Developing an Operations Plan for the Dispatching of an Automobile Component

by

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Executive Summary

Kromberg & Schubert is a cable harness manufacturing company that currently supplies BMW with cable harnesses for their vehicles and has been approached by BMW requesting them to supply cable harnesses for their new F30 series automobiles. In order to meet the new demand by BMW, Kromberg & Schubert have moved several processes to their Botswana branch and as a result must now redesign the entire factory layout.

Most of the layout has already been planned and the only section remaining is the dispatching area. An operations plan for this area will be created using various Industrial Engineering methods and techniques. Only procedures inside dispatching were studied and thus this project will exclude the actual manufacturing of the harnesses. Adjustment of some processes was made in order to discover an improved process flow to help with better utilization of resources such as time, space and employees. The primary aspect that was considered includes the material handling system, dispatch processes, plant layout and work descriptions for worker tasks.

An improved layout was developed which uses 21% less floor space and permits 37% less travel required by the materials in dispatching. This resulted in an improved flow through dispatching. It is recommended that the detailed floor plan instructions, along with the prescribed processes and material handling system given in this report be implemented for the greatest benefit to dispatching, due to a relatively low implementation cost of R606 486. This operations plan will not require additional staff and most material handling equipment is already owned by the company.
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Chapter 1: Introduction

1.1. Background

Kromberg & Schubert was founded on 15 April 1902 by Paul Kromberg and Ernst Schubert in Wuppertal, Germany. They initially started with the manufacturing of insulated electric wires and later in 1932 developed and manufactured cable harnesses for the automotive industry, which has become the company’s primary focus. In 1959 the company started expanding outside of Wuppertal and in 1998 the company began business in Brits, South Africa. The company celebrated its 100th year anniversary in 2002 (www.kromberg-schubert.com).

A cable harness is an assortment of many different cables which connect all electronics inside an automobile. There are several harnesses that are connected to one another. The biggest and most important harness, called the Main harness (see Figure 1.1), is the central harness to which all the others are connected and the second largest is the Audio harness. Depending on the automobile in question, smaller harnesses such as the audio-, cockpit-, door-, roof-, tailgate- and gearbox harness (see Figure 1.2) are connected to the Main harness to link all the electronics. Another type of harness called the Basis harness is required by all automobiles and has the function of simplifying the processes and design of the other harnesses by reducing the number of wires that are required by the other harnesses.

Figure 1.1: Main Harness
Currently Kromberg & Schubert in Brits, South Africa (KSSB) manufactures cable harnesses for BMW E90 series. KSSB has made an agreement to manufacture the cable harnesses for BMW’s new F30 series and as a result KSSB is now in the process of transforming their manufacturing plant to accommodate the new demand which increases from 320 to 340/day.

The manufacturing of several small harnesses namely the gearbox-, door- and cockpit-harnesses will be relocated to Kromberg & Schubert in Botswana (KSRB). This factory will supply three new harnesses to KSSB namely the door-, tailgate- and cockpit harness which will be used to produce the new F30 series harnesses. KSSB will be supplying these new harnesses to BMW. Due to the relocation of the processes involved in the manufacturing of these harnesses the factory floor at KSSB has been redesigned.

1.2. Problem statement

The layout of approximately 90% of the factory has been redesigned and will be implemented at the end of the year 2011. The remaining 10% of the layout includes the dispatching of the final product (see Figure 1.3) where it is stored, labeled, packed and loaded onto a truck and transported to BMW. Other materials which are not part of dispatching must also be stored in this area. These materials are called C-Idsents which are the wires that eventually make up the harnesses (see Figure 1.4).
The only floor space available for the entire dispatching area in the new factory layout is approximately 1284m², the height of the factory roof will not be considered because it is extremely unlikely that it will be exceeded at any point.

The sections that must be located in this area are as follows:

1. C-Ident storage (not part of dispatching operations)
2. Final Main- and Audio-harness storage (a.k.a. KSK)
3. Final Cockpit-, Door- and Tailgate-harness storage (a.k.a. non-KSK)
4. Dispatching processes
5. Dispatch holding area

There is limited floor space available in the factory for the abovementioned dispatch activities. An improved layout plan needs to be developed that optimizes space utilization, improve materials flow and support efficient storage and dispatch operations. Current dispatching processes must be redesigned or improved and material handling equipment needs to be replaced.
1.3. Project aim

The aim of this project will be to develop an operations plan for Kromberg & Schubert’s dispatching activities.

This operations plan must be done through optimizing space-, time- and worker utilization at a minimal cost to the company.

The following will be addressed:

1. Layout
2. Material Handling
3. Dispatch Processes
4. Process Flow
5. Ergonomics

1.4. Project scope

This project will only consider the activities related to the dispatching section of the factory. The only exception is the C-Ident storage area which is part of a different process earlier in the overall process flow of the cable harness. The processes involving the manufacture of the actual harness will not be included in this project.

The scope of this project will exclude implementation. This project will however provide an alternative that the company can use to compare their actual layout implementation and provide possible improvements, since the alternative will be evaluated and compared according to its strengths and weaknesses.

For simplicity the following terms will be referred to throughout this report:

- Main = Main harness
- Audio = Audio harness
- Cockpit = Cockpit harness
- Door = Door harness
- Gearbox = Gearbox harness
- Tailgate = Tailgate harness
- KSK = Main- and Audio harness
- non-KSK = All harnesses other than Main- and Audio harnesses
1.5. Deliverables

An operational plan will be provided, including the following:

1. The most important deliverable will be to develop an improved process flow which will optimize throughput in the dispatching of finished goods.
2. A complete list of all material handling equipment that will be required, such as pallet-trucks will be constructed; this will also include the storage racks.
3. A comprehensive layout will be drawn up to illustrate the processes and process flow.
4. Detailed work descriptions for employees will be specified.

1.6. Activities and tasks

- The first task that must be accomplished is gaining insight into the dispatching of cable harnesses so that the processes involved are understood and will help produce a quality project with reliable information. In order to gain this experience, training at the factory will be done.
- After training in the factory, in depth observations of processes presently used in the dispatch area of the factory will be done to further understand the procedures that are involved.
- Various alternative solutions will be drawn up. The best solution will be selected and refined. Discussions with the facilities planner and the logistics manager must be undertaken to help determine all alternatives more effectively.
- The chosen alternative will be clearly defined and methods from the literature study will be used to evaluate and determine all details of the operations plan.
- A review of the operations plan will be conducted in order to identify any problems, after which corrections and/or improvements will be made where needed.
- Validation of the operations plan will be done by discussing the results with the facilities planner and logistics manager at KSSB to determine if this plan is realistic and correct. The logistics manager can confirm that the operations plan would be acceptable and this will be a good key performance indicator for the validity of the project itself. Validation of the results will also be done to determine whether or not actual improvements are made to the dispatching area.
Chapter 2:  
Current Dispatching Operations

A comprehensive analysis of the current dispatching operations was prepared in order to gain insight and identify problematic areas. This analysis also provides readers with a detailed explanation of the processes currently involved.

2.1. Current dispatching process

The dispatching process currently implemented starts with a worker retrieving three harnesses, namely Cockpit, Door and Gearbox from the assembly line using a pallet truck. The Cockpits are taken to a storage area near the dispatching section, where they are stored until they need to be dispatched, and thus no further work is done on Cockpits.

The Doors and Gearboxes on the other hand are taken to the dispatch section and stored on pallets; from here another worker moves the harnesses to his station and stores them in a buffer. At this station the Doors and Gearboxes are given labels and registered onto the IT system via a computer, the harnesses are then placed inside bags and labels printed at this station are added onto the bags. From here the bags are hanged on a rack where they remain until another worker retrieves the bags.

