pushed from the WAG to the machine keeper's cell phone containing information about the problem and which process it concerns. A problem with this solution is that the control system is very sensitive and would alert the machine keepers rather often. A solution to this could be to change the control limits making the system more tolerant. Likewise, a sensor scale could be used at the containers with powder and ooze. The sensor should notify the WAG when it is time to empty the containers and the WAG should thereafter push an SMS to the transport personnel's cell phone. This solution would eliminate an activity for the machine keeper since no contact with the transport personnel needs to be done. Moreover, the machine keeper's round would not be as dependent on the emptying of the containers, and consequently it could be performed at any time. The benefit is that the machine keeper does not need to discontinue a job he/she is working on. These solutions are in line with Egnell's (1994) view that a process should be automated and unnecessary administrative routines should be minimized.

An investigation if sensors can monitor the processes outside the steelwork would be interesting to do because of the high degree of passive time due to the extensive distance for transportation on the inspection rounds. Changes in temperature as well as moisture, which could affect the terminal, would also be reduced.

6.2 The Control Room

The personnel in the control room are handling a lot of information and communicate with many people, and it would therefore be interesting to analyze their work. However, they lack an important characteristic: the control room operator is not mobile which reduces the potential for mobile solutions greatly since no information gap emerge the personnel and the enterprise. Although, the control room personnel already use cell phone and short-range radio and that, according to Brans (2003), classifies as mobile solutions. The

main reason is the need for fast communication but also because the control room operators communicate with mobile persons.

A solution which considers the control room is if the other personnel at SSAB adopt Push-to-Talk technology the consequence would be that the control room would have to take on the technology as well. This would eliminate the problem with people who are not answering when they are contacted, which the control room personnel felt very urgent. This problem goes both for the people using short-range radios as for the ones using cell phones. Verizon writes at its web site that Push-to-Talk technology makes it possible to send an alert to the person to whom the user wishes to speak so that person can make the contact. If the alert was in form of a vibration, like on Nextel's cell phones, instead of a sound the number of missed calls due to high noise would be reduced at SSAB.

The information needed by the control room comes from the production plan and the other computer systems. This information is normally sufficient for performing the work. If something unexpected happens, the control room is informed over the intercom, phone or short-range radio. In similarity, the control room informs the other stations in the steelwork via the intercom, phone or short-range radio in case of disturbances in a part of the process monitored by them, such as change of tap hole. This could be done solely via a single device with Push-to-Talk technology.

The Push-to-Talk technology could replace the short-range radio, intercom and cell phone, which would leave the control room with virtually one device for voice communication. It would also mean that only the concerned persons within a group would be contacted if group communication is needed, i.e. the groups would be dynamic. Hence, the personnel can be sure an alert or a call is addressed to them, which implies better attention to calls. Moreover, it also means more privacy since the co-workers can not eavesdrop on the conversation. A Push-to-Talk solution would simplify the process, as described by Egnell (1994), because the personnel do not need to listen to conversation which does not concern them and in that way become more focused on their work. The uncertainties of which communication system that should be used to contact a specific person would also disappear if everybody used the same solution. Moreover, this means that more or less all internal voice communication would be instant, and thereby more efficient.

6.3 The IT-Maintenance Personnel

The shift-working maintenance personnel are classified within the highest degree of mobility since they can get emergency calls from all over SSAB. The mobile solution used today is, as for many people at SSAB, an ordinary cell phone with GSM technology. Some problems linked to this solution are, as mentioned above, due to the rough environment. Consequently, the same recommendations still apply. The same goes for the ability to group communication via Push-to-Talk technology since the repairers work in pairs or in bigger groups. Numerous calls are also missed due to noise, and it would therefore be necessary with a vibrator on the terminal. This must be stressed because it is particularly important for the maintenance personnel since they get emergency calls and missed calls could lead to unnecessary disturbance in the main process.

Sometimes when a problem that is new to the maintenance personnel occurs they contact other personnel to see if anyone else is familiar with the problem and to ask for advice. These activities contribute to the passive time but could be eliminated if a careful documentation of every repair was done. Problems are documented today and the documentation is frequently used but it can only be accessed from the places where there are computers. Egnell (1994), as well as many of the other authors presented in the theory, argues that activities which do not create value should be minimised. Egnell (1994) also stresses the importance of maintaining the equipment to make the process more reliable.

It is important that everybody takes responsibility and carefully records every event and not just the major ones. The personnel must trust the documentation, and therefore the information should be more extensive and refer to a contact person. The documentation should contain information about the problem, which machine it concerned, how it was solved and by whom. It could also include a picture to clarify the problem further. If a picture was taken with a cell phone the personnel would be able to use MMS and send pictures to colleagues or entrepreneurs. The pictures could make it easier to explain problems and order spare parts.

A more extensive documentation would be a great help to less experienced personnel, such as newly employed. The documentation would also provide the maintenance personnel with information about new equipment. It is especially important to repair urgent problems fast since these often disturb the process, which in the worst-case lead to a production stop. Better repair history can give information to SSAB about the quality on the equipment which could imply reduced stock of spare parts since uncertainties are reduced. Companies tend to

raise the buffers when the uncertainties increase (Mattsson, 2002). The repair history could also help to inform SSAB about which supplier that offers the products with the highest quality. This will not happen automatically and true and careful documentation is needed.

A mobile solution would support and make this kind of documentation easier as well as it makes it possible to gain access to the documentation at anytime from anywhere, which implies that the personnel would use it more often. A mobile device equipped with all the features the maintenance personnel need, such as phone, ability to write and to access the intranet as well as a camera would increase the chances that the workers utilize the technology to make and use the documentation. It would be too much to carry a cell phone, a PDA and a digital camera and it is a big risk the staff would not bother to carry them around. A notebook or tablet computer is too big and awkward to carry around and the fact that the devices have big screens and better writing facilities do not make up for the size. The device must easily fit in a pocket so the maintenance personnel can work with both hands free. A Smart Phone, which preferably contains a camera and Push-to-Talk technology, would fulfil all needs.

The terminal could act as a dump terminal with the possibility to access internet with either a HTML or a WAP browser and the intranet could be accessed through a VPN, as described by Brans (2003). The maintenance personnel could then log on to the enterprise's computer system and check for similar problems at the problem sight if he/she is uncertain of how the problem shall be solved. Furthermore, they could also take pictures and write about the repair at sight or in the car on the way back to the field workshop while the memories are still fresh. Otherwise, if they have many repairs consecutively, they might forget important details. The unproductive time when travelling to and from a job would also be utilized more efficient. The upload to the enterprise's computer system could be done at the end of each shift since the information is not crucial for their colleagues until the next shift.

The terminal should be ruggedized and extra batteries must be available to make sure the device can be used around the clock since the personnel hands it on to the next shift. This makes it untenable to use WLAN technology since Lindberg (2002) claims that the batteries only last, in the best case, for a couple of hours and that the technology is very expensive. The personnel would most likely not bother to use the solution if they needed to change the battery several times each shift. In this case the future GSM or UMTS technology is the most appropriate since these networks can cover a large area relatively cheap and provide sufficient data transfer rates. Both these type networks require less

electricity than WLAN which increase the standby time on the terminals to days rather than hours.

The ability to access the repair history as well as the technical documents from the manufacturer at the problem sights would make the maintenance personnel's work easier to perform. It would also be possible to place an order during the examination of the equipment, and in doing so the order process is made more efficient since the staff do not have to find a computer to place the orders. Better documentation might also give the maintenance personnel information about spare parts before going to the problem sight, and consequently they can place an order and pick up the spare parts before visiting the problem. However, it also put some pressure on the maintenance personnel to document every problem and write some short facts about it, and thus the terminal must support writing. Brans (2003) argues that the solution that is most preferred is writing on the screen with a stylus which is a technique easy to learn.

A mobile solution as described above could, according to Brans (2003), lead to higher first-time fix rate and less time to repair which would be very important to SSAB since a stop in the production is associated with tremendous costs. Beside the elimination of the bottlenecks caused by lack of information Brans (2003) means that the order process would be more efficient. Egnell (1994) suggests that activities should be easy to perform and that would be the case if the maintenance personnel had technical documents and problem history constantly available. Another aspect is that the maintenance activities would be performed in a more standardized procedure, which Egnell (1994) argues would lead to increased efficiency.

6.4 The Maintenance Mechanics

The mechanics would also benefit from a mobile solution similar to the one suggested for the IT-maintenance personnel, even though the mechanics normally do not answer to emergency calls. However, such a solution would make repairs easier which would make the equipment up and running faster. It would also lead to more repairs each day and probably more time to support the repairers that handle emergency calls. If problem history and technical documents were stored in the same database, the day and the shift-working maintenance personnel could learn from each other. Today it feels somewhat like a barrier between the two groups.

