# Supply Chain Management: Implementation of Level Production and Stable Manufacturing Processes

by

MELISSA BREED

24028780

Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

in the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA

October 2008

Autoliv

## Executive Summary

Autoliv Southern Africa (PTY) LTD is one of a group of world wide companies that produce safety systems for all types of automotives manufactured. Inventory problems have occurred since they have more stock than what is necessary. This puts unnecessary financial strain on the company. Customer demand is not always met in time. In order to address this problem material handling has to be minimised. A new system has to be introduced on the manufacturing floor in order to promote Autoliv's level manufacturing.

## TABLE OF CONTENT

## Table of Figures

## Chapter 1: Introduction

Autoliv Southern Africa (PTY) LTD is one of a group of world wide companies that produce safety systems for all types of automotives manufactured. The company's vision is to substantially reduce traffic accidents, fatalities and injuries. Autoliv's mission is to create, manufacture and sell state-of-the-art automotive safety systems. These systems include airbags for a number of different automobile models, seatbelts, lap belts, strip and webbing buckles, height adjusters and steering wheels. They supply to both South Africa's local market as well as the international market.

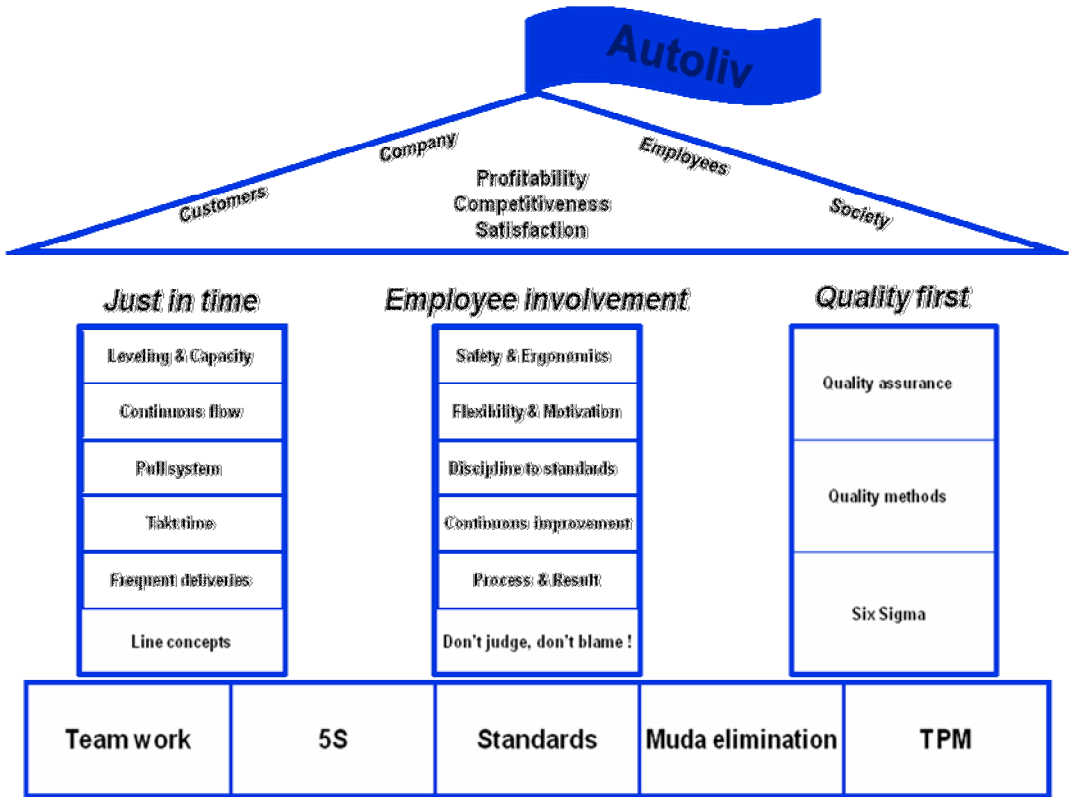
**Figure 1: Products of Autoliv**

## 1.1 Autoliv Production System (APS)

Autoliv Production System is the formalisation of Autoliv's manufacturing culture. The APS enables the plant to grow towards excellence. The purpose of APS is to meet the needs of the customers and employees in order to insure the success of the company and continuous improvement.

The Autoliv Production System (APS) can be illustrated through the image of a house. The house consists of a foundation, three pillars and a roof (see figure 2). The rest of this chapter will be dedicated to the discussion of each of these elements.

**Figure 2: APS House**



### 1.1.1 The Foundation

The foundation consists of five elements namely teamwork, 5S, standards, muda (Waste) elimination and Total Productive Maintenance (TPM). These elements are considered to be the most important constituents of the APS. Teamwork is the most effective way to solve problems and achieving defined results. 5S refers to the first letters of five Japanese words. These words are Seiri (which means to clear out), Seiton (which means to put in order), Seiso (clean and check), Seiketsu (which means to standardise) and Shitsuke (which means self discipline). Standards serve as the basis for verification and diagnosis, training of staff, maintaining best practices and improvement in the workplace. Muda elimination refers to the identification and elimination of non-value adding activities. These activities are referred to as waste and include the following: Over-production, producing defective products, material movement, inventory, over processing, delay and unnecessary motion. Total Productive Maintenance entails that the employees take ownership of the machines in their area and are to maintain and improve the machines.

### 1.1.2 Just-in-Time

Just-in-Time consists of six elements: Levelling and capacity, continuous flow, pull system, takt time, frequent deliveries and line concepts. Each of these elements is subsequently discussed with regards to leveling and capacity. Heijunka leveling is a Japanese word meaning level production volume and variety over a given period of time. Capacity is defined as the ability to meet customer demand at its highest volume.

1.1.2.2 Continuous Flow

Conventional organisation in a traditional plant entails that all of the turning processes, assembling processes and pressing operations are grouped together. This results in inventory that needs to be taken between the processes, long lead times and undetectable problems. In a multi-process organisation all the processes needed to produce one part are located in the same place. Accordingly no inventory needs to be taken between processes, the lead time is shortened,

problems are visible and efficiency of manpower is improved. Hence continuous flow is improved.

1.1.2.3 Pull System

Kanbans is a tool used to introduce a pull system. Kanban is a Japanese term which means signal, it informs the supplier of what the customer needs. In a pull system all processes in the chain are connected with kanbans.

1.1.2.4 Takt Time

Takt Time refers to the pace of production. It is the time required to produce a single component or an entire product in order to meet and not exceed customer demand. It can be calculated as follows:

$$\frac{\textit{Total available production time}}{\textit{Customer demand}} = \textit{Takt Time}$$

1.1.2.5 Frequent deliveries

Suppliers should ideally deliver smaller consignments more frequently. A shorter lead time benefits the company sinve less money are tied up in raw material and finished goods, less warehouse space is needed for storage and also fewer employees and forklifts are needed to manage and track inventory. Quality defects are noticed sooner and reported to the supplier in a timely manner thus allowing these abnormalities to be fixed with minimal scrap and rework.

1.1.2.6 Line Capacity

Flexible capacity requires that heavy automation and complicated machines be replaced with uncomplicated smaller machines. Processes have to be flexible. In order to increase flexibility of the line, change-over time needs to be reduced. One piece flow is the most efficient way to manage manpower and material resources.

### 1.1.3 Quality First

The quality first pillar consists of tree elements: Quality assurance, Quality methods and Six sigma. To prevent the failures of processes quality assurance has to be achieved in materials, personnel, machines and automation. Many methods can be used to assure quality assurance such as Poka Yoke, the Pareto diagram, a quality matrix or a cause and effect diagram. The six sigma workshop leads to the improvement of the product or the process based on the reduction of their variability.

### 1.1.4 Employee Involvement

Employees are the company's most valuable resource and need to be taken into account in every decision that needs to be made. Employees are involved in many projects and make many suggestions to improve the company they work for.

### 1.1.5 The Roof

The roof represents the purpose of the company and is supported by the foundation and pillars. The purpose of APS is to meet the needs of the customers and employees in order to insure the success of the company.

### 1.2 Autoliv's Mission

Autoliv's mission is to be the most reliable, high quality, cost effective and innovative partner in the occupant safety restraint system industry.

## Chapter 2: Project Scope

In this chapter the context of the project and definitions of the problem will be addressed. Issues surrounding materials, the ordering and purchasing system, people relations and methods to solve the challenges will be discussed.

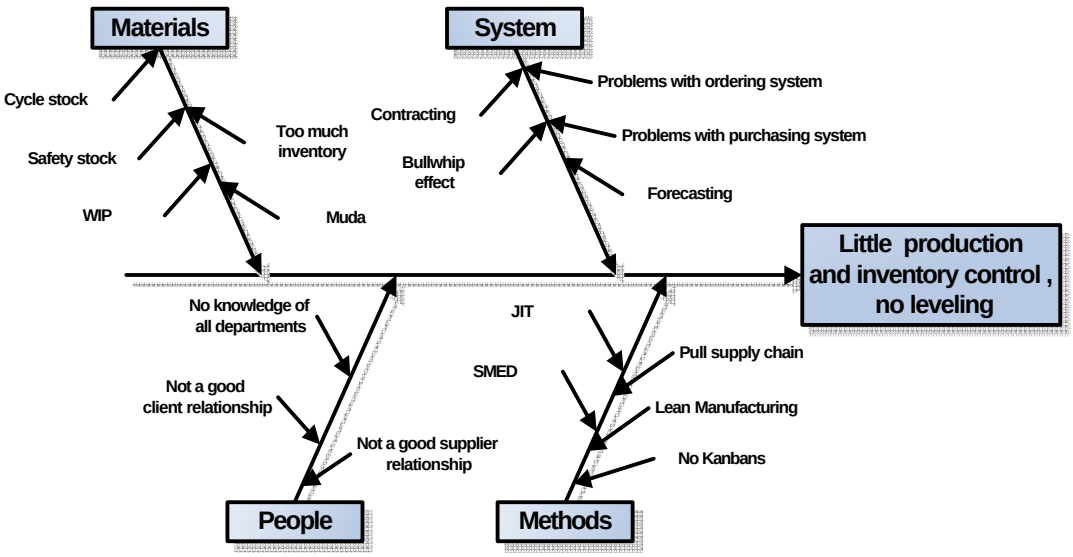
## 2.1 Project Context

The project focuses on introducing level management in all the systems throughout the company. Inventory must be effectively managed and reduced. A kanban system will be implemented on the manufacturing lines and efficiently managed. A pull system created by kanbans will reduce lead time and improve First-In-First-Out (FIFO).

## 2.2 Problem definition

The challenges that Autoliv is facing relates to four aspects within the company's functioning, namely materials, the system, people relations and methods. These problems that are defined in figure 3 are now discussed in more detail.

**Figure 3: Cause and effect diagram**




### 2.2.1 Materials

Autoliv currently has too many inventories on hand. This increases the inventory cost by a large amount. This also leads to muda (waste) in and around the production area. Stock has long lead times and Autoliv has little control over the stock in transit.

### 2.2.2 System

The Bullwhip Effect (oscillations in supply chain) is defined as the variability in observed demand increases with higher stages in a supply chain. This contributes to high cost and poor service in the supply chain. The major cause of the Bullwhip Effect includes demand forecast updating and order batching. Demand forecasting is referred to as an increase or decrease in demand by a firm that tends to get amplified in an order to a supplier. The reasons for this are time lags and quantity uncertainty. In context of demand forecasting, the recency effect is the human tendency to over adjust a forecast in response to signals of changing market conditions. Order batching is ordering more than just what is needed for the immediate future. As a result relatively steady demand observed by a firm is translated into sporadic demand on a supplier. This can cause system slack, time lags, quantity uncertainty, scale economies and misalignment of objectives. The ordering and purchasing system of Autoliv does not give all the adequate information needed. There is no indication of the amount of inventory at the plant and that leads to unnecessary purchasing.

### 2.2.3 People

A good client and supplier relationship is necessary. It is also to Autoliv's advantage that all their personnel are informed of all the operations in each department to promote and understanding of Autoliv's management changes and new system implementations.

### 2.2.4 Methods

The methods that can be used to implement lean manufacturing and Just-in-Time systems are examined. Kanban systems have to be implemented to improve lean manufacturing and Just-in-Time system. This will lead to an improved pull supply chain.

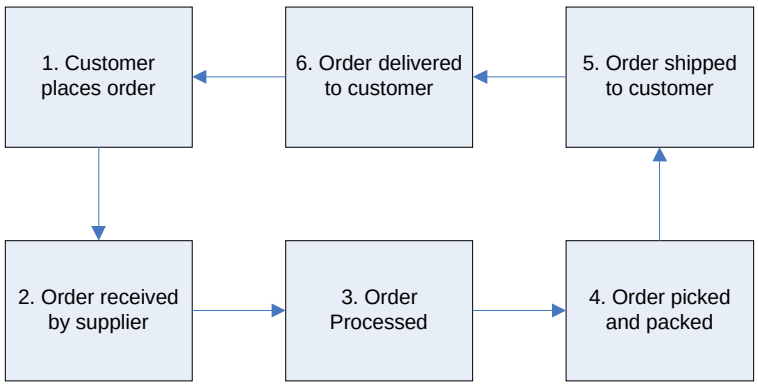
# Chapter 3: Literature review

In this section the technical definitions and types of strategies that are going to be introduced into Autoliv's manufacturing environment will be discussed.

## 3.1 Ordering and purchasing strategy

Gadde and Håkansson (1993) noted that "... what goes on at the interface between individual companies has gradually gained in importance in relation to the effectiveness and development of industrial systems" and that, as a result "... the competitiveness and profit-generated capacity of the individual firm are highly dependent on its ability to handle purchasing", and in this case ordering as well.

**Figure 4: Total order cycle: a customer's perspective**




Ordering and purchasing plays a vital role in the framework of the company. A new developing style that involves careful analysis and planning must be incorporated into the decision making strategy. This requires an understanding of supplier relationships. A comprehension of the product development processes and the scope of quality driven management in the company are vital. All this information leads to a total understanding of how the company operates and the

goals it strives to accomplish. Figure 4 illustrates the procedure that is followed when an order is generated.

### 3.2 Forecasting

Forecasting the amount of each product that is likely to be purchased is an important aspect of inventory management. Most inventory systems require short term forecasting which occur on monthly basis. These forecasts will not be one hundred percent accurate. Time based strategies that focus on reducing the total time from sourcing of materials to delivery of the final product is necessary to compensate for the variability of the forecast. The firm can then respond quicker to changes in demand and therefore of consequently forecasting becomes less critical.

Predicting future demand is important because it allows Autoliv to be primarily proactive rather than reactive. The essence of forecasting is to aid in logistics decision making. There are many types of forecasting of which Autoliv manages demand forecasts. Demand forecasting is the investigation of Autoliv's demand for different finished parts, which includes current and projected demand, inventory status and lead times.

There are numerous reasons for using contracting and forecasting. These methods are used to increase customer satisfaction, using this sufficient information; products can be available to the customer at the right time and in the right amount. Knowing the number of products to be ordered will decrease the probability that there will be shortages of stock. Scheduling of production will be more efficiently, this will increase Autoliv’s ability to evaluate the current schedule and adjust as necessary. Safety stock is inventory which serves as a buffer when demands are uncertain. Better certainty will reduce safety stock levels to a minimum. Small and frequent replenishment shipment to a warehouse offers the advantages of low inventory and an input stream that can be tuned to closely maintain demand. Negotiating superior terms with suppliers can take place which simplifies delivery operations, reduces risk and excess inventory. This all leads to better decisions that can be made by using the information that is provided. This encourages the use of tools and techniques in combination with appropriate information for

problem solving and process improvements. The mentioned advantages can only be possible when the demand is known, by using forecasting and contracting.

Autoliv receives demand forecasts from customers on a monthly basis. Autoliv has a standard procedure that includes taking demand forecast information that was sent from all the suppliers and listing them in an Excel spread sheet calculating the numbers of each product that is going to be needed. This information is used to introduce leveling into the company procedures to prepare Autoliv's production line and to allocate resources accordingly. Figure 5 is an example of the forecast models compiled at Autoliv Southern Africa used to gather information and execute level management.