After the three non-KSK harnesses have been retrieved the Mains and Audios are retrieved from the assembly line. These are taken to the dispatching section where the Audio is stored and the Main is matched with its respective Audio; if the Audio is available it is placed in the same bin as the Main and sent to storage at the final station, else the Main is stored near the Audios until the appropriate Audio becomes available.

The matching procedure for the latter is as follows: Each Main is allocated a specific number which is given to it at the start of its production on the main assembly line. As with the Mains, each Audio also has a number allocated to it and this number corresponds to a Main. Thus each Audio belongs with a particular Main. At the dispatching section the Audios are all stored in bins, with a numbering system on the bins to aid in finding a specific Audio and match it to a Main.

At the final station the bags are retrieved and matched with the appropriate KSK bins. All of the harnesses within these bins are then scanned into the IT system and labeled accordingly making them ready to be dispatched to BMW by means of a truck. These labels contain all relevant information about the harnesses such as their part numbers and type of harnesses.

For a better understanding refer to the process flow diagram in Figure 2.1 given on the next page, this figure is accompanied by a key to explain the acronyms used in the figure.
Figure 2.1: Current Process Flow Chart
### 2.2. Current work description for workers in dispatch

In order to describe exactly what each worker does during the dispatch process the following table was created, which indicates the tasks and roles of each of the five workers involved in the dispatching operations. The task times are also included to help give an idea of how much workload each worker has as well as give an indication of the work balance currently in effect. See Table 2.1 on the following page.

<table>
<thead>
<tr>
<th>Operator #</th>
<th>Role</th>
<th>Detailed task description</th>
<th>Task time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Runner</td>
<td>Use pallet truck to collect pallet with KSK or non-KSK from production line, then store in dispatching area. All KSK’s are stored for 24 hours. Match Mains with Audios in dispatching area according to harness number given in production.</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Non-KSK Packer</td>
<td>Collect Door and Gearbox bins from storage and place in buffer rack. View computer screen for upcoming Doors and Scan all 4 doors in sequence and put in bag. Sequence is: Front door, Passenger door and Rear Doors. Bag label will print; add the label on the door bag. Scan required Gearbox and put in bag. Bag label will print; add the label on the gearbox bag. Store bags on rack.</td>
<td>1:42</td>
</tr>
<tr>
<td>3</td>
<td>KSK Packer</td>
<td>Collect Main with Audio from storage area and retrieve appropriate non-KSK bags from rack. Open KO Program on computer and scan in sequence: Main, Audio bag label Gearbox bag label Door bag labels VDA label will print out for KSK bin, add label to bin and stack bin onto pallet.</td>
<td>2:48</td>
</tr>
<tr>
<td>4</td>
<td>Dispatch</td>
<td>Receive pallet with 8 complete bins. Login on scanner and open program: Scan any VDA label to create a pallet label. Scan the pallet label and the 8 KSK's on one pallet. New pallet label will print with 8 KSK's on it. Stick pallet label on pallet, pallet is now ready for shipment. Open shipment program. Scan all Pallet labels. Confirm number of pallets. Release shipment.</td>
<td>2:43</td>
</tr>
<tr>
<td>5</td>
<td>Loader</td>
<td>Collect released pallets with 8 bins with pallet truck and load pallets onto truck for dispatching.</td>
<td>1:34</td>
</tr>
</tbody>
</table>

**Table 2.1:** Dispatching Work Descriptions
2.3. Current layout

At present the dispatching operations are located approximately 50m from the primary assembly line. All current processes involved in the dispatch operations are depicted in the process flow chart (see Figure 2.1). The distance between each process is displayed on appropriate arrows. The estimated distance that the Door- and Gearbox harness presently travel is about 75m and the Cockpit harness travels 70m, for the Main- and Audio harness it is approximately 77m travel distance. Thus from this information it was estimated that the total distance presently travelled is on average 142m. In Figure 2.2 below is a graphic depiction of the current dispatch area layout which indicates the process flow with arrows and each operator is represented by a number inside a circle, and these numbers correspond to Table 2.1. The location of this area on the factory floor is shown in Appendix B.

Figure 2.2: Current Dispatch Layout
2.4. Current material handling

The following table shows all material handling equipment currently used in dispatching along with a description of what the equipment is used for.

<table>
<thead>
<tr>
<th>#</th>
<th>Material Handling Equipment:</th>
<th>Description of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pallet Truck</td>
<td>Transporting all pallets to and from all stations in dispatching section.</td>
</tr>
<tr>
<td>2</td>
<td>Plastic Storage Bin</td>
<td>Storing harnesses on racks/floor and stacking on pallets for transportation. Also used as final product container.</td>
</tr>
<tr>
<td>3</td>
<td>Manual Handling (by hand)</td>
<td>Stacking bins onto pallets/racks and placing harnesses into bins.</td>
</tr>
<tr>
<td>4</td>
<td>Pallet</td>
<td>Carrying bins for transport between dispatching stations and used as storage shelf for bins.</td>
</tr>
<tr>
<td>5</td>
<td>Metal Rack</td>
<td>Door and Gearbox buffer storage.</td>
</tr>
<tr>
<td>6</td>
<td>Linen Bag</td>
<td>Packaging of Door and Gearbox in small green bag. Packaging Main with Audio in big red bag.</td>
</tr>
</tbody>
</table>

Table 2.2: Material Handling Equipment

In Figure 2.3 below is a graphic representation of all the above mentioned material handling equipment.
Presently all the harnesses are stored inside bins on pallets that stand on the factory floor and are not stored on racks (see Figure 2.4). A rack is only used for the buffer storage of the Doors and Gearboxes. The harnesses themselves are also stored inside plastic bags within their respective bins in order to help protect them from damage and prevent them from getting entangled (see Figure 2.5).
2.5. Current C-Ident storage

The C-Idents are all stored in an isolated area inside the factory (refer to Appendix B). This store is currently situated next to a separate dispatching area. These C-Idents are all stored in small yellow bins, inside metal racks as shown in Figure 2.6. If C-Idents need to be dispatched from this area a worker uses a barcode scanner that indicates to the worker which C-Idents are to be dispatched. The worker then uses a pallet truck to load the required C-Idents and scans them in order to register on the IT system that the C-Idents have been dispatched; they are then taken to the loading dock and dispatched.

![Figure 2.6: C-Ident storage](image)

