Operations Improvements Through Non-Value-Added Step Reduction

By Anthony C. Gambell

B.S., Industrial Engineering, Northwestern University, 1999
B.S., Manufacturing Engineering, Northwestern University, 1999

Submitted to the Sloan School of Management and the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration
and
Master of Science in Mechanical Engineering

In Conjunction with the Leaders For Manufacturing Program
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Abstract

This thesis demonstrates how factories can use the Value Stream Mapping method to reduce both direct and indirect labor cost components through a non-value-added step reduction. The principal objective of this internship was to identify instances of non-value-added work in a product value stream and implement actions to reduce or eliminate it. Operations improvements included actions to eliminate waste through bottleneck utilization improvements, paperwork reduction, planning tool development and safety stock level calculation. From a leadership perspective, this thesis explores the challenges of cross-cultural and second-language change management.

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CHAPTER 1: INTRODUCTION AND PROBLEM BACKGROUND

This thesis represents the results of work performed while on internship at ABB Limited, fulfilling the requirements of the Leaders for Manufacturing Program at MIT. The project was sponsored by ABB's Corporate Research Center and was carried out at Striebel & John, GmbH, an ABB factory located in Sasbach, Germany. This project focused on early stages of lean implementation at one of the largest factories in the company's business unit.

1.1 Problem Statement and Project Motivation

How can factories recognize significant operations improvements through a non-value-added step reduction?

The principal objective of this internship was to identify instances of non-value-added work in a product value stream and implement actions to reduce or eliminate it. Actions included execution of a Kaizan event and reduction of waste in paperwork, planning, and materials management. All efforts fall under a global ABB initiative to implement practices of lean manufacturing.

> *"Batch manufacturing fosters disconnected islands of value-added activity surrounded by moats of non-value-added events. Lean manufacturing blends value-added activities into a continuous-flow process while systematically eliminating non-value added events."* [1]

From a leadership perspective, this internship explores the challenges of cross-cultural leadership and second-language change management.

This project was chosen for a few reasons. Results from the project benefit the local organization, support the development of local incentive-pay initiatives, and support the ABB Business Unit lean manufacturing initiatives.

1.2 ABB Limited Company Background

ABB Limited is a global leader in power and automation technologies. The ABB group of companies employs around 120,000 people in around 100 countries and had 2003 revenues of over $18 billion. [2] Headquartered in Zurich, Switzerland, ABB was formed by the 1988 merger of power technologies giants Asea and Brown, Boveri & Cei. The company, then one of the world's largest electrical engineering firms, began an aggressive growth strategy based on acquisition and decentralized management. In the late 1990s, ABB began to divest of nuclear power, power generation and rail businesses to develop strengths in alternative energy. Recent divestitures of financial services and petrochemical businesses reflect the company's strategic focus on two core areas of business: Power Technologies and Automation Technologies. [3]

1.3 Striebel & John GmbH Company Background

Founded in 1958, Striebel & John began producing sub-circuit distribution boards for the electronics distribution industry. The 1960s and 1970s marked increases in product offerings and the building of a 400 square-meter facility. The factory's primary products are electrical enclosures for residential and industrial applications and can be thought of as sheet metal fuse boxes that come in many shapes and sizes. In 1984, the company began to produce large wall and free-standing cabinets, the focus product line for this thesis.

The 1990s marked a time of great growth for Striebel & John including a factory expansion and broadening of product offering. This led to the 1993 acquisition of Striebel & John by ABB. Striebel & John is a 51%-owned subsidiary of ABB and is grouped in the Automation Technologies Low Voltage (ATLV) Business Unit. Other companies in the ATLV business unit currently exist in Italy, Holland, and the Czech Republic.

The facility, located in Sasbach, Germany, houses all fabrication processes necessary to process sheet steel into finished housings and cabinets. The processes include stamping, bending, bolting, welding, powder-coating (painting), and final assembly of units.

1.4 Current Business Environment

The local organization, Striebel & John, has been facing a very difficult market situation. In the early 1990s, Striebel & John experienced several years of dramatic growth due to the opening of the East German markets. This included a large factory expansion project and the installation of flexible manufacturing equipment. Over the past few years, however, the number of housing starts (a leading indicator for electrical enclosure demand) has dropped significantly. The suppliers who were feeding a market of 680,000 units per year now collectively compete for a market of roughly 280,000 units per year. Margins are very thin and customers demand more and more from their suppliers.

The boom of the 1990s allowed Striebel & John to install new, highly-automated metal forming equipment, enabling a quick improvement in throughput and efficiency. The current environment, with both a shrinking market and shrinking margins, calls on Striebel & John to achieve similar improvements in efficiencies without further investment in large capital equipment. Any improvements to the manufacturing process that reduce NVA work for direct labor improve efficiencies and throughput. Reductions of NVA work for supporting processes, such as production planning and purchasing, enable indirect labor resources to shift their focus from tactical to strategic functions.

Independent of savings in direct and indirect labor, reductions in NVA work also support company efforts to establish a new incentive pay program. The future program involves scaled-payment for quantity of units produced. In such a work environment, it is important that the workers are compensated for their value-added work only.

1.5 Corporate Lean Objectives

One ABB employee, located in Norway, holds responsibility for lean activities across all companies in the Enclosures business unit. His goals include reductions in inventory and lead time as well as increasing the value-added percentage of manufacturing time.

Current Business Unit Lean Targets:

Inventory	8% of revenues
Lead Time	18 working days
Delivery Performance	greater than 95% on-time delivery

Managers from each company in the business unit meet quarterly to discuss performance to lean objectives and present new methods of achieving operations excellence. There are currently no common approaches to lean within this business unit; each company independently chooses its own recipe for lean.

1.6 Thesis Overview

<u>Chapter 2</u> introduces value stream mapping and provides the groundwork for a non-value-added step reduction.

<u>Chapter 3</u> discusses execution of a Kaizan burst and actions taken to increase bottleneck capacity utilization.

<u>Chapter 4</u> is the first of three sections that describes the analysis and actions taken to eliminate NVA work. The focus of this chapter is on reducing paperwork classified as either "Type II" or "Type I Muda".

Chapter 5 is the second of three sections that describes the analysis and actions taken to reduce or eliminate NVA work. The focus of this chapter is on using planning tools to reduce "Type I Muda".

Chapter 6 is the final section that describes the analysis and actions taken to eliminate NVA work. The focus of this chapter is material management and safety stock level determination with the goal of reducing "Type I" muda.

Chapter 7 is the first of two sections that discusses issues of change-management. The focus of this chapter is a cultural analysis including the challenges of working and leading in a second language.

Chapter 8 is the second of two sections that discusses issues of change-management. The focus of this chapter is a strategic analysis of a corporate lean initiative.

Chapter 9 summarizes the actions of the internship and provides further recommendations for ABB and Stribel & John leadership.

CHAPTER 2: VALUE STREAM MAPPING

"Lord, grant me the serenity to accept the things I cannot change, the courage to change the things I can, and the wisdom to know the difference." - Serenity Prayer

2.1 Introduction

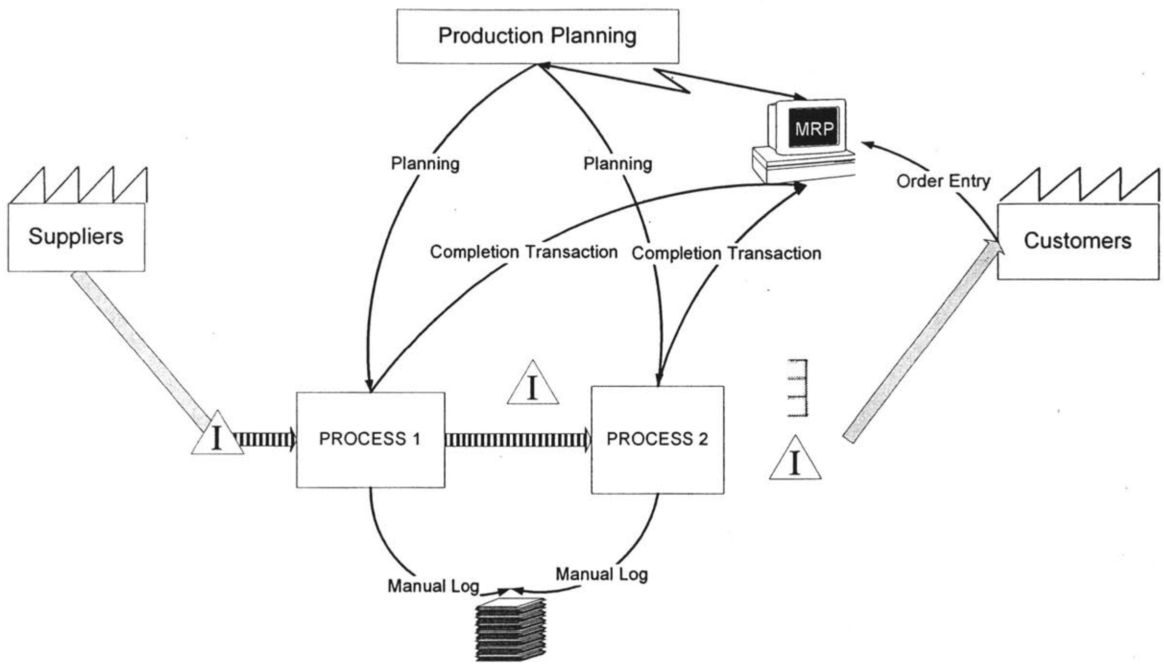
Over the past century, manufacturers have sought to improve their operations through different approaches and methods of change. Perhaps the method that has generated the most widespread attention lately is that of Lean Manufacturing. The five fundamental components of Lean Manufacturing include: Define Value, Identify the Value Stream, Ensure Flow, Establish Pull, and Work to Perfection. [4] This section will focus on the second component: Identify the Value Stream. It will introduce the method of Value Stream Mapping (VSM) and provide a discussion of its use as a tool to identify system wastes.

2.2 Academic Review of Value Stream Mapping

The construction of a value stream map is the first step in the definition of a Lean project. A value stream is a graphical depiction of the flow of materials and information required to satisfy a customer need. It includes all steps, both internal and external to a company, that are generally classified as one of the following:

1) Physical transformation steps, during which manufacturing or assembly work is accomplished
2) Information management steps that plan and communicate customer requirements through the organization
3) Problem-solving tasks that determine how products are conceptualized, designed and released to production

A formal approach to value stream mapping is presented in the book *Learning to See* by Rother and Shook. [6] As contributing writers for the Lean Enterprise Institute, they have developed standard tools, symbols and methods for effective process mapping. A simple example of a value stream map is included below.



The figure shows material flows as parts move from Suppliers, through Processes 1 and 2, and finally to Customers. Material storage locations are indicated by "I" in triangles. Information flows are shown with the small arrows. Of particular importance is the acknowledgement that flows of information are as guilty as flows of material when identifying waste in a value stream.

> *"In any process, activities can be categorized as transformation, storage, transport or inspection. Only transformation adds value, the rest is waste."* [5]

Within each operation, the value stream "mapper" documents individual process steps and their associated process times. Each process step can then be defined as value-added (VA) or non-value-added (NVA).

"A step in the manufacturing process is deemed VA if the customer desires that step to convert the product to specifications. A step is deemed NVA if the customer did not ask for it but it's done anyway because the manufacturer is inefficient, uninformed or dedicated to complexity. Defining each step as VA or NVA leads to a better understanding of costs by overlaying the customer's focus on the product." [7]

Since we have turned our focus to NVA activities, we further define the NVA tasks and increase the resolution of our analysis. Once we fully-understand the nature of each process step, we have a focus and direction for improvement efforts. Some steps may not add value, but they are unavoidable. This is often referred to as Type One Muda. (Muda is the Japanese word for waste.) Steps that do not add value and are also avoidable are considered Type Two Muda.

Type One Muda steps are unavoidable. Our improvement strategy is to identify operations improvements that combine or automate actions and/or reduce time required for the actions. Some examples include unavoidable material movements, required quality inspections, and many tactical planning tasks.

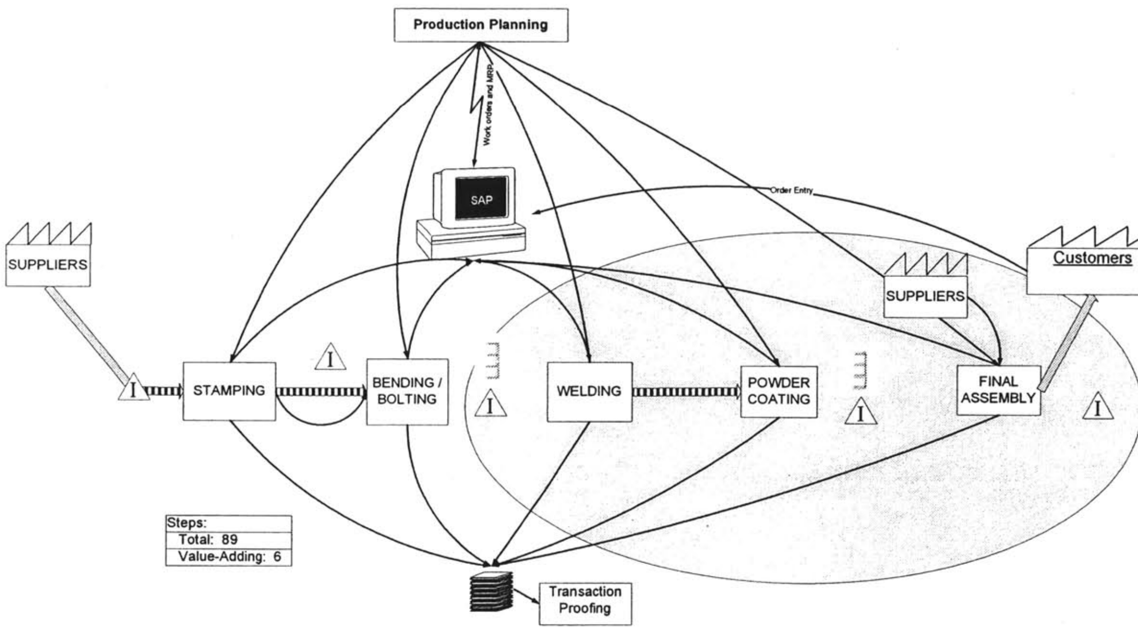
Type Two Muda steps are avoidable. Our improvement strategy is to identify opportunities to eliminate these tasks. Some examples may include excessive or redundant material movements, material waiting, and unnecessary or redundant recording of information.

Value Stream Maps also contain summary information of total process steps, operation process times and average times in inventory. This information is useful when setting goals for a lean implementation.

"In conventional manufacturing industry, products spend less than five per cent of the time they are in the plant being transformed; the rest of the time they are being moved, stored or inspected." [5]

Many well-organized organizations may be surprised when they learn how low their actual product value-added percentages are. For Striebel & John, the value-added percentage was 0.05%. This metric may be one of the most powerful outputs of Value Stream Mapping that can be used to generate support and momentum for a lean implementation.

