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Line Stock Control and Vendor Managed Inventory at Infineon Technologies

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Relatório do Estágio Curricular da LGEI 2004/2005

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Faculdade de Engenharia da Universidade do Porto

Gestão e Engenharia Industrial

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À minha família e amigos,

Abstract

This report refers to the internship that took place between March 2005 and September 2005 at Infineon Technologies – F.S., Portugal, S.A. for the final project of the degree in Industrial Engineering and Management at Faculty of Engineering of the University of Porto. The Internship, called "Line Stock Control and Vendor Managed Inventory" aimed at several objectives: the integration of the existing stocks of raw-materials in the production line in the ERP system, stock reduction of raw-materials, creation of a traceability tool between final products, raw-materials and equipments and the participation in a project of Vendor Managed Inventory.

For the Line Stock Control project, two major types of solutions were found: a software tool for the integration of stocks and a kanban system for raw-materials. Regarding the software tool, two solutions were designed: a "Primary Solution" and an "Alternative Solution". The former is based on the integration of the ERP platform, the MES platform and the production equipment. Its results are exceptional although its costs are extremely high. The "Alternative Solution" represents a more favourable relationship cost/benefits and its results are also quite satisfactory. It is also based on the integration of the ERP and the MES systems although it also involves the creation of a new software tool for traceability, named "Material Manager".

The Kanban solution, named "Materials' Kanban", was inspired in the Japanese concept although adapted to the factory's social and industrial context. It involves the implementation of defined rules and procedures for the stocking and handling of raw-materials. The most relevant benefits of its implementation are a great stock reduction, reorganization of the materials' handling and stocking procedures and a considerable cost reduction.

Finally, the participation in the Vendor Managed Inventory project had the objective of supporting a pilot experiment at the company. It enabled to define an external warehouse, the definition of minimum stock values at both external warehouse and at the company and the definition of the kind and support system of the information transacted.

As a conclusion of the project, it should be said that all the proposed objectives were successfully achieved and that the experience of participating in such an internship was most valuable and enriching at both personal and professional levels.

Resumo

O presente relatório diz respeito ao estágio curricular que decorreu de Março de 2005 a Setembro 2005 na Infineon Technologies – F.S., Portugal, S.A., no âmbito do quinto e último ano da Licenciatura em Gestão e Engenharia Industrial da Faculdade de Engenharia da Universidade do Porto. O estágio, intitulado de "Line Stock Control and Vendor Managed Inventory", teve como objectivos o desenvolvimento de um projecto de integração do stock de matérias-primas existentes na linha de produção no sistema de ERP, redução de stocks, criação de um sistema rastreabilidade entre produto final, matérias-primas e equipamento e participação num projecto de "Vendor Managed Inventory".

Relativamente ao projecto "Line Stock Control", dois tipos de soluções foram encontradas: o desenho de uma ferramenta de controlo de stocks e sua visualização, rastreabilidade e ainda um sistema de kanban. Duas soluções distintas foram desenhadas: para controlo e visualização de stocks e sistema de rastreabilidade: a "Primary Solution" e a "Alternative Solution". A primeira envolve a integração dos sistemas de ERP e MES com o equipamento de produção e representa uma solução quase perfeita, embora extremamente dispendiosa. A "Alternative Solution" representa uma solução de compromisso entre custo/benefício e apresenta resultados bastante satisfatórios. Também esta solução envolve a integração do sistema de ERP com o sistema MES bem como o desenvolvimento de um nova ferramenta, chamada de "Material Manager" que seria responsável pela função de rastreabilidade.

O sistema de Kanban, chamado de "Materials' Kanban", foi inspirado no conceito Japonês de Kanban mas adaptado à organização. Trata-se de um sistema de regras e procedimentos para o aprovisionamento e processamento de matérias-primas. A sua implementação permitiu reduzir de forma significativa o nível de stocks na linha de produção, reduzir custos, reorganizar os processos de manuseamento e armazenamento de matérias-primas.

A participação no "Vendor Managed Inventory" teve como objectivo apoiar o desenvolvimento e implementação de um projecto piloto. O contributo dado foi no sentido de apoiar a criação um armazém externo, definição da distribuição de custos e responsabilidades desse mesmo armazém, definição dos níveis mínimos de stock a serem mantidos pelo parceiro escolhido e determinação do tipo e sistema de suporte de informação transacionada.

Como conclusão do projecto de estágio, poder-se-á dizer que todos os objectivos propostos foram atingidos com sucesso e que a experiência adquirida foi muito importante quer a nível pessoal como profissional.

Acknowledgements

First, I would like to thank Infineon Technologies for the opportunity to develop my internship project. I'm very grateful to have had the chance to work in such an exceptional company. I also want to thank my department, Planning and Logistics, which supported this project and especially my dear colleagues for their fellowship and support.

I'm also very grateful to the Team whose effort and enthusiasm were critical in reaching the established goals. My special thanks go to the company's supervisor, Eng. Paula Faria, whose advice and kindness were the most important to me.

My thanks also go to Prof. José Luís Cabral Moura Borges that supervised the project for the Faculdade de Engenharia da Universidade do Porto and to Prof. João Falcão e Cunha, Director of Graduate Studies in Management and Industrial Engineering on the same Faculty for their useful tutoring and ideas that made this task possible.

Finally, I could not forget to thank Infineon Technologies for the funding of the project and for the unique experience gained.

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1 Introduction

1.1 Scope and Objectives of the Internship

The internship project at Infineon Technologies, SA is within the scope of the fifth and final year of Industrial Engineering and Management at Faculdade de Engenharia da Universidade do Porto. It began in March 2005 and ended in September 2005.

The primary objective of the internship was to define a process that provides visibility for the existing raw-materials in the production line named Line Stock Control. This project was designed in several stages:

- Study of the existing system;
- Analysis of the existing system and identification of improvements;
- Definition of a process for the control of line stocks;
- Support to the implementation of the process.

The secondary objective of the internship was to give support to an existing project of Vendor Managed Inventory. The project's goal was to establish a partnership with a supplier in order to reduce planning effort of raw-materials and reduce of stock levels.

1.2 Structure of the Report

The report's organization was structured so that the reader can find an explanation of the most important points of the internship in the main body of the document and, in appendix, more specific and detailed information about the each subject.

Regarding the main body, an introduction to the internship is made in Chapter 1. In Chapter 2, the projects developed within the internship's scope are presented as well as their objectives and expectations. Chapter 3 is dedicated to the production processes at Infineon Technologies, element that is critical for the understanding of the projects and their solutions. Chapter 4 contains the description of the solutions designed for the Line Stock Control project. Chapter 5 is dedicated to the participation in the VMI project. In this section a definition of VMI and its major benefits is presented as well as the explanation of the support given to the project. The final conclusions of the internship and next projects can be found in Chapter 6 and, in the final section of the main body of the report, Chapter 7, the references that supported the report are presented.

In appendix, the reader can find a brief description of a Siplace equipment, the budget gathered for the "Primary" solution in the Line Stock Control Modules, the specification developed for the "Alternative" solution, the explanation of the prototype developed for the "Simplest" solution, a study of the impact of a kanban system in the modules production line, an analysis to the variation between planned output and real output, a version of the developed Training Manual for the operators, the specification for the Kanban Stage2, the specifications for the "New Functionalities in SAP" and a glossary for the report.

1.3 Infineon Technologies and IFPT

Infineon Technologies AG was founded in April 1999, when the semiconductor operations of parent company, Siemens AG, were spun off to form a separate legal entity. Siemens had been found in 1847 and began their R&D[1] in semiconductors just five years after the Bell Laboratory invented the transistor. During the '60s Siemens Semiconductor Operations developed chips for the market of electronics and in the '70s it already had production sites in Malaysia and in the Philippines. In 1985 Siemens developed one of the first chipsets for the interaction with Integrated Services Digital Network (ISDN) and just five years later it presented the first dedicated chip for the global system for mobile (GSM) for standard mobiles. Through out its history, Siemens Semiconductors allied itself with other companies in order to speed up the pace of development of new products and to embrace new markets. So it began the production of DRAM[2] with IBM, a partner in 1991.

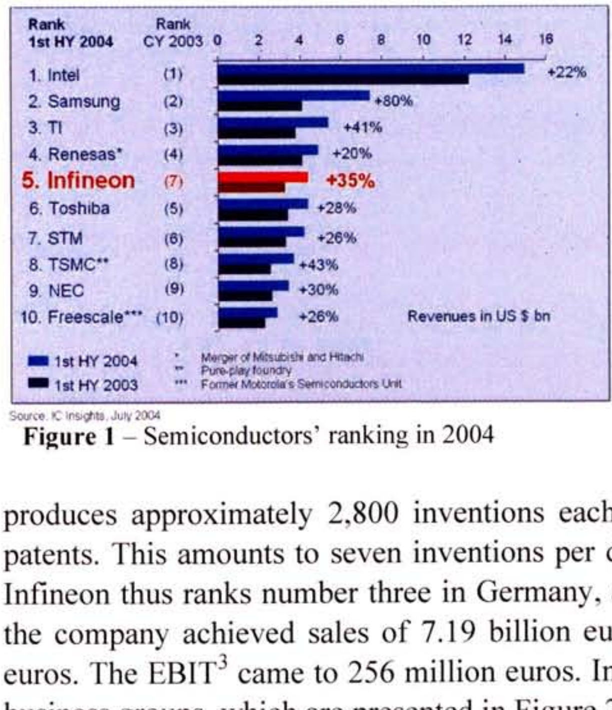

Figure 1 – Semiconductors' ranking in 2004

In 1998 Siemens Semiconductors made it to the top ten in the semiconductors business. However, the prices in the market were decreasing and, therefore, Siemens decided to create a separate group fully dedicated to semiconductors branch – Infineon Technologies.

Today, Infineon has about 36,000 employees worldwide, 7.200 of them involved in research and development. Owing to the innovative strength and creativity of its employees, Infineon produces approximately 2,800 inventions each year and registers some 1,600 of them for patents. This amounts to seven inventions per day. In terms of number of registered patents, Infineon thus ranks number three in Germany, after Siemens and Bosch. In fiscal year 2004, the company achieved sales of 7.19 billion euros and a consolidated surplus of 61 million euros. The EBIT[3] came to 256 million euros. Infineon Technologies AG is divided in several business groups, which are presented in Figure 2.

[1] Research and Development

[2] Dynamic Random Access Memory

[3] Earnings before interest and taxes

Figure 2 – Infineon's Operating Business Groups

Infineon Technologies Fabrico de Semicondutores – Portugal, S.A., from now on called IFPT, is part of the business group Memory Products, or simply MP[4], which is divided into two major types of production factories:

- Frontend factories – where the silicon wafers are produced;
- Backend factories – where the components and modules are produced.

Wafers are a round piece of silicon that contains the dies, brain of the chip. These are produced either in 200mm or in 300mm diameter and are the basis for the production of the chips in the backend sites.

Figure 3 – Infineon's Memory Products Sites

IFPT[5] is a backend site, and so receives the wafers from the frontend sites, and then produces components or modules. The modules are sent to distribution centers to be then delivered to the final client. The chips are sent to other backend sites in order to be assembled in modules and then sent to distribution centers and finally to the customer. IFPT's products can either be components or modules. The latter is the product of the assembly of components and other raw-materials in a PCB[6]. There are two major types of components can be produced at IFPT: the TSOP[7] and the BOC[8]. The BOC has a lot of advantages when compared to the TSOP: it's smaller and, however, it has the same capacity, energy consumption and even better performances than the conventional TSOP and so it's expected to replace it in a few years to come.

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[4] Memory Products

[5] Infineon Technologies Fabrico de Semicondutores Portugal, SA

[6] Printed Circuit Board

[7] Thin Small Outline Package

[8] Board On Chip

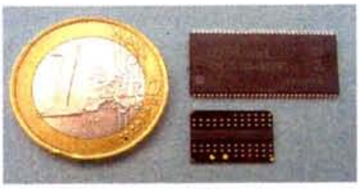

Figure 4 – The BOC and TSOP relative sizes

Although the BOC and the TSOP have the same basic functioning, some processes and raw-materials are different as it will be explained in detail in Chapter 3. Figure 4 exemplifies the physical difference and relative sizes of the TSOP and BOC which highlights the relative size difference.

Production is divided in two main areas: the components area and the modules area. These two production areas are closely connected because most of the components used for modules are built at IFPT. The modules produced at IFPT can be either produced with in-house components or with components sent from other factories, although the most common situation is to use components built and tested at Porto. Figure 5 shows the reader two kinds of modules, one built with TSOP components and one other built with BOC components.

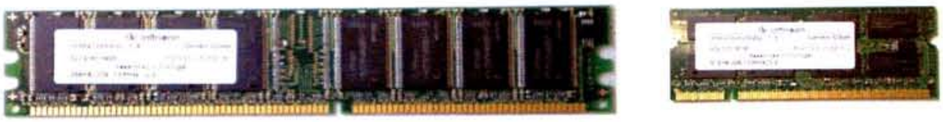

Figure 5 – Module with TSOP and BOC components

The market place for the MP has been growing and enlarging year by year. Nowadays Infineon Technologies is supplying memories for the most traditional segments, such as computing and infrastructure uses, as well as for a new and growing segment of mobile phones and graphic platforms. A representation of the market segments for Infineon Technologies memory products can be found in Figure 6.

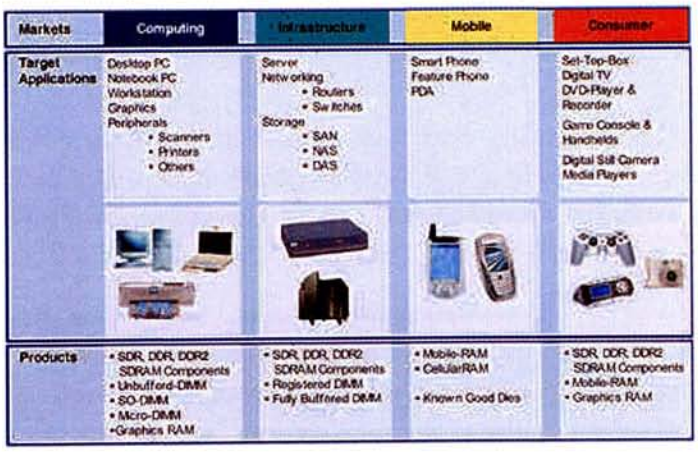

Figure 6 – Market Place for Memory Products

Infineon Technogies has been growing in this competitive market by putting a great effort on R&D[9] and quality of its products. The results of this strategy are the most encouraging because the company's market share is expected to grow and reach around 25% and the total revenue around 30%, as shown in Figure 7.

[9] Research and Devolopment

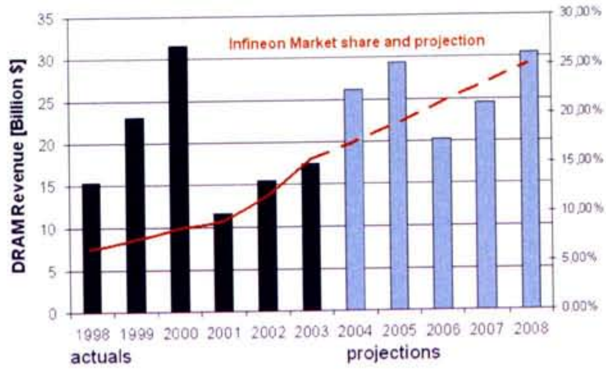

Figure 7 – DRAM's market evolution and projection

The focus of competitive semiconductor manufactures has been the technology development in the Frontend sites and the reducing of costs through mass production in the Backend sites. The reasons for that are:

- Memory products are commodities since there is a low degree of differentiation among them. Once their basic quality requirements are met, their prices become critic;
- The semiconductor industry is very volatile and "capital intensive";
- The semiconductor market demands great innovation, and leaning in this area can be the difference between winning and losing.

Apart from the fact that the products are commodities, the rate of constant innovation is extraordinary. One of the founders of Intel® made a law that describes the DRAM market with an extraordinary precision. "Moore's Law states that the number of transistors available to build or to populate a silicon-based integrated circuit doubles every to years. Achieving this exponential grow in transistor density requires and ever-shrinking transistor size."[6]. Figure 8 shows how the DRAM bit-grow by DRAM density has evolved.

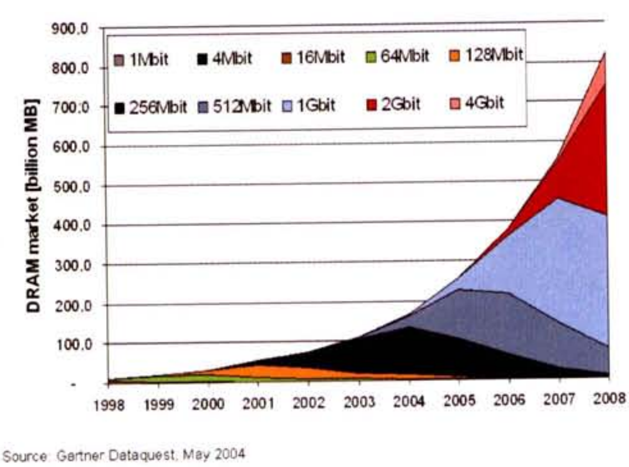

Figure 8 – DRAM Market bit-growth by DRAM density

The conclusion is that in order to succeed in the semiconductors industry, two critical and opposite factors are essential: innovation and low costs. It's the perfect balance between these two indicators that will lead a company to the market's leadership.

2 Overview of the Projects

2.1 Line Stock Control

Objectives

The Line Stock Control project is an initiative from the department of Planning and Logistics at IFPT. Its objectives are:

- Stock in the line should be considered as part of the total stock available for production in SAP;
- Avoid high stock levels due to low visibility of material in-house; high stocks in the line which are not controlled by SAP;
- Avoid false ruptures of stock due to unit high instantaneous consumption;
- Provide traceability between the product, the raw-materials and equipments.

From the analysis of the presented objectives, it's possible to correlate some of issues such as false ruptures and high stock value with the lack of visibility. Because of the lack of control over the existing stocks in the production line, the raw-materials reach very high values without being controlled; false ruptures occur because of the lack of visibility over the mentioned stocks. The impact to the company of having such high stocks was considered to be very high and the constant false ruptures of stocked caused a great confusion and disorder to production.

One final comment should be made regarding the traceability objective. It is nowadays one of the major requisites for the semiconductor industry because the most valuable customers, such as HP, IBM or ATI, demand for it. It enables the possibility to track down quality issues back to the supplier of each single raw-material or equipment, what represents a major break through on the quality assurance of the final product. Therefore, it's one of the major challenges presented to the suppliers of memory products. Infineon Technologies hadn't any method for proving the mentioned traceability and so, this ambitious objective was added to the project's scope.

Initial Situation – Brief Description

In the initial situation, the existing stocks in the production line weren't controlled by the existing ERP platform. Therefore, all these stocks were "invisible" for matters of planning and control. The stocking positions controlled by SAP were limited to the warehouse and the kardexs[10], as exemplified in Figure 9. Raw-materials were consumed once they left the last stock position controlled by SAP, in this case the kardexs. All the raw-materials existing in the production line, and so not controlled by the ERP, were considered WIP[11]. This caused a tremendous impact to the company.

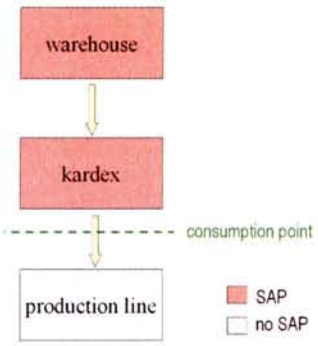

Figure 9 – Initial Situation for the raw-material's flow

Cause-Consequence Relationship

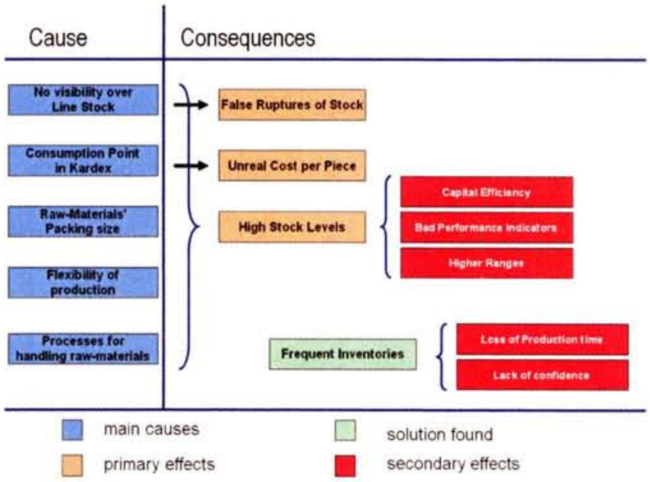

Figure 10 – Diagram Cause Consequence of the problem

The objectives of the internship are quite general and involve very different issues. In order to be able to find solutions for the project, it was important to identify the causes for some of the issues within the scope of the project. The causes found are represented in blue in the Figure 10 while the primary and more visible effects are represented in orange; the secondary effects are represented in red and the solutions being applied, when the project began, in green. Each one of the identified causes will be explained and its influence detailed in the next lines. However, when discussing the consequences of this project, the reader should keep in mind that some of them are uncontrollable or do not belong to the project's scope. They can, however, be influenced or minimized by it.

From the analysis of the figure, it's possible to conclude that having no visibility over the stock in the production line causes false ruptures of stock, primary effect. False ruptures occur because the ERP platform doesn't recognize that the real stock value is higher than the one controlled by it and so causes the material planners to order more material than what is needed. Because IFPT and its personnel are evaluated by some key performance indicators, being that one of them is the cost indicator, the performance of the company and of the material planners are highly affected because of the high stocks of raw-materials, represented in red as a secondary effect in Figure 10.

[10] Kardex is a vertical storage system used at IFPT

[11] Work in Process

Being that the consumption point is the last area controlled by the ERP, in this case the kardex if any stock is available after this consumption point then, it's considered to be fully consumed. This influences the cost per piece[12], which is higher than the reality, causing the performances indicators to penalize IFPT.

The kinds of raw-materials used in the semiconductors industry are also responsible for some of the identified effects and so an introductory comment must be done. These raw-materials are usually very small and delivered in packages that contain a great number of units. For example, one of the raw-materials used for the production of modules and that is handled in reels[13] contains up to one hundred thousand single units in a single package. For that reason, this single reel can be enough for the production of several weeks, usually called range. Nevertheless, the size of the raw-materials makes it virtually impossible to precise the number of single units that remain of the package. The mentioned packing size of the raw-materials is one other cause for the high stock levels because each unit represents a very high cost and stock value and influencing the KPIs[14] in a negative way. This is one of the incontrollable factors mentioned earlier.

IFPT is characterized by having big production flexibility mainly because of a central strategy for this specific factory. This flexibility means that there are a lot of different products running at the same time and the production volume can vary in a great way from week to week. This demand for flexibility affects the number and quantities of each raw-material and the stock value is much higher than in a more traditional industry.

The last main cause that was identified is the applied process for handling the raw-materials. These were being handled by regular members of the production teams. Handling was done without any specific training for it. The quantities and type of raw-materials moved to the production line were defined by the operator empirically. Stocking positions in modules production area weren't defined and so it was impossible to look for a specific raw-material without going through the entire line.

The only existing solution that was being applied to minimize the described effects was to perform frequent inventories – represented in green in Figure 10. These were imprecise, mostly because of the packing sizes and characteristics of the raw-materials and lack of defined stocking positions. Although these inventories solved some of the discussed issues, others arose: operators spent a lot of time in non-productive activities and the confidence on the data gathered was small.

The conclusion of this study to the cause-consequence relation is that the project's scope is very large and its impact is felt in many different areas of the company and in a significant way. It's also possible to conclude that having control over the stocks in the production line and pushing the consumption point forward could bring major advantages to the organization and even minimize other independent factors such as the size of the packing of the raw-materials and the production's flexibility.

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[12] Cost Per Piece is the cost to produce one product; Key Performance Indicator at Infineon Technologies.

[13] Packing unit used for some raw-materials; shape of a bobbin

[14] Key Performance Indicators

Steps and Team of the Project

The project Line Stock Visibility and Integration, from now on called project Line Stock Control, had two main areas of study: the two different production areas (components and modules). Although these two areas are naturally dependent from each other it was necessary to develop the project in two different phases.

In order to define which of the two production areas should be analyzed first, priorities had to be defined, subject that will be explained in detail in Chapter 4. The steps that were chosen for the project are represented in Figure 11.

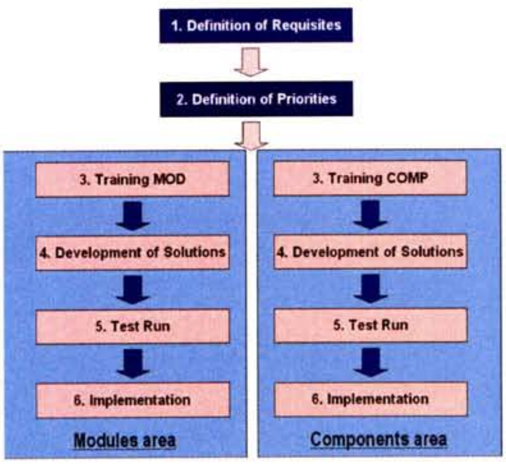

Figure 11 – Steps of the Project

The first phase, the definition of requisites, had the objective of defining clearly what was expected for the project from each one of the related areas. The second phase, definition of priorities, was done to identify which of the production areas was the primary target and within these which were the most important raw-materials. After deciding the priorities training had to be done in order to have a solid knowledge of the processes and other items that are related to the Line Stock project. Having acquired the knowledge of the area in study, solutions should be developed – the development of solutions phase. It was also defined that the developed solutions should have a test run or a trial run before the implementation itself. The objective of this phase was to align minor details of the developed solutions. The final step of the project was the implementation phase. After this phase, the project was to be defined as concluded.

The team for this project involved many different areas and, for that reason, the team had members from many different departments at IFPT as represented in Figure 12.

Line Stock Control Team Structure

Team Speaker	J. Moreira	IFPT PL PP
Core Team	J. Rodrigues	IFPT TO MOD
	A. Pulcastro	IFPT TO MOD
	P. Taveira	IFPT IT
	M. Pinto	IFPT PL MM
	P. Faria	IFPT PL PP
Support Team	J. Nascimento	IFPT AO EOL
	J. Mimoso	IFPT ASY
	A. Azevedo	IFPT PL MM
	A. Silva	IFPT PL PP
	R. Guedes	IFPT PL PP
	H. Matias	IFPT F FC

Figure 12 – Team Structure for the Line Stock Control Project

2.2 Vendor Managed Inventory

The work developed for the VMI[15] project was the participation in the brainstorming meetings within the IFPT team and with the chosen partner. The objective of these meetings was to define a pilot project of VMI with a specific supplier of a given raw-material.

The participation in this logistic strategy was a secondary task of the internship and, therefore, more relevance was given to the Line Stock Control project

An introduction to the VMI, presentation of the developed work and the present status and future steps of the project will be made in Chapter 5.

2.3 Other Projects

Besides the projects identified as the objectives of the internship other smaller projects were developed. These projects can be divided in three main categories:

- Support to the GPPI[16] Project – project that is aligning the raw-materials and BOMs[17] within the cluster;
- Development of new features for SAP, Materials Planning Module;
- Support to Material Planners.

The support given to the GPPI project was the definition of the BOMs for Components at IFPT.

The work developed in SAP, Materials Planning Module, was the creation/modification of new features for the most common transactions. The objective was to facilitate the Material Planners daily routines. The specifications developed for these new features are presented in appendix.

Besides these projects, support to Material Planners was given in extraordinary situations and clearly aren't within the scope of this report and so it will be left aside.

In the subsequent Chapter the reader can find a brief description of the production areas, information that is fundamental for the understanding of the projects as well as of the organization itself.

[15] Vendor Managed Inventory

[16] Global Process Procurement Improvement

[17] Bill of Materials

3 IFPT - The Production

The project developed demanded for a deep knowledge of the production areas. This requisite was clearly identified and so one of the most important steps of the Line Stock Control project was the training undertook in both the production areas. In this point of the document a small description of the production and processes used for handling raw-materials.

3.1 Components Production Area

Production Perspective

The production area of components is divided into several areas such as the Pre-Assembly, Assembly, End of Line, Test and MSP[18], as represented in Figure 13.

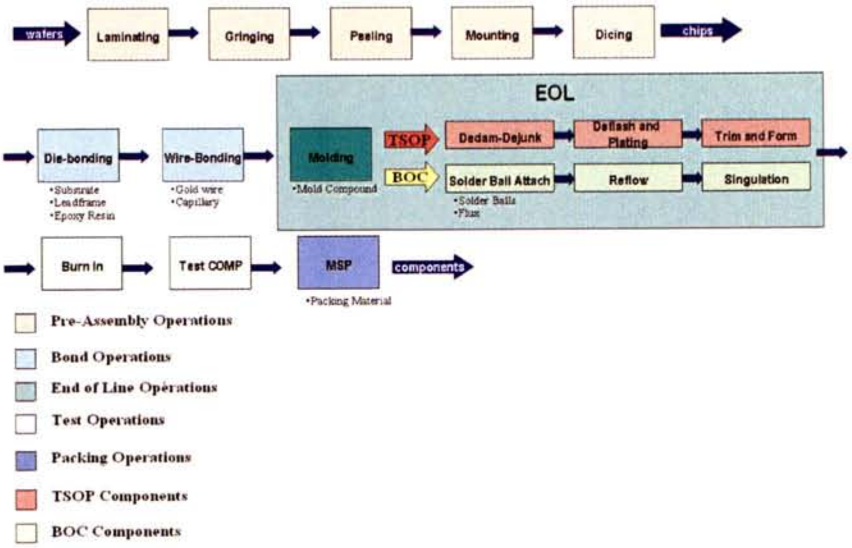

Figure 13 – Production flow in the Components area

The production of semiconductors takes place in a controlled environment for temperature, humidity and number of particules in the air. The Pre-Assembly and Bond Operations are done in a clean room environment of 10K and the other operations in a clean room of 100K. The 10K and 100K refer to the number of particules that are admissable per volume unit. Figure 14 shows the kind of equipment used in the clean room environments.

Figure 14 – Clean room

[18] Mark Scan and Pack

The first production area is the Pre-Assembly in which the wafers sent from the frontend factories are processed to be applied in chips. The first operation is the application of a tape to the active surface of the wafer – Laminating. This tape is applied to protect the chips from the next operation, the Grinding. It consists of decreasing the height of the wafer by erosion. After the grinding, the tape that was applied to the active surface of the wafer is removed, in a operation called Peeling. The wafers are then mounted on a frame that is used to support the following procedures. The following process is called Dicing and consists of the individualization of the chips which are then sent to the Bond Area, first area of the Bond Operations. The first procedure consists of extracting each one of the chips and placing them on the lead frame or in the substrate, depending on if the product is TSOP or BOC respectively. The chip is then placed in the substrate or lead frame in an operation called Die-bonding. The connection is guaranteed between the die and the physical support by a glue made of Epoxy Resin. The components then go though the Wire-bonding, connection of the bond pads[19] to the leads[20] of the support system (substrate or lead frame). The connection is established with the use of a very pure gold wire. After this latter operation, the components go to the End of Line area in which its final physical structure is defined, see Figure 15.

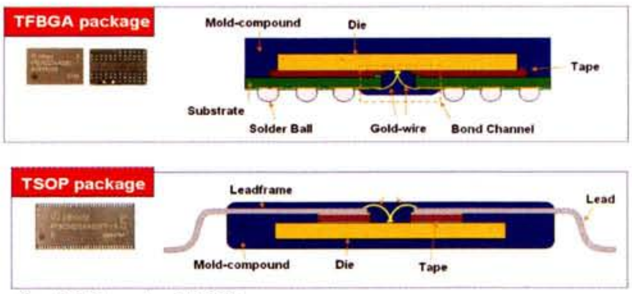

Figure 15 – Cross section of a BOC and a TSOP

The first operation in the End of Line area is the Molding that is the application of a layer of mold compound[21] over the component with the objective of isolating the dies' contacts from the environment. After the Molding the TSOPs and BOCs follow different paths: the TSOP goes to Dedam/Dejunk and the BOC to the Solder Ball attach, as represented in the Figure 13. These different components only meet in the same operation later in the Burn-In. The TSOP then go through the Dedam/Dejunk operation in which the excess of mold compound and the dambar[22] are removed. Already in the Plating area the TSOP components are placed in a solution of Sn and Pb that makes the leads more resistance to the environment, improves the leads' mechanical resistance and the connectivity to the After the Plating the leads are bended and cut from the rest of the strip of lead frames in order to have the TSOP components individualized, see Figure 16.