The mechanics are getting detailed information about what is going to be done in the F-round document, and accordingly they could benefit if they could get access to it from anywhere. The document is often printed before the round so the mechanics can remember what to look for. The maintenance personnel could also report to the system when going on a job and when the job is finished. This would lead to, beside improved routines for time reports and more correct charging, better information to the personnel all over the plant. If the shift-working maintenance personnel are busy the person with the problem can instantly see if the day-working maintenance personnel are available and contact them. After all, the most important thing is that the production process is running.

The maintenance mechanics often go rounds to inspect the equipment and with a Smart Phone they could take notes and schedule the repairs immediately. They do not have to re-entry data or re-plan the repair schedule when they come back to the office. This is an effect that Brans (2003) predicted when using a mobile solution. The schedule is not crucial for the other personnel in the company, and accordingly the application could be running on the terminal and the updates can be uploaded to the enterprise's computer system when the mechanics are at their office. Nevertheless, to take full advantage of the documentation, the device must have the ability to connect to the intranet and the enterprise computer system. Brans (2003) describes this solution as a thick terminal.

The mechanics sometimes use drawings over the equipment in their work but, event though the drawings are in digital form, the screen on a handheld device would be too small for present a drawing in a sufficient way. However, a solution to this problem would be desirable.

Like most other people working with one or more persons out in the process the maintenance mechanics have a need for an easy and efficient way to communicate in the noisy environment. The current solution, when screaming is not enough, is to use the cell phone because the mechanics think it is inconvenient to carry around both a short-range radio and a cell phone. The cell phone is crucial to their work since they need the ability to contact and to be contacted by people outside SSAB. A solution to this problem is the Push-to-Talk technology and, apart from the easy way to communicate, it is possible to choose whom to talk to, which is a coveted feature since everybody does not need to hear a two-way conversation. The problem with the cell phone is that it takes some time to dial and to be connected to the other person. Voice activation can be a solution to the problem but the problem with the time to

connect would still be present. It takes some time to go into the menu and choose the right contact when using the Push-to-Talk service as well and voice activation, when choosing whom to talk to, would be a smart solution in this case too.

Another advantage with a Push-to-Talk solution is that the personnel can take benefit from dynamic groups, i.e. the group's composition can easily be changed via the contact list to match the current need. This is especially useful for the maintenance personnel who often change partners to work with since they work on different locations, and consequently need information from the persons the problem considers.

6.5 The Operation Supervisor

The personnel within the shift-team are currently using different systems for voice communication, which makes it impossible to contact all personnel with one device. The supervisor does not use a short-range radio, and as a result it can be hard to get in contact with certain people instantly. Therefore, the supervisor would certainly benefit from having a phone with Push-to-Talk technology where he/she could include all personnel that are under his/her responsibility in a community. This could lead to better solidarity and more information exchange within the team. The boundary is the number of people in a group and, referring to Verizon's solution in which only 20 people can be members of the same group that would leave out some the personnel in the shift-team. It is, however, possible to use 50 different groups, which gives the opportunity to other logical groupings. The number of groups is more than twice as many as the channels that SSAB is using on the short-range radio today.

If the supervisor used an instant messaging solution he/she could simply send a message to all personnel in the shift-team when needed. This would be useful and instead of calling from person to person on a phone list a message could be sent to everybody when extra personnel are needed. The personnel who want to work could simply answer. The message could also be sent from the computer at the supervisor's office since this solution supports communication between a computer and a cell phone.

Another benefit with a Push-to-Talk solution is higher privacy since no eavesdropping can be done in a conversation between two people, which is possible with the short-range radio system. This can be useful for the supervisor if a person using short-range radio need to be informed about

something private or of sensitive nature. Hence, it can also reduce speculations and spreading of rumours within the shift-team.

The device must be easy to carry around if the supervisor wishes to do so since it is important that he/she always is available, and therefore the solution can not be fixed as for the control room and the production planner. The supervisor thinks that the cell phone that is currently in use is too heavy and inconvenient, mainly caused by the big battery, and accordingly would prefer a lighter one. This is not a problem because, as said by Brans (2003), the battery technology has come a long way during the recent years.

6.6 The Production Planner

The planner is not mobile whatsoever but this person needs to communicate with just about the entire steelwork if the production plans changes rapidly. Instead of contacting each one at the intercom, group communication via Push-to-Talk would be a possible solution. The solution should be fixed, i.e. bigger and more user-friendly than a mobile terminal since voice communication occurs very frequently. The only time the production planner is mobile is during the lunch but it does not motivate a mobile device, such as a Smart Phone.

A fixed Push-to-Talk solution, similar to the intercom, in which the contact list and the people calling appear on a computer screen would be the right way to go concerning all the immobile personnel. The personnel frequently called should have fixed buttons so it will not be necessary to enter the menu and choose the right person every time. The solution could preferably work in a similar way as today; it could also be possible to send text messages from the computer to the different terminals.

Different usernames should be used to each device and in that way it would be possible to identify all incoming calls, which would eliminate the doubts of who it is if the voice is not recognised. It happens regularly that the personnel do not introduce themselves which create confusion of who it is. Names as identification icons could also bring the personnel closer together and make them more personal with each other.

6.7 The Transportation Personnel

The weighing procedure is something that definitely can be performed in a more efficient manner and completely without involvement from the sentry

box. Apart from that the solution requires re-entry of data, it is a big risk that the information typed into the system is wrong. Mattsson (2002) refers to a study in which it is argued that two percent of the manual registrations end up wrong. The weighing process is, however, something SSAB is working on and has done so for a few years. A solution is to have a computer mounted in the vehicle where the driver could type the information and send it to the database. As mentioned earlier the tractor that is operating in the scrap storage is using a similar solution with WLAN technology. Lindberg (2002) means that WLAN is a very expensive solution when it needs to cover large areas, why such a solution is not to prefer in this case. A computer connected to the GSM or UMTS network with Bluetooth technology is a conceivable solution. The transport personnel need a rather large screen and a keyboard to type in the weight and the customer's identification number. The vehicle's own identification number should be preset since it does not change from time to time. The weight could also be transferred directly into the computer from the scale with Bluetooth technology since it is rather short range between the scale and the vehicle. The authors of UMTS - an overview argue that a Bluetooth connection can be established at a range up to 100 meters. Moreover, the authors mean that it is a relatively inexpensive technique. The bandwidth might vary from time to time but Brans (2003) suggests a solution where the information could be sent to the database whenever there is sufficient bandwidth to do so.

The problem with noise in the cabin and bad quality of the conversation would be improved with a wireless hands-free device which should be possible to attach to the hearing protectors. This would let the personnel use it without the protectors as well, and the problem with the frequently broken wires would be solved. The wireless technology that should be used is Bluetooth in line with the add-ons Brans (2003) describes. A Push-to-Talk solution would also be beneficial to the transportation personnel since it is less risk to be disturbed by small talk when they need to contact someone. It would also reduce the disturbance from other communication systems when the conversation is done solely via one device. In addition with the hands-free headset, the Push-to-Talk solution would improve the quality of the communication further.

The transport personnel are highly mobile but it would still be more convenient for them to have a large terminal or, more preferable, a terminal that is able to interact with a large one in the vehicle since most of the working hours are spent in the vehicle's cabin. The fixed solution could be a similar solution to the one in the control room. The roads are bumpy which makes it hard to press small buttons and to select different groups or persons on a small screen and,

moreover, the communication should not take attention from the driving for safety reasons.

6.7 General Requirements on the Equipment

Does the process industry put different requirements on the equipment compared to the consumer market? The personnel's requirements and preferences on the terminal are presented in the section below followed by a discussion on which requirements that have to be considered for the network.

6.7.1 The Terminal

The environment and the specific kind of work at SSAB make heavy demands on the terminals which differs from those ordinary consumers have. Accordingly, the terminal should be adjusted to satisfy the requirements in order to work satisfactory. The questionnaire provided to the personnel at SSAB gave information about their preferences to the cell phone they use today, which is 130x49x23 millimetres and weight 130 grams with a slim battery. The batteries most frequently used are, however, extra powerful, and consequently heavier and bigger. Information about how the personnel ranked certain features of the terminal was also given.