Below is a simplified version of the Striebel & John value stream map. A detailed version can be found in Appendix A.



Following the value stream from left to right, raw material is first procured from suppliers and enters the plant. It then passes through the process steps of stamping, bending/bolting, welding, powder coating and final assembly prior to customer shipment. This step reduction focused on non-value added work in the welding, powder coating and final assembly operations.

2.3 Non-Value-Added Step Reduction Strategy

Although the exercise of mapping a value stream is in itself very worthwhile to an organization, more important is the execution of improvement actions that it generates.

"Books and software suggest that eliminating non-value-added costs is as straightforward as finding those costs. Quite simply, all one must do is eliminate the non-value-added activities. In practice, it's not simple at all. Sometimes, re-engineering projects do bring such sweeping changes. But for most companies and most activities, elimination of non-value-added activities is accomplished in small steps during a long period of time." [8]

The improvement efforts detailed in Chapters 3-6 are examples of how a Value Stream Map can focus an improvement team to eliminate NVA activities. Efforts followed the subsequent steps:

1) "Kaizan Burst": Increase in capacity utilization of pace-setter process
2) Reduction of Type II and Type I Muda by paperwork reduction
3) Reduction of Type I Muda by development of planning tools
4) Reduction of Type I Muda by use of safety stocks

Each step has been dedicated a chapter of this thesis and will be discussed below.

CHAPTER 3: "KAIZAN BURST": INCREASE IN CAPACITY UTILIZATION OF PACESETTER PROCESS

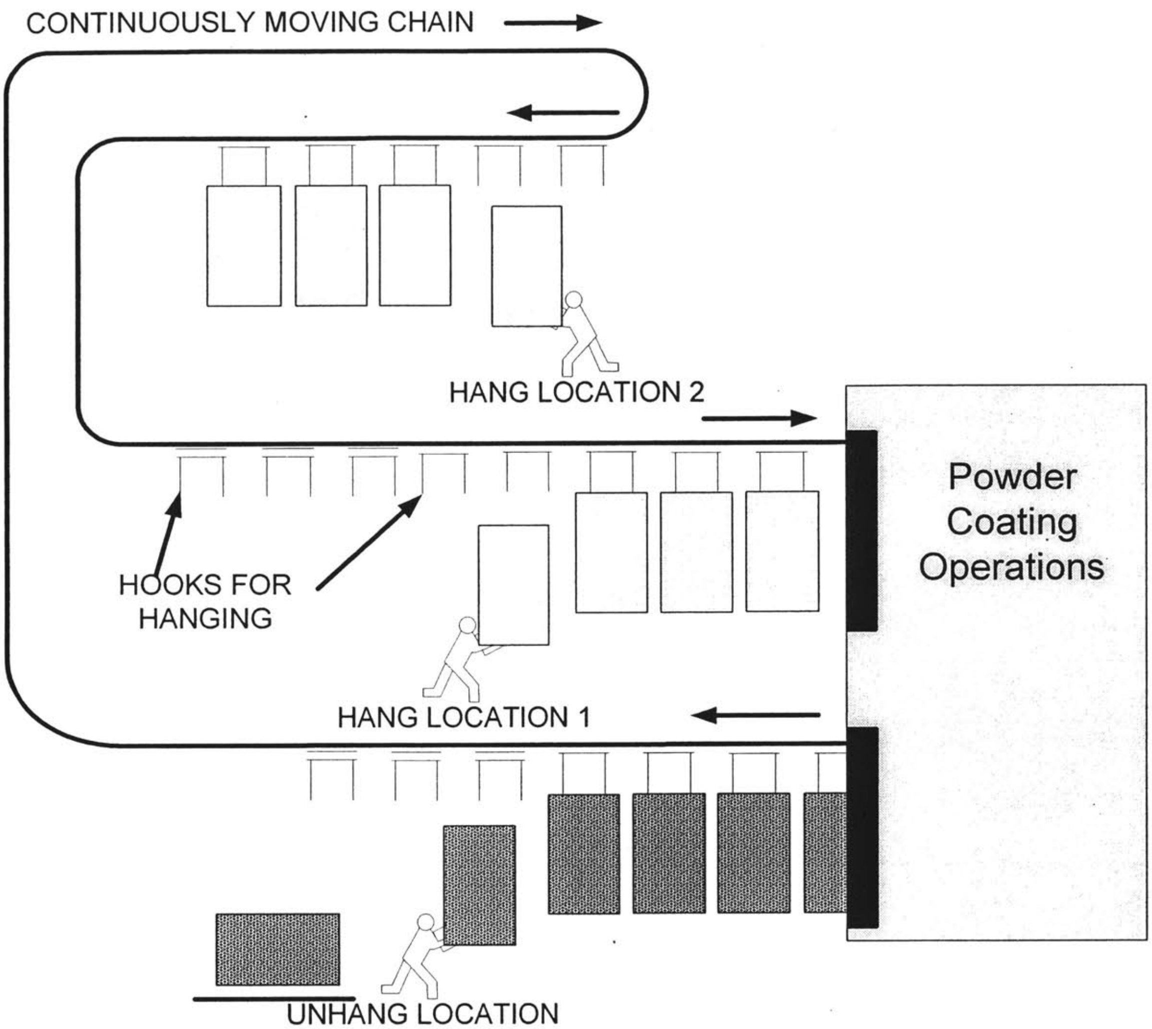
3.1 Introduction

As a company moves toward flow production work centers must be well-prepared to handle smaller batches and more frequent change-overs. This is particularly important when considering the operation of the factory bottleneck, or "pacemaker process". [6] This section discusses the actions taken to increase the capacity utilization of the bottleneck work center: powder-coating. An increase in throughput for the powder-coating work center increases overall system velocity and allows a reduction of inventory in the pre-work center queue. This improvement effort is an example of how value stream mapping exposes opportunities for "Kaizan bursts", focused process improvement efforts that yield great results.

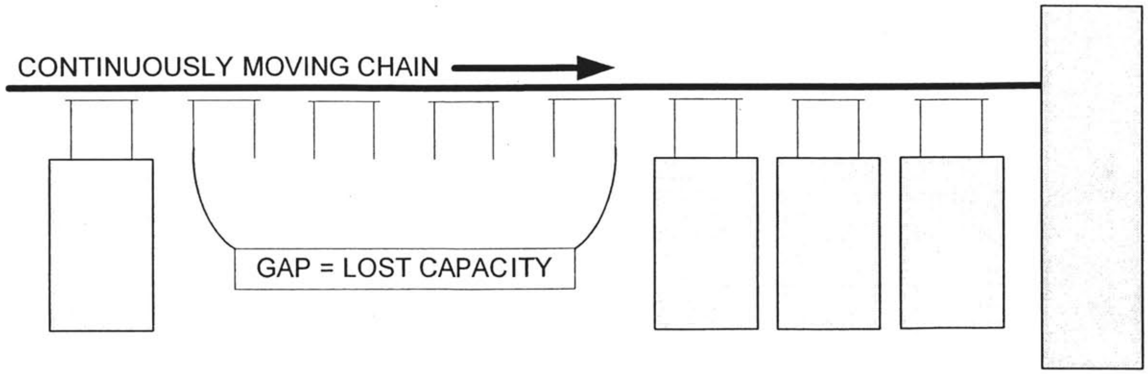
3.2 Characteristics of Problem

The powder coating work center is well recognized and observed to be the Striebel & John factory pacesetter process. The work center is generally staffed for more shifts than the rest of the factory (ie, powder coating is staffed for 3 shifts when the rest of the factory is staffed for 2 shifts.) The work center is planned in large batches based on product color, and material buffers in front of this work center may fill for hours or days before being scheduled.

The powder coating process itself has unique characteristics for operations analysis. The work center consists of a continuously-moving chain that carries all products through the process equipment. Products are removed from pallets and hung onto the chain by hand at a loading station. The product is carried by the chain through a water wash, deionization wash, drier, powder paint spray and bake. Products are then removed from the chain by hand and placed on a pallet for movement. The entire work center process time is around 45 minutes from hang to unhang.



The chain moves continuously, so any unused portions of the chain, seen as gaps between parts, can be considered lost capacity. A gap can occur for many reasons. For example, the process requires a changeover gap with every change of powder color, product height and product type. In other cases, gaps occur that are not necessary and are responsible for lost capacity.



Since the powder coating process is the factory bottleneck, any gained capacity results in increased factory throughput.

3.3 Kaizan Burst Approach

The goal of the Kaizan burst was to fully-utilize available capacity. By observation, it was clear that the resource experienced many large gaps of varying size and that capacity was being lost. The approach used to address the problem followed the following steps:

1. Observe the work center

   The team observed the work center during different times periods over 2 days. Focusing on both the anticipated gaps that occur during change-overs as well as gaps that were not intuitively explainable, the team recorded gap occurrences and estimated time impacts for later analysis.

2. Identify reasons for gaps

   When a non-intuitive gap was observed, team members collected information by immediately interviewing operators and supervisors to determine the root causes. In some cases, further investigation was required to determine the true nature of the gaps and the conditions that caused them.

3. Rank impact of gaps and select opportunities to exploit

   The team then ranked the gap occurrences based on their total impact on bottleneck throughput.

4. Brainstorm actions to reduce or eliminate gaps

   The team brainstormed ideas to reduce or eliminate the three largest gaps. Each improvement involved some type of change that impacted the work center process, the planning process supporting the work center, or both.

5. Implement actions to reduce or eliminate gaps

   Solutions were selected and implemented in the work center.

3.4 Capacity Recapture

Three actions were chosen for implementation based on their contribution to capacity recapture. The three actions are detailed below and include:

Gap 1: Reduction of gap experienced when alternating between two hang locations

Gap 2: Reduction of gap between part numbers

Gap 3: Reduction of gap during color-change

3.4.1 Reduction of gap experienced when alternating between hang locations

There are two physical locations where operators may hang parts on the moving chain. The hang stations are in series and are 75 meters apart. This means that when changing-over from hanging parts at hang-location 1 to hang-location 2, there is an automatic gap of at least 75 meters. Under the current process, operators complete a batch of parts at hang-location 1 before they move, as a group, upstream to hang-location 2. Ideally, this gap should be no more than 20 meters, the distance required for a normal color change. It was discovered that labor requirements for hanging parts varied drastically, but operators worked in groups of three or four regardless of the actual labor requirements for hanging parts. In reality, some parts require three or four operators to be hung on the chain, whereas other parts require only one or two.

If the final batch at hang location 1 was an operation that required only one or two operators, the other two operators could move to the upstream hang location and begin hanging parts before hang-location 1 was exhausted. It became clear that there was some benefit to be gained by "book-ending" labor-intensive parts with parts that required fewer hang operators. Upon implementation, this solution would potentially provide even greater work benefits, since operators could be freed-up sooner to facilitate all change-overs.

The risk in this system lies in the complexity of coordination. It would be labor-intensive to have a supervisor continuously monitor production, moving people from station to station at the precise moments necessary to maintain production rates. Therefore, the objective was accomplished with the production schedule itself. Work was scheduled according to the "book-ending" methodology, causing the desired effect without added supervisory requirements. To coordinate the capacity optimization, four generic change-over scenarios were identified and best-case prioritizations were defined for each. The prioritizations were then translated into scheduling guidelines that would order parts based upon their labor requirements.

The executed solution reduces this major gap by 55 meters per incident and occurs roughly 8 times per week. Assuming a standard cost of capacity for the bottleneck work center, the overall direct labor benefit is roughly 22.425 € ($26,900) per year.

3.4.2 Reduction of gap between part numbers

Production runs of a given color normally include several different part numbers of material. When operators shift from one part number to another, changing the powder-coating specifications may require a change-over gap. Due to supervisor experience and operator habit, it was believed that this gap needed to be 20m.

Detailed analysis of the system indicated that this gap needed to be no larger than 10m. Also, if consecutive part numbers were the same height, no change-over gap was required. The solution to this problem involved nothing more than training the operators and enforcing behavior until the inter-part number gap-distance was less than or equal to 10m.

The executed solution reduces this major gap by 5 meters per changeover and occurs roughly 72 times per week. Assuming a standard cost of capacity for the bottleneck work center, the overall direct labor benefit is roughly 18.350 € ($22,000) per year.

3.4.3 Signal counter setting

The third scenario is a rather simple process modification to a fairly robust process. When changing-over from one color to another, there is a counter that measures the gap from the last part hung of the leading batch to the point when parts of the new batch can be hung. An indicator light alerts operators that the required 20 meters has passed and they begin to hang new parts.

Despite an unquestioned belief that the gap was only 20 meters, observation of the system revealed that the de facto gap was 31 meters. The reason for the error is unknown. Corrective action for this improvement involved adjusting the counter setting to notify operators when the correct gap size had passed.

The executed solution reduces this major gap by 11 meters per changeover and occurs roughly 10 times per week. Assuming a standard cost of capacity for the bottleneck work center, the overall direct labor benefit is roughly 9.350 € ($11,200) per year.

3.5 Results

The labor savings due to the operations improvements described above total over 175 hours per year and $60,000.

From a capacity perspective, these combined improvements capture 910 meters of capacity per week, or 45,500 meters of capacity per year (based on a 50-week year). Assuming 20-meter change-over distances, this means the company could maintain existing throughput rates while increasing the number of change-overs by 45 per week.

3.6 Summary and Recommendations

All of the above actions, from observation to implementation, occurred within a two-week time period. As you can see, significant results were achieved through simple problem identification and solution implementation. Similar Kaizan Bursts should be done regularly to maintain momentum for continuous improvement. The most important factor for this is an engaged work force that has incentives to carry out actions.

The factory should consider the recapture of capacity not only as an opportunity to recognize greater throughput, but as an opportunity to reduce lot sizes. The benefits of changing over to a flow process will far outweigh the perceived costs of increased change-overs.

CHAPTER 4: REDUCTION OF TYPE I & TYPE II MUDA BY PAPERWORK REDUCTION

4.1 Introduction

Since the dawn of the computer age in manufacturing, companies worldwide have undertaken extensive paper reduction efforts. Employees lament the use of paper forms that add tasks to their days without adding value to the customer.

> *"I spend so much time filling out these forms, I feel like a secretary."* - Striebel & John work center operator.

Prior to the use of modern ERP systems for factory planning and execution, companies relied on paper forms for production scheduling, completion tracking, and collection of product quality information. With the introduction of new computer systems, new processes oftentimes fail to replace past processes. They are instead implemented as new processes to be executed in parallel with existing manual processes. This behavior undermines a major intent of computer system use: efficiency.

> *"Many companies have sought to manage complexity by installing expensive enterprise-wide computer systems to track, digest, and manipulate all of the data generated by their far-flung operations. Ironically, the installation and management of sophisticated information systems adds yet another dimension to the web of complexity."* [9]

When new ERP-enhanced processes fail to replace existing manual systems, the result is a system redundancies and non-value-added work. Depending on its function, extra paperwork may be examples of Type I or Type II muda.