**Figure 5: Forecast Model**

| CUSTOMER | CUSTOMER NO. | AZA NO. | PACK QTY | 18 | 23 | 20 | 19 |
|---|---|---|---|---|---|---|---|
| DAB | | | | Mar | Apr | May | Jun |
| TSAM | 45130-02340 B0 | 606250401 | 90 | 3417 | 4394 | 4749 | 4495 |
| TSAM | 45130-02340 E0 | 606250402 | 90 | 474 | 492 | 493 | 279 |
| TSAM | 45130-02330 B0 | 606648701 | 90 | 2374 | 2197 | 2215 | 3185 |
| TSAM | 45130-02330 E0 | 606648702 | 90 | | | | 1 |
| STEERING WHEEL LINE | | | | | | | |
| TSAM | 45100-02850 B0 | 607095160X | 3 | 1967 | 1707 | 1867 | 2669 |
| TSAM | 45100-02A40 B0 | 607095161X | 3 | 0 | 0 | 0 | 1 |
| TSAM | 45100-02860 E0 | 607095250X | 3 | 17 | 41 | 52 | 39 |
| TSAM | 45100-02870 E0 | 607095251X | 3 | 156 | 312 | 170 | 127 |

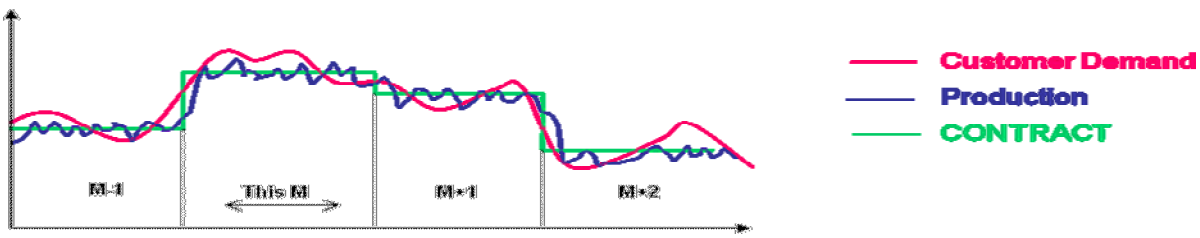
### 3.3 Contracting

A contract between a buyer and a seller defines the terms and conditions of sale. Demand uncertainty can create considerable risk in a supply chain, especially when replenishment lead times are long. This may lead to unhappy customers and lost sales opportunities. The opposite is also a risk. Ordering too much can cause overstocking and high inventory costs. Contracting benefits the client and supplier, because risks related to demand uncertainty are shared. A quantity flexibility contract requires that a client places an order for the total quantity to be delivered monthly. However the client has the flexibility to adjust this quantity within a certain range. If the range is exceeded there will be a penalty. Negotiations will then again take place to authenticate on conditions of sale and product amount (forecasting).

Contracting plays an important role in the ordering and purchasing strategy as well as striving towards lean manufacturing. Autoliv arranges monthly meetings with all their customers. The primary goal is to improve the relationship with customers through discussing all the elements playing a role in the manufacturing process.

A contract is drafted and signed that includes the forecast of daily or weekly orders of the customer. This forecast information is then used to level production in the manufacturing process as seen in figure 6. This process is followed on a monthly basis.

**Figure 6: Contracting**



### 3.4 Lean manufacturing

Waste elimination is a key element in lean manufacturing. There are seven components of waste: inventory, transportation, motion, defects, overproduction, waiting and inappropriate processing. To eliminate waste only the products for which there is a demand should be made. Only exact order quantities should be produced at the appropriate time. Elimination of defects and unnecessary motions are crucial. This must be done throughout the production process. The ideal pursuit is instantaneous single piece flow from the source to the customer.

Setups are required when changing production from one type of product or part to another. Production is halted during setup activities and consequently it is economically infeasible to produce small batches when setup times and costs are high. Setup reductions make setups less costly and less time consuming. To reduce batch sizes the Single Minute Exchange of Dies (SMED) system is implemented.

The ability to change over machines more frequently for manufacturing of different products allow a greater diversity of items made in smaller quantities. This fundamentally alters the basis of production and derives economics of scope. The more responsive the production system is the more it promotes overall systemic effectiveness which is preferential to only increasing the abstract and isolated efficiency. This system promotes flexibility and enhances the ability of a production system to meets the demands of an increasingly differentiated and demanding market.

There are various principles, techniques and practices are used to introduce lean manufacturing in a company. Process analysis can be used to identify room for improvements. Control charts for example are useful in detecting uncontrolled processes so that intervention can immediately take place. Quality control is used when material management activities must be properly administrated and controlled. This requires methods to identify the level of performance. It must be able to measure, report and improve performance. The elimination of delays through shortened production can be achieved by improving production runs and shortening their lead times, this will improve overall productivity.

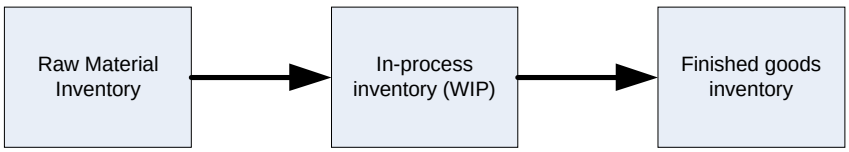
Automation automatically detects and corrects problems.  It enhances the process to make it easy to, not just detect, but prevent defects. Just-in-Time is a system that embodies a set of principles which guides behaviour in an organisation.

Schedule control is the ability to evaluate your current situation and schedule or adjust as necessary. Production balance and leveling must be done when a batch of a certain product type produced is reduced to the minimum size. Standardisation of processes makes it easier to change operations so that planning can be done at a more aggregated level. And implementing a kanban system, this converts the production line into a pull approach for authorising the production and movement of materials.

### 3.5 Inventory

Raw material, work in process, finished products, spare parts and consumables are all different kinds of inventories. Figure 7 illustrates the different types of inventories and where this inventory in is found in the supply chain cycle. Inventory acts as a buffer between the supply and demand of an item and allows an organisation to continue its normal operations while a variability or uncertainty in supply or demand exists.

**Figure 7: Inventory position in the logistics system**




Work-in-process inventory is often maintained between manufacturing operations within a plant. This is to avoid a shutdown should a critical piece of equipment break down and to equalise flow, since not all manufacturing operations produce at the same rate

The stockpiling of work-in-process within the manufacturing complex permits maximum economies of production without work stoppage. Autoliv is focusing on rebalancing production processes to minimise or eliminate the need for work-in-process inventory.

Contracting, forecasts and leveling ensures a steady state in the inventory system. The target inventory level can be reduced through estimating the order size and then calculating the inventory level and the production levels. Autoliv's target inventory level in their parts store will be kept at around three days worth of inventory. Inventory is ordered continuously. The inventory ordering process is controlled with a kanban system.

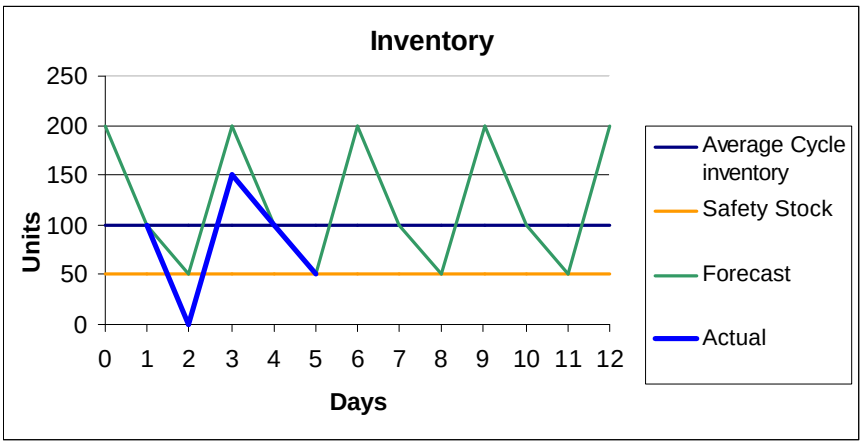
Finished goods inventory can be used to reduce the likelihood of a stockout due to unanticipated demand or variability in lead time. Reduced stockouts may lead to improved customer service. If the inventory is balanced, increased inventory investment will enable the manufacturer to offer higher levels of product availability and less chance of stockout. A balanced inventory is one that contains items in proportion to expected demand.

Cycle stock is created when the inventory used in production is replenished and it is required in order to meet demand under conditions of certainty. Since demand and lead time are constant and known, orders are scheduled to arrive just as the last unit is sold. Thus, no inventory beyond the cycle stock is required.

In transit stocks are items that are on route from suppliers or the company warehouse. They may be considered part of cycle stock even though they are not available until after they arrive at Autoliv. Transit stock is also controlled with a kanban system to visually indicate how long the stock will take to arrive at Autoliv.

Safety or buffer stock is held in excess of cycle stock because of uncertainty and flexibility in demand. Since Autoliv's lead times are constant but demand is variable, the average inventory within an order cycle of three days is calculated. If demand is more than the forecasted demand inventory would be depleted. When the demand is more than the forecast model the safety stock is used to fill the demand as shown in figure 8.

**Figure 8: Average inventory investment under conditions of uncertainty**




### 3.6 Rail management

Rail management is an hourly activity. The rail is a First In First Out tool. The operator follows the sequence of the kanban cards that are delivered from the Heijunka board. The Heijunka board is a board with timeslots, where the kanbans are placed to be manufactured. The rail also is a visual tool to compare the pace of the actual production against the planned production. This represents Takt time.

### 3.7 Pull Supply Chain

A pull approach is reactive. Actual demand is used to signal when to order or produce products. It doesn't rely on future expectations or forecasts to indicate when production should begin. A pull supply chain is maintained with the JIT principle. It operates on the principle that the supply chain must be able to deliver to the market when needed. An advantage of the pull approach is simplicity.

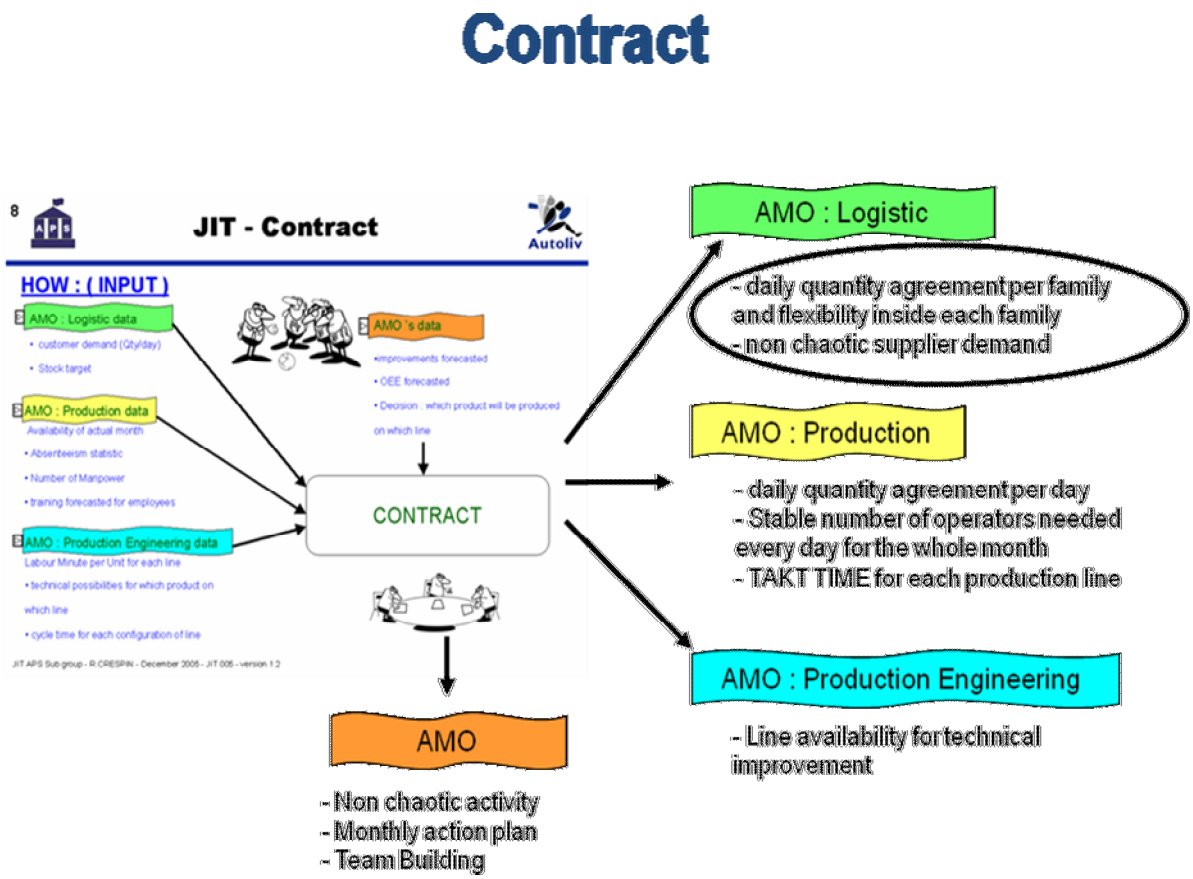
# Chapter 4: Methods

In this chapter the methods used to implement and improve lean manufacturing and Just-in-Time systems at Autoliv Southern Africa are discussed. Implementation of these methods as well as the consequent results is also included.

## 4.1 Implementing the contract

A standard contract was designed and implemented at Autoliv Southern Africa. Figure 9 illustrates the number of inputs from both the customer as well as Autoliv. The outputs that result from this contract are positive not only because Autoliv can plan its resources but it also minimises the risk that the customer has to undertake.

**Figure 9: The contract elements**



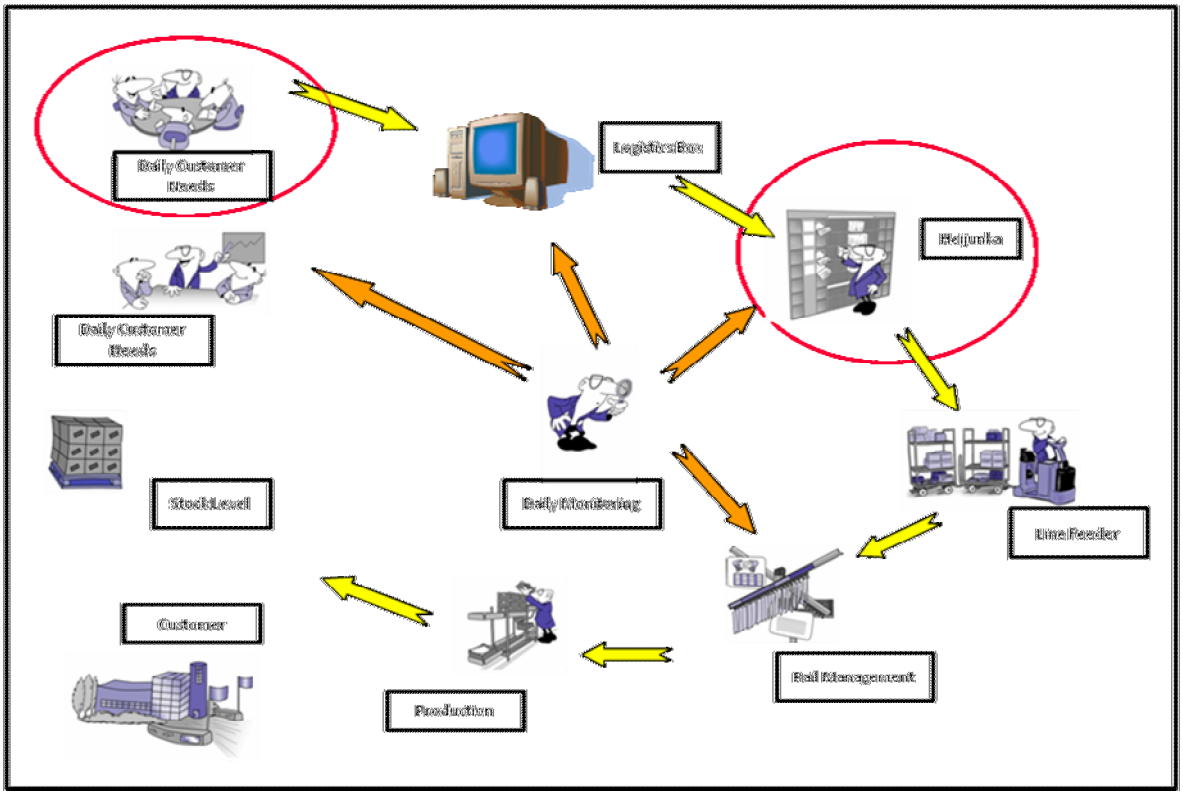
The information collected and compiled by the customer and Autoliv Southern Africa for use in the contract is called logistical data. It includes the quantity of products that the customer expects to order and the stock targets that are set. Stock target levels are the level of inventory that is needed to meet the demand for a product or component over a specified period. The production data specified in the contract includes details of the planned training for employees during the relevant month, the availability of manpower and statistical information like percentage of absenteeism among employees. The production engineering data provided in the contract includes the labour minutes per unit for each production line, the cycle time for each configuration of the production line and the technical possibilities of each product on each line. The production schedule is also taken into account. As a result the logistic department can determine the daily production quantity and the flexibility per product family. A product family is a group of products that are related through common functionalities. The calculated production quantities contribute to an orderly supplier demand thanks to sufficient information available.

Using the daily quantity agreement figures, the production department can determine a stable number of operators needed daily. Takt time can also be determined for each production line. The production engineering can use the information from the production department to determine the un-availability of lines that need technical improvements and schedule their work around the production schedule. The final output is a monthly action plan for all the production lines which utilizes all details given in the contract. This guarantees orderly activities and a proactive rather than reactive plant.

