Production System Design and Implementation in the European Automotive Components Industry

by

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ABSTRACT

In today's highly competitive and global market environment, companies are continually searching for ways to improve upon their business practices to gain a competitive advantage. Over the past decade, significant focus has been directed toward the field of manufacturing operations and in particular toward the successes of the Toyota Production System (TPS). Numerous companies in various industries have tried to implement the TPS system, however, this has been accomplished with varying degrees of success. The main separator of those who were successful from those who failed is the utilization of a thoroughly holistic approach. The Manufacturing System Design Decomposition (MSDD) is such an approach.

The MSDD provides a framework for designing, analyzing, evaluating, improving and controlling manufacturing systems. The frame work is based on axiomatic design decomposition and allows the designer to understand the interrelation between the Functional Requirements (FR's) and Design Parameters (DP's). Many of these DP's can be drawn from successful tools implemented in the Japanese manufacturing companies, primarily Toyota. The MSDD allows the designer to track these FR's and DP's to the high-level objectives of the enterprise. It is primarily this ability of the designer to understand the relationship between the FR's and DP's that has allowed for great success utilizing the MSDD approach.

This thesis presents the Production System Design Framework, which encompasses the MSDD, and sets the theory for its successful implementation in a manufacturing facility in Europe. The thesis is based primarily on the experience of the author utilizing the MSDD and its respective evaluation tools and technique in a supply chain design project and a manufacturing system redesign project in a European climate control components manufacturer. The MSDD played a vital role in the successful implementation of these projects.

Thesis Supervisor: David S. Cochran
Title: Associate Professor of Mechanical Engineering

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Chapter 1: Introduction

1.1 Thesis objective

The objective of this thesis is to present a structured approach for the design of a manufacturing system by demonstrating the successful implementation of a design projects in a European Automotive component suppliers manufacturing systems. This thesis shows how the Manufacturing System Design Decomposition (MSDD) and its respective Evaluation tools were used to demonstrated the successful areas of the redesign project and target areas of future work.

Given the lack of a comprehensive and structured framework to link the various elements of a manufacturing system, the Production System Design Laboratory at MIT developed the Manufacturing System Design Decomposition (MSDD). This tool is useful in designing, controlling, evaluating, and improving manufacturing systems [Opereza, 2001]. A major section of a Visteon plant's manufacturing system was evaluated utilizing the MSDD frame work, this plant is located in Basildon England. Visteon Basildon plant (Basildon plant) is part of the Climate Control division of Visteon UK limited. The Basildon plant manufactures a variety of radiators, intercoolers and condensers for numerous customers e.g. Ford Motor Company, Volkswagen etc. In an effort to become more competitive the Basildon Plant began work on several projects in conjunction with the Productions System Design (PSD) lab at MIT, headed by Professor David S. Cochran. These projects include the Basildon England Simultaneous Material Replenishment Trigger (BESMART), a system to improve the plants internal material supply chain, the Supplier Electronic Replenishment System (SERT), a system to improve the external supply chain of the plant with parts suppliers and keep them up-to-date with actual usage of their parts in plant and a new manufacturing system for the radiator and condenser module product line of the plant known as the Vision 2001 project.

1.2 Thesis outline

Chapter 1 defines the objective of this thesis and provides a summary of each of the five chapters.

Chapter 2 gives a brief history of the origins of the automobile manufacturing industry, and its transition from a craft based industry to a mass production based industry. The chapter concludes with an overview of the Japanese lean manufacturing practices, their background, and the key principles that form the foundation of the Toyota Production System (TPS).

Chapter 3 provides an overview of the Manufacturing System Design Decomposition (MSDD). One of the key capabilities the MSDD provides to a manufacturing system designer is the ability to communicate information across the different levels of an organization. The MSDD accomplishes this by separating means from objectives and explaining the interrelation between the different elements of a manufacturing system and how these achieve high-level requirements. The chapter begins with an overview of axiomatic design as it relates to production system design. Axiomatic design provides the backbone for providing a holistic system view in production system design gives the relation between system objectives, as seen by the customer, and the requirements for subsystem design. The chapter goes on to give a summary of the MSDD and its six branches, or categories: Quality, Identifying and Resolving Problems, Predictable Output, Delay Reduction, Direct Labor, and Indirect Labor.

Chapter 4 presents a case study of an evaluation performed by the PSD team of that analyzes the improvements of the Basildon production system. The chapter concentrates on the radiator and condenser moduling process of the production system. The chapter begins by giving an overview of the products and process in the Basildon plant including the product, material flow and information flow. The chapter continues with a detailed analysis of each branch of the MSDD as it relates to the prior and present production system in the Basildon plant. The chapter concludes by demonstrating how by meeting the FR's of the system performance measures of the system will also improve. The analysis is performed using traditional performance metrics as the evaluating criteria. Potential areas for improvement areas are identified based on this approach.

Chapter 5 presents the work carried out in the Basildon plant on the Basildon England Simultaneous Material Replenishment Trigger (BESMART) project and the Supplier Electronic Replenishment System (SERT) project. This chapter begins by demonstrating the steps undertaken by the team to understand the problems inherent in the material replenishment system for the externally purchased parts. The chapter continues by outline the proposed systems the steps explain the material and information flow for the external parts purchased by the plant.

Chapter 2: AUTOMOTIVE MANUFACTURING:

A HISTORY OF THE INDUSTRY

2.1 Craft Production

Craft production can be defined as the use of extremely skilled workers who utilize simple, flexible tools to create a product made to specific customer requirements [Womack et. al, 1990]. Craft production was characterized primarily by the usage of a skilled workforce in the areas of design, machine usage and part fitting. The training process of these skilled workers usually began with an apprenticeship that enabled them to improve there skill set and would ideally lead to the worker operating their individual workshop, performing contract work for the large assemblers of the day. There was very limited specialized tooling; the skilled craftsmen would utilize general-purpose machine tools to perform their operations.

Due to the high cost of the vehicles production volumes were generally very low at less than one thousand vehicles per annum [Womack et. al, 1990]. Eventually craft production gave way to mass production, however several craft producers are still in business today, primarily due to their exclusivity, prestige and customizability. .

2.2 Mass Production

The father of mass production is generally considered to be Henry Ford. His techniques introduced in the early 19th century drastically reduced costs while simultaneously increasing quality, in the automobile industry. In contrast to craft production mass production was able to work under the assumption that cost per unit drops dramatically as production volume increase [Womack et. al, 1990]. This allowed Ford to manufacture a car that was in the price range of the ordinary man, justifying the high volumes. The craft to mass transition primarily occurred not because of the advent of the moving assembly line as most people think but due to the religious zeal to which Ford followed a gauging system that allowed for the complete and consistent interchange ability of parts and the simplicity of attaching them to each other [Womack et. al, 1990]. The recent advances in machine tools and Fords ability to work with prehardened metals assisted this complete interchange ability. This allowed Ford to overcome the warping that occurred due to the hardening of machined parts in the crafts production industry. These new tools were also designed with very short set-up times that allowed for an inexperienced operator to operate the machines with minimal training. The ability of Ford to reduce the part count via innovative product design also assisted in the transaction to lean. All of these allowed for the reduction of costs as the volume increases [Womack et. al, 1990].

Ford not only pioneered the above stated technological advances but he also made headway in the workforce area and factory design. The most predominant of these improvements was the moving assembly line. As Ford divided his labor into functional groups, dependent on the specific task, he created the functional layout predominant in factories all over the world today. Each specific task could be performed at a specific cycle time. By designing the layout of the factory to this cycle time, which allowed for production to occur at a steady high volume state [Womack et. al, 1990].

Ford faced several challenges as he developed mass production. In particular in the 1920's it became apparent that Ford could not please all his markets with just a single product. To solve this problem he introduced multiple models for different regions of the world. This required the building and tooling of entirely new plants, as the tools were dedicated to particular model. In the 1920's Ford encountered trade barriers that restricted the import of finished goods. To overcome this Ford decided to manufacture the parts in Detroit and ship the less restricted unfinished goods closer to the point of usage for assembly [Womack et. al, 1990].

The lessons of Ford spread quickly throughout the world, not only in the auto industry but numerous other industries. The mass production technique was seen as a giant leap forward to the older methods of craft production. Yet there were side effects to mass production. Due to the cost of the large expensive production lines shut downs were to be prevented at all costs. This institutionalized within the system large buffers between operations consisting of both workers and inventory. The routine jobs and poor factory conditions led to the rise of powerful unions such as the United Auto Workers (UAW) that often had an adversarial relationship with management [Womack et. al, 1990].

2.3 Lean Manufacturing

2.3.1 Background

Numerous definitions abound as to the principles of lean, a term coined by the International Motor Vehicle Program (IMVP) and MIT [Womack, Jones and Roos, 1991] to describe the system pioneered by Toyota Motor Company in Japan. Some of the best are: Perfect Quality, Right Quantity and Right Mix utilizing the least resources [Cochran et. al, 2000].

Lean production was brought about in post World War II era in Japan when Eiji Toyoda and Taiichi Ohno began to develop the Toyota Production System that marked the beginning of the "lean" production era. It is said that necessity is the mother of invention, the Toyota Production system is no exception to the rule. The primary reason that necessitated the development of the Toyota Production system was the need of Toyota to manufacture a wide variety of vehicles from luxury cars to large trucks, in a war ravaged, capital and foreign exchange starved economy, where it was impossible to purchase the large expensive western machinery that was fast and dedicated to a single product. Japan also lacked the benefits of the guest worker that was quite predominant in the western world [Womack et. al, 1990]. This accompanied by the strong labor movement restricted Toyotas use of their workforce as an expendable cost. All of these restrictions forced Toyota to develop the lean production system with its characteristic flexibility, reliability and cost effectiveness in order to compete with the western mass producers.

2.3.2 Principles

The cornerstone of the Toyota Production System is the reduction of waste in every possible form throughout the entire organization by applying a systems thinking approach to avoid sub optimization. Following two basic principles, Toyota was able to reduce costs while delivering products faster and with better quality than their Western counterparts.

Just In Time (JIT):

The Just-in-Time Kanban controlled production management system was developed by trial and error over a period of many years. The development of the system was primarily the result of efforts of Ohno [Neise, 2000]. Just in Time (JIT) basically means to produce the necessary units in the necessary quantities at the necessary point in time. The Kanban system is a tool for achieving this goal. [Monden, 1998].

The first step of Just In Time is calculating your Takt time. This cycle time or takt time is considered to be the heart bit of the factory, and is determined by the rate of demand of the customer [Ohno, 1988]. Takt time (the German word for the musical meter, which came to Japan in the 1930s when Japan was learning airplane manufacturing from German engineers) is the tool to link production to the customer by matching the pace of production to the pace of actual final sales. Determining Takt time is the first step in establishing and effective JIT system. Takt time allows you to determine [Liker, 1997]:

- What are the requirements?
- How many of a suppliers process products are required by its customers?
- How can we create a process that can fulfill that need in a minimum of waste and in the shortest time?

Once the Takt time of a manufacturing system has been established and defined it is possible to implement an effect Pull system. A pull system begins with the end customer who places the order. This causes a manufacturing order to be created which in turn triggers the sub supplier's parts to be ordered. This varies drastically from the traditional system utilized by such forerunners of mass production as GM and Ford, know as the central scheduling system or Push system. The Pull stem relies on the final production step in the system driving production through out the entire system. This system then pulls component parts from the sub supplier up through the supply chain. This is the foundation of supply chain management [Cortada, 1995].

Kanban is a Japanese term meaning card signals, that is, visible records and is a tool for the achievement of JIT production by allowing for the implementation of a Pull system [Cortada, 1995]. There are two basic types of Kanban: withdrawal Kanban and production ordering Kanban. The first specifies amount and type of parts a subsequent process should draw from the preceding process and is not only used in-house, but also to withdraw items from suppliers. The latter prescribes the quantity and type of products the preceding process should supply. Generally, a Kanban of either nature describes a particular part and the stands for a defined quantity of parts. In current literature the utilization of these two Kanban within the manufacturing system is often referred to as a two-card system [Neise, 2000]. Unfortunately a high percentage of people think that Kanban is the cornerstone of the Toyota Production System [Shingo, 1989], when it really is just a tool to aid the principle of Just-in-time, which represents in turn a remarkable difference with traditional mass production systems.

A tool that is used to transfer a pull system through out the Toyota organization is the Heijunka box. The Heijunka box is utilized to level production over a particular time period. Heijunka balances the workload to be performed to the capacity or capability of the process to be completed. This leads to a dual functionality of Heijunka in the reduction of inventories due to the reduction in batch size and the increased model mix and the ability to equate the workloads between production processes to capacity [Colman et. al, 1994].

Toyota's Heijunka is a component of TPS that is widely misunderstood by western manufacturing. It is widely believed that Toyota Freezes their Production schedules (for example the sequence cars are run down a production line) far in advance, and this freezing allows for the smooth running of production. While it is true that Toyota produces Heijunka production planning on a monthly basis, the setting of monthly volumes for different model variation does not lock in the actual production sequence. This sequence can be changed up till the last day prior to the beginning of the production process, body welding and assembly process [Liker, 1997].

"Traditional" mass-producers tend to rely on long run sizes due to long changeovers that make the implementation of a JIT system difficult. The way that Toyota overcame this obstacle was through he implementation of a Single Minute Exchange of Dies (SMED) system.

Ohno was one of the first person to do active work on changeover reduction that enabled Toyota to produce several types of stamped parts on a few presses using multiple dies designed to be change in a relatively short period of time. There are two reasons why this technological advance created greater efficiencies, making small batches eliminated the carrying cost of huge inventories and secondly allowed for quicker and less costly quality detections and correction [Womack et. al, 1990].

SMED is one of the key tenets of TPS. The single minute states that all changeovers should occur in less than 10 minutes, hence the single minute. The principles to achieve this were devised by Shigeo Shingo and are as follows [Shingo, 1987].

- Clearly distinguish internal from external set-up.
- Convert internal to external set up, hence reducing the internal set up and reducing actual machine down time.
- Improve functional clamps.
- Eliminate adjustments.

The benefits of adopting SMED can be summarized as:

- Reduction of batch size increase model mix by reducing change over time. This also leads to a secondary benefit of reducing WIP and finished goods inventory.
- Increased machine operating rates due to reduced set-up time.
- Increased flexibility of the system due to rapid response to mix and volume change.

"Traditional" mass-producers relied on a Push system. This system by forecasting the demand of final car sales. The scheduled amount of cars generates a production schedule for all upstream suppliers of car components and subcomponents. At each of these stages, the production schedule accounts for a "fall-out" or defective-parts rate to ensure that the right amount gets delivered to the subsequent stages. But the fall-out rate, as well as the scheduled demand, is stochastic. Consequently, the amount produced at each stage, doesn't necessarily match the amount sold, therefore resulting in inventory accumulation [Oropeza, 2001].

A push system causes the build up of large uncontrolled "buffer" inventories that cause problems in the system to be hidden. This system is illustrated in Figure: 1-1

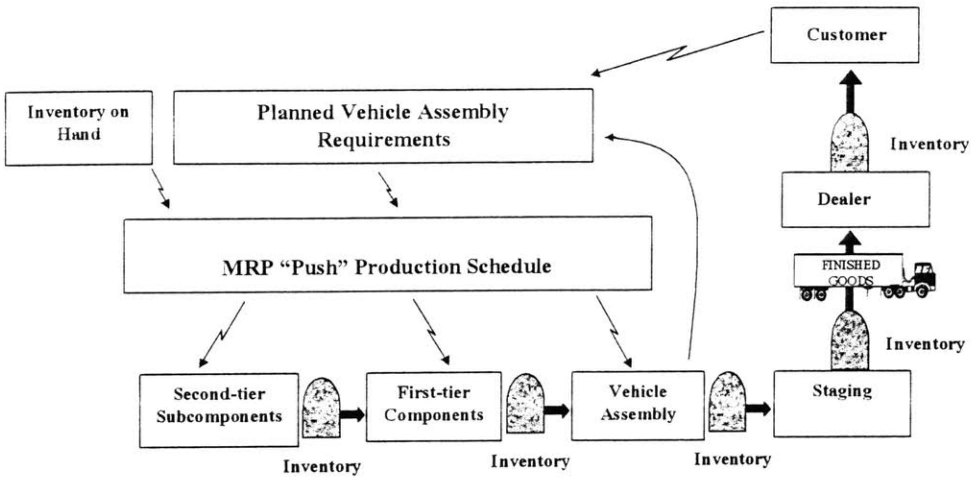


Figure 1-1: Automotive "Push" Production and Scheduling System [Adapted from Cochran, 1999]

The Toyota Production System JIT pull system is based on actual consumed quantities. When a car is sold, the car is retrieved from the assembler's Standard Work in Progress (SWIP). This is similar to a buffer with the major differences being that it is operated on a first in first out (FIFO) system and it is controlled. The necessary upstream components are pulled into the assembly plant to make another car of the same type as the one withdrawn. This system, is illustrated in Figure: 1-2

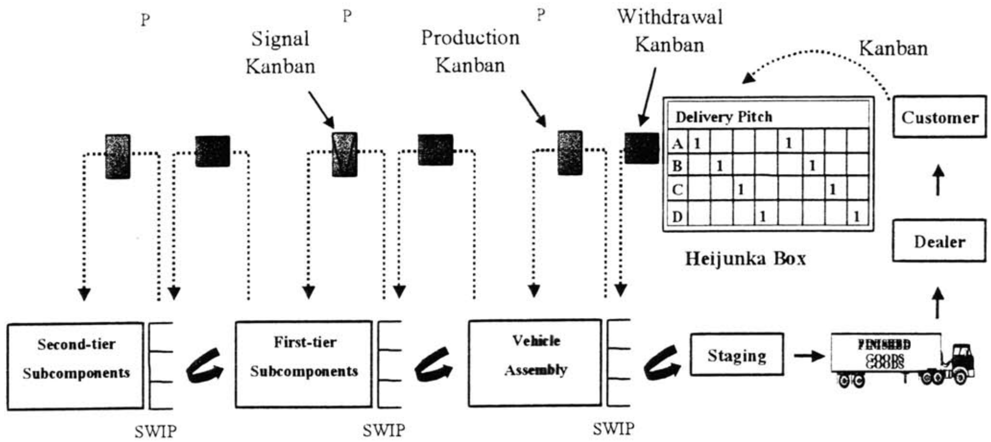


Figure 1-2: Automotive "Pull" Production and Scheduling System [Adapted from Cochran, 1999]

Whenever an item is retrieved from the SWIP at any stage, a signal is sent upstream to request replenishment material to re-stock the missing part at the SWIP. This is done with the aid of production and withdrawal replenishment Kanban cards.

Jidoka:

Jidoka is the abbreviated for of the Japanese word "Ninbenno-aru Jidoka" which might be loosely interpreted as autonomous defects control [Monden, 1993]. This represents the second pillar of the Toyota Production System as illustrated in Figure: 1-3. Traditional mass producers tend to maximize machine utilization for two fundamental reasons: to reduce investment per part produced and to reduce labor per part produced. This results in faster and more automated equipment. At Toyota, operator utilization is considered to be more valuable than the equipment utilization [Shingo, 1989]. This leads to the concept of an idle machine being preferred to an idle worker. At Toyota, they increase the amount of value-added activities by introducing the concept of autonomation. By increasing the machine cycle times, the operators have enough time to operate various machines at the same time, while the others are running. To do this, it was necessary to separate the worker from the machine, allowing him/her to walk away from the machine while the machine performs the operation automatically. This is accomplished by manually feeding the parts to be processed into each machine and by pressing a "walk-away" switch. The machine would then automatically process the part and unload it, finishing its cycle and waiting for the operator to arrive and retrieve the finished part and to load in the new on [Oropeza, 2001].

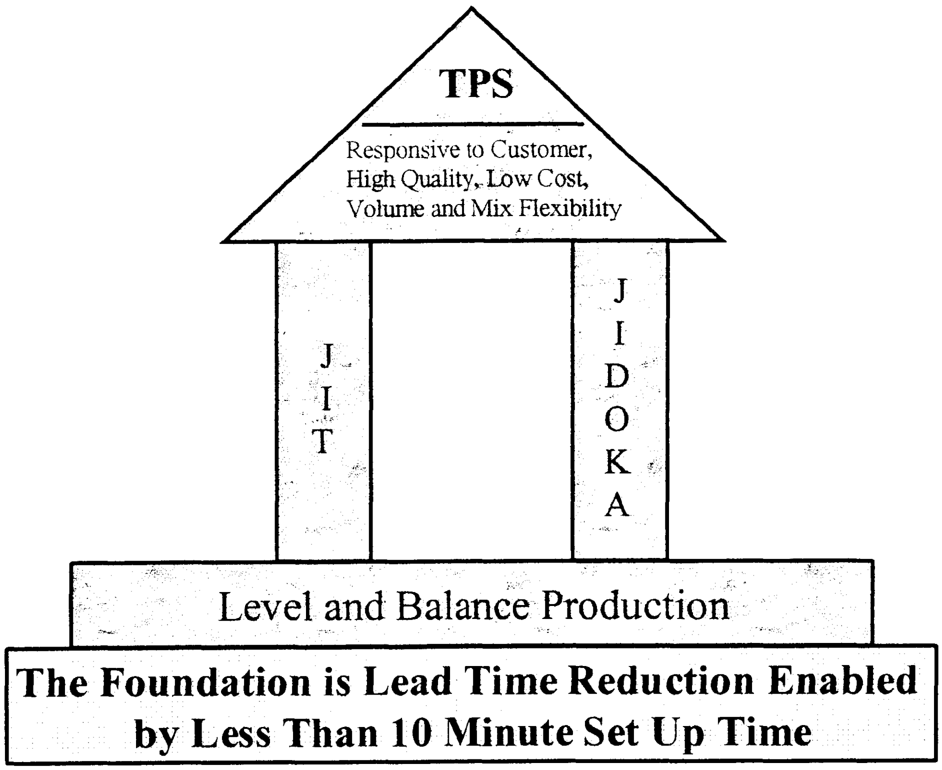


Figure 1-3: The Toyota Production System Design Model [Cochran, 1999]

Within Toyota the concept of Standardized work is integral to their success of continuous improvement. Within Toyota standardized work is accomplished through the use of two devices known as a Standard Operations Routine (SOR) sheet and a Standard Operations (SO) sheet. The SOR sheet lays out a detailed description of the operators work loop while the SO sheet combines the operator work loop with Takt time and amount of WIP [Shingo, 1987].