SSAB is using an old cell phone, which is considered to work fairly well, the size is acceptable but the terminal should not be any bigger. It is approximately two thirds of the respondent who think the size is alright. The weight is very close to being considered too heavy; the answers are almost divided equally between too heavy and alright. Many of the personnel would prefer if the screen on a terminal was bigger than the screen on the cell phone they use today, which is a rather strange finding since virtually everybody claim that they do not use the text message service. A reason could be that the personnel at SSAB often use gloves when they type the number, and therefore want to make sure they type the correct number even if the light is poor, as it is in many places at SSAB. Although, 62 percent of the asked personnel think the size of the screen on their cell phone is alright.

The characteristic that is considered being the most important is durability. Practically everybody ranked durability as very important, that is, a five on the five level scale, see diagram 6.1 below. The influence most important for the terminal to withstand is impossible to detect since most of the personnel hold water, dust and shocks equally important. This finding is not a surprise since the terminal has to endure a lot, both work related and environment related situations which wear out the equipment. The personnel must frequently

maintain the terminal but, nevertheless, it occasionally breaks down. The second most important feature is time between charging which is almost considered as important as durability. It is important with long time between charging since the cell phone in most cases is passed on to the next shift, and consequently is in use around the clock seven days a week. This means inconvenience every time the personnel need to change batteries, why as long time between charging as possible is to prefer. However, it is no significant difference in the day-working personnel's preferences even though their cell phone is personal and could be charged during the night. Another high ranked feature is big buttons but this is considered far less important than the two highest ranked. This supports the assumption that the personnel often type the number with their working gloves on.

The importance of the screen being big is approximately ranked 3.5 on the scale closely followed by the cell phone's weight, which almost is ranked similarly as the importance of ergonomic design, around 3.4. The feature which is ranked least important is small size. To summarize the findings, it shows that functionality is prioritised before characteristics that among ordinary consumers could appear as trendier. The personnel at SSAB favour a robust terminal with a screen easy to read from and large buttons. The size and weight is less important as long as the terminal is easy to carry around in a pocket.

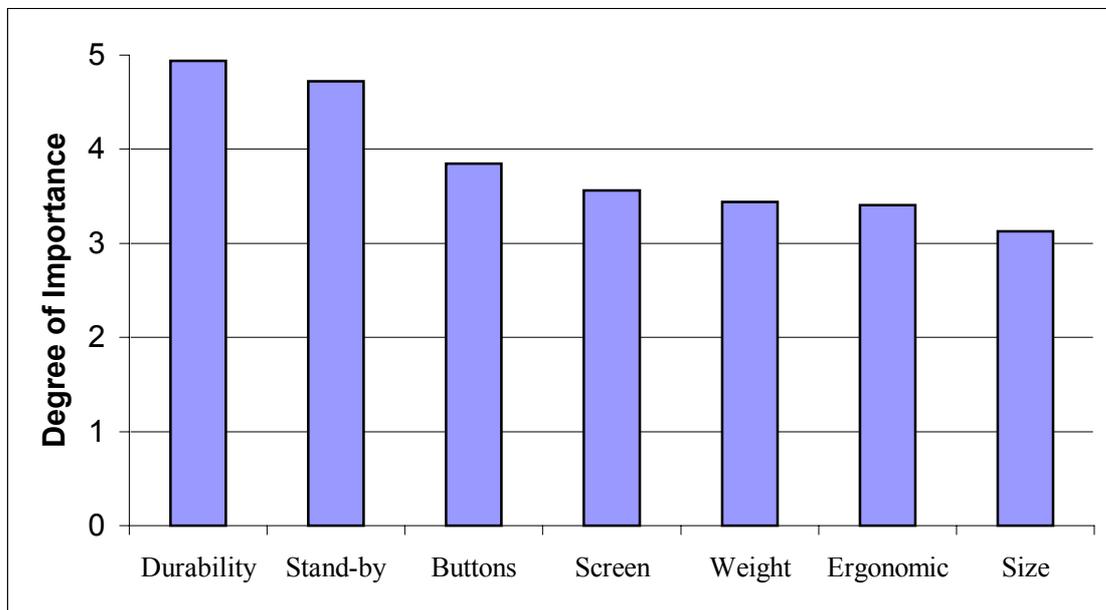


Diagram 6.1. Ranking of different terminal features.

The far most important function or add-on to the cell phone required by the personnel is a vibrator. About 85 percent of the respondents requested this feature. The observations showed that no matter the work position, everybody

experienced the problem that the person they tried to contact sometimes did not answer. Many could also apply the problem to themselves as well since they often missed calls due to noise. It is especially important that people who need to be continuously available have this function. A problem in the production process could get worse the longer time it takes to get a repairer to the sight.

A hands-free headset is another option which is demanded according to the answers in the questionnaire. Many of the respondents work with different kinds of maintenance, and therefore need to work with both their hands free. These findings support the result of the observations and the recommendation to provide the personnel with these functions. There are also some persons working to support the main process that requests a camera in the terminal. This is because, as mentioned above, to clarify the documentation and as a proof in responsibility disputes concerning, for instance, a repair. Pictures could also be used as basis when inviting tenders from external entrepreneurs, regarding a construction work for example.

Personnel who use other equipment than cell phone use it, first and foremost, because it is faster. The second most important reason is the possibility with group communication. Only a few use other equipment because of better network coverage. Many of the respondents give combinations of these as a reason. It seems like the personnel working with electricity have greater problems with the network coverage when using the cell phone. According to them the cell phone is more easily affected than the short-range radio when they are working in relay interlocking plants.

The most important requirement is that the equipment must be able to withstand heavy abuse and the tough environment that SSAB provides. Therefore a ruggedized device is to prefer that is resistant to shocks, water and dust and can handle indoor as well as outdoor use. Brans (2003) claims that a ruggedized device can function in even the toughest environments, and hence met up to SSAB's high expectations. However, the cost must be taken into consideration since a ruggedized terminal is more expensive than an ordinary and if it only stops functioning occasionally it might be more cost efficient to buy new ones at that time. SSAB will also need to have devices in reserve to be able to replace a broken or lost device immediately. The screen on the terminal should be as big as possible to provide comfortable reading of documentation. Although, the device must be easy to carry around since the maintenance personnel are very mobile and sometimes working in small spaces.

To take full advantage of a Smart Phone solution, the users need to do some data entry in order to get a more complete and accurate documentation, and thus the keyboard should support this. The solution earlier suggested, with a stylus, would work since a keyboard with sufficient size on the buttons would be too big. A stylus is also an ideal solution because it can be used even if the user wears gloves. A small size on the terminal but large screen and buttons is a paradox hard to crack, although, size of buttons and screen is higher ranked than a small size on the terminal. The best way to decide the ultimate combination is to let the personnel try some different models in daily work situations.

6.7.2 The Network

When determining the requirement on the bandwidth in mobile networks many factors have to be considered, for instance, the number of users, distance to the base station, and the service provided. If a data service is used, like the ones discussed above, the bandwidth required depend if speech, text or multimedia is sent over the network. Different solutions to use the bandwidth more efficient could also be used. For example, if a template is stored on the device and only text is sent the bandwidth required would be far less (Peter de Bruin, 23-03-2004). Brans (2003) says that the WAG can monitor the bandwidth so data can be transmitted accordingly. Ahtiainen *et al.* (2001) state that the delay of the connection is not an issue; the most important is that the establishment of the connection is fast. An hourglass or a bar chart could appear, similar to many computer programs, to visualize the progress when a network connection is established.

Ahtiainen *et al.* (2001) also describe different UMTS Quality of Service (QoS) classes in which a certain bit rate is guaranteed in each class depending on the service used. Other main factors to separate the QoS classes is the delay, which often is evident to the end-user, and if the traffic is of symmetric or asymmetric type. The different QoS classes suggested are conversational, streaming, interactive and background. The conversational class is representing a real time traffic service, such as voice calls, and thus is the most demanding. This class offers a minimum of fixed delay, no buffering, symmetric traffic and guaranteed bandwidth. The streaming class will normally be used for downloading files from the network, and hence is an asymmetric service. This means that it not as sensitive to delays as the previous QoS class, and buffering is allowed. The last two QoS classes are for end-users not sensitive for delays and can, for instance, be used for WAP; a request is sent and the network responds when there are resources available. This implies that no bandwidth is

guaranteed and the delay can vary and the buffering can be done in order to optimise the efficiency of the network.

SSAB must, obviously, use the conversational class since the cell phone primarily is used for voice calls. If the circuit switched voice calls are used it implies the conversational QoS class (Ahtiainen *et al.*, (2001). When it comes to packet switched data services mentioned, SSAB needs to make a judgement how much inconvenience extra delay involves and compare it with the costs for a higher QoS class. The Push-to-Talk solution also implies a high QoS class since a delay is very annoying when talking to another person and it will not be acceptable at SSAB where the personnel are used to instant talk via the short-range radio system.