Figure 10 depicts the process flow in Autoliv's manufacturing environment. It indicates the sequence flow of each process. First the needs of the customer and supplier are examined and the input of this information is accumulated into the system where it is used to plan the contract details. An action plan is then designed for the production lines, inventory processes and the

inventory levels in the stores. Therefore it is very important to implement these processes correctly.

**Figure 10: Graphical illustration of contracting, leveling and rail management**

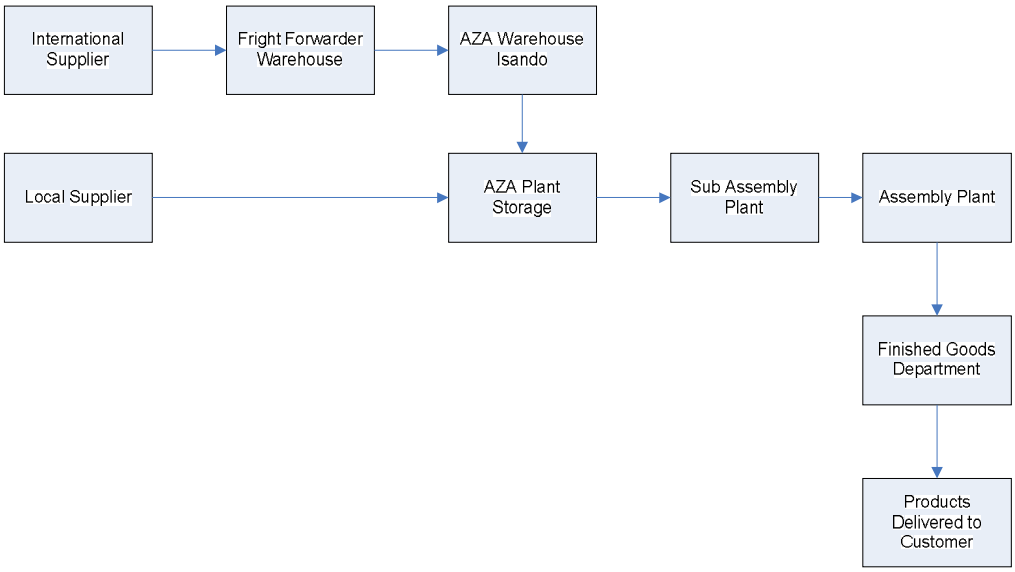



## 4.2 Analysis of the material flow

Material flow plays a major role in Autoliv's manufacturing plant. The flow of material is investigated in order to get a better understanding of the route the material takes externally and internally in the plant. Any form of improvement relevant to material has to take all the processes and procedures that are linked to the material flow process into account. To design the leveling database a thorough understanding of all material movement is needed.

Figure 11 depicts is a high level view of the flow of material. The process of material flow begins where the basic components from suppliers enter the process, and ends where a single unit is delivered to the customer.

**Figure 11: High level view of material flow**




Different components are received from various local and international sources. The international supplies are brought to South Africa via Birkard, a fright forwarder. When the material arrives at Durban it is taken to an external warehouse in Isando. The material is stored there until it is needed at Autoliv's manufacturing plant. The local suppliers deliver their supplies directly to Autoliv's manufacturing plant. A picker-to-part system is used to store he components at the manufacturing plant.

The components are order picked and transferred to the sub assembly plant. After the completion of the sub assemblies it is stored in sub assembly racks. The completed sub

assemblies then go to the assembly lines. The finished product is transported to the finished goods department where they are picked and packed to be delivered to Autoliv's customers.

### 4.3 Value Stream Mapping

A value stream is all the actions (both value added and non-value added) required to take a product through the main flows essential to every product. It refers to the production flow from raw material into the hands of the customer and the design flow from concept to launch.

Taking a value stream perspective means considering the big picture and not just the individual processes. Advantages of value steam mapping include that the entire process is visualised as a whole, waste is recognised, lean concepts and techniques are tied together and the basis of an implementation plan is formed.

### 4.4 Improving the ordering and purchasing strategy

The first action to be taken in the improvement of the ordering and purchasing strategy is to create an information flow process that includes all relevant personnel. This is done through workshops that inform Autoliv's personnel of the key elements in every department and the company's goals.

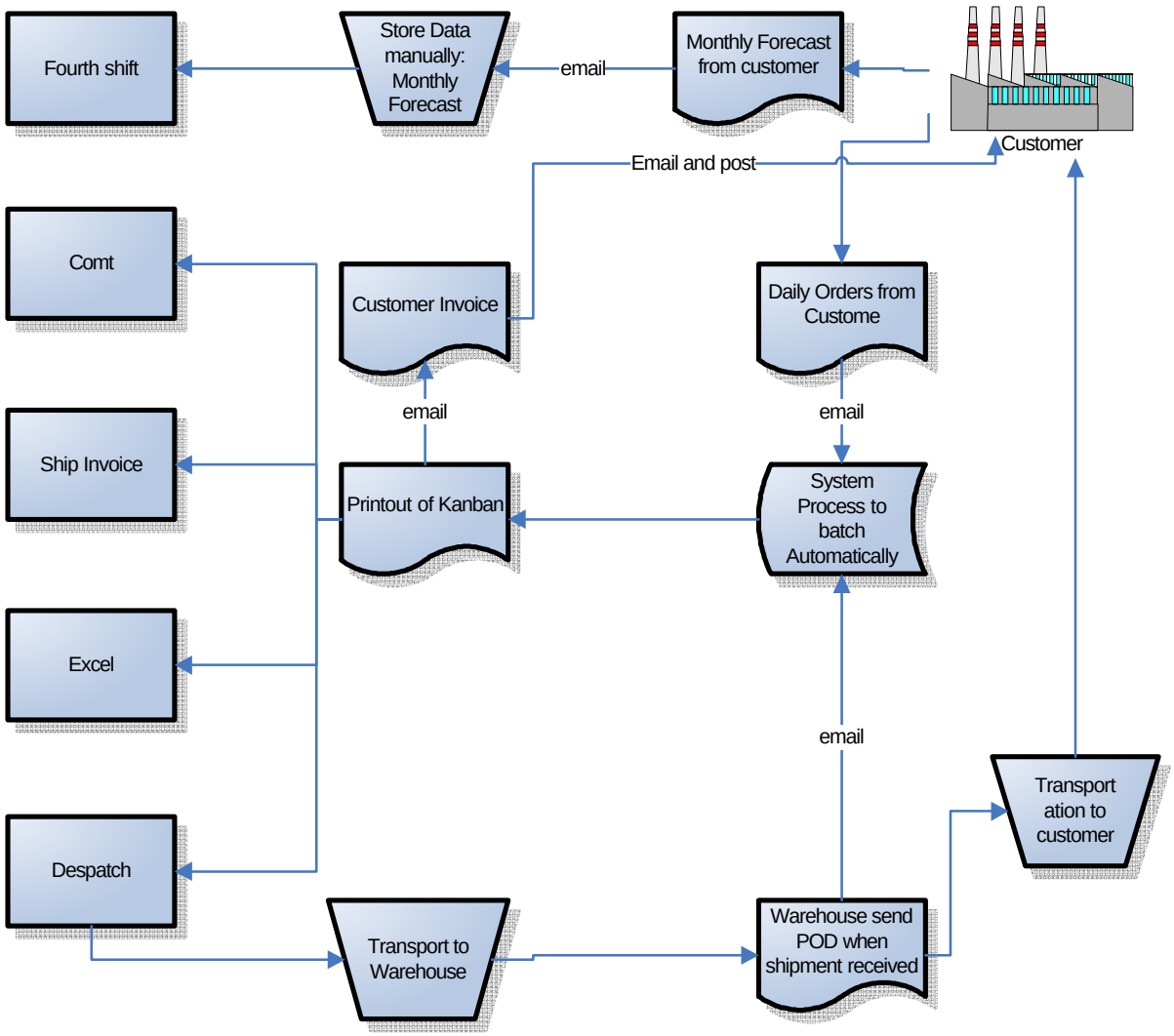
The next step is to set systems in place that will improve the relationships between departments and mobilise acquired information. Autoliv's ordering and purchasing system will be improved by the use of value stream mapping.

#### 4.4.1 The Current state of the purchasing process

The current purchasing process was investigated. The entire process, from beginning to end, was documented using the Value Stream Mapping principle.

Figure 12 illustrates the customer purchasing process. After analysis problems within the processes were identified. Challenges due to the faulty processes were discussed and taken into account during the problem solving initiative.

**Figure 12: Customer purchasing process**



Enterprise Resource Planning (ERP) is used throughout the company. It is a software application that integrates information systems that extent over most of the basic, core business functions. The software application that Autoliv uses is called Fourth Shift. It is structured around a common database shared by common business functions.

The customer e-mails a demand forecast to Autoliv on a monthly basis that is stored in a database. The data is transferred to the production department. This data is captured manually by hand into a program called Fourth Shift. Fourth Shift generates job cards that are used to initiate the manufacturing of the products ordered. The system automatically allocates the orders into batches. A kanban invoice is printed and sent to the finished goods department. The kanban contains picking and packing instructions to enable warehouse withdrawal of the products.

Next the shipping documentation is sent to the ship invoices department. An excel spreadsheet is updated with the order data and compared with the demand forecast that the customer initially e-mailed Autoliv.

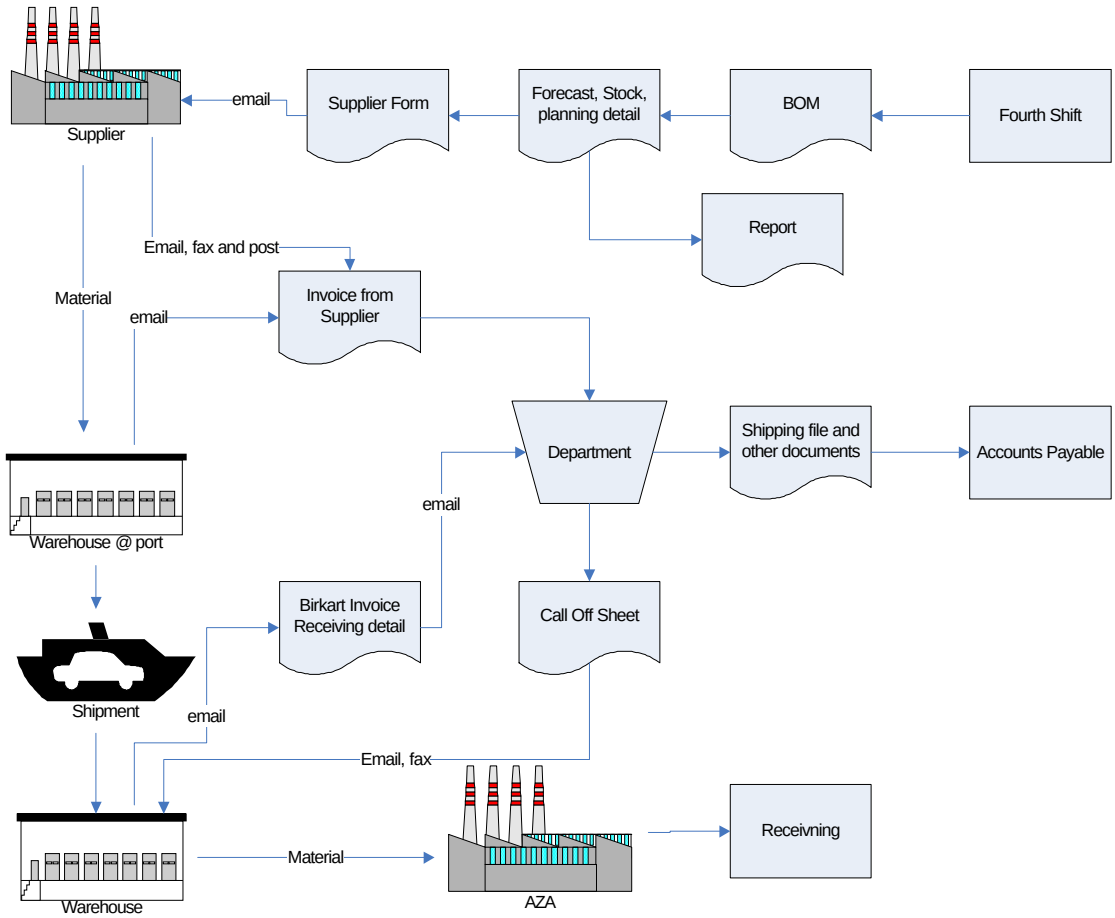
The kanban invoice is e-mailed to the invoice department so they can create an invoice for the customer. The customer's invoice is e-mailed and posted to the customer. The finished goods department generates the order using Fourth Shift.

After the products have been manufactured they are packed into crates for transportation. The order is transported to Autoliv's outgoing warehouse called X-Dock. When it arrives at X-Dock the necessary information is sent to the system process so that the products can be batched into the correct order sizes. The order is delivered to the customer.

### 4.4.2 The Current state of the ordering process

Autoliv's current ordering process was investigated. The Value Steam Mapping principle was used to examine and map the processes as shown in figure 13. The inputs and output were researched and analysed.

**Figure 13: Supply ordering process**



Fourth Shift updates the bill of materials daily. Chase, Jacobs and Aquilano (2006) define bill of materials as follows: "The bill of materials contains the complete product description, listing not only the materials, parts and components but also the sequence in which the product is created." From the bill of material a report is generated that contains forecasts, stock detail and planning detail.

A document containing the product details, quantities and departure week information of the ordered products is e-mailed to the supplier. The supplier e-mails, posts and faxes their corresponding invoices to Autoliv's various department.

When the international suppliers are ready to supply the material needed, they deliver the material to the freight-forwarder. The freight-forwarder collects the material and transports it to their warehouse at the port where the material is managed and shipped to South Africa. The material is then transported from Durban to Autoliv's warehouse in Isando after which the freight-forwarder e-mails the invoice receiving details to all the relevant departments at Autoliv Southern Africa. Autoliv creates shipping files that are sent to the accounts payable department.

When material is needed at Autoliv's manufacturing plant in Chamdor, Krugersdorp a call-off sheet is emailed to the warehouse in Isando. The materials are picked and packed to be transported to Autoliv's manufacturing plant. The material is received and checked into the parts store at Autoliv's receiving department.

### 4.4.3 Addressing the challenges

A general problem solving approach, consisting of seven steps, was used to carefully consider and investigate the ordering and purchasing processes:

1. Identify the problem;
2. Analyse and understand the problem;
3. Identify solutions requirements or expectations;

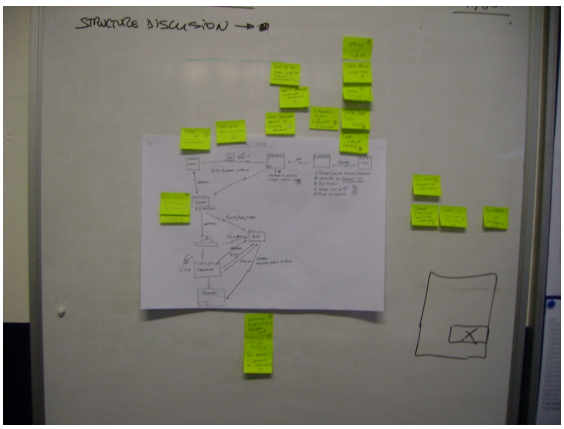
4. Identify alternative solutions and choose the best course of action;
5. Design the chosen solution;
6. Implement the chosen solution; and
7. Evaluate the results.

The implementation of steps 1, 2 and 5 are discussed in the following sections.

#### 4.4.3.1 Identifying and analysing the challenges

The results of the investigation indicate a number of problems within Autoliv's ordering system. They include an excess amount of paperwork, time lost due to the need to double check orders, insufficient communication of goals to employees, the magnitude of information that needs to be processed by the system as well as issues regarding logistics. Each of these challenges are subsequently discussed

**Figure 14: Problem identification**




A problem that occurs regularly is the amount of paperwork that the process generates and the need to double check every step taken in the ordering and purchasing processes. The system relies on manual calculation of stock orders and releases which may result in errors and faulty

calculations. Stock orders therefore have to be double checked in order to minimise errors. This takes up a lot of time. Since the system is mainly focused on order processing, a lack in inventory processing exists. Inventory can therefore not be managed efficiently.
One of Autoliv's policies is to visually display as much information as possible in order to facilitate the personnel's understanding of how systems operate. The visual displays do not include the goals set by the company. This lack of information prevents the personnel from reaching these goals.