Standardization of work allows for ease of continuous improvement as muda and quality errors due to operators work method can easily be detected and corrected. For this reason in the Manufacturing System Design Decomposition designed at MIT, standardized work is dictated as the first step towards effective lean implementations in a medium to high volume repetitive manufacturer [Cochran et. al, 2000]. It is essential that the operator play a decisive role in all improvements made.

Continuous improvement is driven by the lean producer due to their overarching goals of zero defects while reducing costs. These improvements are made in small increments by teams performing Kaizan blitzes. This is defined as a group of people working together over a short period of time to analyses and implement changes to a particular process or operation. In addition to Kaizan blitzes, the individual shop floor operator is empowered to stop the entire production process if they discover a quality problem via an andon cord, usually found above the workers head [Shingo, 1987]. This creates a situation where a large proportion of the plants energies are placed on systematically tracing back to the root cause of the quality issue to insure that it never reoccurs. Poka yoke devices are also implemented to accomplish a similar out come. If a defect is detected a signal is sent to stop the process so as the process can be analyzed [Womack et. al, 1990].
Within a lean organization production is set up to facilitate one-piece flow. One-piece flow is a key tenant of lean production as it allows for quick detection of quality issues

through minimal inventory. A cellular layout helps to facilitate one-piece flow by allowing one multi skilled operator to operate several machines at once hence consuming the least resources. The Cell is a group of processes designed to make a family of parts in a flexible way. The worker in the cell is multiprocess: they can run more than one procees and they can run different kinds of processes [Black, 1991].

The manufacturing cell also provides several other secondary benefits, of which the most notable is its ability to enhance flexibility within an organization. A particular cell can be designed to run at multiple cycle times to match varying takt times by varying the number of operators in the cell and changing the work loops.

Chapter 3: OVERVIEW OF THE MSDD, THE QUESTIONNAIRE AND THE DATABASE

3.1 Axiomatic Design Approach in Production System Design Decomposition

A holistic system view in production system design gives the relation between system objectives, as seen by the customer, and the requirements for subsystem design. Such a relation helps to prevent local sub-optimization [Mierzeja, 2000]. An approach to relate these objectives is the decomposition method provided by the axiomatic design theory [Suh, 1990], which can be understood as a top-down analysis of objectives and requirements [Duda, 1999]. "The ultimate goal of the Axiomatic Design is to establish a science base for design and to improve design activities by providing the designer with 1) a theoretical foundation based on logical and rational thought processes and 2) tools." [Suh, Albano, 1995].

Axiomatic design breaks a problem down by answering two basic questions:

1. What are the objectives of the subsystem?
2. How can given objective be achieved?

The answer to question one establishes what the Functional Requirement (FR) of the system would be and the second questions establishes the Design Parameters (DP) of the system. The pairs of DPs and FR's can be further decomposed into lower levels of details by answering the same questions for the DPs.

The functional requirements (FRs) represent the goals of the design or what we want to achieve, these can also be know as the requirements (Rs). The design parameters (DPs) express how we want to satisfy the functional requirements, these can also be known as the solutions (Ss).

There are two axioms, which guide the design process and enable good designs to be identified. The two axioms are the Independence Axiom and the Information Axiom. They are stated as follows [Suh, 1990]:

The Independence axiom maintains the independence of the functional requirements.

Alternate Statement 1: An optimal design always maintains the independence of the functional requirements.

Alternate Statement 2: In an acceptable design, the design parameters and the functional requirements are related in such a way that specific design parameter can be adjusted to satisfy its corresponding functional requirement without effecting other functional requirements [Linck, 2001].

The Information Axiom minimizes the information content of the design.

3.2 Introduction to the Manufacturing System Design Decomposition

The MSDD decomposes a general system design for discrete parts manufacturing. There are six levels of FR-DP pairs in the Decomposition shown in Figure 3.1 [Cochran et. al., 1999]. The first level FR captures the highest level objective of manufacturing within an enterprise, "Maximize long-term return on investment," and the sixth level functional requirements are specific details of a manufacturing system design. To further decompose this level would require going into detail of the particular manufacturing system in question.

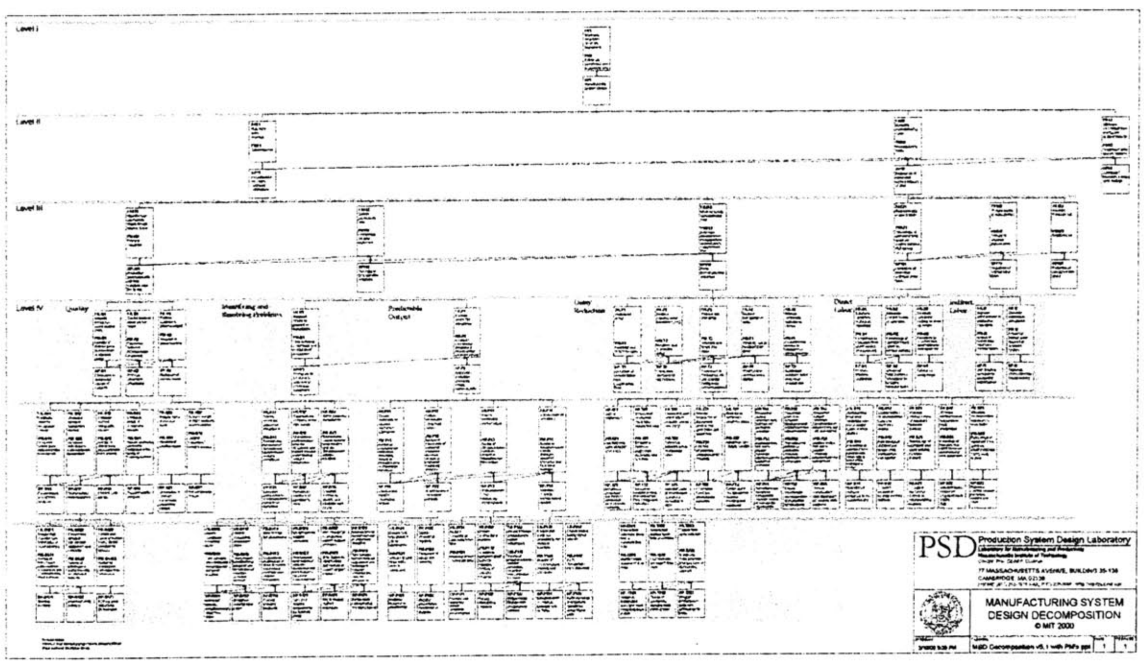


Figure 3.1: Manufacturing System Design Decomposition

Once you have stated the highest level objective of manufacturing within an enterprise you can further decompose the system to the second level FRs of the MSDD which state that to maximize long term investment, you must maximize sales revenue, minimize production costs, and minimize investment over the production system lifecycle. The third level FRs further decompose the design into manufacture products to target design specifications, deliver products on time, meet the customer expected lead time, reduce waste in direct labor, reduce waste in indirect labor, and minimize facilities cost [Oropeza, 2000]. The top three levels are shown here in Figure 3.2.

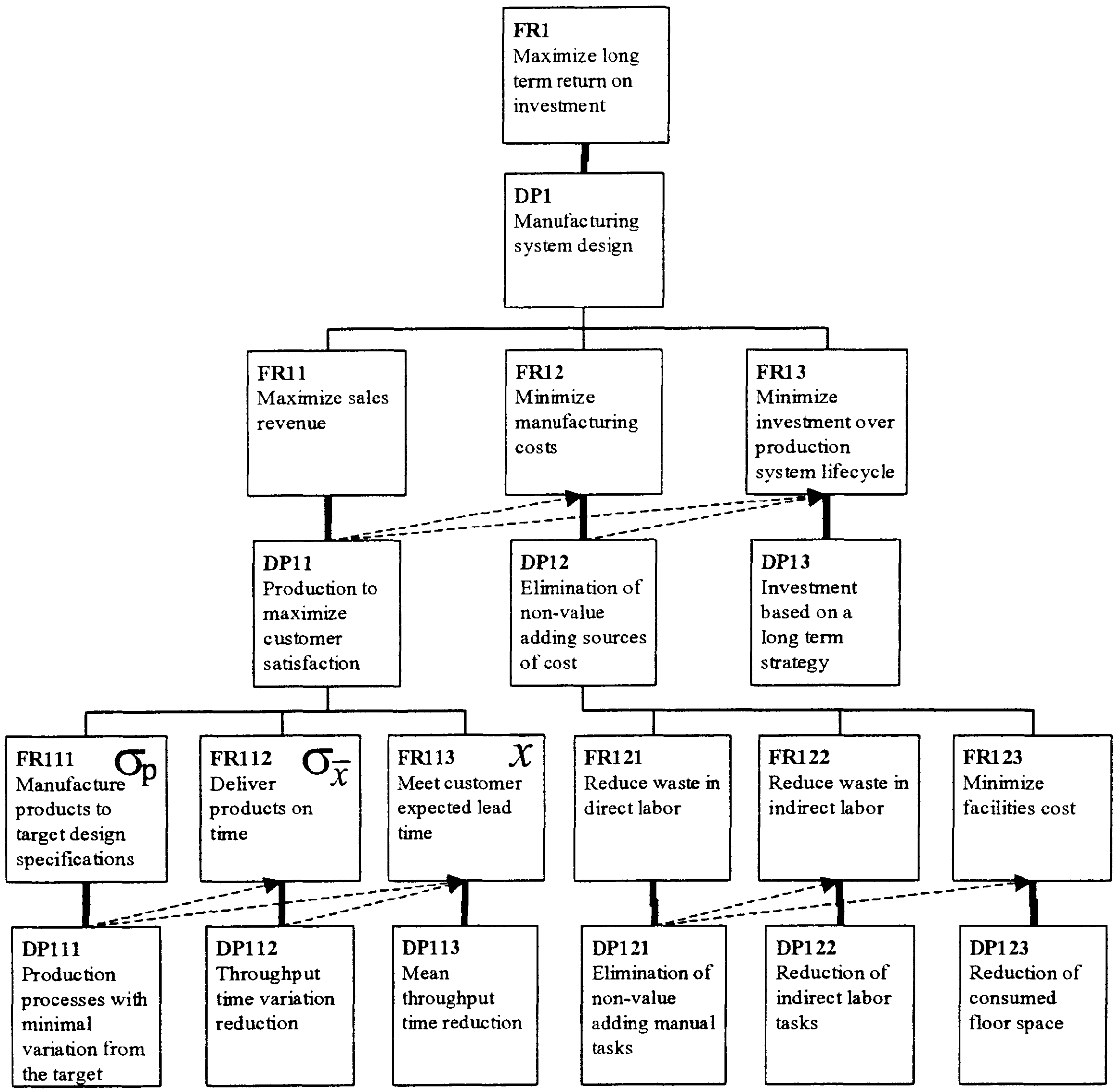


Figure 3.2: High Level Objectives of the MSDD

The lower level objectives (levels 4 through 6) of the MSDD are divided into six branches, or categories: Quality, Identifying and Resolving Problems, Predictable Output, Delay Reduction, Direct Labor, and Indirect Labor. These six branches are illustrated in Figure 3.3, and they are briefly described in the rest of this chapter [Kuest, 1999].

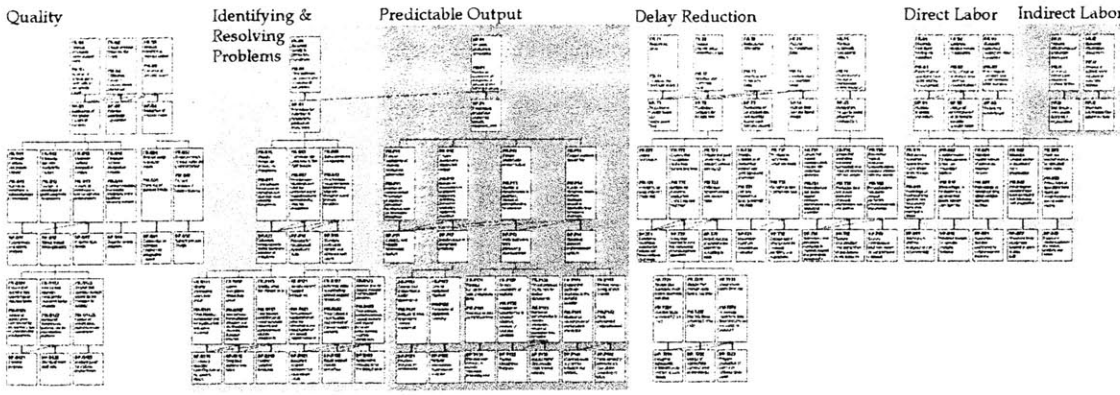


Figure 3.3: Six Branches of the MSDD

3.2.1 Quality Branch

The Quality branch of the Manufacturing System Design Decomposition shown in Figure 3.4 decomposes the following FR-DP pair:

FR 111: Manufacture products to target design specifications

DP 111: Production processes with minimal variation from the mean

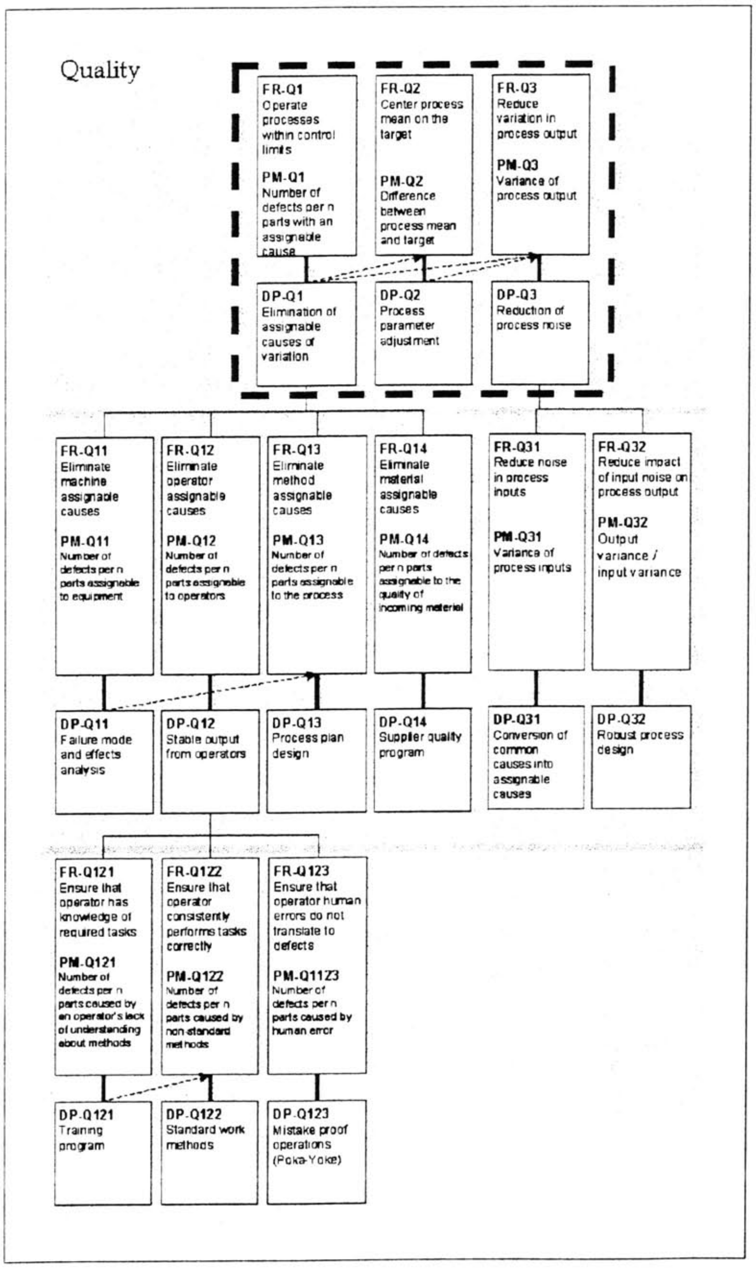


Figure 3.4: Quality Branch of the MSDD

To accomplish DP 111, processes must be stable, be centered on the target mean, and have little variation. For this to occur in a manufacturing environment the MSDD shows that three solutions must be fulfilled, that is eliminate assignable cause of variation, a process parameter must be met and finally production noise must be reduced. Some of these are further decomposed [Oropeza, 2001].

3.2.2 Identifying and Resolving Problems Branch

The Identifying and Resolving Problems branch of the Manufacturing System Design Decomposition shown in Figure 3.7 decomposes the following FR-DP pair:

FR-R1: Respond rapidly to production disruptions

DP-R1: Procedure for detection and response to production disruptions

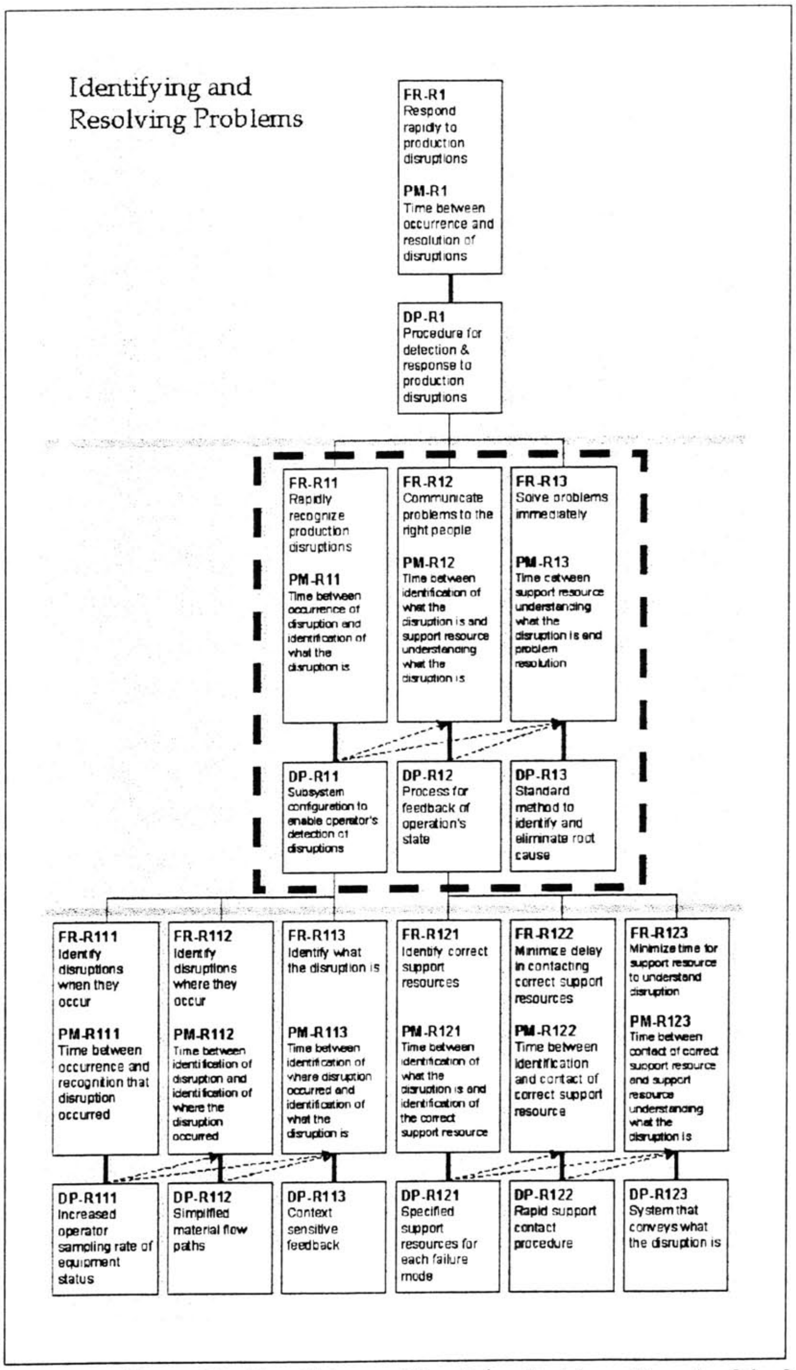


Figure 3.7: Identifying and Resolving Problems Branch of the MSDD

To accomplish DP-R1, a three part process must occur, you must recognize the disruption, communicate the disruption and solve the problem [Oropeza, 2001]. These parameters are further decomposed.