2.6. Gaps, problems and limitations

In Table 2.3 below, the gaps and inefficiencies, possibilities and the approach of what should be done in the operations plan is summarized. All of the details such as space occupied and volumes will be discussed in later chapters of this report. The operations plan is split into five divisions in this table to make it more understandable.
<table>
<thead>
<tr>
<th>Division</th>
<th>Gaps &amp; Inefficiencies</th>
<th>Possibilities</th>
<th>Approach</th>
</tr>
</thead>
</table>
| Dispatching Process | 1. Too many buffers, prevents process from being lean.  
2. Processes can be simplified or removed.                                                                                                                                                                                                                                                                                                          | 1. Complete removal of buffers are impossible, however reduction is possible.  
2. Process simplification is not economical.  
3. Combining some processes is possible.                                                                                                                                                                                                                                                                                                       | 1. Reduction of buffer sizes.  
2. Work towards creating lean processes, by adopting TPS concepts.                                                                                                                                                                                                                                                                                                                          |
| Work Description   | 1. New work instructions depending on level of change in processes.  
2. Probability of excess workers assigned.                                                                                                                                                                                                                                                                                                           | 1. Work instructions can be change at any time, though workers tend to reject change.                                                                                                                                                                                                                                                                                                               | 1. Keep workload equal for all workers.  
2. Keep change to current work instructions to a minimal.                                                                                                                                                                                                                                                                                                                          |
| Layout              | 1. Dispatching layout can be redesigned from bottom up.  
2. Can apply best practices to ensure an improved layout.                                                                                                                                                                                                                                                                                                | 1. Potential for layout with improved material flow.  
2. Possible to provide adequate space for people, equipment and materials to move around.  
3. Enough space to accommodate C-Ident storage.                                                                                                                                                                                                                                                                                                       | 1. Follow SLP procedure to ensure all aspects are taken into consideration.  
2. Take into account space requirements for C-Ident storage area.                                                                                                                                                                                                                                                                                                                 |
| Material Handling   | 1. New equipment can be obtained.  
2. Improved material handling system can be implemented.  
3. Appropriate racks can be installed to maximize cubic space utilization.  
4. Automated machines can be installed for storing and collecting.                                                                                                                                                                                                                                                                                                   | 1. Acquiring new material handling equipment.  
2. Possible for introducing new material handling system.  
3. Conversion of existing racks to fit requirements of new storage.                                                                                                                                                                                                                                                                                                  | 1. Abide by the ten material handling principles.  
2. Do material handling and layout planning simultaneously.                                                                                                                                                                                                                                                                                                                     |
| C-Ident Storage     | 1. New methods for locating and transporting between aisles.  
2. New racks to help improve material flow.  
3. New automating racking system can be introduced.                                                                                                                                                                                                                                                                                                         | 1. Better equipment for transporting materials.  
2. New methods for storing and locating C-Idents.                                                                                                                                                                                                                                                                                                                                                  | 1. Aisle travel must be improved by providing the appropriate material handling equipment.                                                                                                                                                                                                                                                                                                 |

Table 2.3: Gaps, Problems & Limitations
Chapter 3:  
Consideration of Relevant Best Practices

3.1. Process

In the automotive industry the best practice is to implement the Toyota Production System (TPS), also known as “Lean Manufacturing System” or “Just-in-Time System (JIT)”. This system is based on the following two concepts (www.toyota-global.com):

1. Jidoka. This states that when a problem arises the equipment must stop immediately in order to prevent any defective products from being produced. Thus production must stop and the problem must be rectified before production may continue. With this concept quality is “built” into the product.

2. Just in Time. This concept revolves around producing only what is needed, when it is needed, and in the amount it is needed. This helps a company to produce quality products efficiently through the elimination of waste, irregularities, and excessive requirements on the production line.

Based on these two ideas, the TPS can efficiently and swiftly produce a product of high quality that fully satisfies the customer needs.

3.2. Layout

In developing a facility layout it is good practice to apply the following approach (http://www.lean-automation.com):

- Develop the process and manufacturing system
- Develop process requirements and proposed Value Stream Map
- Identify all plant activities and define their working relationships
- Develop flow patterns through the facility
- Develop space requirements for the process and all plant activities
- Develop preliminary block layout options by arranging the activities to achieve the required relationship and flow patterns
- Using the preferred block layout, develop a preliminary layout by adding aisles, shipping receiving docks, personnel aisles, etc.
- Develop final layout recommendations

The latter approach helps to ensure that the required background information that was researched is dependable and comprehensive. This will assist in evaluating the facility layout and develop suggested alterations.
Another good facility planning approach is given below (Tompkins et al., 2010: 297):

- Determine space requirements for each work station and department
- Determine the relationship between work stations
- Develop a relationship diagram
- Arrange the work stations to minimize travel distances and cross flow
- Convert the relationship diagram into a space relationship diagram
- Convert the diagram into a Block Layout
- Effectiveness calculation of proposed alternatives
- Develop initial best layout for feasible alternative
- Modify the feasible alternative and adjust according to practical limitations

This approach is reminiscent of Muther’s Systematic Layout Planning (SLP) Procedure that uses as its basis the activity relationship chart. See Appendix D for a graphic representation.

3.3. Material handling

Material handling and facility layout planning are closely related to each other in the sense that they both share the following aspects:

- Data required for the design of each activity
- Goal is to minimize cost
- Determine flow patterns in the facility
- Determine effective use of space

Due to this it is best to solve these two problems simultaneously. Important in practice are material handling principles which provide guidance and perception to facility designers. As indicated by Tompkins et al. (2010: 179), there are ten material handling principles derived from many years of expert material handling experience. They are as follows:

1. **Planning Principle.** Defines the material (what) and movements (when and where); together these define the technique (how and who).
2. **Standardization Principle.** A reduced amount of diversity and customization in the techniques and equipment used.
3. **Work Principle.** The product of material flow and distance moved gives a measure of work. Where material flow can be volume, weight or count per unit of time.
4. **Ergonomic Principle.** Adapt work or working conditions to fit the worker in order to promote worker comfort and efficiency.
5. **Unit Load Principle.** Unit load can be stored or moved as an individual object, such as a pallet.
6. **Space Utilization.** Accounts for three-dimensional space and thus is counted as cubic space.
7. **System Principle.** A collection of interacting and/or interdependent entities that make up a whole.
8. *Automation Principle*. The mechanization of processes, movement and storage operations, in order to either remove workers from the process or to enhance worker abilities.

9. *Environmental Principle*. Prevent wasting natural resources and to foresee and avoid negative effects on the environment.

10. *Life-cycle Cost Principle*. Include all costs from “birth” to “death”.

These principles can be used as a checklist and application of these principles can assist in improving material handling solutions (Tompkins et al., 2010: 181).
Chapter 4:
Applied Engineering Methods, Tools and Principles

4.1. Defining applicable methods, tools and principles

In this section a description will be given of all the methods, tools and principles that are employed in this project. These descriptions include an explanation and indication of where each method, tool and principle is used.

4.1.1. Methods

*Facilities planning process.* This process entails a general plan that is followed throughout the entire lifecycle of the project. Following this plan will provide an opportunity to achieve reduction in costs and improve productivity, and it is also a continuous process. The facilities planning process consists of ten steps that should be followed. These steps are as follows:

1. Define the objective of the facility.
2. Specify the primary and support activities to be performed.
3. Determine the interrelationships among all activities.
4. Determine the space requirements for all activities.
5. Generate alternative facilities plans.
6. Evaluate alternative facilities plans.
7. Select a facilities plan.
8. Implement the facilities plan.
9. Maintain and adapt the facilities plan.
10. Redefine the objective of the facility.

*Sequencing the required processes.* This method helps to ensure that all the processes involved occur in the correct order. The first task is to determine the overall sequence of activities in the dispatch area using a Gantt chart. Secondly a more detailed process flow must be obtained, and this can be done using a process flow chart. Lastly the work instructions can be drawn up with help from employing a line balancing tool.

*Material handling process.* This procedure will ensure that all the required material handling equipment and systems are considered, which will also improve material flow and reduce risk of damage to materials. The material handling process consists of six steps. They are as follows:

1. Define the objectives and scope for the material handling.
2. Analyse the requirements for moving, storing, protecting and controlling material.
3. Generate alternatives for meeting material handling requirements.
4. Evaluate alternatives for material handling.
5. Select the best alternative for moving, storing, protecting and controlling material.
6. Implement the preferred alternative.
Procedure for layout planning. As discussed in Chapter 3 (p.14) this method is reminiscent Muther’s Systematic Layout Planning (SLP) Procedure and it consists of nine steps. Following these steps will assist in developing a layout plan that considers all relevant desires, such as reducing travel and increasing material flow.