Figure 16 – The TSOP

For the BOC components, the following stage after the Molding is the Solder Ball Attach. In this operation the solder balls are placed over the contacts of the substrate. This enables the connection between the chip and the PCB. Flux is used to improve the soldering between solder balls and substrate. The following operation is the Reflow in which the BOC

[19] Contacts of the dies of the chip

[20] Physical structure that will support the connection between the dies and the external environment

[21] Raw-material made of an Epoxy Resin

[22] shunt that connects all the leads

components go inside an oven for three hours. The objective of this stage is to make the soldering of the solder balls to the substrate.

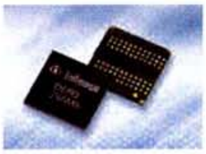

Figure 17 – The BOC

Once the solder balls are connected to the substrate, the BOC goes through the Singulation. Here the strips of substrates, that held several components, are cut in order to have individualized BOC components and get its final physical structure, see Figure 17.

After the End of Line, the components are tested. The first test is the Burn-In, in which the chips are submitted to extreme conditions in order to find the ones that would fail in a future utilization. The following test is the Speed Test. It's this operation that allows the definition of the speed of the chip. If the component goes through all these processes without failing then, it's sent to MSP to be laser marked, scanned, packed and finally shipped to modules or to a distribution center.

Raw-Materials' Perspective

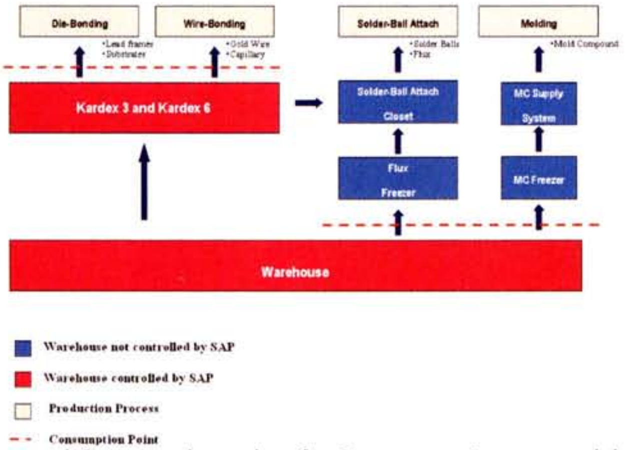

Figure 18 – Stock Positions and Consumption points for Components' raw-materials

All the production areas, Components or Modules, are organized by production cells. The activities in which raw-materials are consumed in the Components area are quite diverse and so raw-materials are placed in many different locations. Their handling is performed by the personnel of each area. For example, substrates and lead frames are handled by line operators from the Bond area. The same principle applies to each of the other areas where raw-materials are needed. The raw-materials' flow and stocking positions are represented in Figure 18.

Figure 19 – Kardex system

Raw-materials are placed in the central warehouse at IFPT and then sent to either the Kardex 3 or 6 or to other buffers such as freezers. The consumption point for financial effects is when a given raw-material moves out from a warehouse/buffer controlled by SAP, marked in Figure 18 with a dotted line. In the present case of the Components production area it can be said that the substrates, lead frames and solder balls and all the remaining raw-materials are consumed when they leave the kardex that is, when they stop being controlled by the ERP system.

Regarding the stock value, this was never very high when it comes to the Bond area because of the existing procedures and characteristics of the raw-materials.

The Solder-Ball Attach area has a closet where solder balls and flux are kept. Its stock value is the correspondent to one/two days of production and, therefore, is quite low. Flux is a raw-material that has to be consumed after twelve hours of stabilization and within a period of two days and, consequently, its stock is always very small. Mold Compound is supplied through an automatic supply system that is connected to the Molding Equipment. The stock value kept in supply system is small and limited to the packing unit being used at the time. There is, however, a buffer for this type of raw-material that isn't controlled by SAP: the freezer that keeps stock for around one week of production. It can be said that the variability of raw-materials used for the production of components is small and so the raw-materials' needs per period of time are quite constant. The amount of raw-materials placed in the kardexs is given by Equation 1.

Equation 1 – Target Definition for the Kardex COMP

$$Target_{KardexCOMP} \approx \frac{WeeklyMRP_{COMP}}{7} \times 2$$

In spite off the precision of the expression, there is spare capacity in both kardexs and so, the amount of raw-materials placed is always higher than the given by Equation 1.

One comment must be done regarding the packing sizes of the raw-materials that are used: a packing unit of a raw-material used for components is much smaller than the ones that are used in the modules area. This is true for all the raw-materials used except for the solder balls. However, the importance of the solder balls in the total cost of a component is very small, as it will be shown in Section 4.1.

The conclusions of the study done to the Components production area are:

- There are many different production and raw-materials' flow within the area;
- Many different equipments and raw-materials are used;
- The stock in the production line is very low and is under control;
- Stocking locations are defined and are respected.

3.2 Modules Production Area

Production Perspective

The Modules production area can be divided into the following production cells: Assembly MOD, De-paneling, VM[23] + Labeling, Module Test, APT[24], QA[25], Packing & Shipping and Rework. Figure 20 exemplifies the basic process flow in the production area of modules.

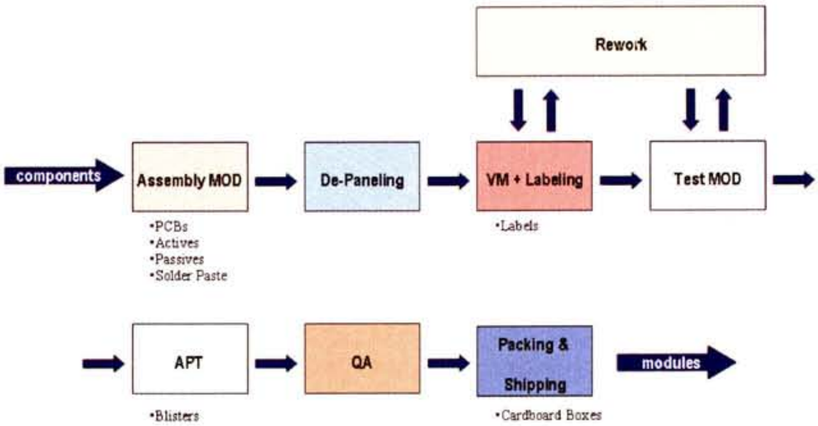

Figure 20 – Production flow in the Modules area

This simplified scheme represents the flow of operations in the modules area: the raw-materials are supplied from the warehouse to Kardexs and then supplied to the Assembly MOD also called SMT[26] area. The components are brought from the components area of production to the SMT area by the operators. In the SMT area the components and raw-materials are assembled to the PCBs. After this procedure the product is already called module. The module then goes through a De-paneling process – individualization of each assembled PCB. After the De-paneling process the modules go through a VM[27], where the basic condition of the module is checked. In this procedure the labels are placed in each individual module. If any defect is detected in this phase the modules are sent to rework. Rework is a manual process done at a workbench, where faulty components are removed and replaced. The product's basic electrical properties are then tested in a process called Test MOD. If any problem is detected in this stage, the module goes to Rework to be repaired. After the Test MOD the product goes through APT[28], where the real performances of the product are tested. A final quality inspection is done after the APT – the QA[29]. In this step all the modules are analyzed and then sent to Packing and Shipping. In the Packing and Sipping

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[23] Visual and Mechanical Inspection

[24] Application Test

[25] Quality Assurance

[26] Surface Mount Technology

[27] Visual and Mechanical Inspection

[28] Application Test

[29] Quality Assurance

the modules are placed in Blisters[30] and cardboard boxes that are marked and labeled according to their contents. After the boxes are marked they're shipped to the customers.

From the consumption of raw-materials perspective, the consumption of most of the raw-materials is done in the SMT lines – except for the blisters and the cardboard boxes. Therefore emphasis was given to the study of this special area. The activities and storage locations of the Assembly area in modules are represented in Figure 21.

Analyzing the production's activities in SMT it's possible to conclude that the components come from the MSP components area, which belongs to the production area of components, to the SMT lines, are store in trolleys and are then sent to the equipments to be used in the assembly of modules.

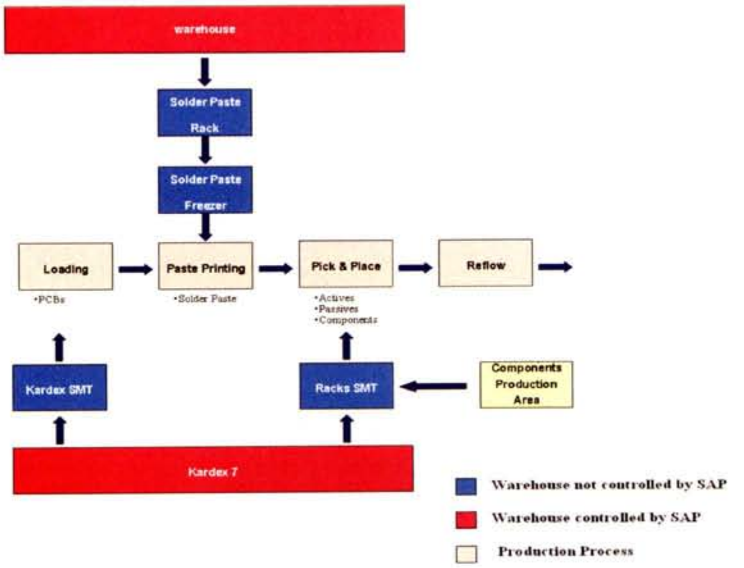

Figure 21 – Process flow and storage locations in SMT

The other raw-materials that are assembled along with the components to the PCBs are supplied from the warehouse to the kardex. The PCBs are usually sent directly from the kardex to the equipment and so the PCB's stock is very low. The other raw-materials that are supplied in reels are first sent to racks that are placed along the SMT lines. These materials are then moved from the racks to the equipments when needed for production.

For the production of a module a special raw-material is used that needs a special treatment: the solder paste. This raw-material, which is used for soldering the PCB's contacts to the other raw-materials, is kept in freezers and then, to be used, has to suffer a stabilization period of twelve hours. So, this material is taken out of the freezers in the warehouse and then taken to the production line where it's kept in a special rack for solder paste. Another particular aspect about this material is that it can only be used for a period of thirty six hours after the stabilization period. Therefore its stock in the production line is never too high. The solder paste is transported from the stabilization racks to the equipment directly.

There are several equipments in the SMT lines: the Printers, the Pick and Place and the Ovens. To this set of equipments displaced in line is called a SMT line. The printers, first equipment of the SMT line, are the equipments to which the PCBs are loaded to be printed with the solder paste – process of printing. PCBs are, at this stage, still connected to each other in groups of seven or more.

[30] Plastic Box that supports the final product

After the printing, active, passive and components are placed in the printed PCBs in the equipments called Pick and Place. These equipments are also called of Siplace, denomination of the supplier. This type of equipment was very important for the solution that has been studied and so a more detailed description of its basic functioning will be made in Chapter 8.

After all the components and materials are placed in the PCBs the latter go through a reflow process that is used to make the soldering. At end the reflow process all the components and raw-materials are soldered to the PCBs. The SMT process ends with the Reflow. The following steps of the production of a module are represented in Figure 20.

Raw-Materials' Perspective

In the Modules production line the raw-materials and components are handled by the line operators. There are, as said before, some racks where the reels are placed. The amount of stock that is transferred out from the Kardex to these Racks wasn't controlled by any existing system, and so the line operator would just move an unknown amount. These racks were also very badly identified and so there were raw-materials that were placed out of their expected location. The line operator that was responsible for making the raw-materials' movements in the production line didn't have any specific training. The basic flow for raw-materials in the modules area is exemplified in Figure 22.

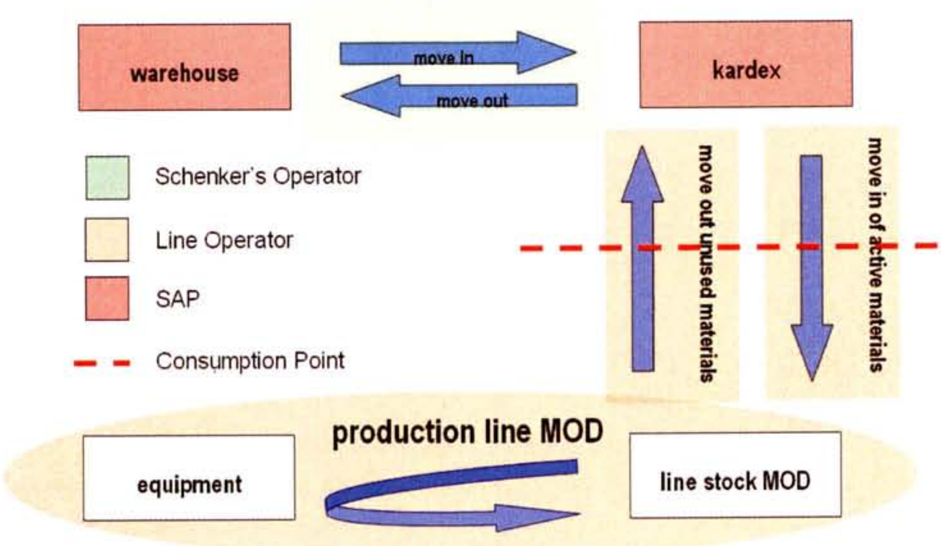

Figure 22 – Initial Materials' Handling Flow

From the analysis of the processes within the modules' production line, one other issue arose: the transactions of raw-materials out of the kardex to the production line weren't being done correctly and so numerous corrections to the available stock had to be done. The most common cause for these errors was the lack of training. One other cause that was discussed was that this isn't and shouldn't be the focus of his activities – the line operator should be focused on the production not in the supply of the production.

The racks were only used for Actives and Passives – the raw-materials supplied in reels. The others, like PCBs, never had a significant stock value.

Again, the reader must keep in mind that the consumption point for raw-materials was the Kardex. Therefore, the stock laying in the racks of the Modules production line was, for financial effects, already consumed.

The supply system of the Kardex was done by specific operators. These operators, the Schenker operators, have specific training for these activities and so were supplying the kardex according to daily targets based on a weekly plan. The targets that were being used for the supplying the kardex was given by Equation 2:

Equation 2 – Target Definition for the Kardex MOD

$$Target_{KardexMOD} \approx \frac{WeeklyMRP_{MOD}}{7} \times 2$$

Equation 2 is an approximation real values used. A delta exists because the operators are given some flexibility regarding the stock values. For example, the operator had the possibility to supply more raw-material if we would thought that some given product was going to be produced in a short period of time instead of the entire week. This situation, producing one given product in just a few days of the production week is quite common and, although it causes some confusion among the production and material planners, it enables the possibility to save equipment setup time.

The conclusions of this analysis to the Modules production area are that:

- The existing stock of raw-materials is, in some cases, very high;
- There aren't any defined stocking locations within the production area;
- Procedures used for the supplying the area are inadequate;
- There are great opportunities for improvements.

4 Line Stock Control

4.1 Introduction

Requisites Definition

The first step of the project was the definition of requisites. In this phase all the involved areas were heard about what they would like to have and control in the line stock control project.

A kick-off meeting that involved all the interested areas of the organization took place to present the project. In this meeting some questions were asked to the responsible about each area in order to define the project. The questions asked are shown in the next lines:

1. What is the purpose for each area?
2. What are the recurring questions that should be solved?
3. What are the main problems that the Line Stock Control should solve?
4. Who is going to use the Line Stock Control system? In which levels?
5. What are the main obstacles that the Line Stock Control team is going to face?
    - In the development phase;
    - When the system is put into function;
6. How frequently is the system going to be used?
7. What kind of information and documents should it provide? If possible specify the desired format.
8. To which degree is it important to define exactly the Line Stock? What kind of information is desired as a result?
9. Which other systems should the Line Stock Control interact with? (SAP, FAB[31], etc)

These simple questions helped the team to align expectations as well as to define the main obstacles of the project. As a result of this meeting it became clear that not all the areas involved had the same expectations. Basically IFPT PL[32] was focused on the consumption issues and visibility of line stock and the production departments, IFPT TO[33] and IFPT AO[34]

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[31] MES (Manufacturing Execution Systems) used at IFPT

[32] Planning and Logistics

[33] Test Operations

[34] Assembly Operations

defined that consumption and visibility were important but traceability[35] would be the most important functionality. We note that, although this project was developed for IFPT, it was an initiative from one specific department, IFPT PL that considered traceability as a secondary objective of the project. The production areas, however, considered the traceability functionality to be the primary objective of the project.

The traceability functionality refers to the capacity to trace which lots of raw-material were used in which lots of the final product being components or modules. The final objective of a fully integrated traceability system is to keep track, for each final product delivered to the client, which single raw-material that was used for its production, which were the equipments used and the production conditions. This is traceability is becoming more and more urgent in the semiconductors business because clients demand for this information. Therefore the project was redefined in order to embrace a secondary objective: the traceability functionality.

As a result, the new objectives of the project were re-defined to be the following:

- Stock in the line should be considered as part of the total stock available to produce in the SAP;
- Avoid high stock levels due to low visibility of material in-house. High stocks in the line which are not controlled by SAP;
- Avoid false ruptures of stock due to unit high instantaneous consumption;
- Traceability between final product and raw-materials and equipments.

Priorities Definition

The second step of the project was defining the priorities. As mentioned before there are two main areas of production: the components area and the modules area. These two production areas are quite different from one another and, therefore, are analyzed separately.

A study was conducted about which of the areas would present a more urgent solution and, as a result, the modules area was chosen as the first target. Main reasons for this choice were:

- This area deals with a larger set of different raw-materials – the differentiation between products is higher;
- The total value of the raw-materials used in modules is higher than in the Components area;
- The existing stock in the production line in units and value is higher in the modules area.

Therefore, the modules production line was the first target of study of the Line Stock Control project. Again, within the modules production area, priorities had to be chosen among the raw-materials and so two different analyses were conducted: a cost impact analysis; and a prioritization by the production engineers and material planners. The two analyses were then aggregated in order to have one final priority definition.

[35] Relation between product, raw-materials and equipments

The definition of priorities was critical for the performance of the project because the amount of different raw-materials used is quite large and clearly not all the raw-materials could be analyzed at the same time.

The same basic procedures and analysis were later also applied to the Components production area – second target of study of the project

Analysis to the Cost Distribution for Modules

As mentioned before, the objective of this analysis was to define which raw-materials influence the most the final cost of a module. For the production of a module different materials are used such as PCBs, EPROM's, Registers, Buffers, Bead Ferrites, PLL[36]s, Resistors, R-nets, Capacitors, Solder Paste and Packing Material such as Blisters[37], Labels and many others. These raw-materials are usually grouped into the following groups:

- PCBs;
- Actives;
- Passives;
- Solder Paste;
- Packing Material.

The analysis was done based on the needs of each group of material for three months. The average need of each raw-material within each group was calculated and then multiplied by the price of each raw-material. This data was then aggregated and compared. The results of this analysis are shown in the following in Table 1 and Figure 23.

Table 1 – Cost Distribution per raw-material group in the Modules area

Material Group	%
Weekly Average Resistors	0%
Weekly Average R-nets	8%
Weekly Average Capacitors	15%
Weekly Average Actives	19%
Weekly Average PCB's	58%
Total Weekly	**100%**

[36] Phase-Locked Loop

[37] Box made of plastic used to pack the modules

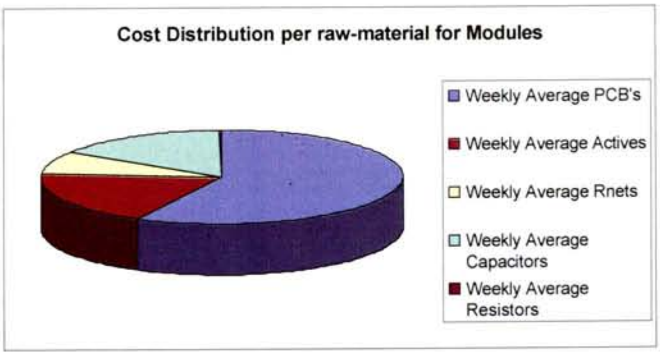

Figure 23 – Cost Distribution per raw-material group in the modules area

A comment should be done regarding the materials' groups of packing material and solder paste. It was impossible to analyze the impact of these groups because there wasn't enough data of the prices of these raw-materials. However the price of these groups is much smaller than the ones of the other studied groups and so its influence was not considered.

The conclusion of this study was that PCBs are responsible for almost 60%, actives are responsible for around 20% and passives, represented in Figure 23 by R-nets, Capacitors and Resistors, for the remaining 20% of the price of a module. Resistors are the cheapest raw-material used in a module.

Team's Priority Definition by Raw-material Group for Modules

The Production Engineers of each area of production were asked to define their priorities according to the line stock, to the value of each raw-material and the variability of consumption for a given period of time. For the modules, area that is being analyzed, the following priorities were chosen:

Table 2 – Priorities defined by Production Engineer MOD

	Material	Priority
Modules	PCB's	1
	Actives	1
	Passives	1
	Labels	3
	Solder Paste	2

Table 3 – Priorities defined by Material Planners

	Material	Priority
Modules	PCB's	2
	Actives	1
	Passives	1
	Boxes	3
	Blisters	3
	Labels	3
	Solder Paste	3

The priority levels defined before are according to a scale from 1 to 3, being that priority 1 represents a higher priority than priority 2, and so on.

Final Priorities by raw-material group for Modules

The final priorities chosen were made by combining all the priorities set by the cost analysis and the priorities defined by the Departments PL and TO[38]. The packing material was defined as the least important group of raw-materials and so it was removed from the scope of the project. The final result is shown in the Table 4.

Table 4 – Final priorities for the raw-materials in Modules

	Material	Priority
Modules	PCB's	2
	Actives	1
	Passives	1
	Labels	3
	Solder Paste	3

These were the priorities that were used in the following steps of the project within the modules area.

Analysis to the Cost Distribution for Components

Again, the objective of this study was to identify which were the most important raw-materials from an economical perspective. The procedure used for the calculation of this cost distribution was the same as the one for used for Modules. The results are represented in Table 5 and Figure 24.

Table 5 – Cost Distribution per raw-material group in the Components area

Material Group	%
Solder Balls	1%
Flux	1%
Packing Material	3%
Gold Wire	5%
Epoxy Resin	5%
Mold Compound	7%
Lead frames	13%
Substrates	63%
Total weekly	**100%**

[38] Test Operations

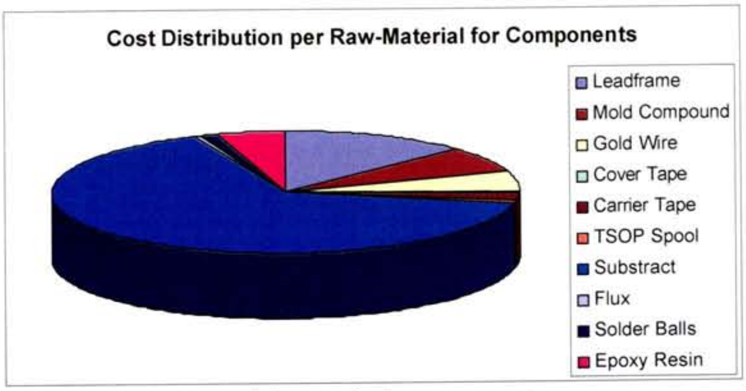

Figure 24 – Cost Distribution per raw-material group in the components area

The conclusion of this study is that the substrates represent 65 % of the total costs. The reader should keep in mind that the substrates are only used in BOC components, around half of the total production volume. Lead frames are the second most expensive raw-material and then there are some other raw-materials with small influence on the total cost of a Component.

Team's Priority Definition by Raw-material Group for Components

As mentioned before, the analysis done to the Components area was the same as the one for the Modules area. In the following table are represented the priorities chosen by the Material Planners and the Production Engineers – already aggregated because both groups had the same priorities.

Table 6 – Priorities defined by Material Planners and Production Engineers COMP

	Material Group	Priority
Components	Substrates	1
	Lead frames	1
	Gold wire	1
	Solder Balls	1
	Mold Compound	2
	Flux	1
	Packing	2
	Epoxy	2

As it can be concluded from the analysis of Table 6, the final priorities that were chosen represent the same priorities identified with the cost distribution study. Therefore, the final priorities are represented in Table 6. After the definition of the priority raw-materials and areas, the project moved on to the study of solutions and their design.

4.2 Modules Production Area - Solutions Designed

4.2.1 Overview of the solutions

The solutions developed for the Line Stock Control project were a Control System based for the line stock and the implementation of Kanban System.

Both solutions, the Control System and the Kanban System represent two different analyses to the same line stock problem. The first, the Control System, represents a solution for the lack of visibility over the Line Stock in the ERP. The second, the Kanban System, represents a procedure and a new way of thinking that tackles the same issue by reducing the stock value and, at the same time, try to have visualization over the stock in the production line.

The Control System solutions were the first to be studied. Three solutions were designed: a Primary Solution, an Alternative Solution and the Simplest Solution, two of which were developed in detail: the Primary Solution and the Alternative Solution. The first provides perfect traceability and consumption definition based on the production equipments. It is, however, expensive to develop. The second solution, named Alternative, provides acceptable performance. Its costs are much lower and acceptable since it could be developed at Infineon Technologies' central IT resources. The Simplest Solution was abandoned because it wouldn't provide traceability between the product and the raw-materials. It was, however, a very useful tool for other points of the global project.

4.2.2 Primary Solution

The objective of the Primary solution is to obtain a perfect system have real consumption and traceability. By observing the basic functioning of the equipments that place the actives and passives in the PCB, which are called Siplace, it became obvious that some of the equipments functionalities could be integrated with the ERP and MES systems and, in this way, create a solution for the Line Stock Control issues. The reader can find a brief description of the mentioned equipments in Chapter 8.

The basic functionalities of Siplace equipments that enabled the mentioned integration are the "load of recipes" and the "placement errors". The first is used for the setup of a line for a new lot/product: to validate the "recipe" the operator has to read the barcode of each raw-material that is going to be placed. The purpose of this procedure is to make sure that the raw-material that is going to be used is the one as in the "recipe". If it isn't, an error message is prompted. The second functionality, "placement errors", consists of tracking done of the number of placements of actives and passives that were made correctly and incorrectly. This information is then aggregated and used for studies of the equipment's reliability. Combining these two functionalities it seemed possible to calculate the precise amount of used units for each raw-material in the recipe. This would provide a precise the consumption value per raw-material. Using that same information to update SAP we could control the line stock in the most precise and perfect way. If it was possible to have this perfect visualization of the consumption then we could start controlling the production line in SAP what represents reaching the defined goals for the Line Stock Control project. Figure 25 exemplifies the basic functioning of the desired software.

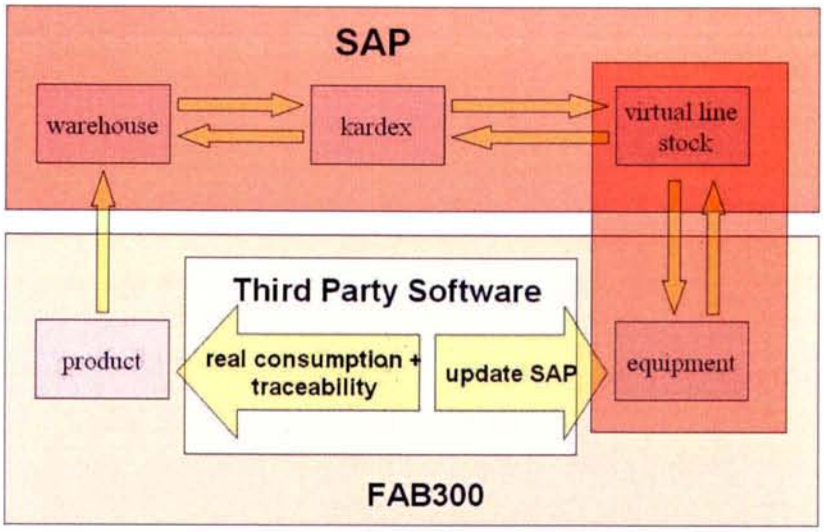

Figure 25 – Primary Solution for Line Stock Control

After the definition of the general functioning of the solution, effort was put on trying to know the Siplace equipments, their language and protocol for communication. A study was made to the possibility to develop a software toll at Infineon Technologies to compute the perfect consumption. The conclusion was that the project would be too big for the central department of IT[39]. The main reasons for this were:

- The equipment's language is very specific:
    - Unknown by the IT team;
- Test phase and development phase would represent a great impact;
    - Dedicated SMT line for tests and implementation;
        - High capital costs involved;
        - High impact to the organization.

Therefore, a solution from a third party had to be found. A study was conducted and three companies were identified. These companies provided software that would make the integration of the number of units placed by a Siplace with the information of which raw-materials are being used, just what was intended. A proposition was then made to these three companies to defy them to try to develop a tool that would provide the traceability functionality between lot of raw-materials and lot of product.

The requisites presented to these companies were the following:

- Traceability between lot of products, lot of raw materials (the ones defined as priorities) and the equipment used;
- Have consumption of the materials accordingly:
    - Per batch number:
        - Quantity;
        - Date of consumption;

[39] Information Technology

- Integrate data with SAP:
    - Consumptions per batch number;
    - Quantity;
    - Date/Time of consumption;
- Materials' scope: PCBs, Actives, Passives and Solder Paste;
- Reliable treatment of data;

The most interesting proposal was done by a company called Kratzer Automation AG – specialists on tools that work on the software provided with the Siplace. This company was then asked to elaborate a budget for the desired software. This budget is presented in Chapter 9.

The main advantages of this Primary solution are:

- Perfect Traceability;
- Perfect Consumption definition;
- Integration with SAP;
- Reliable solution.

The main and perhaps only disadvantage of this solution is:

- High Costs:
    - Budget for the development of the tool and its implementation is around 600,000€.

4.2.3 Alternative Solution

The "Alternative Solution" was intended to solve the same consumption and traceability issues in a simpler and cheaper way than the Primary Solution. It was developed based on adaptations that could be done to the existing ERP and MES systems and with the creation of a new software tool, named "Material Manager". It involves the creation of as many warehouses in SAP as there are SMT lines – so that we would have one warehouse in SAP called equipment for each one of the production lines. In the following lines a description of the most important functionalities used for the Alternative Solution will be presented.

FAB300

FAB300, the MES, is organized by operations and so, when an operator wants to produce a lot he has to make an operation in FAB300 that is named "Move In". The same concept applies to when the operator wants to make the transaction out of one production operation – the operator executes the "Move Out".

SAP R/2

SAP, the existing ERP platform, is organized so that the raw-materials are transferred from one warehouse to the other until the consumption point. In each of these transactions, some basic information is always kept: the time/date of the transference, the batch number[40] and quantity, which together allow the identification of any raw-material. When a transference/consumption of a raw-material is done, this data has to be inputted every time.

The easier way for the reader to understand how this solution was developed is to follow the procedures that have to be made for the production of a lot. The first activity that the operator would have to do is to make the "Move In" in FAB300 of the production lot (operation that consists of moving in a lot of production to a defined operation step, such as the Burn In operation). The basic information of this operation would be kept in the "Material Manager" – the new software that would be developed. Then, depending on the product, the line operator would have to make the raw-materials transfer to the correspondent equipment/production line where the product's lot is going to be produced, information that is stored in the ERP system until consumption is made. When the operation step is over, the operator must make an operation called "Move Out" in FAB300 (operation that consists of moving out a lot of production from a specific production step, such as Burn In). It was then that the "Material Manager" would get the total amount of products produced from the lot and then, according to the BOM, calculate the consumption. It was defined that, for this calculation, a scrap percentage could be introduced. The result of this calculation is the theoretical consumption of raw-materials which is given by the following expression:

Equation 3 – Expression for the Theoretical Consumption

$$Consumption = BOM \times Qty_{produced} \times (1 + Scrap_{\%})$$

[40] Batch number is the lot number that identifies uniquely the raw-material

The three systems, the ERP, the MES and the "Material Manager", would be integrated by the use of trigger/flags between them. For instance, the calculation of the theoretical consumption would start with a trigger/flag that the FAB300 would issue for the "Material Manager". After the calculation of the consumption is done, the "Material Manager" would update SAP by removing from stock the theoretical consumption. If there would be more than one batch number in the same equipment of the same raw-material then the "Material Manager" would indicate SAP that the consumption was made from the older batch. SAP would then be updated by taking out from the available stock in the used production line – represented by equipment in SAP – the theoretical amount consumed.