3.2.3 Predictable Output Branch

The Predictable Output branch of the Manufacturing System Design Decomposition shown in Figure 3.10 decomposes the following FR-DP pair:

FR-P1: Minimize production disruptions

DP-P1: Predictable production resources

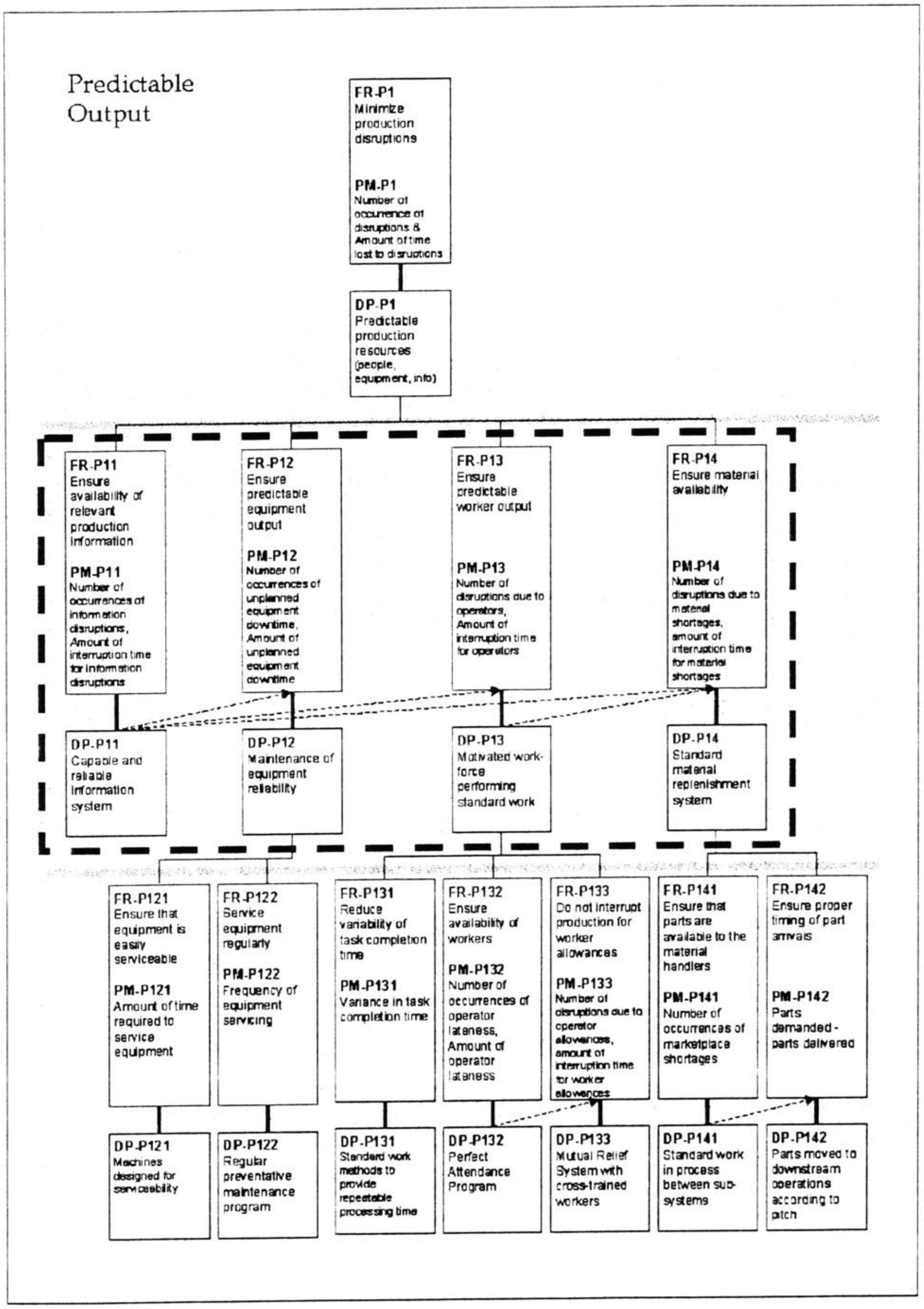


Figure 3.6: Predictable Output Branch of the MSDD

To accomplish DP-P1, four aspects of a manufacturing system must be available and predictable; these include the production equipment, operators, information and materials. Some of these aspects are further decomposed [Oropeza, 2001].

3.2.4 Delay Reduction Branch

The Delay Reduction branch of the Manufacturing System Design Decomposition shown in Figure 3.13 decomposes the following FR-DP pair:

FR 113: Meet customer expected lead time

DP 113: Mean throughput time reduction

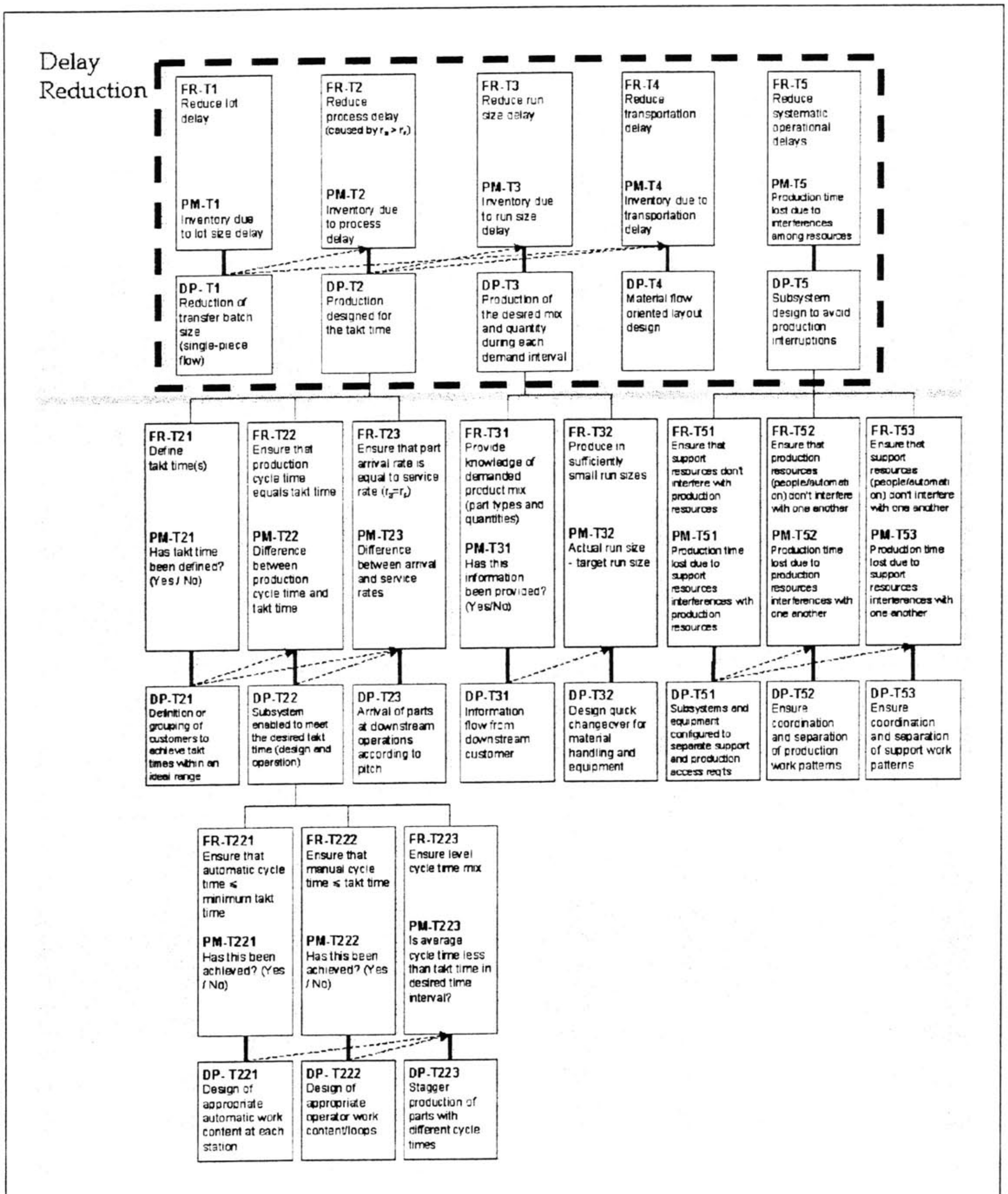


Figure 3.7: Delay Reduction Branch of the MSDD

To accomplish DP 113, five aspects of a manufacturing system must be fulfilled Reduction of transfer batch, production must be designed to takt time, production mix and quantity must be met, a material flow oriented design must be fulfilled and production system must be designed to reduce interruptions. Some of these aspects are further decomposed [Oropeza, 2001].

3.2.5 Direct Labor Branch

The Direct Labor branch of the Manufacturing System Design Decomposition shown in Figure 3.20 decomposes the following FR-DP pair:

FR 121: Reduce waste in direct labor

DP 121: Elimination of non-value adding manual tasks

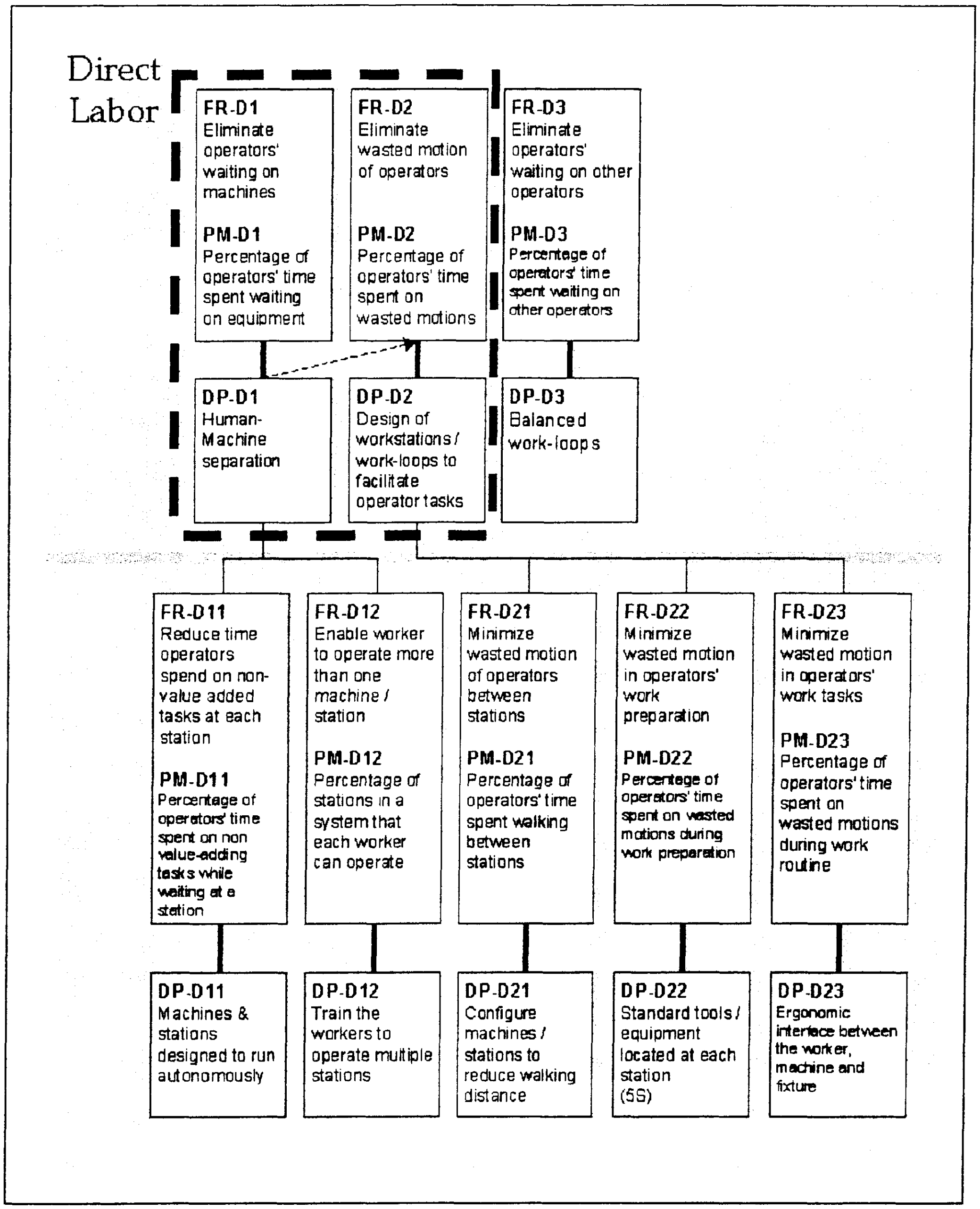


Figure 3.8: Direct Labor Branch of the MSDD

To accomplish DP 121, it is essential to eliminate all operator assignable waste. At this time three forms of operator assignable waste have been identified [Oropeza, 2001]. These include waiting on machines, unnecessary motions, and waiting on operators. Some of these aspects are further decomposed.

3.2.6 Indirect Labor Branch

The Indirect Labor branch of the Manufacturing System Design Decomposition shown in Figure 3.24 decomposes the following FR-DP pair:

FR 122: Reduce waste in indirect labor

DP 122: Reduction of indirect labor tasks

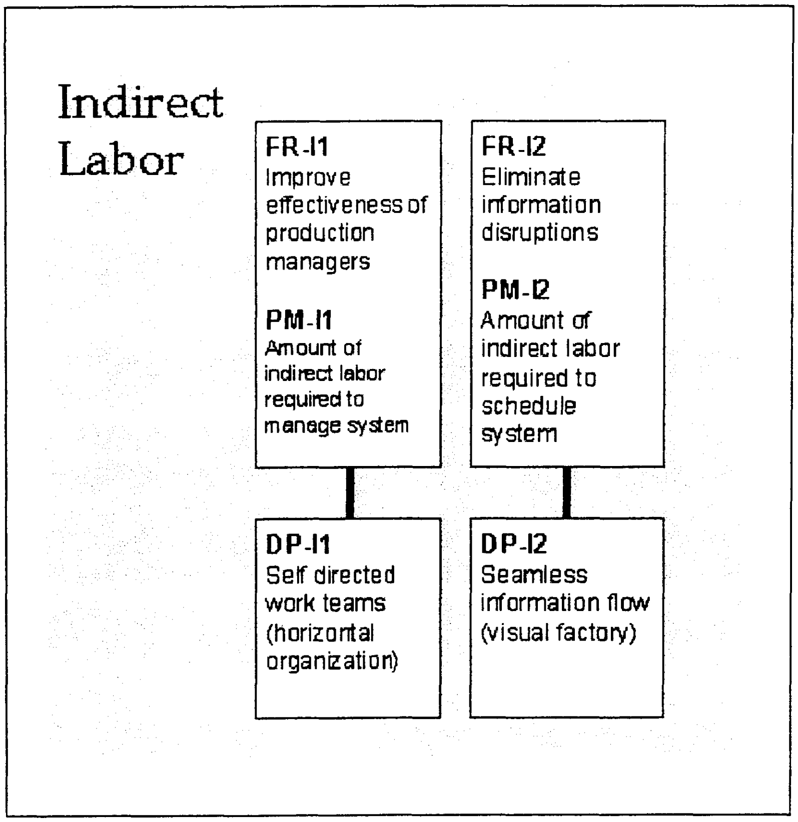


Figure 3.9: Indirect Labor Branch of the MSDD

To accomplish DP 122, the indirect workforce must be utilized more effectively. One way of accomplishing this is by flattening the management structure. In many industries grate effectiveness gains have been realized through more effective scheduling techniques [Oropeza, 2001].

3.3 MSDD Questionnaire

The MSDD questionnaire contains specific questions about the FR-DP pairs stated in the MSDD. The questions use a five-point Likert scale, with each scale measureing a specific content i.e. the content of a particular FR-DP pair. Questions are answered with one of the following choices: (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, (5) strongly agree, and (0) not applicable. Several question in the questionnaire are open ended forcing the respondent to answer in their own words. This can lead to a deeper coverage of the system. It was important in the development of the questionnaire that the number of open ended questions were kept to a minimum due to the wide scope of the MSDD, which would requiring excessive time for respondents to fill out the questionnaire if there were to many open ended questions. Open-ended questions where primarily uses when it is felt that additional information is necessary, e.g., asking for the amount of time spent on equipment maintenance [Linck, 2001]. In it's current state the MSDD questionnaire takes approximately one hour to complete.

The MSDD questionnaire utilized several question to compare and validate the answers of the participant. For example, the following questions are asked about FR-DP P122 "Service equipment regularly." – "Regular preventative maintenance program" [Linck, 2001].

- We dedicate a portion of every day solely to preventive maintenance and follow the preventive maintenance schedule.
- We emphasize proper maintenance as a strategy for achieving schedule compliance.
- We are usually behind production schedule and have no time for preventive maintenance. Repair is our maintenance.

3.4 MSDD Database

The MSDD database provides a graphical user interface for the application of the MSDD questionnaire. This allows for greater ease in administering and analyzing the questionnaire, and to document observations made during the case study.

The general functionality of the database is explained by referring to a database screen shown in Figure 3-3-25 [Linck, 2001]. The numbers are used to explain the functionalities. The user can select one or two questionnaires he/she would like to display (1). FR-DP pairs with associated questions are highlighted as colored boxes. Clicking on any colored box of the MSDD (2') shows the associated questions in the lower half of the screen (2"). The user can change the answer and edit the comment field.

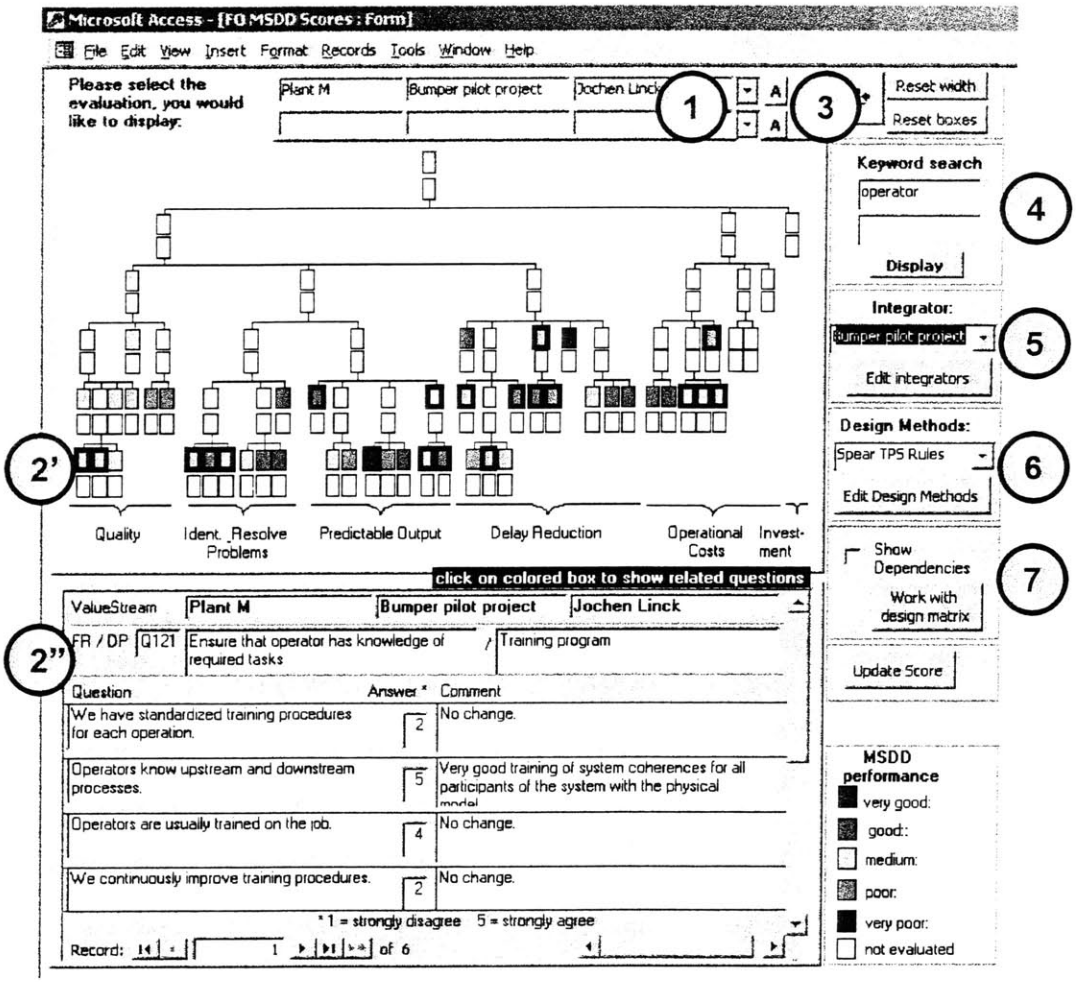


Figure 3-10: MSDD database working window

(3) Clicking on the "A" button next to the questionnaire selection field opens a window with a numerical analysis of the questionnaire. It shows how many questions scored very poor to very good. It also allows filtering of questions by score to facilitate a first analysis of the questionnaire.

(4) The "keyword search" highlights all FR-DP pairs related to an entered word. This feature currently looks in the text of FRs, DPs and questions. The keyword search can greatly support the determination of design objectives and the understanding of the MSDD.

(5) The "integrator" provides a platform to relate FR-DP pairs system design aspects such as cell design and scheduling, or to design projects. The user can select from an array of integrators to highlight related FR-DP pairs.

(6) The sixth functionality shows how the MSDD can be linked with existing manufacturing system design methodologies.

(7) If the box "Show dependencies" is activated, the user can click on any FR or DP box to highlight the dependencies. Clicking on a DP box highlights all FRs that are affected by the DP, clicking on an FR box shows all DPs that affect the FR. This feature can be helpful in determining dependent design objectives. The button "Work with design matrix" directs the user to the administration of the dependencies [Linck, 2001].