Space requirements. In determining the suitable amount of space required for all areas various aspects must be taken into account. This method provides the necessary guidelines to address aspects such as equipment-, material- and personnel space requirements. This method is used along with layout planning.

4.1.2. Tools

Time studies. Multiple time studies were conducted in the dispatching area in order to help determine the time it takes to accomplish each process (see Appendix A). This information is required for the line balancing. During the time studies valuable knowledge about how and why workers do certain things also become available, this can prove invaluable in latter stages of planning.

Line balancing. This tool helps to place the processes in the proper sequence and by doing so it also allows one to determine the cycle time of the dispatching process. With the cycle time it is possible to calculate the maximum rate of through put, along with this you can determine the number of work stations required and this allows you to utilize workers better.

Gantt chart. A Gantt chart is used to display the processes in the sequence that they occur with a short description and it also shows at what point each process begins and ends. This chart is used in the sequencing of required processes.

Process flow chart. The flow chart is used to help describe each process in detail which makes all the procedures involved in dispatch much easier to understand and ultimately improve or change. The chart was used to describe the current and alternative processes that are or should be in the dispatching area. It is also important in the method of sequencing the required processes.

Relationship chart. This chart assists in determining the importance of each process’ relationship with each other inside the dispatching area. Through this it can be decided where each process should be allocated on the facilities layout plan. This chart is essential in the SLP method.

Relationship diagram. This is a more graphical depiction of the relationships between processes that are present in the relationship chart. It simply makes the relationships easier to detect and work with and it is also used in the SLP method.

Space relationship diagram. This diagram is an extension from the relationship diagram and indicates the floor dimensions required by each process/station. The dimensions are graphically shown on the diagram with the appropriate ratios and clearly also used in the SLP method.
Block layout. The block layout is also used in the SLP. This is a representation of the proposed alternatives in a graphical form as they will fit on the actual factory floor. It indicates where each process takes place and the space that is occupied, along with the entrances and exits to the building/rooms.

4.1.3. Principles

Creating a good operations plan requires practical experience. Thus for guidance in developing this operations plan, many different principles are addressed to assist in considering the most important aspects of the layout, material handling and processes. These principles have been created from experience in practice and are listed below with their respective guidelines:

Ergonomic principles:
- User population
- Natural & comfortable body posture
- Critical dimensions
  - Space for the larger user
  - Comfortable reach for smaller user
- Average person fallacy
- Safety

Facility planning principles:
- Provide adequate lead times for planning
- Detailed analysis of requirements
- Get inputs from as many people as possible
- Put the plan on paper and verify assumptions
- The nature of the project will determine the level of detail, scope and people involved

Principles of effective flow:
- Maximise directed flow paths
  - Uninterrupted path
  - No intersection with other paths
  - No backtracking
- Minimise flow
  - Direct delivery at the point of use
  - Single movement between two points of use
  - Combining movement with process steps
- Minimising the cost of flow
  - Minimise manual handling by minimising walking, travel distances and motions
  - Eliminate manual handling by mechanisation or automating flow
Material handling principles:

1. Orientation. Study the problem thoroughly to identify existing constraints to establish future requirements.
2. Planning. Make a plan to include basic requirements, desired options and the consideration of contingencies for all material handling and storage facilities.
3. Systems. Integrate economically viable handling and storage facilities into a system of operations.
4. Unit load. Handle product in as large unit loads as practical/economical.
5. Space utilization. Make effective use of all cubic space.
8. Energy. Include energy consumption of the material handling systems and – procedures.
9. Ecology. Use equipment and procedures that minimise adverse effects on the environment.
10. Mechanisation. Mechanise where feasible to increase efficiency and economy.
11. Flexibility. Use methods and equipment that can perform a variety of tasks in a variety of conditions.
12. Simplification. Eliminate, reduce or combine movement and equipment.
15. Computerisation. Consider computerisation in handling and storage systems for improved material and information control.
17. Layout. Prepare an operation sequence and equipment layout - then select the alternative system which best integrates efficiency and effectiveness.
18. Cost. Compare economic justification in equipment and methods as measured per unit handled.
19. Maintenance. Prepare a plan for maintenance on material handling equipment.
20. Obsolescence. Prepare a long-term and economic policy for replacement of obsolete equipment and methods.
Chapter 5:
Development of Operations Plan

5.1. Application of methods and tools

The execution of the methods and tools that were discussed in Chapter 4 are shown in detail in the following sections of this chapter. The results obtained from these methods will be summarized in Chapter 6.

5.1.1. Sequencing the required processes

A Gantt chart was constructed in order to get a good overview of all the dispatching processes that must occur in sequence as the initial stages of developing the new processes required for dispatching. These processes were derived from currently required processes. This is depicted in Figure 5.1 below.

![Figure 5.1: Gantt Chart](image)

It should be noted that the time to achieve each activity in this Gantt chart is only an estimate and was derived from similar current processes, this was done due to the fact that these processes are not yet implemented. From the Gantt chart is clear that it will take approximately eleven minutes to finish the first harness that passes through the system and the lean time will be roughly three minutes per harness.

Secondly a process flow chart was created to determine the to-be processes and for a more detailed view of the activities that must follow in sequence and to show the material flow in more depth. Refer to Figure 5.2 on the following page.
This process flow chart demonstrates an immediate simplification compared to the current process flow chart in Figure 2.1 on page 5. And thus indicates that there could be a significant improvement already.

Once all the activities that are involved were identified, they were used in the line balancing tool to determine the number of work stations that would be most economical and which activities each work station should be allocated to.

From Figure 5.3 on the next page, it can be seen that the cycle time will be approximately three minutes for the dispatching operations. It is known that the company will implement an extra shift for workers in order to accommodate the added demand for the new F30 harnesses, thus there will be three shifts per day for manufacturing. And as such with the following calculation it can be determined what the maximum production rate will be:
This precedence diagram was constructed using Table 5.1 below. In this table an activity letter has been assigned to the dispatching processes along with a description, time and precedence activity, all of which are used in the line balancing.

**Table 5.1: Precedence Table**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time (min)</th>
<th>Description</th>
<th>Predecessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.5</td>
<td>Retrieve main and audio from production line</td>
<td>none</td>
</tr>
<tr>
<td>B</td>
<td>1.33</td>
<td>Store main and audio on racks</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>Match main and audio</td>
<td>B</td>
</tr>
<tr>
<td>D</td>
<td>0.33</td>
<td>Place in buffer</td>
<td>C</td>
</tr>
<tr>
<td>E</td>
<td>0.5</td>
<td>Receive cockpit, door and tailgate</td>
<td>none</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>Store non-KSK on racks</td>
<td>E</td>
</tr>
<tr>
<td>G</td>
<td>0.33</td>
<td>Place required non-KSK in buffer</td>
<td>F</td>
</tr>
<tr>
<td>H</td>
<td>2.92</td>
<td>Put non-KSK in bags and label accordingly</td>
<td>G, D</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>Scan all</td>
<td>H</td>
</tr>
<tr>
<td>J</td>
<td>0.17</td>
<td>Send to buffer</td>
<td>I</td>
</tr>
<tr>
<td>K</td>
<td>2.75</td>
<td>Stack onto pallet</td>
<td>J</td>
</tr>
<tr>
<td>L</td>
<td>1.5</td>
<td>Dispatch</td>
<td>K</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>17.33</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5.3: Precedence Diagram**

\[
\text{max production} = \frac{\text{production time per day}}{\text{bottleneck time}}
\]

\[
= \frac{(3 \times 8)60}{3}
\]

\[
= 480 \text{ units per day}
\]
The new demand that BMW has given KSSB is that they will require 340 harnesses every day. The required cycle time can thus be calculated as follows:

\[
\text{required cycle time, } C = \frac{\text{production time per day}}{\text{required output per day}} = \frac{1440}{340} = 4.24 \text{ minutes}
\]