4.2 Characteristics of Problem

This section focuses on the paperwork reduction effort performed in the Striebel & John powder-coating work center. The powder coating work center is observed to be the factory bottle-neck. Any reduction in NVA work has the potential to have a direct impact on factory throughput.

The effort begins with a thorough analysis of work center process steps, specifically those that involve the use of paper for planning and recording production runs. The team first examined the value stream map. Within each value stream process step it was easy to identify NVA steps that involved paper reporting and information recording.

Recalling from Chapter 2, steps classified as Type II Muda are those that add no customer value but can be avoided; those classified as Type I Muda add no customer value but cannot be avoided. Through observation and interviews, we are able to discern the function and value of each piece of paper and brainstorm methods to reduce or eliminate them.

POWDER COATING	
STEPS:	MUDA Classification
1. Prepare housings and move to work center (110 sec)	Type I
2. Log job start-time in work center log-book (45 sec)	Type II – Paper
3. Hang housing on moving chain (57.6 sec)	Type I
4. Select proper color (57.6 sec)	Type I
5. Powder-coat housings (45 min)	Value-Added Work
6. Unhang housings from moving chain (25 sec)	Type I
7. Move housings to local inventory location (125 sec)	Type I
8. Complete Material Transfer Form (60 sec)	Type II – Paper
9. Log completion in work center log-book (20 sec)	Type II – Paper
10. File completed work-slip in work center (10 sec)	Type II – Paper
11. Book order completion in SAP (95 sec)	Type I

"Analyzing each process step leads to eliminating the non-value-added activities. 'Whether it's one second or 20 seconds, non-value-added does not add value to the customer." [10]

Once all paper forms were identified, they were redesigned so that all NVA work that was unavoidable would occur on a single sheet of paper. This sheet of paper also functioned as the work center scheduling document.

4.3 Execution and Results

The powder-coating paper-reduction example discussed here is a successful step towards reducing waste. Similar solutions were replicated in other upstream operations, further increasing the impact of the NVA study.

In one roll-forming work center, a single sheet of paper functions as schedule sheet, log-sheet, quality control document and transaction tool (transaction bar codes are printed for each job). The powder coating solution, combined with similar paper reduction efforts in other work centers, effectively reduced overall direct labor costs by 25,000 € ($30,000) per year.

4.4 Summary and Recommendations

Paperwork reduction efforts are straightforward and, for the most part, required two simple things: a motivation to reduce paper-induced waste activities, and persistent questioning of all paperwork activities. The solutions implemented to reduce paper today should be questioned again tomorrow.

A further recommendation is to question the need for paper material transfer (Materiallaufzettel) forms. Perhaps the pallets themselves could contain an information-holding device that could be modified to match the pallet's contents. Also, for some work centers, it could be unnecessary to track both input and output quantities. Use of FIFO lanes and small buffers could guarantee that all material flows through the work center to downstream activities. Lastly, the team often discussed the placement of networked computers on the manufacturing floor to allow real-time access to production scheduling and quality logging information. Such a system would not only reduce delays of information transfer and product completion transactions, it would also enable easier analysis of electronic quality data.

CHAPTER 5: REDUCTION OF TYPE I MUDA BY DEVELOPMENT OF PLANNING TOOLS

5.1 Introduction

Non-Value-Added step reduction is just as important when considering tasks of indirect labor as it is when considering tasks of direct production workers.

> *"[One] key to eliminating non-value-added costs is to systemize/streamline the process. But there's a big catch: I want to systemize it in such a way as to eliminate the "experts" from the process. Now, this may be the most intimidating part of the conversation, but it is where a company needs to go to achieve its goals. And please hear me! I am not saying we will be eliminating the experts. There is a huge difference. I have another use for the experts…Turn them into leaders and/or trainers. They should never be a "dependency" within the system. It turns the experts into slaves of the system, even though they should be out there generating new opportunities for the company in their unique areas of expertise."* [11]

The goal in the case of planning processes is to develop tools that automate tasks that do not require decision-making and therefore promote more-efficienct planners.

5.2 Case Study: Welding Work Center

This section discusses a case study of reducing NVA work in the planning and scheduling of a production work center. In this case, the work center is an operator-loaded robotic welder - one of the more complex work centers in the housing value stream.

5.2.1 Characteristics of Problem

The welding work center is a complex planning puzzle. The process itself imposes several limitations to work center flexibility and straightforward planning.

In the welding process, five parts come together to form a complete cabinet. Each cabinet is comprised of a top, a bottom, two sides and a back. The five pieces are manually-loaded into a part-specific equipment fixture. The fixture is then moved automatically into the welding apparatus and waits in queue for welding. Welding is performed by a robot welder that circles the unit placing the required number of spot welds to complete the housing.

The welding machine manages a rotating series of three fixtures at any given time. This means that the work center is constantly producing three part types at the same time, rotating consecutively through the three fixtures. For example, the welder will always weld one unit of part A, then one unit of part B, then one unit of part C, and then one unit of A again. This repeats until a work order of one part is completed, at which time that specific fixture is changed-over to the next production part on the schedule.

This three-fixture production process has many implications on the planning of the work center. Each fixture has some limitations of its use and can only run a certain subset of parts. Sometimes a fixture may be able to run a certain part, but it cannot be run in parallel with certain other parts. A planner also must consider balancing the work center. Since smaller parts require fewer welds and have consequently shorter process times, the planner will try to "balance" the work center by always scheduling two large parts with one small part. Lastly, a planner must always keep in mind that although a part may have a standard processing time in the ERP system, only one of every three units through the work center will be a given part. This triples the actual work center process time of each part batch.

The original planning process involved several manual planning steps. Within the ERP system, the planner would create work orders, release and print them. He would then create a priority for the work orders by sorting them into three groups and prioritizing them based upon his knowledge of the system. He would then create a hand-written daily plan for use on the production floor. There were several opportunities to automate tasks in this process.

5.2.2 Approach

The perception existed that a planner was required to evaluate and disposition each order in the ERP system. Such assumptions should always be questioned.

> *"Finite scheduling is hard work. It requires accurate and timely labor reporting; carefully constructed routings; properly defined work centers; and realistic work center structure. It is very unforgiving of imprecise information, sloppy operation, or weak administration. It requires monitoring and intervention by schedulers and planners."* [12]

The above quote, though true in the past, is less true with the use of modern information technology tools. The overall approach to reducing NVA work in the work center planning process was to identify each instance of logic or regular decision made by a planner, define a basic system of rules for handling these decisions, and automate them with IT tools.

5.2.3 Development of Tools

The first step in redefining the process was to eliminate several ERP keystrokes performed by the planner. Every day, the planner would review new requirements and create work orders from ERP-suggested planned work orders. When interviewed, the planner stated that he never modified the orders, he merely needed to complete the activities to create the orders. Since no planner evaluation and decision-making was required for these steps, they were automated in the ERP system.

The next step was to develop a scheduling tool that was a functional replication of planner logic. See Appendix B for a more detailed description of the planning tool. All unnecessary evaluation that occurred could be documented in a list of rules and replicated in the logic of a database. Part groups were defined to avoid double-planning of single fixtures. The part groups also functioned to ensure a balanced work center schedule.

The tool was also built to provide a job prioritization based upon a determined set of criteria. In the past, the planner was responsible for monitoring dynamic downstream need-dates and incorporating them into the work center schedule. Under the new process, the jobs are prioritized according to the following logic:

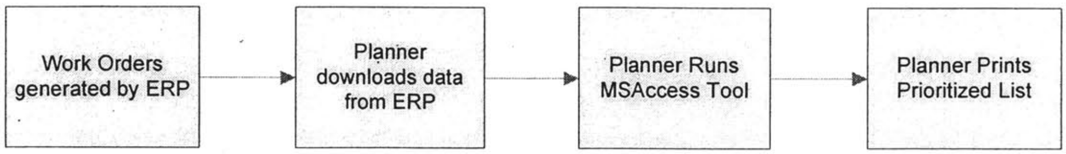
1. Build-to-order parts with early demand dates
2. Build-to-order parts with any demand date
3. Build-to-stock parts

Adding automatic prioritization to the planning tool increased the work center's ability to respond to dynamic demand and reduce internal lead times.

> *The "key to eliminating non-value-added costs is to eliminate delay. Any kind of delay is very expensive/costly. It forces decisions to be postponed, vital information to be withheld and labor and machinery to sit idle."* [11]

The tool allows the work center to manage safety stock levels to a 3-day lead time. Though historically believed to be a 4-day lead time, the planning tool prioritizes based on demand and need-dates and constantly prioritizes parts with early demand dates. This aids as internal safety stock reduction, discussed in Chapter 6.

To summarize, the tool enables the following scheduling process:



5.2.4 Execution and Results

The executed solution reduces daily planner time by 60 minutes per day or 220 hours per year. Similar solutions were replicated in other parallel and down-stream operations, further increasing the impact of the planning study. Overall, these combined efforts reduced NVA planner time by over 700 hours per year.

5.3 Summary

The analysis and actions described in this chapter highlight the importance of efficient flows of information. One suggestion is to continually be aware of new ways to view, sort and present data that will further improve the overall system. Since planning functions are considered non-value-added but necessary tasks, the organization should work to develop systems of fully-automated tactical planning functions, allowing existing resources to develop more sophisticated strategic planning skills. Information technology enables this transition and the author encourages further efforts to improve the flows of information.

CHAPTER 6: REDUCTION OF TYPE I MUDA BY USE OF SAFETY STOCKS

6.1 Introduction

This chapter describes the analysis performed to aid material management throughout the factory. The impetus for change was to reduce Type I Muda experienced by production planners and buyers and detailed on the value stream map. The analysis begins with a description of the problem, focusing on the value of using available IT resources to reduce NVA work. Next the analysis provides an academic discussion of safety stock determination followed by its use in developing a system tool. This chapter will then demonstrate the tool's use as it was piloted for an internal work center in our focus value stream. Finally it will discuss a proposed execution of the tool for purchased parts.

6.2 Characteristics of Problem

In order for planning organizations to fully-leverage an ERP system, they must utilize functionalities that replace manual information-handling, and further develop systems to support the functionalities. Most ERP systems have some type of automatic processing functionality that allows automatic-creation of work orders and/purchase orders. When this functionality is not enabled, planners must regularly review all part numbers, manually creating orders and scheduling them. In most cases, the planner adds little value in this role. This is a vivid example of Type I muda. The planning functions do not add customer value to the product, but they are unavoidable, so our improvement actions focus on automation and time reduction.

To use auto-processing functionalities, system data is very important. The ERP system can easily create and plan work orders as long as it has good data for making decisions. The two critical pieces of information are part lead times and safety stock values. Part lead times are determined internally for make parts and externally for purchased parts. Safety stock levels are often input into ERP systems when new part numbers are added, and are set to reasonable quantities at the time of product introduction. Although the parts are monitored weekly by buyers, system data is rarely reviewed. Companies can recognize great benefits by implementing a process that regularly reviews and determines statistical safety stock levels for all parts.

The project plan for this NVA improvement project was to determine a method of safety stock calculation, develop a tool that utilizes the calculations, and suggest strategies for different part types.

6.3 Academic Review of Statistical Safety Stock Determination

> *"Inventories of different classes of parts should be treated differently."* [13]

6.3.1 ABC Analysis

In most manufacturing companies, costs for components usually demonstrate common characteristics, namely that a small fraction of parts comprise a large fraction of total expenditure. [13] It is then useful to classify parts based upon total expenditure and manage them appropriately.

The standard component classification involves determining the total yearly cost of each part, based on part price and yearly usage, and then ranking them in descending order. In general, classifications follow the following guidelines:

A-parts comprise 80% of total cost and 5% of total part numbers
B-parts comprise 15% of total cost and 15% of total part numbers
C-parts comprise 5% of total cost and 80% of total part numbers

Companies sometimes define their classifications differently. Hopp and Spears [13] suggest that A- and B-parts combined should equal 80% of total cost with 20% of part numbers, but the concept still holds: Identify the small fraction of parts which comprise a large fraction of total expenditure and give them more attention than the large fraction of parts that have little impact on total cost of inventory.

This type of analysis is important because it spotlights the fact that component costs are not uniform across all parts, and they should not be managed uniformly. Managers should acknowledge this behavior and structure their resources (both labor and equipment) to focus on the procurement of A-parts, and establish more automatic systems for the coordination of B and C-parts.

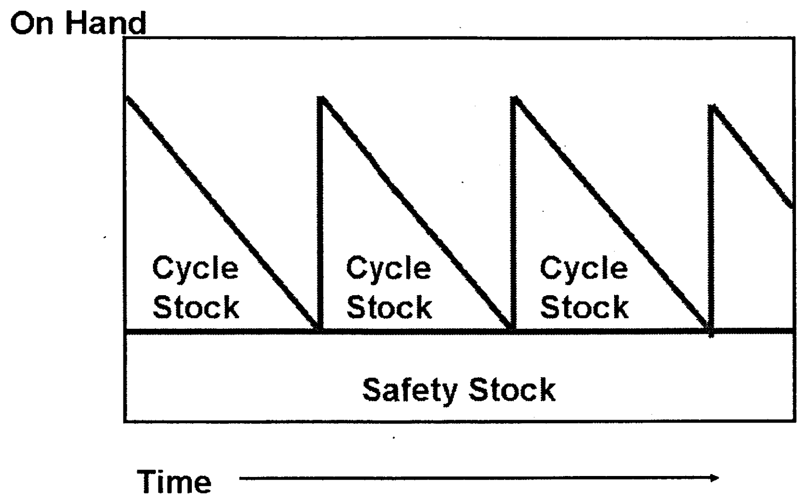
6.3.2 Statistical Safety Stock

The statistical safety stock method detailed here is an application of previously-defined methods, presented in this section as a replication of lecture notes of James Masters, MIT Professor of Civil and Environmental Engineering. [14] To begin this discussion, it is important to first define some terms and variables that will be used throughout.

Cycle Stock is defined as the stock level required to support average leadtime demand.

For this analysis, demand during lead time is denoted as: d'

Safety Stock is defined as an amount of stock held over and above expected lead time usage that is added to the reorder point to control/prevent/eliminate stockouts. (Masters) They are represented graphically below:



[14]

Leadtime usage and safety stock quantity then determine a reorder point (R).

R = d' + Safety Stock

Safety stock is determined as some multiple (k) of the standard deviation (s) of leadtime.

R = d' + k*s

The safety factor, k, is simply a multiplier that represents the variability of forecast error. Since forecast error can be assumed to be normally distributed, the desired service level corresponds with a k-value.

