Supply chain collaboration for maintenance spare parts at DAF Trucks N.V.

Jeroen M.W. Verlinden
January 12th, 2012

UNIVERSITY OF TWENTE.

Supply chain collaboration for maintenance spare parts at DAF Trucks N.V.

September 2010 – January 2012

Master's degree thesis by:
Jeroen Verlinden
S0161047
University of Twente
Industrial Engineering and Management
Track: Production and Logistic Management

Supervisors DAF Trucks N.V.:
01-09-2010 till 01-10-2010: Ir. D. Ruts
From 01-10-2010: Ir. M. Kanters

Supervisors University of Twente:
First supervisor: Dr. van der Heijden
Second supervisor: Prof. Dr. Telgen

Management Summary

This report describes the research carried out for the department Maintenance Material Planning at DAF Trucks N.V. The task of this department is to ensure, at minimum costs, maximum availability of spare parts used for both corrective as preventive maintenance for the entire production facility at DAF Eindhoven. For that purpose there is a spare part inventory consisting of about 28.000 SKU's, with a total value of 17.3 million Euro. The inventory is controlled with help of the ERP software SAP. Once a week the inventory levels are checked with a MRP run and ordered up to a level indicated by DAF as the safety stock. A safety stock as is normally used in inventory control is not used at DAF.

DAF realized that supply chain collaboration could possible increase the efficiency of the inventory control and initiated this assignment to research the possibilities. The research assignment that followed from this is:

"Optimize spare parts inventory control at DAF Eindhoven by improving collaboration with suppliers in the supply chain such that spare part inventory costs (consisting of order-, transportation-, handling-, inventory carrying- and information-costs) decrease, while maintaining or improving the item fill rate. Develop an implementation plan for one or more article groups / suppliers."

In this report an overview is given of the most common supply chain collaboration forms described in literature and how DAF can use them in order to control its inventory in a more efficient way. Each of these forms contributes to different objectives and has other characteristics, and so have the articles that are suitable for each of these forms. In order to identify the right article for the right supply chain collaboration form, an allocation framework is used which analyses the spare parts on the dimensions:

- Value: The purchase price of the article.
- Consumption: How often the article is used over a certain time period.
- Response time: The time that is allowed to replace an article that has broken down.

From this analysis follows if an article is suitable to be part of a supply chain collaboration, and if so, if its fits best to vendor managed inventory, consignment inventory or supplier owned inventory. From this data analysis it appeared that, based on consumption data over the last four years, half of the SKU's in current inventory was never consumed during this period. Another noticeable factor is that although the articles in the inventory are actually spare parts for corrective maintenance, they are often also used for preventive maintenance in the same manner, without prior reservation of the SKU.

From the research appeared that supply chain collaboration for DAF can best be based on a dyadic approach (collaboration with an immediate partner). Selecting a partner must be done carefully, where the most important factor is that DAF already has a good relationship with that partner and also trusts him. To make the collaboration most effective it is further important that the supplier with who will be collaborated represents a large inventory value, must be a financial healthy company and finally must be situated within 250 km from DAF. The supplier Scheib Elektrotechnik GmbH was with help of these criteria selected as the partner for SCC. Scheib mainly delivers electrical- motors and modules to DAF and with a total value of 1.14 million euro worth of articles in DAF's current inventory, it is the largest supplier for DAF.

To successfully implement supply chain collaboration there are many pitfalls to be avoided. Therefore DAF has to establish visibility in their inventory to the supplier, cooperate with them to achieve higher efficiency throughout the whole supply chain and an important success factor is management

support for this collaboration. Before the supplier and DAF start with the collaboration they will have to agree on ownership of transfer, payment terms, selection of eventually third party logistics providers, service levels (fill rate), processes to be followed, lead times of delivery and communication ways. All these issues (except for the last one) have to be stipulated in a contract. On communication ways can be decided via informal agreements since research shows that how information is exactly shared is not important. To encourage both partners to live upon the agreements, penalty costs for underachieving must also be stated in the contract.

For calculating the potential savings of supply chain collaboration, order- and handling costs had yet to be calculated since this figure was not available at DAF as such. From this it appeared that order costs are € 105,- per order and handling costs are € 35,- per order line. Inventory carrying costs are defined by DAF as being 10% and are also used as such in this report. Thereby are also the transportation costs considered, which consists of three scenarios depending on the response time of the article concerned. Further are the information cost considered in case the supply chain collaboration form considered requires intensive information exchange.

A case study was performed to evaluate the potential savings that supply chain collaboration can achieve. First a supplier has to be selected, which was the supplier Scheib. The articles of that supplier were then analysed with the allocation framework and showed that about half of the number of SKU's fulfilled the criteria for supply chain collaboration. Without considering the fee that the supplier will charge for collaboration, it resulted that consignment inventory contributes to the biggest saving, 380 euro per order. Potential savings with vendor managed inventory are 60 euro per order, while supplier owned inventory does not result in any savings. With supplier owned inventory costs per order increase with 20 euro since this segment contains high value articles with high consumption rates that are located at the suppliers' site, which results in high transportation costs. This can also be computed with the decision support tool, with this insight in potential savings DAF can decide how much they would pay to the supplier for supply chain collaboration. Since the potential savings strongly depend on the articles, a second case study was conducted for the largest five suppliers. This confirmed that consignment inventory is the most beneficial concerning the potential savings (220.000 euro annually). But when the fees for the suppliers will be included, the savings will be probably only be modest.

Although supply chain collaboration does not contribute to significant inventory cost savings for DAF, they are advised to implement a consignment inventory collaboration with the supplier Scheib. The possibility for DAF to make us of the knowledge and services of the supplier would be of great help by improving the efficiency of the current inventory control at maintenance material planning, especially for the articles with a low consumption rate which cause many difficulties at the moment (such as having relatively many non-movers on stock). An implementation plan discussed in this report helps to implement a consignment inventory collaboration with Scheib.

Preface

This report is the result of my graduation project for the study Industrial Engineering and Management, track Production and Logistic Management at the University of Twente. My project took place at DAF Trucks N.V. for the department Maintenance Material Planning.

This work could not be performed without the help of a number of people, which I would like to thank.

First of all I would like to thank my university supervisors, Dr. van der Heijden and Prof. Dr. Telgen, for their guidance and the constructive criticism during the feedback sessions.

At DAF Trucks I would like to thank Dennis Ruts, in the short period of time that he was my company supervisor he gave me the opportunity to get to know DAF. I really enjoyed that I could take a look at several departments and found it interesting to observe the various processes at DAF from such a close distance. Further I would like to thank Berry van der Meij, manager of the department Maintenance Material Planning for this possibility and his insights during this project. I would like to thank my company supervisor, Maarten Kanters, for the guidance and support throughout the entire project and his expert view on the project. Of course I would also like to thank the direct colleagues at Maintenance Material Planning for their help and for creating the pleasant working environment.

Finally I would like to thank my parents for their unconditional support throughout my entire study. It has not always been easy, therefore was their continuous support very important to me. It really helped me to get through the difficult times.

With this project I close a chapter of my life and start a new one, which I am really looking forward to.

Jeroen Verlinden

January 2012

Table of contents

Management Summary i

Preface iii

Table of contents iv

1 Introduction to DAF Trucks N.V 1

1.1 DAF Trucks N.V. 1

1.1.1 History 1

1.1.2 Products 1

1.1.3 Production facilities 1

1.1.4 Market 2

1.1.5 Economic Figures 2

1.2 Organization 3

1.2.1 Organization chart 3

1.2.2 Mission / vision MMP 4

1.2.3 Spare parts inventory 5

1.2.4 Order policy 5

1.2.5 Key Performance Indicators (KPI) 5

2 Introduction to the assignment 7

2.1 Problem context 7

2.2 Problem statement 7

2.3 The assignment 8

2.3.1 Assignment objectives 8

2.3.2 Assignment definition 8

2.3.3 Assignment deliverables 9

2.4 Project approach 9

2.5 Research questions 11

3 Current practice at MMP 13

3.1 Spare parts inventory 13

3.2 Supply chain 14

3.3 Spare part characteristics 14

3.3.1 Spare parts value 15

3.3.2 Spare parts consumption 15

3.3.3 Consumable versus repairable SKU’s 17

3.3.4 Delivery times 17

3.4 Performance 17

3.5 Conclusion 19

4 Supply Chain Collaboration 20

4.1 Introduction to Supply Chain Collaboration 20

4.2 Supply Chain Collaboration characteristics 20

4.3 Supply Chain Collaboration forms 21

4.3.1 Collaborative Planning, Forecasting and Replenishment (CPFR) 22

4.3.2 Quick Response (QR): 22

4.3.3 Continuous Replenishment (CR) 22

4.3.4 Vendor Managed Inventory (VMI) 23

4.3.5 Vendor Managed Replenishment (VMR) 23

4.3.6 Consignment Inventory (CI) 24

4.3.7 Supplier Owned Inventory (SOI) 24

4.4 SCC forms compared 25

4.5 Conclusion 27

5 Characteristics for Supply Chain Collaboration 28

5.1 Characteristics potential supplier 28

5.1.1 Supplier selection 29

5.2 Characteristics potential article group 31

5.2.1 Article group selection 39

5.3 Characteristics DAF for collaboration 40

5.4 Future SCC projects 42

5.5 Conclusion 42

6 Savings on inventory associated costs 43

6.1 Elements of inventory associated costs 43

6.2 Inventory associated costs at DAF 44

6.3 Change in inventory associated cost per SCC-form 46

6.3.1 Change with VMI 48

6.3.2 Change with CI 50

6.3.3 Change with SOI 52

6.3.4 SCC-forms combined 55

6.3.5 Extending the SCC 56

6.3.6 Sensitivity analysis of the response time distribution 56

6.4 Conclusion 58

7 Decision Support Tool 59

8 Collaboration agreements 61

8.1 Contract issues 61

8.2 Informal agreements 62

8.3 Potential risks 63

8.4 Conclusion 64

9 Implementation plan 65

10 Conclusions and recommendations 68

10.1 Conclusions 68

10.2 Recommendations 69

References 70

Appendix A. Glossary of terms I

Appendix B. Consumption pattern 2006 – 2009 II

Appendix C. D&B rating Scheib Elektrotechnik III

Appendix D: Cost assumptions VII

1 Introduction to DAF Trucks N.V.

First the situation in which the assignment will be carried out is sketched. Therefore is in this chapter a closer look taken at DAF Trucks N.V. later referred to as DAF.