This implies that with the three shifts every day KSSB will in fact be able to meet their demand, because the cycle time is less than the required cycle time. Although the calculated max production seems more than enough to meet demand it must be noted that this is calculated without allowances. Now that the required cycle time has been obtained it is possible to calculate the theoretical minimum number of work stations \( N_t \) required in the dispatching area. This is done using the following calculation:

\[
N_t = \frac{\sum \text{activity times}}{\text{required cycle time (C)}} = \frac{17.33}{4.24} = 4.09 \approx 5 \text{ stations}
\]

With the information that was calculated above, the activities were divided equally among the work stations. This was done using the Largest Number Following (LNF) and Largest Candidate Rule (LCR) heuristics. Table 5.2 and 5.3 below were used for these heuristics.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.5</td>
</tr>
<tr>
<td>B</td>
<td>1.33</td>
</tr>
<tr>
<td>E</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>0.33</td>
</tr>
<tr>
<td>G</td>
<td>0.33</td>
</tr>
<tr>
<td>H</td>
<td>2.92</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
</tr>
<tr>
<td>J</td>
<td>0.17</td>
</tr>
<tr>
<td>K</td>
<td>2.75</td>
</tr>
<tr>
<td>L</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Table 5.2: Activity Times**

<table>
<thead>
<tr>
<th>Station #</th>
<th>Activity</th>
<th>Idle time (min)</th>
<th>Cumulative time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A, B</td>
<td>0.41</td>
<td>3.83</td>
</tr>
<tr>
<td>2</td>
<td>E, C, F, D, G</td>
<td>1.08</td>
<td>3.16</td>
</tr>
<tr>
<td>3</td>
<td>H</td>
<td>1.32</td>
<td>2.92</td>
</tr>
<tr>
<td>4</td>
<td>I, J</td>
<td>1.07</td>
<td>3.17</td>
</tr>
<tr>
<td>5</td>
<td>K, L</td>
<td>-0.01</td>
<td>4.25</td>
</tr>
</tbody>
</table>

**Table 5.3: Activity Allocation**
From Table 5.3 the true cycle time can be obtained from the station with the highest cumulative time, which in this case is station 5 with a true cycle time of 4.25 minutes. The efficiency of this particular activity allocation was calculated as follows:

\[
\text{efficiency} = \frac{\text{sum of activity times}}{\text{actual number of stations} \times \text{required cycle time}} = \frac{17.33}{5 \times 4.24} = 82\%
\]

With all of the information gathered from the calculations above, it was determined that each station will be allocated a single worker with the appropriate material handling equipment as determined in section 5.1.2. The only exception will be for station 2 which will be divided, due to the distance between activities C and D, and activities E, F, and G. Thus station 1 will be responsible for activities A, B, C and D. And station 2 will be accountable for activities E, F and G. See Table 5.4 below.

<table>
<thead>
<tr>
<th>Station #</th>
<th>Activity</th>
<th>Idle time (min)</th>
<th>Cumulative time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A, B, C, D</td>
<td>-0.92</td>
<td>5.16</td>
</tr>
<tr>
<td>2</td>
<td>E, F, G</td>
<td>2.41</td>
<td>1.83</td>
</tr>
<tr>
<td>3</td>
<td>H</td>
<td>1.32</td>
<td>2.92</td>
</tr>
<tr>
<td>4</td>
<td>I, J</td>
<td>1.07</td>
<td>3.17</td>
</tr>
<tr>
<td>5</td>
<td>K, L</td>
<td>-0.01</td>
<td>4.25</td>
</tr>
</tbody>
</table>

Table 5.4: Planned Activity Allocation

Although the table above indicates that station 1 will not have enough time to complete its tasks, this solution is more practical, and any adjustments will need to be made for excess work load if it is deemed necessary after implementation.

5.1.2. Material handling process

This process consists of six steps that were followed in order to properly determine all the required and most suited material handling equipment.

Step 1: *Define the objectives and scope for the material handling system.*

The objective of the material handling system is to efficiently move the product through the dispatching processes, while minimizing travel time. This material handling system will only focus on the dispatch area and the C-Ident storage. Any external material handling that is relevant will be considered in decision making.
Step 2:  Analyse the requirements for moving, storing, protecting and controlling material.

The material handling system must be able to transport eight bins, which weigh approximately 30kg each with dimensions of 800x600x300mm³, which are used primarily for the KSK harnesses and final product packaging. These bins must be stored or retrieved from racks safely and quickly without damaging the product and/or bin. These bins must be taken to all the work stations in the dispatching area as swiftly and with as little handling as possible. The bins must also be stored before they are dispatched and after they have been labelled accordingly. Bins with dimensions of 300x600x400mm³ are used for storing non-KSK harnesses, which weigh roughly 15kg. These must be stored when they arrive from KSRB, and they must be easily accessible for picking purposes.

Currently the materials are protected by means of using linen bags and plastic bags, which works well and should be kept in use as the bags are already being used and would thus not incur any additional cost.

Step 3:  Generate alternatives for meeting material handling requirements.

In Table 5.5 three alternatives were created which provides the details about how they move, store, protect and control materials respectively, in order to meet the material handling requirements that was set out in step 2. Costs will be approximated with a cost rating in this table, this rating was determined from observable reasons. The detailed costs of the material handling system are determined in step 5 for the selected alternative.
Step 4: *Evaluate alternatives for material handling.*

With the purpose of finding the best alternative for the material handling system the following table was constructed. This table lists several advantages and disadvantages for alternatives A, B and C respectively, this is accommodated by a value rating for each individual alternative.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Alternative A</th>
<th>Alternative B</th>
<th>Alternative C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moving</strong></td>
<td>Use pallet trucks to move bins on pallets between all stations.</td>
<td>Use a pedestrian stacker to retrieve pallets from the production line and move them to/within KSK storage area. For moving between work stations a roller conveyor belt is used. Use a pallet truck for moving pallets to/from dispatch truck and for moving non-KSK arriving from KSRB.</td>
<td>Use pallet trucks to move pallets containing bins at final- and non-KSK storage areas. Use roller conveyor for movement between work stations. An automated racking system will feed conveyor with required bins.</td>
</tr>
<tr>
<td><strong>Storing</strong></td>
<td>Store materials in bins. Store bins on pallets standing on the floor. Use roller racks for non-KSK bins, for picking.</td>
<td>Store materials in bins. Store KSK bins in racks using pedestrian stacker to assist in lifting. Non-KSK bins are to be stored in racks with rollers, to allow easy picking. Use a sloped rack for the non-KSK buffer.</td>
<td>Install a completely automated racking system to receive, feed and store KSK bins. For non-KSK storage it is the same as for alternative B.</td>
</tr>
<tr>
<td><strong>Protecting</strong></td>
<td>Use plastic bags for audio and non-KSK harnesses. Use linen bags for KSK and final packaging.</td>
<td>Same as for alternative A.</td>
<td>Same as for alternative A.</td>
</tr>
<tr>
<td><strong>Controlling</strong></td>
<td>Use hand held barcode scanner to identify the required materials.</td>
<td>Same as for alternative A. Also use a visual tagging system for identifying KSK bins that are matched (such as ribbons or LED’s).</td>
<td>Automated racking system will control flow of KSK’s and supply required bins. A hand help barcode scanner is used for identifying required non-KSK.</td>
</tr>
<tr>
<td>Cost rating</td>
<td>Low</td>
<td>High</td>
<td>Very high</td>
</tr>
</tbody>
</table>

*Table 5.5: Alternatives for Material Handling*
In Table 5.6 above, a simple rating system was used which awards 10 points for each advantage and subtracts 10 points for each disadvantage. This rating system simply provides a quick overview of the most desired alternative. To avoid bias the fine points of the advantages and disadvantages were all taken into consideration for the selection of best alternative, as well as the practicality of implementation.
Step 5: Select the best alternative for moving, storing, protecting and controlling material.