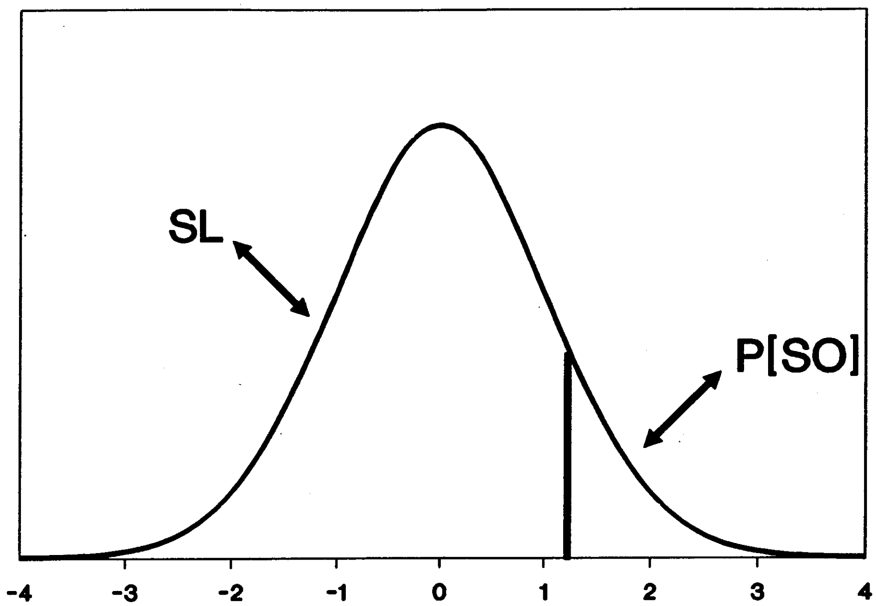
Service level (SL) is defined as the probability that leadtime demand will not exceed R.

SL = P[d'<=R]

Similarly, the probability of a stock out is:

P[SO] = 1 - SL

A Normal Probability Distribution



Example k-SL values are included in the following table and come from the Table of Cumulative Normal Probabilities (Appendix D):

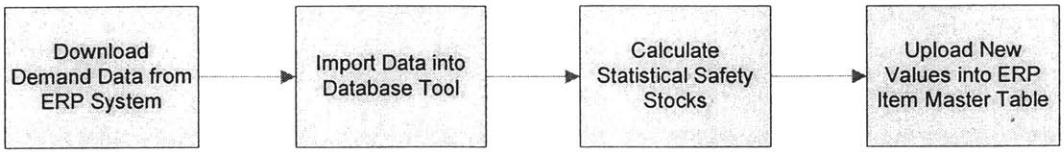
K-value	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Service Level	50%	69%	84%	93%	98%	99%	99.9%	99.99%

Given an appropriate set of daily demand data, d' and s are calculated. Then, upon choosing a service level and its corresponding value of k, a reorder point R is calculated for each part.

6.4 Development of Tool and Process for Regular Safety Stock Calculation

The above analysis is rather straightforward, but becomes overwhelming (and rather wasteful) when applied manually in a manufacturing environment where thousands of components are concerned. It is necessary, therefore, to automate these calculations using available information and database software.

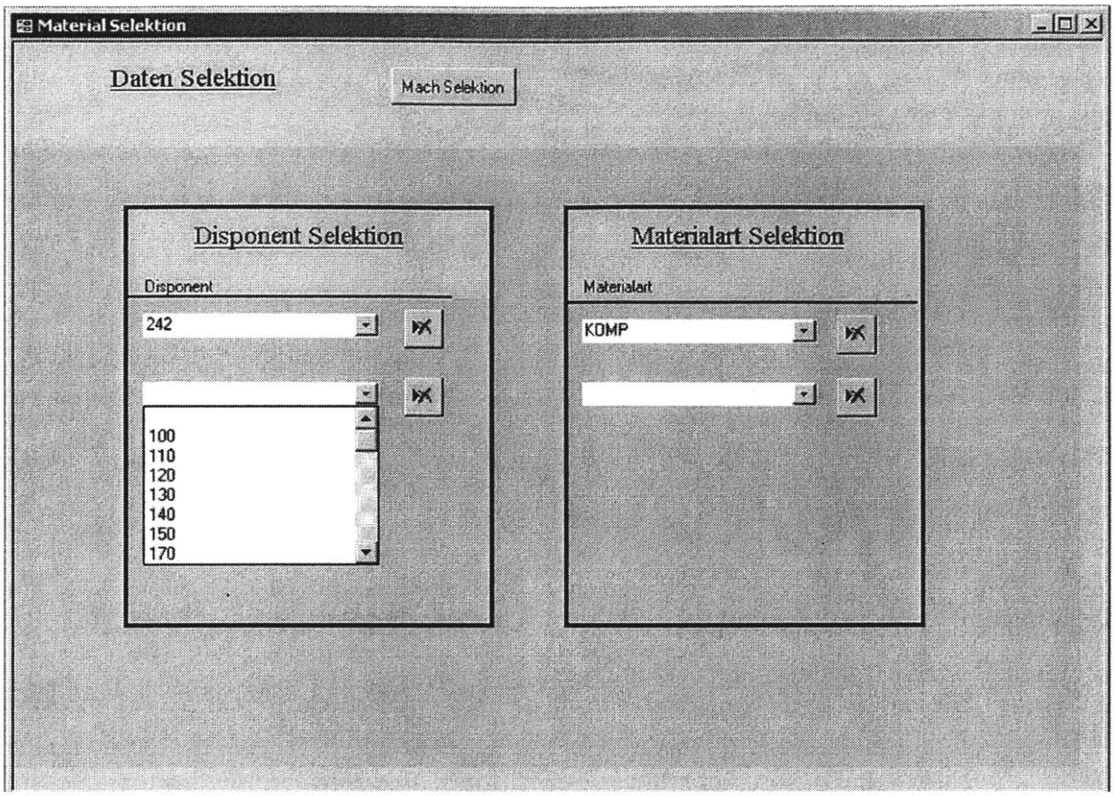
Safety Stock Calculation process:



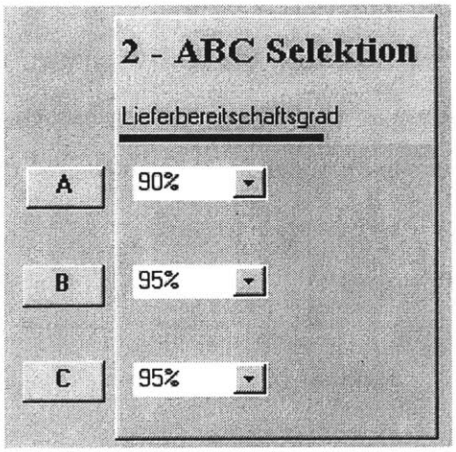
A database tool was created and distributed to planners responsible for safety stock decisions. Basic features of the tool will be discussed here, but a complete description can be found in Appendix C.

Author Note: When describing screen-shot features, they will be discussed in English with their German translations in parentheses.

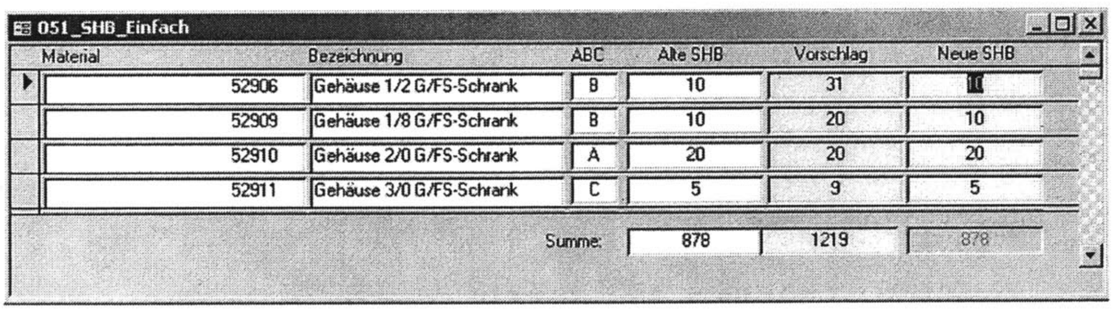
The safety stock calculation tool allows users a lot of flexibility in part selection. In the data selection (Daten Selektion) panel, users may choose to calculate safety stock levels for any set of part-numbers. Categories of selection are: buyer or controller number (Disponent Selektion) and part type (Materialart Selektion).


Material Selektion
Daten Selektion
Mach Selektion
Disponent Selektion
Disponent
242
100
110
120
130
140
150
170
Materialart Selektion
Materialart
KOMP

The tool then combines the concepts of ABC-classification with Statistical Safety Stock calculation in the Safety Stock Calculation Panel. Users may choose a different service level (Lieferbereitschaftsgrad) for each class of parts.



Upon making the above selections, the tool performs the safety stock calculations for all parts. The user can then review the suggested safety stock levels and, when desired, make adjustments. An example output view is included below


051_SHB_Einfach

Material	Bezeichnung	ABC	Alte SHB	Vorschlag	Neue SHB
52906	Gehäuse 1/2 G/FS-Schrank	B	10	31	10
52909	Gehäuse 1/8 G/FS-Schrank	B	10	20	10
52910	Gehäuse 2/0 G/FS-Schrank	A	20	20	20
52911	Gehäuse 3/0 G/FS-Schrank	C	5	9	5
	Summe:		878	1219	878

The columns include (from left to right) Material Number, Description, ABC class, Current Safety Stock Level (Alte SHB), Suggested New Safety Stock Level (Vorschlag), and User-Manipulated New Safety Stock value to be uploaded (Neue SHB).

The tool also provides the user with options to view summary information, including projected average inventory values and comparisons with other service levels. When all parts have been reviewed and the user is satisfied with new safety stock determinations, then the user can choose to create an output file that will be uploaded into the ERP system.

6.5 Planning Strategy: Make parts

This section describes the safety stock determination processes as piloted with a set of internal parts, setting the safety stock levels for welded housings, the focus product line for this project. As discussed in Chapter 5, the welding work center is now planned by auto-processing functions. Accurate safety stock values are critical for the success of that planning process.

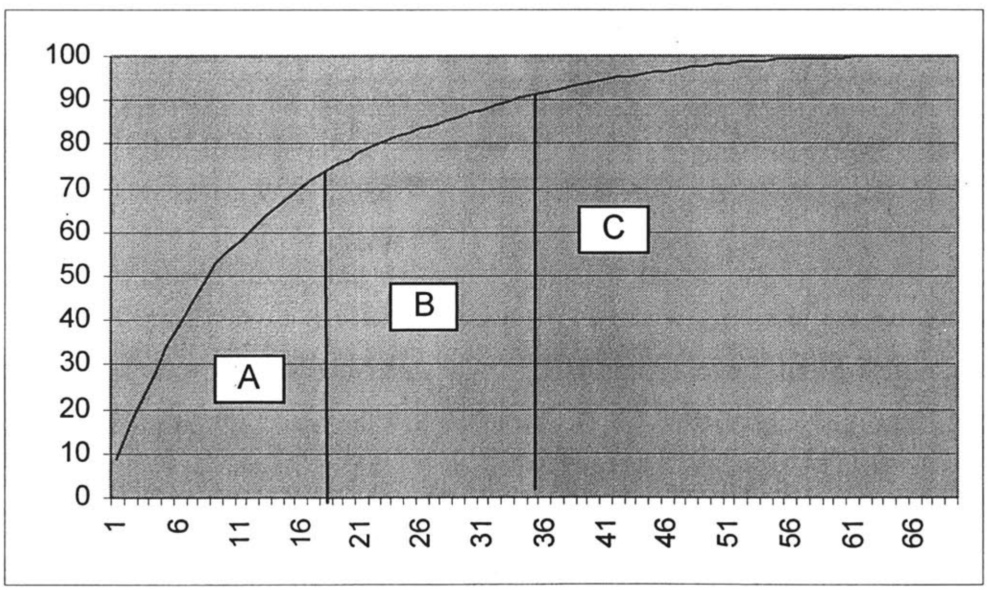
6.5.1 Pilot Parts: ABC Analysis

The first step is to perform an ABC analysis for the welded housing part numbers.

A parts = 80% of spend / 30% of parts

B parts = 15% of spend / 29% of parts

C parts = 5% of spend / 41% of parts



The first thing to observe here is that the parts do not demonstrate normal ABC behavior. This makes sense, since the welded housings are comparatively homogeneous. Their input components are relatively homogeneous as well and much of the cost-differentiation occurs at a downstream operation: final assembly.

Based on the ABC analysis, all welded housings will be supplied to downstream operations with the same service level.

6.5.2 Pilot Parts: Safety Stock Strategy

Through discussions with the work center planner, we developed a strategy for welded-cabinet safety stocks. The team decided on proper values for data selection, lead time and service level.

1) Data selection

   When using a statistical method to make operations decisions, proper selection of input data is critical. It's important to have a dataset large enough to analyze a predictive set of datapoints. A time period of three months was chosen for this analysis.

   One should also consider the overall demand characteristics of the product. Does product demand experience seasonality or trending? For welded housings, the parts are more generic than their finished goods part numbers. Seasonality effects of more than 300 finished goods part numbers are pooled into 80 base cabinet part numbers, dampening the seasonality fluctuations.

2) Lead time (from order signal to availability at next process)

   In the past, welded housings were managed (physically and electronically) to a four-day lead time. With the implementation of a prioritized planning tool (Chapter 5), this lead time could be reduced to three days. Although SAP auto-processing settings have a time window of five days, a standard lead time of three days was used to calculate safety stock levels.

3) Service Level

   The final decision has to do with Service Level. Since Service Level is an ambiguous concept, defined here as the probability that lead time demand will not exceed a calculated quantity R, a different approach was taken. Several possible safety stocks were calculated to examine the total stock impact of different service level choices.

069_Calc_DurchBestand_%

Prozent	Alte Durch Bestand	Neue Durch Bestand	Alte DurchBestand €	Neue DurchBestand €	Unterschied	Ist-Zustand Palletten	Neue Palletten
85%	1.309	1.206	59.334 €	53.348 €	-5.667 €	302	318
86%	1.309	1.224	59.334 €	54.150 €	-4.865 €	302	321
87%	1.309	1.245	59.334 €	55.182 €	-3.833 €	302	331
88%	1.309	1.263	59.334 €	55.963 €	-3.051 €	302	339
89%	1.309	1.282	59.334 €	56.814 €	-2.200 €	302	344
90%	1.309	1.309	59.334 €	58.153 €	-861 €	302	353
91%	1.309	1.330	59.334 €	59.121 €	106 €	302	357
92%	1.309	1.353	59.334 €	60.113 €	1.099 €	302	366
93%	1.309	1.387	59.334 €	61.697 €	2.683 €	302	377
94%	1.309	1.423	59.334 €	63.327 €	4.313 €	302	389
95%	1.309	1.458	59.334 €	64.929 €	5.915 €	302	402
96%	1.309	1.503	59.334 €	66.815 €	7.801 €	302	417
97%	1.309	1.550	59.334 €	69.098 €	10.084 €	302	427
98%	1.309	1.631	59.334 €	72.677 €	13.662 €	302	460
99%	1.309	1.740	59.334 €	77.756 €	18.742 €	302	492

From this summary, one can observe that a Service Level of 90% will maintain the current stock level (1,309 units). Selecting a Service Level of 90% indicates a desire to maintain existing stock levels, but to correct the existing safety stock quantities.