Chapter 4: VISTEON BASILDON VISION 2001 PROJECT

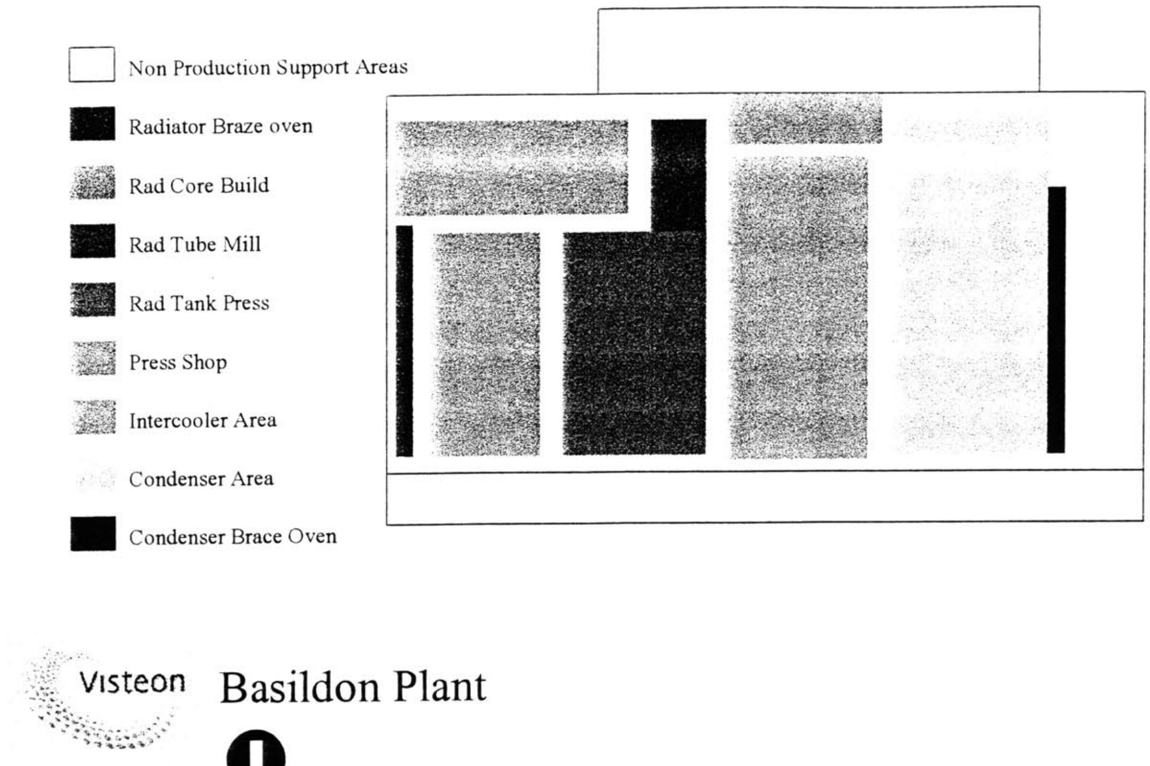


Figure 4-1: Schematic of Basildon Plant Physical Layout prior to Vision 2001

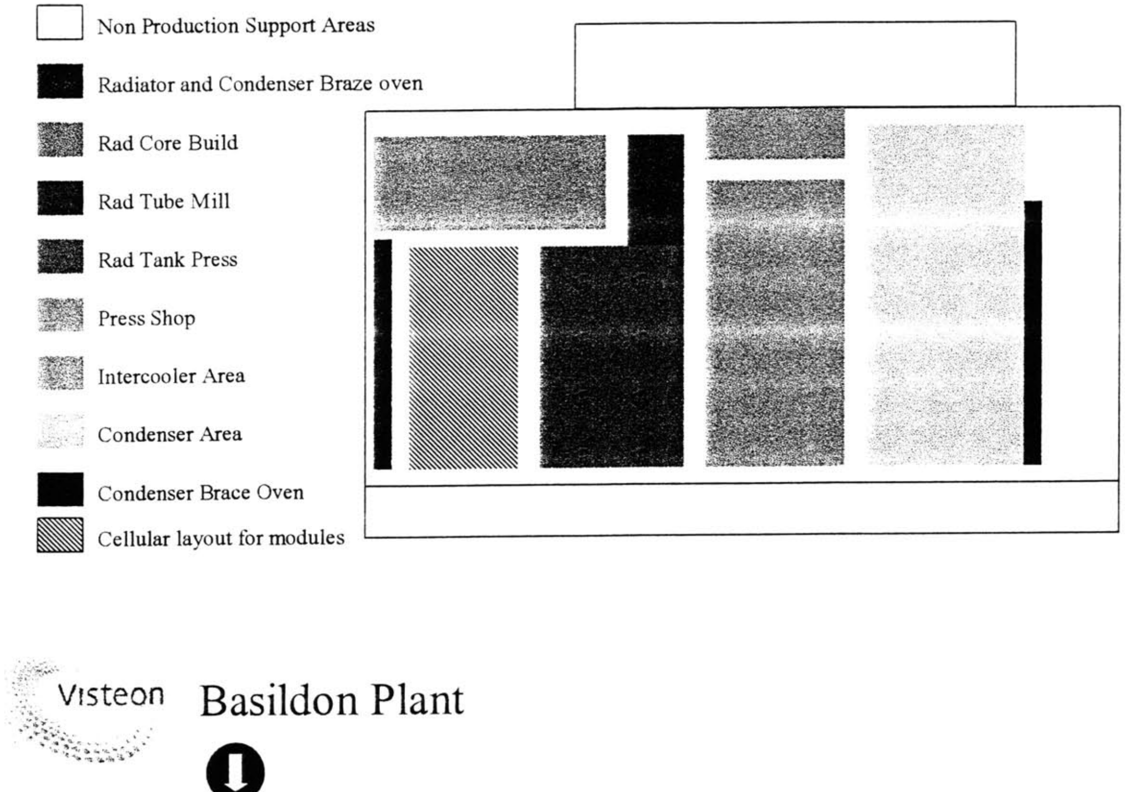


Figure 4-2: Schematic of Basildon Plant Physical Layout post Vision 2001

4.1.2 Product and Manufacturing Process Overview

4.1.2.1 Product Introduction

For the purpose of this case study we will concentrate on the Radiator and the Condenser product lines as they combine to form the module shipped to the customer. An exploded view of the module can be seen in
Figure 4-3.

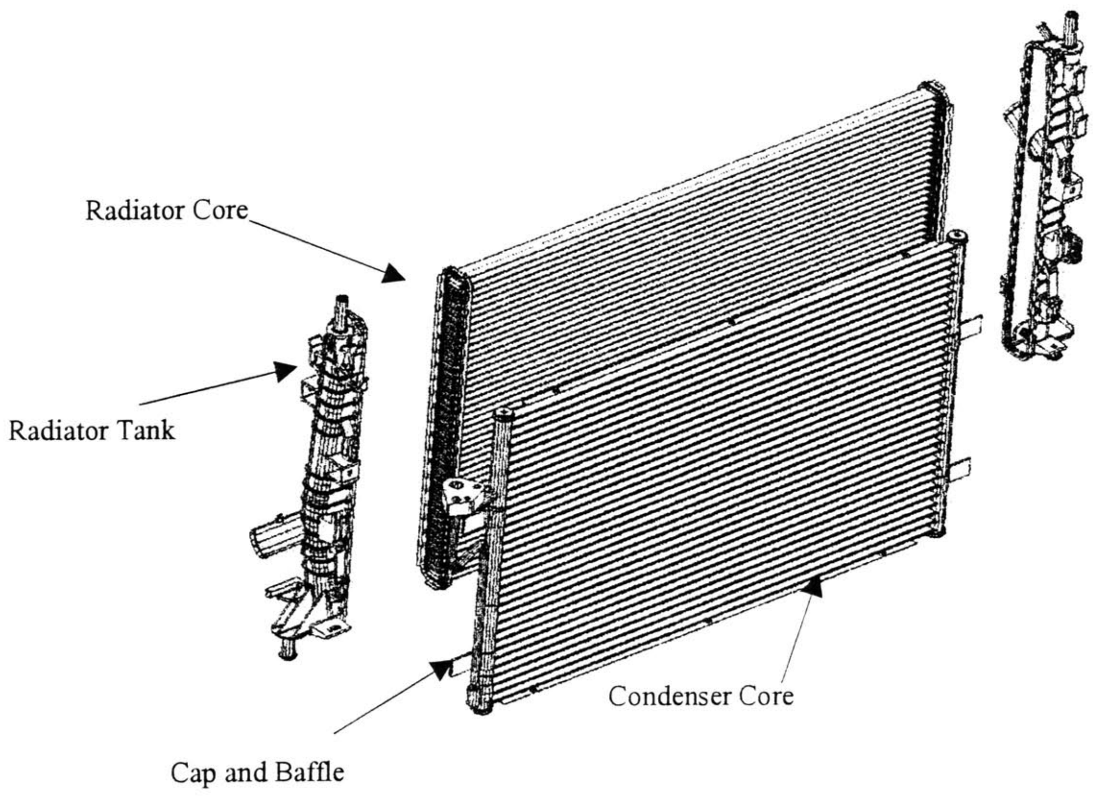


Figure 4-3: Exploded View of Radiator and Condenser module.

A majority of the component parts used to manufacture the radiator and condenser that make up a module are manufactured within the Basildon facility. The major part that is manufactured by external suppliers are the radiator tanks manufacture by 6 di fferent injection molding suppliers and shipped in from the US, UK and Japan. These parts are referred to as EP parts within the Basildon facility.

4.1.2.2 Manufacturing Process Overview

The Module can be decomposed into two major categories, the Radiator and the Condenser. These categories combine to form the module. The basic manufacturing process is similar for both products and includes the core build, braze and final assembly.

4.1.2.2.1 Radiator Assembly Overview

4.1.2.2.1.1 Product and Process Introduction

The Radiator assembly process can be categorized into two groups pre-braze and post-braze.

Figure 4-4 shows a schematic of two groups combining into the final product. The pre-braze processes refers to all radiator assembly processes before the brazing process. At this stage all the assembled parts are aluminum and held together by the side supports and headers. The brazing process essentially fuses all the contact surfaces together. The Brazing process is a complex combination of varying temperature ovens to allow for the precise heat treatment of the product.

The post-braze operations begin with the tank press process which is the final assembly stage assembling the radiator tanks to the radiator core. This is followed by a quality check test know as the leak check. Every radiator undergoes a leak check, and is immediately preceded by the buy off process, comprising of scanning a barcode label on the radiator to enter it into the MRP system as a completed product.

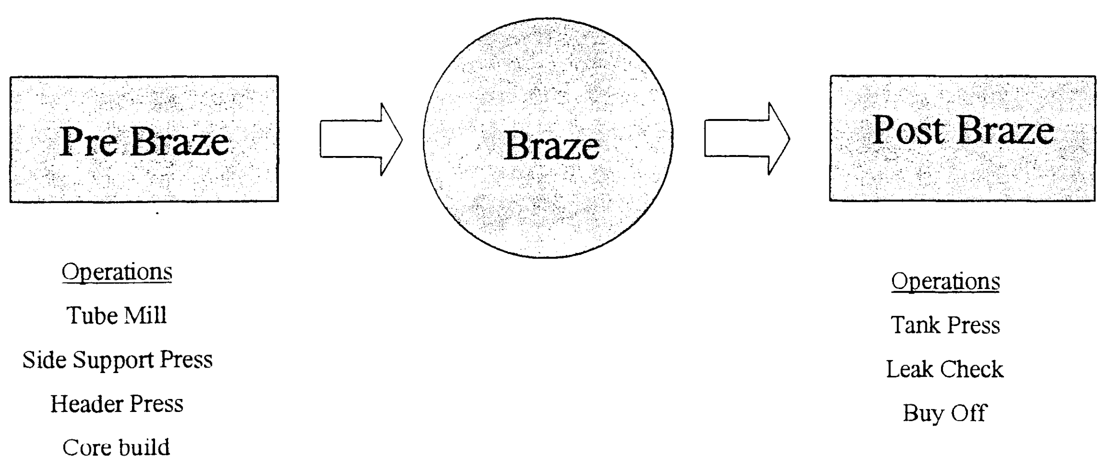


Figure 4-4: Schematic of Processes for Radiator

4.1.2.2.1.2 Product Variety and Families

The two product varieties that we are concerned with for this case study are the C170 and CD132 product families, for the Modeo and Focus car families. The major differences between these two families can be characterized in 3 areas:

I. Radiator Tanks
II. Tube diameters
III. General dimensions

4.1.2.2.2 Condenser Assembly Overview

The assembly process for the Condenser is very similar to that of the radiator. As shown in Figure 4-5, the primary difference is most of the assembly is done prior to the brazing process, and there are no plastic end tanks used in the assembly.

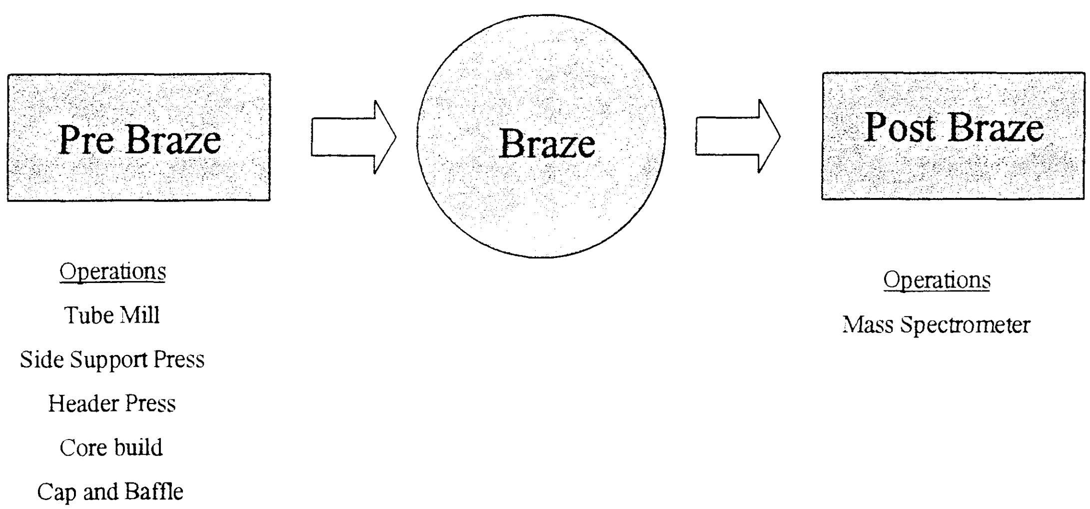


Figure 4-5: Schematic of Processes for Condenser

The primary differences that can be noted from the figure are the cap and baffle operation that is performed after the core is built, which is the final assembly step before brazing. After brazing a quality check is performed called the mass spec test.

The condenser and radiator are then assembled to each other to form a module. The total assembly procees for radiator and condenser system can be seen in Figure 4-6.

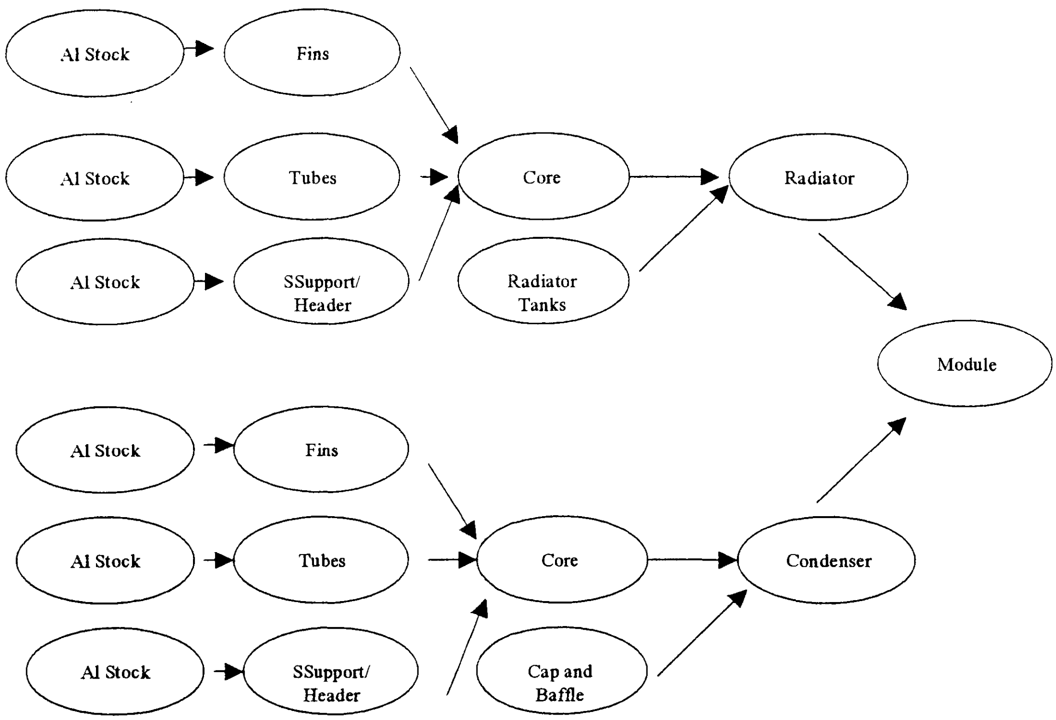


Figure 4-6: Bubble diagram of Module assembly process.

4.2 Value Stream Description

4.2.1 Pre Vision 2001 (2000)

4.2.1.1 Overview and Physical Layout

A schematic of the departmental layout is shown in Figure 4-7. The top figures shows all 3 groups that make up the Radiator and HC Condenser production area. The bottom right portion of the figure highlights the location of the HC Condenser department and the Radiator department on the Basildon area map. The bottom left portion of the figure illustrates a high-level flow path between the different departments. As shown on the left side of Figure 4-7, the CD- 132 condensers must travel from the HC Condenser to the Radiator tank press assembly cells to be moduled and C 170 Radiators must travel from the radiator tank press cell to the condenser cell to be assembled, an estimated distance of 500 feet. The pallets that transported the condenser and radiators hold 16 radiators each or 52 condensers each.

In general, the operating pattern for the Radiator and Condenser business unit is 3 shifts of 8 hours each. Excluding breaks and lunch, there is a total of 7.2 hours of work per shift.

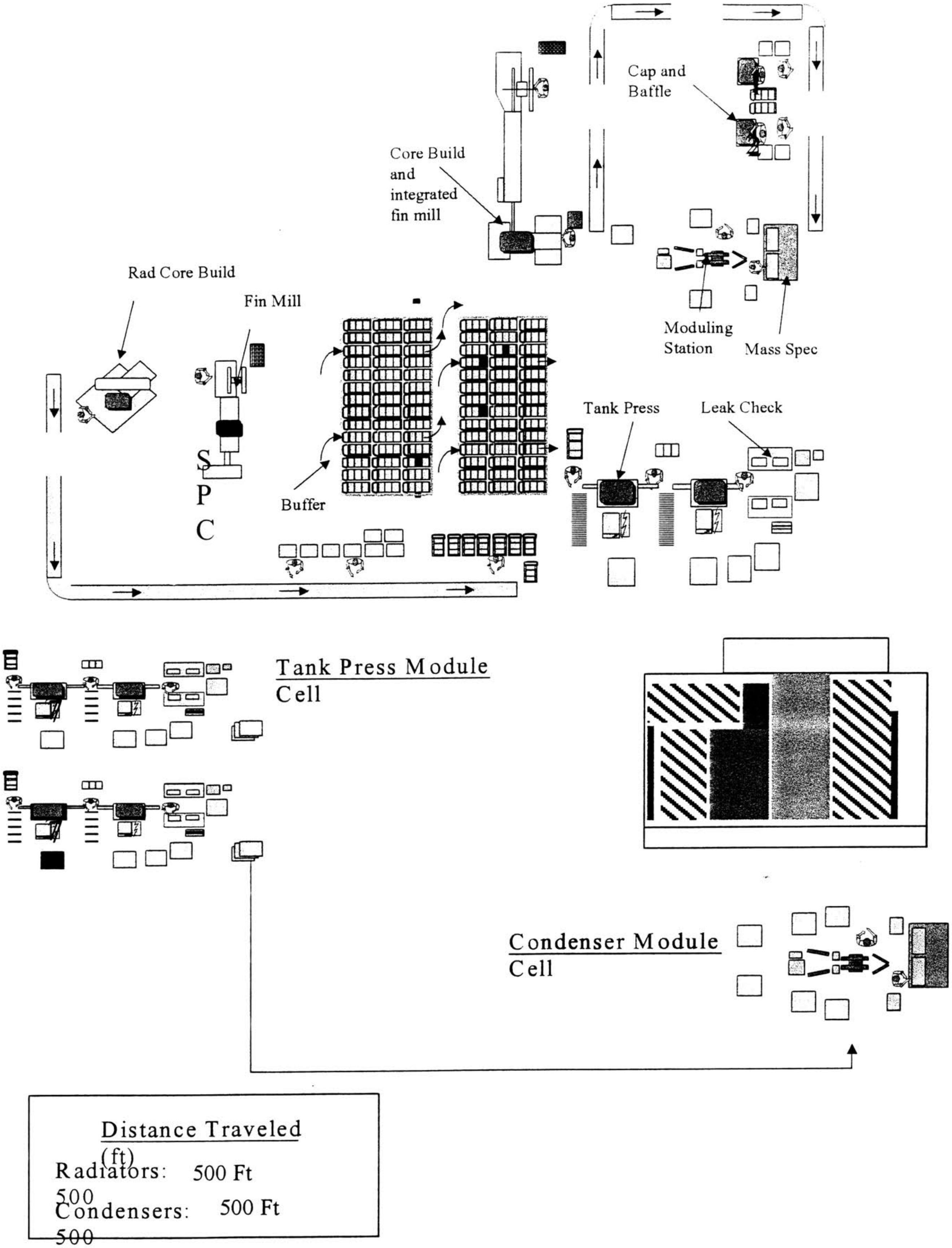


Figure 4-7: Schematic of the departmental layout of radiator and condenser area

4.2.1.2 Operations Management

4.2.1.2.1 Material Flow & Information Flow

The core processes for departmental layout begins with four schedules being sent to the two departments. One schedule is sent to the Radiator core build a second schedule is sent to the radiator tank press, a third schedule is sent to the condenser core build area and finally a fourth schedule is sent to the Condenser final assembly cells. The value stream map can be found in Figure 4-8.