From the evaluation in step 4 and discussions with the facility planner, alternative B was determined to be the most advantageous and practical, it is thus the best choice of material handling system that should be used. The material handling equipment that is required along with their costs in each part of the dispatching operations is listed in Table 5.7 below (Note: stations used in table refer to the stations in section 5.1.1). The details of the racking and roller conveyor that is to be used will be discussed in section 5.2.

<table>
<thead>
<tr>
<th>Station</th>
<th>Equipment</th>
<th>Cost (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electric pedestrian stacker</td>
<td>202 764</td>
</tr>
<tr>
<td></td>
<td>Wireless barcode scanner</td>
<td>6 741</td>
</tr>
<tr>
<td>2</td>
<td>Pallet truck</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Wireless barcode scanner</td>
<td>6 741</td>
</tr>
<tr>
<td>3</td>
<td>Computer</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Computer monitor</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Keyboard</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Mouse</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Fixed barcode scanner</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Printer</td>
<td>*</td>
</tr>
<tr>
<td>4</td>
<td>Computer</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Computer monitor</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Keyboard</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Mouse</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Fixed barcode scanner</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Printer</td>
<td>2 044</td>
</tr>
<tr>
<td>5</td>
<td>Pallet truck</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Wireless barcode scanner</td>
<td>6 741</td>
</tr>
<tr>
<td></td>
<td>C-Ident storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computer</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Computer monitor</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Keyboard</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Mouse</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Fixed barcode scanner</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Wireless barcode scanner</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Printer</td>
<td>*</td>
</tr>
</tbody>
</table>

* these items are currently owned and do not have to be purchased

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total:</td>
<td>225 031</td>
</tr>
</tbody>
</table>

Table 5.7: Dispatching Material Handling Equipment Required

Step 6: Implement the preferred alternative.

Purchase the required equipment; ensure employees obtain training needed for all equipment such a driving license for the pedestrian stacker.
5.1.3. Procedure for layout planning

In order to develop a layout plan that considers all relevant requirements this procedure’s nine steps were followed, the application of these are given below.

**Step 1: Determine space requirements for each work station and department**

In the new plant layout there will be limited space available for the dispatching operations. The location and size of the available space is shown in Appendix C. All of the essential space requirements for each activity in dispatching were estimated by consulting the facilities planner and making informed judgments on the actual minimum space required for each activity such as the space occupied by the operator and equipment, all of which is given in the following table. Refer to Table 5.8.

<table>
<thead>
<tr>
<th>#</th>
<th>Activity</th>
<th>Space requirement (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KSK receiving</td>
<td>80</td>
</tr>
<tr>
<td>2</td>
<td>Main storage</td>
<td>280</td>
</tr>
<tr>
<td>3</td>
<td>Audio storage</td>
<td>220</td>
</tr>
<tr>
<td>4</td>
<td>KSK buffer storage</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Bagging and labeling</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Scan all</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>Dispatch buffer storage</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>Dispatch storage</td>
<td>380</td>
</tr>
<tr>
<td>9</td>
<td>Non-KSK receiving</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>Cockpit storage</td>
<td>90</td>
</tr>
<tr>
<td>11</td>
<td>Door storage</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>Tailgate storage</td>
<td>90</td>
</tr>
<tr>
<td>13</td>
<td>Non-KSK buffer</td>
<td>140</td>
</tr>
<tr>
<td>14</td>
<td>C-Ident receiving</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>C-Ident storage</td>
<td>770</td>
</tr>
<tr>
<td>16</td>
<td>C-Ident send off</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Total:</td>
<td>2440</td>
</tr>
</tbody>
</table>

*Table 5.8: Space requirements for dispatch activities*
Step 2: *Determine the relationship between work stations*

After the space requirements have been determined an activity relationship analysis was performed. In Figure 5.4 an activity relationship chart was constructed in order to show the relationships between all of the activities involved in the dispatching operations. The appropriate keys are located inside this figure to describe each letter and number used in the chart.

![Activity Relationship Chart](image)

*Figure 5.4: Activity Relationship Chart*
Step 3 & 4: Develop a relationship diagram and arrange the work stations to minimize travel distances and cross flow

The relationship diagram is depicted in Figure 5.5. All the unimportant nodes were not included in this diagram, because they are not critical and it will not make any difference if they are located close/far from each other. This also improves readability on the diagram. A key that shows the line meanings is also included.

![Figure 5.5: Relationship Diagram]

Step 5: Convert the relationship diagram into a space relationship diagram

From the above figure and from the space requirements specifications in step 1, a space relationship diagram is constructed. The diagram shows the relative size of each activity in the dispatching area, with the same relationships between activities. This is illustrated in Figure 5.6 on the following page.
Step 6: Convert the diagram into a block layout

In this step a couple of alternatives are presented in block diagrams (see Figure 5.7, 5.8 and 5.9), namely alternative A, B and C. These diagrams have been altered to also show the material flow through the dispatching area using arrows, and the sixteen activities from the activity relationship chart are presented by numbers in circles. It should be noted that a detailed layout is only considered for the selected alternative in step 8 & 9.
Figure 5.7: Block Layout Alternative A

Figure 5.8: Block Layout Alternative B
Step 7: **Effectiveness calculation of proposed alternatives**

For the purpose of determining which of the above alternatives are most effective, Table 5.9 was prepared. This table consists of several advantages and disadvantages for each alternative. As with the material handling evaluation, a simple rating system is used to give each alternative a value rating. Certain advantages are not included in the table, because these are all present in the three alternatives and would thus be redundant. An example of such an advantage is the non-KSK buffer that is located near the roller conveyor, which is the case in all of the alternatives.
## Table 5.9: Advantages & Disadvantages for Layout Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Rating</th>
</tr>
</thead>
</table>
| A           | • Provides additional space for expansion  
             • Non-KSK storage is easy to access (i.e. close to receiving bay)  
             • No cross flow | • Activity 1 and 16 share travel points, this may cause congestion  
             • Receiving for KSK is far from production line  
             • Non-KSK storage located far from non-KSK buffer  
             • C-Ident storage is far from its send off point | -10 |
| B           | • KSK receiving located close to production line  
             • C-Ident operations are close together  
             • Non-KSK storage is close to non-KSK buffer | • Long travel time from KSK storage to roller conveyor  
             • Cross flow occurs  
             • Two-way flow in same travel corridor  
             • Non-KSK receiving located far from non-KSK storage  
             • Little space to move between C-Ident storage and non-KSK storage | -20 |
| C           | • KSK receiving located close to production line  
             • Little travel overall  
             • Good flow from KSK storage to roller conveyor (i.e. "straight")  
             • Non-KSK storage located near non-KSK buffer  
             • No cross flow  
             • No two-way flow  
             • C-Ident operations are close together | • Non-KSK receiving at medium distance from non-KSK storage | 60 |

From the table above it is clear that alternative C is the most desirable, and by a reasonable amount as seen from the rating of 60 compared to the -10 from its closest rival. Alternative C will be further developed and modified according to practical limitations in step 8 & 9.