Using a 90% Service Level, the planner then ran the tool and reviewed suggested safety stocks. Upon making some manual adjustments for new products and special case parts, the planner completed the process and uploaded the safety stock values into SAP.

6.5.3 Results of Pilot

As discussed above, the purpose of this pilot was to correct safety stock levels, not to reduce them. Prior to correction, the safety stock levels were providing a service level of 69%. Therefore, the first result is an increase in statistical service level from 69% to 90%.

The second result was a reduction in inventory. Since the correction involved reducing stock levels of some higher-cost items, replacing them with other lower-cost items, the aggregate safety stock value experienced a reduction by 7.000 € ($8,400). In this case the correction resulted in an inventory reduction. Similar corrections may involve increases in inventory dollar-value when keeping overall inventory quantities static.

6.5.4 Further Analysis: Fill Rate

It is important to provide a little more resolution to the above Service Level term. Service level is defined as the probability that lead time demand will not exceed a calculated quantity. Perhaps a more useful metric is that of Fill Rate. Fill rate, or item availability, is defined as the fraction of demand met with off the shelf stock. This section is also based upon lecture notes of MIT Professor James Masters.

$$\text{Fill Rate} = 1.0 - (\text{Expected Units Short} / \text{Order Quantity})$$
$$FR = 1.0 - E[US]/Q$$

Expected units short (E[US]) can be defined as:

$$E[US] = N[k]s$$

As before, "s" is the standard deviation of demand during lead time. We obtain N[k] by converting the k-value into standard deviations's worth of expected units short. (The conversion table, "Table of Unit Normal Loss Integrals", can be found in Appendix E)

Therefore,

$$FR = 1.0 - N[k]s/Q$$

To analyze this in the context of our problem, the N[k] value is determined for a service level of 90%. For SL = 90%, k = 1.28 and N[k] = .04750.

The FR value is then calculated for each part number to obtain an aggregate Fill Rate. The resultant Fill Rate for the pilot parts is 98.8%. This can easily be interpreted to say that 98.8% of the time, downstream operations will fulfill requirements with housings pulled from stock.

6.5.5 Next Steps and Projections

The author suggests lot-size reduction as a next step for operations improvements in this area.

Reducing welding Lot Sizes by 50% will allow production to do one of two things:

1) maintain 90% service level with only 900 cabinets, reducing safety stock value by 18.000 € ($21,600).

-or-

2) maintain 1300 cabinets and achieve 98.5% service level. A 98.5% service level achieves near 100% Fill Rate.

Similar improvements could also be achieved through lead time reduction efforts.

6.6 Planning Strategy: Purchased Parts

The process used in the section is similar to the one used for the determination of purchased part safety stocks. As discussed above, the goal is to identify parts and develop systems in ERP to enable auto-processing functions. Accurate safety stock values are critical for the success of an ERP-managed procurement process.

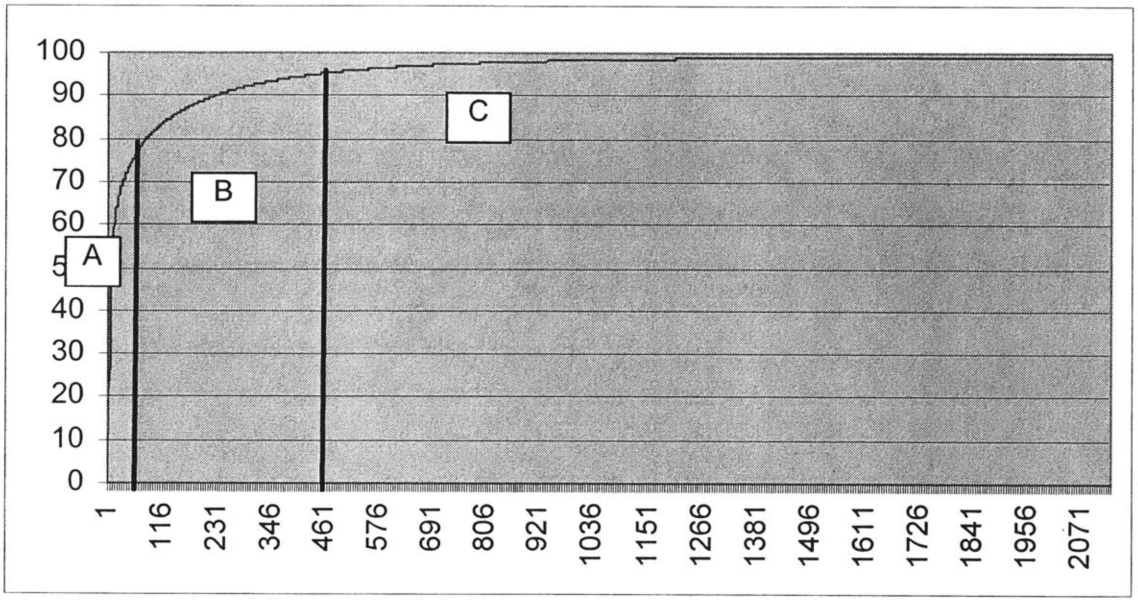
6.6.1 Purchased Parts: ABC Analysis

The first step is to perform an ABC analysis for the purchased part numbers.

A parts = 80% of spend - 4% of parts

B parts = 15% of spend - 17% of parts

C parts = 5% of spend - 79% of parts



As shown in the above graph, purchased parts at this ABB facility are nearly a textbook example of part-cost behavior. The recommendation below will be consistent with textbook interpretations of this behavior.

6.6.2 Purchased Parts: Strategy Recommendation

In order to achieve the greatest efficiency of indirect labor resources, time should be focused on decision-making tasks that have the greatest business impact. In the case of purchasing, this means buyers should spend their time managing A-parts and develop systems to automate the procurement of B and C parts.

Striebel & John buyers should use the safety stock calculation tool to determine appropriate safety stock levels for all B & C parts and activate automatic processing. A approach similar to that used for make parts could be used by first correcting safety stock levels to maintain the current part count, and then reducing stock levels as desired. An arbitrary starting point is to set safety stock service levels at 95% for B-parts and 99% for C-parts, keeping in mind that higher safety stock levels for the cheaper 20% of parts will not have a great impact on overall stock levels.

As far as A-parts are concerned, employees should work to develop systems of continuous smooth flow with minimal or no safety stock. Procurement lot sizes should be small and the factory should maintain less than one week of supply on-hand

6.7 Summary

The analysis and actions described in this chapter focus on the development of material management systems that are designed to both improve operations performance and reduce non-value-added work. As demonstrated with this tool, companies are often able to support greater service levels with less inventory if they are managing their inventory levels effectively.

One key insight is that companies should focus their time and money managing the items that most impact plant performance (A-parts) and establish robust, highly-automated systems to manage the remaining items. Similar to chapter 5, this discussion highlights the benefit of information technology tools when analyzing large datasets and enabling data-based decision-making. When planners are able to make informed, data-based decisions, then they will be able to schedule and prioritize material much more effectively, reducing total system waste.

CHAPTER 7: CHANGE MANAGEMENT I: CULTURAL ANALYSIS

7.1 Introduction

The purpose of this chapter is to raise awareness of issues faced when working in a second culture and language, and to examine the impact it has on change leadership. The reader should be aware that the issues presented in this chapter draw conclusions based mostly upon the author's personal experiences carrying. While previous chapters have been founded on collected data, this section draws conclusions based upon personal interactions, assumptions and opinions. This chapter in no way implies that the behaviors discussed here are typical of German workers or ABB employees.

7.2 Cultural Landscape

Corporate vs. Local Issues

In large organizations with multiple factories, it is often a challenge to manage companies to both corporate and local objectives. This is particularly true with large, global organizations. ABB's decentralized structure, and small corporate staff, has nurtured a culture that thrives on local innovation and hands-off corporate support. Most people at this project location refer to themselves not as ABB employees, but as Striebel & John employees. The building signs and literature reinforce this, displaying "Striebel & John" over "ABB". In many respects, this makes sense. Prior to acquisition by ABB, Striebel & John had established its brand in the industry and it would have been foolish to erase that brand recognition. Customers expect the name Striebel & John and the ABB culture supports this decentralized structure.

Such disconnection, however, makes corporate initiatives difficult. Corporate lean objectives are more complicated and difficult to coordinate, and there are few instances of information-sharing across factories. When lean objectives are driven at the business unit level to be executed by the local organizations, success of the initiatives are highly dependent upon local leadership and commitments to lean.

"Although team members focus on issues broader than their local site, their participation with the team often reflects their local circumstances." [15]

Further research in this area is appropriate, with the goal of finding the best possible system of lean standardization while maintaining the strengths of a decentralized culture.

Age-gap Challenges

One cultural challenge that exists in many companies involves the general division of employees along generational lines and the specific division when new technologies are introduced.

Striebel & John is an established organization, boasting several employees who have worked at the Sasbach facility for more than 25 years. The company has also hired many newer, younger employees and promoted them to leadership positions. The culture is notably divided with different roles and different expectations for each group. The younger employees are often less knowledgeable, but they tend to be more involved with process improvement efforts. Older employees exhibit a wealth of experience and knowledge, yet they seem to have specialized work within static, defined roles. We see similar divisions when considering the use of new technology. Some employees have stronger computing skills and the ability to use them to do their jobs more efficiently; others cling to less-efficient manual processes.

These cultural scenarios create a reinforcing technology gap, where employees with strong computer skills are given more responsibility for change and improvement, increasing their desires for additional technology knowledge acquisition. Other employees, entrenched in existing perspectives, spend less time in process improvement projects, resent the employees who have assumed leadership roles, and participate less in improvement efforts that benefit the company.

The key insight here is that Striebel & John has two distinct cultural groups that must be leveraged in different ways. The groups are visible and strong, and they complement each other well. Each group is strongest when the other group is strongest. Therefore, it is important to acknowledge the existence of such disparate cultural groups and cultivate systems that allow them to achieve their potentials and work together efficiently.

7.3 Analysis of Leadership Strategy When Communicating in Second Language

The greatest environmental factor that impacted the author's role in this project involved communication. Few employees at the factory spoke English, so the author had no option but to learn German. The language barrier made him an "outsider" and, despite attempts at sense-making and assimilating, he experienced a constant struggle to gain respect and credibility.

The company culture seemed unwilling to meet him halfway on language issues and continued to maintain social walls throughout the internship period. The author raises this point with some trepidation when considering the English-language requirements imposed by most US companies. Such language requirements are necessary for the efficient operation of companies and it's understandable that a company would not sacrifice such efficiencies for a short-term internship project. However, as companies become ever more global and multi-cultural, those able to effectively integrate outsiders and manage across languages will someday realize a global competitive advantage.

One can only postulate the root causes that obstructed the author's ability to have common work interactions with colleagues. Perhaps it was because he was an intern, or because he was an American in a German factory, or perhaps it was due to his poor German skills. A very reasonable explanation is that his project role, to reduce non-value-added work, may have been threatening to some employees. It could have been any one or a combination of these factors. Regardless, it's reasonable to think that much of the resistance experienced was simply due to the fact that he was an "outsider", lacking the efficiencies of formal and informal networks.

7.4 Reflections on Cross-cultural Change Management

> *"And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, then to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.."* [16]

One of the most valuable take-aways from this internship was the experience in cross-cultural change-management. Every change leader faces things that enable change and things that work to resist change. Cross-cultural change leadership may involve multiple languages, unexpected cultural norms, and assumptions about differences, not to mention issues that exist in same-cultural change-management. The key is for leaders to be aware of these factors, work to recognize those that are real constraints, and then take action to drive change within those constraints.

The author's struggle to learn German during the first couple months of work strained his ability to effectively lead teams. The author found that when faced with challenges of influence in the organization, he was able to accomplish more by working through a German colleague. Such a person is often referred to as a "gate-keeper". In this way, the author was able to influence change by leveraging the informal networks of a respected coworker.

The author also had success using creative communication methods. In many situations, messages were communicated by drawing pictures and using hand-gestures. In other situations, the best thing to do was to find real-life examples. He learned how to say "Can you show me?" in German and moved meetings from the conference rooms to the factory floor. The key insight here is that when verbal communication is strained, much can be accomplished by utilizing the other senses of sight and touch.

Another method of working within the constraints is to consider one's audience and focus deliberate language choice on the words that would be most important and influential for those individuals. When working with one gentleman, an appeal to logic was always the most persuasive method of influence. Recognizing this constraint, it was easier to bring focus to the difficult tasks of communication and have success.

In the end, a leader can learn best by doing – by attempting to lead change in a different culture and to recognize the new issues that arise.

7.5 Lessons Learned

> *"Leadership cannot be taught, but it can be learned."* [17]

The above quote holds true when discussing cultural sensitivity and cross-cultural leadership. Individuals likely learn best by doing, but value must be also recognized in the telling of stories and sharing of lessons learned from people who have had cross-cultural experiences. Presented below are the four most significant insights obtained from this project.

1) Language is a powerful enabler...or disabler

It will be increasingly important for manufacturing leaders to recognize language barriers and work to eliminate them. This requires cultural sensitivity and patience. Leaders should work to engage all employees, especially when working in environments with an English-skills requirement.

2) Cultural differences are real, but be careful about assumptions

It's important for leaders to be aware of cultural differences, but not to jump to conclusions about what they mean. Until one really understands a culture, it's really best to ask questions and model behavior. Making incorrect assumptions can be quite costly, not to mention embarrassing.

3) "The hard stuff is easy. The soft stuff is hard. And the soft stuff is more important than the hard stuff." [18]

The greatest difficulty of any change exists in the implementation. This difficulty is certainly amplified when a common language is not present. Leaders who develop proficiency in standard and cross-cultural communication skills will ultimately better-develop their employees and achieve far greater goals.

4) Figure out a way

Change must happen. At the end of the day, there is a job to be done. A lack of language skills is no excuse for reduced performance. The author's struggles with language in no way reduced the project expectations. Similarly, organizations have no excuse for allowing language to be a performance-inhibiting issue. As mentioned above, companies and managers that are able to effectively integrate outsiders and manage across languages will someday realize a global competitive advantage.

CHAPTER 8: CHANGE MANAGEMENT II: STRATEGIC ANALYSIS

8.1 Introduction

> *"ABB is an organization with three internal contradictions. We want to be global and local, big and small, and radically decentralized with centralized reporting and control."* [19]

This section discusses three major strategic design issues experienced while on internship at ABB - Striebel & John. The first is the formal structure of the corporate lean initiative. The second is the way in which responsibilities are divided among planners and controllers. The final section discusses the definition of a "change agent" role in the organization.