1.1 DAF Trucks N.V.

DAF designs, both technical and esthetical, and produces trucks, thereby delivering the customer a total transport solution, with high availability and low costs per kilometre.

A truck consists for a large part (about 75%) of purchased parts, but still, DAF develops and produces a lot in house. Ranging from cable looms to chassis' and from engines till cabins. Engines are also sold separately to external parties, mainly for busses and coaches or special vehicles.

1.1.1 History

DAF Trucks N.V. as we know it today finds its origin in 1928 as a small workshop owned by the brothers Hub and Wim van Doorne. In 1932 they started producing trailers under the name "Van Doorne's AanhangwagenFabriek, in short DAF. After World War II the market for transportation vehicles grew rapidly, on which the brothers van Doorne reacted by developing a truck, which was first produced in 1949. In 1957 they opened an engine factory where four engines per hour could be produced. For sake of comparison, now in 2010 this is about fifteen engines per hour.

In the period from 1958 till 1975 DAF also produced 850.000 passenger cars. DAF sold the passenger car business to Volvo Car. When later also the production of trailers was stopped the company entirely focused on the development, production and sales of trucks.

In 1996 DAF became a PACCAR company. PACCAR is a North-American company and possesses besides DAF also the truck brands Kenworth and Peterbilt. With this acquisition the future of DAF trucks N.V. was assured. New trucks and engines were introduced to the market on a regular basis, and not without success, DAF was voted "truck of the year" in 1997, 2002 and 2007. In the most successful year until now, 2008, DAF sold about 60.000 trucks (1).

1.1.2 Products

DAF is represented in the light-, medium- and heavy duty trucks segment. DAF trucks that are produced at the moment are the DAF LF (light segment), DAF CF (medium segment) and the DAF XF (heavy segment). For each truck several axle assemblies and cabin editions (the level of luxury) can be chosen, thereby offering the customer a wide range of applications in which the truck can be deployed, from distribution in city centres till distribution between (international) warehouses with large distances to cover. As already mentioned DAF's product portfolio also consists of engines, available in power ranges from 200 (6.7 litre 6 cylinder) till 485 (12.9 litre 6 cylinder) horsepower. Several techniques are developed to meet EPA 2010 emission standards (2).

1.1.3 Production facilities

Near the location where Hub van Doorne once started DAF there is a large production facility. Here the design and development of the trucks takes place. The trucks CF and XF are produced in Eindhoven, as well as the engines and some parts for the axles and cabins. The production of the axles and cabins is done at the production plant in Westerlo, Belgium. The finished axles and cabins are transported to Eindhoven where the final assembly of the truck takes place.

A second assembly facility is in Leyland, the United Kingdom. They assemble all the DAF LF's and also some CF and XF's.

Total area in Eindhoven is almost 900.000m^2 and the base for 4070 employees. Westerlo covers approximate 400.000m^2 and has 1496 employees. Then there are also another 600 employees in Leyland and other subsidiaries (3).

1.1.4 Market

DAF's most important markets are West- and East-Europe, were most sales go via a dealer network. Besides selling trucks, the independent dealer is also responsible for service and the sales of spare parts. In other areas (among which Scandinavia, Portugal, Turkey) trucks are sold to customers by independent importers (4). Besides these two sales channels there are also agents. For each truck sold holds that it is built to order and then shipped to the dealer, importer or agent who delivers the truck to the customer.

In the next years DAF will increase focus on her position on the American market. One initiative for this was already mentioned in Dutch newspapers, namely that DAF is planning on building a production facility in Brazil.

1.1.5 Economic Figures

The transportation sector was heavily influenced by the economic crisis of the last few years. Figure 1.1 shows the sudden drop in demand for trucks in the year 2009 in relation to previous years.

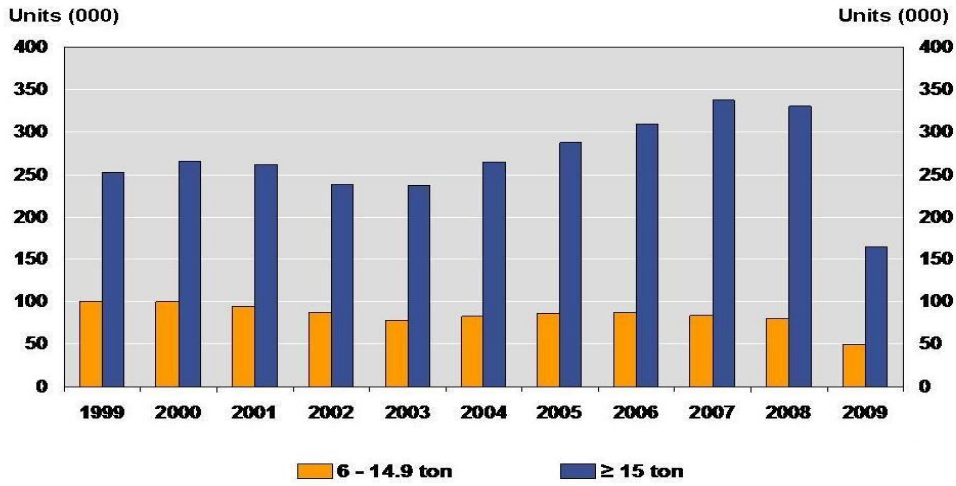


Figure 1.1 Annual truck market **(1)**

This market drop has also struck DAF, but their lean culture, achieved through the PACCAR Production System, and the attitude of continuous improvement throughout the entire organization has resulted in a positive financial result for 2009 too. In that year 16.460 CF and XF trucks and 5.300 LF's trucks were sold. This means having a market share of 14.8% in the EU (plus Norway and Switzerland) in the segment over 15 tons. For the 6 to 15 ton segment this was 9.3% (1).

Figure 1.2 shows how big the impact of this economic crisis on the turnover actually was. But again, considering the circumstances DAF is really satisfied with this result, operating margin after taxes was 1 million Euro positive.

1.2 Organization

1.2.1 Organization chart

In Figure 1.3 the organizational structure of DAF is partly depicted. To stay within scope of the project is focused on that part of the organization in which the department Maintenance Material Planning (MMP) is deployed, since this project is carried out for this department.

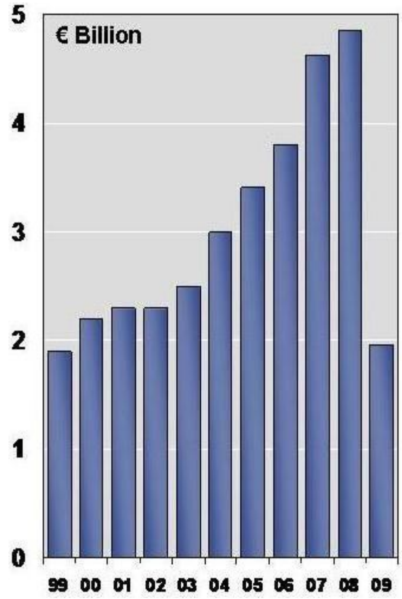


Figure 1.2 Annual DAF turnover (€ billion)

MMP is part of Maintenance Operations (MO) and is therefore also part of the division Operations. Operations is responsible for all the machines and logistic activities needed for producing the trucks (directly and indirectly). MO foresees in both the preventive and corrective maintenance of these production machines, and tries to achieve a maximum uptime of the machines. The thereby belonging supply of spare parts for the production machines (for both preventive and corrective maintenance purposes) is arranged by Maintenance Material Planning, who controls the spare parts inventory. MMP employs material planning and warehouse employees, and has a warehouse which is located in the factory. This warehouse services internal customers (from the whole DAF Eindhoven plant).