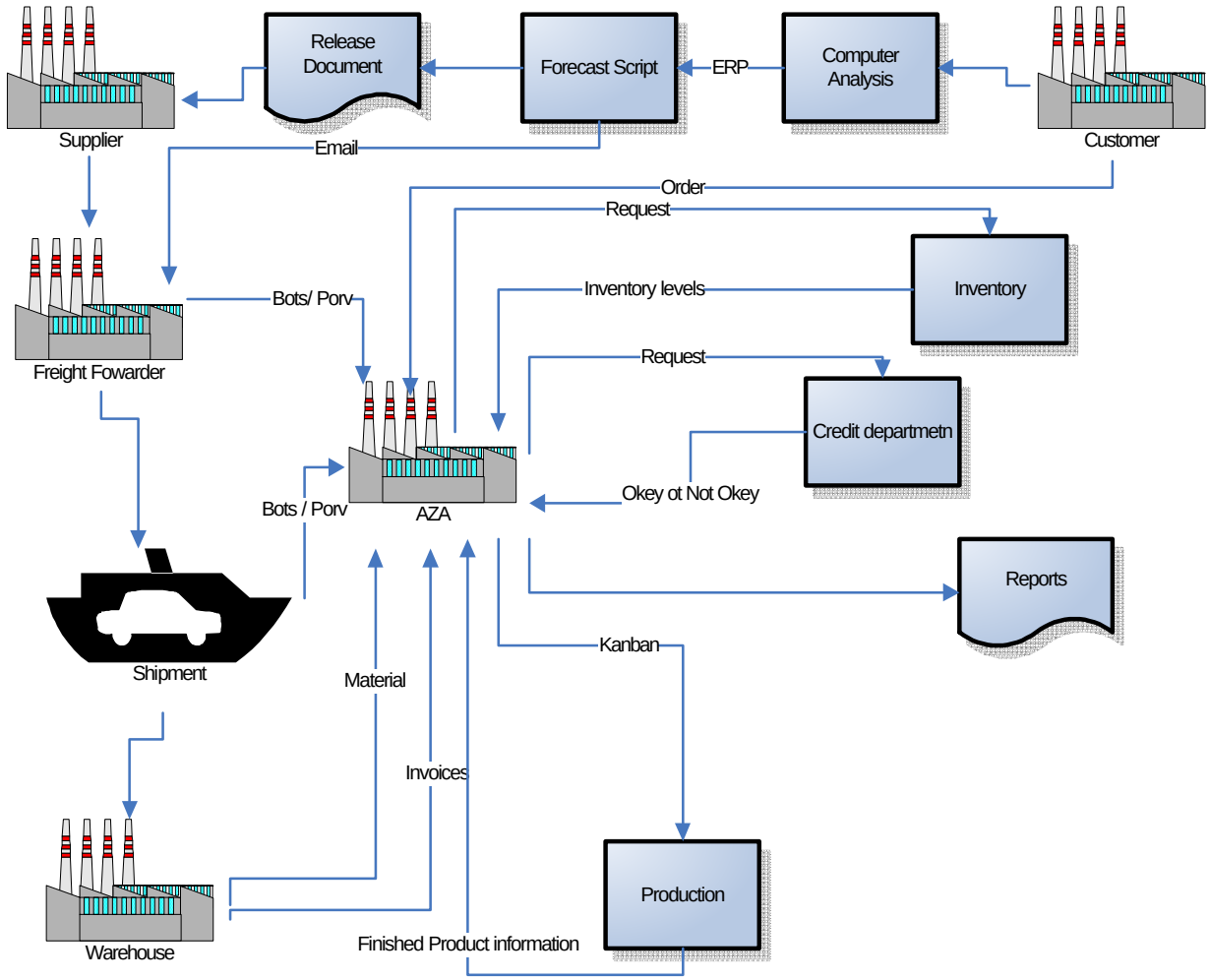
The ordering and purchasing systems was originally designed to handle only a few components at a time. Autoliv has grown over the years and the components they use have also grown to a large number. This causes the system to struggle with the magnitude of information entered into the system. Excess theoretical information overloads the system causing it to be too sensitive when change occurs, for example when a forecast is updated or changed. As a result the system has to be stabilised.

The last challenge that needs to be addressed relates to logistics. Autoliv fails to integrate logistics with manufacturing and customer ordering. Only manufacturing and customer orders were initially used in the system design. When logistics aren't taken into account, the state of the inventory and stock isn't invisible to the department.

#### 4.4.3.2 Design the chosen solution

After all the limitations within the ordering and purchasing systems were identified and new processes were initiated the solution illustrated in figure 15 was introduced. The ordering and purchasing process was combined cancelling out any duplication that occurred within the separate processes. The input time was also minimised.

**Figure 15: Proposed solution**




The standard contract that is implemented entails a full customer analysis as well as the information needed to plan the material forecasted for the orders.

Once the order enters the order processing system various checks are made to determine whether the desired product is in stock and in the quantities needed. The customer's credit is verified before the order is accepted.

The product is then scheduled for production. The product is back-ordered if necessary and a production order is issued. The inventory file is updated regularly. A report indicating the inventory balance is also generated.

The following steps in the order processing are to provide information for invoicing. A letter of acknowledgment of the order is send to the customer, picking and packing instructions are sent to the warehouse to enable withdrawal of the product and shipping documentation are sent to the freight-forwarder. All these processes are automated seamlessly to reduce excess input data and avoid the errors, paper shuffling and non-value added manual effort.

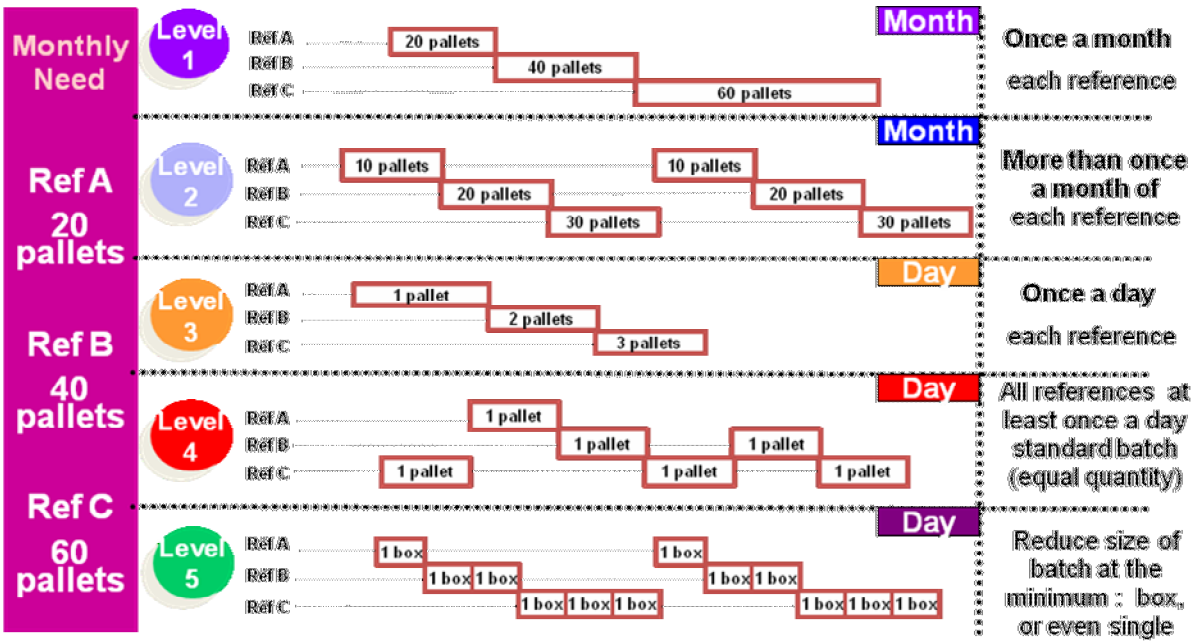
After the inventory report has been generated it is analysed. Preparations are made to ensure that arrival of a kanban from the stores (to signal which product need to be reordered for the suppliers) initiates the ordering process.

In future Autoliv's material suppliers will receive documentation that state the quantities needed for production. The customer can then be prepared for the costs due when an order arrives from Autoliv. This system streamlines the delivering and receiving of material.

### 4.5 Leveling and reducing batch sizes

Leveling can be adapted to the rhythm of the customer's needs. In some levels the number of references made monthly is established. Autoliv Southern Africa is currently situated between levels two and three. Accordingly their production runs take place on a weekly basis. Autoliv strives towards reaching the top level. This will reduces the batch sizes to a minimum (a box size or single product) and increase the number of production runs in a month as seen in figure 16.

**Figure 16: Reference levels and Production runs**




All Autoliv plants has to function at a reference level higher than that of their customer. The smaller the batch size the less stock is needed on the facilities. This enables the company's predictability and reliability in the eyes of their customers. When Autoliv is producing smaller batch sizes they can exert better control over their systems. It creates an environment of minimal logistical risk for the customer.

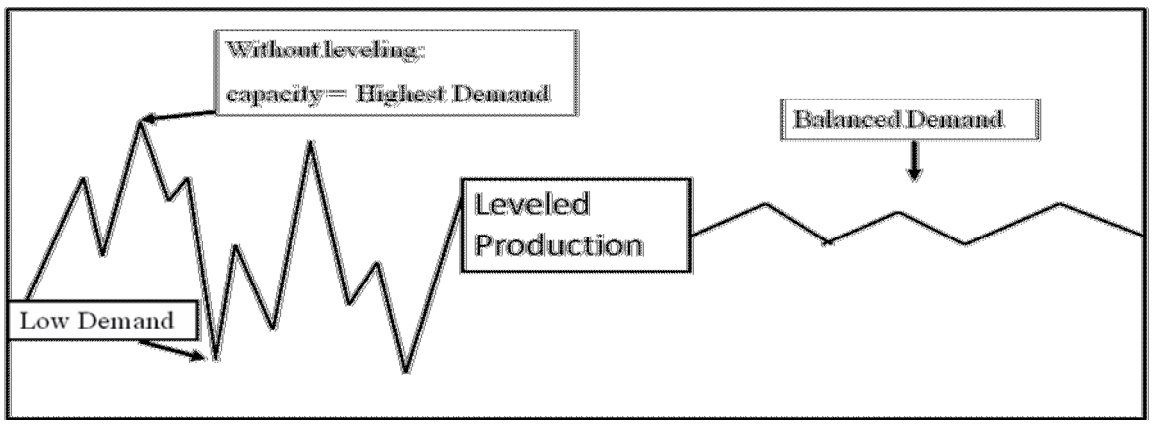
It also provides a flexible environment within which Autoliv's operations can take place. If down time occurs the customer can still be assured of a percentage of their order since change can easily be accommodated. The risk of not being able to meet the customers needs are therefore decreased.

### 4.6 Leveling

Leveling is introduced after a contract has been negotiated and signed by the customer. Figure 17 illustrates the positive influence that Leveling can have on the demand levels in a company. Leveling is implemented daily. When it is introduced correctly into the system, the size of a specific product batch is reduced to a minimum.

The three elements that play a role in leveling are volume, variety and time. When demand is level it enables the company to determine their need for manpower, the volume of material used and at what time to use the machinery.

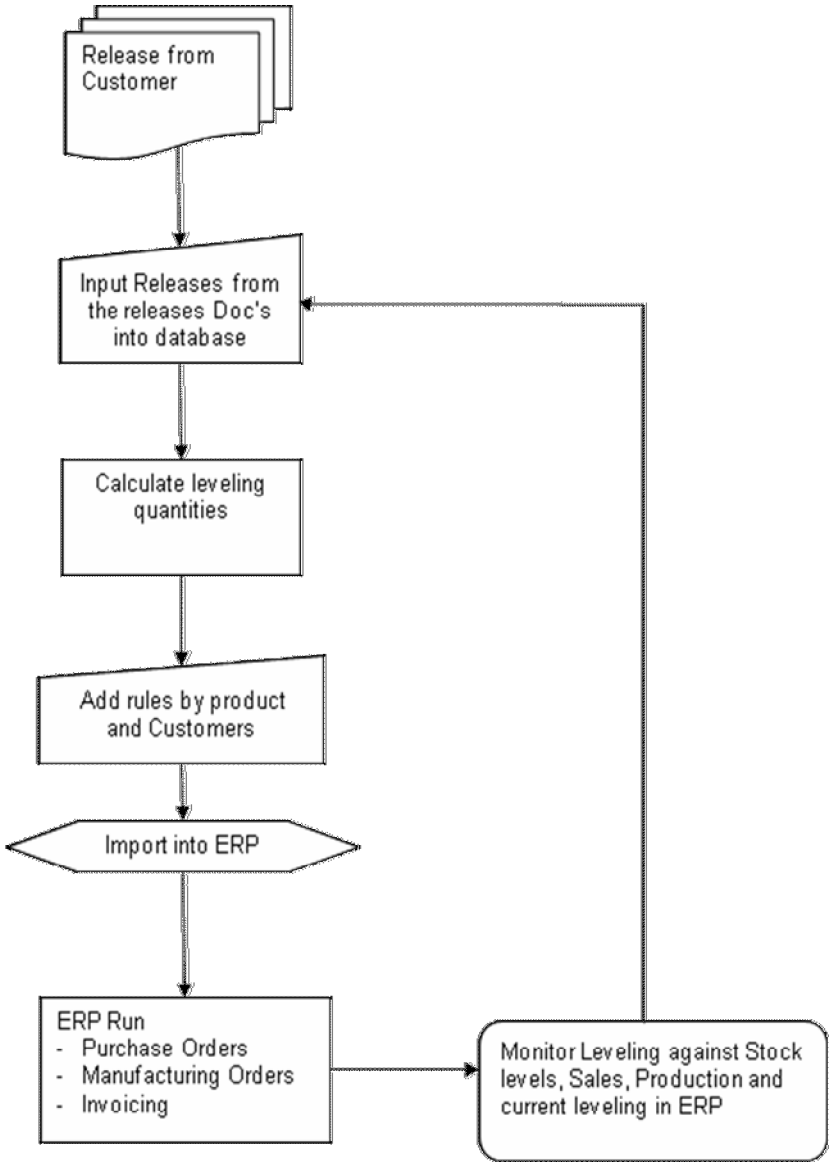
**Figure 17: Leveling production**



## 4.7 Leveling Analysis

In order to incorporate leveling into the business process a new system was designed. Firstly a high level overview (see figure 18) was designed to indicate where and when leveling should take place in a system.

**Figure 18: High-level view of the Leveling Process**



### 4.8 Leveling Database

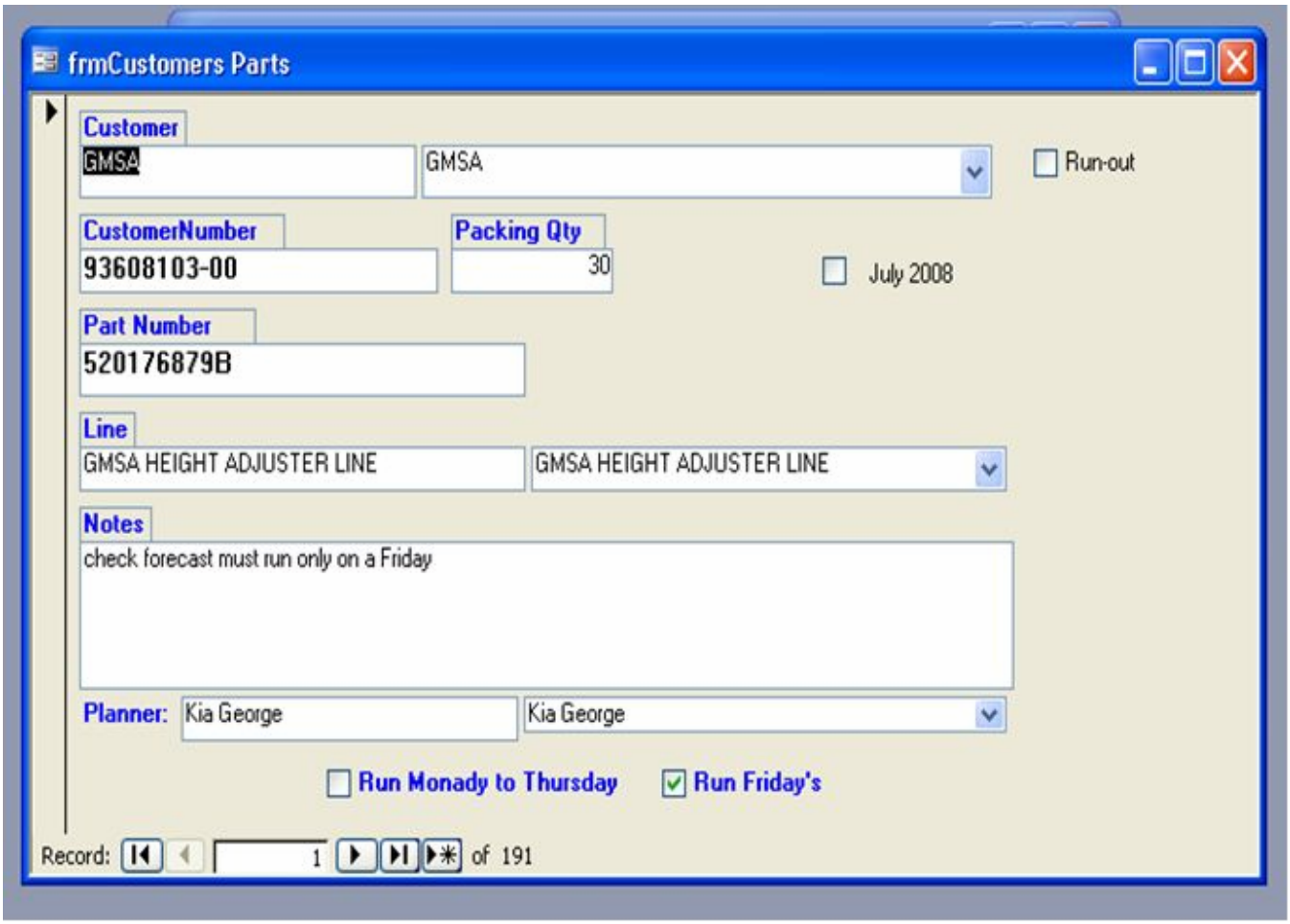
A new database to introduce leveling, was designed in Microsoft Office Access (see figure 19). The leveling database incorporates forecasting into the production planning to enable calculation of the level quantities per product that needs to be produced each month. The database is linked to the company's ERP (Enterprise Resource Planning) system. The ERP system is an integrated software solution that is used to manage Autoliv's available resources.