To be able to put requirements on the system's capacity it is essential to consider the number of users, and especially the peak utilization. How many requests the system should be able to handle in one second is also interesting as well as the number of users that can be synchronizing at the same time. It is important to think of how the system should react when the load is at its heaviest (Brans, 2003).

Security is a vital issue when considering a mobile solution. Questions that need to be answered are; how sensitive is the information sent over the network and which are the threats? It is important that the right person uses the device and that no unwanted persons can log on to the corporate network. Brans (2003) argues that VPN is a frequently used method among enterprises today to let the employees take part of the information in the enterprise resource planning system. Moreover, this technique uses special software to encrypt data on both sides of the exchange. SSAB is currently using a VPN model and has no reason to change it even if handheld devices were used. The information which will be sent over the network is not sensitive and extra security measures are not required. Information about strategy, financial and investment decisions and so forth will not be sent by the personnel that are working in the process, but technical documents concerning new machinery can occasionally be sent.

A more essential issue than the data sent is if the terminal is lost or stolen, or an employee happens to reveal the authentication to an outsider. This could mean unwanted intrusion in the enterprise resource planning system and that sensitive information leaks out. A solution to this problem is to limit the information available to the personnel depending on their need, i.e. deny access to certain enterprise applications and data. Another measure is to see to that the devices never leave the company site. This is an issue especially concerning the day-

working personnel since their terminal is personal, and hence is taken home in the evening. The information over the network is not more sensitive than the information sent today and the security issues to focus on are therefore to protect the device and the company from intrusion. Brans (2003) describes different ways for this but the most practical, and a method to which the personnel are familiar, is to use a username and a PIN code as authentication to the device. The device must in its turn be authenticated by the enterprise before the user can log on to the WAG, which is done in a similar way as to the device. The PIN code should, however, be different from the previous, which could be shorter since it is of less importance. Brans (2003) warns for overkill when deciding security requirements since security is associated with costs and complications for the users. Needless to say is that a virus protection program should be used to prevent disturbances in the system.

An important issue is how much downtime SSAB can tolerate. The production process requires good communication to work satisfying, and SSAB will stand without a backup system if the short-range radio system disappears to make way for the Push-to-Talk technology. The process is continuously operating which creates problems to maintain the system since it always needs be up and running. A production loss implies heavy losses and SSAB should consider redundant systems, i.e. an extra system as backup. The companies delivering the service might also offer support, which can guarantee only short periods of downtime. The system must in any case be resilient, which means it rarely crashes.

6.8 Business Opportunities

According to Doyle (2002) a SWOT-analysis can be conducted to find business opportunities and strengths as well as threats and weaknesses when an internal or external change has taken place. Dwyer (2002) means the analysis should be done on different levels in a firm, for instance at product level. These facts support the use of the analysis on a mobile solution.

6.8.1 SWOT-analysis

The SWOT-analysis is divided into two phases; the first phase consider a Push-to-Talk solution with vibrator alerts and the second phase is to use a Smart Phone solution, including phase one technology together with a camera. It is a ruggedized terminal which is considered in both phases.

Phase one

The first solution includes a cell phone with Push-to-Talk technology and vibration alerts.

Strengths

Uniform communication system

Better network coverage than the short-range radio system

Faster and more practical communication than an ordinary cell phone

One device to carry

Fewer communication devices at SSAB

The personnel become more available

More durable terminal

Weaknesses

One system is more vulnerable

There is a risk for situations with stoppage in the control room if many try to contact it at the same time

More expensive than a short-range radio system concerning variable costs

Opportunities

The personnel could be proud and more engaged if the company provides them with the latest technology

New applications, for example instant messaging

Technology in its infancy

Small size on the terminal

Threats

People can be suspicious towards new technology

The costs are uncertain, especially the variable ones

New technology can suffer from problems in the beginning

The most beneficial that a phase one solution would mean for SSAB is the uniform communication system. It would reduce the confusion of what type of device certain people are using and eliminate the extra work when personnel using different systems want to contact each other. This solution would also mean a more efficient communication between persons working in different groups, mainly maintenance personnel, who can create more dynamic groups. The communication would be faster and more convenient than over the cell phone used today. Furthermore, the availability would increase since all personnel are using the same device in addition with the vibration alert function. This solution can replace many of the voice communications systems

at SSAB and since the new system covers all needs fewer terminals would be required altogether. More durable terminals imply less maintenance, and as a consequence reduced costs. Higher durability would also mean that the buffer of terminals can be reduced since the terminals would break more seldom.

The biggest weakness with this solution is that the production process could be disturbed if the communication system crashes. The control room would not be affected to a greater extent since the personnel can use the fixed line connection but a crash would have an influence on certain crane drivers. A crash in the communication system would also have an effect on the support processes, such as maintenance, machine keepers and transportation. SSAB should consider a backup system or make deals with the companies supplying the solution to be guaranteed a minimum of unplanned downtime or fast support if something happens. The stoppage that occasionally could occur in the control room is not a big issue since the communication is very short and the caller could retry after a few seconds, otherwise a solution where the calls are placed in a queue would be possible. The person occupied could also get a message when someone else is trying to contact him/her, which would reduce the risk of disturbing small talk. Another weakness is that the communication, unlike short-range radio communication, would be charged. However, the fixed cost would probably be less than today since the short-range radios are very expensive, typically 20 000 SEK each, and a standardized ruggedized terminal would probably cost less.

Opportunities involved when deploying this type of mobile solution is more engaged co-workers since they become proud and feel that SSAB invests in their work situation. Examples of this have been noticed with similar solutions; see the practical examples in chapter 2. Instant messaging is another service that could mean better, more efficient work and it would be especially useful for managers who can send text messages from the computer to all personnel at the same time. It would facilitate the information from the managers to the blue-collar personnel.

The technology is new and will develop in the future, which could imply new useful applications for SSAB. Moreover, the technique has a potential to reach many users, both the enterprise as well as the consumer markets, and thereby get cheaper and develop faster. The big and successful companies involved vouch for this too. The size of the terminal is another issue not to forget since a cell phone typically is lighter and smaller than the short-range radios used today at SSAB. The public could also see an enterprise using new technique as an attractive employer.

The most obvious threat is technology hostility, which means that the personnel would not bother to use the new solution since they believe the old one works better. Therefore, the equipment must be easy to use and provide visible benefits for the personnel. The costs are yet uncertain with this kind of solution but different enterprise solutions will for certain be available from the network operators, examples are already starting to develop in America. As with all new technology the Push-to-Talk technology could suffer from teething problems in the beginning which could create inconvenience for the user.

Phase two

The second phase solution is to support documentation and involves a Smart Phone with a camera as well as the solution described previously.

Strengths

More accurate information
More extensive documentation
More efficient repairs and maintenance

Weaknesses

Costs, both fixed and variable

Opportunities

Find information from the enterprise system wherever employees are
Reduce the administrative routines

Threats

Could be a lengthy procedure to use the solution
Suspicion towards new technology
The technology

The strengths with this solution are principally that the documentation becomes more extensive, more accurate and is available to the maintenance personnel anywhere. Better documentation throughout all of SSAB could result in many benefits, for example more precise internal charging and better knowledge about the quality of the spare parts and of the machines. This information is very important to SSAB because it means that more problems can be prevented, and thus fewer disturbances would occur in the production process. The suppliers could also be evaluated in a more precise manner. Among the maintenance personnel this would lead to faster first-time fix rate and faster repairs. The reason is that the documentation can be reached from anywhere

and used to find a solution to the problem. The unproductive time could also be utilized more efficiently since the maintenance personnel can work in the car and do not need to find a computer. A group of people that would benefit a lot of this solution is the newly employed maintenance personnel since they lack experience of how problems usually are solved. The large amount of equipment on the plant take a very long time to learn and it is impossible to be fully thought. The solution would lead to that newly employed can start to work efficient faster.

The camera would clarify issues within the documentation further and it can also increase the maintenance worker's confidence since they can take pictures after a repair. A picture would eliminate disputes if someone claims that the repair was done in an insufficient way. Pictures could also be used in the communication with entrepreneurs so they can prepare and bring the right equipment.

The most immediate weakness is concerning the costs, which can be rather high. The network operators charge somewhere around 0.10 SEK per kilobit transferred today or include a specific amount of free data transfer in the subscription. The costs would probably be less in the future when the competition for data services increases among the network operators. However, the preferable solution would be if a fixed monthly cost would be used with unlimited amount of data transfer, like in the United States for example.