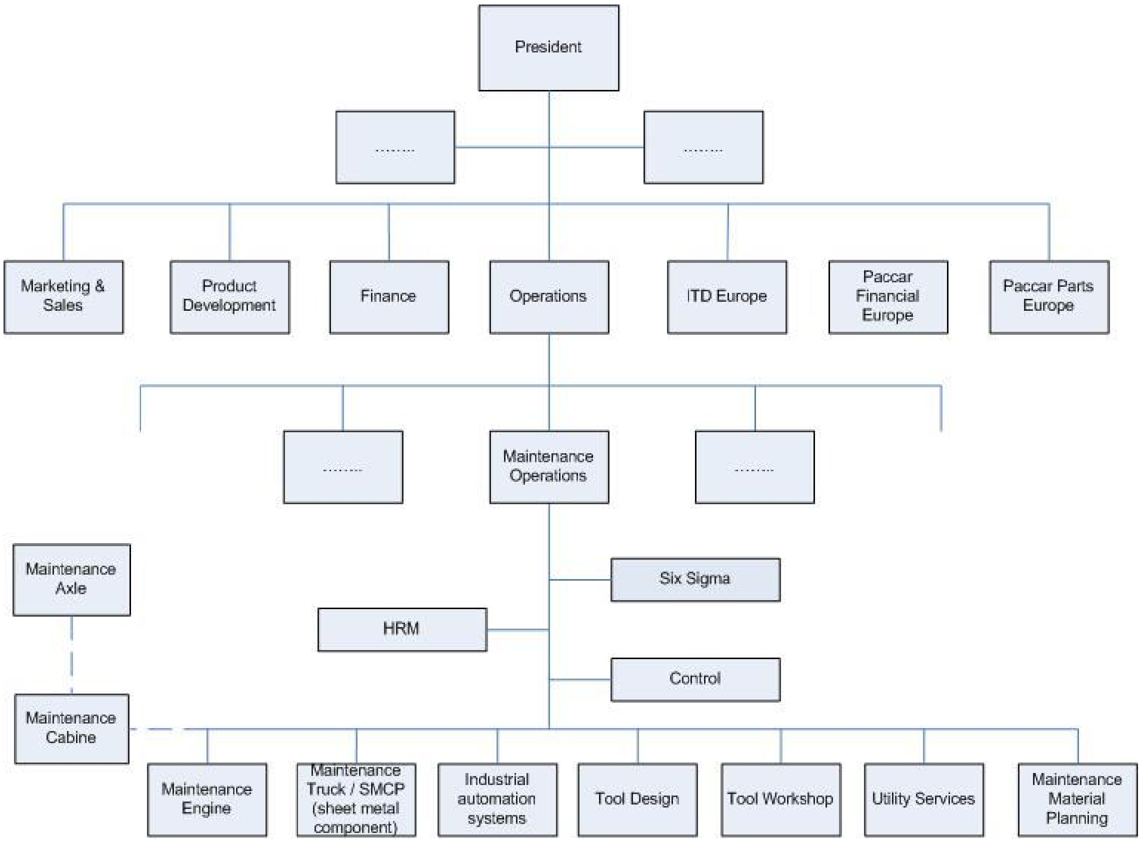


Figure 1.3 DAF Structure

1.2.2 Mission / vision MMP

As is already mentioned this research is carried out at the department Maintenance Material Planning, and is initiated to partly contribute to the mission of MMP, which is defined as:

Mission MMP:

> *"MMP ensures within Maintenance Operations (MO) maximal utilization of spare parts against minimal costs.*
> *MMP ensures that SAP contributes to efficient company procedures within MO and delivers functional support to the end-users of SAP."*

In order to achieve this mission MMP strives for the following vision:

Vision MMP:

- *"Having the correct spare parts at the right amount at the right moment in time and in correct quality for the customer."*
- *"Enabling end-users to perform actions in SAP in an efficient way."*
- *"Enabling employees to carry out their jobs safely and offering them a challenging job."*

1.2.3 Spare parts inventory

The warehouse stores 28.041 stock keeping units (SKU's), representing a total value of about 17.3 million Euro. The articles range in value from 1 eurocent to 67.500 euro per article. 7.4% of inventory are repairable items which are repaired both internally as externally. One could roughly apply the Pareto principle to the inventory because 20% of the articles represent 84% of total inventory value. Since the articles are both used for preventive as for corrective maintenance, demand per article can vary significantly, on which will be further elaborated in chapter 3. Current inventory was supplied by 600 different suppliers.

1.2.4 Order policy

For controlling inventory MMP uses the ERP software SAP. The inventory levels are reviewed once a week and when needed ordered up to a level which is defined in SAP as the safety stock (SS). Although this term is incorrectly used, it will be used as such in this report for clear communication within DAF. So they use the SS term from SAP as their order up to level, when during a review period SAP denotes current value is below SS, a request for order is initiated which replenishes stock till the "safety stock". MMP checks this purchase requisition after which Purchasing starts the purchasing process and actually buys the required products. The supplier delivers the products to the expedition department of DAF (occasionally the supplier delivers directly to the MMP warehouse). Expedition further distributes it to the MMP warehouse where they are stored until they are needed.

Which articles should be stored and what SS they should have is decided by Maintenance Engineering (ME). They also communicate the specifications of these articles to Purchasing, who then start the procurement for the articles.

1.2.5 Key Performance Indicators (KPI)

Performance of the MMP department is monitored by several key performance indicators (KPI). These are defined at a higher level within the organization and are the direct responsibility of the MMP-manager. In this chapter the KPI's will be described, in chapter 3 they are discussed.

The KPI's are:

- Service level $\geq$ 98%: MMP aims with the term service level at a type 2 (β) service level, or also called fill rate (5). This KPI measures item fill rate for two different cases, one for normal events where an order consists of a request for a number of articles smaller than or equal to the safety stock. The second case is for when the requested number of articles in one order is larger than the safety stock. When this situation occurs it is not within powers of MMP to fulfil this request. These different cases are introduced to have a clear view of where the problem of a backorder lies, with the inventory, with the amount of articles requested or with determining the safety stock.
- Inventory reliability $\geq$ 98%: This KPI indicates if the inventory level as denoted in SAP is in fact the actual inventory level. This is important to prevent situations where a SKU must be backordered because it is not in stock while this should have been according to the inventory level denoted in SAP. The inventory reliability is checked by performing cycle counts, once a week 150 locations are at random selected. Inventory at those locations is then counted and denoted by the warehouse employee. A MMP employee compares this count with the inventory level as is denoted in SAP. After each cycle count the inventory reliability is calculated as the percentage of SKU's for which actual inventory is equal to the inventory

denoted in SAP, and at the end of each month the results of the cycle counts are transferred to an average percentage over that month and is used as the KPI.

- Inventory value $\leq$ €17.5 million: Since having inventory costs money this KPI is introduced such that the total inventory will not become too large. The value for this KPI is simply calculated by summing up the purchase price for each item currently in stock (one SKU can contain multiple items). Current total inventory value is denoted in SAP.

2 Introduction to the assignment

Now we have established the area in which the assignment will be conducted, we can zoom in at the motive for this graduation assignment. To guide this project the method of van Aken (6) is applied, which leads to a project proposal consisting of:

- The problem context
- The problem statement
- The assignment
- The project approach
- The costs of the project
- The organization of the project

The last two points are out of scope for this project, since costs of a graduation project are relatively low for DAF and the organization of the project is the sole responsibility of the author.

2.1 Problem context

In the previous chapter DAF is described and what the role of the maintenance material planning department within DAF is. In its role, MMP faces a dilemma; on the one hand internal customers, figuratively spoken, expect all articles to be in stock in excessive amounts. On the other hand, MMP is restricted by Key Performance Indicators (KPI's) and even by the amount of storage space. It is quite a balancing act to assure availability of spare parts and not having unnecessary articles on stock, since demand for spare parts is not known in advance. In current practice this resulted in a large spare parts inventory, as well in amount as in value (approaching the maximum total value which is defined by the KPI).

2.2 Problem statement

Having too much inventory causes problems such as low Return On Investments, high handling costs, risk of parts becoming obsolete etc. Thereby the high inventory at DAF causes problems on administrative grounds, many articles are on stock, where some have only minor (technological) differences from another article. This requires very consequent and technical naming and coding of articles. Since this is not always realized inventory reliability decreases, which again can result in having unnecessary articles on stock since articles are incorrectly ordered. The last problem to be addressed is the problem of space availability in the warehouse. The warehouse is not full yet, but having some extra room creates the possibility of improving the warehouse layout (e.g. pay attention to slow/fast movers).

To solve these problems several projects are initiated, but MMP management feels that one area for a possible solution is unutilized, partly because knowledge in that area is missing. MMP management would like to gain knowledge about how collaboration with suppliers in the supply chain could reduce inventory costs, since research has shown that firms engaged in collaborative relationships achieved competitive advantages (7), higher services levels, increased flexibility (8) (9), inventory reduction (9) and inventory costs reduction (10) (11). Examples of this collaboration are principles such as Vendor Managed Inventories (VMI), Collaborative Planning, Forecasting and Replenishment (CPFR) and Continues Replenishment (CR) (12), (9). Reason for DAF to investigate how collaboration in its supply chain can be helpful in reducing her inventory related costs. Therefore the problem statement for this assignment is defined as follows:

"How can DAF apply collaboration in the supply chain such that inventory costs are reduced?"

2.3 The assignment

The problem statement discussed in the previous paragraph was DAF's motive to initiate this graduation assignment. The initial assignment such as delivered by DAF was as follows:

> *"Reduce spare parts inventory of DAF Trucks Eindhoven with about € 200.000,- and reduce operational costs with equal or higher material availability. The scope of the research embodies the research and implementation of supply chain integration with suppliers and / or DAF Westerlo."*

This assignment description has an "action problem" characteristic since apparently there is a discrepancy between norm and reality (6). During the orientation phase this description is further evaluated to see what DAF really expects from this assignment. From this is concluded that the specified amount of inventory value reduction isn't necessarily the most important. The main reason for initiating this graduation assignment by DAF is that they would like to gain more insight in how collaboration with suppliers could reduce inventory costs, and how this could be implemented for article groups used within DAF. This gaining insight character creates the need to formulate a knowledge problem (6). This will be later discussed when the knowledge problems are defined.