**Figure 19: Leveling Database Menu**

### 4.8.1 Customer detail

A number of information databases were created and interlinked to promote sharing information. A customer detail database (see figure 20) was created to accumulate customer information. A customer number is automatically assigned to each customer and is used throughout the system. This improves the identification process.

**Figure 20: Customer detail database**



### 4.8.2 Forecasted demand

When a contract is signed by the customer, the forecast information supplied by the customer is introduced into the system. By selecting the “Releases New” option the customer release form is displayed (see figure 21). The requested part number is chosen from a list and then the stipulated order amount is entered into the system. The “date on release” window displays the date the information was uploaded.

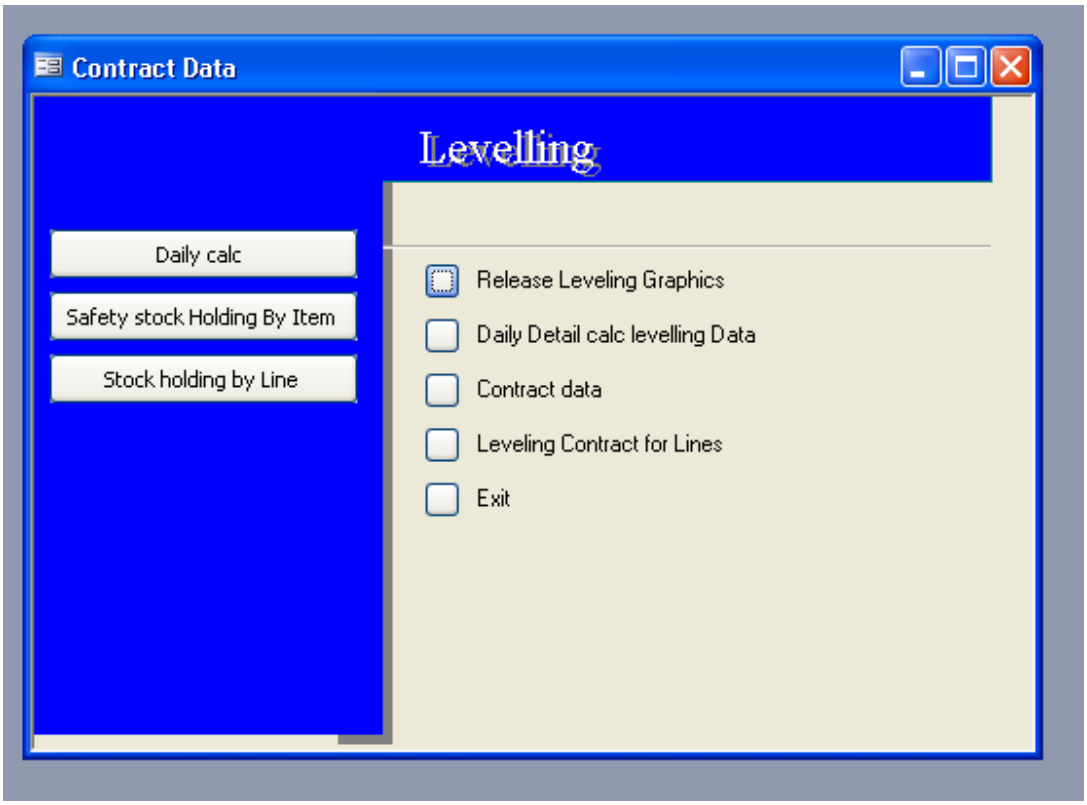
After the demand forecast data has been introduced into the system the leveling calculations are automatically updated.

**Figure 21: Customer release form**

### 4.8.3 Contract data

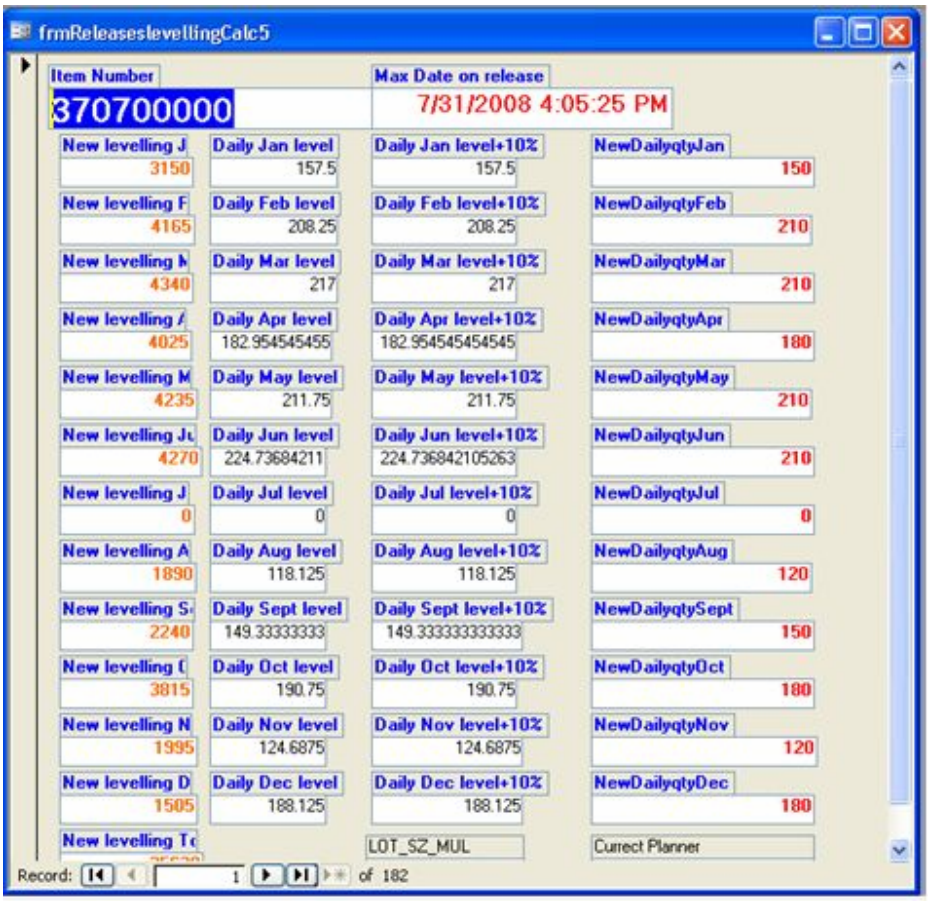
On the leveling database menu (see figure 22) there is a contract data option. The contract data is fed into the database and then used to calculate and display the leveling product quantities.

**Figure 22: Contract Data Menu**



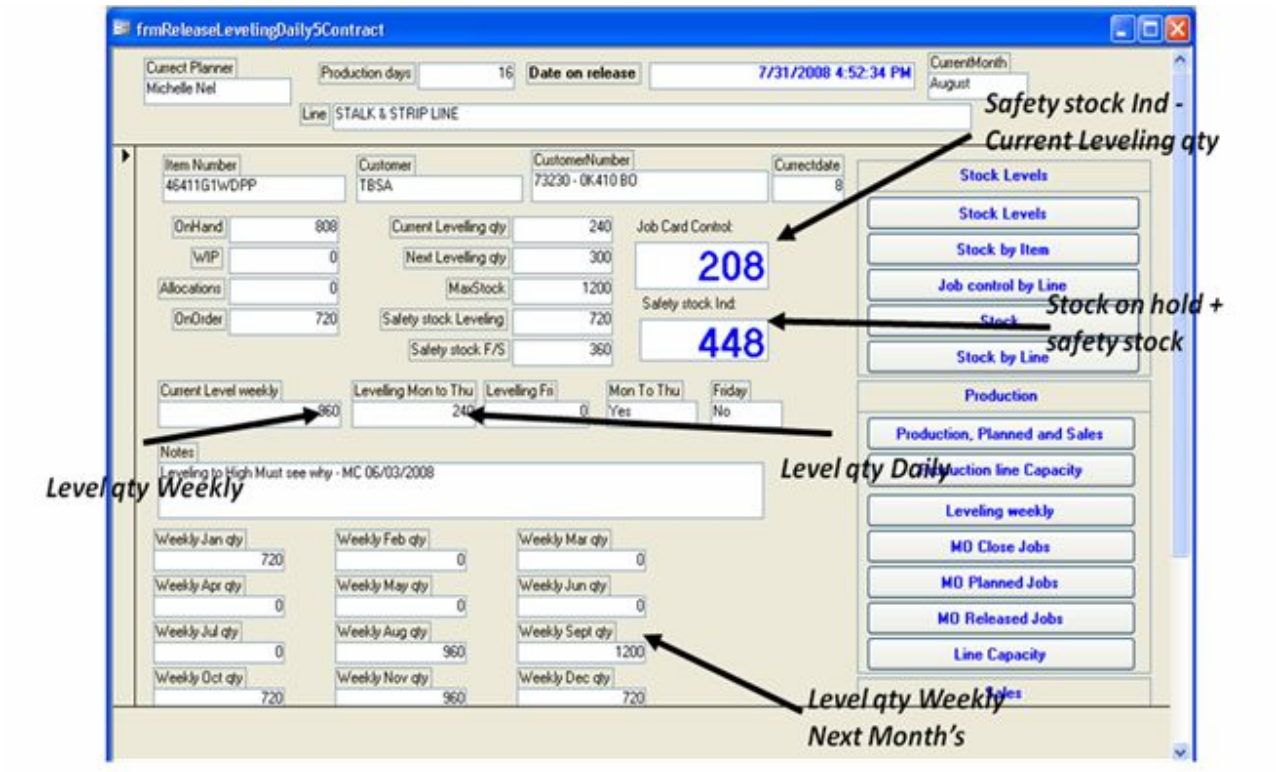
There are two main options used to display the leveling quantities. The daily leveling numbers are automatically calculated. The leveling quantities are displayed on a daily basis as seen on the screen below (figure 23). The leveling quantities are then imported into the ERP system (Enterprise Resource Planning) to plan logistics, resources and production.

**Figure 23: Daily detail calculation leveling data screen**



Clicking on the leveling contract for lines button reveals a summary of each product on each line as can be seen in figure 24. The weekly and daily leveling quantities are displayed. Inventory logistics are also included in that, the stock on hold and safety stock available is also displayed. The First-In-First-Out principle is applied which means that the stock on hand and safety stock are released first. The Job Card Control screen displays the amount of safety stock that is not allocated to be released during that week. The next week's stock on hand is calculated accordingly and taken into account when issuing the job card.

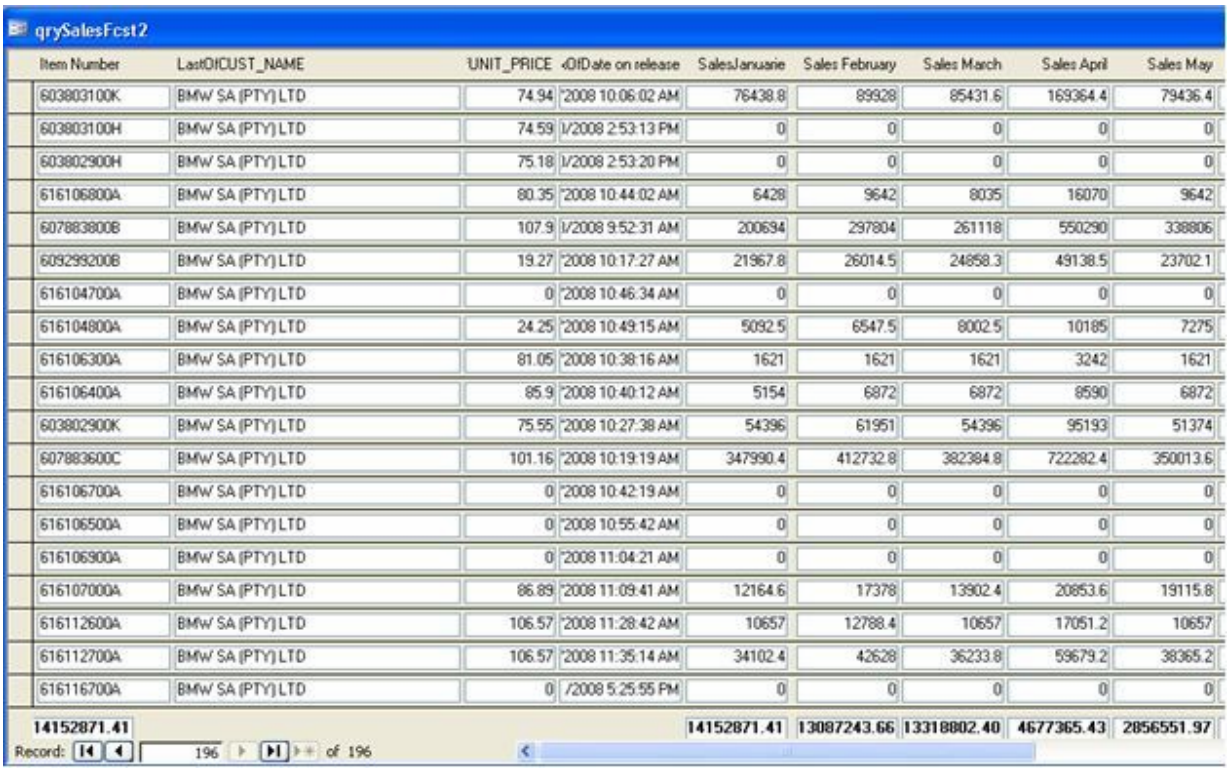
**Figure 24: Leveling contract for lines screen**



### 4.8.4 Sales from releases

The actual demand or sales numbers is monitored since the contract states that if the customer exceeds or fails to meet the initially forecasted amount of orders the contract has to be revised to suite the customer's and the company's needs. An example of an actual sales record can be viewed in figure 25. The information is used to compare the actual sales and the customer forecasted demand. Consequently the customer can be informed of any irregularities and suggestions can be made to improve the contract between Autoliv and its customers.