**Step 8 & 9:** *Develop initial best layout for feasible alternative and modify the feasible alternative and adjust according to practical limitations*

The chosen alternative C was developed in detail according to the demand, bin size, bin holding capacities, etc. All of this is discussed in section 5.2 on the following page.
5.2. Synchronized layout and material handling development

As discussed in Chapter 3, material handling and the plant layout was created simultaneously, thus their details are interconnected and must be analyzed together as a single entity. This section will consist of an in depth analysis of the costs and space requirements for the proposed layout and material handling system, as was determined in section 5.1.

Note: The final placement of all racks and the roller conveyor discussed in this section will be given in Chapter 6. Refer to Appendix E and F for final placement.

5.2.1. KSK Storage

The new demand for the F30 harnesses are 340 complete harnesses per day and it is the company’s policy to keep any KSK’s in storage for 24 hours before they are processed further. With this information it was estimated that storage space for approximately 500 main and audio harnesses respectively would be sufficient, because there are 3 shifts and only 340 spaces will be filled at all times leaving 160 spaces of allowance for the remaining harnesses that are constantly being taken out and replaced.

It was now possible to determine the size of the racks that was needed; this was done by considering the practical limitations of space available and ergonomic aspects such as reach for workers. After calculating the various aspects of the bin dimensions, the rack sizes were obtained and a quotation was requested from a company called APC Storage Solutions SA. The sketches that accompanied this quotation are presented in Figure 5.10. The final cost of racks for KSK storage surmounted to R190 022, this includes installation and assembly.

As can be seen in the figure the racks will be stacking up to five bins high, one bin deep and the length of the racks will be 15.64m. In order to accommodate for worker reach the first row of the racks will be removed so that the bins stand on the ground, this will lower the rack height by 0.2m, making the maximum reach height only 1.6m. Each bin is estimated to weigh 30kg and each rack level can hold up to 400kg, which is more than enough to store the bins. With these racks only 480 bins will be storable for both main and audio harnesses respectively, which were deemed to be adequate. To accommodate the pedestrian stacker that is going to be used, the aisle width will have to be more than 2m for quick, easy and safe maneuverability.

Audio harnesses will use the same bins as main harnesses, thus they will use the same racks. The only difference will be that audio bins will be packed with two audio harnesses to save on space, and in effect this will require half the racks that main harnesses will need.
5.2.2. Non-KSK Storage

The demand for the non-KSK storage was obtained from the company for the doors, cockpit and tailgate. These demands were 62, 88 and 36 respectively for each non-KSK, and each one of these require a single small grey bin. It is company policy that five days safety stock is kept of the non-KSK harnesses, with an additional ten percent storage space. The calculation that follows will determine the amount of bins that need to be stored.

\[
\text{total bins} = (62 + 88 + 36) \times 5 + 0.1 \times (62 + 88 + 36)
\]

\[= 949 \text{ bins}\]

Since the amount of storage space was now known, it was possible to determine the rack size needed. Once again a quotation was requested from APC Storage Solutions SA, and the sketches for these racks are depicted in Figure 5.11. The non-KSK racks were estimated to cost R173 096, including installation and assembly.

As with the KSK racks, these racks will also stack five bins high, one bin deep and the racks will have a length of 11.7m. The bottom 0.2m will also be removed for accommodating reach, which will be 1.6m. The bins weigh about 15kg, and thus the 400kg limit of the racks is more than adequate. These racks are capable of storing 960 bins, which is more than the required 949 bins calculated above. For ease of movement there will be an aisle width of 1.5m provided.

Figure 5.10: KSK Storage Racks
5.2.3. Non-KSK buffer

With the new layout the demand for materials flowing in and out of the non-KSK buffer was estimated to remain about the same, thus it is possible for the same amount of racks to be used for this buffer. The current racks that are being used will be a good choice because of the fact that they can be fed from the rear, a feature which is currently not being used. These racks are also sloped at a slight angle which means the rear feed will be easy due to gravity. Another obvious benefit to using the current racks is that no additional costs will be incurred. The length and width of these racks are measured to be 9.6m and 1.4m respectively. The racks can be seen in Figure 5.12, unlike the figure these racks will also be placed next to each other alongside the roller conveyor as depicted in Appendix E and F.
5.2.4. Roller conveyor

In determining the specifics of the roller conveyor, it was decided that the conveyor should hold a buffer of five bins on either side for the KSK buffer storage and dispatch buffer storage respectively. Between the two work stations and the buffers there will be a 1m gap, this is just so that workers will have some room to work with. After the bagging and labeling station there will be a bin kanban that will serve the purpose of preventing a bottleneck if one workstation is working at a slightly faster pace. In order to provide sufficient room for workers to work comfortably, there will be a 1.5m gap between the roller conveyor and the non-KSK buffer. The conveyor will be constructed at a height of 0.6m and at a slight angle, providing workers with a comfortable reach and less effort needed to move bins along the roller conveyor. The equipment that has to be used in the two work stations will be mounted on top of the conveyor, in order to save on floor space and reduce the need for workers to move around. APC was asked once again to quote on this roller conveyor; the cost that was quoted was R18 337. A top view of the roller conveyor setup can be seen in Figure 5.13.
5.2.5. Dispatch storage

The bins retrieved from the dispatch buffer storage will be placed onto pallets and then taken to the dispatch storage, where they will be placed in rows on the plant floor. After a debate with the facility planner it was decided that an area of approximately $100\text{m}^2$ should be provided for the dispatch storage. This area will be capable of storing up to 21 pallets, which is deemed to be an ample amount. Because each shift should be supplying roughly 15 pallets with each pallet containing 8 harnesses, implies that about 120 harnesses per shift must be stored and there is a capacity to store as much as 168 harnesses per shift. An example of what the dispatch storage could look like is shown in Figure 5.14, a top view of the pallets placed in rows.

Figure 5.13: Roller Conveyor

Figure 5.14: Dispatch Storage
5.2.6. C-Ident storage

The demand that was given by the logistics department is approximately 1150 C-Ids for the F30 series. Each C-Ident on average consists of five bundles (Figure 1.4) and each bundle contains on average 100 wires, all of which fits into a single bin. It is company policy to keep a five day stock of each C-Ident, which means that the C-Ident storage area will have to be capable of holding 5750 (1150x5) bins.

KSSB currently owns 86 racks (Figure 2.6), each of which is capable of storing 70 bins. This entails that there is enough racks to hold up to 6020 (86x70) bins, which is sufficient and no additional racks or bins need to be purchased. It is planned that 84 of the racks be used, which will provide storage space for 5880 (84x70) bins. An aisle width of 1.5m will be used for the maneuverability of the pallet truck. The proposed C-Ident storage layout is given in Figure 5.15 below.
Chapter 6:
Results and Validation

6.1. Defining the results

This section will provide a summary of all the results obtained throughout this report. The summary is followed by a validation of the results in the subsequent section.

6.1.1. Proposed layout

The new proposed dispatching layout is given in Figure 6.1 below. The figure indicates the station locations throughout the entire dispatching area that was discussed in Chapter 5, Table 5.4. For an indication of the flow of materials refer to Appendix E, and for the dimensions of the layout refer to Appendix F.

Figure 6.1: Dispatch Layout with Stations
6.1.2. Proposed dispatching processes

In order to show the actions in each process, the following table was created to summarize all the activities that each worker will be responsible for in the newly proposed dispatch operations. Refer to Table 6.1 below.