Traceability would be performed by the "Material Manager". This software would associate the lot of product to the batch numbers of the raw-materials by using the same relation that was used for the update of SAP. After the "Material Manager" has performed the described procedures then the "Move Out" in FAB300 would be done. The described functioning of the Alternative Solution is exemplified in Figure 26.

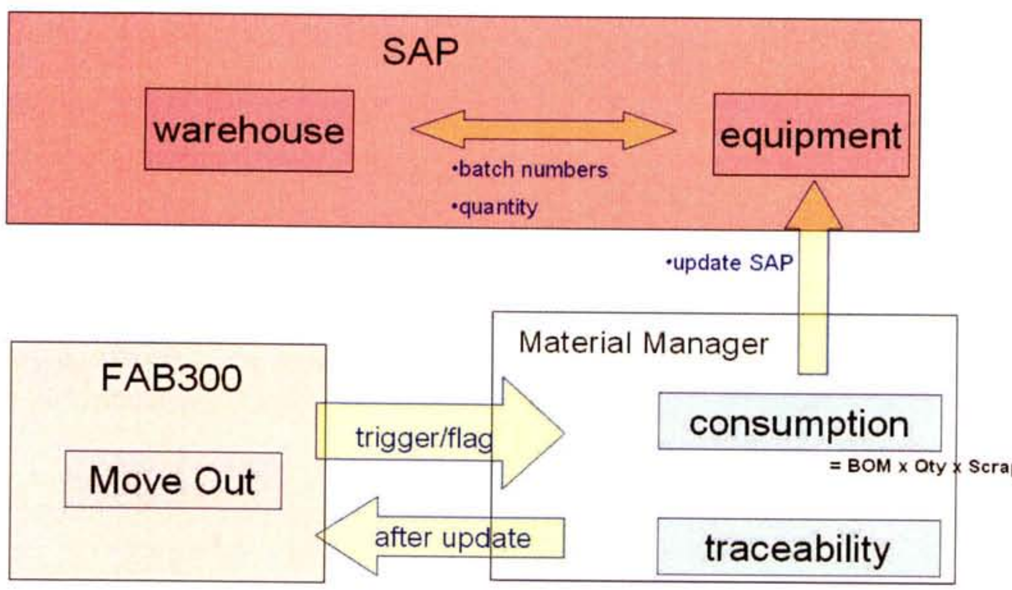

Figure 26 – Alternative Solution for Line Stock Control

The Alternative Solution would perform both desired main functionalities: the consumption definition with integration of the line stock in SAP and the traceability functionality. Its main advantages are:

- Good traceability;
- Acceptable control over consumption;
- Possible to develop with the Infineon Technologies IT resources.

Its main disadvantage is that consumptions are estimated and, therefore, the confidence on the stock levels is quite reduced. In order to improve the stock levels reliability regular inventories must performed what involves reasonable costs for the company. A specification was later developed for this solution and can be found in Chapter 10.

4.2.4 Simplest Solution

The objective with the Simplest Solution is to have an alternative that would be very easy to implement and develop. It would only solve the primary objective of the project: consumption calculation of the raw-materials. It's based on the same concepts presented before for the Alternative Solution: the theoretical consumption.

Equation 4 – Expression for the Theoretical Consumption

$$Consumption = BOM \times Qty_{produced} \times (1 + Scrap_{\%})$$

This solution would involve the creation of a warehouse in SAP called equipment and a virtual line stock.

The consumption would be subtracted from the existing stock in the equipment warehouse by using the same procedure described for the alternative solution: calculation of the theoretical consumption and then making the consumption to the batch numbers that were first moved to the warehouse equipment in SAP. The main advantages with this solution are:

- Very simple solution;
- Quick Implementation;
- Flexible – to new products and materials.

And its main disadvantages are:

- Imprecise solution for consumption;
- No traceability;
- Information's format not compatible with SAP:
    - Incompatible with batch data;
    - Restricted to quantities and SAP codes.

This solution was left aside because, although it's very simple when compared to the others, it doesn't have the same potential as the Primary and Alternative Solutions do. A prototype was however built. It was developed in Excel for the Engineering Materials[41], a smaller group of the raw-materials within the Modules area. Its objective was to would be used as a trial version for the testing of the Prototype. However, this test was never made mainly because of some special requisites: the engineering raw-materials would have to be isolated from the remaining raw-materials, what was thought to cause great entropy to the established procedures in the production line.

One other curious aspect about this prototype is that it became a very powerful tool in on other point of the project. When appropriate, its relevance will be explained. A detailed description of the Prototype is presented in Chapter 11.

[41] Materials that are being qualified for use in production

Overview of the Benefits and Implementation perspective

Regarding a final overview of the benefits and implementation perspective, the Primary Solution is the one that offers better results. It is, however, very expensive to develop and implement and, for that reason, its implementation perspective depends on the support of the worldwide organization to this project. In order to gain support to this solution, the other backend factories were contacted for their opinion, which is presented in the following point of the document.

The Alternative Solution presents an approximation to the real consumptions and traceability what provides good results at a reasonable cost. The other backend factories prefer the Primary Solution to the Alternative Solution however, costs are a great limitation and so the Alternative Solution is much more likely to be the one developed.

The Simplest Solution only provides an approximation to the consumption of raw-materials and, therefore, has already been left aside. It was used as a Prototype in order points of the project, as it will be explained later on. Its implementation perspective is, consequently inexistent.

IFPT has sent all the presented solutions Infineon Techonologies central IT resources and is currently waiting for their decision on which solution is to be developed.

Feedback from the other backend sites

Contact was established with the other Infineon Back End sites, Malacca in Malaysia, Suzhou in China and Dresden in Germany. The objective was to present the project and solutions found to the other sites and to get their feedback:

- Total alignment with the Requisites presented by IFPT;
- Total alignment with the Solutions presented by IFPT;
    - China and Malaysia prefer the primary solution to the alternative one.

After this feedback all the conditions were gathered for the submittal of an IT request for the project.

One other improvement opportunity was found when the solutions for the Line Stock Control were being developed. It was identified that the stock in the production line was not only invisible but also very high and so it seemed possible to develop a new solution – the Kanban System, which is presented in the following point.

4.2.5 The Kanban System

When the Line Stock solutions were being developed soon it was revealed that the Line Stock was not only invisible in SAP but also uncontrolled. It seemed that the stock value in the Modules production line was high. And so, a studied was done to know how much stock is in the production line.

Study to the impact of a Kanban in Modules – Overview

The objective of this study was to identify the impact of a Kanban in the Modules production line. This study is quite extensive and so it will be presented in chapter 12.

The conclusion of this study is that applying a set of rules and targets for the amount of stock that should be in the production line and keeping those targets based on a Daily Plan, IFPT could save up to around 250000€ and reduce the average stock volume of actives and passives up to 75%.

The application of this Materials' Kanban would provide other benefits that, although relevant, can't be that easily quantified. All the expected benefits of applying the Kanban System are listed bellow:

- Reorganization of the stocking positions;
- Reduction of the CpP[42] in the modules area;
    - Main performance indicator of the production area and of IFPT;
- Reduce the amount of errors that occur with the handling of raw-materials;
- Save up to 250000€ per year in raw-materials;
- Reduce the Line Stock MOD in 75%.

Kanban – the Concept

Kanban is a technique that was developed by the Japanese industry that is based on a Pull system of production. The essence of the Kanban concept is that a supplier or the warehouse should only deliver components to the production line as and when they are needed, so that there is no storage in the production area. Within this system, workstations located along production lines only produce/deliver desired components when they receive a card and an empty container, indicating that more parts will be needed in production. Since Kanban is a chain process in which orders flow from one process to another, the production or delivery of components is pulled to the production line. In contrast to the traditional forecast oriented method where parts are pushed to the line.

The Kanban concept was originally developed by Toyota in the 1950s as a way of managing material flow on the assembly line. Over the past three decades the Kanban process has developed into an optimum manufacturing environment leading to global competitiveness.

[42] Cost Per Piece

In the 1950's Japan was going through an economical crisis. The Second World War had just ended and Japan's industry, specially the car industry, was facing a big competition from the American Industry. In the beginning of the 1950's the most successful production system was still Mass Production and so the Japanese car industry had to adapt itself in order to become competitive in their market.

The Japanese market was, after the Second World War, small and so it demanded for many different products in a small scale, concept that is antagonist to the whole concept of Mass production. A solution came from Taichii Ohno at Toyota who studied Mass Production adapted it to the post-war reality of Japan. To this new production philosophy is called Lean Manufacturing. This new concept of production had huge differences to the Mass Production which are represented in Figure 27.

Lean Manufacturing	Mass Production
•Small volumes of production	•Large volumes of production
•Great variety of products	•One single product
•Very small setup times	•Very long setup times
•Flexible Machines and Tools	•Unflexible Machines and Tools
•Small Batches	•Large Batches
•Focused on the individual	•Focused on the task
•Pull production system	•Push production system
•Team development	
•Just in Time	
•Quality Policy	

Figure 27 – Lean Manufacturing versus Mass Production

Toyota and the Japan's car industry soon applied these concepts and soon gained supremacy in this industry. The concepts developed soon were adapted to other Japanese industries with great success and Japan became an economical superpower. The impact of the development of the Lean Manufacturing and the Toyota Production System was felt at a global scale. Although this issue influenced a lot the today's production systems and philosophies, this analysis doesn't belong to the scope of this project and so it will be explored in one other opportunity.

Regarding the Kanban concept, the Japanese refer to it as a simple parts-movement system that depends on cards and boxes/containers to take parts from one work station to another on a production line. It stands for Kan- card, Ban- signal and its essence is that a supplier or the warehouse should only deliver components to the production line as and when they are needed, what reduces storage in the production area dramatically. Within this system, workstations located along production lines only produce/deliver desired components when they receive a card and an empty container, indicating that more parts will be needed in production. In case of line interruptions, each work-station will only produce enough components to fill the container and then stop. In addition, Kanban limits the amount of inventory in the process by acting as an authorization to produce more inventory. Since Kanban is a chain process in which orders flow from one process to another, the production or deliveries of components are pulled to the production line. In contrast to the traditional forecast oriented method where parts are pushed to the line. Therefore, a Kanban is not just a way to reduce inventory, it's an all new way of thinking.

A Materials' Kanban at IFPT

The concept presented before is the general description that can be found in books about this subject. The semiconductors' industry, and more specifically IFPT, has some characteristics to which the Kanban concept should adapt.

A Kanban System is known to produce best results in repetitive manufacturing environments. A repetitive manufacturing environment is:

> *"the fabrication, machining, assembly and testing of discrete, standard units prodiced in volume, or of products assembled in volume from standard options... [it] is characterized by long runs or flows of parts. The ideal is a direct transfer of parts from one work center to another."*

Hall (1983)

It was clear that the concept of repetitive fabrication did not apply to IFPT and so the feasibility of a materials' Kanban was discussed. The main issue was that the Modules' production had variations that shouldn't be disregarded. A study was done to the production's variation and this impact on the feasibility of the application of the materials' Kanban. This study is presented in chapter 13. Its conclusions were that, although the flexible production system causes some emergency procedures to happen, it's better for the organization to have a flexible production and therefore, trained emergency procedures, rather than to have an inflexible production system. Consequently, it was concluded that the solution was not to try to solve the variations of production but, instead, to try to solve the consequences of this flexibility in the best possible way.

The concept presented before is the general description that can be found in books about this subject. The semiconductors' industry presents some characteristics that make it impossible to apply the textual Kanban, as it was defined above, although the concept is still valid. What was developed in this project has the same basic theoretical concept defined before but applied to the semiconductors and IFPT's reality.

The Kanban that was developed in this project was applied to raw-materials and its objectives were:

- To reduce stocks in the production line;
    - Expected reduction of 60% to 70% of actual stock;
- To reduce invested capital;
    - Real consumption closer to system consumption (closer to CpP);

The scope of this Kanban was, in an initial phase and within the Modules production line, the actives and passive raw-materials. Two implementation phases were developed for the Kanban: Stage1 and Stage2.

The first phase was applied as a short-term solution and was used for the test and evaluation of the process. The handling of the raw-materials was performed by a production operator that had training, the targets for the inventory were defined on a weekly basis and the control system that was applied was the available space in the racks and the technological support system was built on Excel.

The second phase is a final solution for the Kanban system. The handling of the raw-materials is performed by specific trained personnel, named Material Handlers, its targets are going to be settled on a daily basis and supported and controlled by the ERP system.

These two stages can be resumed as one short term solution, that improves the present scenario considerably, and a second stage that optimizes the line stock and procedures used to handle the raw-materials. Although these first and second stages were to be developed for the Modules production line, the solutions developed were designed with the objective of simplifying a possible future application of this system to the Components production area. Figure 30 illustrates the desired situation after the implementation of the second stage of the Kanban in the Modules area.

4.2.5.1 Materials' Kanban - Stage1

The previous figure represents the desired flow and structure of the raw-materials with the implementation of the Kanban. This desired final status demands the development of an IT project and, therefore, can be only available in the mid/long term. Since it was needed to reduce the line stock as soon as possible a first stage was developed. This stage was already implemented with the use of some alternative solutions. Figure 28 exemplifies how Stage1 was implemented at IFPT.

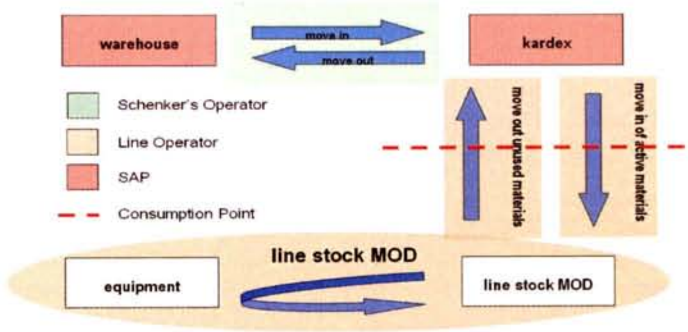

Figure 28 – Kanban Stage 1

The main conclusion that should be taken from the analysis of the figure is that there aren't any major changes to the information system that controls the raw-materials' flow. The main changes introduced by this solution are:

- Redefinition of stocking positions;
- Reorganization of the stocks layout;
- Implementation of a new control process of stocks and replenishment of stocks;
- Defined processes and responsibilities for handling raw-materials.

The stocks in the production line were placed in many different positions what was quite confusing for the operators and made stock control much harder. Figure 29 exemplify the change introduced to the stock locations.

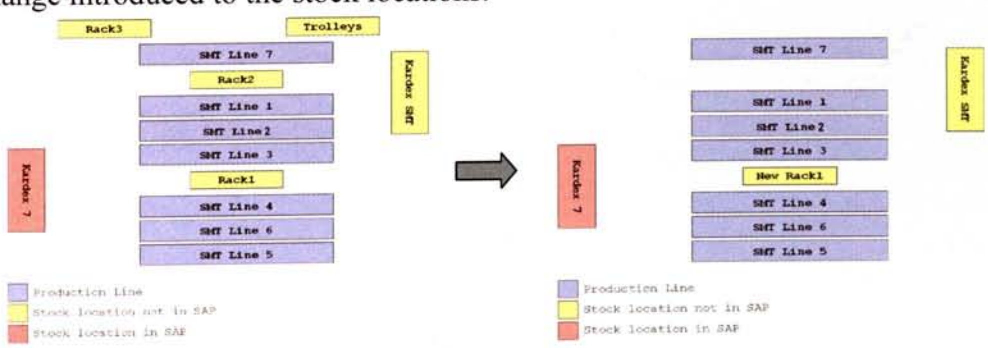

Figure 29 – Initial and Final Stock Locations in the Modules Production Line

As it can be concluded from the analysis of the previous figure, the stock locations not controlled by SAP – the ones that present lack of visibility – were reduced from five to two final locations. This involved the installation of new racks, represented in the figure by "New Rack1". These new racks had a different organization: they were all tagged with the code of the raw-material that should be placed in each location, organized by type of raw-material and dimensioned accordingly to the needs of each raw-material. The limited space in the rack for each raw-material was calculated in order to only be possible to place in the rack the amount needed for production. This limitation of space was what made possible the control of the stock levels. The replenishment of stocks was done by the modules line operators but new procedures and rules were created. The operators had specific training for the function and a training manual was created. This training manual that was given to the line operators is presented in chapter 14.

The main differences from this new replenishment procedure and the former one is that no longer the quantities moved to the production line were decided by the line operators without any structured procedure. From this stage onwards, stock value available in the production line was limited by the space available in the racks and controlled by the Production Engineers and Material Planners. The targets of the amount and type of raw-materials that should be transferred were defined accordingly to weekly needs that were then made available to the operators with the use of a report based on Excel.

Has it can be concluded, this first implementation stage involved more changes to the physical processes and storage locations than to any control system itself. The main reason for this two stage implementation steps is that the creation of a control system demands for IT[43] resources which were unavailable. The results obtained with this short term solution were very satisfying and are presented in the following point of the document.

Stage 1 – Results of the First Implementation Week

The results of the implementation of the first stage were very encouraging and are represented in the next table:

Table 7 – Impact of the first implementation week compared with CW 26

Variation – Compared data with CW26	
Total Stock CW26	1088
Stock Reduction	-53%
Target Reduction	-27%

It must be said that the targets that were chosen were very conservative, but still the stock reduction was of 53%. The Target Reduction refers to the stock reduction that would take place if the values that the operators place in the production line were the targets. The difference between the Stock Reduction and the Target Reduction exists because the targets are consumed as the shift goes by, and so, the conclusion that should be made is that the maximum stock in the Modules Production Line reduced considerably. The two different inventories that were made in the same period of the day revealed that the stock was reduced in 53%.

[43] Information Technologies

4.2.5.2 Materials' Kanban - Stage2

The second implementation stage of the Kanban represents the implementation of an integrated controlled warehouses by the ERP platform. The Figure 30 shows the desired final status for the Kanban implementation.

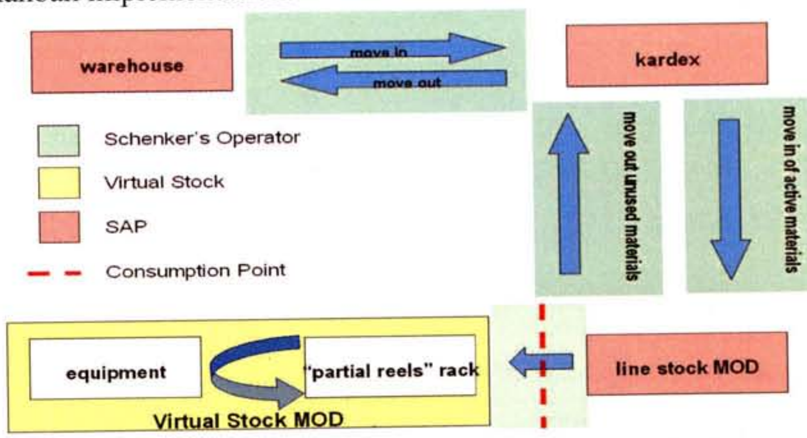

Figure 30 – Desired final flow for Kanban Stage 2

As it can be concluded from the analysis of the previous figure, there were other changes that were programmed for this second stage. The Material Handler, personnel that makes the raw-material transfer from the kardex to the production line, is now a specialized operator. The objective is to have very specific personnel doing this operation, what frees the standard modules line operators for their main function: the production equipments and processes.

The ERP system used by IFPT is going to control in this second phase a buffer in the production line called "line stock MOD". This buffer is currently holding a great amount of raw-materials that should be controlled by SAP. Physically this buffer in SAP will represent the racks were raw-materials in its full packages are placed. The consumption point of the raw-materials will also be changed from the kardex to the "line stock MOD". This is measure is supposed to bring us the major advantages of all because of the integration and visibility of the high stocks that are available in the production line.

Once these raw-materials leave the ERP system, what physically is represented by being removed the racks and being partially used, the system will still have some visibility over the quantity that exists in open packages. This will be possible with a simple calculation that was also represented for the "Simplest Solution" for the Line Stock Control given by Equation 5.

Equation 5 – Consumption Calculation

$$Consumption = BOM \times Qty_{produced} \times (1 + Scrap_{\%})$$

Once again, the prototype developed for the "Simplest Solution" was relevant for the definition of this consumption calculation. All these details are explained in the Specification presented in Chapter 15.

4.3 Components Production Area - Solutions Designed

As mentioned before, the existing stocks of raw-materials in the components production area are quite smaller than in the modules area. Operators within the components area have very well defined procedures for supplying the equipments and so there isn't much gap for optimization of either the stock value or handling procedures.

Two main solutions were presented: the application of the Alternative Solution, presented earlier for Modules, to the components area, and one other solution that involves controlling in SAP the existing buffers of raw-materials in the production line. The impact of these both solutions was analyzed and the implementation of an "Alternative Solution for Components" presents the following advantages:

- Implementation of Traceability between the Component and the raw-materials applied;
- Consumption estimation of the raw-materials within the scope of analysis;
- Control over the stocks in the production area;

However, this solution would also bring some disadvantages:

- For flux, epoxy resin and mold compound:
    - Very difficult to apply a solution without major changes to production processes;
- Doesn't have 100% visualization over consumption:
    - Stocks are estimated;
    - No control over material scrapped;
- Restructuring of the existing procedures for handling the raw-materials:
    - Could cause a big entropy; impact could be negative;
- Regular inventories are needed to keep level of confidence;
    - Not as critical as for MOD because of low stock level in the production line;

Since the "Alternative Solution for Components" was left aside, it seemed that it would be possible to bring some visibility to the existing stock in the production line if the stoking buffers were controlled by SAP.

As presented before, the raw-materials that contribute the most to the total cost within the Components area are the substrates and the lead frames – combined relative cost of almost 80%. These raw-materials, lead frames and substrates and gold wire have a tight control in the production area and so its stocks are basically limited to WIP[44]. The raw-materials whose buffer in the production line are possible to control in SAP are the mold compound, flux, epoxy resin and solder balls – combined relative cost of 14%. The impact of controlling these raw-materials responsible for 14% of the total cost is small because its stock is already very small, as discussed in Section 4.1.

[44] Work In Process

The conclusion of this analysis was that the benefits of controlling the line buffers were much smaller than the benefits and the confusion that it would bring to the line operators. It was also concluded that the Components area of production is working in a very efficient way: stocks are low and well controlled and the procedures are adequate and should be kept. Therefore, the work developed within the scope of the internship was kept as a reference for future studies, its results presented to the organization and this point of the project closed.

In the following chapter, Chapter 5, the reader can find the contributed given to the VMI project as well as its presentation and definition.

5 Vendor Managed Inventory

5.1 Introduction

VMI stands for Vendor Managed Inventory and is a logistic strategy that integrates both distributor and supplier. This kind of logistic strategy involves a close connection between the supplier and client. In theory the supplier manages the inventory levels and purchases of the materials he supplies.

A VMI partnership brings benefits for both parties. The distributor's major advantages are:

- Reduced Inventories – this is the most obvious advantage of VMI. Using the VMI process, the supplier is able is able to control the lead-time component of order point better than a customer with thousands of suppliers they have to deal with. Additionally, the supplier takes on a greater responsibility to have the product available when needed, thereby lowering the need for safety stock. Also, the supplier reviews the information on a more frequent basis, lowering the safety stock component. These factors contribute to significantly lower inventories;
- Reduced Stock-outs - The supplier keeps track of inventory movement and takes over responsibility of product availability resulting in a reduction of stock outs, there-by increasing end-customer satisfaction;
- Reduced forecasting and purchasing activities: As the supplier does the forecasting and creating orders based on the demand information sent by the retailer, the retailer can reduce the costs on forecasting and purchasing activities;
- Increase in sales: Due to less stock out situations, customers will find the right product at right time. Customers will come to the store again and again, there-by reflecting an increase in sales.

For the supplier, the major advantages are:

- Improved visibility results in better forecasting: Without the VMI process, suppliers do not exactly know how their customers are going to place orders. To satisfy the demand, suppliers usually have to maintain large amounts of safety stocks. With the VMI process, the retailer sends the POS data directly to the vendor, which improves the visibility and results in better forecasting;

- Reduces PO[45] errors and potential returns: As the supplier forecasts and creates the orders, mistakes, which could otherwise lead to a return, will come down;
- Improvement in SLA[46]: Vendor can see the potential need for the item before it is actually ordered and right product is supplied to retailer at right time improving service level agreements between retailer and supplier;
- Encourages supply chain cooperation: Partnerships and collaborations are formed that smooth the supply chain pipeline.

A VMI project is quite complex and so several issues must be considered for its establishment. Vendor managed inventory process impacts the many different replenishment practices on the retailer side. The retailer and the supplier must establish clear guidelines on inventory levels and fill rates. The VMI process involves exchange of critical and sensitive information between retailer and supplier. If this data is not shared or not accurate as per the established guidelines, it will have severe impact on the overall success of the VMI process. High-level descriptions of the various activities involved in establishing the VMI process are described below.

Management Commitment and Buy-in from Inventory Staff

If a retailer is establishing the VMI process, it should be treated as a strategic initiative and the objectives of this process should be communicated to the organization especially for the inventory and replenishment planners. The strategic management team should understand the concept of VMI and be ready to accept the concept of inventory management by a third party. Employees should be given a complete overview of VMI and the benefits the organization receives from the VMI process. The support of inventory analysts, e-business analysts and replenishment planners are very essential for the success of this program.

Data Synchronization and EDI Set Up

The product data like UPC and other catalog information should match between retailer and vendor. Prior to start up, product data should be audited and differences with respect to product data should be resolved. Also, a process for communicating the product data changes should be established. Ensure that the vendors are setup in EDI system. Verify and validate that the inbound and outbound transmission occurs as intended and in accurate manner. EDI testing is an iterative process and should be done covering all possible documents exchanged and for all types of products.

Setting up the Agreements

As discussed earlier, in the VMI process, the vendor creates the order and maintains the stocking plan for the retailer. To avoid situations where retailers question suppliers regarding the creating of orders for a product that they did not require and to prevent over and

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[45] Purchase Orders

[46] Service Level Agreement

under allocations scenarios, agreements on inventory turns, fill rates, frequency of replenishment and SLAs should be predetermined.

Data Exchange

Two types of data exchange occur between retailer and supplier. One is a one-time exchange of retailer's sales history that allows the supplier to base the inventory. The second type of data exchange is ongoing product activity data exchange. Product activity data exchange primarily contains quantity on-hand, sales volumes, back orders and returns. Product activity data exchange can be daily/weekly depending on the need.

Ordering

Upon receiving the data, the vendor calculates the reorder point (ROP) for each item based on the movement of data and any overriding guidelines established. The quantity available with retailer is then compared to the calculated reorder quantity at the item/location level and order quantities are determined. The created orders will be then communicated to the retailer.

When it comes to fulfillment, the VMI customers generally receive priority service for replenishment. Since vendors control the forecasting and fulfillment, even package quantities can be modified to reduce processing at customer receiving facilities.

Invoice Matching

Once the retailer receives the product, invoices are matched and payments will be made to the supplier accordingly. The important point in VMI is the ownership of the inventory. VMI does not change the ownership of the inventory.

Measurement

An effective measurement process should be agreed upon and implemented to monitor the success of VMI. This should include improvements in inventory turn over, stock availability, inventory reduction and distribution.

The VMI is a central project from Infineon Technologies and was being developed at Porto in cooperation with a specific supplier – Advantek. This company produces packing material such as cover and carrier tape for components. Several factors influenced the choice of this first strategic partner:

- Advantek has a deep experience in VMI – has developed several similar partnerships with other clients;
- Characteristics of the supplied material – the needs for cover and carrier tape are quite constant over the time. This makes it easier to implement a pilot VMI project;
- Willingness to establish this protocol as soon as possible.

At the time the internship started, the VMI project at IFPT had already began and the objective, at the time, was to define the process for the data exchange between IFPT and Advantek and the setting up of the agreements.

5.2 Achievements

The effort spent on the VMI project in the internship was the participation in the brainstorming meetings within the team and with Advantek. These meetings lead to the definition of the following points of the VMI partnership:

- External Warehouse – it was decided that an external warehouse was to be built close to IFPT; this warehouse doesn't belong to IFPT:
    - Cost Distribution – it was agreed with Advantek that the costs of this warehouse were supported by Advantek accordingly to the existing stock;
    - Responsibilities – the External Warehouse should belong to Schenker – logistic partner of both Infineon Technologies and Advantek;
- Stock Levels:
    - Minimum stock – it was first aligned at IFPT which should be the stock value at this External Warehouse and at IFPT's warehouse. The minimum stock values were then agreed with Advantek;
    - Stock level tracking – it was defined that Advantek is responsible for keeping track of the stock levels at both IFPT and the External Warehouse in order to place the POs[47]. These POs, although placed by Advantek, must be communicated with IFPT every single time.
- Data Exchanged:
    - What kind of data:
        - Inventory;
            - Organization;
        - Needs forecast;
    - Plan flexibility:
        - Frozen zone;
        - Variability that is allowed to the forecast;
    - Timeframe:
- Data Exchange support system:
    - Definition of the IT support tool for the data interface with Advantek;

[47] Purchase Orders

5.3 Status and Future Steps

The VMI project at Infineon Technologies is currently on hold because of different prioritization from the Central Infineon Technologies. Therefore, the work developed came to an end by the time that the points described earlier were defined.

The next steps of the project would be:

- Creation of the External Warehouse;
- Trial Run for testing the data exchange system;
- Final implementation.

6 Final Conclusions and Future Projects

The final conclusion of the project is that all the proposed objectives were fulfilled, new tools and solutions were developed and implemented, while others were designed and are waiting for development.

In the Line Stock Control project, two perspectives were followed in order to reach the desired objectives: the development of a software tool and the development and the implementation of a Kanban System.

Considering the software tool, two solutions were presented for the modules production line, a "Primary Solution" and an "Alternative Solution". The "Primary Solution", integration of the Siplace equipments with SAP, was designed in detail with the support of an external company that would develop the tool. The latter would provide perfect consumption, given by the amount of pieces consumed by the equipment itself, and traceability between each product and raw-materials used and the equipments used to process it. The "Alternative Solution" that implies the development of a tool that integrates the existing ERP platform and the MES platform. This solution would also fulfill the established objectives based on estimated consumptions. The consumptions are calculated according to the BOM and so scrap amounts are neglected. This solution would be possible to be developed by the Infineon Technologies' central IT resources.

Both these solutions were presented both internaly and to the other backend factories, being that all the Infineon Technologies' backend sites supported the project showing a clear preference for the "Primary Solution". The documents and specifications that support the Line Stock Control "Primary" and "Alternative" solution were sent to the IT's central resources and are now waiting for prioritization to be developed.

Regarding the Kanban system, two different implementation stages were developed: Stage1 and Stage2. The main difference between these two implementation stages is that Stage2 depends on an IT solution to be finalized. Therefore, at the time that the internship was over, Stage1 had been implemented. It allowed cutting down stocks by around 50% for active and passive raw-materials within the Modules production area just in the first implementation week. It also identified old raw-materials standing in the production line in the total value of 120,000€. These raw-materials are slowly being sold to other sites or companies and so a great deal of this total value has been saved. The physical layout was also changed what reduced the number of stocking positions in the production line and optimized space. The procedures and responsibilities for handling the raw-materials were refined what improved the total performance of the area. From a financial perspective, the Kanban is expected to save up to 250,000€ in raw-materials in the Modules production line.

Considering the components production, this area was studied in detail and it was concluded that it wasn't worthwhile to implement any changes to the existing system. On the one hand, this area is working very well, from the raw-materials perspective, and so trying to change so very well defined procedures could cause some confusion in the production line. On the other hand, the most significant raw-materials, from a cost saving perspective, are already so closely controlled that it seems almost impossible to optimize the area.