**Figure 25: Sales from releases screen**



qrySalesFcst2

| Item Number | LastOfCUST_NAME | UNIT_PRICE | LastOfDate on release | SalesJanuarie | Sales February | Sales March | Sales April | Sales May |
|---|---|---|---|---|---|---|---|---|
| 603803100K | BMW SA (PTY) LTD | 74.94 | 2008 10:06:02 AM | 76438.8 | 89928 | 85431.6 | 169364.4 | 79436.4 |
| 603803100H | BMW SA (PTY) LTD | 74.59 | 1/2008 2:53:13 PM | 0 | 0 | 0 | 0 | 0 |
| 603802900H | BMW SA (PTY) LTD | 75.18 | 1/2008 2:53:20 PM | 0 | 0 | 0 | 0 | 0 |
| 616106800A | BMW SA (PTY) LTD | 80.35 | 2008 10:44:02 AM | 6428 | 9642 | 8035 | 16070 | 9642 |
| 607883800B | BMW SA (PTY) LTD | 107.9 | 1/2008 9:52:31 AM | 200694 | 297804 | 261118 | 550290 | 338806 |
| 609299200B | BMW SA (PTY) LTD | 19.27 | 2008 10:17:27 AM | 21967.8 | 26014.5 | 24858.3 | 49138.5 | 23702.1 |
| 616104700A | BMW SA (PTY) LTD | 0 | 2008 10:46:34 AM | 0 | 0 | 0 | 0 | 0 |
| 616104800A | BMW SA (PTY) LTD | 24.25 | 2008 10:49:15 AM | 5092.5 | 6547.5 | 8002.5 | 10185 | 7275 |
| 616106300A | BMW SA (PTY) LTD | 81.05 | 2008 10:38:16 AM | 1621 | 1621 | 1621 | 3242 | 1621 |
| 616106400A | BMW SA (PTY) LTD | 85.9 | 2008 10:40:12 AM | 5154 | 6872 | 6872 | 8590 | 6872 |
| 603802900K | BMW SA (PTY) LTD | 75.55 | 2008 10:27:38 AM | 54396 | 61951 | 54396 | 95193 | 51374 |
| 607883600C | BMW SA (PTY) LTD | 101.16 | 2008 10:19:19 AM | 347990.4 | 412732.8 | 382384.8 | 722282.4 | 350013.6 |
| 616106700A | BMW SA (PTY) LTD | 0 | 2008 10:42:19 AM | 0 | 0 | 0 | 0 | 0 |
| 616106500A | BMW SA (PTY) LTD | 0 | 2008 10:55:42 AM | 0 | 0 | 0 | 0 | 0 |
| 616106900A | BMW SA (PTY) LTD | 0 | 2008 11:04:21 AM | 0 | 0 | 0 | 0 | 0 |
| 616107000A | BMW SA (PTY) LTD | 86.89 | 2008 11:09:41 AM | 12164.6 | 17378 | 13902.4 | 20853.6 | 19115.8 |
| 616112600A | BMW SA (PTY) LTD | 106.57 | 2008 11:28:42 AM | 10657 | 12788.4 | 10657 | 17051.2 | 10657 |
| 616112700A | BMW SA (PTY) LTD | 106.57 | 2008 11:35:14 AM | 34102.4 | 42628 | 36233.8 | 59679.2 | 38365.2 |
| 616116700A | BMW SA (PTY) LTD | 0 | /2008 5:25:55 PM | 0 | 0 | 0 | 0 | 0 |
| 14152871.41 | | | | 14152871.41 | 13087243.66 | 13318802.40 | 4677365.43 | 2856551.97 |

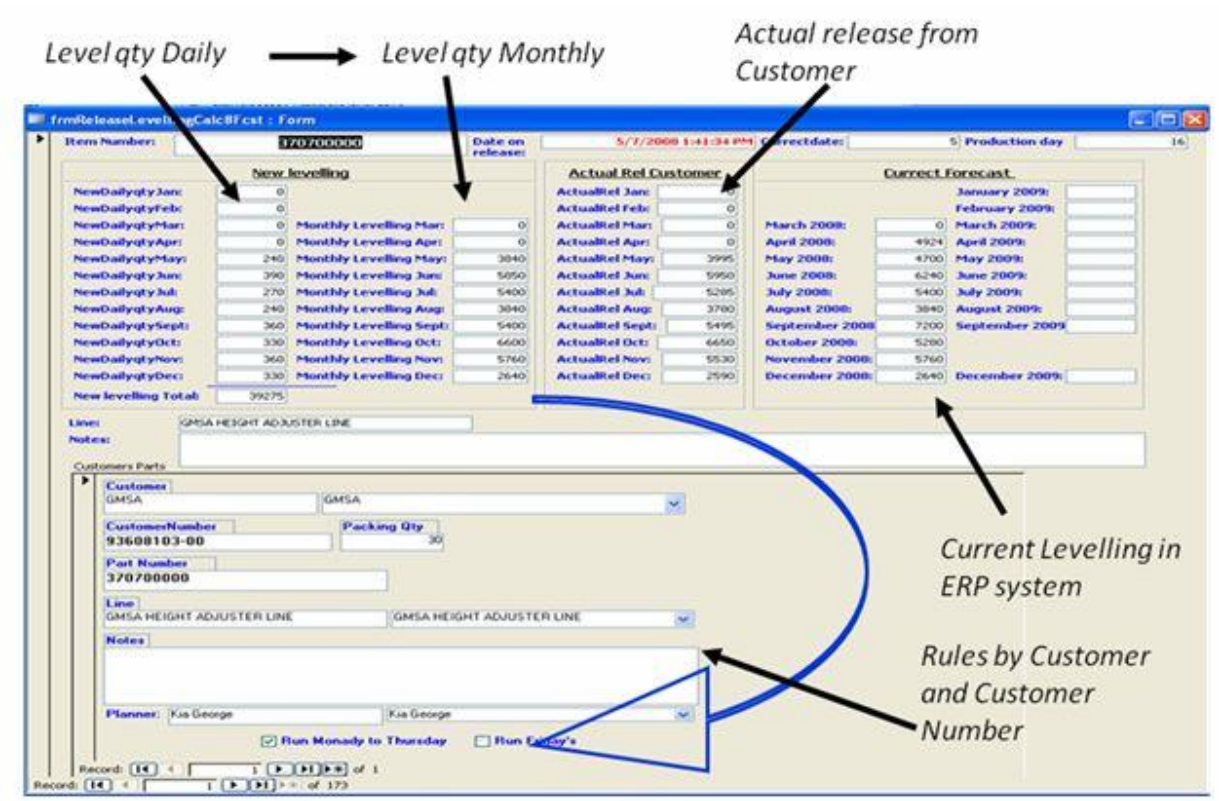
Record: 196 of 196

### 4.8.5 Summarised data

The summarised data page displays a summary of the projected and actual number of sales as well as the customer's specifications. It enables the viewer to compare the projected and actual sales.

The demand forecast was used to calculate the daily and monthly level quantities and are displayed in the leveling forecast screen (see figure 26). The actual demand ordered by the customer is displayed next to the leveling data. The current level quantities that are allocated in the ERP system are also indicated. The customer's detailed information is displayed at the bottom of the screen along with any additional requests from the customer.

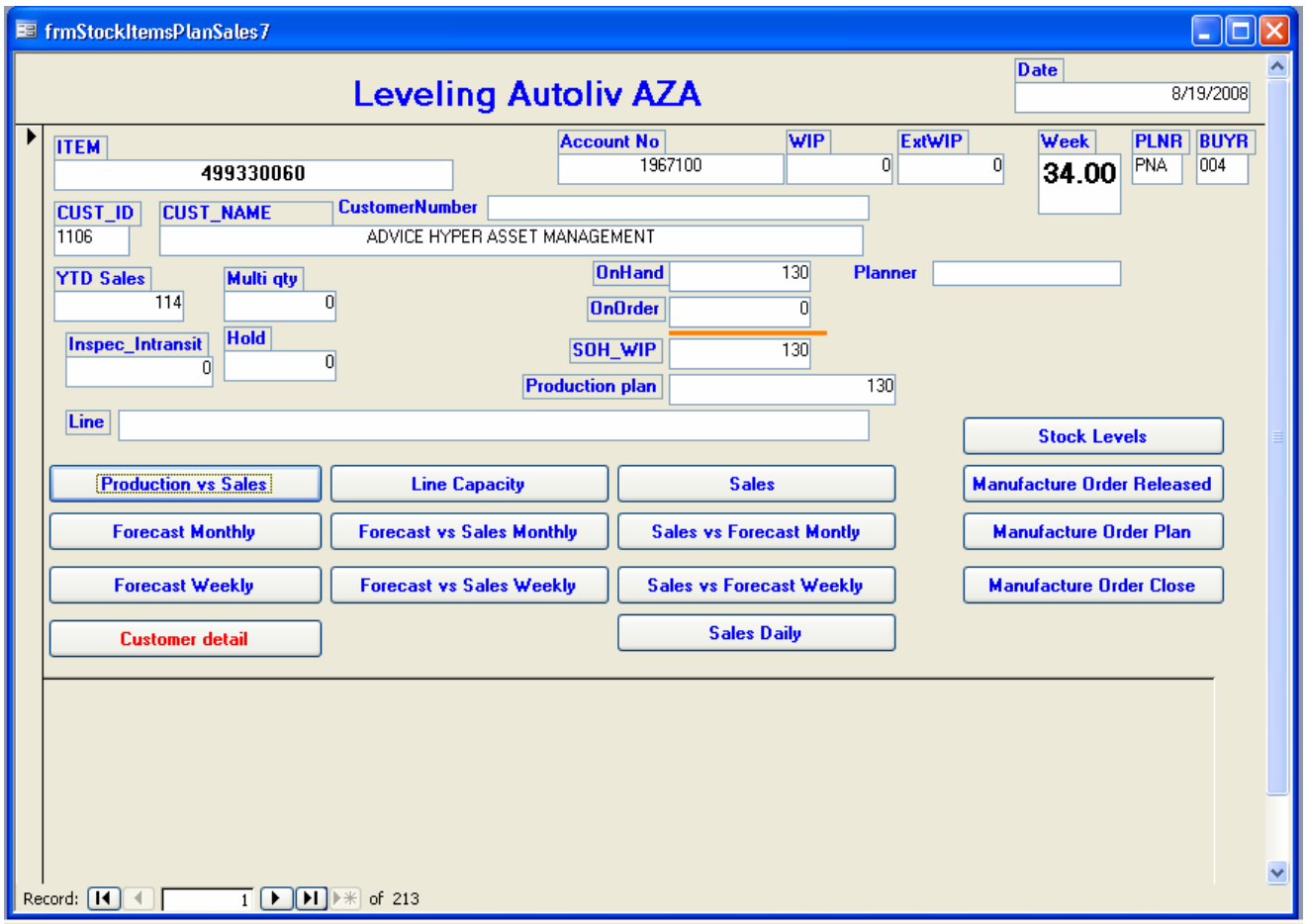
**Figure 26: Summarised data screen**



### 4.8.6 Master Database

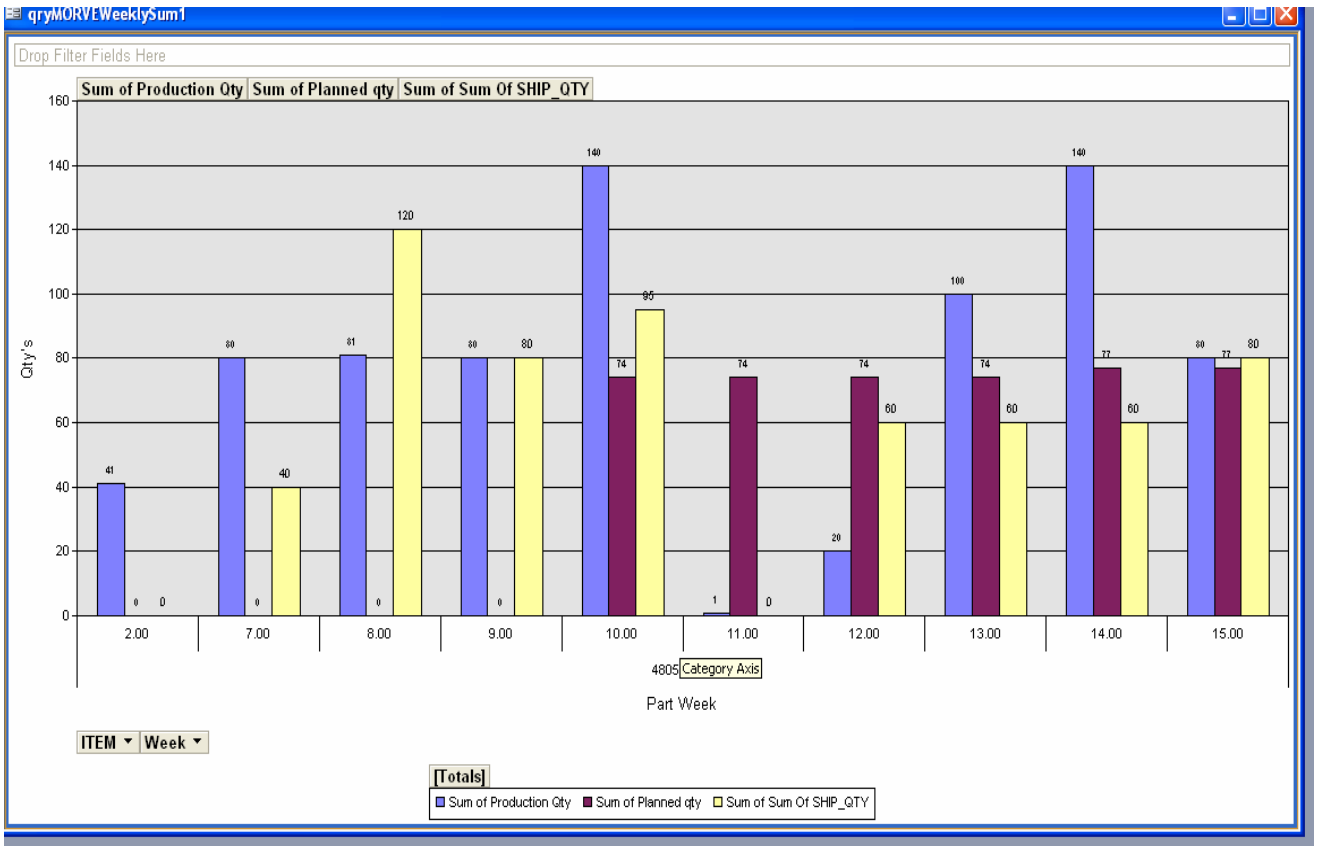
The master database (figure 27) was created to display the information needed for every item number. The information is used to plan for inventory as well as the overall logistics at Autoliv. The information is displayed in graphs. The information gathered in other databases is used to calculate these graphs. The graphs indicate production vs. sales, line capacity, sales, forecast monthly and forecast vs. sales monthly, sales vs. forecast monthly, forecast weekly, forecast vs. sales weekly, sales vs. forecast weekly as well as stock levels.

**Figure 27: Master database screen**



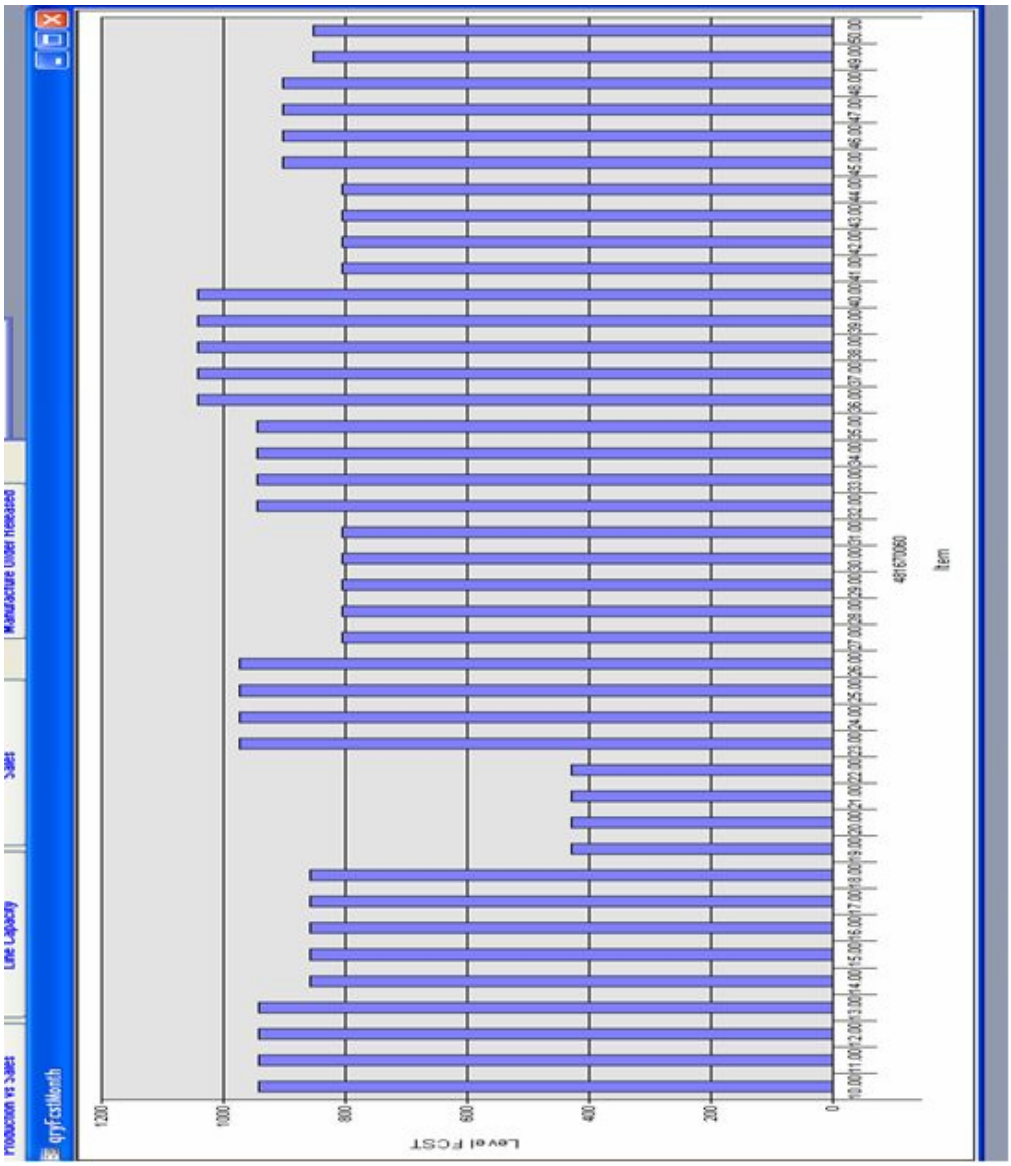
The graph in figure 28 is an example of the graphs that can be displayed using the forms function in Microsoft Office Access. For every part number the production vs. sales graph indicates the actual number of parts produced weekly vs. the planned production number and the actual number of parts that was shipped out.