<table>
<thead>
<tr>
<th>Station #</th>
<th>Operator role</th>
<th>Detailed task description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KSK Runner</td>
<td>Use pedestrian stacker to collect pallet with KSK from production line, then store on KSK racks. All KSK’s are stored for 24 hours. Match Mains with Audios in station 1 according to harness number given in production. Store matched KSK’s in KSK buffer on the roller conveyor.</td>
</tr>
<tr>
<td>2</td>
<td>Non-KSK Runner</td>
<td>Collect non-KSK’s arriving from KSRB and store in non-KSK storage racks. Check barcode scanner and place required non-KSK’s in non-KSK buffer rack.</td>
</tr>
<tr>
<td>3</td>
<td>Non-KSK Packer</td>
<td>Receive matched KSK from KSK buffer storage and retrieve appropriate non-KSK from non-KSK buffer rack. View computer screen for upcoming Doors and Scan all 4 doors in sequence and put in bag. Sequence is: Front door, Passenger door and Rear Doors. Bag label will print; add the label on the door bag. Scan required Tailgate and put in bag. Bag label will print; add the label on the tailgate bag. Scan required cockpit and put in bag. Bag label will print; add the label to cockpit bag. Store bags in KSK bin. Send bin along conveyor to station 4.</td>
</tr>
<tr>
<td>4</td>
<td>Scanner</td>
<td>Receive KSK bin with non-KSK bags inside. Open KO Program on computer and scan in sequence: Main, Audio bag label Tailgate bag label Cockpit bag label Door bag labels VDA label will print out for bin, add label to bin. Scan any VDA label to create a pallet label. Scan the pallet label and the 8 KSK’s on one pallet. New pallet label will print with 8 KSK’s on it. Place label in bin and send bin along conveyor to dispatch buffer.</td>
</tr>
<tr>
<td>5</td>
<td>Dispatch Runner</td>
<td>Get bin from station 4 and stack bin onto pallet. Stick pallet label on pallet, pallet is now ready for shipment. Open shipment program. Scan all Pallet labels. Confirm number of pallets. Release shipment. Collect released pallets with 8 bins with pallet truck and load pallets onto truck for dispatching.</td>
</tr>
</tbody>
</table>

Table 6.1: Proposed Work Descriptions
6.1.3. Proposed material handling and storage racks

A summary of all the material handling equipment and the racks that will be required is given in Table 6.2 below. This table also provides the cost of acquiring the respective material handling equipment and the racks that are needed.

<table>
<thead>
<tr>
<th>Station</th>
<th>Equipment</th>
<th>Cost (R)</th>
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<tbody>
<tr>
<td>1</td>
<td>Electric pedestrian stacker</td>
<td>202 764</td>
</tr>
<tr>
<td></td>
<td>Wireless barcode scanner</td>
<td>6 741</td>
</tr>
<tr>
<td></td>
<td>APC rack for KSK</td>
<td>190 022</td>
</tr>
<tr>
<td>2</td>
<td>Pallet truck</td>
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</tr>
<tr>
<td></td>
<td>Wireless barcode scanner</td>
<td>6 741</td>
</tr>
<tr>
<td></td>
<td>APC rack for non-KSK</td>
<td>173 096</td>
</tr>
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<td>3</td>
<td>Computer</td>
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<tr>
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<td>Keyboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mouse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed barcode scanner</td>
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</tr>
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<td></td>
<td>Printer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>APC roller conveyor</td>
<td>18 337</td>
</tr>
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</tr>
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</tr>
<tr>
<td></td>
<td><strong>Total:</strong></td>
<td><strong>606 486</strong></td>
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</tbody>
</table>

* these items are currently owned and do not have to be purchased

Table 6.2: Proposed Dispatching Material Handling Equipment

6.1.4. Proposed C-Ident storage

The new C-Ident storage area will have 88% additional space for the workers to maneuver with the pallet truck. The actually processes used in this storage area, however, will not be altered in any way, apart from the additional space that is provided.
6.2. Validation of results

The proposed layout has additional space available, due to two separate areas of dispatching and C-Ident storage being brought together into a smaller area of the plant floor. The current area used for both the dispatching operations and the C-Ident storage is approximately 1629 m$^2$, compared to the amount of space the proposed layout will use of 1284 m$^2$. This implies that roughly 21% of floor space will be saved with the proposed design. In the proposed layout the travel distances between work stations have been drastically reduced. The current layout requires materials to move a total of about 162m, whereas the proposed layout only needs materials to move generally 102m. That means a reduction of 37% movement on the plant floor will be required. The proposed design was calculated to be approximately 82% efficient. This efficiency is going to be accompanied by a better flow throughout the dispatching area.

As with current operations, only five workers will be needed for the dispatching activities. The separate activities, however, has been changed slightly to accommodate the new layout and location of stations. The processes are expected to be completed at the same mean rate as current processes, which will not have any negative impact in the proposed design.

Most of the material handling equipment will be acquired from the currently owned material handling equipment, which will save the company a lot of money. The latter is a feasible option because the proposed dispatching processes were kept as similar as was possible to current dispatching processes. Investing in the electric pedestrian stacker is highly recommended, because it will drastically increase the travel speed and reduce fatigue for the KSK runner.

In the proposed C-Ident storage an ample amount of additional floor space has been made available, compared to the current space available to move around. The current C-Ident storage has an aisle width of 0.8m, which is simply not enough for a pallet truck to turn around, making movement between aisles particularly slow. The proposed C-Ident storage will provide an aisle width of 1.5m, which is an international standard that gives enough space for proper maneuverability. There will also be enough room for personnel to walk comfortably past one another. The increased work area will also improve worker morale; due to them not feeling cramped the whole time.

6.3. Conclusion

The development of the operations plan has achieved a theoretically improved process flow, in that it allows materials to flow through the dispatching section much more efficiently due to the additional space and layout of the dispatching activities. This reduces the start-up flow through dispatching operations, but this does not reduce the mean time to produce a complete harness.

All of the relevant material handling equipment has been listed in Chapter 6, Table 6.2. The equipment will help improve the processes, by providing workers with the appropriate tools to move materials around more easily and quickly. The racks will improve material flow by
organizing materials more effectively in dispatching, saving on cubic space on the plant floor and also bringing materials closer together.

A complete layout of the new operations plan is provided in three separate diagrams, this was done because there is too much information to fit into a single diagram (See Appendix E, F and Figure 6.1). These three layouts give all of the information related to the operations plan. This includes the location of all the activities that must occur in dispatching, the flow of the materials through the area and lastly the relevant dimensions of all the racks, aisles etc.

A comprehensive list of the tasks that each individual worker has to perform at their assigned stations was given in Chapter 6, Table 6.1. These tasks are reminiscent of the current tasks being used, although some tasks have been relocated and combined to other stations’ tasks in order to conform to the new operations plan. This balance of work orders is expected to be divided equally among workers with respect to the time they take to accomplish; however, this will only be truly determinable once the operations plan is implemented in practice.

The total investment cost of implementing the proposed operations plan will be R606 486. This cost is of course subject to change, due to unforeseen costs that may occur.
References


Lubbe, R. Quotation drawings. APC Storage Solutions SA.
APPENDIX A

Time Study Results
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APPENDIX B

Current Layout
APPENDIX C
Space Available for Dispatch Operations
APPENDIX D

Systematic Layout Planning (SLP) Procedure
APPENDIX E

Proposed Dispatch Layout Flow
APPENDIX F

Proposed Dispatch Layout Dimensions