The participation in the VMI project was also a very interesting for the internship project at IFPT. Although no major objectives had been defined for this project, some important goals were achieved such as the definition of the external warehouse, the definition of stock levels and the kind of data exchanged and its support system. Participating in such a global project and team was definitely a surplus of the internship and an enriching experience. The project is currently on hold because of a different prioritization set from central Infineon Technologies.

Other smaller projects, which weren't initially planned, were developed. These smaller projects are improvements to SAP with the objective of making the Material Planning easier. They were submitted to IT's central resources and are currently being developed. Although it wasn't the objective of the internship, support was given to the Material Planning Group in very exceptional situations. This support was to help the Material Planners in urgent cases that had to be solved the most urgently as possible. One might consider this support to be irrelevant for the internship but, if we consider that the objective of the internships are to make the connection between the university and the professional world then, the experience was most valuable and interesting.

Regarding the future, it would be very interesting to continue participating in the VMI project and participating in the development and implementation of a final Line Stock Solution. One other interesting project would be to study the implementation of RFID[48] tags to critical raw-materials such as trays or other expensive raw-materials. These RFID tags would enable the tracking down of the physical parts in the IFPT's entire facility.

---

[48] Radio Frequency Identification

7 References

[1] www.icinsights.com

[2] www.kingston.com

[3] Infineon Technologies (2004), "Semiconductors: Technical information, technologies and characteristic data", Infineon Technologies, Munich

[4] J. Browne, J. Harhen and J. Shivnan (1996), "Production Management Systems", Addison-Wesley Publishers Ltd.

[5] Hall, R. W. (1983), "Zero Inventories", Dow Jones-Irwin, USA.

[6] www.intel.com

8 Appendix A: Basic Functioning of a Siplace Equipment

The Siplace equipments are used to place the raw-materials and components in the PCBs. Figure 31 exemplifies the basic functioning of these equipments:

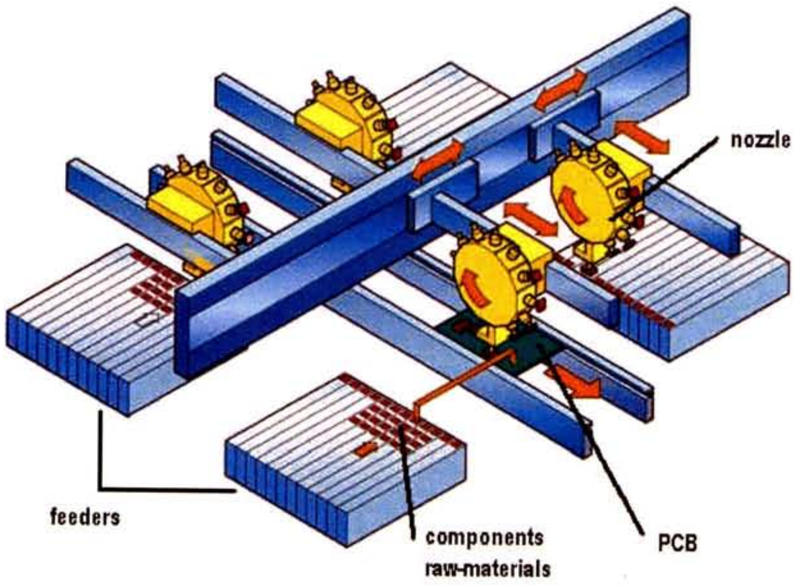


Figure 31 – Siplace Equipment

Basically there is one PCB to which are being assembled the components and the raw-materials. The latter are supplied through some devices that are called feeders. The function of these feeders is to unroll the reel where the components/raw-materials are, and to supply them to the nozzle. This tool grabs the components/raw-materials and then places them in the PCB. Figure 31 illustrates the case where all the components are supplied in reels, but it is also possible to have the components supplied in trays[49].

These equipments have an advanced internal language and programs that were developed by the supplier of the equipment. There is some software that was developed on these platforms and that is now being used, at IFPT, to control the performance of the equipments. The data that was being used, at the time that this project began, was the efficiency of the equipment – number of components placed correctly versus number of total components, and the distribution of the operative status of the equipment.

[49] Alternative support system for components; mainly used in intermediate steps of the production flow

Another functionality that is available in these types of equipments is the load of the recipes[50] accordingly to the product that is going to be produced. This is done when a new setup is made for the equipment. Each time a new setup is done, the operator has to check if the raw-materials that are placed in each feeder are the same as in the recipe. The operator validates the raw-material by reading the latter's barcode with a scanner that is available in the Siplace. If the raw-material is the same, then the operator checks the following raw-material placed in the feeder. Otherwise, the operator has to change the raw-material that is placed in the feeder. Figure 32 exemplifies the data that was being used of the operating Siplace equipments.

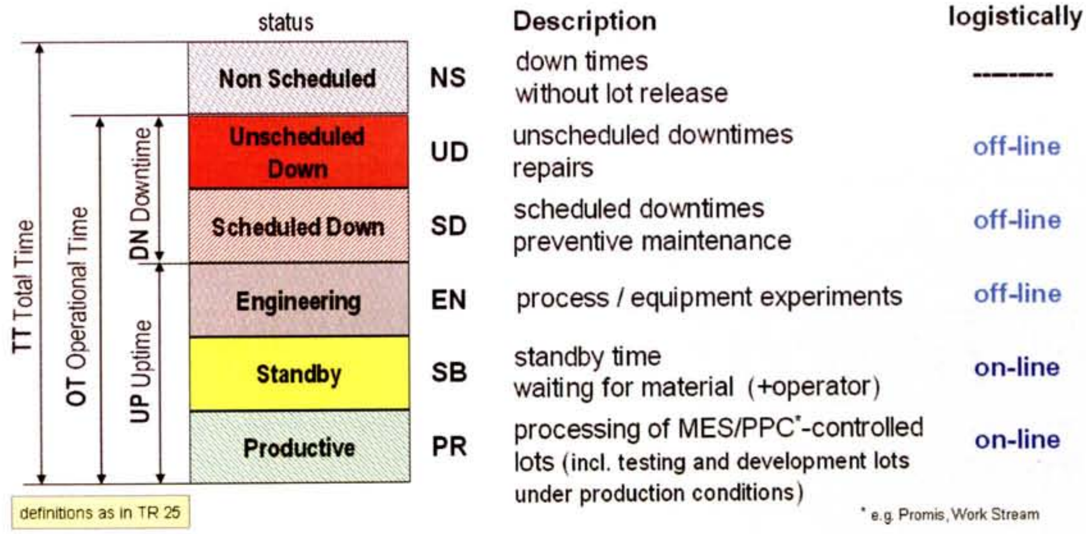


Figure 32 – Operating Status of the Siplace equipments

[50] Instructions for the SIPLACE equipment

9 Appendix B: Budget from Kratzer Automation AG - Primary Solution

kratzer
AUTOMATION

*intra*FACTORY®

Indication quote

25000-01-A0

vom 06.06.2005

intraFACTORY@

Traceability and Material Management

Kunde:
Infineon
Mr. Moreira

Porto
Portugal

Autor / Ansprechpartner:
Holger Siebers

Tel.: +49-89-32152-424
Email: Holger.Siebers@kratzer-automation.com

Peter Erhard

Tel.: +49-89-32152-201
Email: Peter.Erhard@kratzer-automation.com

intraFACTORY® Richtangebot 25000-01-A0
Traceability and Material Management vom 06.06.2005

Holger Siebers, Peter Erhard Seite 2 von 9

9.1 Introduction

The status of this paper is an indication quote. It should give you the main points and the budget of our proposal.

As all your requirements are not known at the moment there could be changes in the budget, this is because of classification reasons. Especially engineering can vary depending on how much is covert with our standard packages. Also the hardware equipment needed to satisfy your traceability solution could vary.

[LIT1] e-mail exchange with Mr. Moreira, Creation Date 3.6.2005.

9.2 Fundamentals

The foundation for this document is the e-mail information and request you have send to us. You have requested a proposal for a traceability solution to the production line the layout is described later on.

Assumptions

There are uncertainties about the number and types of machines and software systems you are using in your production. At this early stage some of the information remains classified on your side.

The following quote is an estimation of a budget you will need for integrating a traceability system in your production. The estimation is based on the requirements that we know at the moment about your system. For a calculated quote there has to be a requirement analysis in advance.

We can offer you a complete requirement analysis in cooperation with your system engineers separately. The cost of the analysis will be accounted in case of an order for the intraFACTORY@ traceability system.

Production Line

Assumptions about your production lines and the SMT machines you are using:

Line	machine	manufacturer	Type	number	software station	software line level
SMT	SMT-placement	Siemens	HSxx	14	503.03	LRL.503.03
SMT	SMT-placementr	Siemens	Fxx	6	407.xx	
SMT	SMT-placement	Siemens	HFx	1	505.01	SIPLACE PRO
SMT	Reflowoven			7		
Depanelling	Depaneller			3		
Test				3		

- The overall number of machines to connect are 34.

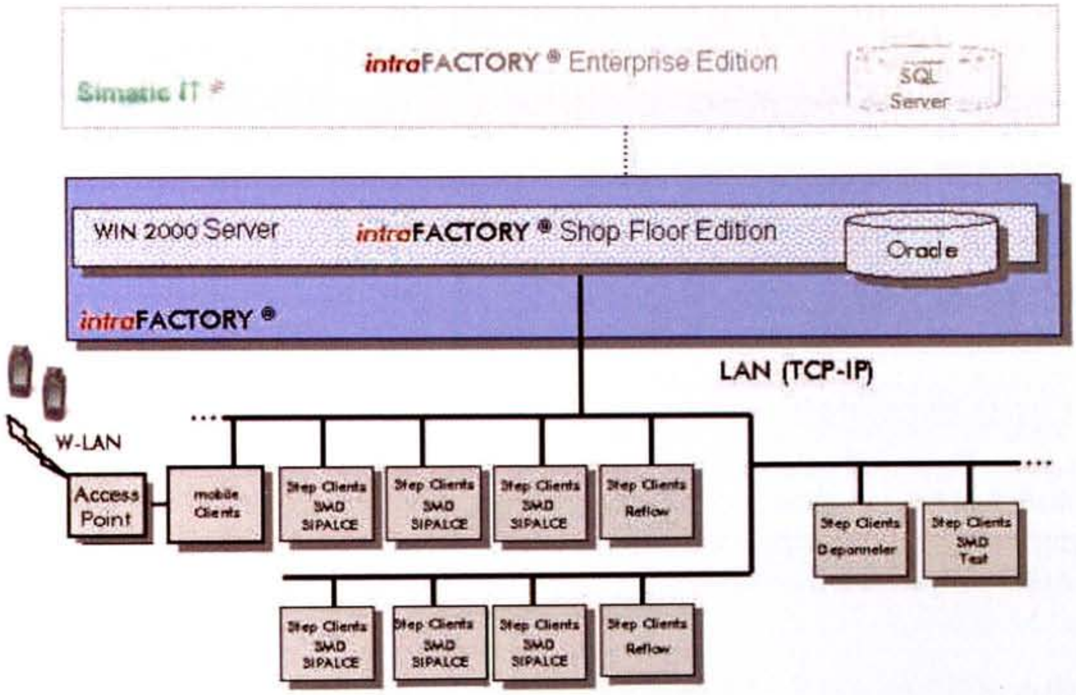
Throughput

- You are producing 312 000 000 products per year out off the PCB's at the beginning of your line;
- From these 312 000 000 products you are building 12 000 000 single products consisting of more than one part and 190 000 000 which are already the final product;
- You need one month online access to the traceability data and the data must be archived during the period of 1.5 years;
- At all of your depanelling machines, you have approximately 10 modules which are labeled per second;
- As "worst case scenario" 60 components are placed on one single product.

Open issue:

- 202 000 000 single products a year with max. 60 components each sums up to 12 120 000 000 used components per year;
- If there were 21 Siplace HS60 (best case for placement performance) in the line the maximum rate of used components would be (60 000 per hour * 24h * 365d) 525 600 000 components;
- The difference could lead to varying hardware assumptions from real situation at you production.

Software



Open issue:

- It is not known which interface technology could be used to interface your FAB300 system.
- You want online access to the stored data history of the last one and a half years. The performance you need on this behalf is still open

The production at Porto

IntraFACTORY@ should make traceability data available on a workflow like the following outlined by the e-mail from Mr. Moreira:

1- Loading of the PCB's into the printing machine (printer/ labeler)

2- Print of the solder paste on to the PCB

3- Move to Pick & Place equipment

4- Place the components and materials on the PCB

5- "Move Out" of the Pick & Place

6- "Move In" the Oven for Reflow

7- Depanelling of the modules by cutting the PCB's

8- Labeling of the module

9- Testing and Inspection

10- Packing & Shipping

At the moment are no possibilities available to identify a PCB be for the depaneller attaches a serial number on the cut modules. So the traceability solution must run on timing data from the Siplace machines. Because of this there will be a reduced accuracy in the data.

9.3 Project Management

Timetable

The exact timetable has to be agreed on by all stakeholders after the initial requirement phase of the project. Certain aspects of this project are not known to all stakeholders because of the early stage.

Project Management

There will be a dedicated person in charge of the project by Infineon (Porto) and there will be one project manager from KRATZER AUTOMATION AG for the project. The dedicated person in charge from Infineon must be reachable for KRATZER AUTOMATION AG at normal business hours during the project. There has to be a substitute during vacation.

Risk management

There will be a continuous risk management throughout the hole project, the process for it has to be agreed upon by all stakeholders in advance to the project start.

Installation and Integration

According to the timetable agreed upon there will be iterating approach to installation and integration.

Documentation

There will be standard documentation provided with the intraFACTORY@?Shop Floor Edition. Additional documentation will be provided for the software engineering parts of the project.

Training

Training for the on site users is not part of this indication quote.

9.4 Budget

intraFACTORY@ Licenses

Please take in account that we also have a site license.

Other Licenses

IntraFACTORY assumes

- Oracle DB Licenses
- Windows Server 2000 or 2003 Licenses

The license models and the number of licenses depend on number of users and/or number of used cpu's in your factory.

Server modules	fee per part	#	
intraFACTORY® Server	8.000,00 €	1	8.000,00 €
intraFACTORY® Manager	8.000,00 €	1	8.000,00 €
intraFACTORY® Material Manager, mobile	8.000,00 €	1	8.000,00 €
intraFACTORY® Traceability	8.000,00 €	1	8.000,00 €
IntraFACTORY® QDE, MDE/BDE	8.000,00 €	1	8.000,00 €
IntraFACTORY® Connector (ERP, MES, etc.)	8.000,00 €	1	8.000,00 €
intraFACTORY® Client Module	Summe	0	
IntraFACTORY® manual Workplace	Summe	0	
IntraFACTORY® workplace 1. - 9.	1.500,00 €	0	
IntraFACTORY® workplace 10.-19.	1.300,00 €	0	
IntraFACTORY® workplace 20. - 49.	1.200,00 €	0	
IntraFACTORY® workplace 50. - 149.	1.000,00 €	0	
		0	
IntraFACTORY® machine connection (Labeller, printer, SMT pick & place stations, AOI, ICT, Reflow, etc.)	Summe	34	
IntraFACTORY® machine connection 1. - 9.	1.500,00 €	9	13.500,00 €
IntraFACTORY® machine connection 10. - 19.	1.300,00 €	10	13.000,00 €
IntraFACTORY® machine connection 20. - 49.	1.200,00 €	15	18.000,00€
IntraFACTORY® machine connection 50. - 149.	1.000,00 €	0	
		0	
intraFACTORY® mobile Workplace	Summe	9	
IntraFACTORY® mobile workplace 1. - 9. (assuming 9 mobile workers for 7 lines)	1.500,00 €	9	13.500,00 €
overall sum			106.000,00€

Engineering

Engineering consists of the following packages:

- Requirement Analysis;
- Engineering:
    - System and Interface Specification;
    - Configuration of database, production equipment, workflow, and customer specific add-ons;
    - Documentation.
- Installation and test at the customer site **(1)**:
    - intraFACTORY@DB;
    - intraFACTORY@Server, "Material Manager", Traceability Module, QDE,MDE,BDE Module;
    - 21 intraFACTORY@Step Clients for traceability data from Siplace Pro;
    - intraFACTORY@Step Clients for the depaneller station;
    - intraFACTORY@Step Clients for the AOI test station;
    - 9 intraFACTORY@mobile clients.
- Project and Change Management according to ISO 9001;
- Configuration Management;
- Risk Management;
- QA and error tracking.

(1) Installation and Integration on one production line (or part of it) first and an iterative approach to the installation process.

Under the above given assumptions (see 9.2) we are estimating for the engineering part a budget of 280.000,00 €. This budget can vary depending on a requirement analysis, which is to be done in advance.

Hardware

At this stage and under the assumptions taken we recommend the following hardware. If we are going in follow up negotiations about this quote you will get a detailed budgeted proposal for the hardware.

The configuration suggested is adequate for the known outline of your production lines. The hardware which will be provided if needed.

- The configuration and the amount of servers and PC's varies due to performance aspects. We recommend a minimum of 1 cluster consisting of two HP server for the intraFACTORY@database (ORACLE 9i) 1 cluster consisting of at least 1 HP server and the intraFACTORY@application - for setup control, material management and process data acquisition 9 mobile terminals - Infrastructure: LAN, printers, etc.

IntraFACTORY@ Database Server

Consisting of two:

- ProLiant ML370 G4 Rack Model Intel Xeon 3.20GHz/1MB Processor and adequate additional equipment

IntraFACTORY@ Application Server

Consisting of two: ProLiant ML370 G4 Rack Model Intel Xeon 3.20GHz/1MB Processor and adequate additional equipment

Storage

Consisting of:	HP Storage Works Modular Smart Array 1500cs
	PCI-X- to – Fibre channel
	SNA switch etc.
	Modular SNA array controller
	HP 146.8GB Pluggable Ultra

The needed capacity depends on the results of the requirement analysis. We assume a minimum of four discs for this SNA

Mobile Terminal

- 9 mobile terminals Symbol PDA PPT8846-T2BY0DWW Windows CE 4.1, 1D Scanner, WLAN 11 Mbps WW radio, 31RAM / 32 ROM, PIM Key, Color with Charging Station and AC CRD8800 - 101S
- WLAN equipment (Access Point Spectrum 24 AP-4131-1050-EU-WW)

Hardware Budget

There is a 3 years warranty next business day onsite through the hardware manufacturer (in this case HP).

We estimate a budget of 210000€ for the needed hardware (incl. mobile equipment). Please take in account that there is also the possibility to use alternative hardware suppliers (In this case it would be actually IBM). The advantage of this configuration is the high performance capability and scalability (if needed). As mentioned above we have not all the information yet to decide about your exact hardware needs.

9.5 Final Overview Prices

intraFACTORY® Licenses	106 000,00 €
Engineering (estimated)	280 000,00 €
Hardware (estimated)	210 000,00 €
Other licenses (not applicable)	
Overall	596 000,00 €

All prices exclusive VAT

9.6 General

Basis of our fulfillment are our 'General Conditions for the Use of Software Products', date 31.7.2002.

This offer is valid for 30 days.

Unterschleißheim, 06.06.2005

KRATZER AUTOMATION AG

10 Appendix C: Alternative Solution - Specification

Line Stock Control v2.0– The System

Requirements Specification

Version 1.0

10.1 Overview

10.1.1 Purpose of the product

The purpose of the product is to be the support for a project of Line Stock Control. The project's objectives are:

- Stock in the line should be considered as part of the total stock available to produce in the SAP.
- Avoid high stock levels due to low visibility of material in-house. High stocks in the line which are not controlled by SAP.
- Avoid false ruptures of stock due to unit high instantaneous consumption.
- Have traceability over materials
- Better control over Own Stock. Effects on:
  - Scrap (because of phase out).
  - Improve use of consignment agreements.
  - Control over expiration dates.
  - Needs of the materials.

In the first phase of the project the different areas involved were heard about their requisites for a system that would control stocks and provide traceability.

After this first phase was concluded priorities regarding the F1 Materials had to be defined. And so priority was given to Modules area and to the following materials within the Modules area:

- PCB's
- Actives and Passives
- Solder Paste

Some solutions were thought in order to accomplish the objectives: a most perfect one, an intermediate one and a simpler one. This solution refers to the intermediate one. The solution developed for this project can be resumed in Figure 33.

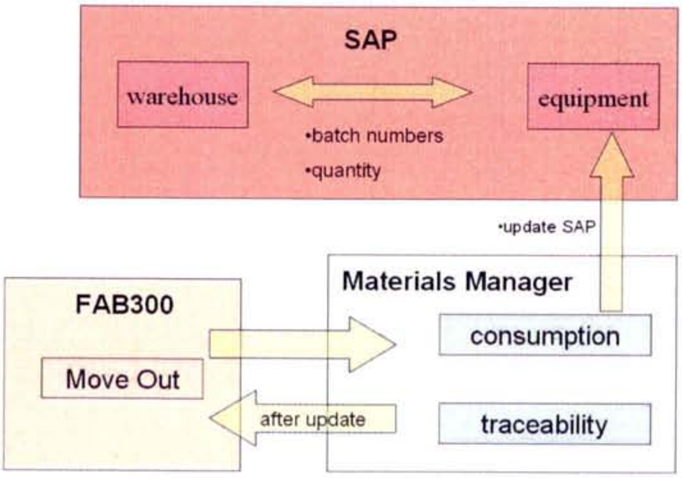


Figure 33 – System's Overview

For the solution presented before it's necessary to create, in SAP, two new warehouses and a new system that was called Materials Manager System. These two new warehouses represent the SMT Kardexs (Kardexs not connected with the warehouse used to store raw materials and others) and racks and the other stock warehouses like the equipments themselves. These new warehouses should be integrated in SAP because they store a lot of materials that aren't taken into account for stock value.

The new system can be considered as a system to store information about Consumables and Durables. It should store basic data considering the F1 materials, such as the one for the traceability function, and perform some other functions that are going to be described in a following point. The basic functionalities desired for the Line Stock Control are:

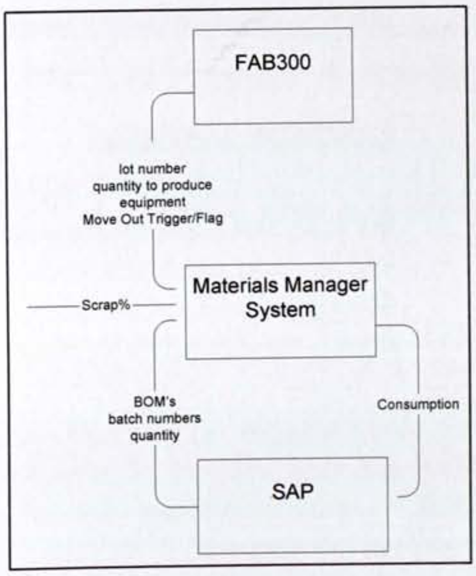
- Traceability between lot of products, lot of raw materials (the ones defined as priorities) and the equipment used;
- Give consumption of raw materials by batch number (identification of the raw material lot) in a compatible way for the SAP stock update.

The functionalities mentioned before are to be applied later to a wider group of materials in the Modules area and to the Components area as well. The specification of requisites that follows is, therefore, for the Modules area and for the priority materials.

10.1.2 Areas of application, system integration and delimitation

As mentioned before the product is to be applied, in a first phase of development, to the Modules area for the control of the following materials:

- PCB's;
- Actives;
- Passives;
- Solder Paste.



The system, once fully integrated, should make possible the communication between SAP, Materials Manager system and FAB300. The basis for this communication should be the Materials Manager system, as shown in Figure 34. The data that is necessary to communicate between all of these systems is represented in the next picture. The next lines of this document are a general overview of how the system should work in an integrated way.

In the SMT area the operators should move the material both physically and in the SAP system whenever they need it in the equipment. When the production of a lot as finished in the SMT line then the Line Control System should perform the traceability functionality and the consumption functionality. For that FAB300 should issue a trigger or flag to Materials Manager system in order to the latter one know when to perform the calculation of consumption, traceability and update of stocks in SAP. The data necessary from SAP is quantities of each batch in the equipment/line in consideration and the BOM's. The system should also be connected with the FAB300, the MES software, in order make the input of lot number and HYS to Materials Manager system. Traceability over products and raw materials should be given in Materials Manager system.

10.2 Users

The system is to have many different users. These users were grouped together by the type of use they'll make of the system. The groups are the ones defined bellow:

Table 8 – Users of the System

Users	Type of Use		
	Input Data	Traceability Visualization	Consumption Visualization
Line Controllers	yes	yes	No
Dept. PL	no	yes	yes
Dept. QM	no	yes	No
Dept. TO	yes	yes	No

10.3 Product requirements

Functional overview

As described earlier the basic functionalities are:

- Traceability between lot of products, lot of raw materials (the ones defined as priorities) and the equipment used;
- Give consumption of raw materials by batch number (identification of the raw material lot) in a compatible way for the SAP stock update.

In the following point of this document a more detailed description of each one and other functionalities will be given.

Functional description

The following points of this report are a description of the functionalities desired for the Line Stock Control System. A distinction has been made between the most important ones and the less important ones – called other functionalities. There is also a point for a brief description of how the association between batch numbers and quantity consumed should be done – the algorithm for traceability.

10.3.1.1 The traceability function

The traceability functionality should allow the visualization either by doing a search by lot number or by batch number. The function Traceability should be structured in the following way:

<u>Search by Lot Number:</u>

Inputs:

- *Lot number*

Outputs:

- *Equipments used*
- *SAP number*
  - *Batch numbers*
    - *Date of consumption*
    - *Quantity used of each batch number*

<u>Search by Batch Number:</u>

Inputs:

- *Batch Number*

Outputs:

- *Equipments were consumption was held*
- *Lot numbers*
  - *Date of consumption*
  - *Quantity used on each lot number*

The traceability should be done automatically by the Materials Manager system system according to the batch numbers moved from SAP warehouses virtual line stock to the equipment and the BOM for the product being produced.

An algorithm must be defined for this function so that it is possible to do the association of the quantities used of each batch number. In a following point a detailed description of such algorithm will be done.

10.3.1.2 The consumption function

Consumption should be calculated by multiplying the BOM by the quantity produced by a scrap percentage. What this means is that the BOM must be inputted from the SAP system according to the product in production and then, for each material in study (PCB's, Actives, Passives and Solder Paste), multiply the product's quantity by the material needs in the BOM plus a scrap percentage, given by Equation 6.

Equation 6 – Consumption's formula

$$Consumption = Qty_{\Pr oduced} \times Qty_{BOM} \times (1 + Scrap\%)$$

The consumption value should then be used to update the SAP system. For this update the data should be in the form:

<u>Consumption in SAP system should have the following structure:</u>

- Batch number:
  - Quantity used;
  - Data of consumption.

For that to happen it is necessary that the traceability function to be done at the same time as the consumption calculation.

10.3.1.3 SAP Update

The update of the SAP system corresponds to the consumption of the raw materials. The data for this functionality should be structured as it follows:

- Batch number:
  - Quantity used;
  - Date of consumption.

10.3.1.4 Algorithm for the Traceability function

In the presented solution the operator in the line of SMT does no longer make any inputs of which raw materials are going to be consumed. Instead the Line Stock Control System should do this automatically. To do so an algorithm must developed. This algorithm should do the following operations:

1. Get from the consumption function the quantity used per SAP number;
2. Get the data of which lot number was produced and in which line or equipment;
3. Check in the SAP warehouse equipment which batch numbers are at the correspondent line used for production;
4. For each batch number associate the quantity used. It can happen that there are more than one batch numbers at the equipment and so it must be known how much of each batch number it was consumed.

If there are two batch numbers of the same SAP number moved at different times then the consumption should be first made to the one that was moved first. If the consumption is more than the quantity available in the first batch then the remaining consumption should be considered to happen to second batch and so on.

If there are two batches moved at the same date/time – because there are recipes that demand two reels, for instance – then consumption should be distributed in an equal way through the batches moved at the same time to the warehouse in SAP equipment.

The former procedure was just a proposal of how the association could be done. Others might be found and, hopefully, simpler ones. For this algorithm to work some prerequisites are necessary:

- The operator moves in SAP from the Virtual Line Stock to the Equipment only the materials that are going to be used at the moment. If the recipe needs to reels of the same component then the operator should move these two reels at the same time;
- If a splice operation is necessary or the replacement of a reel in the equipment then the operator must first make the movement of the material in SAP from the Virtual Line Stock warehouse to the Equipment warehouse and then physically do the movement in the line;
- There are as many Equipment warehouses in SAP as many SMT lines.

10.3.1.5 Other functionalities

The BOM Input functionality consists of the input of the BOMs from SAP to the Materials Manager system according to the product's HYS. Therefore this functionality implies the input of all the BOMs existing in SAP and of the HYS that is being produced. Then, a query must be done in order to match the BOM with the HYS. The BOM is the output of this functionality that should then be the input for the Consumption Function.

Another functionality that the system capability to receive a trigger/flag from FAB300 when the lot is moved out. The objective of this function is to trigger the consumption function and therefore the traceability function and the SAP update with the consumption of the materials used. The next diagram represents the system and how the different functionalities should interact.

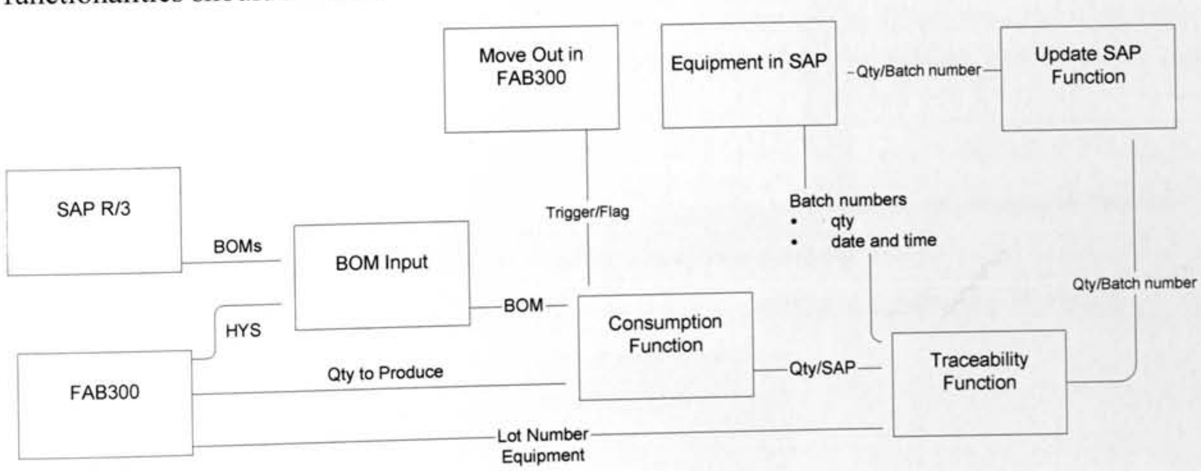


Figure 35 – System's Functions and Flows

10.4 External interfaces

The external interfaces to be developed are the ones that make the connection between FAB300 and Materials Manager and between Materials Manager and SAP. The interface between Materials Manager and FAB300 must support the issue of a trigger/flag for Materials Manager in order for the latter one to know when the "Move Out" was made and so can calculate the consumption, give the traceability and then update SAP. The inputs from

FAB300 of the HYS, quantity to produce and equipment where production is going to happen must be passed on to the Materials Manager.

A new interface between Materials Manager and SAP must be developed. This new interface would have to support the input from SAP of the BOMs and the update of the stocks in SAP after the calculation of the consumption and traceability functions.

The user interfaces that must be developed are the ones for the traceability visualization. In the next point of the report an idea of the kind of information desired and some draft of the design will be presented.