The employees and the managers at SSAB have an opportunity to increase the electronic communication and to give the personnel more responsibility; some administrative routines that previously were performed by others could be done by the personnel. It could for instance be to send invoices to entrepreneurs. The possibility to connect to the ERP-system can also provide for opportunities such as more information about how the process operates and so forth. The solution at Boliden indicates better information about the enterprise and its strategy among the workers which could help to increase the team spirit.

A threat already mentioned is reluctance towards new technology and new routines. Some persons might think that it is awkward to write on a small screen if they are used to work with desktops. Hence, it is important to inform the personnel about the benefits so they use and contribute to the documentation. The involvement of many suppliers in this type of solutions is also a threat since it might make it hard to define each one's area of responsibility, which could lead to more work as well as to conflicts. The 3G network is still rather new, TeliaSonera has just recently opened its network to

the public, and that creates a certain bit of insecurity of how the technology functions. Another issue is the 3G phones, many companies have not launched 3G phones and the cell phones on the market are said not to fulfil the network operators' expectations.

7 CONCLUSIONS

This chapter summarizes the report and highlights the most important findings from the research.

The production process at SSAB is highly automated and it is to a great extent operated from different control rooms with computers and other fixed equipment for communication, which make many of the personnel immobile. The process is running continuously and normally everybody directly involved in the production process is informed by the enterprise's computer system. Hence, the potential for a mobile solution is modest for personnel operating the main process since no information gap exist for this group. However, when changes in the production plan or other problems occur there is a need to inform the operators and the communication increases, which creates a need for efficient communication. SSAB is currently using two solutions that classify as mobile solutions, the short-range communication system and the cellular network system. There are also other communication methods frequently used, such as the intercom and the computer. This constitutes a problem to the whole of SSAB since it creates inefficiency concerning the communication. The personnel can be confused over what communication device to use when to contact a certain person and, more important, extra time is often required in order to obtain the right equipment to be able to contact the person needed. This opens up an opportunity window for a mobile solution since there are mobile solutions that have the potential to improve the efficiency of the communication.

Many of the problems and inefficiency are due to the old terminals manufactured for the public consumers. Even if the terminal is considered to be relatively durable, it does lack important technology which is needed at SSAB. The add-ons used, such as hands-free headsets and vibrators, have not been able to function properly in the tough environment. Therefore, a more durable technique is needed which is also reflected in the findings from the questionnaire.

The personnel in the support processes are the ones most affected by this problem since they are highly mobile and need to be highly available as well, both by internal and external personnel, and consequently carry a cell phone. A lot of the communication in these groups is done in groups or pairs during a job. The conversation is typically involving short messages to make the work more effective but since they are obligated to carry a cell phone a short-range radio is not carried. The personnel feel that it is inconvenient to carry both a

cell phone and a short-range radio, and do therefore only carry one device even though the communication in many cases would be more efficient and practical with two devices, i.e. ability to instant and group communication as well as communication with people via the telephone network.

The desired solution is to adopt a system in which both the short-range radio characteristics as well as the ones on a cell phone is offered. The Push-to-Talk technology meets up to these needs. However, the terminal should not be too big or too heavy to carry in a pocket and, the most important requirement; it should be able to handle the rough environment at SSAB. Thus, the terminal should be ruggedized and be resistant to influences from shocks as well as from water and dust. Future solutions must also be equipped with a vibrator function since many of the personnel experience problems with their work due to missed calls. This is essential for everybody but first and foremost for the maintenance personnel who can not be contacted in any other way than by a cell phone when they are out working. Moreover, this group needs to be available to fix problems at all times and time wasted could imply unwanted consequences on the production process. Requests for a more powerful ring signal as well as speaker have been noted during the observations too.

The short-range radio system works well today but some of the system's characteristics are considered to be annoying; it is impossible with privacy and irritating situations occur when people occupying the channel with personal talk. These inconveniences are likely to be eliminated with Push-to-Talk technology since it is possible to use dynamic groups which would reduce the problem with occupied channels. Dynamic groups also imply privacy between the people who are conversing since the user can choose exactly whom to speak to, which is very convenient for the maintenance personnel who work with different people daily.

Another opportunity is to decrease the time for unplanned stops which increases the potential for a mobile solution for the maintenance personnel further. This group is very mobile and it is important they get sufficient information to be able to repair a problem no matter where it is located. Unnecessary trips will otherwise occur from time to time, which adds to the total of passive time. Furthermore, with the ability to find a solution from someone who has experienced a similar problem would reduce the time taken to find the problem and solve it. SSAB would without doubt benefit from better documentation in many ways, both concerning quality management and repairs.

The requirements on the terminal differ somewhat from the requirements among the ordinary consumers because the industry mainly sees to functionality rather than to new technology or fashion design, which is used in the marketing to consumers. Private consumers can also accept more disturbances in the network while the industry's production process in many cases can depend on that the network is working all right. The personnel at SSAB definitely want a durable terminal, which is resistant to everything from environment and work influences to issues related to clumsiness.

7.1 Summary

A summary of the most important findings:

Needs

- Instant talk
- Dynamic groups
- Uniform communication system
- Access to the ERP system from anywhere

Requirements

- A ruggedized terminal which can handle the environment in the process industry

The business opportunities arise from more efficient communication and access to information anywhere. The most obvious threats are due to costs and the vulnerability with using only one communication system.

8 RECOMMENDATIONS

This chapter gives recommendations and proposes issues to consider for Ericsson Research AB from the experience at SSAB. It also gives suggestions of future research.

The special requirements on the equipment in the process industry demand special cell phones manufactured solely for the process industry market and the findings in this report should be a foundation for further research within this area. If Ericsson has the ambition to focus on the process industry and provide solutions, it is important that the terminal fulfils the needs. A terminal which is an uncompromising solution for the industry and not for heavy consumer use should be available for the process industry to increase Ericsson's credibility. The opinions among the personnel at SSAB are somewhat disappointing with respect to the cell phones, even though cell phones that are promoted to withstand heavy abuse have been tried. Naturally, SSAB could do more in order to find terminals that are better suited for industry needs since there are companies that customize cell phones to be more appropriate for the environment in which the phones are used. However, a more standardized phone specially made for the process industry's characteristics would probably be cheaper and more easily available to SSAB.

The Push-to-Talk technology should be presented as a technology that could replace the short-range radios but, as mentioned earlier, the solution would not be efficient if the terminals do not work properly. The partial automation, i.e. the process is monitored and operated from control rooms, at SSAB also requires a fixed terminal with Push-to-Talk technology. This must be available if SSAB is to adopt a solution.

SSAB is aware of the benefits involved with good documentation of repairs and other maintenance work but probably not of how much it is neglected among the employees. It is important to communicate how a mobile solution could support good documentation and make the personnel able to take advantage of it.

8.1 Future Research

To receive a more complete picture of SSAB's needs with respect to mobile solutions should future research include enterprises which are interacting with SSAB, such as suppliers, customers and entrepreneurs working at SSAB.

Future research should also include other enterprises within the process industry to confirm that the same condition reigns for the entire industry.

It is easier to work with the old and familiar technology than with the new if no clear evidence of the benefits is presented. A recommendation to Ericsson is therefore to run a pilot at an enterprise within the process industry to be able to support the assumptions with numbers from time studies and so forth. It is an extensive job but a case study to prove the solution's efficiency would be a basis for future marketing and cooperation with other enterprises. It is important to thoroughly inform and educate the personnel before initiating the study so the time is utilized efficiently. Otherwise, if the personnel do not know how to operate the equipment, they could be reluctant to use it and the benefits can vanish.

The literature mainly concerns so called mobile professionals, i.e. travelling salesmen and similar groups, for these groups it is sufficient to use terminals manufactured for public consumers since the environment in which they work often is comparable to the one for consumers. A recommendation to future research is to understand how the industry wants the design on the terminal and which technology and functions that should be easily accessible. For example, the best and most convenient way to change community without entering the menu; is it with a scroll function or with voice interaction?

9 FULFILMENTS OF THE OBJECTIVES

This chapter provides the reader with a discussion of how well the objectives of this thesis are fulfilled.

The first objective: analyse the select personnel from an information flow, communication flow, and production flow perspective. Categorize the personnel's degree of communication, information, responsibility, and availability and compare them in relation to the personnel's mobility.

Relevant personnel have been selected in cooperation with SSAB as well as Ericsson Research AB and the information and communication flow are analysed. Flowcharts are also designed whenever it is meaningful. The production flow perspective is, more or less, kept in the background since the personnel most interesting to the study are working in support processes, and hence working to support the production process in different ways. The diagrams of the chosen characteristics show a wide spread, which should be representative for the industry and help to apply the findings on other enterprises within the industry.