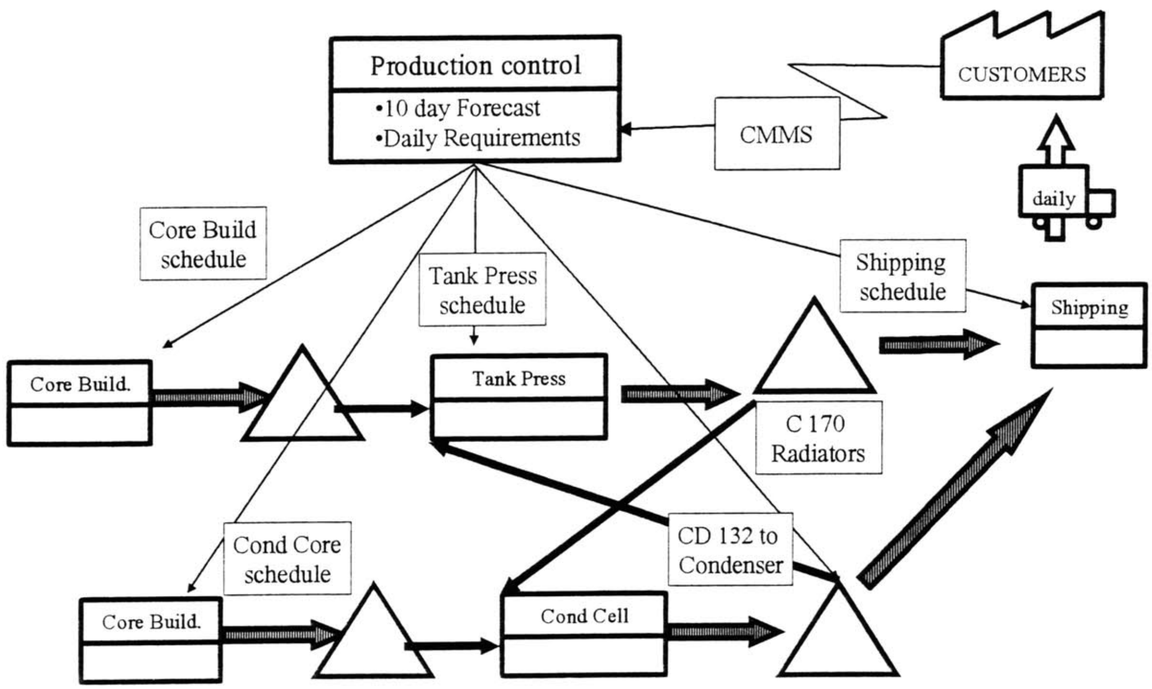


Figure 4-8: Value stream map of departmental area

4.2.1.2.1.1 Radiator

The radiator production process begins with the core build process producing to their schedule and sending product to the uncontrolled inventory held between the core build process and the tank press process. The tank press cell produces the final radiator and depending on whether the product is a CD 132 or C 170 the final product is either moduled with a condenser or transported to the Condenser department for moduling.

Prior to Vision 2001 and the implementation of the BESMART system all material replenishment was accomplished by utilizing an order sheet that forecasted at the beginning of the shift the usage for the entire shift. This system had several inefficacies that were improved upon through the implementation of the BESMART system (see Chapter 5).

4.2.1.2.1.2 Condenser

The condenser production process begins similarly with the core build process producing to their schedule and sending product to a smaller inventory area in respect to the radiator core inventory area. The core build cell performs the final quality check and depending on whether the product is CD 132 or C 170 the final product is either moduled with a radiator or transported to the Radiator department for moduling. Prior to BESMART all material replenishment was accomplished by utilizing an order sheet that forecasted at the beginning of the shift the usage for the entire shift. This system had several inefficacies that were improved upon through the implementation of the BESMART system (see Chapter 5).

4.2.2 Post Vision 2001 (2001)

4.2.2.1 Overview and Physical Layout

A schematic of the new cellular layout is shown in Figure 2-3. The left portion of the figure highlights the location of the new HC Condenser and Radiator moduling department on the Basildon area map. This new layout has reduced the need to transport product between the HC condenser department and the Radiator department, reducing forklift traffic through the facility (see Chapter 5).

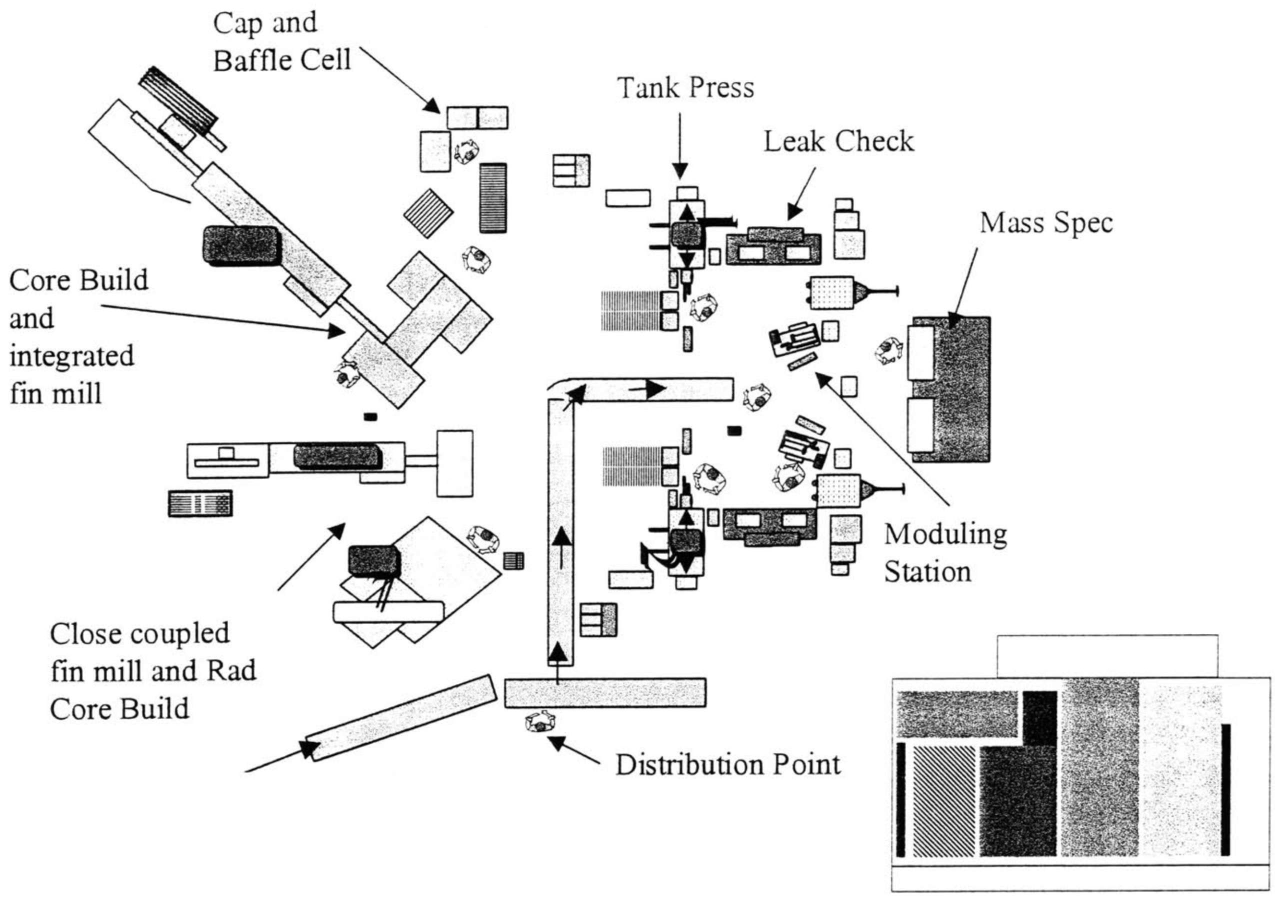


Figure 4-9: Layout of the green-end and hard-end capacity cells.

In general, the operating pattern for the Radiator and Condenser business unit is 3 shifts of 8 hours each. Excluding breaks and lunch, there is a total of 7.2 hours of work per shift. The Module production system works on a five-day week with the option to work on Saturday and Sunday.

4.2.2.2 Operations Management

4.2.2.2.1 Material Flow & Information Flow

The new system has reduced material and information flow in the system, by creating a more customer focused layout. The core processes for the new layout begins with three schedules being sent out to one department group. One schedule is sent to the Radiator core build a second schedule is sent to the condenser core build area, a third schedule is sent to the Radiator and Condenser module cell. The values stream map can be found in Figure 4-10.

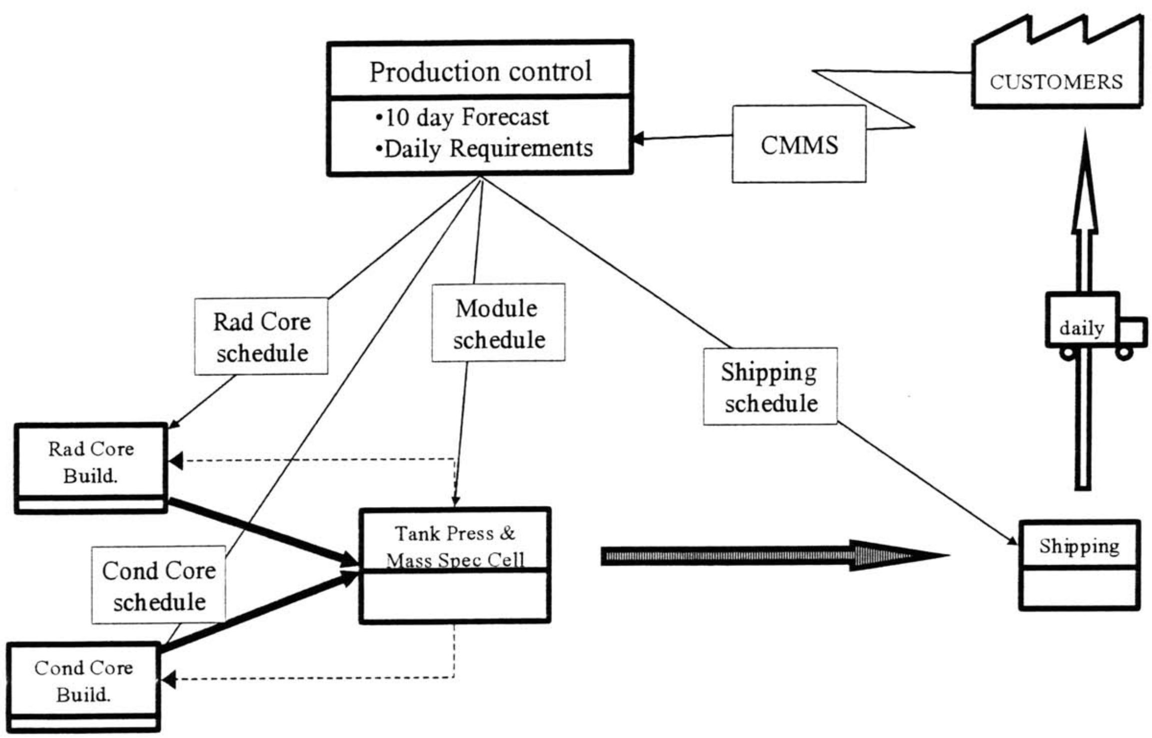


Figure 4-10: Present State Value stream map of Moduling process

4.2.2.2.1.1 Radiator

The radiator production begins with the core build process producing to their schedule and sending product to the tank press process located in the radiator and condenser module cell. The tank press process produces the final radiator, which is sequenced with a condenser to be moduled in the same cell. Prior to BESMART all material replenishment was accomplished by utilizing an order sheet that forecasted at the beginning of the shift the usage for the entire shift. This system had several inefficacies that were improved upon through the implementation of the BESMART system (see Chapter 5).

4.2.2.2.1.2 Condenser

The condenser production process begins with the core build process producing to their schedule and sending product to mass spec process located in the radiator and condenser module cell. The major difference with this process over the pre vision 2001 is the fact that the cap and baffle process is done prior to the core build. In the radiator and condenser module cell the condenser goes through the final quality check in the mass spectrometer after which the condenser is moduled with a sequenced condenser. Prior to BESMART all material replenishment was accomplished by utilizing an order sheet that forecasted at the beginning of the shift the usage for the entire shift. This system had several inefficacies that were improved upon through the implementation of the BESMART system (see Chapter 5).

4.2.3 Future State of Vision 2001 Project

Figure 4-11 captures the ideal future state map for the system. This system relies on maintaining a marketplace between final assembly and shipping that would trigger production throughout the line. This marketplace would rely on a Kanban system for replenishment. The build information between final assembly and core build would occur via the transfer of Braze clips, which will trigger the need to build new product.

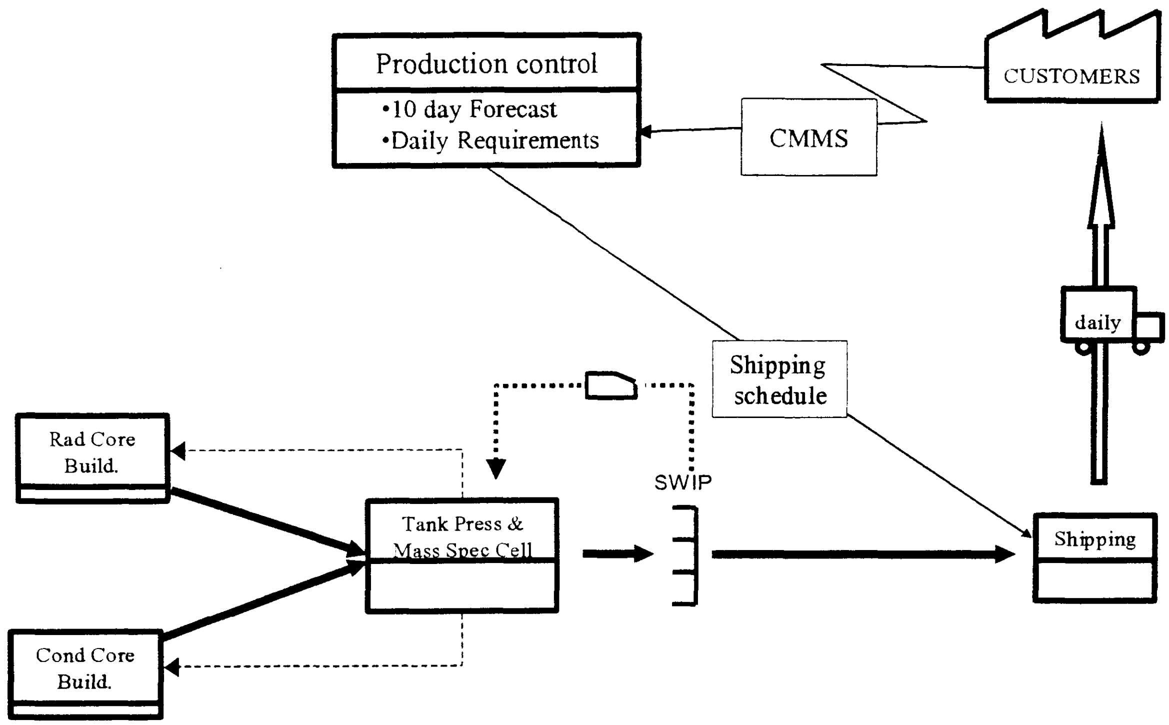


Figure 4-11: Future state Value stream map of Moduling Process

4.3 MSDD Evaluations of Moduling Process

4.3.1 Pre Vision 2001 (2000)

This evaluation was performed on the module value stream prior to Vision 2001. The evaluation of this area will highlight the overall system design aspects with respect to the MSDD.

4.3.1.1 General MSDD Evaluation

The overall evaluation of the Pre Vision value stream is shown in Figure: 4-12. The score of each FR-DP pair comes form the evaluation preformed by a member of the PSD lab very familiar with the Basildon plant operations. This allowed for a truly independent review. Among the 42 leaf-level FR-DP pairs, there are 5 very poor, 13 poor, 17 moderate, 7 good and zero very good scores. The overall evaluation result of module value stream is straddling the poor to medium poor region.

Pre Vision 2001 (2000)

	[illegible]	Poor	Moderate	Good	[illegible]
Quality	0	4	5	0	0
ID&R Prob	2	4	1	0	0
Pred Output	1	4	3	0	0
Delay Red	2	1	6	3	0
Labor	0	0	2	4	0
Total	5	13	17	7	0

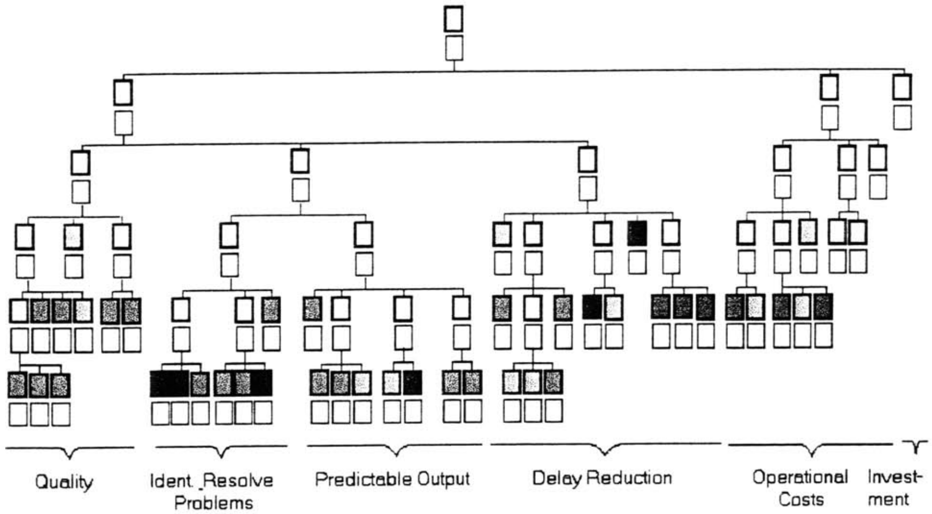


Figure 4-12: MSDD evaluation result of Pre Vision 2001 (2000)

Table 4-1 lists the top and bottom 5 pair performers of the evaluation. Each of the top five performers deals with the design of the work. This is a particular aspect stressed during the training originally attended by the engineers. Due to the training and seminars performed at the Basildon plant by Prof. David Cochran the engineers began to understand some of the issues caused by productions lines that were set up to minimize labor content without really examining the work. From these classes the engineers began to attack the work by designing effective cells. Identification of problems is extremely difficult in the old system as the delay as product flows from the core build to the tank press meant that quality issues could go undetected for up to 2 days. One of the poorest performers is the existence of a regular preventive maintenance program.

Top 5 FR-DP Performers

ID Num	FR	DP	Score
D23	Minimize wasted motion in operators' work tasks	Ergonomic interface between the worker, machine and fixture	4
D21	Minimize wasted motion of operators between stations	Configure machines / stations to reduce walking distance	4
D11	Reduce time operators spend on non-value added tasks at each station	Machines & stations designed to run autonomously	4
T53	Ensure that support activities people/automation) don't interfere with one another	Ensure coordination and separation of support work patterns	4
T52	Ensure that production activities don't interfere with one another	Ensure coordination and separation of production work patterns	4

Bottom 5 FR-DP Performers

ID Num	FR	DP	Score
T31	Provide knowledge of demanded product mix (part types and quantities)	Information flow from downstream customer	1.429
T4	Reduce transportation delay	Material flow oriented layout design	1.333
P132	Service equipment regularly	Regular preventative maintenance program	1.25
R111	Identify disruptions when they occur	Increased operator sampling rate of equipment status	1.2
R112	Identify disruptions where they occur	Simplified material flow paths	1

Table 4-1: Top and bottom pair performers of moduling area (2000)

4.3.1.2 Evaluation by MSDD Branch

4.3.1.2.1 Quality (FR-DP Qx)

The Basildon plant has implemented several Poke yoke devices that prevent them from sending bad quality product to the customer. However, the scrap rate within the system is disturbing. Process quality is reflected by the large inventories of scrapped radiators and condensers in the repair area. There are problems inherent in the system design and operation contributing to the defect rate at Basildon.

	FR	DP	Comments (Pre-Vision)
Q1	Operate processes within control limits	Elimination of assignable causes of variation	Standardized work methods have been developed and are effectively displayed; however workers do not effectively follow work methods and there is no method of enforcement.
Q2	Center process mean on the target	Process parameter adjustment	The processes are within tolerance; however there is no formalized root cause analysis available to ensure that error does not re occurs.
Q3	Reduce variation in process output	Reduction of process noise	Issues are not dealt with a soon as they occur they are noted and brought up in a VPS meeting at a later date. This hampers the ability to do a formal root cause analysis; the VPS meeting is not effective methods of presenting issues.