10.5 User interfaces (GUI)

The solution presented here only demands the development of a user interface for the visualization of the traceability. In this form the user must be able to search which batch numbers were used in a specific lot number (inputted by the user in the form) and to search which lot numbers used a specific batch number (inputted by the user in the form). The data in the search by lot number should be organized by SAP Number in order to make the interpretation of the results easier. The data regarding the equipments used by a lot number should be visualized on a different interface. The access to this interface should be done by clicking the correspondent button. The forms described could have the following formats:

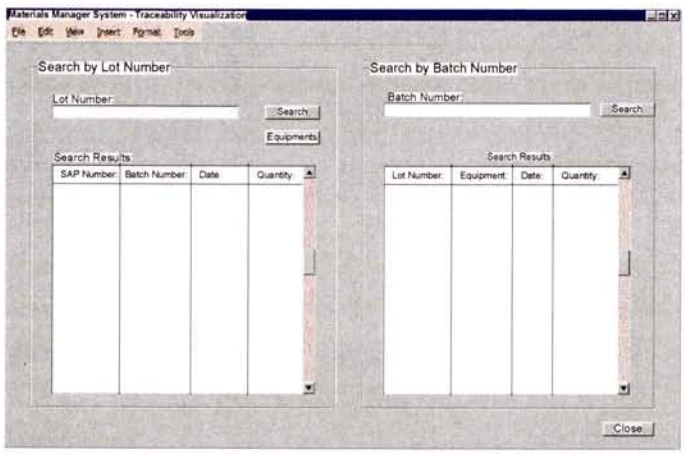


Figure 36 – Interface Traceability

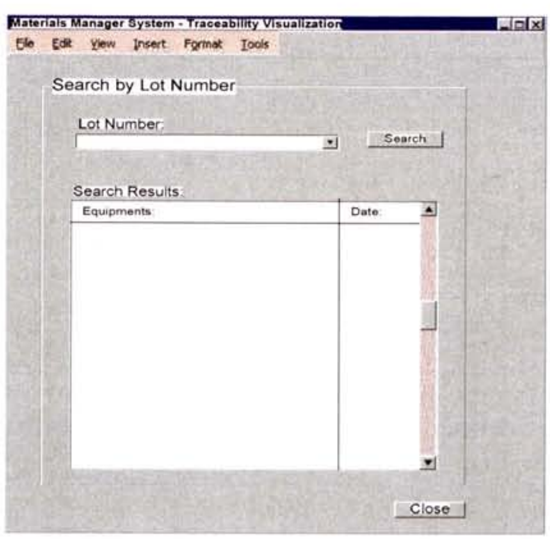


Figure 37 – Interface Traceability Equipment

A comment should be done regarding this latter interface presented. In the first phase of development of this project the attention is focused on materials only used in the Pick and Place equipments and so the results of the former interface will represent the lines in SMT used. Therefore this interface might be considered inappropriate, but one must keep in mind that this is just the first phase of development. Solutions developed for this phase of the project should have a range of applicability as wide as possible.

10.5.1 System interfaces

As mentioned before new interfaces have to be developed or updated. These new interfaces can be divided into interfaces between FAB300 and Materials Manager system and interfaces between Materials Manager system and SAP. The interface between the Materials Manager and FAB300 should support the following data transference:

- HYS;
- Lot number being produced;
- Quantity to produce;
- Equipment;
- Trigger/Flag that the "Move Out" was made so that the system can start the calculation of the consumptions and the traceability function.

Considering now the interfaces between Materials Manager system and SAP new forms must be developed. These interfaces must support two types of transfers: the data from SAP to Materials Manager system and the update of information from Materials Manager system to SAP. The data transfer from SAP to Materials Manager system should allow the following functionalities:

- Input of data – BOM's.

The update of SAP should allow the following data transfer from Materials Manager system:

- Batch number:
  - Quantity to "Move Out" in SAP – consumption in SAP.

11 Appendix D: Prototype - Simplest Solution and Daily MRP

The Prototype was developed with the objective of being a solution for the Line Stock Control – the Simplest Solution. However, the prototype was developed in a way that was possible to use it as a Daily MRP – functionality that was very helpful in the definition of daily targets for the Kanban System and the calculation of the daily consumption. The Prototype was built in Microsoft Excel with the support of Visual Basic.

In the next point of the document the basic functioning of the Prototype will be explained in detail.

11.1 Objectives

As mentioned before, the objectives of the Prototype was to present a short-term solution for a control system for the Line Stock Project. The objectives were to calculate every day what was the consumption of raw-materials in the Modules production area and for the chosen raw-materials – presented in a prior point of the document.

11.2 Inputs

The inputs for the Prototype are:

- The BOM's – imported from SAP;
- List of all the existing raw-materials within the scope of analysis;
- The daily Output for Modules – number of modules that come out of the Modules production line. Imported from BO[51];
- Raw-materials transferred from the warehouse to the production line – inputted by the line operators.

11.3 Outputs

The outputs basic output of the Prototype is the quantity of stock of each raw-material placed in the production line.

[51] Business Objects – software used for reports of the manufacturing indicators

11.4 Basic Functioning

The several steps that the Prototype goes through to get the quantity of stock available are resumed in the following list:

1. Import all the existing raw-materials within the scope of the project;
    a. Place that data in a list identifying the raw-materials by SAP Number;
2. Open all the BOM;
3. For each raw-material and for every different product (BOM), check if the raw-material is used in it and in which quantities;
    a. Place that data accordingly;
4. Open the Modules Output and then, for each product produced, multiply the quantities obtained in point 3 by the total amount produced – quantity consumed;
5. Update the stock available in the production line by subtracting the initial existing amount by the quantity consumed.;

As it can be concluded from the previous description, the Prototype can be used for calculating the existing amount of stock per raw-material in the production line and as a MRP. This MRP can run for any desired timescale since it is not as flexible as the SAP's MRP.

11.5 Interfaces

The first interface of the system is used to visualize the MRP for the Modules area – the "ConsumptionMOD" sheet, as represented in Figure 38. This interface is updated by clicking on the "Update" Button in the interface.

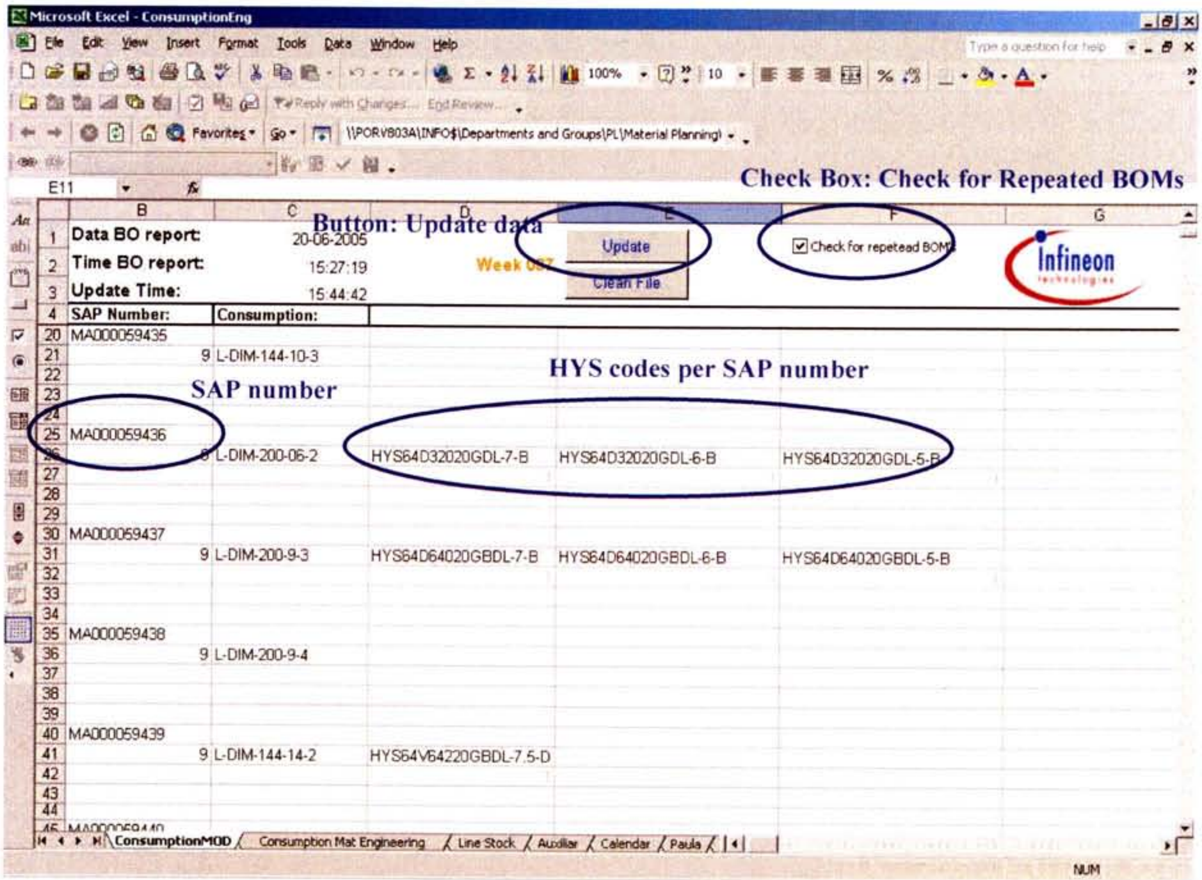


Figure 38 – Interface for the calculation of consumptions

One other functionality is available by clicking in the checkbox "Check for repeated BOMs". If active, the Prototype will check if there is any error in the data relative to the BOM by analyzing if there are any repeated BOM – this would cause the system to make the calculation of the consumption incorrectly. The date of the last update of the Prototype is also available and is compared to current date. If it isn't the same then the Prototype warns the user that the file isn't updated.

The calculation of the results takes around 5 minutes and, afterwards, the user of the system can select which raw-materials are desired for control in the interface represented by **Error! Reference source not found.**.

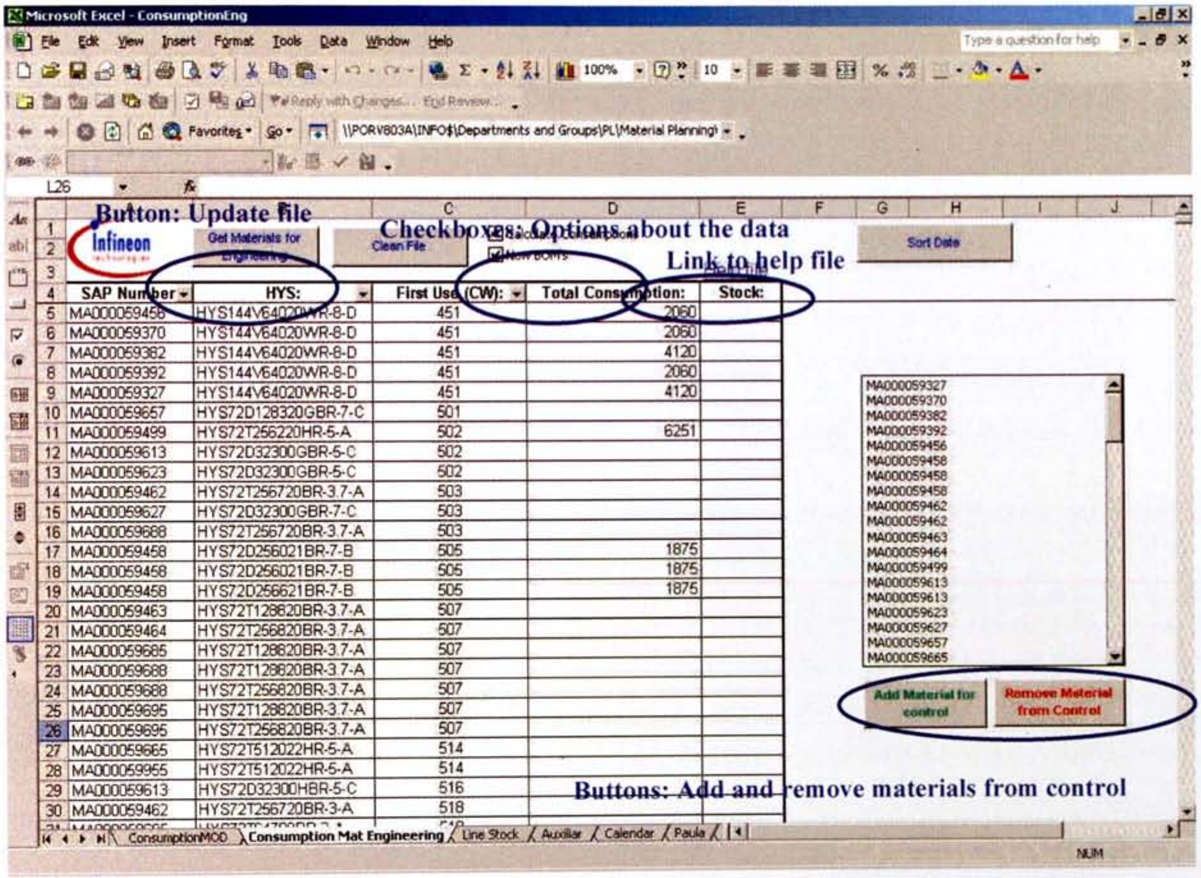


Figure 39 – Interface for visualization of the raw-materials and their selection for control

In this interface the user can select the desired raw-materials by clicking on the combo box on the left of the interface. After clicking on the desired items the user should use the button "Add Material for Control".The same combo box is used when the user wants to remove a given raw-material from control: selects the desired raw-material and then clicks on the "Remove Material from Control" Button. A help file is available with instructions about how the program works by clicking on the hyperlink "Help File". Other functionalities are also available in this interface such as the "Calculate Consumptions" and the "New BOMs" checkbox.

The Output of the Prototype is presented in the final interface, the "Line Stock" sheet. In this interface the user can have access to the existing stock in the Production Line, as exemplified in Figure 40.

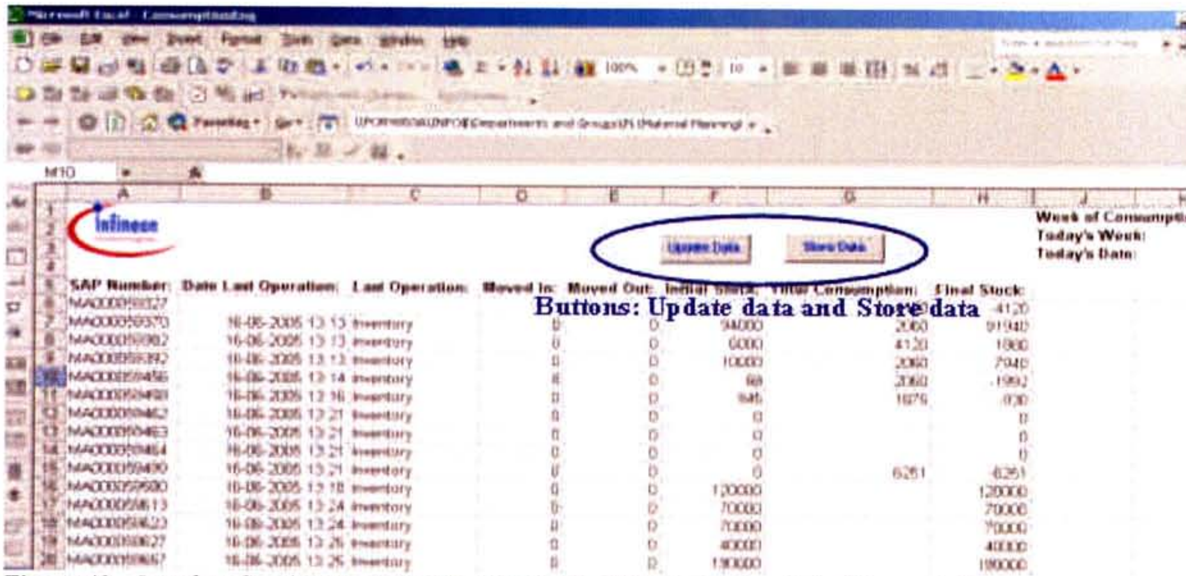


Figure 40 – Interface for visualization of the line stock of the materials selected for control

The user can have access to the existing Line Stock by clicking on the "Update data" button. This functionality imports the consumption of each selected raw-material to the interface. The "Store Data" button is used for the storing of the information about the line stock. If pressed, the Prototype will save all the information in a new Excel file in a specific path and with the name of the period of analysis. After this, it will update the file for a new week of calculation.

As mentioned before in Section 11.2, the line operator has to give the information of which raw-materials were moved to the production line. In order to standardize this kind of information, a new interface was developed: the "Input Stocks" sheet, which is represented in **Error! Reference source not found.**.

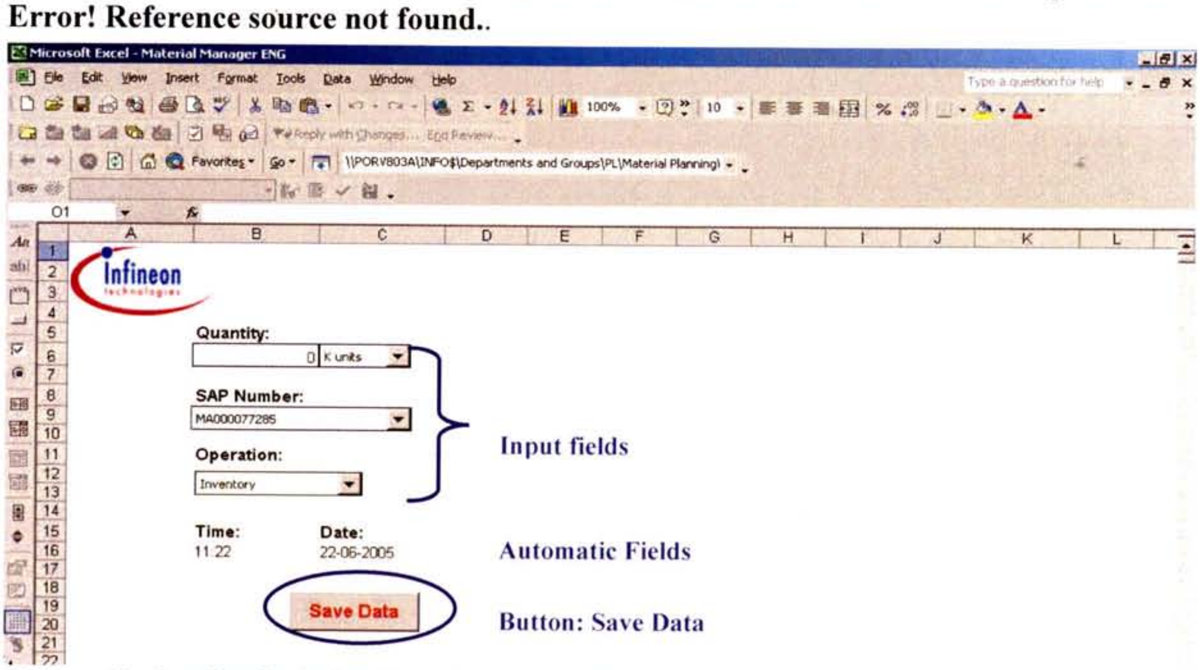
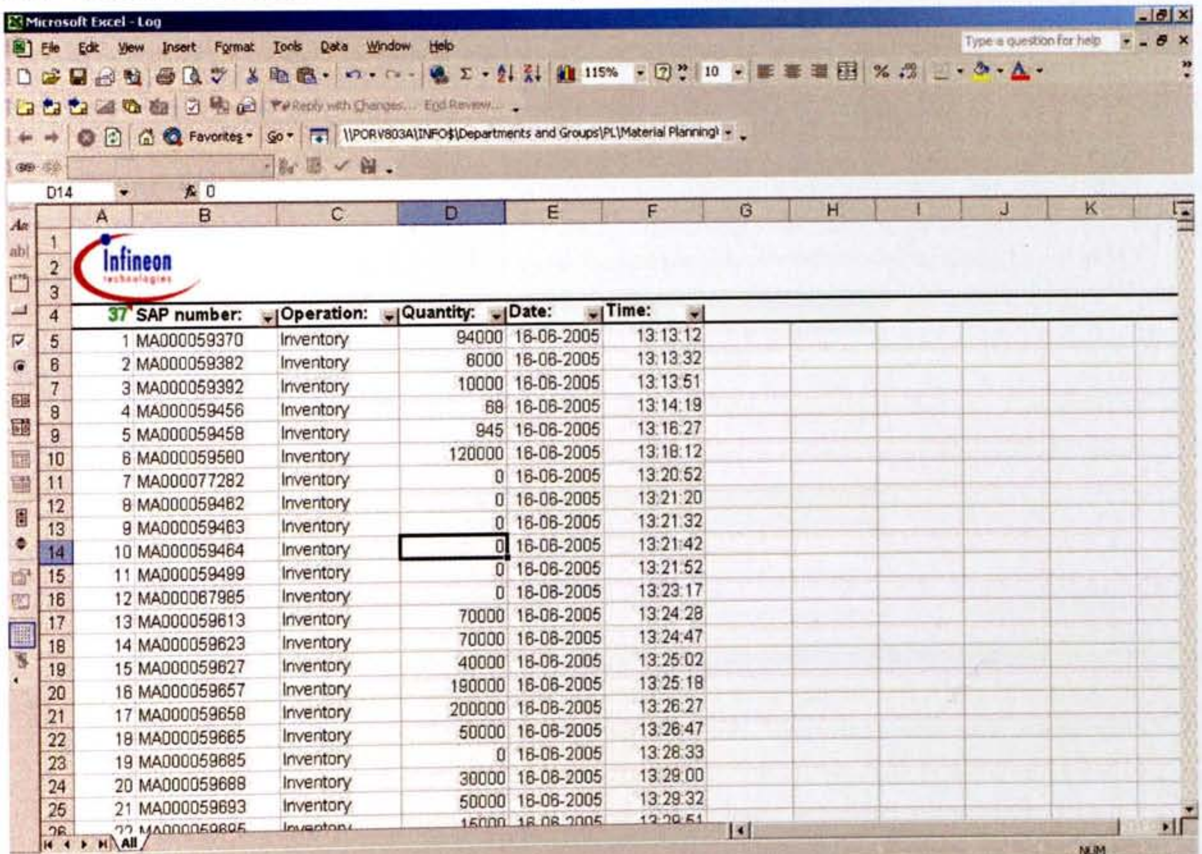


Figure 41 – Interface for the handling of the stock of the materials selected for control

The user of this interface makes the input of the quantity transferred manually using the input box. Then he chooses which basic unit was entered (single units or 1000 units). Then, using the combo box, the user chooses the raw-material that was transferred and the operation that was held – Inventory "Move In" and "Move Out". The automatic fields are information that the Prototype fills up by himself, for matters of control. When all the data was filled up, the user clicks on the "Save Data" button in order to save the information. A message box will prompt confirming all the inputted data. If the operation chosen is "inventory" then, the Prototype, will calculate that the selected raw-material has the available quantity inputted by the user. If the operation chosen is "Move In" then, the Prototype, will calculate the available existing stock by adding the inputted quantity to the existing one of the selected raw-material. If the operation chosen is "Move Out" then, the Prototype, will calculate the available existing stock by subtracting the inputted quantity to the existing one of the selected raw-material. All the data that is referent to these operations is saved in a "Log File" for matters of control. This interface represented by Figure 42.



37	SAP number:	Operation:	Quantity:	Date:	Time:
1	MA000059370	Inventory	94000	16-06-2005	13:13:12
2	MA000059382	Inventory	6000	16-06-2005	13:13:32
3	MA000059392	Inventory	10000	16-06-2005	13:13:51
4	MA000059456	Inventory	68	16-06-2005	13:14:19
5	MA000059458	Inventory	945	16-06-2005	13:16:27
6	MA000059580	Inventory	120000	16-06-2005	13:18:12
7	MA000077282	Inventory	0	16-06-2005	13:20:52
8	MA000059462	Inventory	0	16-06-2005	13:21:20
9	MA000059463	Inventory	0	16-06-2005	13:21:32
10	MA000059464	Inventory	0	16-06-2005	13:21:42
11	MA000059499	Inventory	0	16-06-2005	13:21:52
12	MA000067985	Inventory	0	16-06-2005	13:23:17
13	MA000059613	Inventory	70000	16-06-2005	13:24:28
14	MA000059623	Inventory	70000	16-06-2005	13:24:47
15	MA000059627	Inventory	40000	16-06-2005	13:25:02
16	MA000059657	Inventory	190000	16-06-2005	13:25:18
17	MA000059658	Inventory	200000	16-06-2005	13:26:27
18	MA000059665	Inventory	50000	16-06-2005	13:26:47
19	MA000059685	Inventory	0	16-06-2005	13:28:33
20	MA000059688	Inventory	30000	16-06-2005	13:29:00
21	MA000059693	Inventory	50000	16-06-2005	13:29:32

Figure 42 – Interface for the visualization of all the operations of handling the materials

12 Appendix E: Study to the impact of a Kanban in Modules

The impact of the stock value in the Modules production line had to be studied and so an inventory to this stock was done. It's very hard to make a full inventory because it would be necessary to count all the existing raw-materials in the equipments and so just the racks were analyzed. The materials' groups that were inventoried are the Actives and Passives – the ones that presented more stock in the production line. This study was done with data collected from two different weeks in order to have a bigger level of confidence in the analysis.

The first study was to the amount of line stock MOD compared to the weekly MRP needs. The number of existing number of reels in the line stock MOD is shown in tables 9 and 10.

Table 9 – Analysis to the number of reels needed per week versus inventory in week 34

number of reels MRP week	number of reels inventory
1900.00	883.00
100%	46%

Table 10 - Analysis to the number of reels needed per week versus inventory in week 39

number of reels MRP week	number of reels inventory
2096.00	1088.00
100%	52%

The data shown before means that the existing stock would be enough half a week. If the fact that only the racks were inventoried it's easy to conclude that the line stock MOD is enormous. The raw-materials' needs were analyzed individually one by one. The conclusion of this analysis is that there are two main groups of raw-materials, when it comes to needs' volume: the major runners[52] and the minor runners[53]. The following analysis was to if these main runners were to be supplied on a daily basis the needs for a week's production divided by seven (number of production days per week) and the minor runners supplied in order to have always the amount needed for the week the stock reduction would be very big. The results of this analysis are presented in Table 11.

[52] High Volume

[53] Low Volume

Table 11 – Impact of the application of Daily Targets based on a Weekly Needs in week 34

Daily Targets - Weekly Planning	
Stock reduction	**-41%**
Estimated €	**138652**
old materials €	60512
Stock reduction €	78141

Table 12 – Impact of the application of Daily Targets based on a Weekly Needs in week 39

Daily Targets - Weekly Planning	
Stock reduction	**-59%**
Estimated €	**200792**
old materials €	125040
Stock reduction €	75753

The conclusion to take from the presented data is that the stock in the Modules production can be reduced from around 40% to 60% just by applying a target definition for the stock volume. Although the rules applied were very simple, the results were very promising. From a financial perspective IFPT could save an amount from 140000 to 200000€. The old materials item refers to raw-materials that aren't used anymore for production and that are in the production line. The cost of those materials was the value used as a cost saving point if the targets were applied.

There is a variation presented in the two different weeks of analysis that can be explained by some factors:

- Since there aren't any stock targets, the volume available in the production line fluctuates a lot;
- The inventory done in the week 34 was done by another element of the team who might have used other inventory methods;
- The rules applied could de slightly different;
- It's very hard to make an inventory to the Modules area because of the characteristics of the materials.

Another analysis was done based on a different setting of the targets. In this analysis the targets were defined daily based on a Daily MRP. The Daily MRP would provide the daily needs per material type. Using these needs it was possible to set up exact amount of material that should be placed in the production line per day.

As mentioned before, the MRP that is currently available in SAP is weekly and therefore an alternative had to be used – the prototype developed for the Simplest Version of the Line Stock Control Project. This prototype revealed itself as a powerful tool to define the daily targets.

A study of the impact of the use of the daily targets was done and its results are represented in Table 13.

Table 13 – Impact of Daily Targets based on Daily Needs for week 34 and 39

Targets - Daily Planning		
week 34	Average €	-158582
	Benefits (€/year)	168097
	Cost Old Materials (€)	10457
	Total Benefits (€/year)	**179181**
week 39	Average €	-101475
	Benefits (€/year)	107563
	Cost Old Materials (€)	125040
	Total Benefits (€/year)	**240105**

Table 14 – Daily Impact of Daily Planning based on Daily Needs for week 34

Targets - Daily Planning	Reels Needed	Delta no Old Mat	Delta with Old Mat	Delta € (%)
Day 1	275	-69%	-75%	**-90%**
Day 2	239	-73%	-78%	**-91%**
Day 3	258	-71%	-76%	**-67%**
Day 4	303	-66%	-72%	**-64%**
Day 5	310	-65%	-72%	**-90%**
Day 6	288	-68%	-74%	**-88%**
Day 7	171	-81%	-84%	**-93%**
Average	263	-71%	**-76%**	**-83%**
Max	310	-65%		
Min	171	-81%		

Table 15 - Daily Impact of Daily Planning based on Daily Needs for week 39

Targets - Daily Planning	Reels Needed	Delta no Old Mat	Delta with Old Mat	Delta € (%)
Day 1	231	-69%	-74%	**-83%**
Day 2	260	-65%	-71%	**-88%**
Day 3	258	-65%	-71%	**-87%**
Day 4	231	-69%	-74%	**-91%**
Day 5	310	-58%	-65%	**-93%**
Day 6	293	-61%	-67%	**-90%**
Day 7	175	-77%	-80%	**-89%**
Average	251	-66%	**-72%**	**-89%**
Max	310	-58%		
Min	175	-77%		

The conclusion of this study is that applying a rules and targets for the amount of stock that should be in the production line and keeping those targets based on a Daily Plan, IFPT could save up to around 250000€ and reduce the average stock volume of actives and passives up to 75%.

The application of this Materials' Kanban would provide other benefits that can't be that easily quantified but are also important. All the expected benefits of applying the Kanban System are listed bellow:

- Reduction of the CpP[54] in the modules area;
    - Main performance indicator of the production area and of IFPT;
- Reduce the amount of errors that occur with the handling of raw-materials;
- Save up to 250000€ per year in raw-materials;
- Reduce the Line Stock MOD in 75%.

[54] Cost Per Piece

13 Appendix F: Analysis Planned versus Real Output

If a Kanban System was to be applied to the raw-materials in the Modules production area then a production plan should be used for the definition of the correct amount of stock that should be made available for production. The reader should keep in mind that having the correct stock value in the production line is the ideal situation when it comes to savings and optimization of resources but it demands a great planning effort. However, if the stock level reveals to be higher than the optimal value then the company is misusing resources. If the stock level is lower than optimal the most obvious consequence is that production will stop due to lack of raw-materials what represents a tremendous impact to the organization.

The objective of this analysis was to compare the differences between the production and the real output in order to establish the confidence gap that should be applied to the stock values in order to avoid production breaks due to lack of raw-materials. An analysis was done with 1526 days of production/product. The results are illustrated in Figure 43.

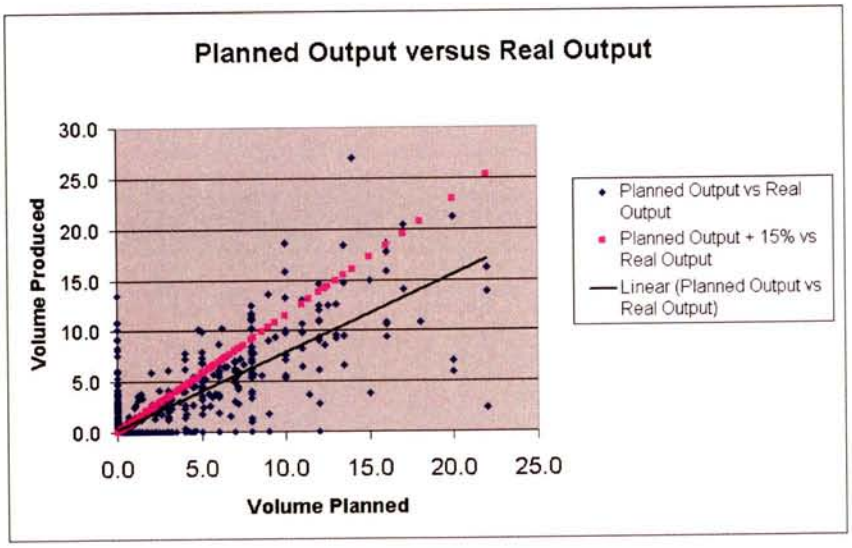


Figure 43 – Analysis of the Planned Output versus Real Output

The data illustrated in the previous figure was condensed in Table 16

Table 16 – Analysis of the Planned Output versus Real Output

number of days/products	1526	100%
number of Productions not Planned	145	10%
number of Plan>Production	227	15%
number of Plan=Production	1046	69%
number of Plan<Production	253	17%
number of Productions Fulfilled	1273	83%

Basically, from the raw-materials perspective, the most problematic situations are the ones represented by the points of Figure 43 that are above the line that represents the Planned Output versus Real Output. These situations mean that the volume produced is higher than the volume planned and so that the production line would have to request more raw-materials from the warehouse. These situations represent 17% of the total number of cases studied.