2.3.1 Assignment objectives

With this project DAF wants to save on inventory associated costs. This can be done via three different ways, which are the objectives of this assignment:

i. Reducing inventory value. Holding SKU's in the inventory is a costly business. Not only does this require labour and needed storage space, it also means that money that otherwise could have been used elsewhere (e.g. for investments) is now tied up in the inventory. Reducing the total inventory value also reduces this lost. Thereby would reducing the inventory contribute positively to the KPI inventory value, since at the moment inventory value approaches the maximum as captured in the KPI. Although must be said that this latter one is not a very important objective, since there are bigger factors that influence inventory value and that cannot be influenced by MMP (for example when a new machine is purchased needed spare parts are stored which can increase inventory level significantly).
ii. Reduce handling and thus also handling costs. This aspect was already taken up in the initial assignment description, and considers the work involved with managing the spare parts by the material planners and the warehouse employees.
iii. Reduce needed storage space. Having a warehouse is also a costly business (the building, storage- and picking equipment), thereby articles on stock require extra handling (for example cleaning or controlling inventory with cycle counting). Thus reducing needed storage space also reduces the costs associated with holding inventory.

2.3.2 Assignment definition

Now we have gained more insight in the company and the nature of the problem and what is expected from this project, the initial assignment is adjusted and defined as:

Final assignment:

> *"Optimize spare parts inventory control at DAF Eindhoven by improving collaboration with suppliers in the supply chain such that spare part inventory costs (consisting of order-,*

transportation-, handling-, inventory carrying- and information-costs) decrease, while maintaining or improving the item fill rate. Develop an implementation plan for one or more article groups / suppliers."

In the initial assignment also the collaboration with DAF Westerlo was mentioned as a potential area of interest. Due to limited time for this project it is decided to leave DAF Westerlo out of scope, and focus only at DAF Eindhoven.

2.3.3 Assignment deliverables

The main deliverables of this assignment are:

- Overview of supply chain collaboration forms (with suppliers) which can reduce inventory costs, thereby indicating important characteristics for successfully implementing that concept and its advantages and disadvantages.
- Decision support tool: Tool in which a potential article group (SKU's delivered by a certain supplier) is evaluated based on quantitative inputs (e.g. value, demand rate), and results in an advice for a suitable collaboration form for that article group. Also an estimation for the potential savings is given by this tool.
- Implementation plan for a specific article group: For one (or more) article group(s), proposed by the decision support tool, the implementation steps for the proposed collaboration form is worked out in an implementation plan. This implementation plan enlights all important aspects needed to successfully implement a collaboration, including agreements made with suppliers and propositions about inventory control. The actual implementation is out of scope for this research.

2.4 Project approach

In order to solve the project in a structured way a framework is set up which guides the project. Aim is to employ findings from theory to the practice situation of DAF, just as is done with the conceptual project design as described by van Aken et al. (6).

In the framework, displayed in Figure 2.1, can be seen how three information resources, to know; information obtained by interviews with management of MMP, interviews with employees of MMP or purchasing, and theory found in books and articles, are the input for in fact three main streams that are later linked together. These main streams are: the objectives of this assignment, current practice and characterisations of current inventory, and findings from theory. Aim is to, depending on the specific objective of the assignment (as described under points i to iii in paragraph 2.3.1) apply concepts from theory to the current situation within DAF. The evolving combinations will be discussed and how they can contribute to the specific project aim by exploring potential cost savings for these combinations (collaboration form applied to an article group).

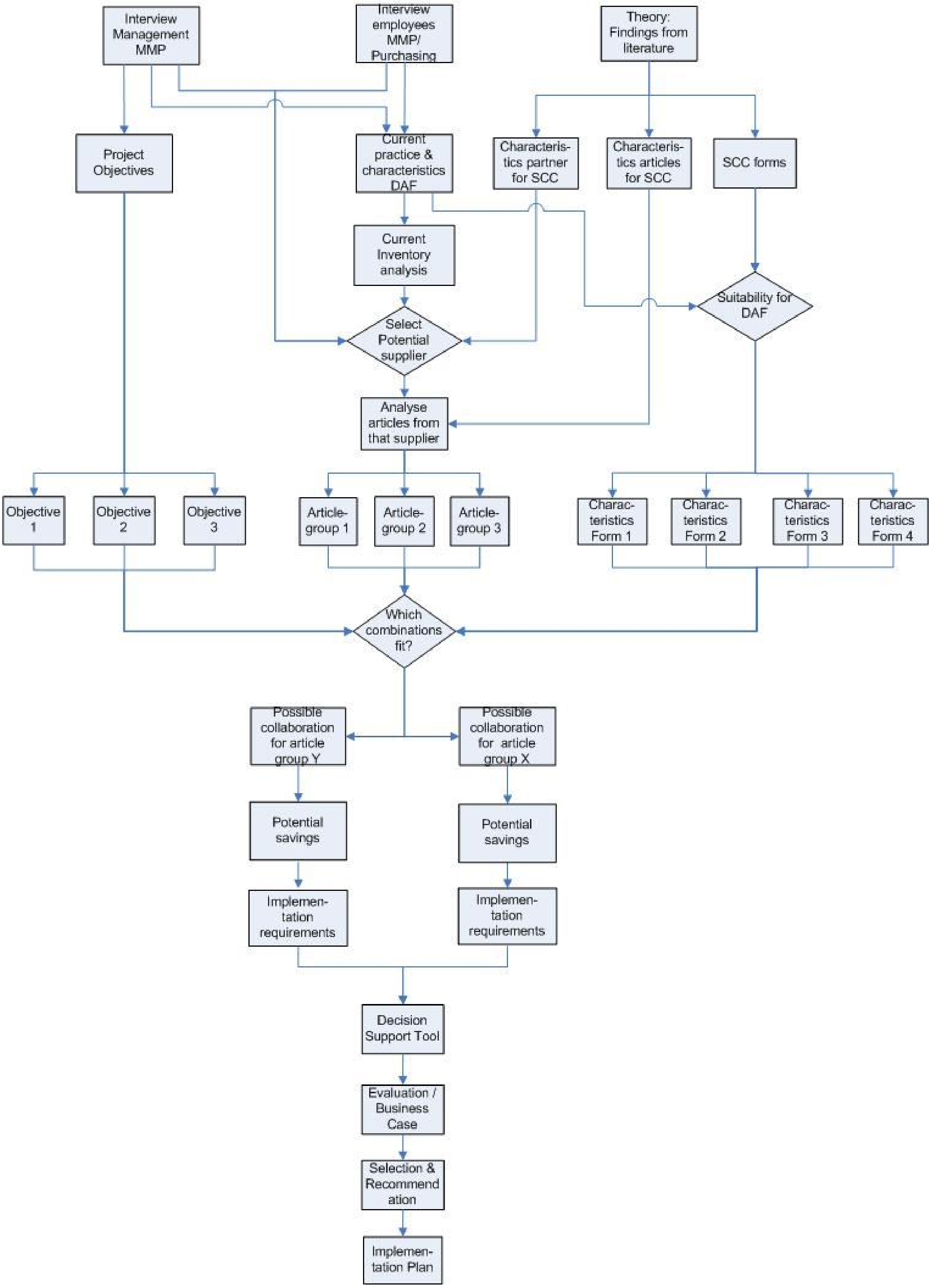


Figure 2.1 Project approach

2.5 Research questions

Solving the assignment as was described at the beginning of this chapter requires knowledge about several topics, which are called knowledge problems. These can also be considered as sub-questions.

Knowledge problems / sub-questions:

1. *How is currently spare part inventory managed at MMP and what are the characteristics of the spare parts?*
2. *Which collaboration forms with suppliers concerning spare parts inventory control are mentioned in literature?*
   For these collaboration forms:
   a. *Which characteristics should a potential supplier have in order to make him an interesting partner for collaboration with DAF Eindhoven?*
   b. *Which characteristics should a spare part article group (e.g. value, demand rate) have in order to be valued as a potential article group?*
   c. *Which characteristics should DAF Eindhoven have or further develop in order to have a successful collaboration with suppliers?*
3. *How to combine the above inputs into a suitable decision support tool which decides on the potential (potential savings, achievability of collaboration) of implementing a collaboration form with a supplier for an article group?*
4. *What are the potential savings when this collaboration form is also applied to other article groups or products from a certain supplier? And for the whole inventory?*
5. *How should DAF cooperate with a potential supplier in order to let a collaboration form for an article group succeed?*
   a. *Which agreements should be stipulated by a contract?*
   b. *For which aspects will informal agreements do?*
   c. *What are the potentials risks of such a collaboration?*

For answering question 1 will be started by interviewing the manager of the MMP department, who is the problem owner of this project. (First he will be asked for some insights in the problem and can be asked which information is available and which persons can offer further information). Next a discussion will be held with the maintenance material planner, in which potential interesting article groups will be discussed. Thereby has this person knowledge about current practice. Further are interviews held with head of purchasing, maintenance supervisor and an employee of PACCAR parts. These persons are interviewed to gather information that is not directly available by MMP, but besides that these interviews were very useful for getting to know DAF. A very important data source is SAP. SAP stores much information, but not how data is gathered. So SAP data appeared only useful after critically evaluating how to use this data. Discussions on that topic with the MMP manager and the SAP functional administrator were thereby critical.

Then literature is studied such that question two can be answered. A literature review should give insight in current inventory control models for spare parts and how these could be applied to contribute in achieving this assignment. Where question 2a emphasizes the spare parts itself, question 2b concerns the potential partner and question 2c addresses important aspects for DAF to maintain or develop. For this last mentioned topic interviews with one of the material planners will be held to reveal how currently collaboration with partners is arranged. Thereby written procedures within DAF are expected to be helpful in establishing current collaboration with suppliers and partners.