8.2 When Corporate Strategies Collide

ABB is known as a flagship decentralized company. Individual ABB companies have great autonomy in their strategic decisions, including their lean manufacturing strategies. Recent efforts at the corporate business unit level to formalize lean efforts have been strained.

The ABB business unit lean strategy is developed by an individual corporate employee in Norway, who then works to influence and align the companies to the goals and objectives. The problems occur when the corporate objectives are not fully-supported by the local companies or are not fully-communicated to the project team.

> *"Determining how to implement can be delegated to middle managers and consultants, but the decision to embark on the journey – and the allocation of resources to support it – has to come from the chief operating officials, and they must understand their commitment to the process."* [1]

The challenge for local leaders is to identify the value of global corporate collaboration, and coordinate local actions that support global objectives without sacrificing the innovative spirit of local continuous improvement.

In conclusion, it appears that ABB has a strategic design that supports but does not enforce corporate lean manufacturing initiatives.

8.3 Local Strategic Design

When examining the project group, it seemed that the organizational grouping of employees has the potential of inhibiting grander lean implementation efforts. Each work center has two people who have management responsibility. Controllers are responsible for a work center's processes and people; planners are responsible for work prioritization and on-time delivery. As planners are driven to reduce lead times, controllers have incentives to increase work center utilization. A planner's efforts to meet his or her objectives through lot size reduction will face resistance from the controllers who have incentives to maintain high work center utilization rates.

This strategic design is not, in itself, detrimental to the organization. It is a system of balanced power by which two employees discuss issues and make decisions that best meet company objectives. However, the metrics used for each type of manager cause system strain and may slow the implementation of lean manufacturing. Conflicting metrics inhibit collaboration and slow change efforts. A strong lean effort requires alignment of goals and metrics towards a common goal.

8.4 "Change agents"

Striebel & John has implemented a system of internal "change agents". These individuals are hand-picked by Striebel & John upper management as employees capable of driving change within the organization. They receive off-site training on group dynamics and decision-making and are key individuals on team initiatives.

The logic behind the "change agent" philosophy is sound, but it may not be the best strategic method to drive organizational change. Singling out a hand-picked group of employees sends several signals to the rest of the organization. This may discourage other employees from participating in change efforts. Other employees may even resist change initiatives because they were not selected as an official company change agent. The company could seek out alternative methods, eg. training or incentives, to engage ALL employees as change agents.

CHAPTER 9: THESIS SUMMARY

This chapter provides a review of all concepts discussed in this thesis and summarizes the results. The first section focuses on technical aspects; the second focuses on organizational change aspects; the third provides closing remarks and final takeaways from the project.

9.1 Technical Analysis

This thesis discusses the use of value stream mapping to direct the actions of a non-value-added step reduction. The first step was to map the internal value stream and collect performance data for each process step. The next step was to identify steps that we unnecessary, or non-value-added, and generate tools or processes that eliminated or reduced the time necessary for those steps. Actions included reducing wasteful time-gaps in the bottleneck work center, reducing paperwork for planners and operators, developing planning tools that improve information flow efficiency, and calculation of safety stocks levels to automate tactical planning functions.

The Non-Value-Added step reduction yielded reductions in costs, labor time and inventory levels. The actions described in this thesis reduced yearly operations costs by over $90,000 and planner labor time by 700 hours. The inventory pilot demonstrated a situation where the company was able to increase service level from 69% to 90% and simultaneously reduce inventory by $8,000. Further reductions in inventory can be expected with each iteration of safety stock review.

9.2 Organizational Change Analysis

This thesis discusses change management issues that arise when leading factory improvement efforts as corporate lean implementations are often met with resistance. This thesis also discusses some challenges faced when leading change in a different culture and second language.

There are a number of insights that arise from this discussion:

First, strategic design is very important for change leadership. Without proper incentives, employees will often resist change, even if it makes their jobs easier.

Second, when working in a second language, change leadership has a whole new set of challenges. It is important for both individuals and organizations to properly acknowledge these challenges and then to seek creative ways to work through these challenges.

Third, while recognizing that multi-cultural change-management is difficult, it should be viewed not as a constraint but as an opportunity for competitive advantage. Companies and managers that are able to effectively integrate outsiders and manage across languages will someday realize a global competitive advantage.

9.3 Concluding Remarks

Perhaps the greatest opportunities for ABB, and many other companies that are considering lean implementation, exist in the definition of their operations strategy. One path is for the company to fully-embrace lean principles.

> *"Companies that have enjoyed the greatest success in transitioning to lean manufacturing are those that take a holistic approach and view the transformation as a fundamental restructuring of the Enterprise, including its organizational structures, business and information systems, workforce policies, incentive systems, and relationships with customers and suppliers."* [20]

However, if this strategy is not feasible, the tools of lean should not be discarded. As demonstrated in this thesis, value stream mapping and non-value-added step reduction are effective stand-alone tools for operations improvements.

The work performed as part of this thesis was both challenging and educational, and it provided immediate gains for ABB. A greater benefit will come over the years as ABB continues to strive for operational excellence. The company has the experienced resources and motivated leadership necessary to develop new tools and processes that reduce waste and satisfy the needs of their customers now and in the future.

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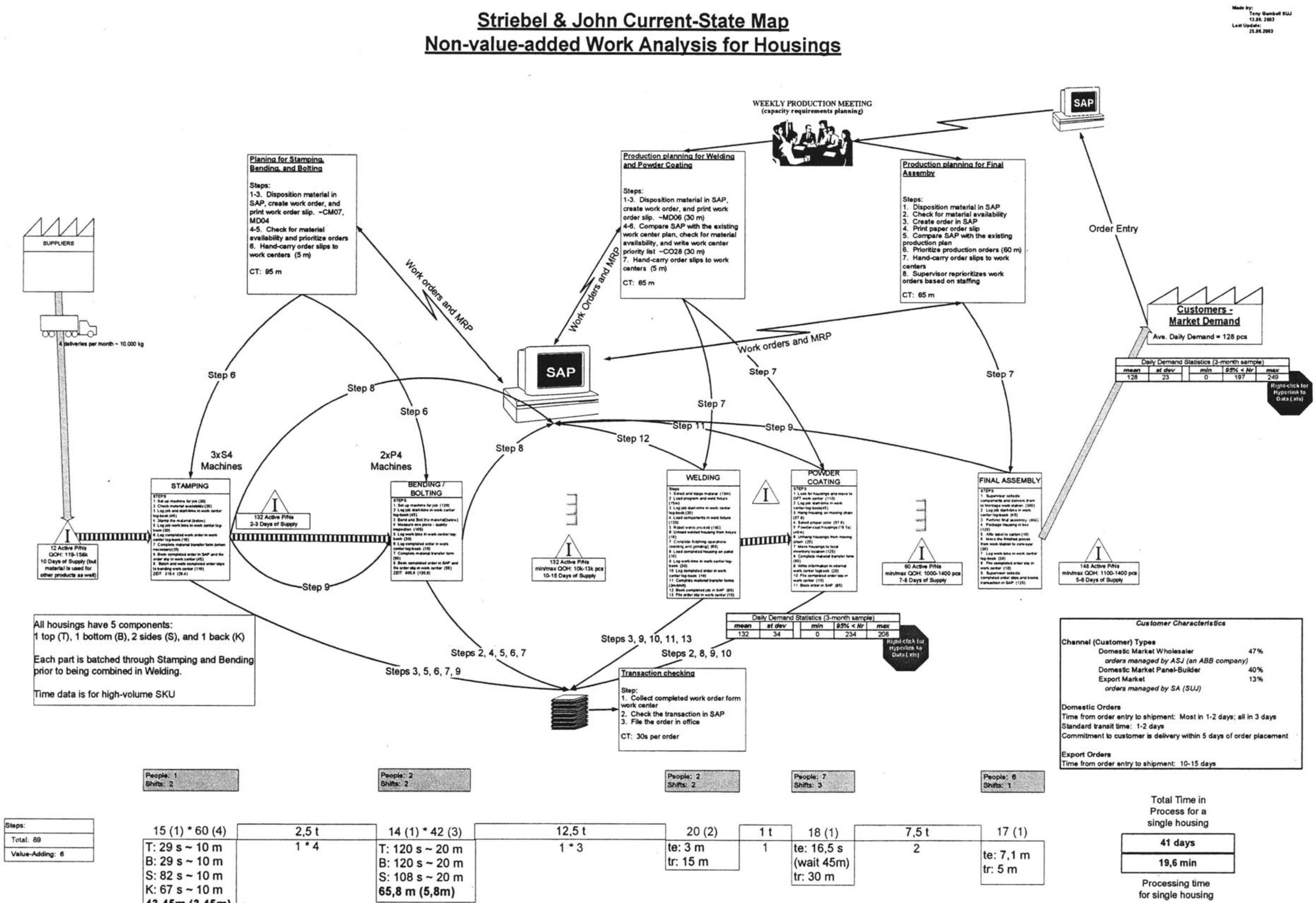
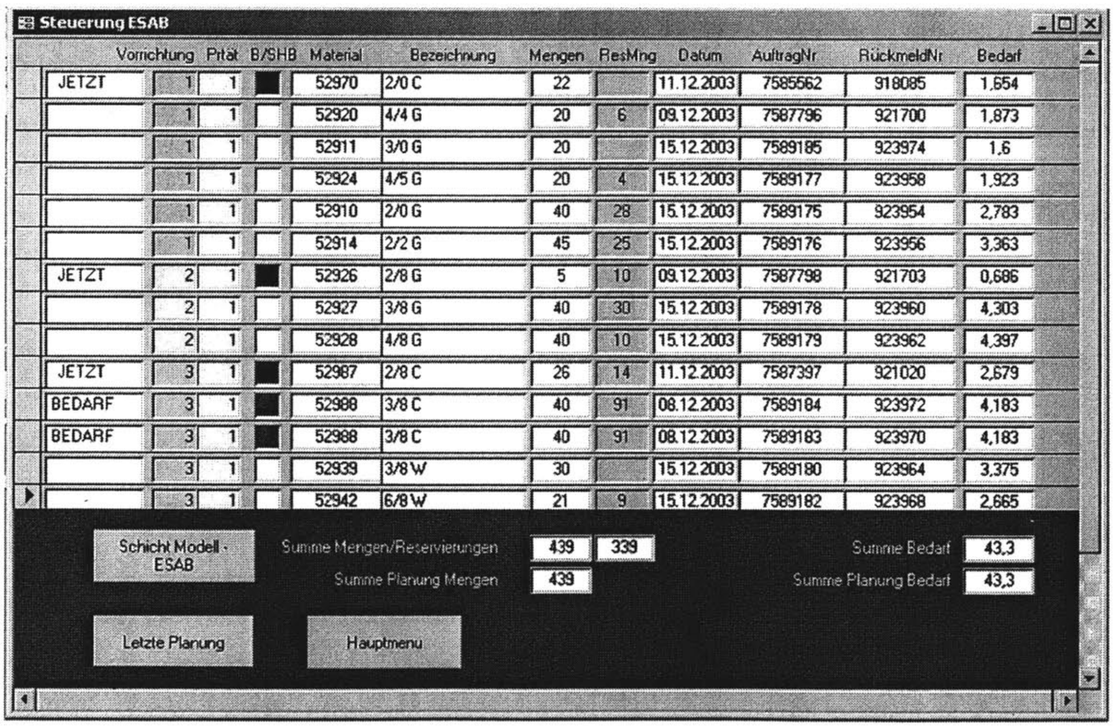
APPENDIX A: Striebel & John Value Stream Map (VSM)



APPENDIX B: Planning Tool Description

This section includes screenshots of the Planning Tool. When necessary, German words are provided in parentheses.

This control screen contains all open orders for the welding work center. Looking across the columns from left to right, the user can see which products are currently running in the work center, indicated by the word NOW (JETZT). The planner can also quickly identify those work orders that are filling demand as opposed to safety stock, indicated by the word DEMAND (BEDARF)
The second column provides a suggested grouping of work orders for the three fixtures. The planner then has the flexibility to accept the suggested priority of work orders or to change it by manipulating the numbers in the third column.
All additional columns to the right contain work order information including part number, description, quantity, etc….
In the red section at the bottom, the planner can review total quantities planned (Summe Mengen) and hours of capacity required (Summe Bedarf),



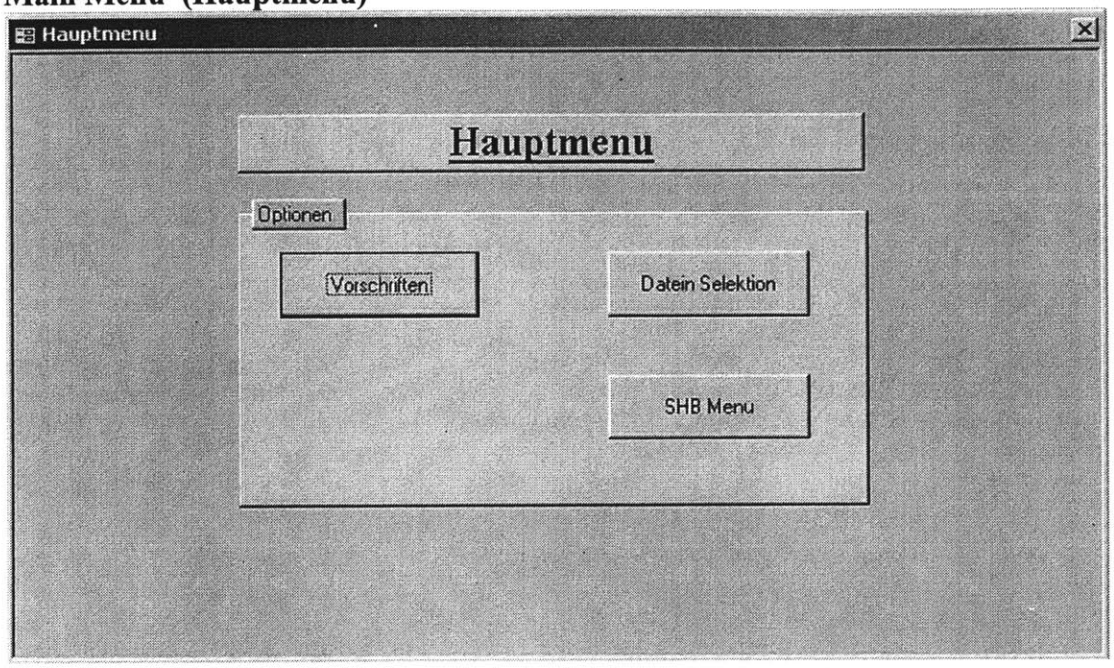
	Vorrichtung	Prität	B/SHB	Material	Bezeichnung	Mengen	ResMng	Datum	AuftragNr	RückmeldNr	Bedarf
JETZT	1	1		52970	2/0 C	22		11.12.2003	7585562	918085	1,654
	1	1		52920	4/4 G	20	6	09.12.2003	7587796	921700	1,873
	1	1		52911	3/0 G	20		15.12.2003	7589185	923974	1,6
	1	1		52924	4/5 G	20	4	15.12.2003	7589177	923958	1,923
	1	1		52910	2/0 G	40	28	15.12.2003	7589175	923954	2,783
	1	1		52914	2/2 G	45	25	15.12.2003	7589176	923956	3,363
JETZT	2	1		52926	2/8 G	5	10	09.12.2003	7587798	921703	0,686
	2	1		52927	3/8 G	40	30	15.12.2003	7589178	923960	4,303
	2	1		52928	4/8 G	40	10	15.12.2003	7589179	923962	4,397
JETZT	3	1		52987	2/8 C	26	14	11.12.2003	7587397	921020	2,679
BEDARF	3	1		52988	3/8 C	40	91	08.12.2003	7589184	923972	4,183
BEDARF	3	1		52988	3/8 C	40	91	08.12.2003	7589183	923970	4,183
	3	1		52939	3/8 W	30		15.12.2003	7589180	923964	3,375
	3	1		52942	6/8 W	21	9	15.12.2003	7589182	923968	2,665

Upon review, the planner then selects a button (Schicht Model – ESAB) to create the work center planning sheet.