These situations can be divided into two main situations: the case when no production was planned marked with a red circle in the previous figure and the case when the real output is higher than planned. Both these situations are often, 17% of all cases, but natural. The main reason for what was explained is that the semiconductors' industry is very capital intensive therefore, if there is spare capacity of production, this will be used to the limit in order to bring costs down. Figure 44 exemplifies the variation between the planned output and the real output.

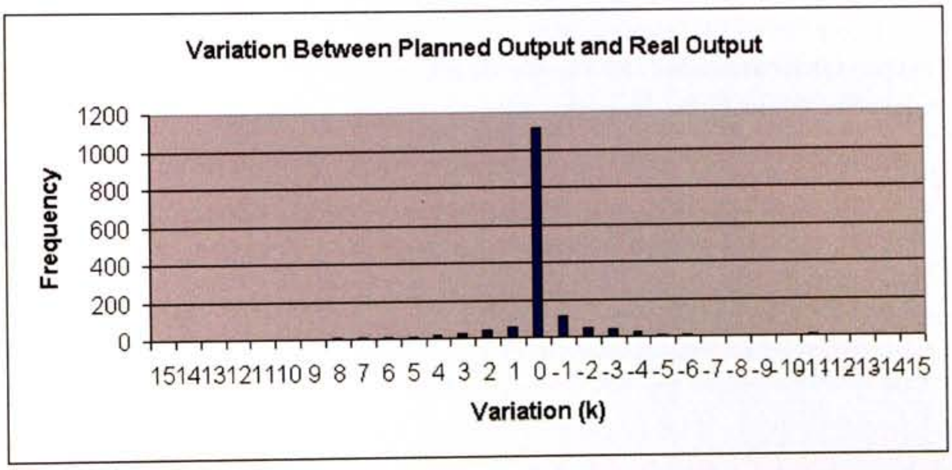


Figure 44 – Representation of the Variation between Planned and Real Output

Therefore, it was defined that the situations when the real output is higher than the one that was planned shouldn't be limited but, instead, foreseen. It was studied the impact of considering that the planned output was higher in 15%. The impact is represented in Figure 43 by the points in rose and in Table 17.

Table 17 – Analysis of the Planned Output plus 15% versus Real Output

number of days/products	1526	100%
number of Plan+15%<Production	198	13%
number of Productions not Planned	145	10%
number of Productions Fulfilled	1328	87%

Making the planning of the raw-materials according to the production plan plus 15% would make us cover more 4% of the cases than the initial analysis. However, emergency procedures for the supply of the production line would still amount for 13% of the total cases.

One other analysis was done but doing a planning of the raw-materials according to the production plan plus 50%. This would make us cover more 6% than the initial analysis.

Table 18 – Analysis of the Planned Output plus 15% versus Real Output

number of days/products	1526	100%
number of Plan+50%<Production	170	11%
number of Productions not Planned	145	10%
number of Productions Fulfilled	1356	89%

What should be concluded from this analysis is that using a higher production plan would reduce the number of times that the existing raw-materials run out in the production line. On the other hand, the line stock would increase considerably.

Even if this safety gap of 50% was applied, emergency procedures still had to be executed in order to prevent extraordinary situations. These situations, according to the study, amount for 11% of the situations.

In order to compete in a flexible industry companies themselves should be flexible and so it was concluded that having high stocks in the production line wasn't the solution. Instead, emergency procedures for the supply of the production line should be defined and optimized to reduce the flexibilities' impact.

14 Appendix G: Training Manual

Training Manual – Management of Materials MOD

Objective:

- Reduce line stock;
    - Economical Savings;
- Reduce ruptures of stock;
    - Reduce stops of production;

How:

- Define every week how much material should be in the racks – targets;
- Keep those targets on a daily;

Scope:

- Actives;
- Passives.

Targets:

- Change every week;
- In an Excel report;
    - Path to file

Procedures:

- Once per week – first shift of Saturday;
    - Change spaces in racks;
        - According to the targets in the Excel file;
    - Fill up the spaces in the racks;
- Every shift;
    - Fill up the spaces in the racks;
    - Place all the open reels in the respective rack – labeled "Used Reels";

Please see next pages for more detailed information

Procedure: First Shift Saturday

1. Open Excel report;

2. Print Excel report;
   a) Beginning of Shift Report;
   b) Mid Shift Report;

3. Go get trolley and move it to the inventory racks;

4. Adjust space in racks and take out materials that aren't going to be used – only full reels;

   a) Refill all empty spaces with partial reels from the "Used Reels" rack;
   b) Write down the number of remaining empty spaces on the inventory racks. Do this for all the materials;

5. Go to kardex;
   a) Take out the new materials;
      1. for each material in the report take out the quantity that was written earlier on – quantity to fill up the space in the rack;

NOTE: DO NOT ADD ANY NEW MATERIAL TO THE "USED REELS" RACK.

6. Update SAP;
   a) For each material taken out of the kardex;
      1. make the transaction in SAP;

7. Put the new materials in the trolley;

8. Move the trolley to the racks;

9. Fill up the inventory racks.

NOTE: DO NOT ADD ANY NEW MATERIAL TO THE "USED REELS" RACK.

Procedure: Every shift

1. Open excel file;

2. Print Excel report;
   a. Beginning of Shift Report;
   b. Mid Shift Report;

3. Go get trolley and move it to the racks;

4. Count the empty spaces in the inventory racks;
   a. For each material;
   b. Refill all empty spaces with partial reels from the "Used Reels" rack;
   c. Write down the number of remaining empty spaces on the inventory racks;

NOTE: DO NOT ADD ANY NEW MATERIAL TO THE "USED REELS" RACK.

5. Go to kardex;
   a. Take out the new materials;
      1. for each material in the report take out the quantity that was written earlier on – quantity to fill up the space in the rack;

6. Update SAP;
   a. For each material taken out of the kardex;
      1. make the transaction in SAP;

7. Move the trolley to the racks;

8. Fill up the racks;

NOTE: DO NOT ADD ANY NEW MATERIAL TO THE "USED REELS" RACK.

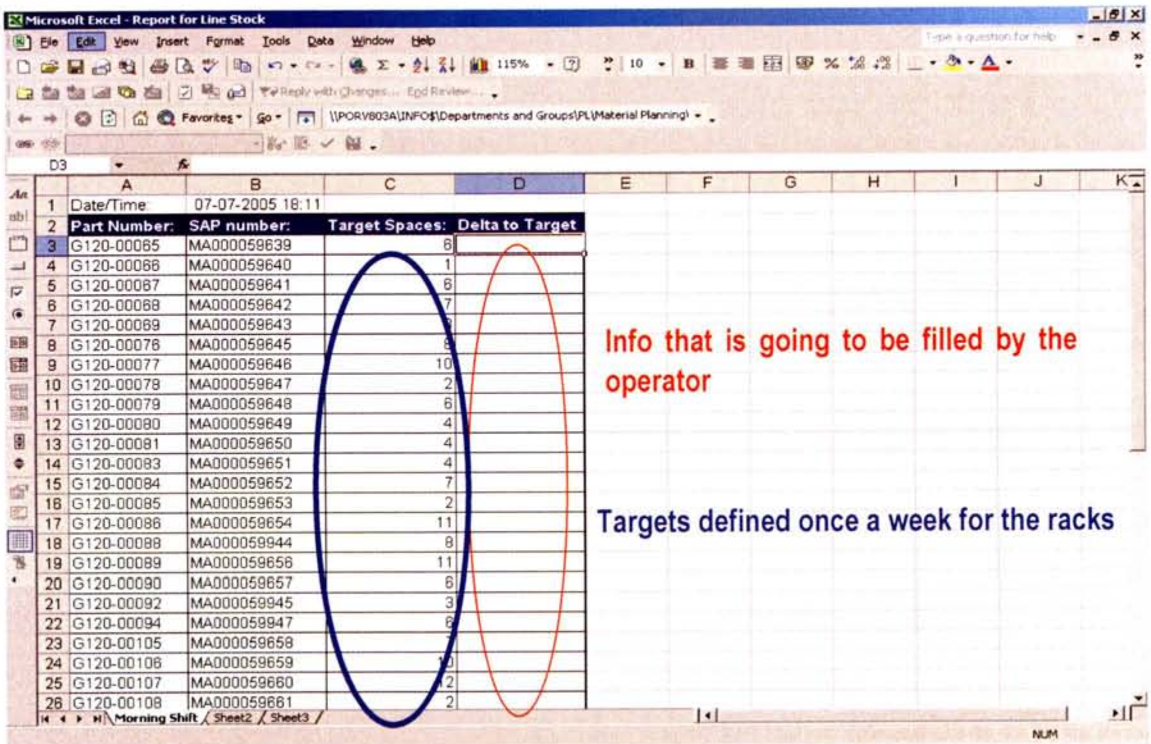
IF IT IS NEEDED TO TAKE MORE MATERIAL FROM THE KARDEX TO THE PRODUCTION LINE IN THE MIDDLE OF THE SHIFT:

1. Fill up the report "Mid Shift Changes";
2. Go to the kardex;
3. Remove material;
4. Update SAP;
5. Store the material in inventory rack;

Excel Report Beginning of Shift:

Objective of the report:

- Representation of the weekly targets;
- Keep a record of the amount of the material that must be moved to the production line;
- Make the operator's job easier;



	A	B	C	D
1	Date/Time:	07-07-2005 18:11		
2	Part Number:	SAP number:	Target Spaces:	Delta to Target
3	G120-00065	MA000059639	6	
4	G120-00066	MA000059640	1	
5	G120-00067	MA000059641	6	
6	G120-00068	MA000059642	7	
7	G120-00069	MA000059643	[illegible]	
8	G120-00076	MA000059645	8	
9	G120-00077	MA000059646	10	
10	G120-00078	MA000059647	2	
11	G120-00079	MA000059648	6	
12	G120-00080	MA000059649	4	
13	G120-00081	MA000059650	4	
14	G120-00083	MA000059651	4	
15	G120-00084	MA000059652	7	
16	G120-00085	MA000059653	2	
17	G120-00086	MA000059654	11	
18	G120-00088	MA000059944	8	
19	G120-00089	MA000059656	11	
20	G120-00090	MA000059657	6	
21	G120-00092	MA000059945	3	
22	G120-00094	MA000059947	6	
23	G120-00105	MA000059658	[illegible]	
24	G120-00106	MA000059659	[illegible]	
25	G120-00107	MA000059660	12	
26	G120-00108	MA000059661	2	

Figure 45 – Report for beginning of shift

Excel Report Mid Shift Changes:

Objective of the report:

- Adjustment of targets;
- Keep a record of the amount of material needed that wasn't planned;
- Improve the weekly targets.

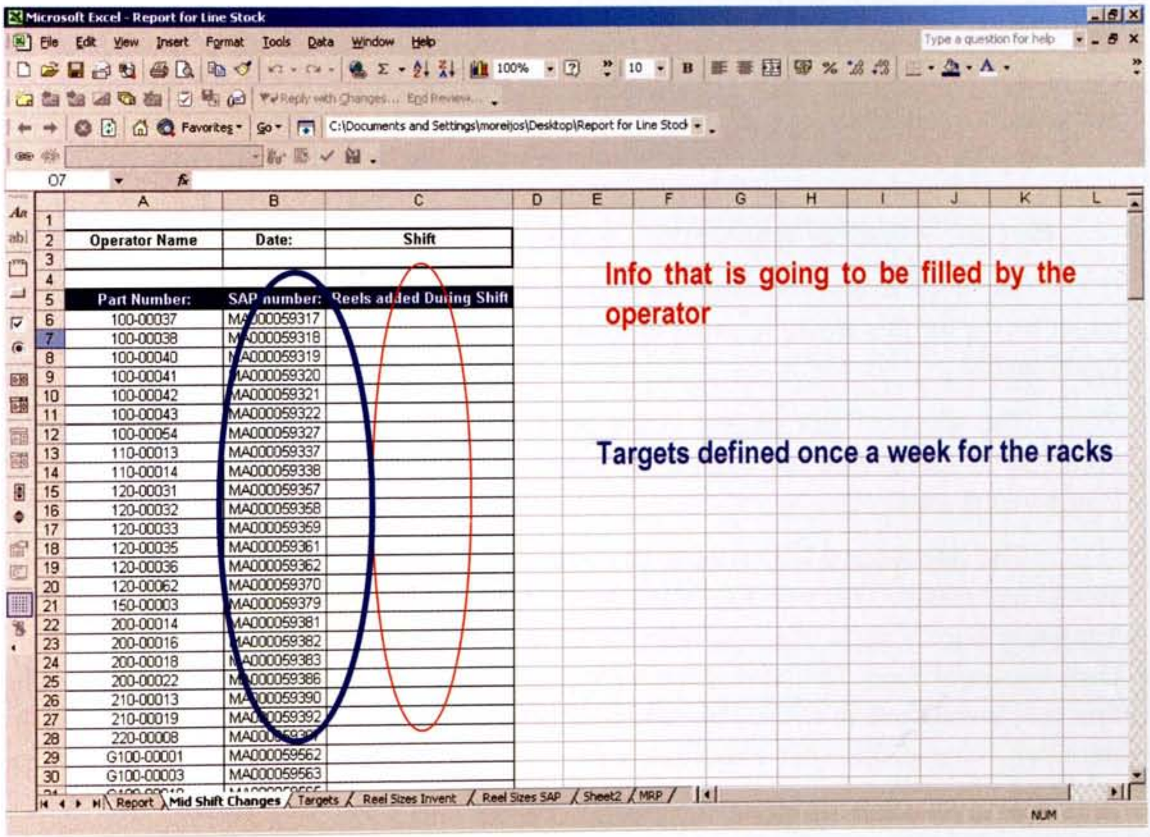


Figure 46 – Report for Mid shift changes

15 Appendix H: Specification Kanban Stage2

15.1 Overview

15.1.1 Purpose of the product

The purpose of the product is to have a system in SAP for the control of the stocks in the Modules production line. The objectives of the project are to reduce and control the stock in the Modules production line.

15.1.2 Areas of application, system integration and delimitation

The objective of reducing the line stock MOD is going to be achieved by setting daily target levels for this stock. In order to do so a daily MRP is needed to support the daily needs functionality.

The scope of this project is the production area of Modules at IFPT. However, the objective is to develop the Kanban system in a way that it could be easily applied to the Components area.

The line stock MOD should be controlled in SAP and so an extra warehouse in SAP should be created. This new line stock in SAP should only contain full packages of materials. Therefore once a pack of a raw-material is open, it should be moved in SAP and physically from the warehouse. The production's procedures will be slightly changed in order to support this new warehouse in SAP. The new warehouse, line stock MOD, should be considered for the stock value as the other warehouses are.

A Daily MRP should be developed in order to support the definition of the target stock values – necessary to define the needs of each material according to a daily plan. Daily targets for the line stock should be defined automatically according to the Daily MRP. These targets should then be presented to the operator in a SAP report. Another functionality that the product should have is the calculation of the virtual amount of material available after the line stock warehouse – virtual stock MOD. All these functionalities will be explained in a following point of the report.

15.1.3 Users

The users of the product can be divided into several groups as shown in the next table:

Table 19 – Users of the product

User Group:	Department:	Functionalities Used:
Material Planners	IFPT PL PP	Visualization of the line stock MOD
		MRP report with new warehouse included
		Visualization of the virtual stock MOD
"Material Manager"s	IFPT PL MM	Visualization of the line stock MOD
		Movements of materials from and to new warehouse
		Visualization of stock targets MOD
		Visualization of the virtual stock MOD
Line Operators/Material Handlers		Visualization of the line stock MOD
		Movements of materials from and to new warehouse
		Visualization of stock targets MOD
		Visualization of the virtual stock MOD
Production Engineers	IFPT AO/TO	Visualization of the virtual stock MOD
		Visualization of stock targets MOD
		Visualization of the line stock MOD

15.2 Product requirements

15.2.1 Functions

15.2.1.1 Functional overview

The desired functionalities for the product are:

- A Daily MRP – for establishment of daily stock targets;
- Creation of a function called stock targets;
  - Based on the daily MRP;
  - Report with these targets organized by Part number;
- The creation of a new warehouse in SAP – line stock MOD;
  - That represents the line stock: racks of actives and passive materials, racks for solder paste and other materials that are placed in the line;
  - Only full packages;
  - Consumption point of raw-materials should change to the point when the materials leave this warehouse;
- Consideration of this new warehouse for the MRP's stock in-house;
- Visualization of the stock in the new warehouse – as it is for any of the other existing SAP's warehouses;
- Creation of a virtual line stock – called virtual stock MOD;

- It's not a warehouse in SAP – just a reference for the stock that should exist in the equipment and open packages of raw-materials;
- Represents the stock of opened package units;

Figure 47 shows how the all system should be integrated.

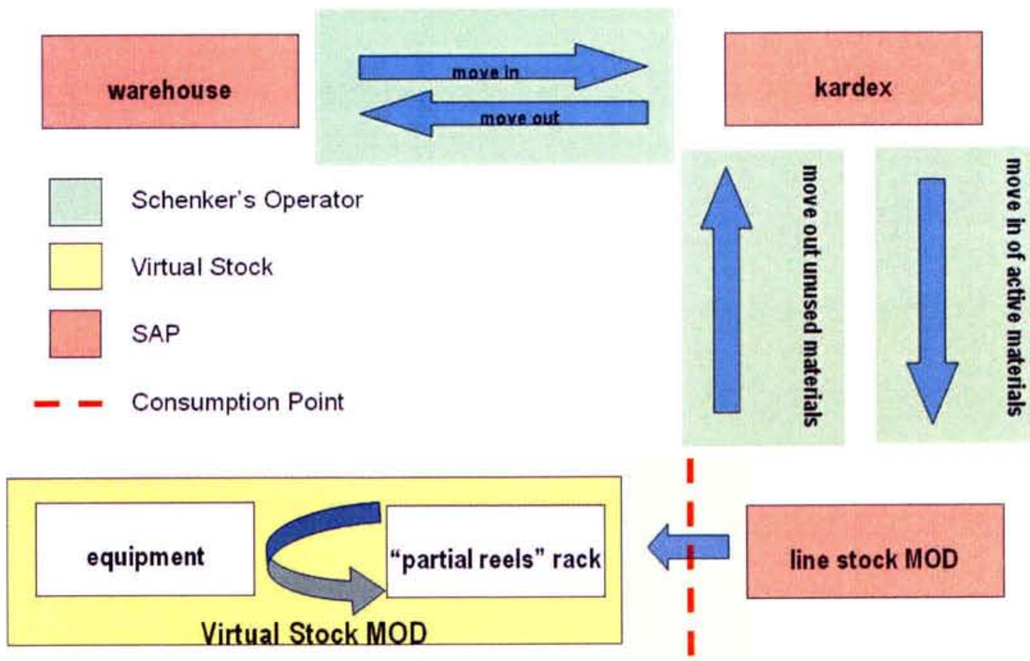


Figure 47 – Final functioning of the System

15.2.2 Functional description

15.2.2.1 Daily MRP

This functionality is to have a Daily MRP. Naturally, this MRP should be based on a daily production plan. The daily plan is already done by the IFPT's volume planners every Friday to be applied on the following week.

The objective of this MRP plan is to define the needs for production of each material. This information will be then used to establish the daily stock targets.

There is no need to have all the other functionalities that the weekly MRP has. It should just calculate the needs per material. These needs should be sorted either by Part number or by SAP number.

15.2.2.2 Daily Targets - Definition

The daily targets that are going to be defined are based on the Daily MRP output. These targets should then be presented either per part number or per material – both options should be available. The calculation of the maximum targets should be made by multiplying the MRP needs by a safety factor. This factor should be defined per material. The minimum stock is to be defined per material type. The target stock is given by the following expression:

$$TargetStock = MaxStock - Stock$$

Therefore the Target Stock can be positive, if it is needed to "Move In" material or negative, if the amount of material in stock is too high.

Maximum Stocks will be defined for the Kardex and for the Line Stock MOD. The visualization of these stocks should also be done differently.

The targets for the Kardex should take into account the existing stock and targets for the Line Stock MOD:

Equation 7 – Target Stock Definition for the Kardex

$$TargetStock_{Kardex} = MaxStock_{Kardex+LineStock} - Stock_{Kardex+LineStock}$$

Equation 8 – Maximum Stock value for the Line Stock

$$MaxStock_{LineStock} = DailyMRP_n \text{, n=present day}$$

Equation 9 – Maximum Stock value for the combined Kardex and Line Stock

$$MaxStock_{Kardex+LineStock} = DailyMRP_n + DailyMRP_{n+1} \text{, n=present day}$$

The targets that should be used for the Line Stock MOD are:

Equation 10 – Target Stock Definition for the LineStock

$$TargetStock_{LineStock} = MaxStock_{LineStock} - Stock_{LineStock}$$

15.2.2.3 New warehouse in SAP - Line Stock MOD

This new warehouse that should be created is going to represent the racks and other storage places in the production line. It's going to have only raw-materials in their full packages. The present situation is represented by the following picture:

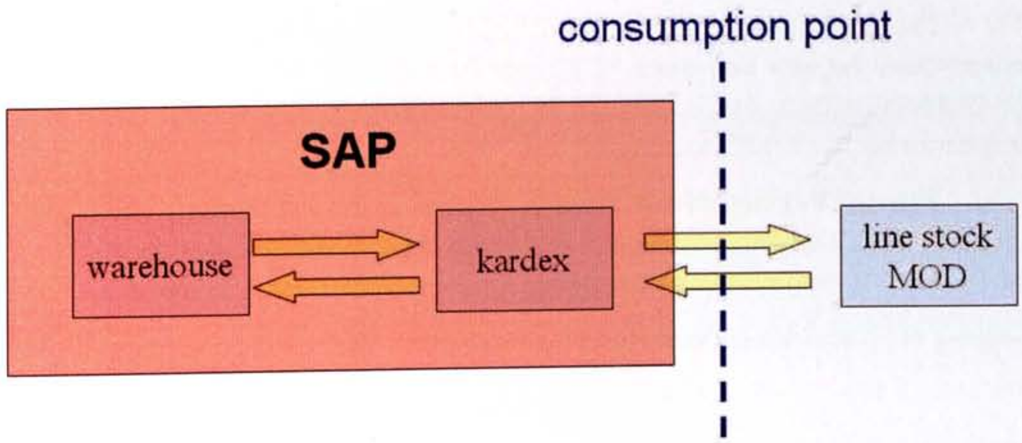


Figure 48– Present situation of the SAP for the modules area

The desired structure is represented in Figure 49.

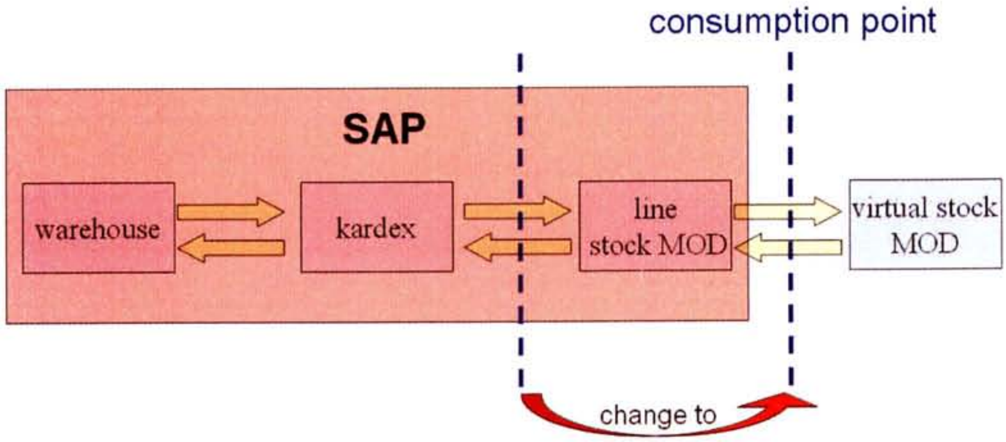


Figure 49 – Desired structure for the warehouses in SAP

This new warehouse should be treated as the other existing warehouses – kardexs and warehouse. The consumption point of the F1 Materials (F1MO) should change from the after the kardex to after the line stock.

The current weekly MRP should consider the new warehouse as part of the existing stocks – as it does with all the other SAP warehouses.

15.2.2.4 Virtual Stock MOD

This new functionality has the objective of controlling the stock of raw-materials whose package has been open – such as open reels. It will be of great importance to control the existing stocks in the equipments feeders in the area of modules.

This virtual stock should work as a virtual warehouse in SAP – the material once moved from the new line stock MOD warehouse to the production line should be consumed, for financial effects but, at the same time, moved to this virtual warehouse. This should happen for all the F1MO materials.

The consumption of this existing material in the virtual stock MOD should be made by a function that calculates the amount of product produced and then multiplies this amount by the BOM55 of each product plus a scrap amount. This relation is shown by the next equation:

Equation 11 – Consumption Definition for the Virtual Stock MOD

$$Consumption = Qty_{produced} \times BOM \times Scrap\%$$

This should be done for all the raw-materials in analysis. The Quantity produced can be easily be inputted from a report in BO[56]. The BOMs are in SAP.

This consumption function should update the stock in the virtual stock MOD every day at 00:00 – after the production day is over.

---

[55] Bill of materials

[56] Business Objects

It should be possible to make adjustments to the stock available in the Virtual Stock MOD, just as it is for a regular warehouse.

15.3 External interfaces

15.3.1 Daily MRP - Interface

The desired format for the Daily MRP is very similar to the Weekly MRP. The following figure represents the output of the weekly MRP (material needs view).

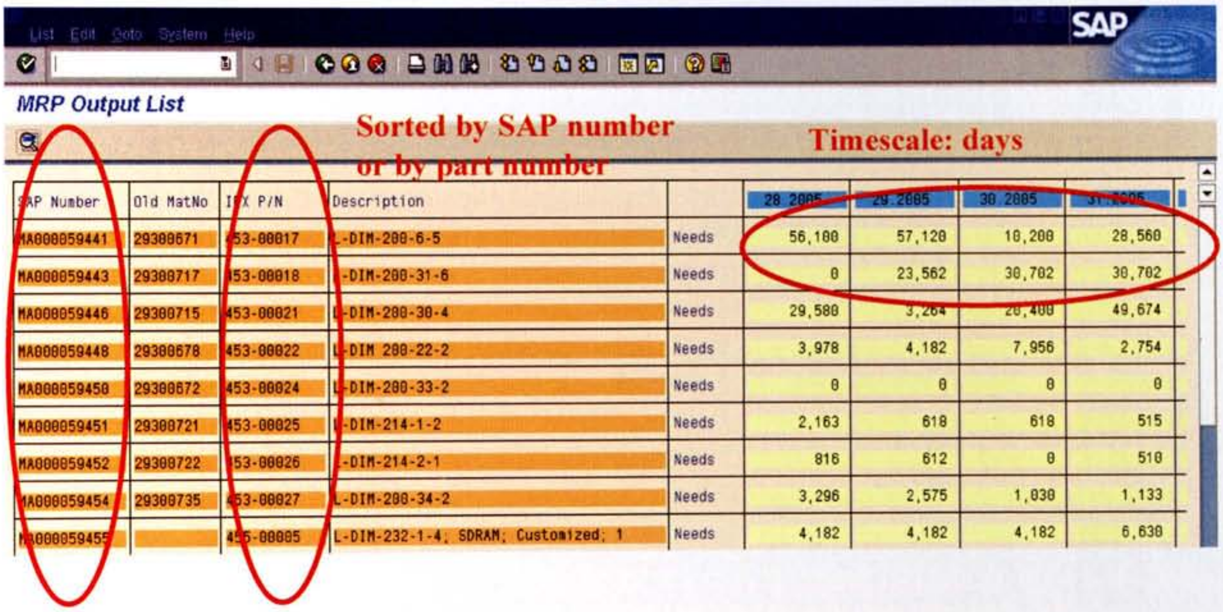


Figure 50 – Current Weekly MRP Output (material needs view)

The differences between the existing MRP output and the desired format for the output of the Daily MRP are represented in red:

- The output should be either sorted by SAP number or IF Part number;
- The timescale should be in days.