Literature research will also be the base for the answer on question four where contract management will have the emphasis. Input for question three follows from question two and preferences from DAF, which will be discussed with the manager of MMP and the DAF supervisor for this project.

3 Current practice at MMP

In chapter one current practice at MMP was already briefly discussed. In this chapter this will be further elaborated by analysing current spare parts inventory, having a look at the performance of MMP and discussing who from the current suppliers is the most interesting partner for implementation of this assignment.

3.1 Spare parts inventory

The spare parts inventory is initiated to support continuity of the production machines. Which production machines are bought is decided by Process Engineering (PE), within the limits of a yearly budget given by PACCAR. PE obtains information from the suppliers concerning the needed spare parts for that machine. This information is given to Maintenance Engineering (ME), who actually decides on which spare parts will be stocked and in which amount. This inventory is controlled by a policy that has the most similarities with an (R,S) Policy. As has already been mentioned, DAF (incorrectly) considers the order up to level (S) and the safety stock (SS) as denoted in SAP as the same. So when in the weekly MRP run is established by SAP that inventory for an article has dropped below the level which is defined as SS in SAP, an order is placed which orders an amount that replenishes that article till the SS level (which is in fact the order up to level S).

Each machine is classified on an ABC level, where only class A and C are used. Class A for machines that directly influence total capacity of the whole factory when a failure occurs, and class C for machines that in case of a failure do not influence the total capacity since output of that machine can be generated by a parallel machine (13). ME creates per machine a part tree. In this way can also be looked back which parts are used for which machines. This part tree is handed over to MMP, who checks the article description on completeness and correctness and codes the articles. From that moment the part tree together with the associated article numbers can be administrated in SAP and the spare parts are purchased by Purchasing.

ME has two departments who maintain (preventively and correctively) the production machines, one department per factory (truck- and engine-factory). They can be considered the customers to which MMP supplies. In case of corrective maintenance a mechanic requests needed spare parts via a work-order in SAP to the warehouse. With preventive maintenance this work-order is initiated automatically by SAP, based on a maintenance schedule prepared by the Maintenance Engineer. As soon as a work-order is released, it is automatically sent to the warehouse, where the warehouse employee picks the spare parts such that the mechanic can directly get the part when he arrives at the warehouse. The warehouse employee administrates this transaction in SAP manually. If current inventory drops below SS, this is established by a weekly MRP run in SAP and a request for order (in Dutch “Aanvraag tot Bestelling”, short ATB) is generated. This ATB is manually checked by a material planner from MMP, and sends in case of approval the ATB to purchasing. They connect the ATB to the contract DAF has with the supplier concerned and order the needed articles. The supplier delivers the articles to the dispatch department of DAF, who receives the goods and is responsible for the further internal logistics. Thus MMP (mostly) receives the goods from this department, but sometimes the goods are directly delivered to the MMP warehouse by the supplier. The warehouse employee receives the goods and manually books these into SAP and stores them at the location denoted by SAP.

There is one alternative for the process where an article is requested via an order. Sometimes a mechanic is not sure which part he needs and he then takes an article from the warehouse so that he can try at the machine if the article is the correct one. This temporarily transaction should be administrated as a reservation. When then the article appears to be the good one the mechanic sends a working-order in which is stated that he already received the article. The warehouse employee then books this into SAP as a definitive transaction. If the article was not correct, the mechanic returns it to the warehouse and the warehouse employee then disposes the temporarily booking. But this alternative procedure is not always correctly followed. Given the semi-open warehouse characteristic of the warehouse some mechanics do not, or forget to, administrate this reservation. Then inventory level of that article is not correctly denoted in SAP for the moment the mechanic has not returned the article. This can be for a short period, e.g. an hour, but in the past it has also occurred that this period even was a few weeks. The mechanic has then put that article in their workshop (where their tools are stored and where the workbenches are) and the article is only then returned when the workshop is cleaned up. In case the article taken by the mechanic is in that period selected in the at random generated counting activity, stock level is corrected and an order is placed with the next MRP review. When then the article is returned a surplus (having more inventory then is denoted with the inventory levels) has been caused.

3.2 Supply chain

MMP manages the spare parts, but does not buy them. Procurement is arranged by the Purchasing department of DAF. When current inventory is taken as the basis for analysis, it shows that there are 600 different suppliers (as was already mentioned in paragraph 1.2.3). An interview with the head of the department “Non Production Purchasing” (responsible for the procurement of the spare parts) showed that currently active suppliers are not yet reduced, but they are still willing to reduce the number of suppliers since maintaining relations with that many suppliers is almost impossible.

After the supplier has delivered the articles they are kept on stock until they are requested by the customers. Except for a small part of the articles, mainly cylinder-head screws. These relatively cheap articles are accommodated under a two-bin system, and can be taken without administrating this. When one bin is empty warehouse employees restock this empty bin with a new bin. This is administrated in SAP such that with the next review period the inventory is restocked till the order up to level (as DAF defines as SS).

3.3 Spare part characteristics

In this paragraph the spare parts are described, except for the articles from the two-bin system, those are left out of scope since these are treated differently from the other articles.

Spare parts are divided into three main categories:

- Tool parts: Hand tools used in production such as air wrenches, electrical drills etc.
- Trading articles: articles that can be bought by several suppliers, e.g. bearings, filters, speed reduction gear, electrical consoles, sensors etc.
- Machine parts: articles that are machine specific and in general can only be bought at the machine builder.

There is no strict guidance for deciding to which group an article belongs. In the past coding the article was being done in such a way that each group had its own number composition. But nowadays this system is polluted to such a degree that one cannot for sure recognize an article based on its number.

3.3.1 Spare parts value

As is already mentioned current inventory consists of about 28.000 SKU's representing a total inventory value of about 17.3 million euro. The Pareto principle can be applied to current inventory (meaning that (roughly) 20% of the inventory generates 80% of the total inventory value), but besides those expensive spare parts there are many low-value articles, namely 30% of the SKU's have a value below ten euro. Remarkable is that the value of the current (total) inventory is much higher than would be the case when each SKU's was replenished till the order-up-to-level (as was explained in paragraph 1.2.4, DAF refers to this as the safety stock). The inventory value for the current situation is given in table 3.1, extracting the value of the safety stock from this amount shows that the excess inventory has a total value of 3,83 million euro. This can at least partly be declared by the fact then when a machine is disposed, some of its parts are kept on stock for other machines. Those parts are booked at the purchase price for such an article when it would be bought new. The consequences from this will not be addressed any further in this report.

	Total Value (rounded to nearest € 1000)
Current inventory	€ 17.327.000
Inventory totally replenished (SS for DAF)	€ 13.497.000
Excess inventory	€ 3.830.000

Table 3.1 Inventory value for different situations

3.3.2 Spare parts consumption

Spare part consumption is analysed by looking at all transactions that administrated the articles given out in the period 2006 – 2009. This administration is done in SAP under a so called 261-booking. Thus non-moving articles (as we define those articles that were not given out during the period 2006 - 2009) are not administrated as such, and will be derived by subtracting the moving articles (SKU's that are minimal once given out and thus were administrated in the SAP 261-booking) from the current inventory, which is shown in Table 3.2. There can be seen that of the moving articles a number of them are not part of current inventory anymore. To account for that these are added up to the number of articles currently in inventory.

	Derivation or Calculation	*SKU*
Current inventory	SAP download on 02-09-2010	28.041
Total number of movers	SAP "giving-out" transactions (in SAP coded as 261)	15.192
Non-courant Movers (Movers that are not part of (current) inventory anymore):	Comparing list of movers with list of current inventory	1.661
Non-mover (over period 2006 – 2009)	Current inventory (28.041) - # of movers (15.192) + # of non-courant movers (1.661)	14.510

Table 3.2 Derivation of number of non-movers

From table 3.2 we can see that half of current inventory (to be exact: (14.510 / 28.041) * 100% = 51,7%) can be classified as non-mover, thus has not been used for at least the period 2006-2009. The non-movers currently on stock have a "safety stock" value of 7,2 million euro. Although it is not strange for a spare part that demand is low, it is remarkable that that many articles experience no consumption for a long period of time. Thereby, there are also many SKU's that were only a few times used during this period. In Figure 3.1 is zoomed in at the number of SKU's that have been consumed twenty times or less in the period 2006 – 2009 to give an idea of the consumption pattern of the spare parts at DAF. (The complete histogram for the consumption pattern is given in appendix B).