APPENDIX C: Safety Stock Database Tutorial

This section includes screenshots of the Safety Stock Calculation Tool. When necessary, German words are provided in parentheses.

Main Menu (Hauptmenu)

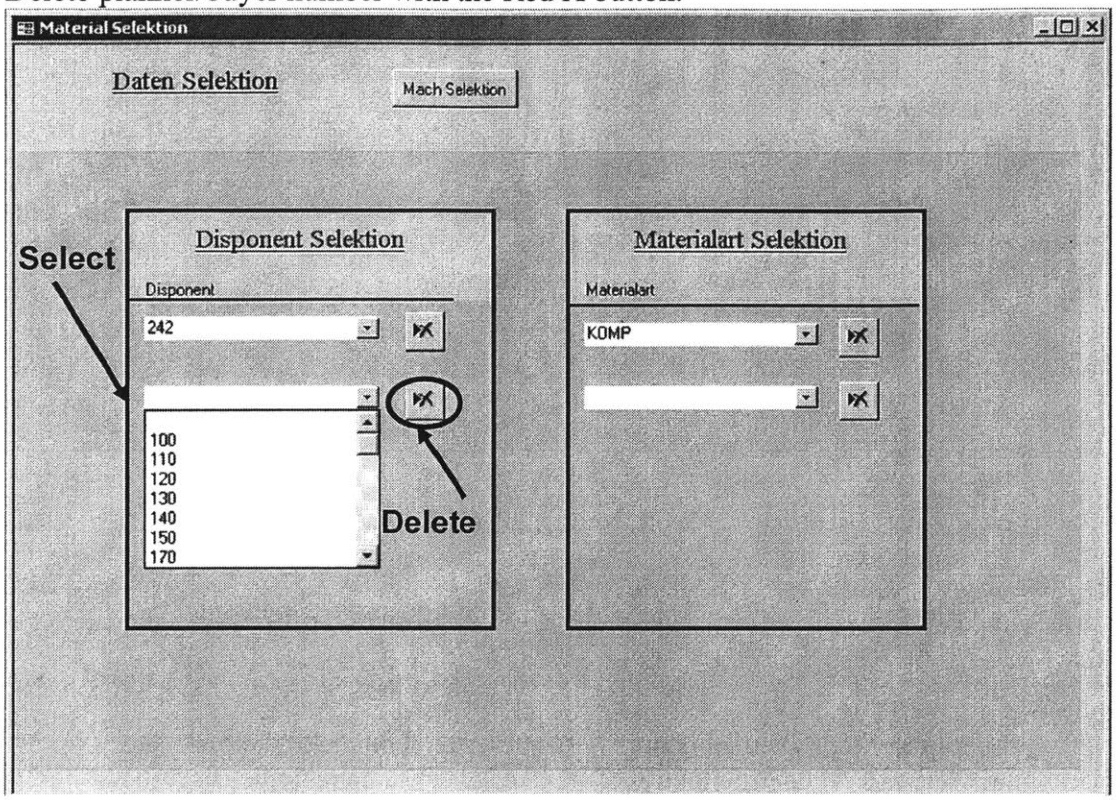


Options (Optionen)

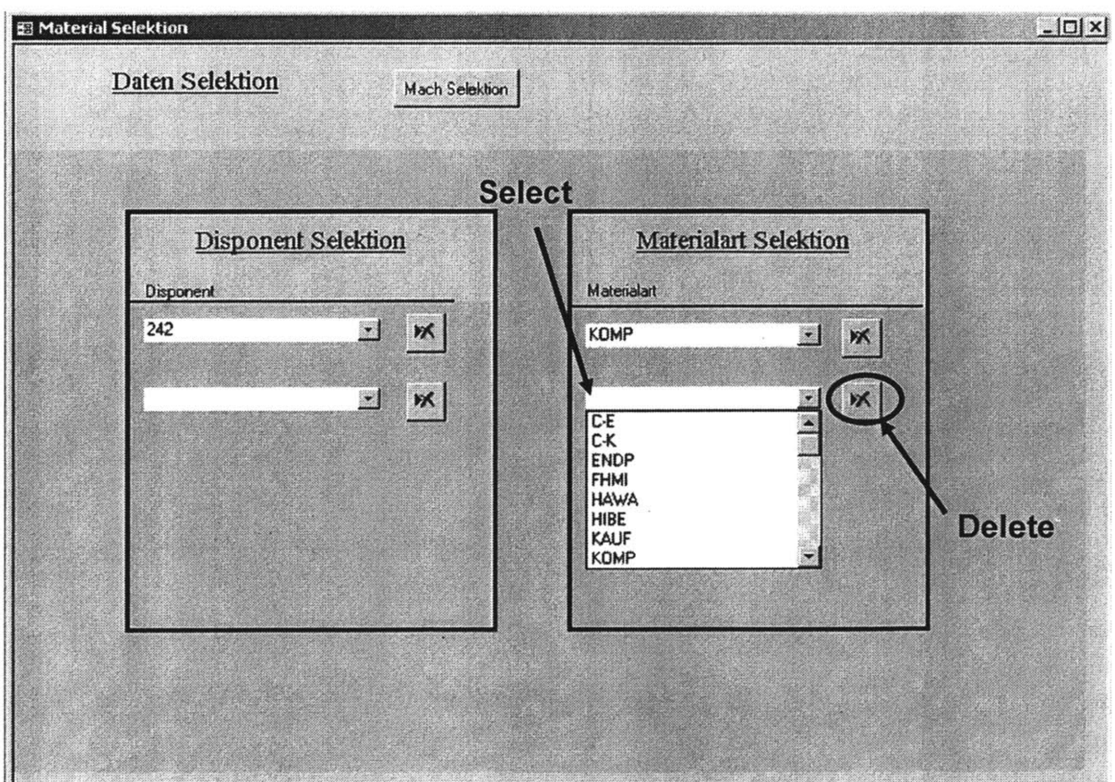
Preparation Steps (Vorschriften) = Information about SAP downloads
Data Selection (Daten Selektion) = Data Selection panel to be discussed below
Safety Stock (SHB) Menu = Safety Stock Panel to be discussed below

Data Selection

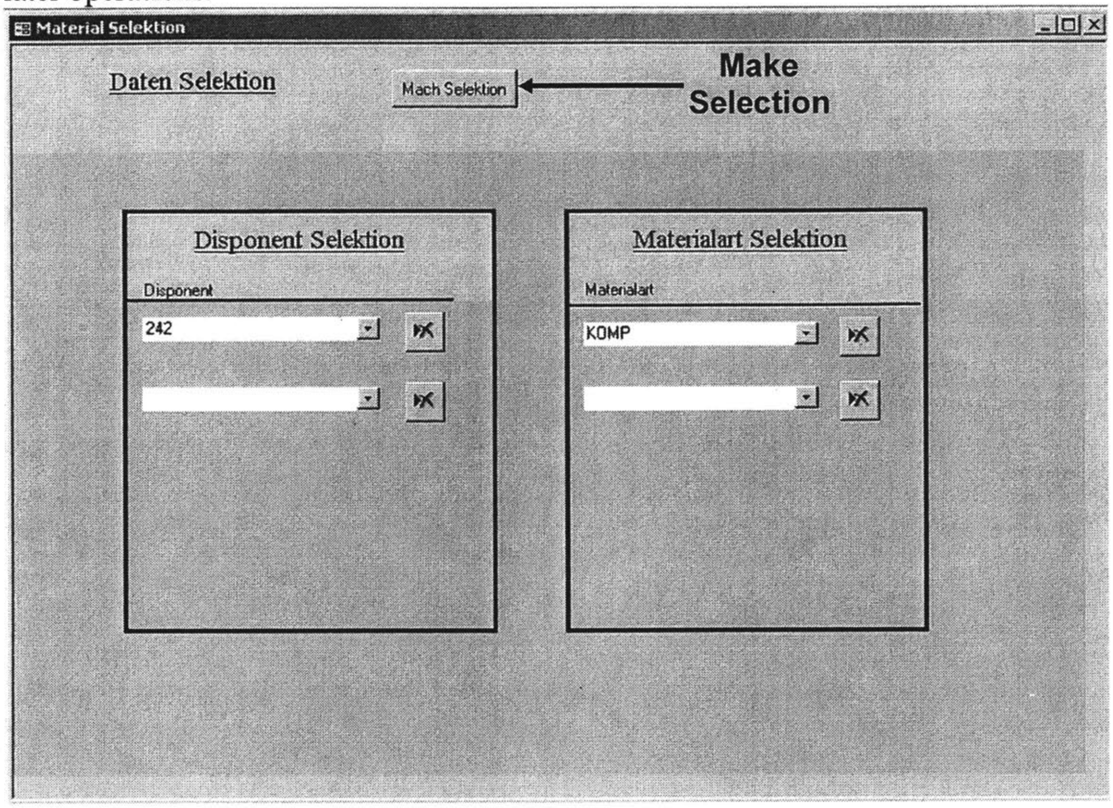
1) Select one or more part groups, designated by planner or buyer number (Disponent). Options are limited to those included in the SAP Material Master.
Delete planner/buyer number with the Red X button.



2) Similarly select part type (Mateiralart)



3) Make selection (Mach Selektion). Access will create a subset of the data to perform later operations.



After selecting desired data, Access will return to the Main Menu panel.

Safety Stock Menu (SHB Menu)

1-Data Selection (Daten Selektion) (Data selection information is shown in the upper bar)

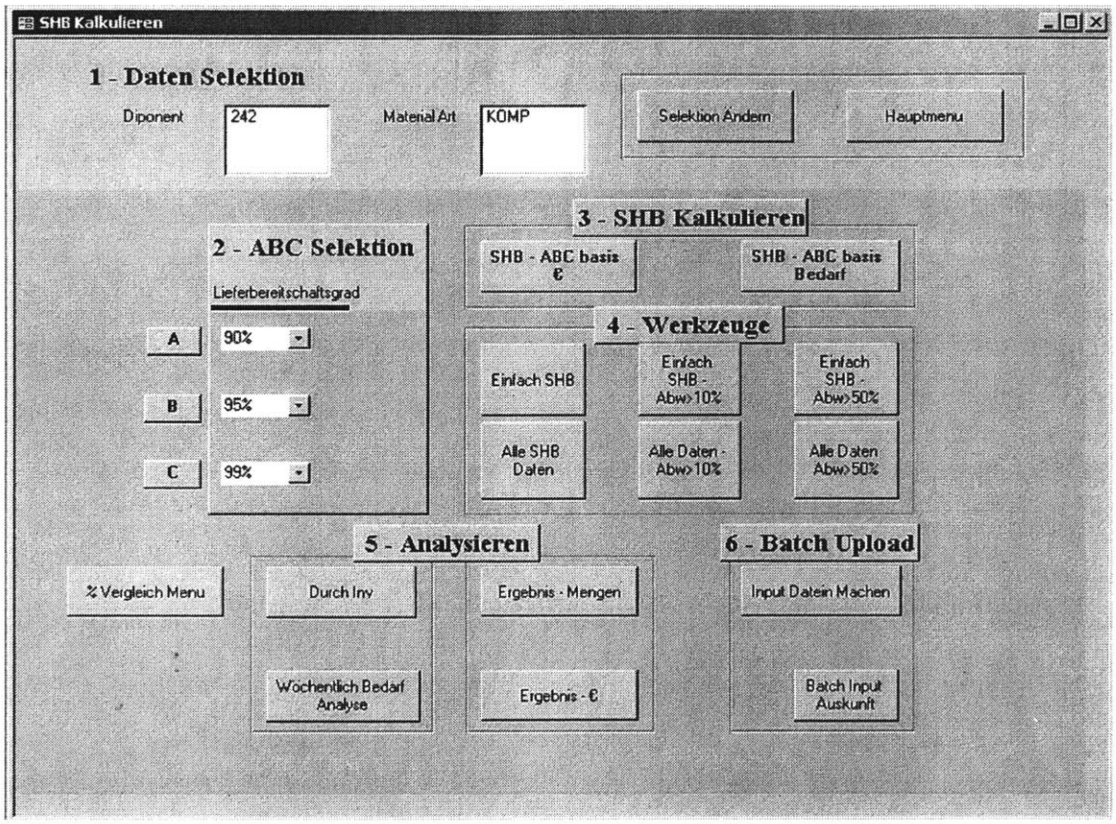
The first two boxes are for information only. They display the data selection as a confirmation for the user.

Change Selection (Selektion Ändern) Button:

This button will return user to the Data Selection Panel

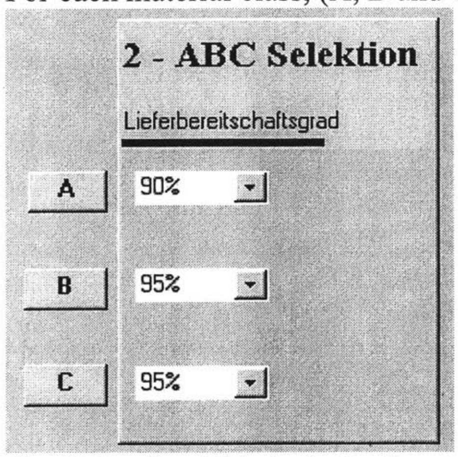
Main Menu (Hauptmenu) Button:

This button will return user to the Main Menu



2 - ABC Selection (Selektion)

For each material class, (A, B and C) choose a service level (Lieferbereitschaftsgrad).



The following table includes the statistical Z-values (Z-Nummer), the possibilities for service level (Prozent) selection. (Z-values are statistical safety factors.)