The second objective: identify and analyse situations where possible improvements can be done with mobile solutions, that is, identify the process industry's needs for such solutions.

The analysis identifies different situations where improvements can be done, both small changes as well as major ones. Together with the description of the present situation at SSAB the reader is provided with a clear picture of how the information and communication are at the moment. It also gives examples of problems; both observed and by complaints from the personnel within this area. The problems are compared with existing mobile solutions from the theory and examples applicable on the problems are given in the analysis.

The third objective: list the process industry's requirements on mobile solutions

The requirements on the terminal are drawn from the questionnaire as well as from the interviews and the observations. The personnel's opinions are gathered to find the most important wishes and requirements. The requirements for the network are much more difficult to foresee since personnel at SSAB do not have any perceptions about this and there are also many factors which affect the network. As a result, a discussion about the factors to consider and

what is important for the buyer according to the theory is presented. Information from the observations at SSAB is also included in the discussion.

The fourth objective: provide a summary over business opportunities related to standardized mobile solutions for the process industry.

Opportunities associated with the mobile solutions are described in two SWOT-analyses, together with the strengths, weaknesses and threats. The solutions are presented in two phases to clarify the benefits and weaknesses with each solution.

The thesis' objectives and the purpose are concerned to be fulfilled with respect to the motivation above. Moreover, the answers to the research questions are to find in the theory, where the different technology and the elements included in a mobile solution are presented. The presentation is ended with two brief examples from the industry. Chapter two also provides a discussion about future services in the UMTS network. Where to find the answers to the last research questions are described above since those questions are closely related to the objectives.

References

Literature

Ahtiainen, A. Kaaranen, H. Laitinen, L. Naghian, S. & Niemi, V. (2001). *UMTS Networks – Architecture, Mobility and Services*. West Sussex: John Wiley & Sons, Ltd.
ISBN: 0471 48654 X

Aronsson, H. Ekdahl, B. & Oskarsson, B. (2003). *Modern logistik – för ökad lönsamhet*. Lund: Grahns Tryckeri AB
ISBN: 91-47-06489-7

Bjørnland, D. Persson, G. & Virum, H. (2003). *Logistik för konkurrenskraft – ett ledaransvar*. Lund: Wallin & Dahlholm Boktryckeri AB
ISBN: 91-47-06491-9

Brans, P. (2003). *Mobilize Your Enterprise – Achieving Competitive Advantage Through Wireless Technology*. Upper Saddle River, New Jersey: Prentice Hall Inc.
ISBN: 0-13-009116-2

Casati, A. & Shneyderman, A. (2003). *Mobile VPN: Delivering Advanced Services in Next Generation Wireless System*. Indianapolis, Indiana: Wiley Publishing Inc.
ISBN: 0-471-21901-0

Dahmström, K. (2000). *Från datainsamling till rapport – att göra en statistisk undersökning*. Lund: Studentlitteratur
ISBN: 91-44-01458-9

Doyle, P. (2002). *Marketing Management and Strategy*. 3rd edition. Harlow: Financial Times/Prentice Hall
ISBN:0-273-65150-1

Dwyer, F. R. & Tanner, J.F. (2002). *Business Marketing – Connecting Strategy, Relationships and Learning*. 2nd edition.
New York: McGraw-Hill
ISBN: 0-07-241063-9

Easton, J. (2002). *Going Wireless – transform your business with mobile technology*.
New York: HarperCollins Publishers Inc.
ISBN: 0-06-621336-3

Egnell, P-O. (1994). *Processledning – en arbetsmodell samt erfarenhet från svenska organisationer*.
Luleå: Tekniska Högskolan Luleå
Rapp. Hög 1994:42 L

Ericsson Eurolab GmbH (1999). *UMTS, an overview*. (Student text for internal purposes).

Evans, N.D. (2001) *Business Agility – mobile business strategies for the 21st century companies and markets*.
Harlow: Financial Times/Prentice Hall
ISBN: 0-13-066837-0

Informationsgruppen, SSAB Tunnpå AB, Luleå (2002). *Stålboken*.
Luleå: Luleå Grafiska

Krajewski, L. & Ritzman, L. (2002). *Operation Management – strategy and analysis*. 6th edition.
Upper Saddle River, New Jersey: Prentice Hall
ISBN: 0-201-61545-2

Lewis, P., Saunders, M. & Thornhill, A. (2000). *Research Methods for Business Students*. 2nd edition.
Harlow: Financial Times/Prentice Hall
ISBN: 0-273-63977-3

Lindberg, H. (2002). *Trådlösa nätverk – WLAN, WEP och Wi-Fi*.
Lund: Studentlitteratur
ISBN: 91-44-02696-X

Larsson, E. & Ljungberg, A. (2001). *Processbaserad verksamhetsutveckling*.
Lund: Studentlitteratur
ISBN: 91-44-01270-5

Mattsson, S-A. (2002). *Logistik i försörjningskedjor*.
Lund: Studentlitteratur
ISBN: 91-44-01929-7

Newman, W. M. & Lamming, M. G. (1995). *Interactive System Design*
Cambridge: Addison – Wesley
ISBN: 0-201-63162-8

Segerstedt, A. (1999). *Logistik med fokus på Material- och
Produktionsstyrning*.
Malmö: Liber Ekonomi
ISBN: 91-47-04390-3

Svenska Akademiens ordlista över svenska språket (1998)
Stockholm: Nordsteds Ordbok
ISBN: 91-7227-032-2

Interviews

Bertil Åhs, Radiosystem Bertil Åhs, 11-12-03

Customerservice 3, 08-12-03

Peter de Bruin, Ericsson Research AB, 23-03-04

Robert Johansson, SSAB, 27-01-2004

Tommy Änst, TietoEnator, 16-11-03

Articles

Verkstäderna, *Skärm ger dubbel dator*, number 11, 2003

Smältdegeln, *Världstvåa*, 2003

Internet Sources

Dell.com, 18-11-2003

Ieab.se, 01-12-2003

Nextel.com, 05-12-2003, 01-03-2004

Nytechnik.se 01-12-2003

Pricerunner.se, 03-12-2003

Ssabtunnplat.com, 08-01-2004

Telia.se, 02-12-2003

Tre.se, 02-12-2003

Verizon.com, 01-03-2004

Questionnaire concerning requirements on cell phones

My name is Claes Arnesson and I am studying my last year of Industrial Engineering and Management at the University of Technology in Luleå. I am currently doing my master's thesis at Ericsson Research AB. The thesis's purpose is to find opportunities for mobile solutions in the process industry and requirements on the equipment. I would be truly grateful if you could spare a couple of minutes of your time and complete the questionnaire.

Thank You!

Q.1. What do you work with?.....

If you use a cell phone in your work continue with question **Q.2.**, if not, continue with question **Q.17.**

Q.2. Which type of cell phone do you use in work today?.....

Mark the box that fit you the most

Q.3. What do you think about the size of the cell phone you use in work today?

Too big Alright Too small

Q.4. What do you think about the weight of the cell phone you use in work today?

Too heavey Alright Too light

Q.5. What do you think about the screen on the cell phone you use in work today?

Too big Alright Too small

How important is the following features on the cell phone you use in work?

Rank the degree of importance on a scale from 1 to 5, where 1=not important and 5=very important

Q.6. Be small

1 2 3 4 5

Q.7. Weigh little

1 2 3 4 5

Q.8. Big screen

1 2 3 4 5

Q.9. Big tangents

1 2 3 4 5

Q.10. Ergonomic design

1 2 3 4 5

Q.11. Long time between charging

1 2 3 4 5

Q.12. Be durable

1 2 3 4 5

Q.13. What is the most important that the cell phone needs to handle with respect to durability?

Dust Damp Shocks Other.....

Q.14. Which functions or add-ons do you want on a cell phone you use in work? *(more than one box can be marked)*

Vibrator Camera Hands-free Other.....

Q.15. Do you use some other services than voice, for instance SMS or WAP?

Q.16. Do you have any other wishes or ideas concerning the cell phone you use in work?

More than one box can be marked

Q.17. Do you sometimes, or always, use other communication equipment?
In that case what?

Short-range radio Phone Computer Other.....

Q.18. Why do you use this equipment?