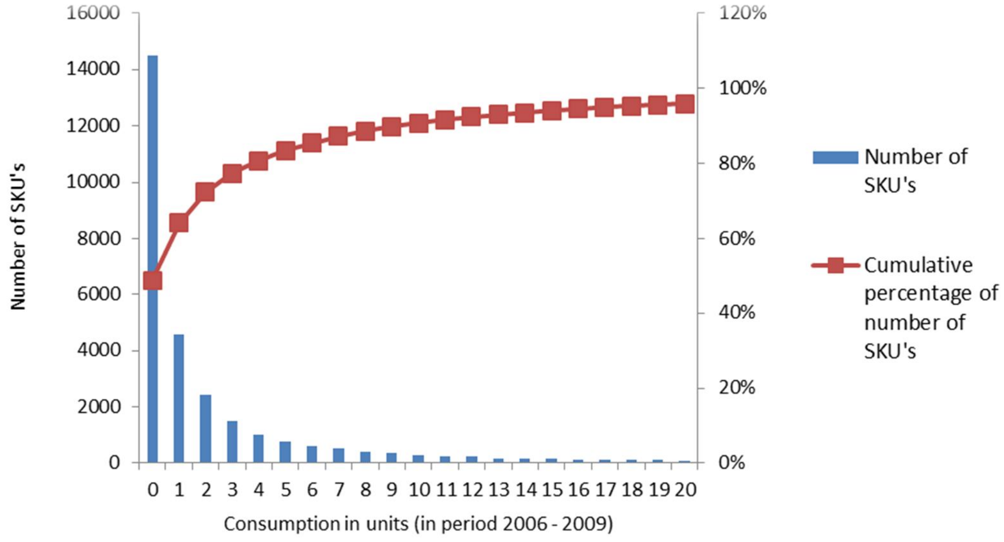


Figure 3.1 Number of SKU's consumed less than 20 times in 2006-2009

The cumulative percentage that approaches the 100% quickly indicates that almost all SKU's currently on stock experienced none or only very little consumption. This is quite noteworthy and having that many non-movers raises the question if some of these SKU's still need to be part of the inventory. Therefore an extra analysis is made for those non-moving articles to see if they maybe could already have been disposed in the past. All articles that haven't shown any movement over that period are checked for machine relations. It appeared that for 20% of the non-movers no machine relation is administrated in SAP. Possibly this could partly be declared by the fact that some machines were already part of the production equipment before SAP was introduced, and that the relationship exists but is never correctly administrated. To verify this, the relations are also checked for the articles that did have demand in that period. For those movers that are part of current inventory (about 10% of the articles that did have demand in the considered time period are not part of the inventory anymore) holds that 64% of those articles have no machine relation administrated. This could mean that there are machines disposed without disposing the articles that are only related to that specific machine. Another reason for a missing relation can be on administrational grounds. Considering the large percentage it is not plausible that this is only caused by one of the two reasons. Therefore we cannot simply assume that articles without a machine relation administrated can directly be disposed. Although this information could be helpful for further analysing whether or not information of current inventory is totally up-to-date, it is out of scope of this project to audit all the missing relations. Data evolved from this observation is handed over to the manager of the MMP-department.

Besides the non-movers there are also some articles that are often used for being a spare part. Reason for this can be that there is no clear difference in used articles for preventive or corrective maintenance, as was already mentioned earlier. Preventive maintenance is scheduled, but in practice parts are not preventively replaced, but instead machines are visually inspected and when needed parts are replaced. So it is not known in advance which parts are needed for conducting preventive maintenance to a machine, so that typically preventive maintenance articles (such as sensors, filters) are treated as being corrective maintenance spares.

However, it must be said that this information is not 100% accurate because data is directly used from SAP where an article given out but later returned back is still administrated as usage. It can for example occur that an article is given out to a mechanic, who afterwards discovers that he cannot use it, and returns it to the warehouse (directly, or even after a few days/weeks in case he puts the article in the workshop and is returned only then when they for example clean up the workshop). This is booked in as a retrieval of goods, just as it would be when delivered by a supplier. Negative effect of this is that this is denoted as consumption, while in fact this is not the case. But in spite of this data not being totally accurate we can still conclude that most articles show no consumption, since this figure would only be higher when data was 100% correct.

3.3.3 Consumable versus repairable SKU's

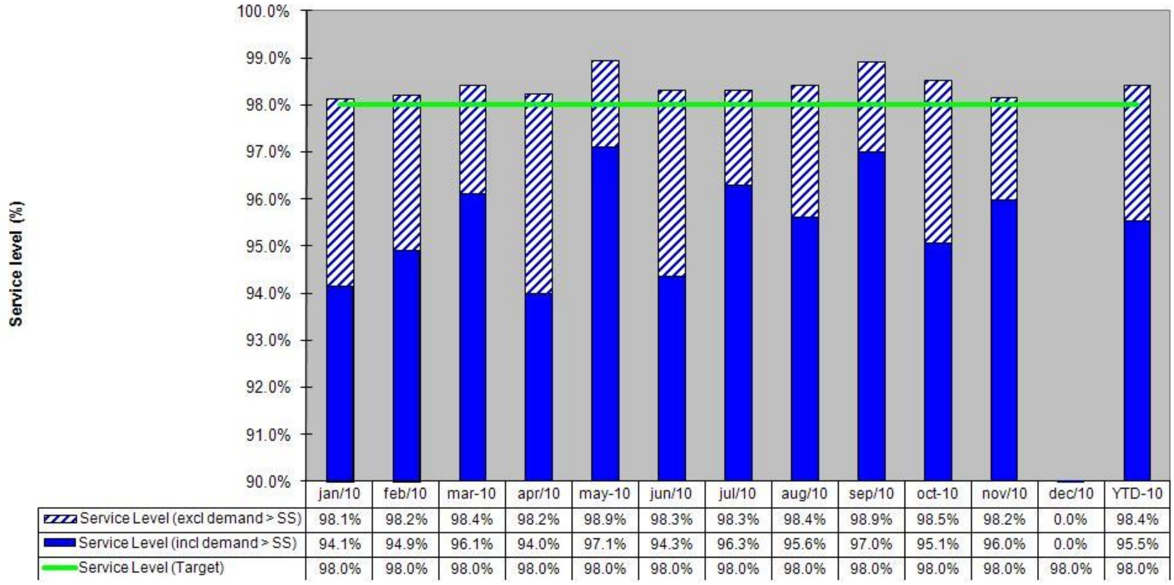
Data from SAP shows that 7.4% of all spare parts are repairable items. Repair can both be done internally or externally. Repairable items at DAF are in general the more expensive items (value larger than 500 euro), but unfortunately accurate data for this is not available, since sometimes articles are booked in at a price of €0.01. This is done when spare parts belonging with a new machine are given as part of a warranty contract. Result from this is that actual value of the article is not known.

3.3.4 Delivery times

MMP administrates per spare part what the delivery time is and denotes this in SAP. Information concerning this is directly given by the suppliers. A monitoring activity among deliveries showed that not all data given by the suppliers is correct. Therefore delivery times for the article group / supplier that will be chosen for collaboration in this project, (current) delivery times must be verified again in case this information would be needed.

3.4 Performance

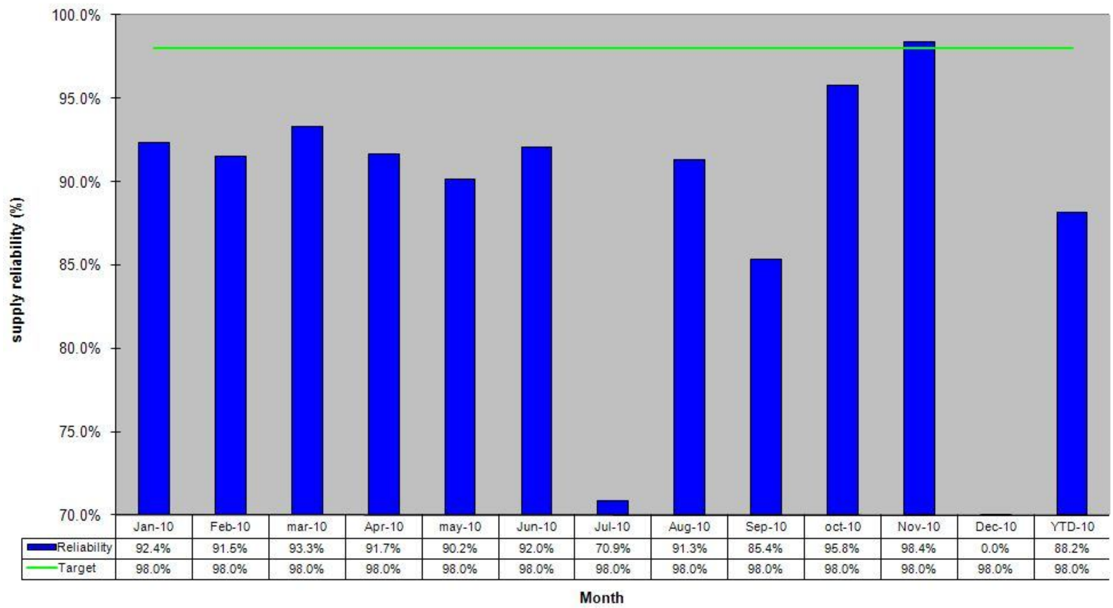
Performance is constantly measured via the KPI's mentioned in chapter 1. Performance criteria concerning inventory value and item fill rate (for those situations where the requested demand was smaller than or equal to the safety stock) are met. Figure 3.2 on the next page displays the service level, as was defined in chapter 1, over the first eleven months of 2010. To be seen is that the overall service level (so for all demands, including those larger than the safety stock) does not meet the target of 98%. The service level only for demands smaller than the safety stock does meet the target. The last bar, YTD-10 is the average over the months mentioned, to be seen is that average for the service level including and excluding demand larger than the safety stock are respectively 95,5% and 98,4%. So from this figure can be concluded that each month there are several demand requests for more SKU's then there is safety stock, for example caused by preventive maintenance where spare parts are not ordered at forehand. For those cases the service level does not fulfil the KPI, while the KPI is fulfilled for the situations in which demand is not larger than the SS, thus probably for situations in which spare parts are requested for corrective maintenance.



	jan/10	feb/10	mar-10	apr/10	may-10	jun/10	jul/10	aug/10	sep/10	oct-10	nov/10	dec/10	YTD-10
Service Level (excl demand > SS)	98.1%	98.2%	98.4%	98.2%	98.9%	98.3%	98.3%	98.4%	98.9%	98.5%	98.2%	0.0%	98.4%
Service Level (incl demand > SS)	94.1%	94.9%	96.1%	94.0%	97.1%	94.3%	96.3%	95.6%	97.0%	95.1%	96.0%	0.0%	95.5%
Service Level (Target)	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%

Figure 3.2 Service level per month (January till November 2010)

Another KPI already defined in chapter 1 was inventory reliability. In Figure 3.3 the inventory reliability is displayed, again, the last bar indicates the average over those months. As this figure shows, inventory reliability is only met in November, and is very variable per month. But this can be due to the fact that count cycle lists (which indicate which shelves have to be counted) are generated at random. But nevertheless, the supply reliability is too low so it is important that the improvement seen in October and November continues.