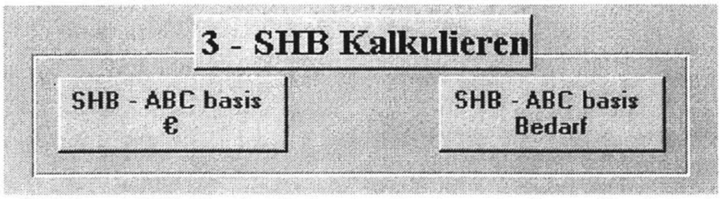
041_Statistik_Daten : Table

Prozent	Z-Nummer
0%	-1
50%	0
70%	0,524401003
75%	0,674490366
80%	0,841621386
81%	0,877896582
82%	0,91536549
83%	0,954164534
84%	0,994457423
85%	1,036432877
86%	1,080320544
87%	1,126390998
88%	1,174987574
89%	1,226528639
90%	1,281550794
91%	1,340754352
92%	1,405073817
93%	1,475791578
94%	1,554772098
95%	1,644853
96%	1,750686351
97%	1,880789569
98%	2,053748176
99%	2,326341928

Important:
0% is a signal to ignore parts in the selected part class. If the user desires to calculate safety stocks for B&C parts only, then the safety factor should be set to 0% for A parts.

50% is a signal to carry out the calculations without additing safety stock. The suggested safety stock values for these parts will equal demand during lead time.

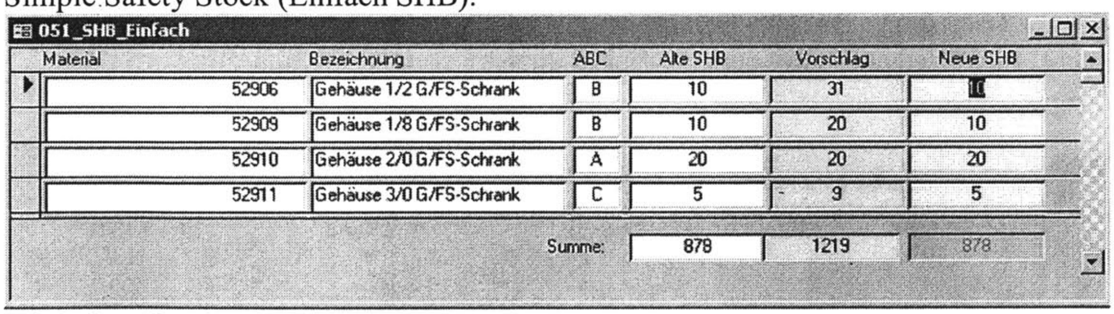
3 – Safety Stock Calculation (SHB Kalkulieren)
Select method of ABC Analysis.



„SHB – ABC Basis €" is standard analysis method that determines ABC classes based upon cost-weighted demand. "SHB – ABC basis Bedarf" is to be used when the user desires to calculate ABC classes based only on demand.

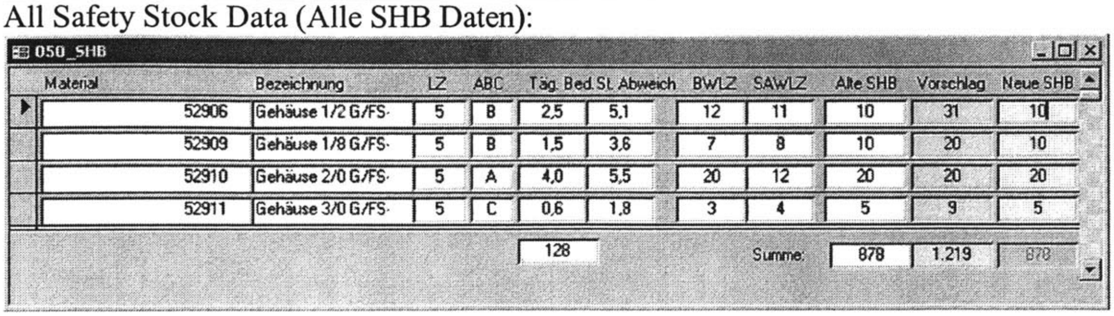
4 – Work tool (Werkzeuge)
The Work tool screen has six options. All six buttons reveal safety stock information in different forms. The buttons in the top row display easy (Einfach) analyses, with only overview calculations. The bottom row provides additional information (Alle Daten) including part-by-part statistical data.

Simple Safety Stock (Einfach SHB):



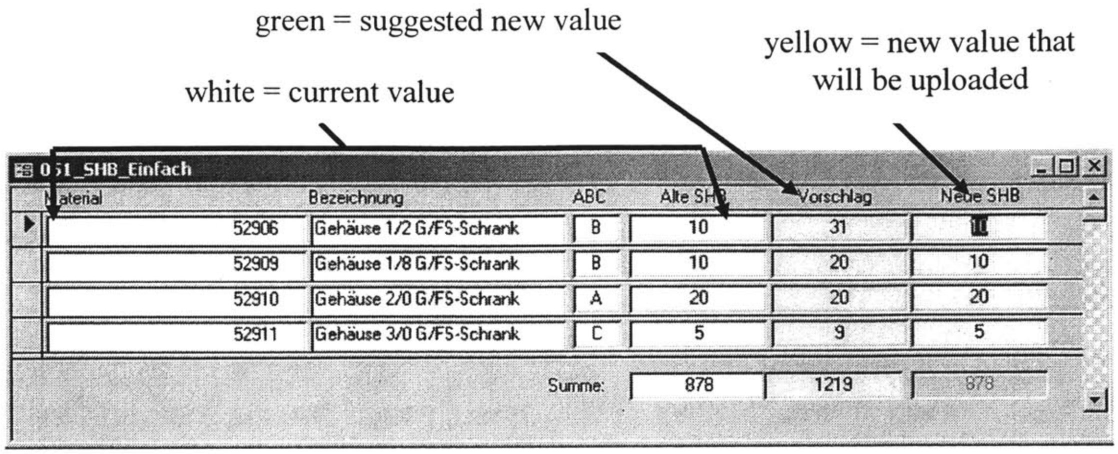
Material	Bezeichnung	ABC	Alte SHB	Vorschlag	Neue SHB
52906	Gehäuse 1/2 G/FS-Schrank	B	10	31	10
52909	Gehäuse 1/8 G/FS-Schrank	B	10	20	10
52910	Gehäuse 2/0 G/FS-Schrank	A	20	20	20
52911	Gehäuse 3/0 G/FS-Schrank	C	5	9	5
		Summe:	878	1219	878

All Safety Stock Data (Alle SHB Daten):

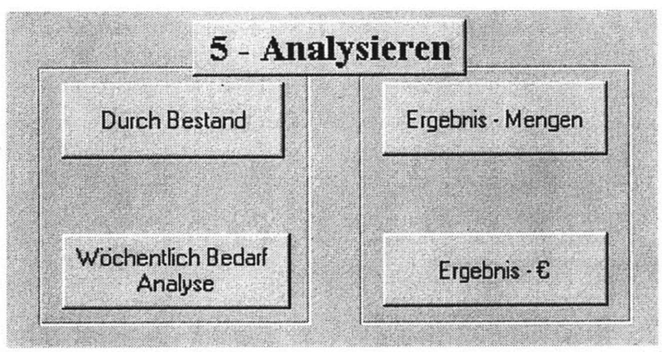


Material	Bezeichnung	LZ	ABC	Täg. Bed.	St. Abweich	BWLZ	SAWLZ	Alte SHB	Vorschlag	Neue SHB
52906	Gehäuse 1/2 G/FS-	5	B	2,5	5,1	12	11	10	31	10
52909	Gehäuse 1/8 G/FS-	5	B	1,5	3,6	7	8	10	20	10
52910	Gehäuse 2/0 G/FS-	5	A	4,0	5,5	20	12	20	20	20
52911	Gehäuse 3/0 G/FS-	5	C	0,6	1,8	3	4	5	9	5
				128			Summe:	878	1.219	878

Important:
In most cases, the color-scheme uses the following convention:



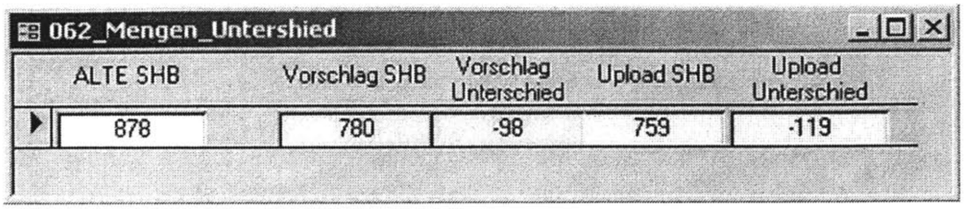
5 – Analysis (Analysieren)



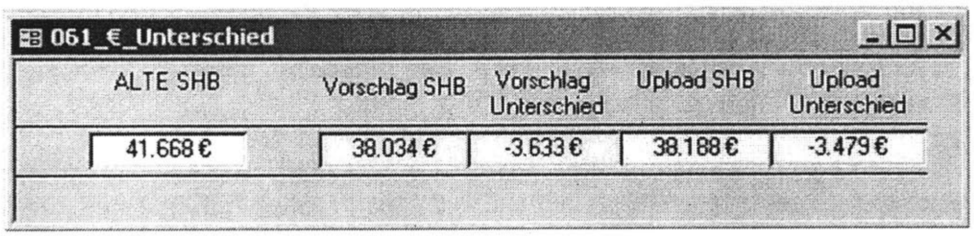
Average Inventory (Durchschnitt Bestand) : This screen provides a comparison of the current, suggested and new scenarios based upon theoretical calculations of average inventory.

Weekly Demand Analysis (Wochentlich Bedarf Analyse) : This table displays weekly demand per material.

Result in Pieces (Ergebnis – Mengen) **:** This screen provides a comparison of the current, suggested and new scenarios based upon total number of units in safety stock values.



Result in Euros (Ergebnis - €) : This screen provides a comparison of the current, suggested and new scenarios based upon total Euro-value of units in safety stock.



6 – Batch Upload

When the user has completed safety stock analysis, then this screen creates a batch file for upload into SAP.

APPENDIX D: Normal Table

A Normal Table
[K <=> SL Conversion]

K	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9278	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

APPENDIX E: Table of Unit Normal Loss Integrals

An Unusual Normal Table
K <=> N[K] Conversion

K	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.3989	.3940	.3890	.3841	.3793	.3744	.3697	.3649	.3602	.3556
0.1	.3509	.3464	.3418	.3373	.3328	.3284	.3240	.3197	.3154	.3111
0.2	.3069	.3027	.2986	.2944	.2904	.2863	.2824	.2784	.2745	.2706
0.3	.2668	.2630	.2592	.2555	.2518	.2481	.2445	.2409	.2374	.2339
0.4	.2304	.2270	.2236	.2203	.2169	.2137	.2104	.2072	.2040	.2009
0.5	.1978	.1947	.1917	.1887	.1857	.1828	.1799	.1771	.1742	.1714
0.6	.1687	.1659	.1633	.1606	.1580	.1554	.1528	.1503	.1478	.1453
0.7	.1429	.1405	.1381	.1358	.1334	.1312	.1289	.1267	.1245	.1223
0.8	.1202	.1181	.1160	.1140	.1120	.1100	.1080	.1061	.1042	.1023
0.9	.1004	.09860	.09680	.09503	.09328	.09156	.08986	.08819	.08654	.08491
1.0	.08332	.08174	.08019	.07866	.07716	.07568	.07422	.07279	.07138	.06999
1.1	.06862	.06727	.06595	.06465	.06336	.06210	.06086	.05964	.05844	.05726
1.2	.05610	.05496	.05384	.05274	.05165	.05059	.04954	.04851	.04750	.04650
1.3	.04553	.04457	.04363	.04270	.04179	.04090	.04002	.03916	.03831	.03748
1.4	.03667	.03587	.03508	.03431	.03356	.03281	.03208	.03208	.03137	.02998
1.5	.02931	.02865	.02800	.02736	.02674	.02612	.02552	.02494	.02436	.02380
1.6	.02324	.02270	.02217	.02165	.02114	.02064	.02015	.01967	.01920	.01874
1.7	.01829	.01785	.01742	.01699	.01658	.01617	.01578	.01539	.01501	.01464
1.8	.01428	.01392	.01357	.01323	.01290	.01257	.01226	.01195	.01164	.01134
1.9	.01105	.01077	.01049	.01022	$.0^{2}9957$	$.0^{2}9698$	$.0^{2}9445$	$.0^{2}9198$	$.0^{2}8957$	$.0^{2}8721$
2.0	$.0^{2}8491$	$.0^{2}8266$	$.0^{2}8046$	$.0^{2}7832$	$.0^{2}7623$	$.0^{2}7418$	$.0^{2}7219$	$.0^{2}7024$	$.0^{2}6835$	$.0^{2}6649$
2.1	$.0^{2}6468$	$.0^{2}6292$	$.0^{2}6120$	$.0^{2}5952$	$.0^{2}5788$	$.0^{2}5628$	$.0^{2}5472$	$.0^{2}5320$	$.0^{2}5172$	$.0^{2}5028$
2.2	$.0^{2}4887$	$.0^{2}4750$	$.0^{2}4616$	$.0^{2}4486$	$.0^{2}4358$	$.0^{2}4235$	$.0^{2}4114$	$.0^{2}3996$	$.0^{2}3882$	$.0^{2}3770$
2.3	$.0^{2}3662$	$.0^{2}3556$	$.0^{2}3453$	$.0^{2}3352$	$.0^{2}3255$	$.0^{2}3159$	$.0^{2}3067$	$.0^{2}2977$	$.0^{2}2889$	$.0^{2}2804$
2.4	$.0^{2}2720$	$.0^{2}2640$	$.0^{2}2561$	$.0^{2}2484$	$.0^{2}2410$	$.0^{2}2337$	$.0^{2}2267$	$.0^{2}2199$	$.0^{2}2132$	$.0^{2}2067$
2.5	$.0^{2}2005$	$.0^{2}1943$	$.0^{2}1883$	$.0^{2}1826$	$.0^{2}1769$	$.0^{2}1715$	$.0^{2}1662$	$.0^{2}1610$	$.0^{2}1560$	$.0^{2}1511$
3.0	$.0^{3}3822$	$.0^{3}3689$	$.0^{3}3560$	$.0^{3}3436$	$.0^{3}3316$	$.0^{3}3199$	$.0^{3}3087$	$.0^{3}2978$	$.0^{3}2873$	$.0^{3}2771$
3.5	$.0^{4}5848$	$.0^{4}5620$	$.0^{4}5400$	$.0^{4}5188$	$.0^{4}4984$	$.0^{4}4788$	$.0^{4}4599$	$.0^{4}4417$	$.0^{4}4242$	$.0^{4}4073$
4.0	$.0^{5}7145$	$.0^{5}6835$	$.0^{5}6538$	$.0^{5}6253$	$.0^{5}5980$	$.0^{5}5718$	$.0^{5}5468$	$.0^{5}5227$	$.0^{5}4997$	$.0^{5}4777$

Note on Superscript Notation: $N[3.50] = .0^{4}5848 = .00005848$