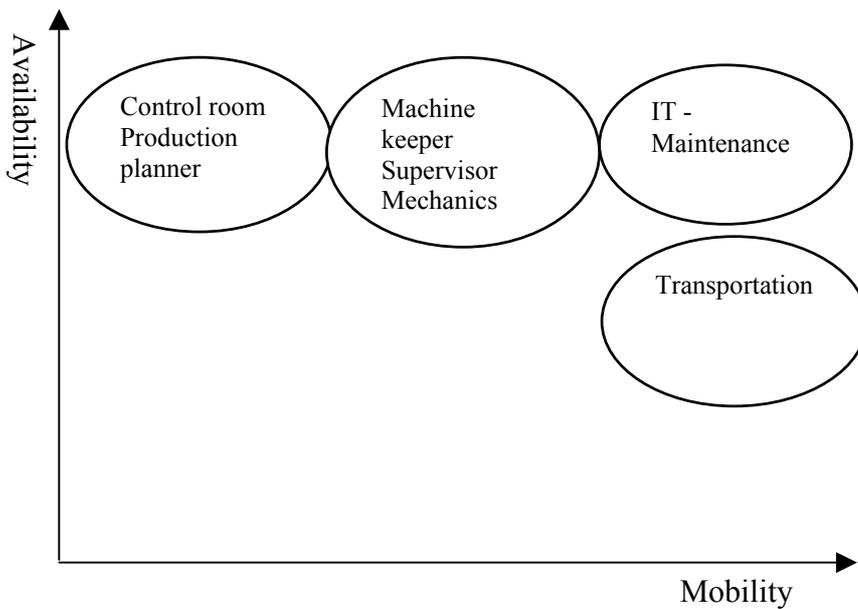
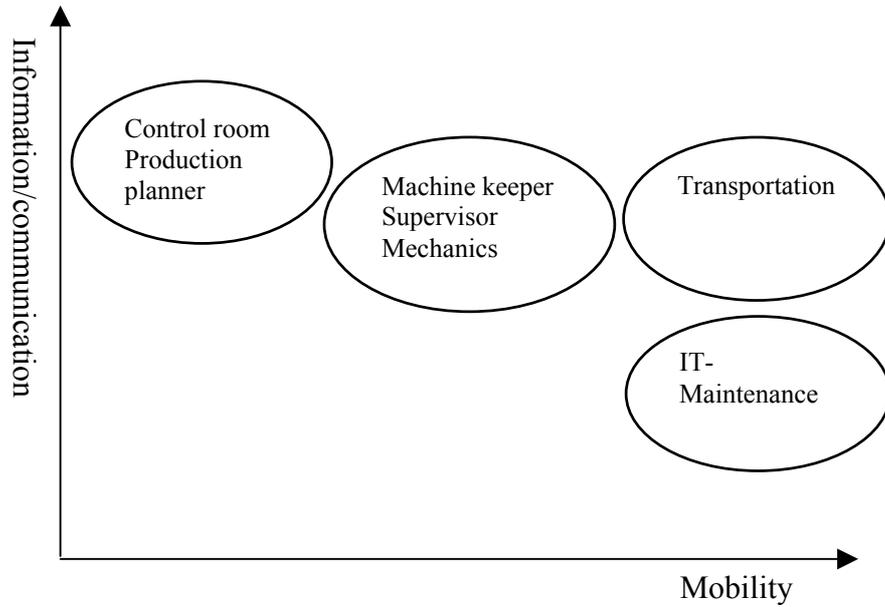
Faster Better network coverage Ability to group communication

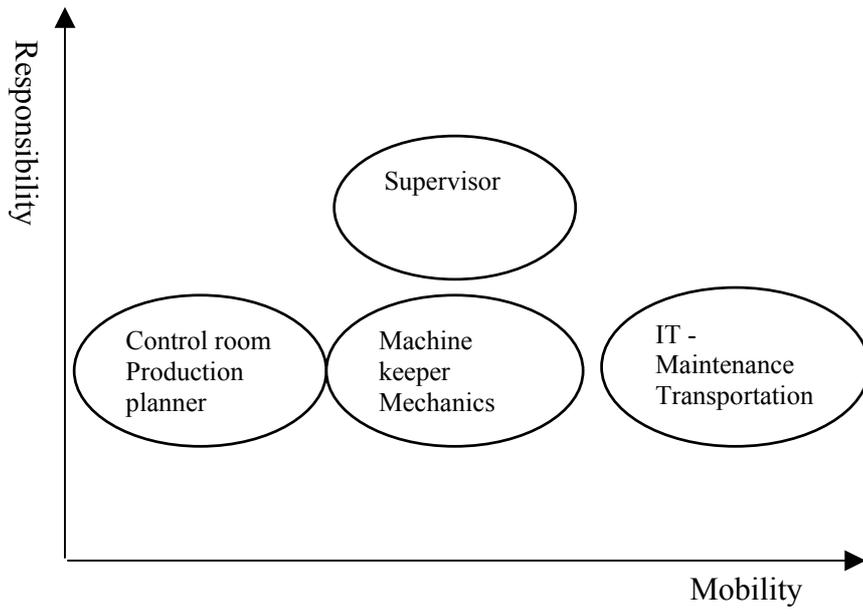
Other.....

Thank you for participating!

Visual Categorisation of the Respondents

Graphic categorization of the different professions studied concerning the degree of the selected characteristics in relation to mobility.

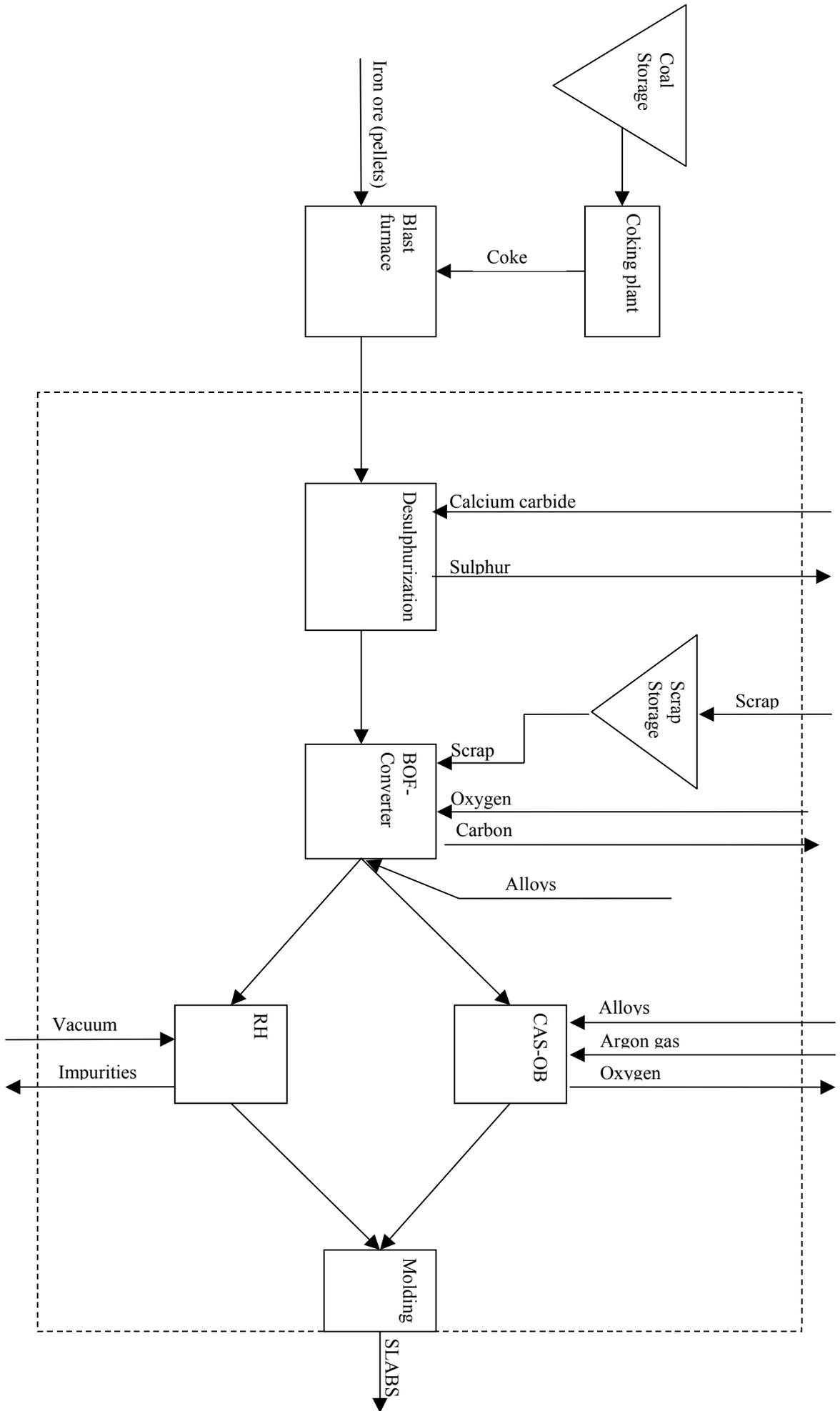




The Production Process at SSAB

Follow the production flow on the next page for better understanding.