	Jan-10	Feb-10	mar-10	Apr-10	may-10	Jun-10	Jul-10	Aug-10	Sep-10	oct-10	Nov-10	Dec-10	YTD-10
Reliability	92.4%	91.5%	93.3%	91.7%	90.2%	92.0%	70.9%	91.3%	85.4%	95.8%	98.4%	0.0%	88.2%
Target	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%

Figure 3.3 Inventory reliability per month

3.5 Conclusion

Current spare part inventory consists of slightly over 28.000 SKU's. Total inventory represents a value of 17.3 million euro. Remarkable is that 51,7% of these SKU's, with a total value of 7.2 million euro, has never been used in the considered period (2006 – 2009). Since for 20% of current inventory there is no relation found in the system the expectation arose that many articles stored in the warehouse were not courant anymore. This is also the case for many articles that did experience consumption in that period, thus we cannot simply conclude that all these articles can be disposed since they will never be used again. However, it is worthwhile to further investigate this observation.

Inventory is controlled with help of the ERP software SAP. Inventory level is checked weekly with a MRP run and ordered up to a level indicated by DAF as the safety stock. A safety stock as is normally used in inventory control is not used at MMP.

A problem faced by running the warehouse is that in practice the difference between preventive and corrective maintenance is not always made. This can result in requests for a number of articles larger than the safety stock, which then cannot be fulfilled. Because of that situation the KPI service level is divided in two figures, one for requests smaller then SS and one for requests larger then SS. Further the supply reliability is monitored. Performance of MMP in that area is insufficient. One reason (not the only one) for this can be that the warehouse is often used as an open warehouse, which decreases control since sometimes it occurs that a mechanic who takes an article himself does not or forgets to administrate this transaction.

4 Supply Chain Collaboration

This chapter will describe the theoretical aspects of Supply Chain Collaboration and discuss its several different forms which are elaborated upon in literature. This will be done by focusing on answering the second research question which is formulated as follows:

> *"Which collaboration forms with suppliers concerning spare parts inventory control are mentioned in literature?"*

4.1 Introduction to Supply Chain Collaboration

Before introducing Supply Chain Collaboration (abbreviated to SCC (14)) we will decide on a definition for 'supply chain' since literature offers many different definitions. Lummes and Vokurka (15) have created a summary definition which will also be used in this report, and thus a supply chain is defined as:

> *"all the activities involved in delivering a product from raw material through the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all these activities".*

In this broad definition the three fundamental stages of a supply chain, procurement, production and distribution (16), can be recognized.

Supply chain collaboration is defined as: *"when two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation"* (17). Three structures can be distinguished in collaboration: vertical collaboration (cooperation between two or more organizations at different levels in the supply chain), horizontal collaboration (cooperation between two or more unrelated organizations) and lateral collaboration (combining and sharing capabilities in both vertical as well as horizontal manners) (17).

In paragraph 2.2 was already briefly discussed to what positive results SCC can contribute. Some benefits from supply chain collaboration discussed in the literature are for example:

- Competitive advantages (7)
- Higher service levels (8)
- Greater economic benefits in comparison to traditional (market exchange) relationships (Paulraj et al. 2008, cited in (18))
- Bullwhip effect is reduced (not eliminated) (19) (20)
- Inventory level reduction up to 50% without compromising customer service levels (20) (9)

Supply chain collaboration can be situated between arm's length relations, which are purely transactional and do not have any degree of collaboration, and joint ventures or vertical integration, which involves common ownership of the supply chain (21). To summarize, SCC is characterized by collaboration between partners and does not entail common ownership of the supply chain.

4.2 Supply Chain Collaboration characteristics

There are several ways to be engaged in SCC (Cooper 1997, cited in (14)). To start with, there is the dyadic approach which only entails collaboration between immediate partners in the supply chain.

Next to that, in a second approach a channel leader, called channel integrator, is used who leads the supply chain collaboration. The third method of engaging in SCC uses a fourth party logistics provider (4PL) for coordinating and controlling the collaboration. In contrast with a third party logistics provider (3PL), in which the third party is an operator, a 4PL is an (independent) consultant who leaves the logistic handling to other parties (Van den Berg (2001) cited in (22)). The fourth method, vertical integration, adopts ownership of other channel members and therefore is not considered as collaboration by Kampstra (14). The project at hand will focus on the dyadic collaboration approach, which is a good starting point since it does not rely on third parties, and thus does not make the already difficult implementation of such a collaboration even harder.

Next to these different approaches to SCC, the intensity of the collaboration can also differ, which can be characterized according to the 4C supply chain typology (23). 4C stands for the four main configurations: the communicative, coordinated, collaborative and co-opetitive. The communicative configuration has the lowest level of collaboration; each of the entities is independent and fully autonomous and there is no shared set of pursued global objectives. It is a supply chain that is not managed, but just exists and involves short term relations when necessary (Mentzer et al. 2000, cited in (23)). The partners communicate, but the sharing of information is restricted to the transmission on a nearest-neighbour basis (e.g. supplier to manufacturer) of transactional data such as prices, due dates etc. (Mentzer et al. 2000, cited in (23)). The next type is the coordinated configuration, where the supply chain leader coordinates the supply chain collaboration in a hierarchical way. In this form, more information is shared through the coordinator to the whole supply chain and there is a common goal which is determined by the coordinator (23). In the collaborative configuration, the entities agree on a set of collectively defined objectives, decisions are made centrally and there is supply chain-wide information sharing in order to reach the common objectives. The highest level of collaboration is in the co-opetitive configuration. This involves a partnership between the supply chain entities, which results in a jointly agreed on goal and supply-chain-wide information sharing (23).

Already since the beginning of this report there is spoken of collaboration in the supply chain, which insinuates that the desired collaboration goes further than the communicative configuration. As is just indicated, the focus will be on the collaboration between two partners in the supply chain, without having a third party supply chain leader. (A supply chain leader must be a third party since he may not be the first entity that comes up with the collaboration ideas (14)). Since the scope of this research is on collaboration with DAF and her supplier(s) (instead of collaboration with the whole supply chain) with collaboration the collaborative configuration as described above is meant.

4.3 Supply Chain Collaboration forms

Now the definition and main characteristics of SCC have been discussed, in this paragraph there will be elaborated on some SCC forms. The following SCC forms will be described in this paragraph.

- Collaborative Planning, Forecasting and Replenishment (CPFR)
- Quick Response(QR)
- Continuous Replenishment (CR)
- Vendor Managed Inventory (VMI)
- Vendor Managed Inventories (VMI)
- Consignment inventory (CI)
- Supplier Owned Inventory (SOI)

4.3.1 Collaborative Planning, Forecasting and Replenishment (CPFR)

The Voluntary Industry Commerce Standards (VICS) describes CPFR as "*a business practice that combines the intelligence of multiple trading partners in the planning and fulfilment of customer demand*" (12) (24). It is a standard methodology for companies in the same supply chain to work together in order to reduce costs while increasing revenue and customer satisfaction (25).

The customer and the supplier share information, such as marketing information on promotions and forecasts (25), on a shared webserver (26). The supplier can then predict demand more accurately, safety stock at the customers can be reduced and inventory costs decrease. Suppliers benefit from this collaboration since they use these forecasts in order to improve their production planning. Order decisions are made by the customer, based on the forecasts jointly made by the customer and the supplier. Besides the jointly made forecast, the customer remains responsible for the other aspects such as storage of articles, setting inventory levels and the ownership of the inventory.

Because of the improved forecasts safety stock can be reduced by implementing CPFR, which can contribute to two objectives DAF has for this project (as was described in paragraph 2.3.1), namely reducing inventory value as well as the storage space needed.

4.3.2 Quick Response (QR):

Derived from CPFR is QR, "*a partnership where retailers and suppliers work together to respond more quickly to consumer needs by sharing information*" (15). It is a Just-In-Time (JIT) partnership that, just as with CPFR, incorporates marketing information on promotion, discounts, and forecasts into the manufacturing and distribution plan (15). With this information the supplier can synchronize his production and inventory control with the actual sales of his customer, since he is now better capable in forecasting demand. Order decisions are made by the customer. Where CPFR improves inventory control by better forecasting future demand, QR's biggest improvement is the combination of forecasting future demand and decreasing response time to the market. So just as with CPFR the customer is still responsible for setting inventory levels, initiating replenishment orders and owning the inventory. Since there are no significant differences in the characteristics between QR and CPFR, QR will not further be considered.