**Figure 28: Production, Leveling and Sales**



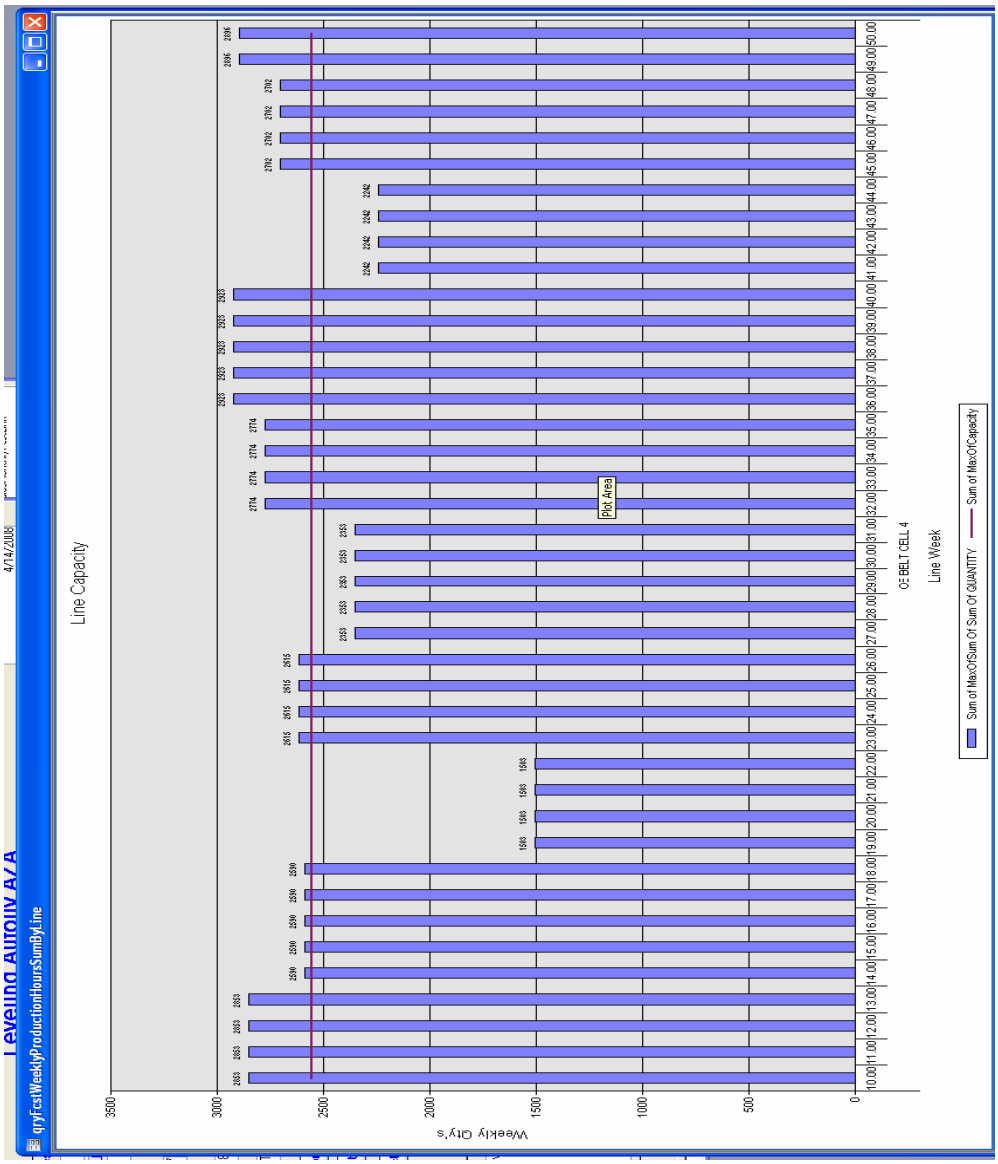
The monthly forecasted information and the contract details are used to calculate, leveling that enables the production of a stable amount of products every week for the duration of a month. Leveling for each product is recalculated each month to provide for the customer's demand. Figure 29 is a visual display of the monthly leveling numbers of each product.

**Figure 29: Leveling using the monthly forecast data**



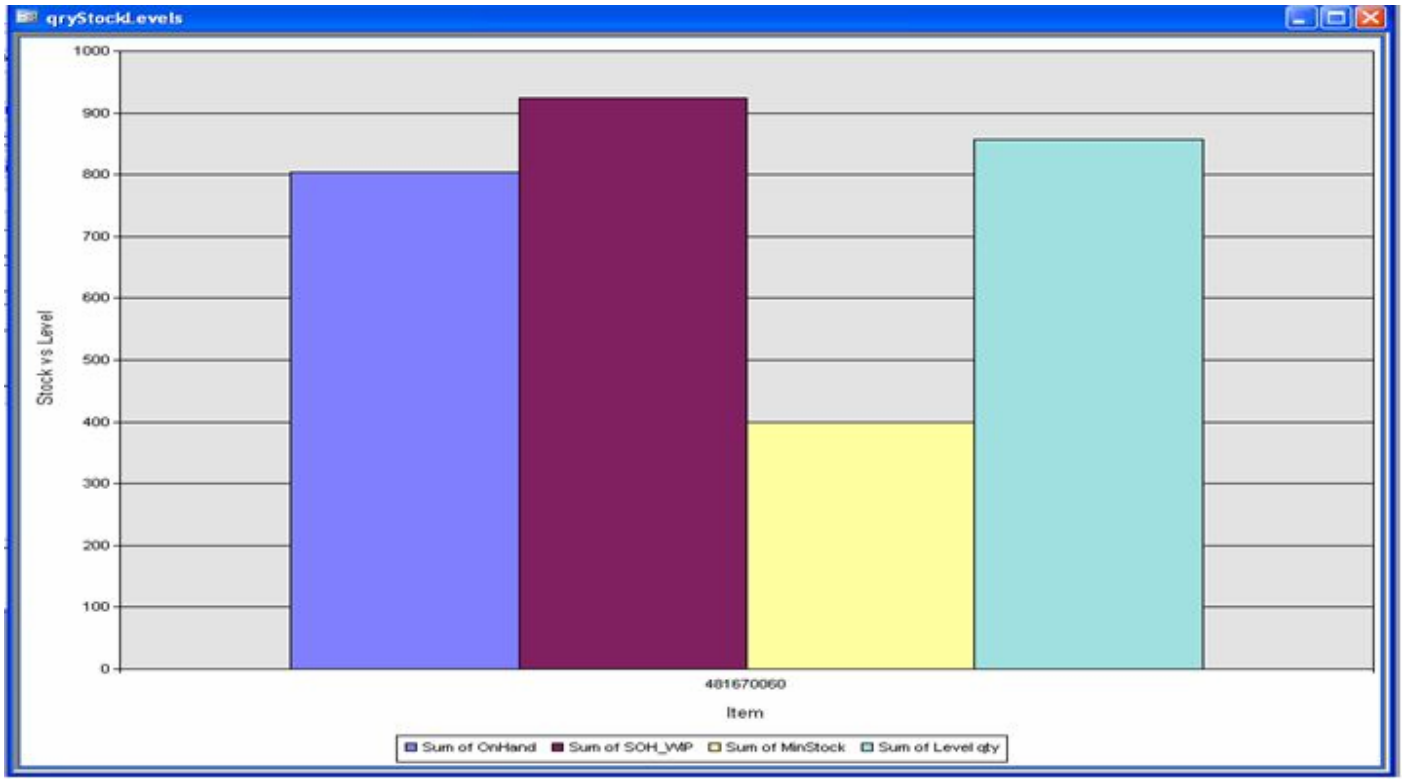
To prevent backorders the weekly capacity of the line on a dayshift is calculated and continuously checked (see figure 30). When the leveling amount exceeds the line capacity additional planning is done to ensure that the target is met. A night shift may be introduced when stock is insufficient or the product will be taken out of the safety stock.

**Figure 30: Line capacity**



Inventory levels are continuously checked to ensure that there are enough stock for all the planned operations. Figure 31 illustrates how the inventory is constantly measured against the ordered quantities of a product. The work in progress, which is the material that is being used on the lines, is also displayed to provide a constant idea of the exact amount of inventory.

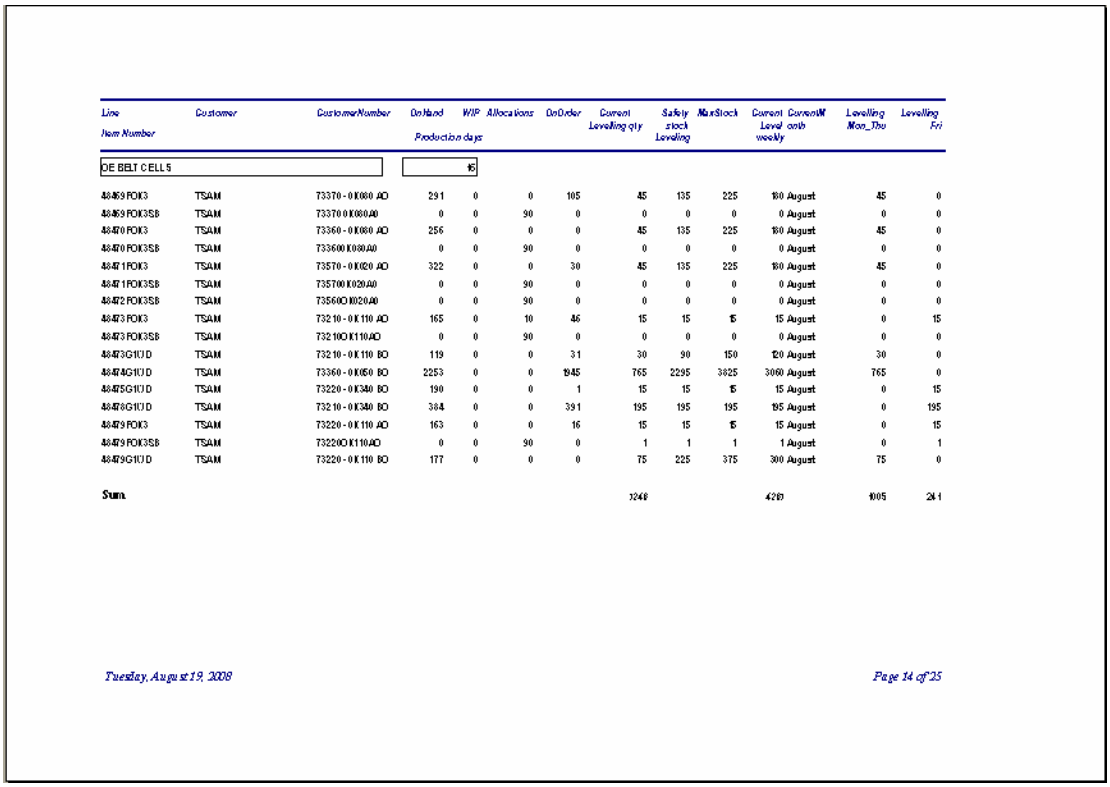
**Figure 31: Inventory levels**



### 4.8.7 Reports

A leveling report is created that continuously summarises every phase. This information is used to constantly improve Autoliv's operation. Figure 32 illustrates a leveling report that contains all the relevant information needed to improve Autoliv's leveling.

**Figure 32: Leveling report**



| Line / Item Number | Customer | CustomerNumber | OnHand / Production days | WIP | Allocations | OnOrder | Current Levelling qty | Safety stock Leveling | MaxStock | Current Level weekly | CurrentM cmb | Levelling Mon_Thu | Levelling Fri |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OE BELT CELL 5 | | | 15 | | | | | | | | | | |
| 48469 FOK3 | TSAM | 73370 - 0 K060 AO | 291 | 0 | 0 | 105 | 45 | 135 | 225 | 180 August | | 45 | 0 |
| 48469 FOK3SB | TSAM | 73370 0 K060 A0 | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 August | | 0 | 0 |
| 48470 FOK3 | TSAM | 73360 - 0 K060 AO | 256 | 0 | 0 | 0 | 45 | 135 | 225 | 180 August | | 45 | 0 |
| 48470 FOK3SB | TSAM | 733600 K060 A0 | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 August | | 0 | 0 |
| 48471 FOK3 | TSAM | 73570 - 0 K020 AO | 322 | 0 | 0 | 30 | 45 | 135 | 225 | 180 August | | 45 | 0 |
| 48471 FOK3SB | TSAM | 735700 K020 A0 | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 August | | 0 | 0 |
| 48472 FOK3SB | TSAM | 73560 O K020 A0 | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 August | | 0 | 0 |
| 48473 FOK3 | TSAM | 732 10 - 0 K 110 AO | 165 | 0 | 10 | 46 | 15 | 15 | 15 | 15 August | | 0 | 15 |
| 48473 FOK3SB | TSAM | 732 10 O K 110 AO | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 August | | 0 | 0 |
| 48473 G1 O D | TSAM | 732 10 - 0 K 110 BO | 119 | 0 | 0 | 31 | 30 | 90 | 150 | 120 August | | 30 | 0 |
| 48474 G1 O D | TSAM | 73360 - 0 K050 BO | 2253 | 0 | 0 | 1945 | 765 | 2295 | 3825 | 3060 August | | 765 | 0 |
| 48475 G1 O D | TSAM | 73220 - 0 K340 BO | 190 | 0 | 0 | 1 | 15 | 15 | 15 | 15 August | | 0 | 15 |
| 48476 G1 O D | TSAM | 732 10 - 0 K340 BO | 384 | 0 | 0 | 391 | 195 | 195 | 195 | 195 August | | 0 | 195 |
| 48479 FOK3 | TSAM | 73220 - 0 K 110 AO | 163 | 0 | 0 | 16 | 15 | 15 | 15 | 15 August | | 0 | 15 |
| 48479 FOK3SB | TSAM | 73220 O K 110 AO | 0 | 0 | 90 | 0 | 1 | 1 | 1 | 1 August | | 0 | 1 |
| 48479 G1 O D | TSAM | 73220 - 0 K 110 BO | 177 | 0 | 0 | 0 | 75 | 225 | 375 | 300 August | | 75 | 0 |
| Sum | | | | | | | 3248 | | | 4269 | | 1005 | 241 |

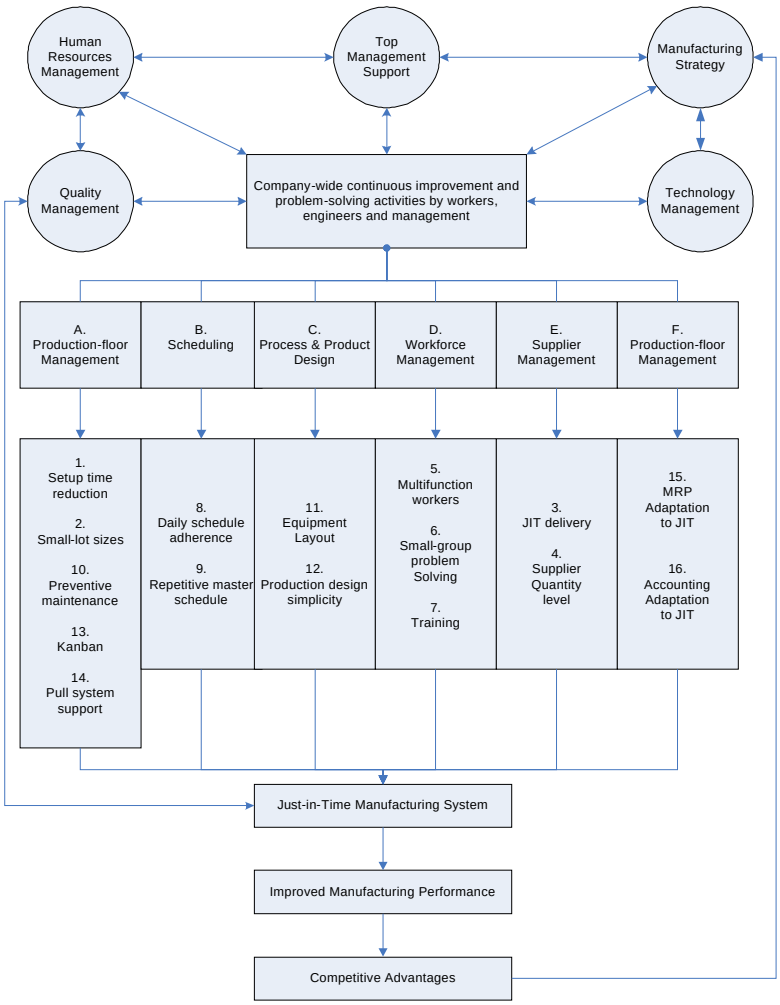
Tuesday, August 19, 2008 — Page 14 of 25

### 4.9 Just-in-time

The Just-in-time (JIT) system utilizes kanbans to link purchasing, manufacturing and logistics. JIT defined as a production strategy, is a working method that reduces manufacturing costs and improves the quality of production. Waste is eliminated and more effective use is made of

existing company resources. JIT defined as a philosophy is based on the principle of immediate delivery of the exact amount of goods when required or in advance. JIT is a program that seeks to eliminate non-value-added activities with the objective of producing high-quality products, high productivity levels and lower levels of inventory. The Just-in-Time (JIT) system promotes the development of long-term relationships between Autoliv and suppliers or customers through the formation of alliances with suppliers and shared decision making. In general JIT benefits firms in four areas: improved inventory turns, better customer service, decreased warehouse space and improved response time.