Quality		Poor	Moderate	Good	Very Good
	0	4	5	0	0

Figure 4-12: MSDD evaluation result of Pre Vision 2001 system (2000)

4.3.1.2.2 Identifying and Resolving Problems (FR-DP Rx)

Basildon overall performance in this area is poor. Identification and communication of production disruption is camouflaged by large buffers in inventory between processes. Fire fighting and lack of satisfactory support characterize the production problems. Due to the fact that parts can be in this large buffer for up to 2 days quality problems can go unrecognized for this extended period of time. This leads to large scrap rates and product being sent to the repair area.

	FR	DP	Comments (Pre-Vision)
R11	Rapidly recognize production disruptions	Configurations to enable detection of disruptions	The large buffer of up to 2000 radiators between the core build and tank press process does not allow for detection of quality issues
R12	Communicate problems to the right people	Specified communication paths and procedures	The plant has radio communication and IT paging systems. However the factory is missing visual systems such as an Andon board.
R13	Solve problems immediately	Standard method to identify and eliminate root cause.	There is no standard problem solving method. Problems are noted, a quick fix is implemented and the problem is brought up at weekly or bi weekly meetings at which point it is to late to do an effective root cause analysis.

ID & R		Poor	Moderate	Good	Very Good
	2	4	1	0	0

Figure 4-13: MSDD evaluation result of Pre Vision 2001 system (2000)

4.3.1.2.2.1 Predictable Output (FR-DP Px)

One of the major roots causes challenging the ability of the Basildon plant to maintain predictable output stems from the lack of preventative maintenance. Maintenance of equipment to ensure availability is characterized by a system that utilizes a fire fighting methodology. The system is not set up to allow for preventive maintenance as the plant runs three 8 hr shifts and often works on weekends not allowing any time for preventative maintenance. The system also runs on a forecast push system in the delivery of EP parts. A survey was carried out to determine the average amount per week of lost production time attributed to waiting for stock to be delivered to the point of fit on the shop floor (see the attached copy of the results). Across the plant the average Production time lost was 36.9 hours per week. The current process also required a manual stock check each shift and the filling out of 7 - 8 A4 stock sheets across the plant identifying the parts required and the expected delivery time of each part which then had to be taken to the Warehouse, this was considered to be a waste of the Supervisors time.

	FR	DP	Comments (Pre-Vision)
P11	Ensure availability of relevant production information	Capable and reliable information system	The information system in the plant relies primarily on planning and scheduling, which is never correct and requires constant adjustment. This takes up a majority of the supervisor's time in the facility.
P12	Ensure predictable worker output	Motivated workforce performing standardized work	The workforce is not very well educated on lean techniques and the need to transfer knowledge, participate in continuous improvement. There is a reward system in place for suggestions however there is still a high level of distrust between management and the union workers
P13	Ensure predictable equipment output	Maintenance if equipment reliability	There is no preventative maintenance program set up in the plant. Due to the shift structure of the plant 8 3hr shifts 6-7 days a week, Preventative maintenance programs would be difficult to set up.
P14	Ensure material availability even thought fallout exists	Standard material replenishment approach	The present system relies on a forecast system and due to machine unreliability forecasts are constantly revued, causing double handling, and an inability to keep track of inventory leading to stock outs.

Pred Output		Poor	Moderate	Good	Very Good
	1	4	3	0	0

Figure 4-14: MSDD evaluation result of Pre Vision 2001 system (2000)

4.3.1.2.2.2 Delay Reduction (FR-DP Tx)

The overall performance in the Delay Reduction category is poor. The departmental layout and machine design greatly contributes to the poor performance in the five types of delays. However, scheduling practice and long changeover times tend to drive the large run sizes in the master schedule. In addition these large runs sizes are intended to be balanced to production scheduling in assembly. The end result is a long throughput time and limited responsiveness to changes in customer demand.

	FR	DP	Comments		
T1	Reduce lot delay	Reduction of transfer batch size (single-piece flow)	Parts are being transported in big batches, lot delay is still a major part of total production delay.		
T2	Reduce process delay	Production designed for the takt time	Due to the knowledge gained by the engineers within the plant on lean techniques a very good first attempt has been made to balance hr mfg process to takt time		
T3	Reduce run size delay	Production of the desired mix and quantity during each demand interval	Some work has been done to reduce setup times of machines however there is still a false belief that long runs are better than short runs. Production schedule are not leveled.		
T4	Reduce transportation delay	Material flow oriented layout design	The layout of the system does not allow for short transportation distances and also creates large buffers and s disconnect between the corebuild and final assembly stations		
T5	Reduce systematic operational delays	Subsystem design to avoid production interruptions	The support activities doesn't interfere much for production activities. Operators' operations are not likely to interfere with each other. Standard support work patterns are not established yet.		
Delay Red.		Poor	Moderate	Good	
	2	1	6	3	0

Figure 4-15: M MSDD evaluation result of Pre Vision 2001 system (2000)

4.3.1.2.2.3 Labor (FR-DP Dx)

Each labor group is set up autonomous to the other. There is very little information transfer from the different stages of the operation. Due to the large buffers between the operations the work is not balanced with each operation receiving individual schedules. The relationship between direct labor and management can be tense with labor being very weary of new ideas from management and vice versa being weary of the giving any continuous improvement information.

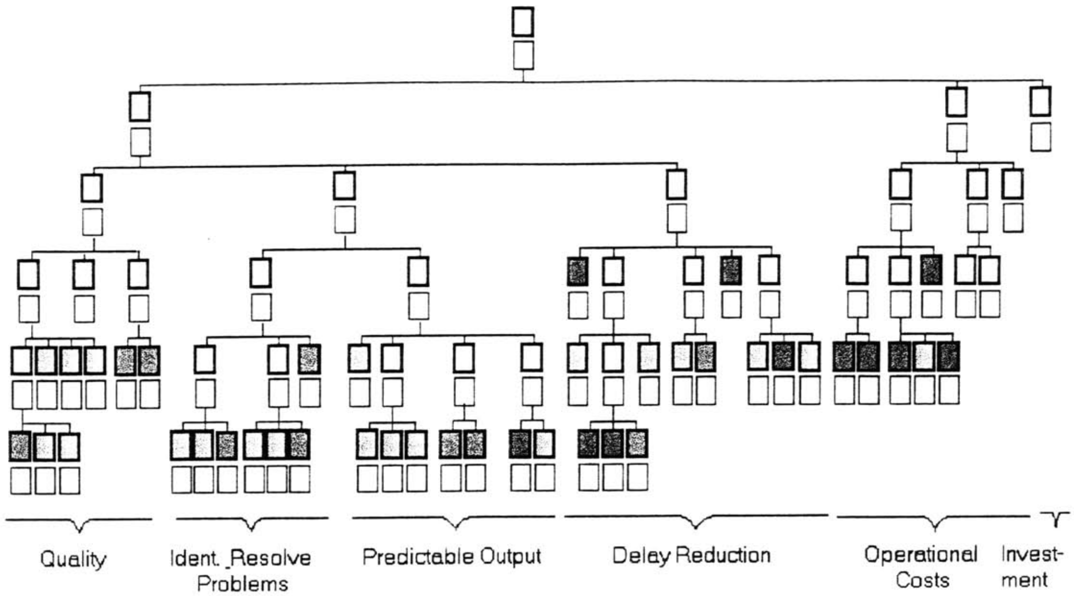
<table>
<tr><th></th><th>FR</th><th>DP</th><th colspan="3">Comments</th></tr>
<tr><td>D1</td><td>Eliminate operators' waiting on machines</td><td>Human-machine separation</td><td colspan="3">Most of the machines have a very short cycle times, the only machine that has issues with man machine separation is the fin mill.</td></tr>
<tr><td>D2</td><td>Eliminate wasted motion of operators</td><td>Design of workstations / workloops to facilitate operators tasks</td><td colspan="3">Originally the system was designed to maximize the machine operation uptime, however with lean training given to the engineers at the plant progress has been made to design better work loops</td></tr>
<tr><td>D3</td><td>Eliminate operators' waiting on other operators</td><td>Balanced workloops</td><td colspan="3">In almost all cases, operators work in isolation. Work content across operators and across departments is not well-balanced.</td></tr>
<tr><td rowspan="2">Labor</td><td></td><td>Poor</td><td>Moderate</td><td>Good</td><td></td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>4</td><td>0</td></tr>
</table>

Figure 4-16: MSDD evaluation result of Pre Vision 2001 system (2000)

4.3.2 Post Vision 2001 (2001)

4.3.2.1 General MSDD Evaluation

Figure 4- 17 shows the MSDD evaluation result of the post Vision 2001 manufacturing system. The score of each FR-DP pair comes form the evaluation preformed by a member of the PSD lab very familiar with the Basildon plant operations. This allowed for a truly independent review. Among the 42 leaf-level FR-DP pairs, there are 0 very poor, 6 poor, 19 moderate, 16 good and 1 very good scores. The overall evaluation result of module value stream is straddling the moderate to good region. On average this is a one-point shift in the plants performance.



		Poor	Moderate	Good	
Quality	0	2	7	0	0
ID&R Prob	0	3	4	0	0
Pred Output	0	1	5	2	0
Delay Red	0	0	3	8	1
Labor	0	0	0	6	0
Total	0	6	19	16	1

Figure 4-17: MSDD evaluation result of Post Vision 2001 system (2001)

Table 4-2 shows the top and bottom pair performers of the post vision 2001 evaluation. Among the best 5 pairs, all 5 relate to physical planning and design a highlighted strength of the Basildon plant. A simplified system design physically integrating all the process into a customer focused group's leads to much easier detection of where disruptions occur. One of the key improvements that can be seen in the rating of FR-D11 and FR-T221 was the introduction of the close-coupled fin mill and core build. This design was key in leveling production. We can summarize that the capacity cell area has taken into design consideration a number of FR-DP pairs from the Direct Labor branch. However, improvements can still be achieved in areas relating to preventative maintenance, root cause analysis and solving problems immediately to ensure predictable operation of the production cells.

Top 5 FR-DP Performers

ID Num	FR	DP	Score
D21	Minimize wasted motion of operators between stations	Configure machines / stations to reduce walking distance	4.125
D11	Reduce time operators spend on non-value added tasks at each station	Machines & stations designed to run autonomously	4.167
D3	Eliminate operators' waiting on other operators	Balanced work-loops	4.25
T221	Ensure that automatic cycle time <= minimum desired production pace (or takt time)	Design of appropriate automatic work content at each station	4.417
T52	Ensure that production activities don't interfere with one another	Ensure coordination and separation of production work patterns	4.5

Bottom 5 FR-DP Performers

ID Num	FR	DP	Score
P132	Service equipment regularly	Regular preventative maintenance program	1.5
Q32	Reduce impact of input noise on process output	Robust process design	2
Q31	Reduce noise in process inputs	Conversion of common causes into assignable causes	2.25
R13	Solve problems immediately	Standard method to identify and eliminate root cause	2.25
R113	Identify what the disruption is	Feedback of sub-system state	2.333

Table 4-2: Top and bottom pair performers of moduling area (2001)

Figure 4-18 shows the comparison of the evaluation results of the post Vision 2001 system (upper) and the pre Vision 2001 system (lower). Out of 42 FR-DP pairs, 16 of them are same or very close for both systems and the post Vision 2001 system is better in the other 26 pairs. The comparison shows clearly that the Post Vision evaluation result is much better than the pre Vision results. However, the fact that 16 pairs have not changed there is still a need for improvement.

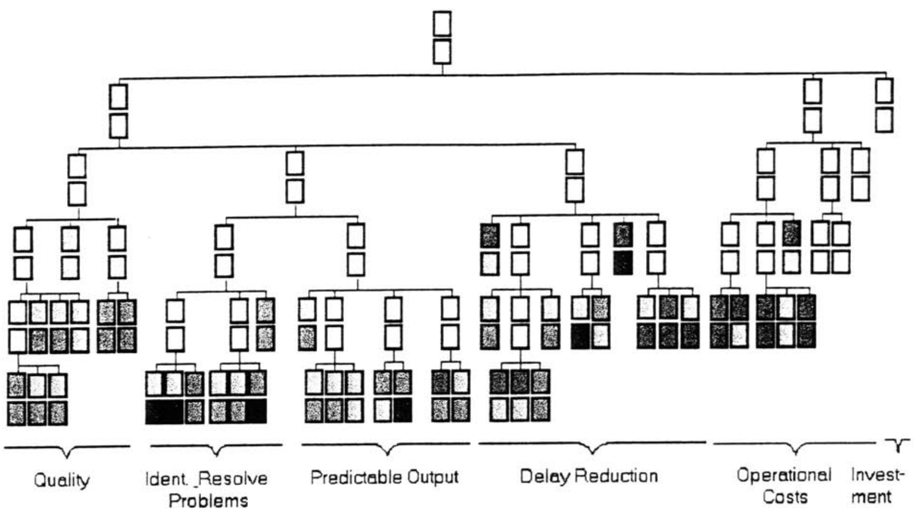


Figure 4-18: Comparison of two evaluation results

4.3.2.2 Evaluation by MSDD Branch

4.3.2.2.1.1 Quality (FR-DP Qx)

Quality was not one of the main targets of the Vision 2001 project, for this reason only a slight increase in quality was noted. This can be attributed primarily to the increase in knowledge of upstream/downstream processes of the operators. However, areas still exist for continuous improvement. Operators work in continuous loops that can vary from cycle-to-cycle and operator-to-operator. Best practices in work methods have not been captured and shared across the workforce. The plant needs to put in place and effectively utilize cause and effect tools and databases.

	FR	DP	Comments		
Q1	Operate processes within control limits	Elimination of assignable causes of variation	Through some initial training of the operators in the concepts of lean techniques and the fact that they are seeing the results of some of the initial initiatives the operators are more apt to following the standardized work methods laid out by the engineers		
Q2	Center process mean on target	Process parameter adjustment	The processes are within tolerance; however there is no formalized root cause analysis available to ensure that error does not re occurs.		
Q3	Reduce variation in process output	Reduction of noise	The Basildon plant has begun to attack issues when they occur instead of waiting for the VPS meeting at a later date. This is a first step in doing better root cause analysis; however a formal method is not laid out.		
Quality		Poor	Moderate	Good	
	0	2	7	0	0

Figure 4-19: MSDD evaluation result of Post Vision 2001 system (2001)

4.3.2.2.1.2 Identifying and Resolving Problems (FR-DP Rx)

This is an area that the Vision 2001 plan has greatly enhanced. The reduction throughput time from a couple of days to a couple of hours is one of the great improvements. The plant has identified that its ability to recognize and log problems when they occur is an issue. To this effect the VPS department has developed and is in the process of implementing a very simple IT device to track quality issues when they occur and to send a warning notice to all the people in the system when an error is noted X number of times. However, real-time communication of takt time and the cell's status is not evident through information devices (e.g. – andon boards, alarms) or through process design (e.g. – accumulating empty containers). Communication and resolution of problems has had marginal-to-no improvements primarily in maintenance.

<table>
<tr><th></th><th>FR</th><th>DP</th><th colspan="3">Comments</th></tr>
<tr><td>R11</td><td>Rapidly recognize production disruptions</td><td>Configuration to enable detection of disruptions</td><td colspan="3">removal of the large buffer between the core build a switch to one piece flow from final assembly has enabled quicker and unavoidable detection of production disruptions through equipment/process failure. However, operators cannot easily and accurately determine, on a frequent basis, whether they are ahead or behind production schedule.</td></tr>
<tr><td>R12</td><td>Communicate problems to the right people</td><td>Specified communication paths and procedures</td><td colspan="3">The plant has radio communication and IT paging systems. Response times to these communication methods are still however considered slow. The factory is missing visual systems such as an Andon board.</td></tr>
<tr><td>R13</td><td>Solve problems immediately</td><td>Standard method to identify and eliminate root cause.</td><td colspan="3">There is no standard problem solving method available in the plant. Problems are noted, a quick fix is implemented and the problem is brought up at weekly or bi weekly meetings at which point it is to late to do an effective root cause analysis. Due to the more customer focused indirect labor units set up as well as the direct labor units it is easier to assign responsibility leading to slight improvements in solving problems.</td></tr>
<tr><td>ID&R</td><td></td><td>Poor</td><td>Moderate</td><td>Good</td><td></td></tr>
<tr><td>Probe</td><td>0</td><td>3</td><td>4</td><td>0</td><td>0</td></tr>
</table>

Figure 4-10: MSDD evaluation result of Post Vision 2001 system (2001)

4.3.2.2.1.3 Predictable Output (FR-DP Px)

The primary factor that has aided in improving predictable output is the BESMART system due to its effect on the material supply program that ensures material availability. There are still some steps that need to be implemented to extended the benefits of the BESMART system across the entire supply chain. Within the operation communication has improved due to the close proximity of all the different process. There has also been an improvement in communication between management / engineering and the shop floor as the customer focused production groups have been extended to encompass engineering and management. However, production disruptions do still occur, the major causes of which arise from support functions external to the area including a weak preventive maintenance program execution to ensure high equipment availability.

	FR	DP	Comments
P11	Ensure availability of relevant production information	Capable and reliable information system	With the new BESMART pull system the information system has become much simpler and much more reliable, This system has freed up a significant portion of the supervisors time allowing them to spend more time on continuous improvement and root cause analysis. The facility could still use a andon board to ensure that everyone is in tune with all nessesary information.
P12	Ensure predictable worker output	Motivated workforce performing standardized work	The direct labor workforce has become more educated on lean techniques and the need to transfer knowledge, participate in continuous improvement. One of the key ways that the workforce was motivated to participate in standardized work was through the building of life size demos of the new cell layouts so that their input could be incorporated into the new design inspiring a sense of ownership.
P13	Ensure predictable equipment output	Maintenance of equipment reliability	There is no preventative maintenance program set up in the plant. Due to the shift structure of the plant 8 3hr shifts 6-7 days a week, Preventative maintenance programs would be difficult to set up. This is the next major target of improvement for the facility
P14	Ensure material availability even though fallout exists	Standard material replenishment approach	With the new BESMART pull system the material replenishment system is not affected by machine breakdown as severely. This system has freed up a significant portion of the supervisors time allowing them to spend more time on continuous improvement and root cause analysis.

Pred. Output		Poor	Moderate	Good	
	0	1	5	2	0

Figure 4-21: MSDD evaluation result of Post Vision 2001 system (2001)

4.3.2.2.1.4 Delay Reduction (FR-DP Tx)

Overall, performance in the Delay Reduction branch has increased from poor to a moderate-to-good condition. Layout design, and human-machine separation have enabled psudo single-piece flow within the cells. As a result, improvements in throughput time and reduction in lot, process, and run size delays have been achieved. However, a pull system is suppose to exist between final assembly and the core build, via the braze clips being returned. However, discipline issues and a lack of trust in the robustness of the pull system by operators and supervisors has made this system ineffective. Once this occurs only one schedule to final assembly would need to be made for the entire process.

<table>
<tr><th></th><th>FR</th><th>DP</th><th colspan="3">Comments</th></tr>
<tr><td>T1</td><td>Reduce lot delay</td><td>Reduction of transfer batch size (single-piece flow)</td><td colspan="3">Within the system between corebuild and final assembly single piece flow has been implemented however, the supply of raw materials particularly to the core build stage is still done in large containers due to the long runs of the down stream process. Change over times need to be aggressively attacked to reduce these numbers. A effective KANBAN system needs to be implemented for these parts as well to aid in reducing the batch sizes.</td></tr>
<tr><td>T2</td><td>Reduce process delay</td><td>Production designed for the takt time</td><td colspan="3">Due to the knowledge gained by the engineers within the plant on lean techniques a very good first attempt has been made to balance the mfg process to takt time, hence within the cells, production is generally balanced to takt time. However, customer-supplier relations are not clear nor directly linked throughout the value stream.</td></tr>
<tr><td>T3</td><td>Reduce run size delay</td><td>Production of the desired mix and quantity during each demand interval</td><td colspan="3">Production schedule are now leveled in the entire system.</td></tr>
<tr><td>T4</td><td>Reduce transportation delay</td><td>Material flow oriented layout design</td><td colspan="3">The layout of the system allows for minimal transportation distances and has reduced the buffers between the process 16 times with the final assembly pacing the rest of the system.</td></tr>
<tr><td>T5</td><td>Reduce systematic operational delays</td><td>Subsystem design to avoid production interruptions</td><td colspan="3">The support activities doesn't interfere much for production activities. Operators' operations are not likely to interfere with each other. Standard support work patterns are not established yet.</td></tr>
<tr><td rowspan="2">Delay Red.</td><td></td><td>Poor</td><td>Moderate</td><td>Good</td><td></td></tr>
<tr><td>0</td><td>0</td><td>3</td><td>8</td><td>1</td></tr>
</table>

Figure 4-22: MSDD evaluation result of Post Vision 2001 system (2001)

4.3.2.2.1.5 Labor (FR-DP Dx)

There has been quite an improvement in labor knowledge of the concepts of "lean" and the benefits. Over the last 2 years the Basildon plant has made several improvements that the operators have seen the benefits of and are hence more open to new things. The Vision 2001 system has also aided in balancing the work loops and improving communication between the operators at different stages of production due to their close proximity.