15.3.2 Daily Targets - Interface

This interface is going to be used mostly by the line operators that will support the Kanban physically. The desired format for the interface of the Daily Targets Line Stock MOD is shown in the next figure:

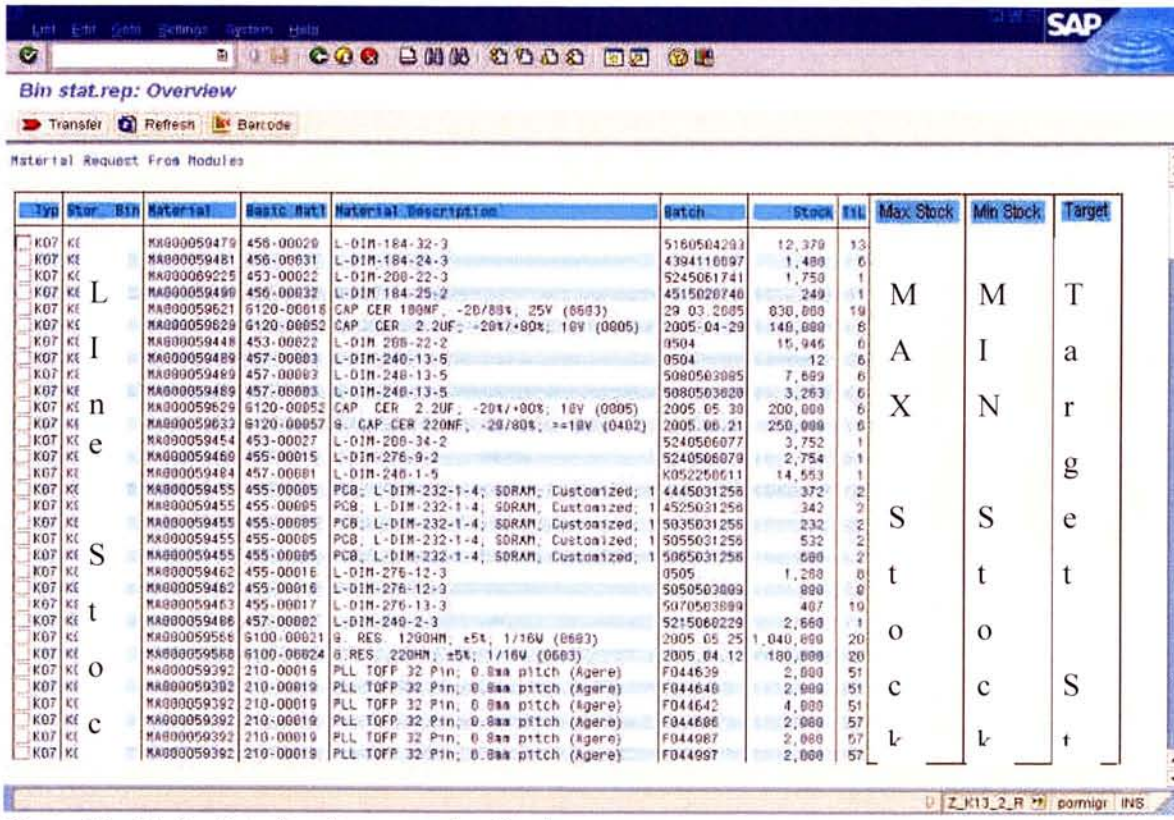
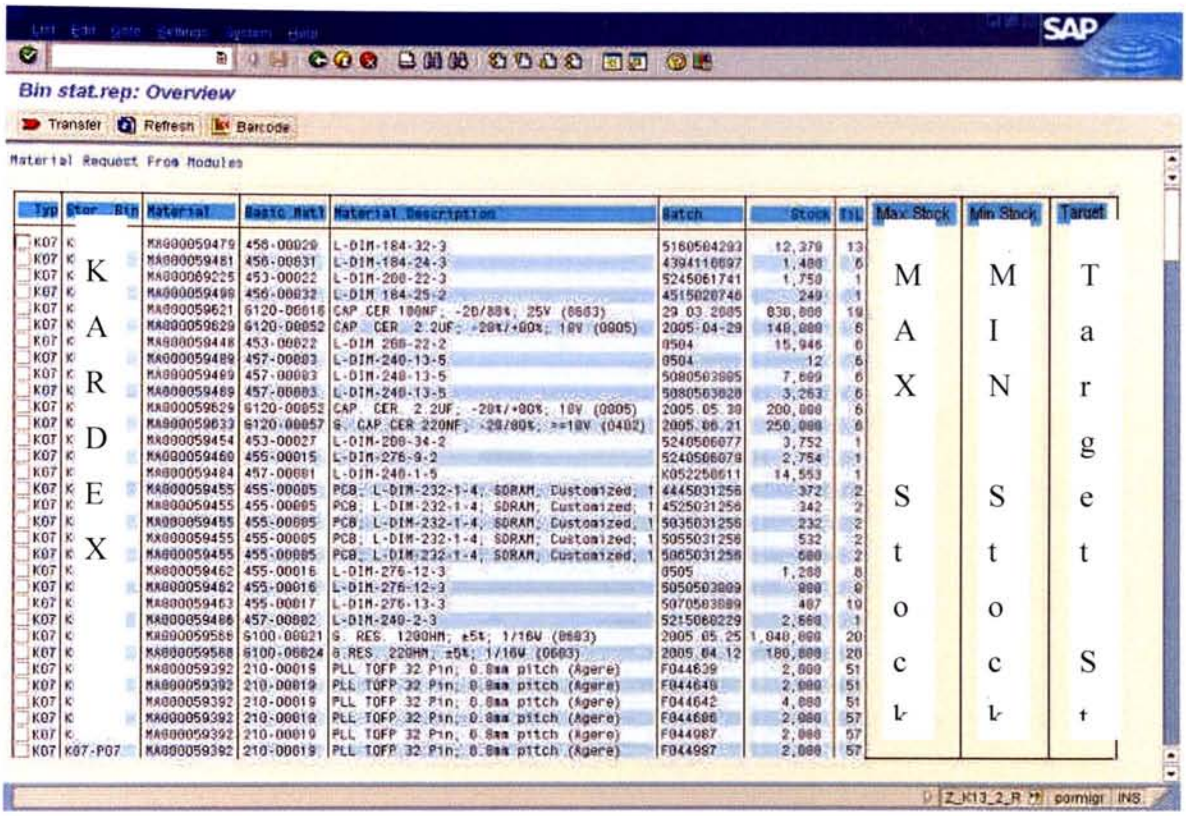


Figure 51 – Desired interface for targets visualization

The desired format for the interface of the Kardex is very similar to the one represented before:



Typ	Stor	Bin	Material	Basic Matl	Material Description	Batch	Stock	TrL	Max Stock	Min Stock	Target
K07	K		MA000059479	456-00029	L-DIM-184-32-3	5160504293	12,379	13			
K07	K		MA000059481	456-00031	L-DIM-184-24-3	4394110697	1,400	6			
K07	K		MA000069225	453-00022	L-DIM-200-22-3	5245061741	1,750	1			
K07	K		MA000059498	456-00032	L-DIM 184-25-2	4515020746	249	1			
K07	K		MA000059621	6120-00016	CAP CER 100NF; -20/80%; 25V (0603)	29.03.2005	830,000	19			
K07	K		MA000059629	6120-00052	CAP CER 2.2UF; -20%/+80%; 10V (0805)	2005-04-29	140,000	6			
K07	K		MA000059448	453-00022	L-DIM 200-22-2	0504	15,946	6			
K07	K		MA000059489	457-00003	L-DIM-240-13-5	0504	12	6			
K07	K		MA000059489	457-00003	L-DIM-240-13-5	5080503005	7,609	6			
K07	K		MA000059489	457-00003	L-DIM-240-13-5	5080503020	3,263	6			
K07	K		MA000059629	6120-00052	CAP. CER. 2.2UF; -20%/+80%; 10V (0805)	2005.05.30	200,000	6			
K07	K		MA000059633	6120-00057	G. CAP CER 220NF; -20/80%; >=10V (0402)	2005.06.21	250,000	6			
K07	K		MA000059454	453-00027	L-DIM-200-34-2	5240506077	3,752	1			
K07	K		MA000059460	455-00015	L-DIM-276-9-2	5240506078	2,754	1			
K07	K		MA000059484	457-00001	L-DIM-240-1-5	K052250611	14,553	1			
K07	K		MA000059455	455-00005	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	4445031256	372	2			
K07	K		MA000059455	455-00005	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	4525031256	342	2			
K07	K		MA000059455	455-00005	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	5035031256	232	2			
K07	K		MA000059455	455-00005	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	5055031256	532	2			
K07	K		MA000059455	455-00005	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	5065031256	600	2			
K07	K		MA000059462	455-00016	L-DIM-276-12-3	0505	1,200	8			
K07	K		MA000059462	455-00016	L-DIM-276-12-3	5050503009	900	8			
K07	K		MA000059463	455-00017	L-DIM-276-13-3	5070503009	407	19			
K07	K		MA000059486	457-00002	L-DIM-240-2-3	5215060229	2,660	1			
K07	K		MA000059566	6100-00021	G. RES. 120OHM; ±5%; 1/16W (0603)	2005.05.25	1,040,000	20			
K07	K		MA000059568	6100-00024	G.RES. 22OHM; ±5%; 1/16W (0603)	2005.04.12	180,000	20			
K07	K		MA000059392	210-00019	PLL TQFP 32 Pin; 0.8mm pitch (Agere)	F044639	2,000	51			
K07	K		MA000059392	210-00019	PLL TQFP 32 Pin; 0.8mm pitch (Agere)	F044640	2,000	51			
K07	K		MA000059392	210-00019	PLL TQFP 32 Pin; 0.8mm pitch (Agere)	F044642	4,000	51			
K07	K		MA000059392	210-00019	PLL TQFP 32 Pin; 0.8mm pitch (Agere)	F044606	2,000	57			
K07	K		MA000059392	210-00019	PLL TQFP 32 Pin; 0.8mm pitch (Agere)	F044987	2,000	57			
K07	K07-P07		MA000059392	210-00019	PLL TQFP 32 Pin; 0.8mm pitch (Agere)	F044997	2,000	57			

Figure 52 – Desired interface for targets visualization

15.3.3 Module II - Interface

The virtual Line Stock MOD and the Line Stock MOD should be considered as regular warehouses for the visualization of stocks and so the following interface should have the possibility to pick the each of these warehouses.

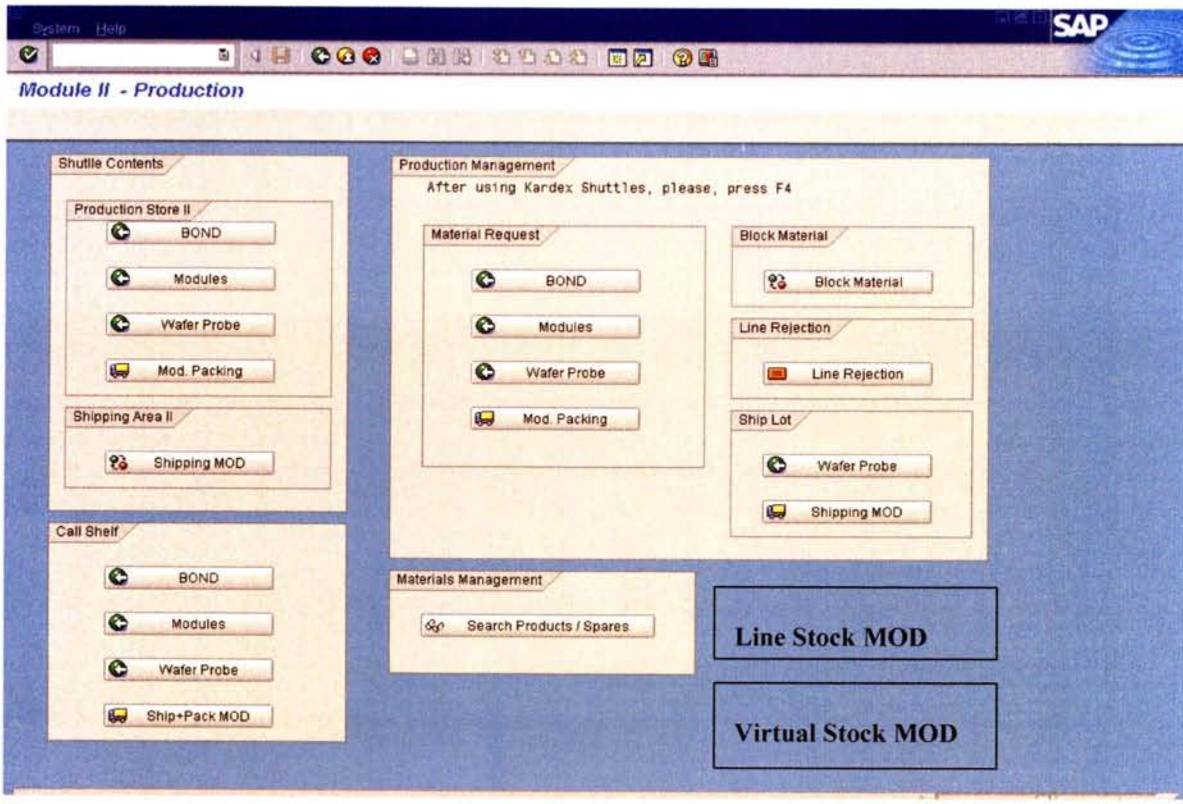
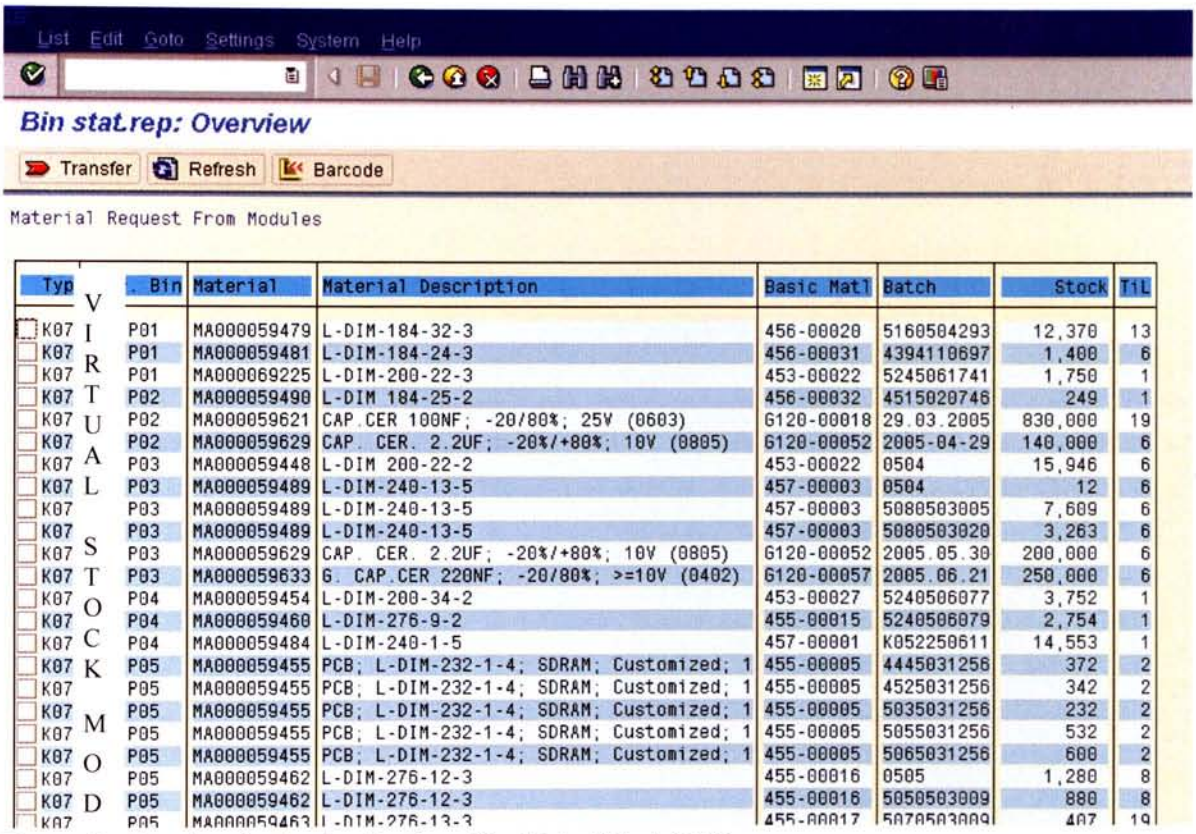


Figure 53 - Interface for the warehouses from Module II

15.3.4

15.3.5 Virtual Stock MOD - interface

This interface is going to be used for the visualization of the theoretical available stock in the production line. Therefore, the visualization of the virtual amount of stock available in the equipments and open packing units should be visualized as a regular warehouse.



Typ	. Bin	Material	Material Description	Basic Matl	Batch	Stock	TiL
K07	P01	MA000059479	L-DIM-184-32-3	456-00020	5160504293	12,370	13
K07	P01	MA000059481	L-DIM-184-24-3	456-00031	4394110697	1,400	6
K07	P01	MA000069225	L-DIM-200-22-3	453-00022	5245061741	1,750	1
K07	P02	MA000059490	L-DIM 184-25-2	456-00032	4515020746	249	1
K07	P02	MA000059621	CAP.CER 100NF; -20/80%; 25V (0603)	6120-00018	29.03.2005	830,000	19
K07	P02	MA000059629	CAP. CER. 2.2UF; -20%/+80%; 10V (0805)	6120-00052	2005-04-29	140,000	6
K07	P03	MA000059448	L-DIM 200-22-2	453-00022	0504	15,946	6
K07	P03	MA000059489	L-DIM-240-13-5	457-00003	0504	12	6
K07	P03	MA000059489	L-DIM-240-13-5	457-00003	5080503005	7,609	6
K07	P03	MA000059489	L-DIM-240-13-5	457-00003	5080503020	3,263	6
K07	P03	MA000059629	CAP. CER. 2.2UF; -20%/+80%; 10V (0805)	6120-00052	2005.05.30	200,000	6
K07	P03	MA000059633	G. CAP.CER 220NF; -20/80%; >=10V (0402)	6120-00057	2005.06.21	250,000	6
K07	P04	MA000059454	L-DIM-200-34-2	453-00027	5240506077	3,752	1
K07	P04	MA000059460	L-DIM-276-9-2	455-00015	5240506079	2,754	1
K07	P04	MA000059484	L-DIM-240-1-5	457-00001	K052250611	14,553	1
K07	P05	MA000059455	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	455-00005	4445031256	372	2
K07	P05	MA000059455	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	455-00005	4525031256	342	2
K07	P05	MA000059455	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	455-00005	5035031256	232	2
K07	P05	MA000059455	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	455-00005	5055031256	532	2
K07	P05	MA000059455	PCB; L-DIM-232-1-4; SDRAM; Customized; 1	455-00005	5065031256	600	2
K07	P05	MA000059462	L-DIM-276-12-3	455-00016	0505	1,280	8
K07	P05	MA000059462	L-DIM-276-12-3	455-00016	5050503009	880	8
K07	P05	MA000059463	L-DIM-276-13-3	455-00017	5070503009	407	19

Figure 54 – Interface for the visualization of the Virtual Stock MOD

16 Appendix I: New Functionalities for SAP

16.1 MRP Report - Range with no deliveries

16.1.1 Overview

The objective with this request is to have a better knowledge of which is the most important PO[57] and Planned Deliveries and the impact on the stock if these PO aren't fulfilled. Therefore it would be useful for a material planner to have visualization over the range if the PO is fulfilled and if it is not fulfilled.

16.1.2 Functional Specification

It was thought that a way to have the functionality described above is to have to different ranges: the "range" and the "no del range". The "range" is the range that is being used now: considers available stock and the planned deliveries. The "no del range" should consider the available stock.

[57] Planned Order

Figure 55 represents the current report used for MRP:

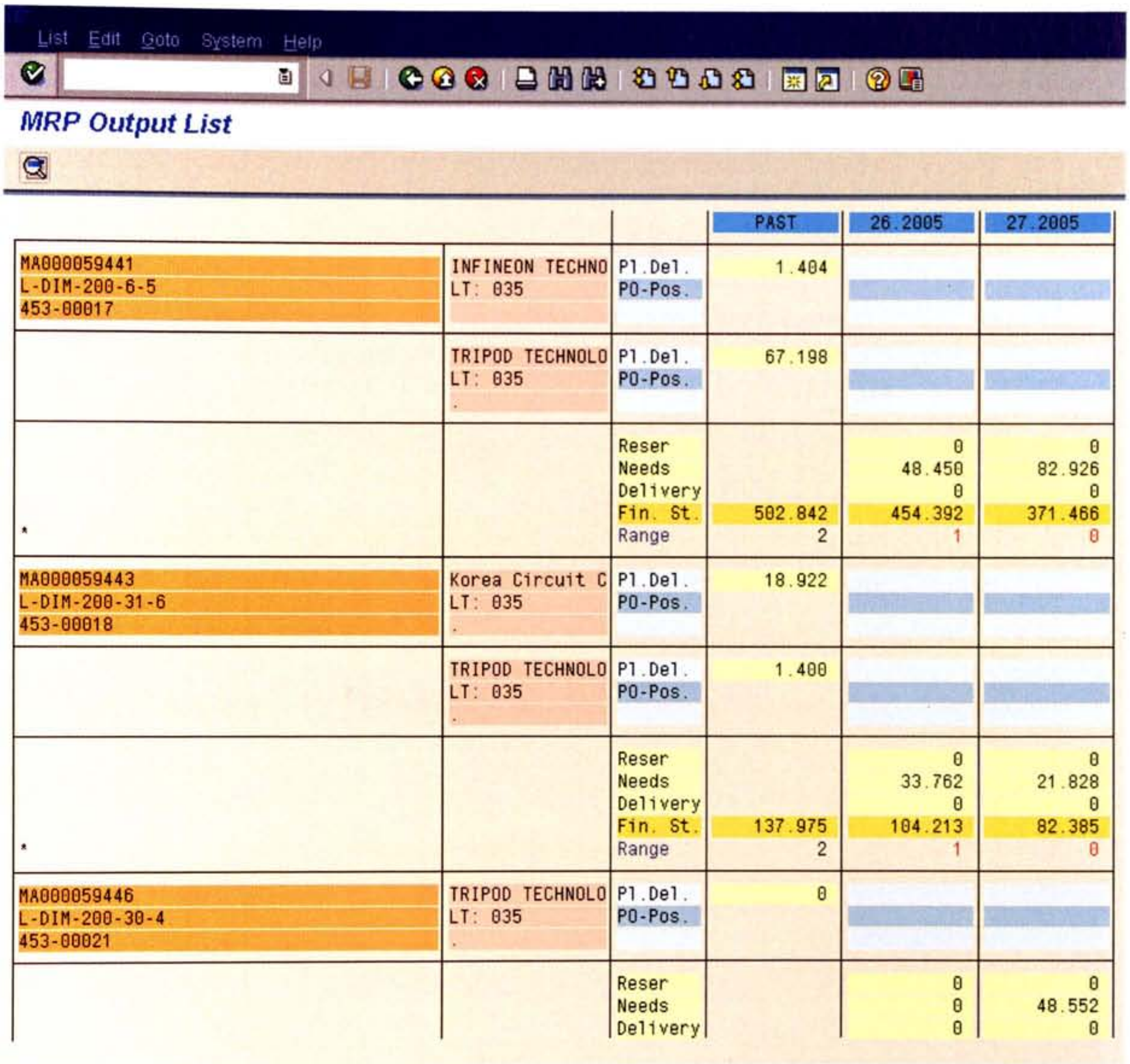


Figure 55 – Current MRP Output List

The desired MRP Output List design could be the one shown in the next figure:

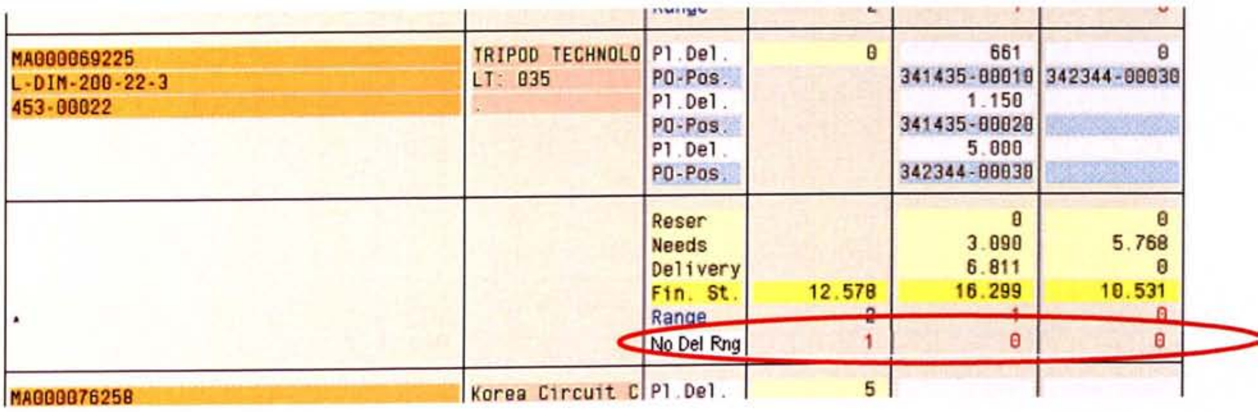


Figure 56 – MRP Output List with the No Deliveries Range

In order to have this new range in the report an extra line must be added to the list.

A comment should be done to the format used for this No Del Range information: its importance relatively to the Range is lower and, therefore, the format and colors used for the "No Del Range" should take this in consideration.

16.2 MRP Report - Confirmed PO

16.2.1 Overview

The objective with this request is to have the confirmed PO – Purchase Orders – with a different format in the MRP report. This change in the MRP format would provide to the Material Planners an easy of identifying the PO that are confirmed and so to apply they're effort on unconfirmed POs.

16.2.2 Functional Specification

The current design of the MRP report – ZREPMRP – doesn't differentiate the confirmed POs from the unconfirmed POs.

The design of the existing report in the default view is the one shown in the next figure:

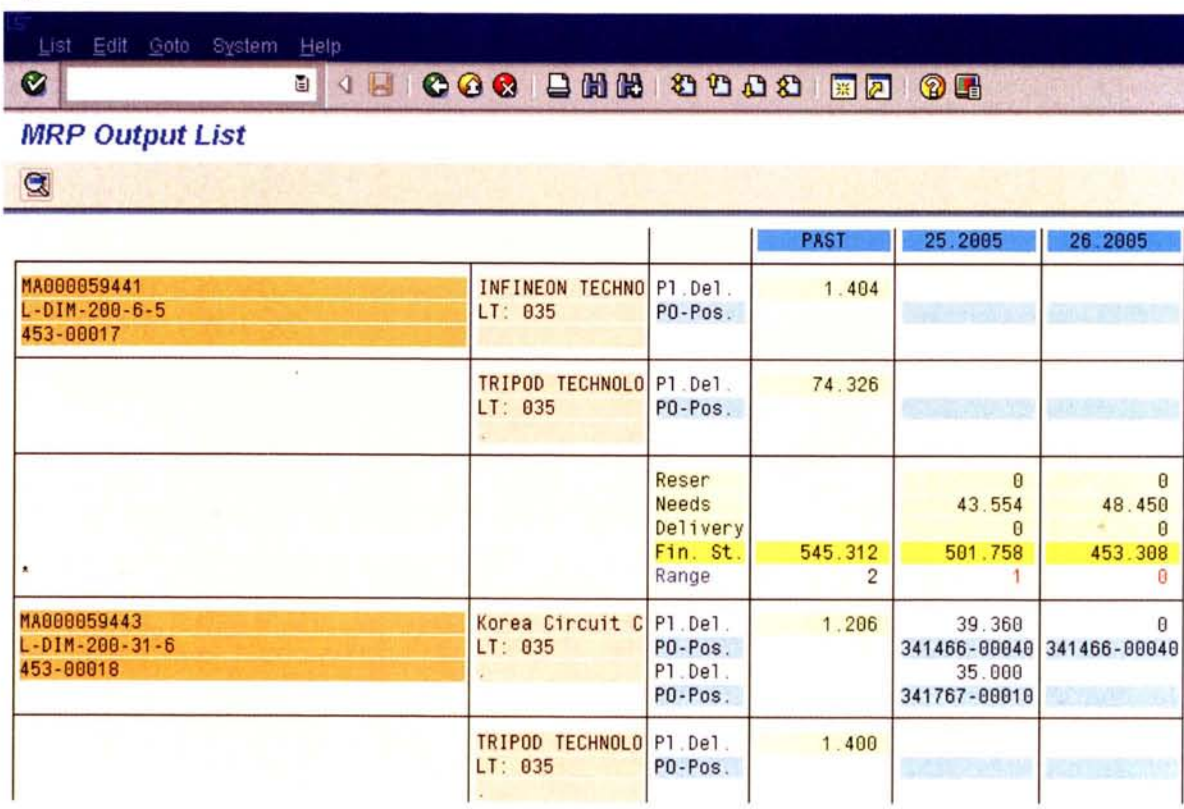


Figure 57 – Current MRP Output List

To know the status of a PO, the user must double click on the desired PO and then choose the desired material. Figure 58 show the procedure to open a PO and confirm its status.

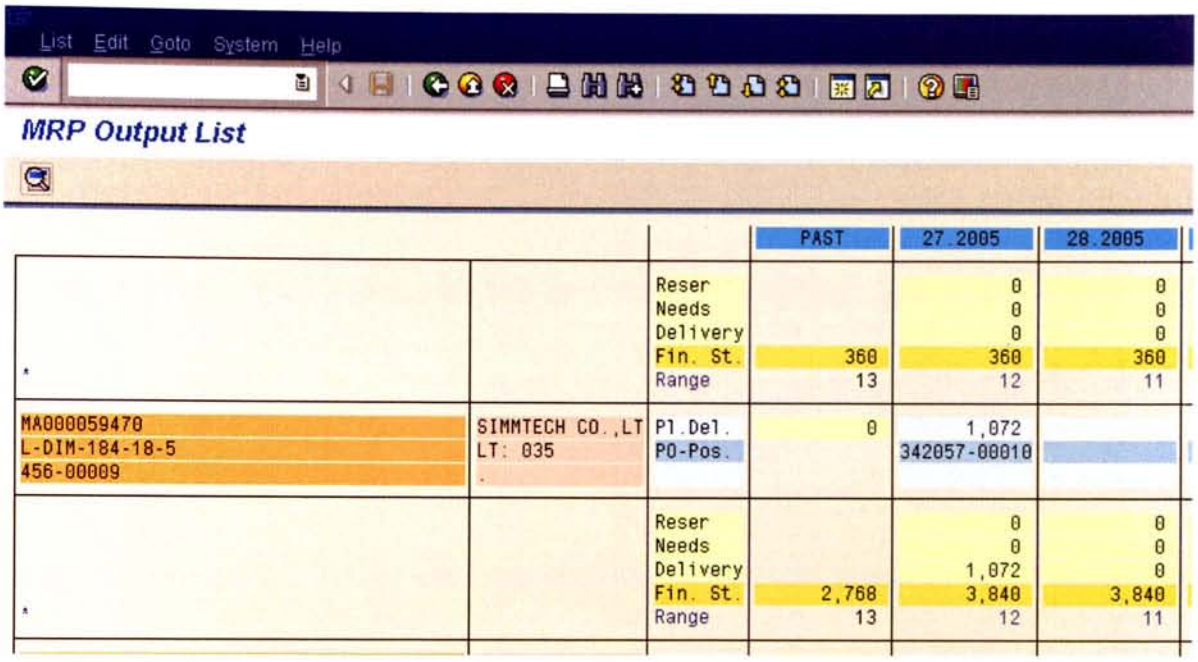


Figure 58 – Interface ZREPMRP and procedure to show the PO

After a double click the following interface should open:

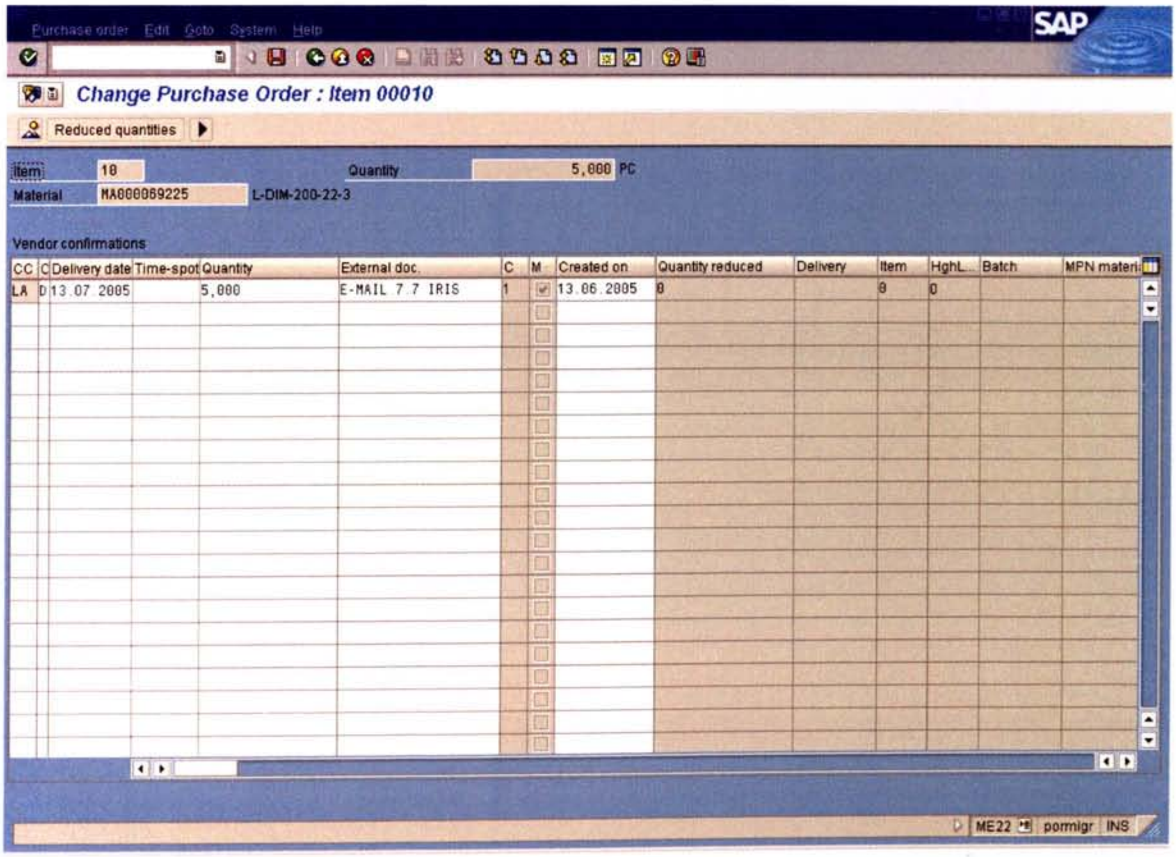


Figure 59 – "Change Purchase Order: item overview" interface

Once the "Change Purchase Order: item overview" interface is open the user must select the desired SAP number and then click the menu "Item", "Confirmations", "Overview".

If a PO is confirmed then the following interface shows the information about the PO. Otherwise it will be empty.