**Figure 33: JIT operation framework**

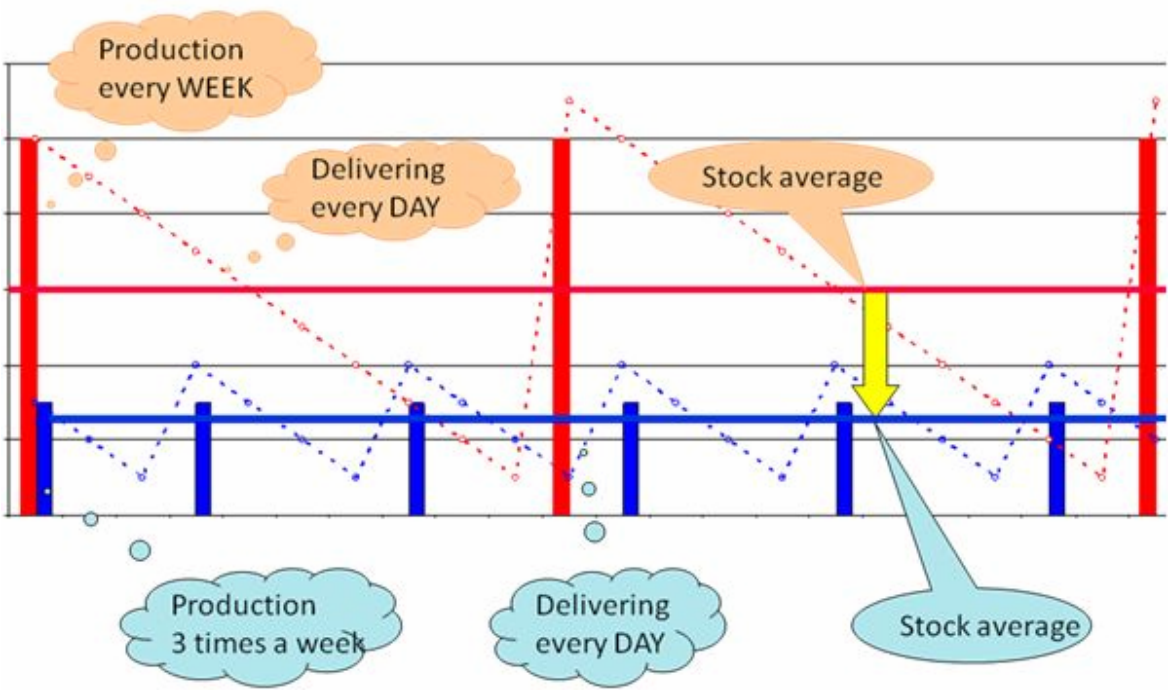


The advantages of improving JIT include the encouragement of small delivery lots according to the immediate needs for production usages which leads to less inventory required. Long-term purchasing agreements are made between client and supplier. Extensive exchange of information about production schedules, production processes, etc is made possible. Buyers and suppliers work together to reduce costs.

### 4.10 Inventory Scales

When the weekly produced lot sizes decrease because of leveling, the material used also decreases. This has an effect on the inventory levels in that the average inventory level will decrease and deliveries will take place more often as shown in figure 43.

**Figure 34: Inventory in relations to batch sizes**



### 4.11 Measures of inventory management effectiveness

The key measure of effective inventory management is the impact of inventory on corporate profitability. Effective inventory management can improve profitability by lowering costs. Ways to decrease inventory-related costs include reducing the number of backorders or expedited shipments and purging obsolete stock from the system which will improve the accuracy of forecasts. Autoliv focuses on improving their forecasts in order to reduce backorders.

Effective inventory management will increase the ability to control and predict how inventory investment will change in response to management policy. Inventory turnover serves as a measure of inventory performance.

$$\text{Inventory turnover} = \frac{\text{Annual rand sales volume at cost}}{\text{Average rand inventory investment}}$$

The inventory turnover ratio indicates the number of times Autoliv sells its inventory during the year. It's the ratio of annual cost of sales to the most recent inventory at the company.

High inventory levels are undesirable since it represents an investment with a very low return rate. It can also be to the company's detriment if product prices drop or if the product no longer needs to be manufactured and there are still a large number of parts in the inventory stores.

In general the higher the inventory turnover ratio the better the company is performing. This ratio can be used to compare companies' performances within the industry.

Autoliv's inventory turnover was 3.8 on 1 January 2008.

$$\frac{R183483000}{R48285000} = 3.8$$

Thanks to the introduction of a kanban system in the inventory store and leveling of the production rate at Autoliv, the inventory is slowly decreasing and production is stabilising. This contributed to the increase in inventory turnover that was visible on 31 June 2008.

$$\frac{R93103000}{R23872560} = 3.9$$

The fact our country's inflation rate is steadily increasing it will have a negative impact on the inventory turnovers of a number of companies in South Africa. The rising inflation rate has not yet had a negative impact on Autoliv's inventory turnover. The reason for this is that Autoliv is an international company that supplies to the international market which has not yet experienced a downturn in activity.

Autoliv's biggest customers are BMW, Volkswagen, Toyota and General Motors and they all export in batches of a minimum of 50% of their products sales. A downturn in activity in the international motor industry is expected towards the end of the 2008. Autoliv has the advantage of being able to prepare themselves for the possible downturn by a gradually reducing their stock. This will prevent stock build ups due to long lead times and prevent inventory turnovers from weakening.

Autoliv is very positive toward change and is motivated to pursue the set inventory turnover ratio goal of 7.

## 4.12 Kanban

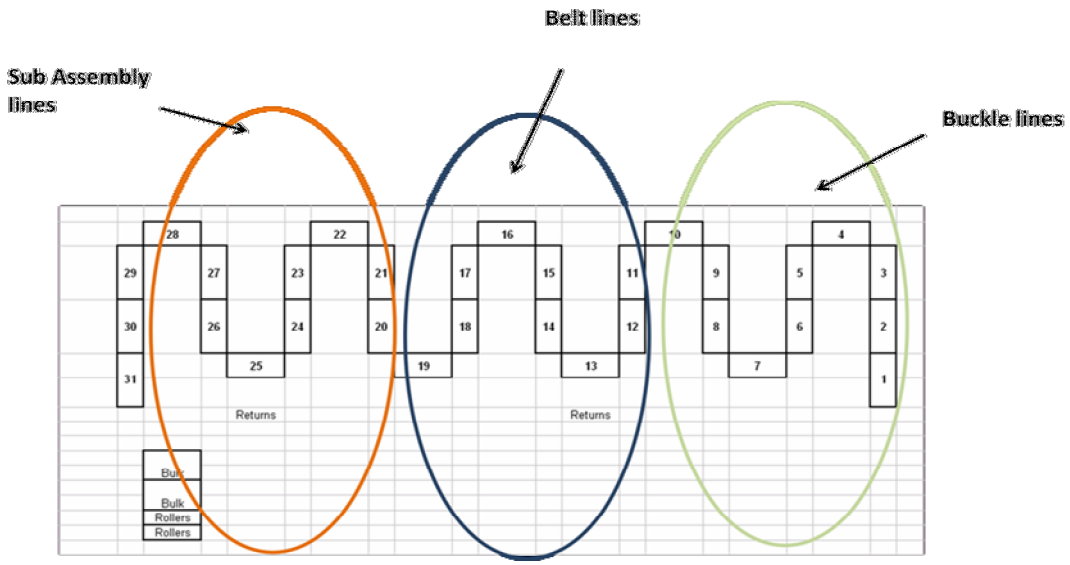
Kanban is a Japanese word which means visible record or card. Kanbans is a practical way of co-ordinating supply and demand. The philosophy of kanban states that parts and materials should be supplied at the very moment they are needed in the factory production process. It simplifies operations. The advantage of using the kanban system is that it needs very little management. The cards (kanbans) are attached to containers with a standard quantity of a single part number. There are two types of kanbans namely move kanban cards and production kanban cards. When a worker starts to use parts from a container the move kanban which is attached to it, is removed and the kanban is picked up by the feeding work centre. This is the signal for the work centre to order or send another container of parts to replace the one now being used. The replacement container has a production kanban attached to it which is replaced by the move kanban before it is sent. The production kanban then authorises the production work centre to fill another container with parts. These cards circulate within or between work centres. Completed units are “pushed” down to the line to form a stock of work in progress in front of the next station. Each kanban card represents a standard number of parts being made or used within the production process. The amount of work-in-process inventory can easily be controlled by keeping tract of the number of kanbans on the plant floor.

For the kanban system to be effective there are a few rules that must be adhered to. Only one kanban may be attached to a container at any specific time. The work centre that is using the kanban must initiate the movement of parts from the feeding or preceding work centre. The manufacturing of parts without a kanban production card is prohibited. Only the exact amount of parts indicated on the kanban card should be produced. Kanban cards must be handled on a First-In-First-Out (FIFO) basis. Completed parts has to be stored at the location indicated on the kanban card.

### 4.12.1 Analysis for the kanban System

The Bill Of Material (BOM) was used to estimate the average amount of raw material parts used in every 3 day cycle. Hence the number of boxes (units) of raw material needed in the dynamic stores is calculated. Spaces on the dynamic rack are allocated to every unit and the units that are used in the production lines are group together as illustrated in figure 35.

**Figure 35: Dynamic store allocation**




One is issued for every unit of parts. The suppliers are listed and a symbol is allocated to each supplier which is used on the kanbans. Kanbans are printed and issued to each unit in the dynamic racks.

### 4.12.2 Introducing a kanban system to regulate inventory

As the supplies arrive from the suppliers each replenished unit receives a kanban card. The units are store in the dynamic racks of the warehouse with their kanban cards. When the units are collected from the different locations on the dynamic rack and transported onto the manufacturing floor, the kanban card that accompanies the unit is placed onto a collection board. The cards in the collection board serve as reminders to order the next batch of components. When the components have been ordered, the kanbans are placed into the supplier receiving board to inform the warehouse personnel that the stock is in transit. It also indicates the time it will take for the stock to arrive at the plant. Figure 36 exemplifies the process.

**Figure 36: Supplier loop short distance kanban**

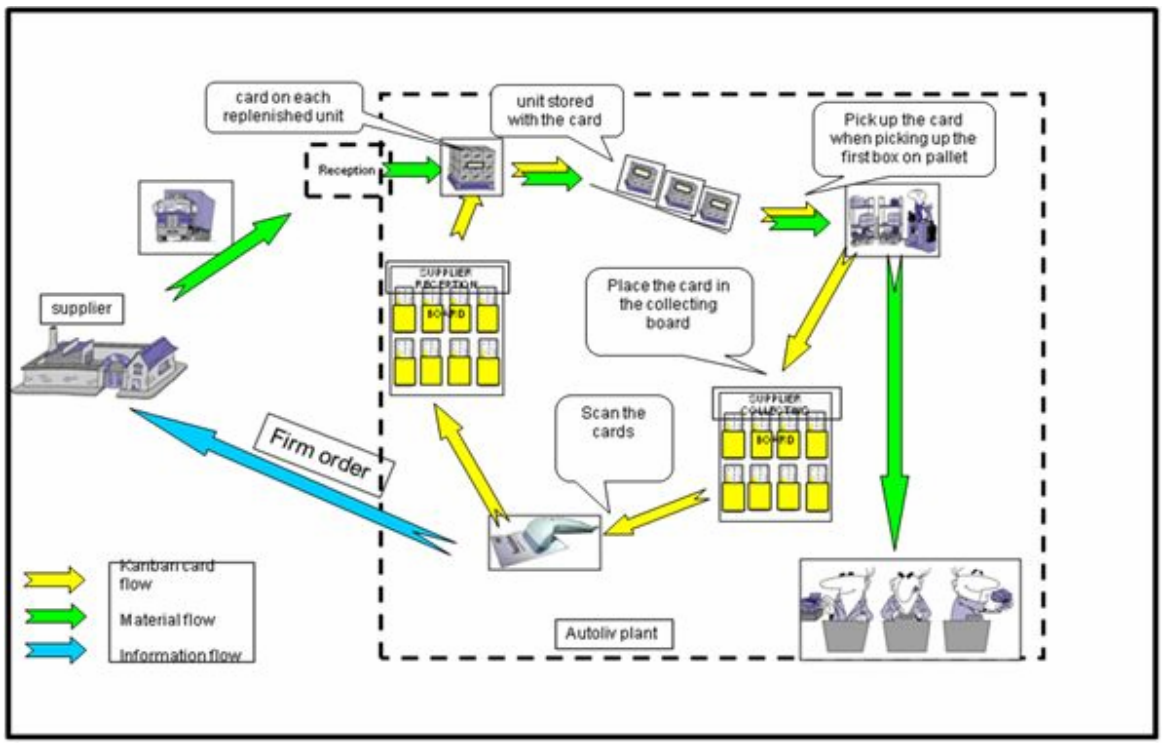


**Figure 37: Kanban cards in stores**




## Chapter 5: Summary

Autoliv's business objectives were achieved through thorough training of all the relevant personnel involved with the processes. Additional visual information is made accessible to all the employees, which improves communication. Management of the processes and implemented systems at Autoliv is improving through continuous training. Implementation of a kanban system in the inventory stores and the new improved systems that were developed for inventory levels and leveling throughout the company eased the management of inventory. The implementation of standard customer and supplier contracts together with regular meetings to discuss risks, capabilities and planning promotes Autoliv's relationship with both their customers and suppliers.

The deliverables reached include the introduction and implementation of stable processes between departments and minimal material handling. The success of committing customers to standard contracts had a positive influence on the implementation of leveling throughout the manufacturing plant, increasing work performance and managing inventory.

Thanks to the introduction of leveling and the necessary planning that goes with it, production hours were reduced. Several nightshifts are not needed any more which resulted in a large amount of savings.

Better planning enables the production lines to be more flexible and the reduction of manpower. Extra resources are managed by using and shifting the excess manpower to other production lines.

## Chapter 6: References


1. BENTLEY, L.D. & WHITTEN, J.L. 2007. Systems Analysis & Design for the Global Enterprise. McGraw-Hill

2. BOTHA, M.C. 2008. Logistics Engineer at Autoliv Southern Africa (PTY) LTD

3. BREWER, A.M., BUTTON, K.J. & HENSHER, D.A. 2001. *Handbook of logistics and supply chain management*. Permagon

4. CHASE, R.B., JACOBS, F.R. & AQUILANO, N.J. 2006. *Operations Management for Competitive Advantage.* McGraw-Hill

5. GADDE & HAKANSSON. 1993. *Professional Purchasing.*

6. KRETSCHMER, D. 2008. MD of Autoliv Southern Africa (PTY) LTD

7. LAMBERT D.M., STOCK, J.R. & ELLRAM, L.M. 1998. *Fundamentals of Logistics Management*. McGraw-Hill

8. LE ROUX, S. 2008. APS Engineer of Autoliv Southern Africa (PTY) LTD

9. RATUTI, A.S. & EVAS, J.R. 2005. *Principles of Operations Management*. Thomson

10. SHOOK, M.R.J. 2003. Learning to See, value-stream mapping to create value and eliminate muda. Massachusetts: Brookline

11. WEBSTER, S. 2008. Principles and tools for supply chain management. McGraw-Hill

12. Autoliv Training guide

**World Wide Web Sites:**

13. BIZWIS CONSULTING. *Inventory Turnover Ratio.* http://www.bizwiz.ca/inventory_turnover_ratio.html, (17 June 2008)

14. BNET BUSINESS DICTIONARY. *Definition of target stock level.* http://dictionary.bnet.com/definition/target+stock+level.html, (19 June 2008)

15. INTUITIVE FREQUENT ASKED QUESTIONS. *What is ERP?* http://www.intuitivemfg.com/FAQ/G_whatiserp.html, (4 August 2008)