	FR	DP	Comments		
D1	Eliminate operators' waiting on machines	Human-machine separation	Most all operators run 2 machines. There Basildon plant did a very good job of balancing each process to run at takt time within the operators work loop.		
D2	Eliminate wasted motion of operators	Design of workstations / workloops to facilitate operators tasks	The workloops and narrow equipment design reduces walking distance. Ergonomics in transporting the heavy gears between stations have improved with the use of gravity rails. There is limited success in implementing standardized locations of work tools.		
D3	Eliminate operators' waiting on other operators	Balanced workloops	Workloops within the cells are somewhat balanced. In some cases, an operator can work ahead of the other operators for a limited time.		
Labor	[illegible]	Poor	Moderate	Good	Very Good
	0	0	0	6	0

Figure 4-23: MSDD evaluation result of Post Vision 2001 system (2001)

4.4 Measurables and the Achievement of the MSDD

4.4.1 Motivation

In a conventional manufacturing environment performance measures have been used to evaluate the overall performance of manufacturing systems. These measurables primarily focused on aspects such as inventory, capital investment, floor area, and direct labor. The MSDD has taken a systemic perspective into manufacturing system design and evaluation. The MSDD provides that a well-designed manufacturing system should achieve high performance in both quantifiable and non-quantifiable measures. In terms of quantifiable measures, a system design solution that satisfies the requirements of the

MSDD should be highly consistent with and ensure the satisfaction of the assessed performance measures. Traditionally the non-quantifiable measures have been ignored due to the effort required to gauge them accurately. The MSDD attempts to successfully gauge these non-quantifiable measures in a systematic manner.

The following sections intends to prove the hypothesis of the designers of the MSDD that the manufacturing system that performs better on the FRs stated by the MSDD will also have superior measurable performance.

4.4.2 Analysis Method

In order to use the MSDD to compare different quantifiable performance of manufacturing systems, the FRs that most directly impact a given set of measurables have been identified. Table 4-3 lists ten major general manufacturing measurables and their corresponding FRs. As indicated by boldface, a number of FRs have been rolled-up to an appropriate parent level FR. Moreover, an asterix indicates FRs not evaluated in the MSDD Evaluation Tool v5.3.

General Mfg. Measurable	***FRs***	***Number of leaf-level FRs***
Floor Area	T4, D21, 123*	2
In-cell inventory	**P13**, T1, **T3, T5**	8
WIP	**P14**, T1, **T2**, T4	9
Throughput time	**113**	12
Direct labor	**121**	6
Indirect labor	**R1**, P11, P123, **P13**, **P14**, T51, T53, **122***	15
Good parts/labor hour	**111, 112, 113**	36
Internal Scrap	**111, 112, 113**	36
# of product models	T223, **T3**, D22, 13*	4
Capital Investment	123*, 13*	--
Bold indicates an MSDD branch containing leaf FRs evaluated herein * indicates FRs not used in the MSDD Evaluation Tool		

Table 4-3: Measurables and FRs for design comparison

In order to provide a comparative baseline, the data has been volume adjusted. For conciseness of presentation, the data has been also been normalized and formatted as shown below [Won et al, 2001].

4.4.3 Evaluation and Comparison of Pre Vision 2001 (2000) and Post Vision 2001 (2001)

The data in Table 4-4 compares the data collected on the Pre Vision 2001 (2000) and Post Vision 2001 (2001).

Operational Measures	***Performance***		***Satisfied Leaf FRs***	
	Pre Vision (2000)	***Post Vision (2001)***	***Pre Vision (2000)***	***Post Vision (2001)***
Floor Area	1	0.91	1 of 2	2 of 2
In-cell inventory	1	1	5 of 9	8 of 9
WIP between core build and final assembly	1	0.06	2 of 9	8 of 9
Throughput Time	1	0.03	5 of 12	11 of 12
Capital Investment	1	1.07	2 of 2	2 of 2
Direct Workers	1	0.93	6 of 6	6 of 6
Indirect Workers	1	0.95	4 of 15	6 of 15
Good Parts / labour - hour (w/o overtime)	1	0.93	9 of 36	20 of 36
# of Products	1	1	1 of 4	3 of 4

Table 4- 4: Machining performance of measurables and FRs.

In all cases except for capital investment the Post Vision 2001 system exhibits superior measurable and MSDD performance. Of particular note is the WIP and the Throughput time of the Post Vision 2001 system. This was key as one of the major proposed improvements of the system was in improving flexibility and reducing scrap through quick problem ID, Delay reduction and increasing predictable output.

Chapter 5: VISTEON BASILDON BESMART PROJECT

5.1 Overview

Material supply supports the manufacturing system by interacting with the three major elements of any manufacturing system design: people, equipment/material, and information. In addition, material supply interacts with manufacturing systems on two levels: externally and internally. The first layer, external, describes the exchanges that result in material transfer from external suppliers into initial contact with the requesting source. The second layer, internal, focuses upon the interactions that result in the completion of material delivery to the requesting source. Within the framework of the MSDD, effective material replenishment strategies are characterized by designs that successfully integrate all five elements into a stable manufacturing system design.

The objective of this case example is to highlight an effective material supply design and operation. As such, twenty-three FRs within the MSDD have been identified to material replenishment functions (Figure 5-1). For this case example, six FRs and their DPs have been selected to highlight these dependencies as reflected in the MSDD.

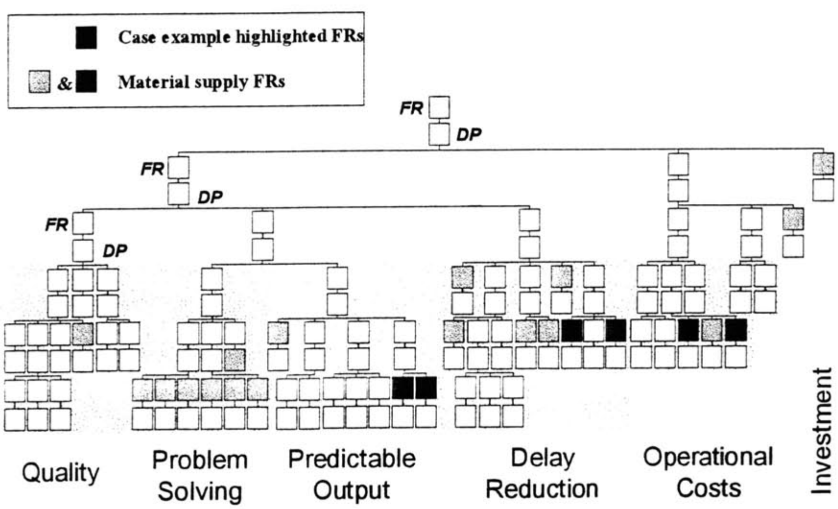


Figure 5-1: FRs that affects Material Supply Design and Operation

The goals of the Basildon England Simultaneous Material Replenishment Trigger (BESMART) project were to develop a pull system for the externally purchased parts (EP parts) to be delivered to the line side operators from a designated marketplace. Included within this project is the incorporation of EP parts suppliers into an efficient pull system to replace the stock removed from the market place, hence reducing the inventory on hand at the plants. This system would work hand in hand with the new pull system being developed for the line side operator. For this project we develop a system that would work with the existing systems in the plant and would be applicable to all areas of the plant. The system is based around one of the major high volume products, radiators and it's respective EP parts. Once a system has been created for radiators, it can then be rolled out for all the other products manufactured in the plant.

5.2 Understanding The Problem

The first step of the project was to understand the problem. In order to accomplish this we took guided and unguided tours of the plant to understand the production system of the radiators, condensers and condensers. To familiarize ourselves with the Visteon Production System model we reviewed several documents detailing the system. Several meetings were held with other VPS team members, Material Handling and Logistics (MP&L) group members and including the plant manager and engineering manager in order to capture their vision of the plant of the future and how the project can align with their needs. To get supplier input we had several meetings with one of the plant's major suppliers located in Birmingham, England. At these meetings we discussed ways in which communication between supplier and customer could be improved so as to increase just in time delivery. Finally we visited the Bridgend Ford plant in Bridgend Wales, as an example of a plant utilizing the smart card/call system envisioned for Basildon plant. From all our meetings we were able to formulate several solutions to the stated problem.

The design of the system was broken into two parts. The first was the development of the line side replenishment pull system for EP parts. The second was the development of pull system for the supplier of EP parts.

5.3 Existing Systems

The existing line-side replenishment system required a shift Supervisor to visit each line-side stations at the beginning of a shift. The Supervisor would review the stock levels, determines minimum & maximum components per rack and physically count the number of parts used at each station. Using this information, the supervisor then makes a judgment on the parts that will be required in order to complete the shift target on component production. This information is recorded on a stock sheet, which is broken into 8 columns, one for each hour of the shift. The parts to be delivered are recorded in each column on an hourly bases. This stock sheet is then sent to the warehouse where the picker is responsible for delivering the parts to the rollers located in the hole in the wall * at which time a forklift driver will deliver it to the appropriate line side station.

The above method of stock delivery falls short of the principles and methods of the developed under the Toyota Production System, due to the lack of flexibility once the EP parts delivery schedule to the shop floor has been made. The system is highly dependant on the shift supervisors and his judgment on what will be required, hence this introduces a large amount of human error. The major problems of this system are that the plant often ends up with too much stock or too little stock on the line side. This system also relies on the shift supervisor physically going up into the warehouse on the occasion that a rush order or build change is required, a regular occurrence. The major benefits of introducing a better system are that it would release the shift supervisor to take on other duties and decrease the amount of inventory on the shop floor, which would allow for the input of new business into the plant, by increasing space on the shop floor.

* The hole in the wall is the 8 ft elevation between the warehouse and the production floor.

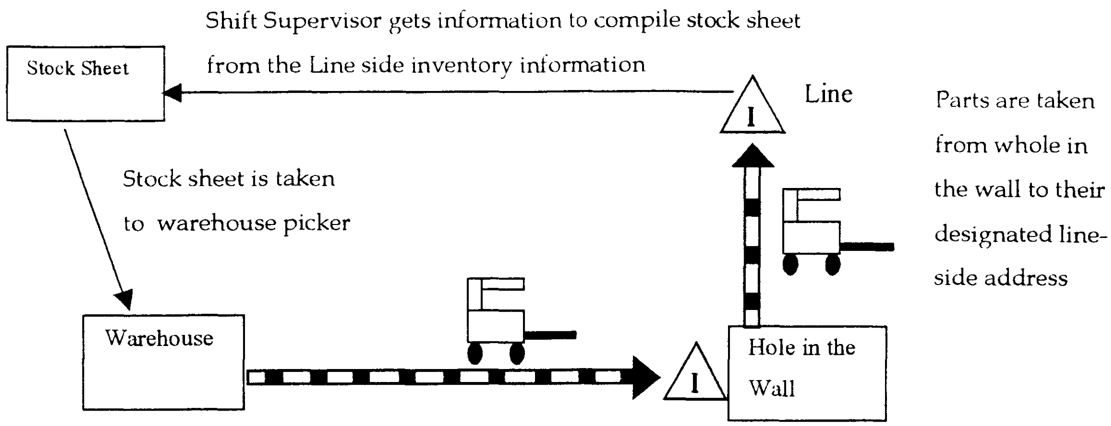


Figure 5-2: Schematic of existing EP parts ordering system

5.1.1.1.1.1 Flow chart of existing line- side replenishment

The existing supplier replenishment system for EP parts starts with the customer requirements being sent via CMMS to our suppliers as well as to the plant**. This information is used to develop the production schedules in the daily production meetings. The information from these meetings is given to an individual in MP&L responsible for ordering stock χ. This individual then combines this information from that gathered from the warehouse on stock levels*** to manually calculate the requirements of the plant. This information is sent to the supplier and that is the quantity of product shipped to the plant. The supplier then ships the product within 24 hours. In the case of supplier located outside England, weekly supplies are shipped by sea and stored at satellite storage facility managed by a logistics company. The daily requirements are sent to these companies and those are the volumes shipped daily. Below is a flow diagram of the existing process.

** Note not all suppliers are on CMMS. Hence they receive faxes from the Basildon plant about our requirements

χ Primary contact in this area is Chris Davies

*** This information is gathered every 3 days.

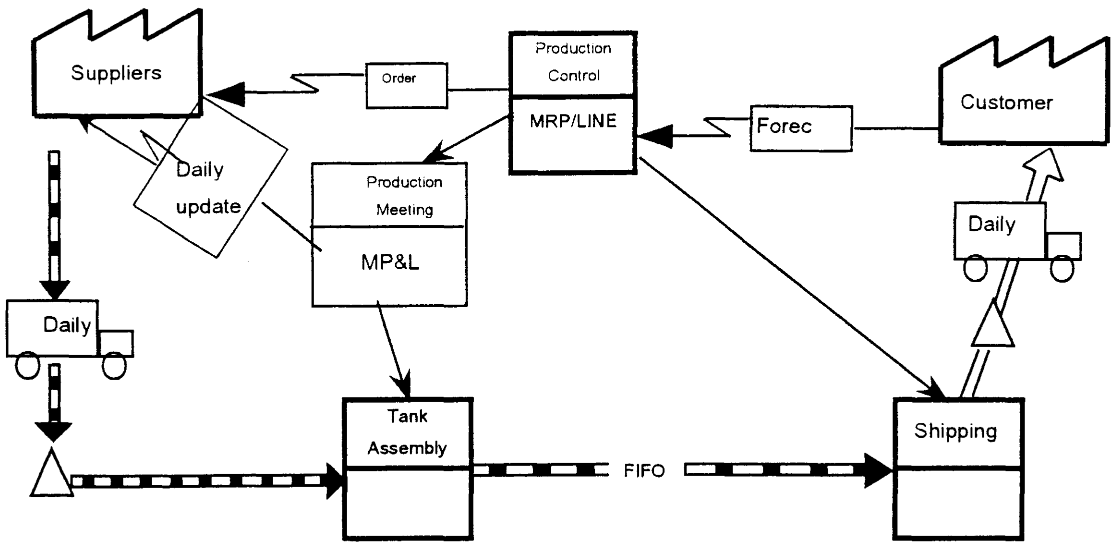


Figure 5-3: Value Stream of Existing Supplier Replenishment System

The warehouse is not set up in a market place fashion at this time. The warehouse is presently divided into 3 sections a receiving pitch, fast moving area and slow moving area with racking. The pitch is presently too large, this encourages the practice of leaving stock in the pitch for an extended period of time. The fast moving area organization can be made more effective. Each row has a list of parts to be stored there. However, within the row pallets are stacked wherever space is available. The slow moving section is the only labeled section of the warehouse. This section has laminated signs on the racks that show what is stored in those particular racks and where they are located. Observing this system we have found it inadequate as the picker wastes an immense amount of time on unnecessary tasks. Below you will find a flow diagram that shows the process that the picker uses to locate a requested part.

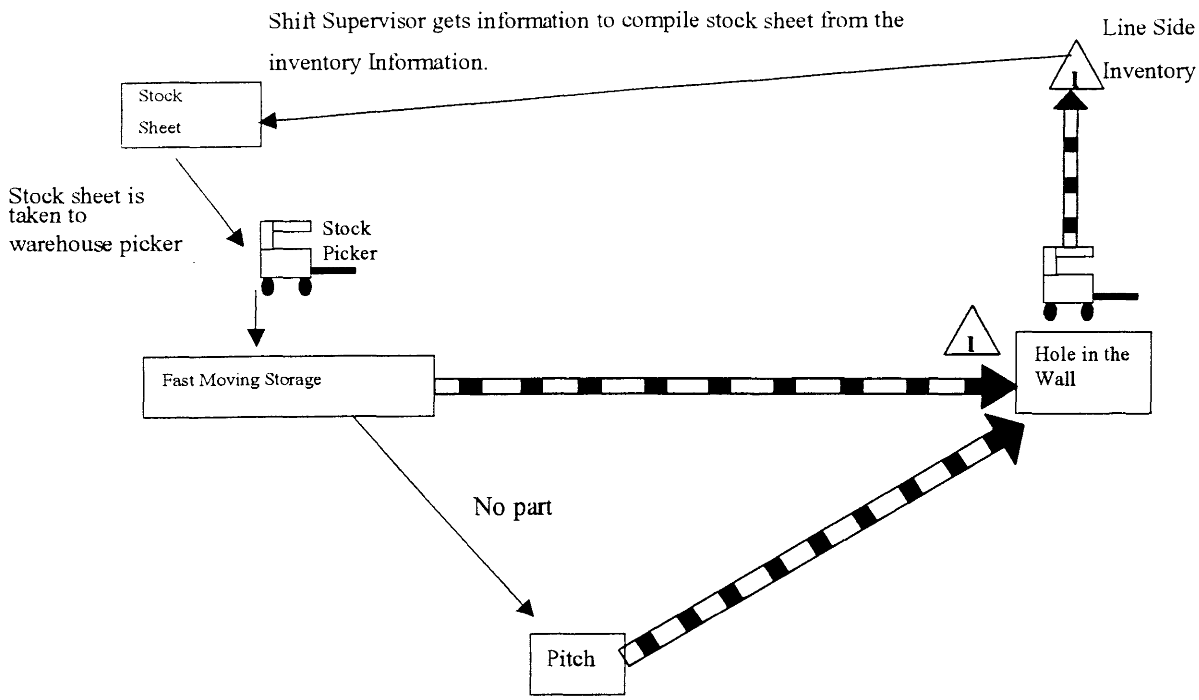


Figure 5-4: Part Retrieval process for Fast Moving Parts

This system has several inadequacies, the most obvious being the time wastage as the picker walks around the fast-moving and pitch areas looking for a part. There is also time wasted by the individual taking stock levels.

5.4 Proposed Solutions- Line-side Replenishment System

The system that we envisioned and has been implemented revolves around the utilization of the existing PC terminals at each individual buyoff station in the plant. A software program has been designed that would run simultaneously with CMMS3 at each buy off stations. This program will be password accessible by the operator of the buy off station. The program will allow the operator to select the radiator that he/she is building. This will in turn display a list of all the EP parts that are used in manufacturing that radiator. This screen will allow the operator to order by number of parts or pallets that he/she will require. The operator will also have the option to order the parts urgently if need be. The operator will have the option to invoke another screen that gives him/her a status report on all pending orders. The operator will also have the capabilities to cancel an order utilizing the same screen that allows him/her to check on the status of the order. At his/her terminal there shall be functionality for the use of the group leader to return stock to the marketplace via a third screen.

At the market place there is a single terminal situated at a convenient height for the picker (forklift driver in warehouse). This terminal has its own system, which will display a list of pending requests and their status (Normal or Urgent). The picker will select items to be picked and this will automatically print a docket for each item. On return from the stacks the operator will enter an Acceptance signal or OOS signal against each item. At this stage this acceptance will be done manually using a mouse and clicking on the appropriate button, however it is envisioned that bar codes could play a significant and useful role in this operation.

In the event that nil stock is found in the market place a signal shall be sent to the operator on the line-side as well as to the MP&L office. This shall trigger them to send an urgent request for product to the supplier. It is envisioned that this process could be automated by sending an email or fax to the supplier that will alert them that we are out of stock and to send the amount of stock required to replenish the market place.
The MP&L office has the capabilities to view a pop up dialog display with a list of requests/orders. The list will have user configurable parameters for date range, station ID, request status etc. Tables of radiators and associated parts will be maintained from the CMMS database. These options will be password controlled.
A development company called Wychtree Technologies was contracted to develop the BESMART software. There quote for the BESMART system is £8,500 plus VAT . As a team we believe this to be a very reasonable cost and are quite confident that Wychtree Technologies will be able to deliver on their proposal. This primarily stems from the work that the company did with the Visteon Swansea plant in which they were extremely satisfied with.

By implementing the BESMART system we believe that inventory on the shop floor can be reduced by up to 50%. This translates into an approximate cost of £ 2,090,000 per annum in inventory costs. This also translates into 50 square feet of space in the tank press area, which could be used for an additional 2 tank presses increasing the number of tank presses by 10%. A 12.5% gain in shop floor supervisor productivity would also be gained.

5.5 Proposed Solutions- Supplier Electronic Replenishment Trigger

The Supplier Electronic Replenishment Trigger (SERT) revolves around the use of a marketplace. This marketplace will be housed in the existing warehouse and will comprise of a mapped out area with designated positions for all our high volume, medium volume and low volume parts. Each part will have a Min/Max level that will be set up using the daily requirement of the plant. The max level that has been agreed on is a 1.5 day supply .Our suppliers would only need to receive information about product flow out of the market place, as it will be their responsibility to replenish what is taken out, hence keeping the marketplace at a constant volume.

The first step in defining a solution for the Supplier Electronic Replenishment Trigger (SERT) was to brainstorm solutions. From this process we developed 10 different solutions. In order to analyze all the solutions we developed a weighted scoring model. In preparing the weighted scoring model we received input on the weights of each criteria from the plant manager, MP&L manager, Senior VPS engineer, Visteon Lean mfg coach, twoVPS team member. Compiling all the input from these individuals a model was developed. The criteria/weights that were used upon rating the solutions are as follows.

Criteria	Weights (%)
Flexible solution that can be applied plant/company wide	15
Implementation cost	5
User friendly	10
Payback	20
Installation time of new system	2.5
Compatibility with supplier system	5
Compatibility with plant system	10
Robustness of system	15
Product replenishment rate/Marketplace size	12.5
Upgradeable	5

Table 5-1: Part Retrieval process for Fast Moving Parts

The solutions that were in the top five percent based on the prior weighted scoring model are below in descending order: -

Solution 1 - Web Based Ordering System

This system will compile a database of all calls that arrive into the marketplace that will be set up once the BESMART system is introduced into the plant. This database will be accessible to our external suppliers via an extranet site. It is then the responsibility of the external supplier to ship the amount of material used during the time elapsed since their last shipment. The market place will hold anywhere from 1-2 days of supply allowing for any variation in production to occur. Special circumstances will need to be put in place for the low usage parts. For these low usage parts once a call has been place to the marketplace an email will be sent to the supplier informing them that an order has been requested and that they should check the web site. The email will contain a direct link to the site where their order is stored. All shipments for replenishment will be made within 24 hrs. There will be a minimum shipment level that will be established within the system that will ensure that shipment costs are not wasted shipping insignificant volumes. Necessary security measures will be put in place to protect the system and Visteon.