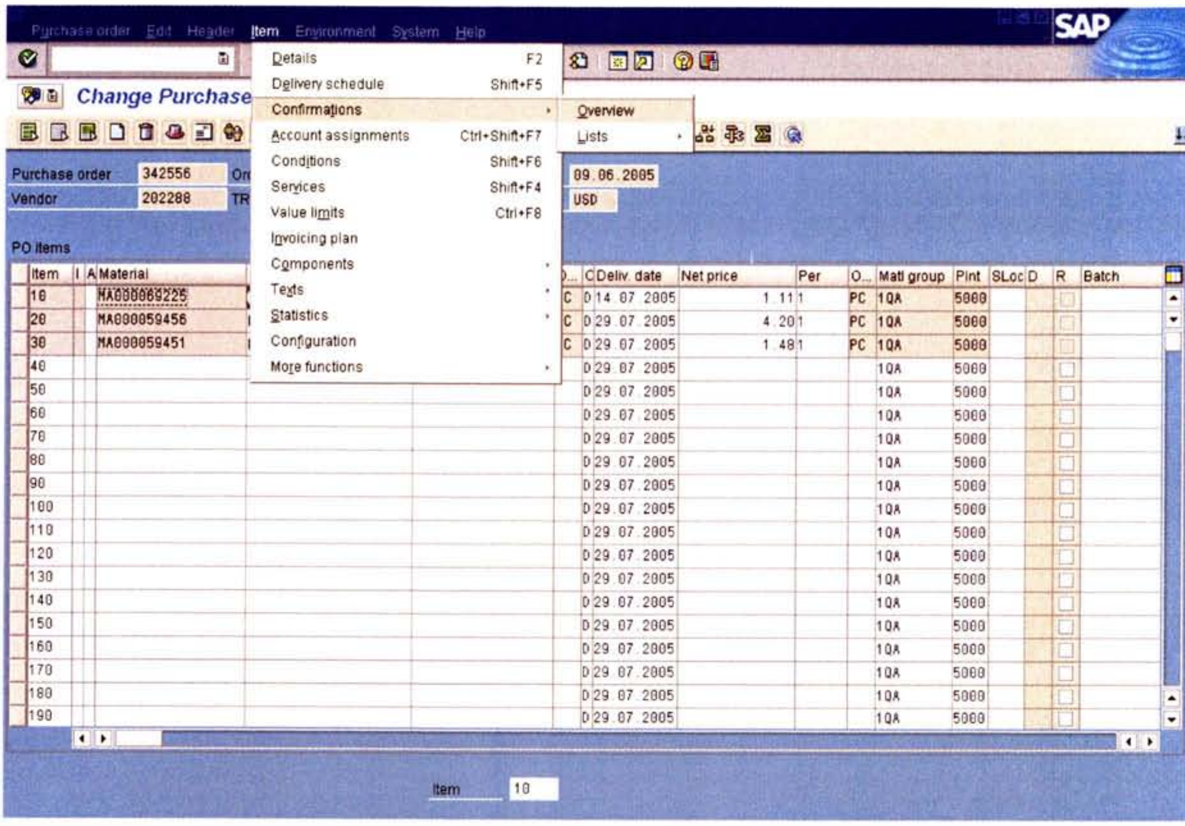


Figure 60 – "Change Purchase Order" interface

The objective with this request is to have the confirmed POs in a different color/format in the ZREPMRP default output report. The new design could be the one represented by Figure 61.

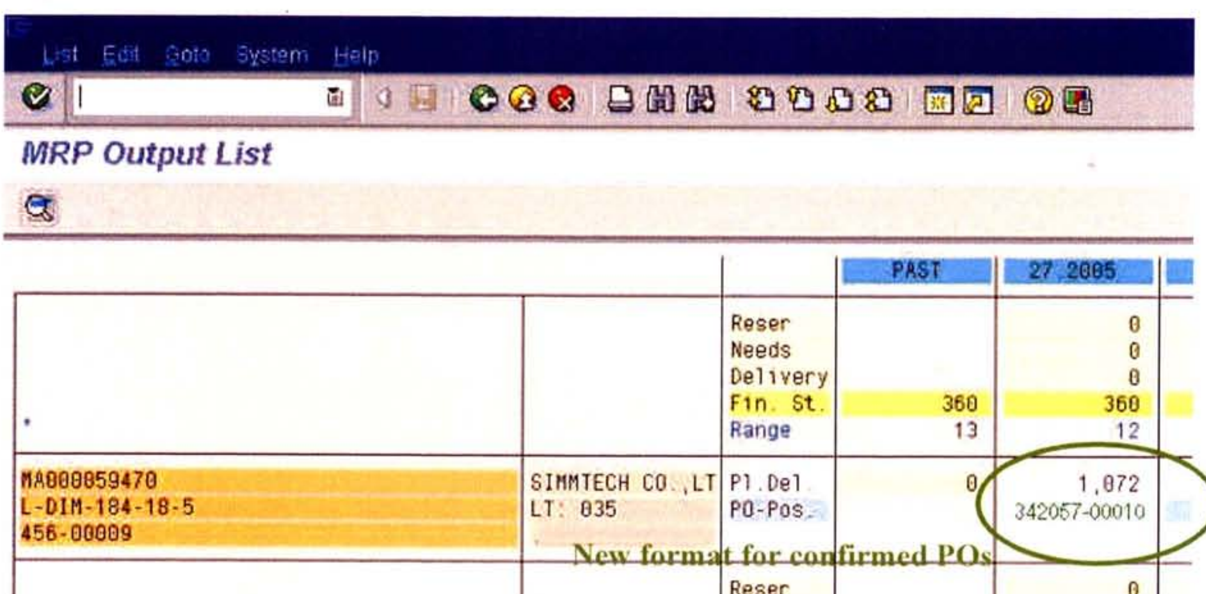


Figure 61 – Desired format for the ZREPMRP default output

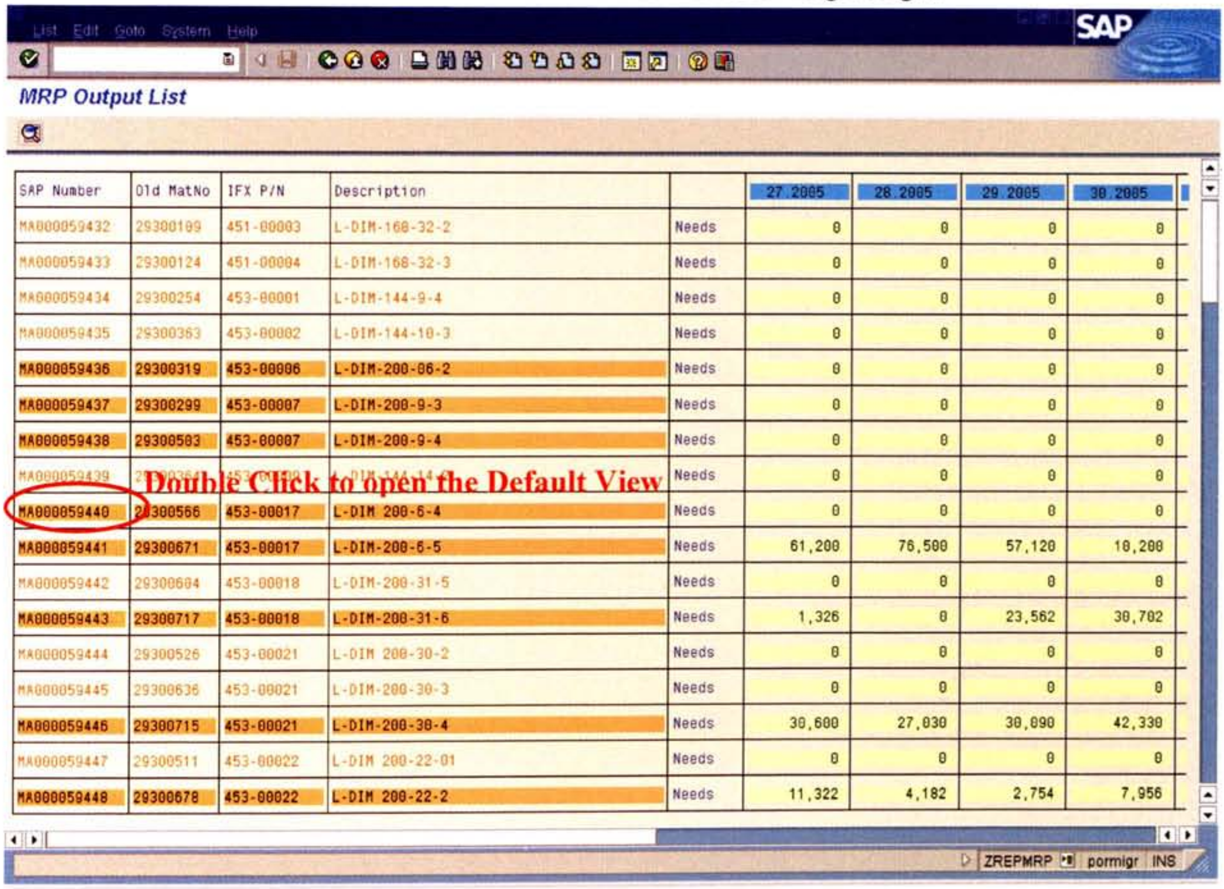
16.3 MRP Output - Material Needs view

16.3.1 Overview

The MRP Output List has different available views. One of them is the "Material Needs". It was decided, among the Material Planners at IFPT, that the "Material Needs" view was going to be used for the weekly follow up of the materials' status. But to do that it's necessary to have a direct link between the Material Need's view and the Default Output.

16.3.2 Functional Specification

The user should be able to open the default output for a specific SAP number from the material needs view. The material needs view has the following design:



SAP Number	Old MatNo	IFX P/N	Description		27.2005	28.2005	29.2005	30.2005
MA000059432	29300109	451-00003	L-DIM-168-32-2	Needs	0	0	0	0
MA000059433	29300124	451-00004	L-DIM-168-32-3	Needs	0	0	0	0
MA000059434	29300254	453-00001	L-DIM-144-9-4	Needs	0	0	0	0
MA000059435	29300363	453-00002	L-DIM-144-10-3	Needs	0	0	0	0
MA000059436	29300319	453-00006	L-DIM-200-06-2	Needs	0	0	0	0
MA000059437	29300299	453-00007	L-DIM-200-9-3	Needs	0	0	0	0
MA000059438	29300503	453-00007	L-DIM-200-9-4	Needs	0	0	0	0
MA000059439	[illegible]	[illegible]	[illegible]	Needs	0	0	0	0
MA000059440	[illegible]300566	453-00017	L-DIM 200-6-4	Needs	0	0	0	0
MA000059441	29300671	453-00017	L-DIM-200-6-5	Needs	61,200	76,500	57,120	10,200
MA000059442	29300604	453-00018	L-DIM-200-31-5	Needs	0	0	0	0
MA000059443	29300717	453-00018	L-DIM-200-31-6	Needs	1,326	0	23,562	30,702
MA000059444	29300526	453-00021	L-DIM 200-30-2	Needs	0	0	0	0
MA000059445	29300636	453-00021	L-DIM-200-30-3	Needs	0	0	0	0
MA000059446	29300715	453-00021	L-DIM-200-30-4	Needs	30,600	27,030	30,090	42,330
MA000059447	29300511	453-00022	L-DIM 200-22-01	Needs	0	0	0	0
MA000059448	29300678	453-00022	L-DIM 200-22-2	Needs	11,322	4,182	2,754	7,956

Figure 62 – MRP Output List in the Material Needs view

The Material Needs view doesn't have much information regarding the PO and so, in some cases it's important to open the default view. That should be done by double clicking the SAP number that the user desires to see in the Default Output. Then the Default Output should be open but the results should only be the selected SAP number.

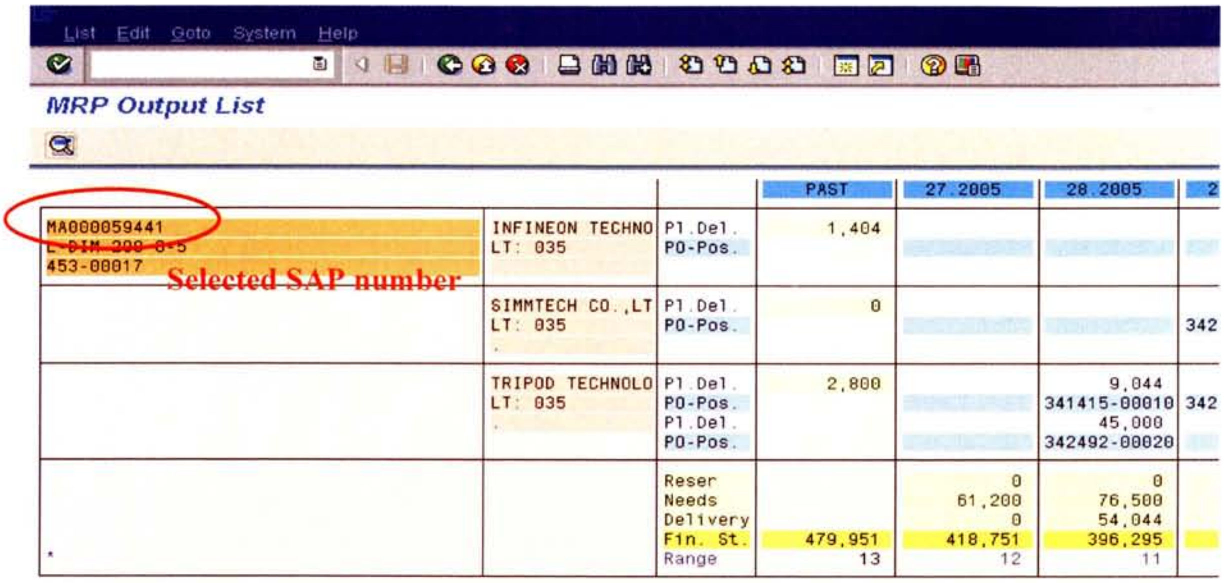


Figure 63 – MRP Output Default view for the selected SAP number

16.4 Phase Out Products - Visualization in MRP Report

16.4.1 Overview

The MRP report in SAP should have the information for each material if the material is going to be discontinued – Phase Out. The purpose of this is that, this way, the material planner has a better visualization over the materials doing a phase out and can make a better planning of materials.

16.4.2 Functional Specification

The user should have the visualization if the Material in the MRP report is going to have a Phase Out. The desired design could be the one in the next figure:

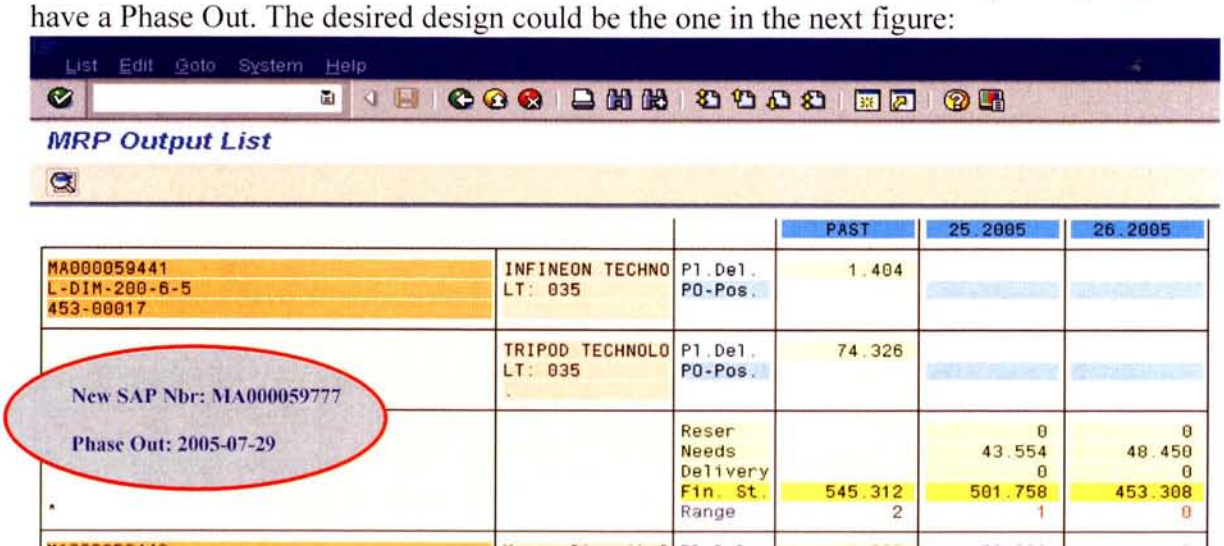


Figure 64 – Desired Interface for the MRP default Output

Currently the information that a material is going to have a phase out is inputted in the following transaction in SAP:

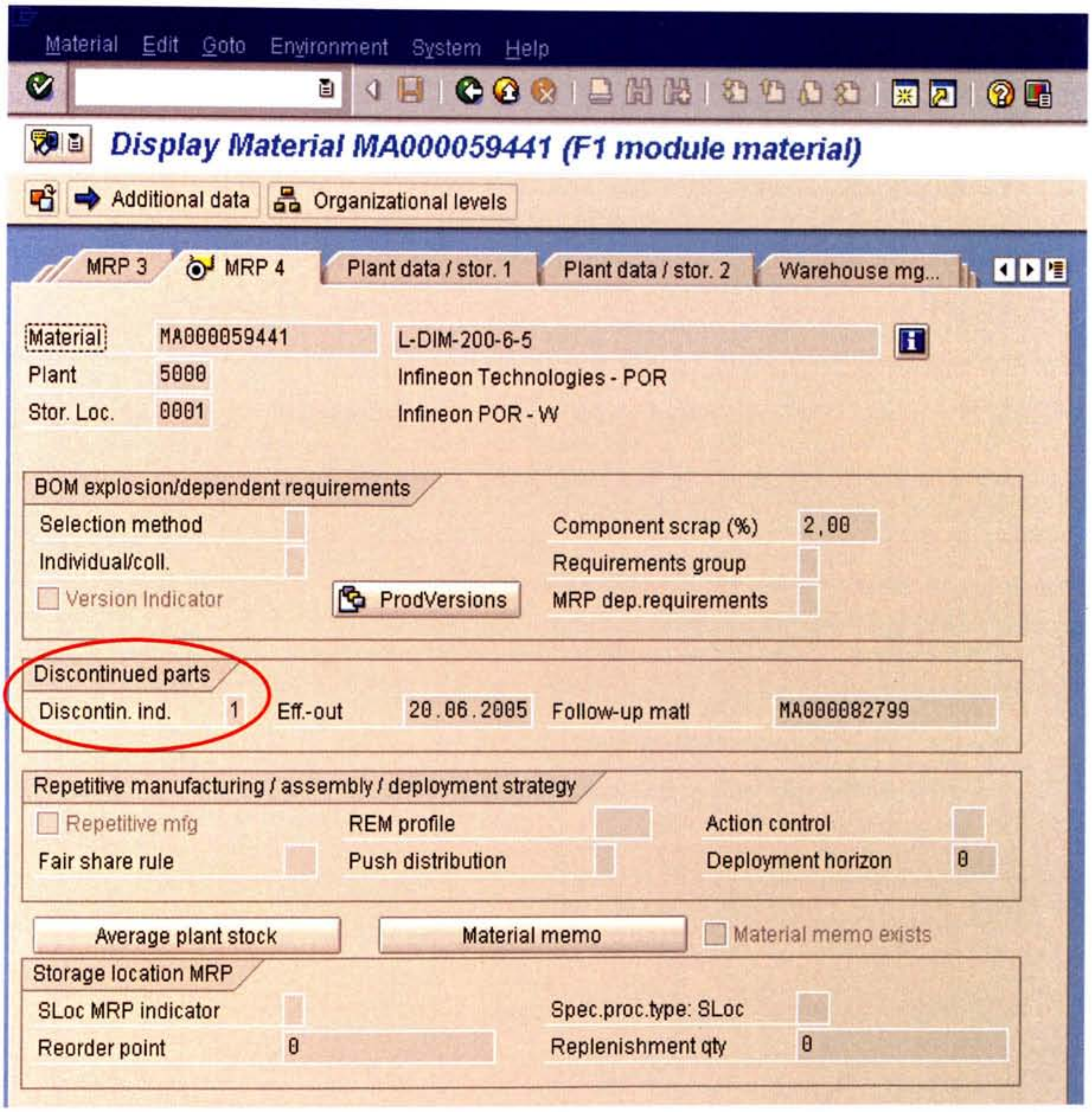


Figure 65 – Interface of the Material Master MM02, view MRP4

As shown in the figure above, this information that is needed to be represented in the SAP MRP report is already available in this system in the Material Master.

16.5 Vendor Analysis - Search Options

16.5.1 Overview

The MC$4 – "Vendor Anaysis: Purchasing Values: Selection" – transaction in SAP is designed in a way that it's only possible to do a search by vendor. The objective with this request is to have this search done by vendor, as it is now, and by SAP number and Material Controller (MRP).

16.5.2 Functional Specification

The MC$4 – "Vendor Anaysis: Purchasing Values: Selection" –transaction in SAP has currently the following format:

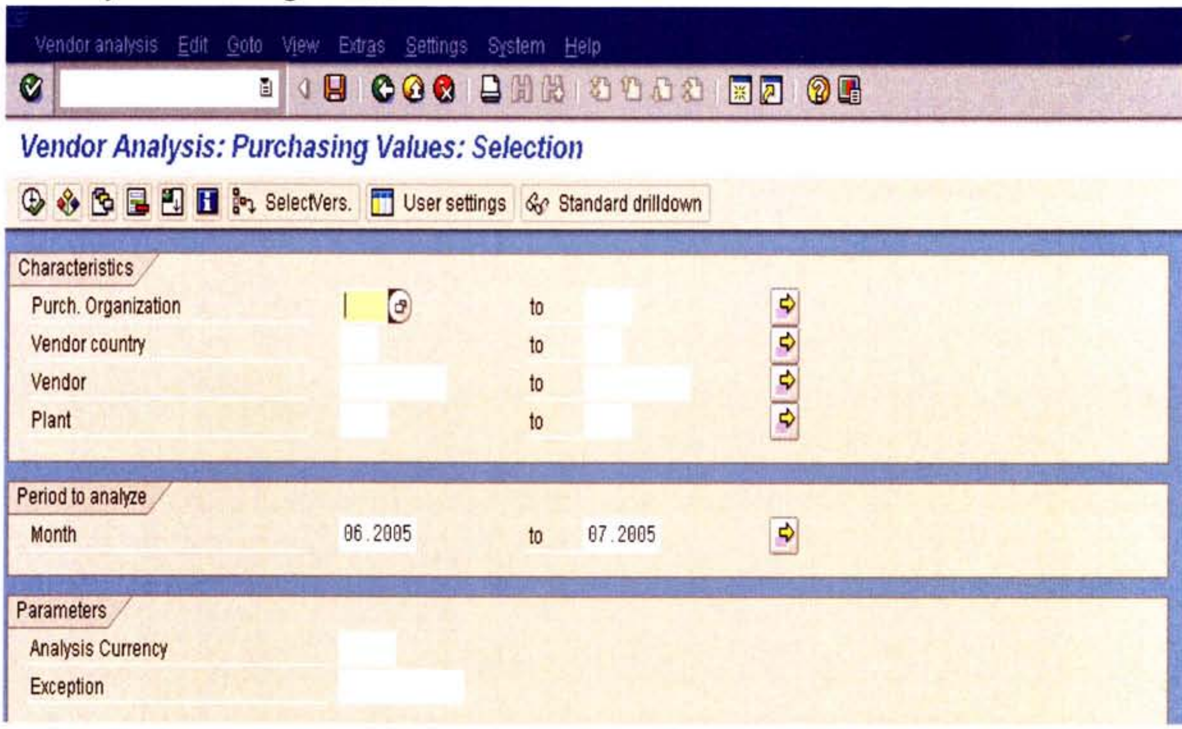


Figure 66 – Interface for the MC$4 transaction in SAP

As mentioned before the objective is to have the option of doing the search by SAP number and Material Controller.

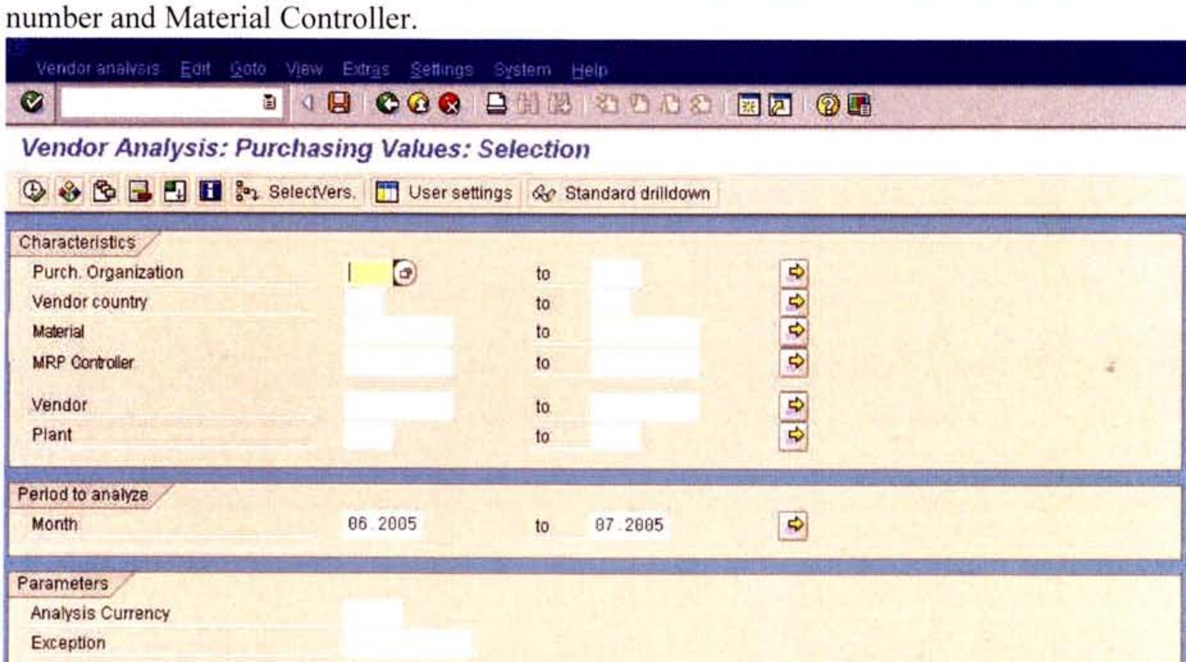


Figure 67 – Interface for transaction MC$4 with the desired search fields

The search options that should be added to the transaction are marked with a red circle.

17 Appendix J: Glossary

Active Component	Unlike a passive component, one that can add useful electrical power to a signal. Active components are often semiconductors. [3]
Back End	In semiconductor manufacturing, the package assembly and test stages of production. Includes burn-in and environmental test functions. Compare front-end. [1]
BGA	(Ball Grid Array) - A chip package having solder balls on the underside for mounting. BGA allows for a reduction in die package size, better heat dissipation, and greater module densities. [2]
Batch	See lot [3]
Bit	The smallest unit of information a computer processes. A bit is 1 or 0. [2]
BOM	Bill of Materials [3]
Bond Pad	A relatively large metal surface on a semiconductor die which provides the electrical contact with a package or test probes [3]
Bond Wire	A connection wire for semiconductor chips, mostly made of gold [3]
Buffered Memory	A memory module that contains buffers. Buffers re-drive the signals through the memory chips and allow the module to include more memory chips. Buffered and unbuffered memory cannot be mixed. The design of the computer memory controller dictates whether memory must be buffered or unbuffered [2]
Burn-In	A hardness test during which electronic components are operated under pressure for several hours or days with increased voltage and temperature so that early failures occur before delivery to the customer. This measure increases the quality of the remaining components. [3]
Byte	Eight bits of information. The byte is the fundamental unit of computer processing; almost all specifications and measures of computer performance are in bytes or multiples thereof. [2]
Chip	Popular term describing a small piece of silicon that contains a complete discrete component or an integrated circuit. Many chips are made on a single wafer, then separated into dice (plural of die) and packaged individually. [1]
Cleanroom	A confined area for manufacturing ICs in which the humidity, temperature, and particulate matter are precisely controlled. The "class" of the cleanroom defined by

the maximum number of particles in one cubic foot of cleanroom space. [1]

DDR SDRAM	(Double Data Rate Synchronous Dynamic Random-Access Memory) - The latest generation of SDRAM technology. Data is read on both the rising and the falling edge of the computer clock, thereby delivering twice the bandwidth of standard SDRAM. With DDR SDRAM, memory speed doubles without increasing the clock frequency. [2]
Die	A single square or rectangular piece of semiconductor material into which a specific electrical circuit has been fabricated. Plural: dice. [1]
Die Bonding	The method of securing the die to a package with conductive adhesives or metal alloys. [1]
DRAM	A volatile memory chip (memory is lost when the power is turned off) in which the presence or absence of a capacitive charge represents the state of a binary storage element (zero or one). The charge must be periodically refreshed. [1] (Dynamic Random-Access Memory) - The most common form of RAM. DRAM can hold data for only a short time. To retain data, DRAM must be refreshed periodically. If the cell is not refreshed, the data will disappear. [2]
Electroplating	Deposition of an adherent metallic coating onto a conductive object placed into an electrolytic bath composed of a solution of the salt of the metal to be plated. Using the terminal as the anode (possibly of the same metal as one used for plating), a DC current is passed through the solution affecting transfer of metal ions onto the cathodic surface. [1]
EPROM	Erasable Programmable Read-Only Memory. A non-volatile memory chip (memory is retained when the power is turned off) whose contents can be erased by exposure to ultraviolet light. [1]
Front End	In semiconductor manufacturing, the fabrication process in which the integrated circuit is formed in and on the wafer. Compare back end. [1]
Leadframe	A stamped or etched metal frame, usually connected to the bonding pads of a die by wire bonding, that provides external electrical connections for a packaged electrical device. [1] A rigth-angled metal frame with ipn wiring and linking elements in between for package mounting. The wiring is punched during mounting. [3]
Lot	A quantity of components that have passed through the manufacturing process together. Changes in the manufacturing process affect all parts of a batch. Lot is also called batch. [3]
Memory	General term for computer hardware that stores information in electrical or magnetic form. Memories accept and hold binary numbers only. [1]
Memory IC	An IC consisting of memory cells and usually including associated circuits such as those for address selection and amplification. A class of integrated circuits that store digital information. Examples: ROM, EPROM, EEPROM, Flash memory, DRAM, and SRAM. [1]
Moore's Law	An observation made in 1964 by Gordon Moore (one of the founders of Intel) that the number of transistors on Integrated Circuits chips doubles every year. This

	trend continued unbroken until the end of the century, even though one and na half years have been required since the late 70s. [3]
Passive Component	An electrical component without gain or current-switching capability. Commonly used when referring to resistors, capacitors, and inductors. [1]
Passive Component	In contrast to na active component, a passive component only stores, consumes or transfers useful electric power. Examples of such components are resistors, capacitors and coils. [3]
PCB	(Printed Circuit Board) - Generally flat, multi-layer boards made of fiberglass with electrical traces. The surface and sublayers use copper traces to provide electrical connections for chips and other components. Examples of PCBs include: motherboards, SIMMs, and credit card memory. [2]
	Random Access Memory. A memory that may be written to or read from any address location in any sequence. Random access in the sense of providing access to any storage location in the memory. See DRAM and SRAM. [1]
RAM	(Random-Access Memory) - A memory cell configuration that holds data for processing by a central processing unit (CPU). Random means the CPU can retrieve data from any address within RAM. See also Memory. [2]
Registered Memory	SDRAM memory that contains registers directly on the module. The registers re-drive the signals through the memory chips and allow the module to be built with more memory chips. Registered and unbuffered memory cannot be mixed. The design of the computer memory controller dictates which type of memory the computer requires. [2]
	An element (e.g., silicon and germanium) whose electrical conductivity lies between that of conductors (copper) and insulators (glass). Has relatively high resistance in a pure state and much lower resistance when small amounts of impurities are added. [1]
Semiconductor	A crystalline material that in its pure form has conductivity between a conductor and a insulator. This conductivity increases in the presence of certain foreign matter that disturbs the crystal structure. The specific addition of certain foreign matter can influence the properties of the semiconductor in a very particular and reproducible way. In the broader sense, "semiconductor" also denotes electronic components that are manufactured on the basis of semiconductor materials. [3]
Silicon	A solid element (number 14 on the periodic table) that is abundantly available in the form of SiO2. Its extreme abundance, moderate processing temperatures, and the stability of its native oxide make it the preferred semiconductor material. [1]
SMT	Surface-Mount Technology. The mounting of components on the surface of a printed circuit board, as contrasted with through-hole mounting where component leads extend through the board. [1]
SO-DIMM	(Small-Outline Dual In-line Memory Module) - An enhanced version of a standard DIMM. A 72-pin small-outline DIMM is about half the length of a 72-pin SIMM. 144-pin and 200-pin modules are the most common SO DIMMs today. [2]
Substrate	The underlying material on which a microelectronic device is built. Such material may be electrically active, such as silicon, or passive, such as alumina ceramic. [1]