1. The coal is imported and stored at SSAB.
2. The coal is heated and becomes coke.
3. Iron ore from LKAB is transported to SSAB.
4. Coke and iron ore are mixed in the blast furnace.
5. The blast furnace is tapped and the hot iron is transported into the steelwork building.
6. The sulphur is reduced by an injection of calcium carbide at the desulphurization station.
7. The hot iron is refined in the BOF-converter, which is an oven where the iron's temperature is adjusted and the carbon content is reduced. The carbon content is reduced by an injection of oxygen and the iron is cooled with scrap. Different types of alloys are also mixed in the iron to get the right quality of the steel. In the BOF-converter is the iron transformed to steel.
8. After the BOF-converter the steel can either go to the CAS-OB station or the RH station. In the CAS-OB station is a hood placed over the ladle and the steel is further refined by adding more alloys. Argon gas is also added to prevent the steel from being affected by the air. The RH station reducing the carbon contents in the steel to extremely low proportions. To be able to reduce the carbon the steel is treated under vacuum in a vacuum chamber.
9. In the molding station the steel is solidified and cut into blocks called SLABS.
10. The SLABS are transported to the rolling mill in Borlänge.



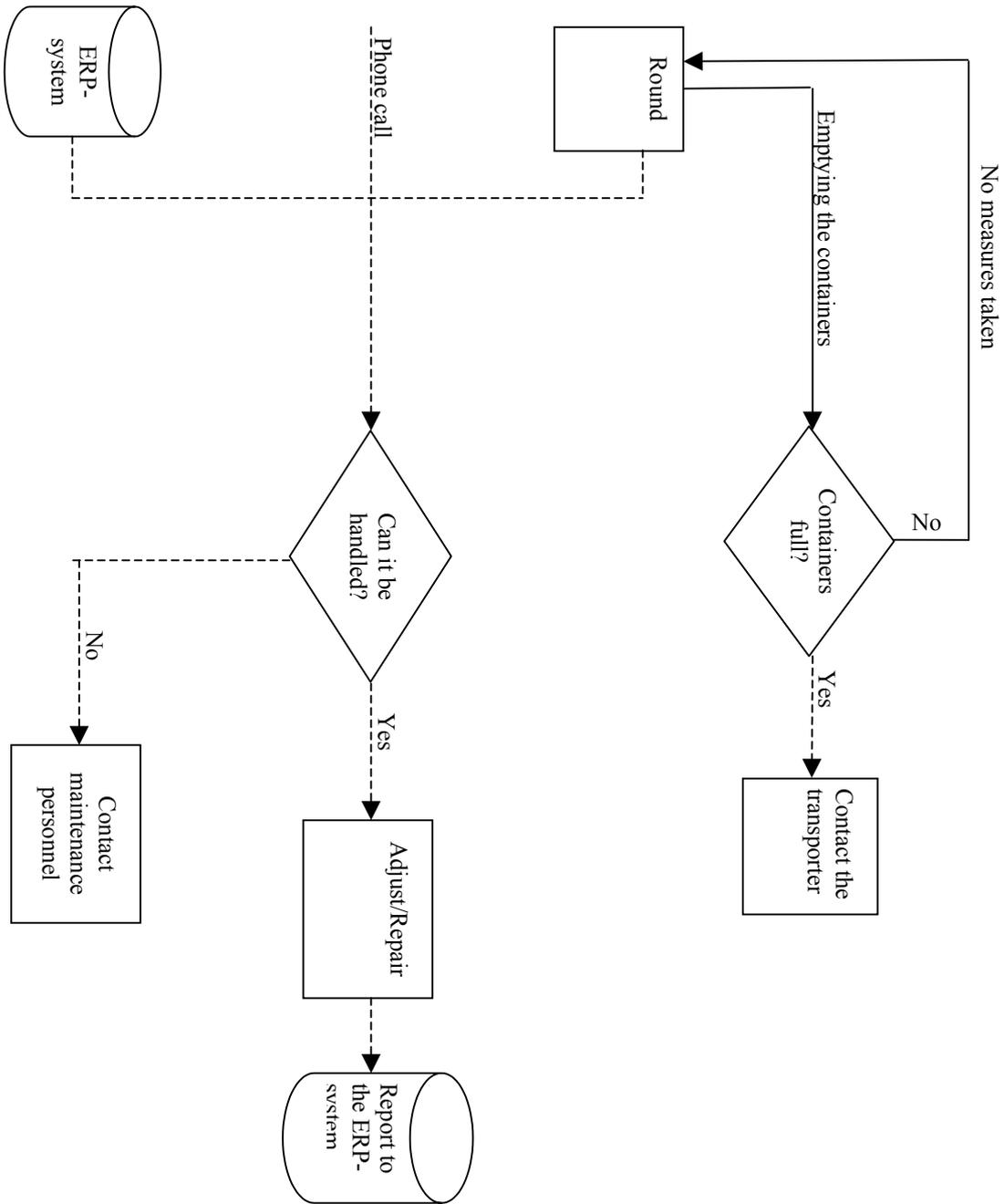
The steelwork building

Picture of Ericsson S868

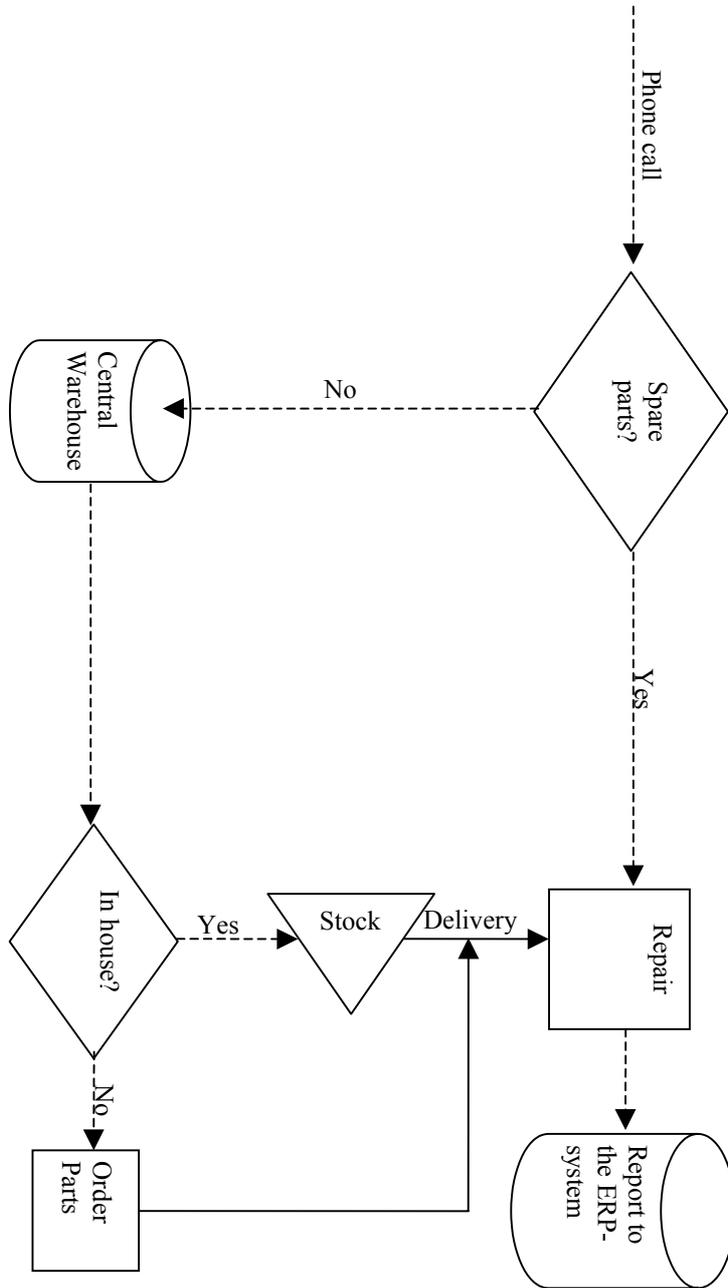


The size of an Ericsson S868 can be seen in the picture, the depth is 23 millimetres and it weights 130 grams with a slim battery.

Flowchart-The Machine keeper's Information Flow



Flowchart-The IT-maintenance's Information Flow



Flowchart-The Maintenance Mechanic's Information Flow