Solution 2 - Fax Based Ordering System-Automatic

The product that is called from the market place is stored in a database similar to solution 1 above. This data is then retrieved from a database and automatically faxed to the supplier as an order sheet. The supplier then ships the product following the same procedure stated in solution 1.

Solution 3 - Email Based Ordering System-Automatic

The product that is called from the market place is stored in a database similar to solution 1 above. This data is then retrieved from a database and automatically email to the supplier as an order sheet. The supplier then ships the product following the same procedure stated in solution 1.

The other solutions that were brainstormed were: -

Solution 4 - Card Based Ordering System

This system uses the smart card system to replenish the stock in the market place. The supplier places a card on a pallet. This card is then placed in a card box as the forklift driver delivers the pallet to the line. The cards are then collected and sent back to their respective suppliers who in turn ship the product out based on the cards received.

Solution 5 - Email Based Ordering System-Manual

The product that is called from the market place is stored in a database similar to solution 1 prior. This data is then retrieved manually and is broken down into its respective suppliers list and emailed to the suppliers by an individual in MP&L.

Solution 6 - Fax Based ordering system - Manual

This system is very similar to that of solution 4, except the orders are faxed instead of sent via email.

Solution 7 - **Pallet based system**

Each pallet is designated for a particular product/supplier as the product on that pallet is used the pallet is returned to the supplier to be filled up and sent back. The pallet becomes the trigger for replenishment.

Solution 8 - **Operator Based Ordering System - Barcode reader - Web**

As an operator scans the finished radiator at the buy off stations, a system keeps a database of the product used and this database can be used to generate an ordering pull system using solution 1 prior.

Solution 9 - **Operator Based Ordering System - Barcode reader - Email automatic**

As an operator scans the finished radiator at the buy off stations, a system keeps a database of the product used and this database can be used to generate an ordering pull system using solution 3 prior.

Solution 10 - **Operator Based Ordering System - Barcode reader - Email manual**

As an operator scans the finished radiator at the buy off stations, a system keeps a database of the product used and this database can be used to generate an ordering pull system using solution 4 prior.

The system that we are most in favor of at this time is the Web based system. Presently the Ford Bridgend plant has a similar system up and running with two of their suppliers, the Visteon Swansea plant and the Visteon Belfast Plant. However, these suppliers are both part of Visteon and hence have access to the Ford Intranet. Our site would need to be an extranet site to cater to the majority of our suppliers that do not have access to Visteon Intranet.

We propose creating a web page that will have Read Only access for our external parts suppliers to interrogate the database that will hold the calls from the marketplace. The web page will have the following screens.

Login Screen: This screen will allow the supplier to log into the web page and change their password

Parts Usage Identification Screen: This page will give read only access to the part numbers associated with the user ID entered.

Online Part Usage Display Screen: This screen will display parts and usage defined in the Parts Usage Identification Screen.

The following paragraphs outline the essential features of each proposed operation.

Login Page:

Login:

Invoke by mouse click on a screen button LOGIN.

Popup dialog prompts for username and password.

On hitting OK a second screen will be displayed, which will be the **Part Usage Identification Screen**.

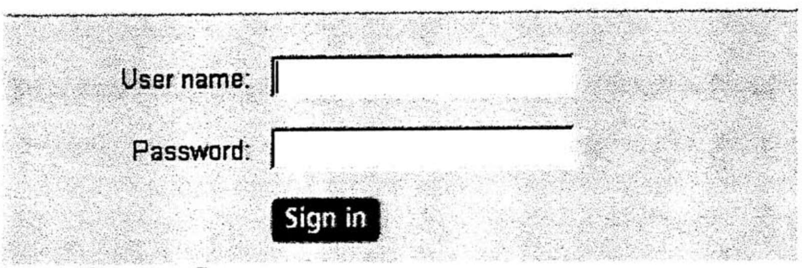


Figure 5-5: Example of Log in screen

Change Password:

Invoke by mouse click on a screen button CHANGE PASSWORD.

Popup dialog prompts for username and password

On hitting OK a second popup dialog screen is displayed which requests the user to enter current password and a new password of 5-8 characters.

Help:

Invoke popup dialog by mouse click on a screen button HELP.

Popup dialog displays information about the Application Screen.

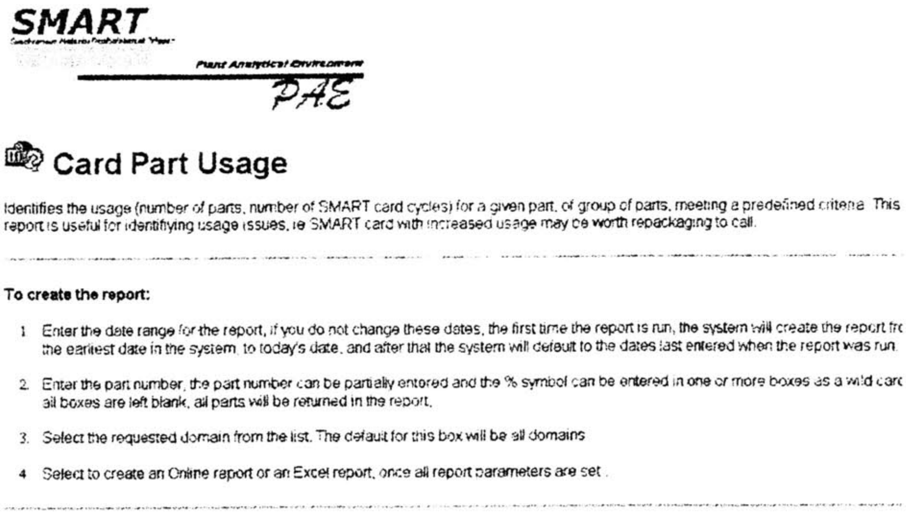


Figure 5-6: Example of Pop up Dialog help screen

Part Usage Identification Screen:

Enter Part and Duration of Usage:

Enter via pull down menu the Start and End Dates and Times (in hours and minutes) that you would like to view part ordering.

Enter part number to view usage or use a pull down menu that will allow the user to view groups of product, example All, Radiators, Condensers, Condensers etc.

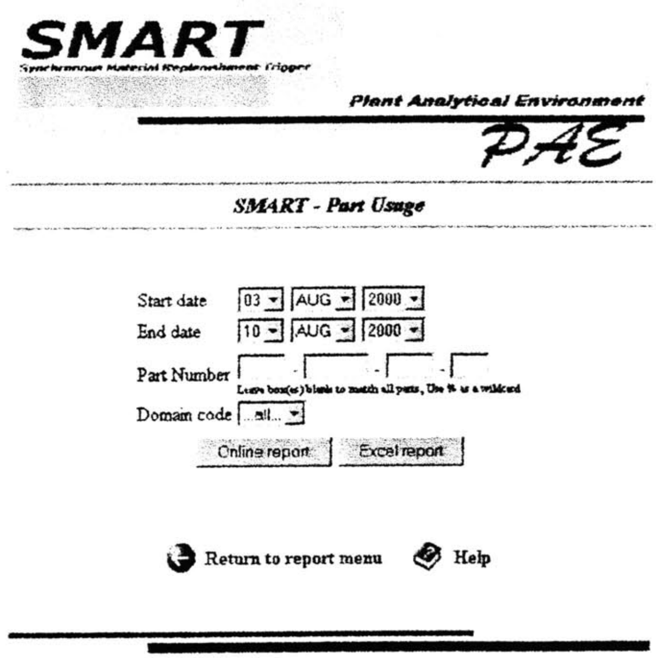


Figure 5-7: Example of Part Usage Identification Screen

Request Online Report:

Invoke by mouse click on a screen button ONLINE REPORT.

This takes them to the next screen **Parts Usage Display Screen.**

Request Excel Report:

Invoke by mouse click on a screen button EXCEL REPORT.

Popup dialog prompts user if they want to save the file or open it from current location.

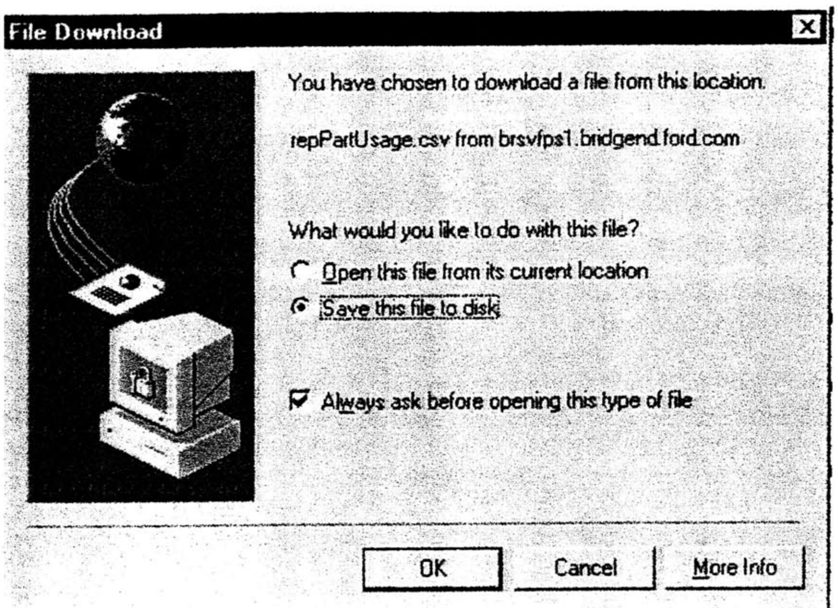


Figure 5-8: Example of Request Excel Report dialog box

Log Out:

Close the **Part Usage Identification Screen** by mouse click on a screen button LOG OUT, and return to **Log In Screen**.

Help:

Invoke popup dialog by mouse click on a screen button HELP.

Popup dialog displays information about the Application Screen.

Online Part Usage Display Screen:

View Usage:

Screen displays Usage tables of requested parts over requested duration.

All information entered on the **Part Usage Identification Screen** is displayed at the top of the page.

Log Out:

Close the **Online Part Usage Display Screen** by mouse click on a screen button LOG OUT, and return to **Log In Screen**.

Help:

Invoke popup dialog by mouse click on a screen button HELP.

Popup dialog displays information about the Application Screen.

Excel Part Usage Display:

If the user chooses to save the file they may then save it to file.

If the user chooses to display the data it will be in the following format.

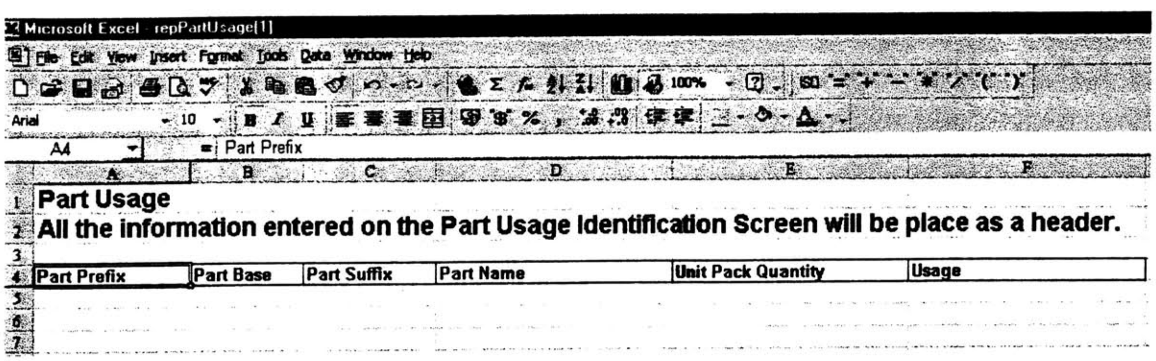


Figure 5-9: Example of Excel file in Ford Bridgend SERT system

In some cases multiple suppliers supply a single part. Hence it will be necessary to include in the database a factor so as when a supplier pulls up the usage it does not show them actual usage it shows them the Actual usage X the supplier factor.

An Internet company that has a good history of hosting secure Visteon/Ford websites would host the web page. Hence, the only necessary costs of the SERT (Supplier Electronic Replenishment Trigger) system would be to develop a web site to allow the external suppliers to interrogate the server with all the information on calls to the marketplace and pay a monthly fee to the company hosting our website.

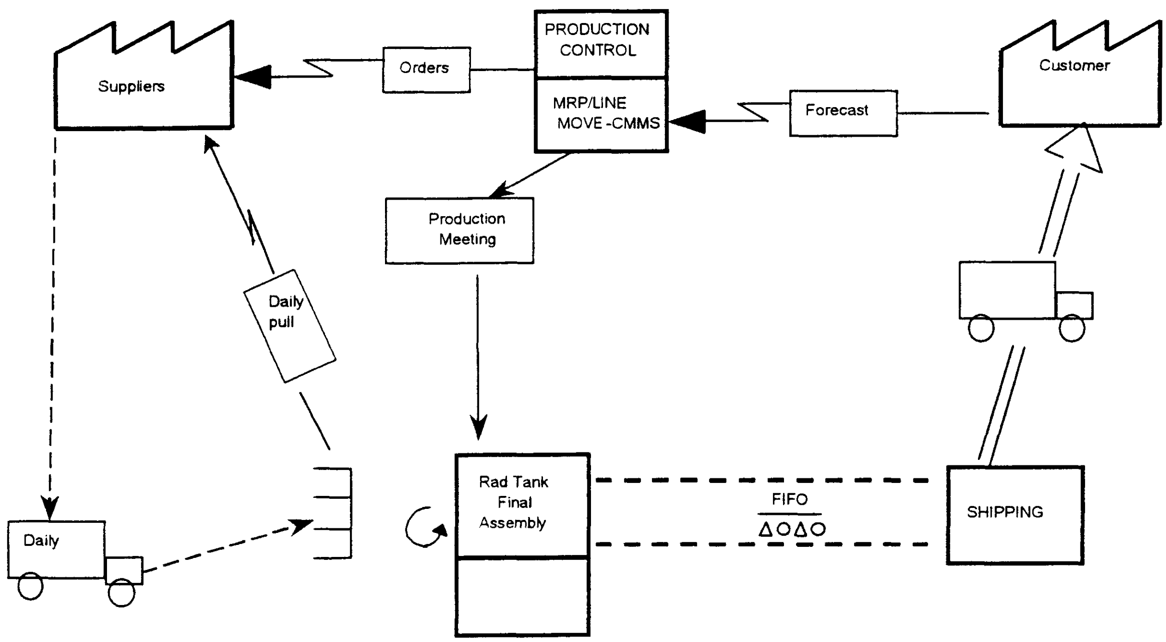


Figure 5-10: Proposed SERT system

At this point we are in the stages of getting a definitive quote from systems developers on the building of the actual website. At this time the best quote that we have received is from Wychtree Technology. We have all been very impressed with the interaction that we have had with this development company to date. The final quote is expected within the week and will be in the range of £3500 ± £1500 plus VAT. We received another quote from Logica, which was quite substantially more than that received by Wychtree Technology. Logica estimated between £50,000 - £250,000 to implement the entire system from the SERT system to the BESMART. The lowest quote to host the SERT web page that we have received to date is approximately £750 a month received from IOC. There will also be a onetime set up cost of £ 1500 for the web page. This would put the entire IOC/Wychtree Technologies system minus the hardware requirements at approximately £15,000. Discussions with members of the MP&L group in Swansea have shown that they are using a similar SERT system with Bridgend and it allows them to accomplish their job in almost a quarter of the time.

The benefits of implementing the SERT system are numerous. Talking with the MP&L department at Ford Bridgend where a similar system is in operation it has reduced inventory in their warehouse drastically by running a min/max system and having their suppliers replenish their usage to their max levels as well as drastically reducing the workload in the MP&L office. Initial estimates are that, by implementing such a system in the Basildon plant we will reduce the work load of the MP&L analyst by up to 50% freeing them up to accomplish numerous other tasks. This converts into a cost saving of £12,000 per analyst, per annum.

5.6 Proposed Solutions- Marketplace

The proposed solution for the market place begins by re-designating the types of parts used in the plant into 3 categories. High volume parts can be defined as parts with a one and a half day requirement of greater than four pallets. Medium volume parts are defined as parts with a one and a half days requirement of four to three pallets.

The diagram below shows the proposed layout of the new marketplace. Also shown are the estimated space requirements for all the radiator tanks used in the plant.

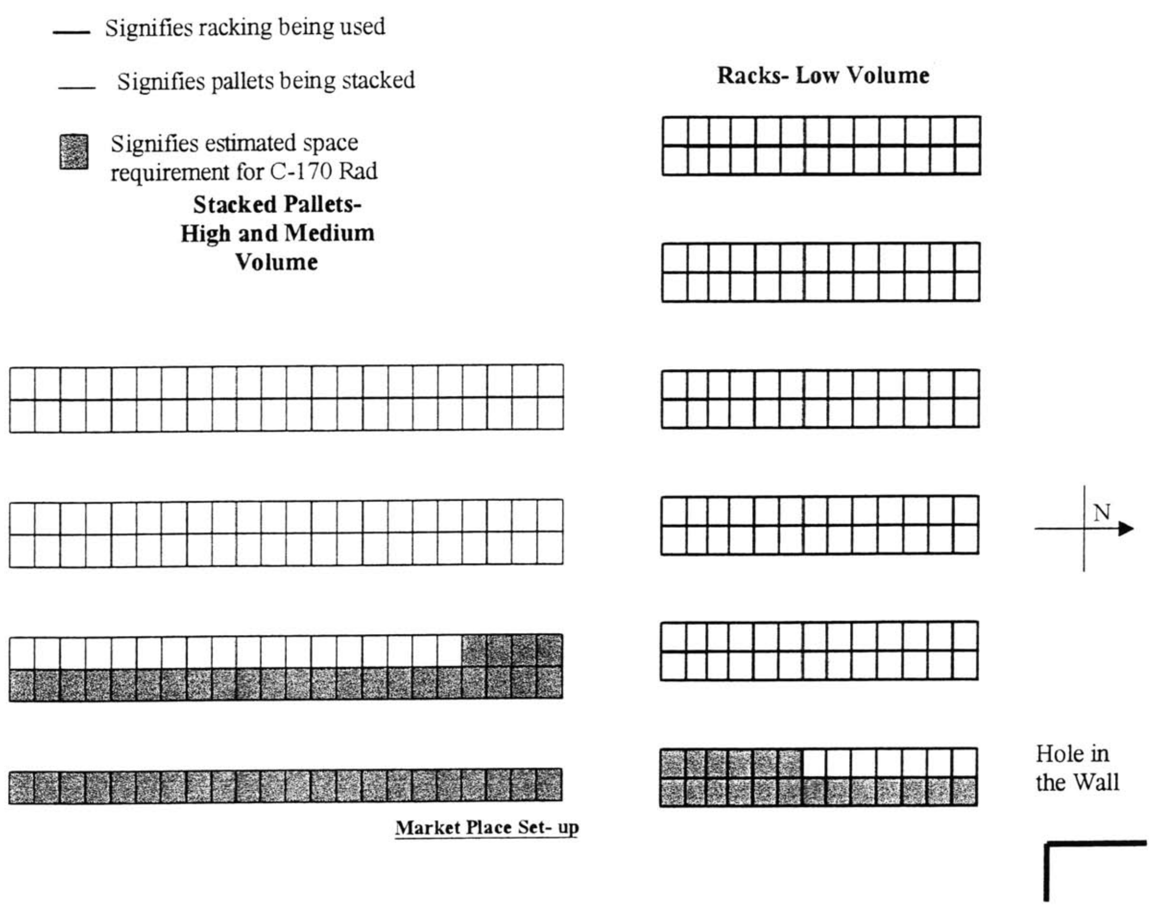


Figure 5-11: Proposed Marketplace layout

In the preceding solution the only on cost would be to mark up the designated positions with placards hung from the roof using chain link[β]. However to improve FIFO in the plant it would be better to utilize racking through out the entire market place. This would require an extra on cost of £38,000 (quoted by Dexion, see Appendix B, Richard Mason) and would reduce the amount of pallets that can be stored in the fast and medium moving section of the marketplace by 10%. A suggestion to increase FIFO in the warehouse is to change the sticker color on the chep pallets arriving into plant on daily basics rotating the colors every seven days. Most all-high and medium volume products will be used in that period of time and it will be easy to trace defective product once detected.

We also examined implement gravity fed roller racking. This would force the implementation of FIFO but would not utilize the space available in the marketplace very economically as most of our parts in the fast moving area would be only 4 deep. The cost of implementing the gravity fed roller racking would be approximately £60,000.

5.7 Acceptance of Users Involved

A fundamental question at this stage is **"Will the Systems be accepted by users without resistance?"** The procurement of this new, easy to use BESMART and SERT systems has been ramified by the demand from the shop floor line side operators, shift supervisors, MP&L and the VPS team. From the initial discussions, about 90% of all the users would like to do away with the existing system and they prefer this new computerized system as their choice. The primary reasons sighted for this were: -

- Reduced time wastage on waiting for material handling and delivery
- Eliminate human error
- Reduce paper work
- Encourage the use of computer system
- Maintain stock control at line side and market place
- Maintain production operations.
- Achieving overall performance and production target

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would require the remarking of the entire market place.

All the users are currently using the computerized CMMS3 barcode system and are well acquainted with the computer environment. They are comfortable with the use of keyboard and track ball mouse to select an object from the computer desktop. However, it must be recommended that training be given to all users in the areas of basic use of computer skills, and the use of BESMART software.

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