4.3.3 Continuous Replenishment (CR)

Continuous Replenishment (CR) (27) is described in literature under several terms, such as: Continuous Product Replenishment (CPR) (28), Continuous Replenishment Programs (CRP) (9) (29), Continuous Replenishment Policies (30) or Continuous Replenishment Planning (CRP) (Andraski 1994 in (31)). In this report Continuous Replenishment (CR) will be used. CR is preceded by Efficient Consumer Response (ECR) (15), in which information is quickly sent up the supply chain so that future demand can be anticipated far more accurately. With CR this information (real time inventory status, demand (9)) is sent automatically by computers allowing the supplier to increase the replenishment frequencies (9) and replenish the customer just-in-time (15). The customer is still responsible for the order decision (9) just as for storing the articles and the financial ownership of them. CR can be seen as one step for VMI (which will be discussed in the next paragraph).

Due to this more efficient (possible due to the better information the supplier receives) and faster collaboration between the customer and the supplier, safety stocks can be reduced, which results in lower total costs of handling inventory through the entire supply chain.

4.3.4 Vendor Managed Inventory (VMI)

"*VMI is a collaborative commerce initiative where suppliers are authorized to manage the buyer's inventory of stock-keeping units*." (32).

With VMI the vendor (this can be a manufacturer, reseller or distributor (33)) becomes responsible for managing the inventory at the customer's site (34). Inventory is still owned by the customer and stored at his premises (10). This has the benefit that the supplier is better in forecasting and managing their products because they only have to manage a relatively small portfolio of products, in contrast to the customer who would have to manage a broad portfolio of purchased articles (35). The supplier is responsible for setting target inventory levels and making restocking decisions (29) (34). Claassen et al. (35) indicate that in case of absence of a customer's trust in the supplier's capabilities to replenish just-in-time, the customer may set tight min-max limits, thereby leaving less leeway for the supplier to decide upon the optimum replenishment schedule (35).

When VMI is applied the supplier can benefit from this collaboration because he is better able to align (and stabilize (35)) his production process to customer demand since information about actual demand and forecasted demand is available at an early stage (35).

VMI differs from CR in the responsibility for setting target inventory levels and making the order decision. While with CR it is still done by the customer (possibly in deliberation with the supplier), in VMI it is the supplier who takes the responsibility for these activities (29) (9).

Implementing VMI requires both the sharing of information and the coordination and integration of processes between buyers and suppliers (32). For sharing information EDI programs are very convenient, but not necessarily required since data can also be exchanged through other means such as e-mail (36). However, information shared through EDI has a larger impact on collaboration effectiveness than information shared via traditional ways (35). Whichever specific way of information exchange is chosen, it is important that it takes place because VMI's strong reliance on the extensive sharing of information (37). As already pointed out, not only data must be shared but supply chain partners must also maximize the visibility of their processes, because the major weakness of VMI lies in the insufficient visibility of the whole supply chain [9].

The data that has to be exchanged includes the availability of resources (e.g. capacity, inventory), the status of performance (e.g. time, costs, flexibility), the status of processes (e.g. forecasting, ordering, replenishing) and the status of contract and can be exchanged in real time or on demand (17).

Quite similar to VMI is SMI, Supplier Managed Inventory. Whereas VMI includes the coordinated management of stock-keeping units, SMI deals with the flow of raw materials and component parts that are inbound to a manufacturing process (38). Consequently, this means that with SMI demand for materials depends upon demand for finished goods further in the chain. Concerning VMI demand is independent. Therefore, since the spare parts at DAF are finished products, SMI is not applicable and for that reason SMI will not further be discussed in this report.

VMI contributes to the same aspect as CR, thus reducing the needed handling and therefore also the handling costs.

4.3.5 Vendor Managed Replenishment (VMR)

The literature offers different definitions of VMR. Claassen et al. (35) differentiate between VMI and VMR by considering VMR as a first step towards VMI. In VMR the vendor takes responsibility for ordering, inventory management and replenishment. Claassen et al. (35) describe that many of the VMI collaborations are actually VMR collaborations according to that definition. But they also state that their research was not extensive enough to prove that statement. Next to that most literature does not define VMR (or at least not differently from VMI). Based on those latter two reasons VMR will in this report not further be considered.

4.3.6 Consignment Inventory (CI)

With CI, goods are (financially) owned by the supplier until they are used by the customer. Who should physically store the goods is not unanimously agreed upon in literature. For example Gümüs et al. (39), Valentine and Zavanella (7), Ru and Wang (40) state that articles are stored at the customer's premises. While Zhang et al. (41) and Piplani (10) state that the physical possession of goods can be both at the supplier and customer's premises.

With CI the customer incurs no capital costs for holding this consignment inventory, since it is only paid for articles when they are actually used. Within CI there are two variants, the first where the customer makes the replenishment decision (then called Retailer Managed Consignment Inventory (RMCI) by Ru and Wang (40)) and the second where the supplier makes the replenishment decision, referred to as Vendor Managed Consignment Inventory (VMCI) (Ru and Wang (40)) or as consignment and vendor-managed inventory (C&VMI) (Gümüs et al. (39)).

Usually the customer, DAF is this case, gains the most from CI (39).

In the following chapters of this report it is assumed that concerning CI the order decision is still made by the customer. The variant in which the supplier is responsible for the replenishment decision is referred to as Supplier Owned Inventory (SOI) and will be further elaborated on in the next paragraph.

To summarize, in this report Consignment Inventory will be seen as a form of SCC in which the supplier financially owns the inventory and also stores the articles. The customer remains responsible for initiating replenishment orders. Here, it is important to notice the difference in definition of CI as understood by DAF. DAF assumes CI as the case where the supplier stores the articles in the warehouse of DAF, and DAF only pays for the articles when they are used. Currently, this is especially the case for articles delivered as spare parts for a new machine, and this CI only applies during the warranty period of the new machine. After this period, DAF decides which articles to buy and store in the DAF warehouse, the other articles must then be taken back by the supplier. However, as already mentioned, in this report the earlier mentioned definition will be used. In order to have a successful CI collaboration the supplier must have insight in consumption data (39).

In the definition as will be used in this report, CI can contribute to multiple objectives at the same time. First, since the supplier remains the financial owner, the inventory value at the customer's premises decreases. Hence, the supplier also stores the article(s) at his premises, thereby reducing also the needed storage space at the customer's site. Finally, needed handling of the inventory decreases partly. Not having to store the articles in the warehouse, also means that some of the required inventory handling is not needed anymore (i.e. cycle counting, article administration such as coding and receiving goods). Order costs however remain with the customer.

4.3.7 Supplier Owned Inventory (SOI)

As was already described in the previous paragraph, CI is by some authors considered to be a form of SCC in which the supplier is, besides financially owning the articles, responsible for initiating replenishment orders. This situation is called Supplier Owned Inventory (SOI) (10) or Vendor Owned Inventory Management (VOIM) (42), and is defined as a situation in which the supplier owns and manages the inventory at the buyer's, customer's or 3PL's premises. In this report this distinction will also be used and referred to as Supplier Owned Inventory (SOI). Since with SOI the supplier handles the inventory of the customer, he is also responsible for deciding upon the order-up-to-level, after discussing the required service level with the customer. In order to successfully manage the customers inventory, the supplier has to have real time access to data, just as with VMI as is already discussed in paragraph 4.3.4. Just as

4.4 SCC forms compared

The most common forms of supply chain collaboration described in literature are now discussed and defined. For the sake of clarity these SCC forms will be summarized in table 4.1 on the next page by stating for each type the most important factors. In the first column, it is depicted at which party the inventory is physically stored, then in the second column, it is pointed out who financially owns the inventory. The third column shows who gives the order for replenishments where after in the two following columns is stated who sets the inventory levels. The table continues with which information has to be shared among the partners and who uses this information to make a forecast. The last column indicates to which of the objectives mentioned in paragraph 2.3.1 the SCC-form contributes.

	Inventory storage at:	Inventory financially owned by:	Order decision made by:	Set inventory levels:		Info exchange from customer to supplier:	Forecast made by:	Contributes to objective:
				Min inv level / Service level:	Order-up-to-level (S):			
CPFR	Customer	Customer	Customer (based on jointly made forecasts)	Customer & supplier	Customer & supplier	Marketing information on promotion & discounts	Customer	Inventory value reduction Storage space reduction
CR	Customer	Customer	Customer	Customer & supplier	Customer & supplier	Real time inventory level, Consumption data	Customer & supplier	Handling costs reduction
VMI	Customer	Customer	Supplier	Customer & supplier	Supplier	Real time inventory level, Consumption data	Supplier	Handling costs reduction
CI	Supplier	Supplier	Customer	Customer	Supplier	Consumption data	Supplier	Inventory value reduction Storage space reduction Handling costs reduction
SOI	Customer / 3PL / Supplier	Supplier	Supplier	Customer & supplier	Supplier	(Real time inventory level)[1] Sales data	Supplier	Inventory value reduction (Storage space reduction)[1] Handling costs reduction

Table 4.1 Most important characteristics of the SCC-forms described in literature

[1] When inventory storage is at the supplier or 3PL

For DAF it will be the first time to be engaged in SCC. It means for DAF (and its partner) an adaption of current working methods and a direct focus on the SCC on hand. For that reason it will be best for such a first SCC that just one will be implemented, instead of multiple SCC-forms at a time. For that reason we will also make in this report a selection of SCC-forms that we will further focus on. In this report will further be focused on the SCC-forms VMI, CI and SOI. Since with these SCC-forms the supplier plays a bigger role than with CPFR and CR (as can be seen from the comparison in table 4.1). The benefit of the supplier having a bigger role in this SCC is that the benefits for DAF are bigger. For example with VMI and SOI the supplier takes over the inventory control, where with CI the supplier takes over the inventory storage. Where CPFR and CR biggest contribution lie in a more efficient approach, without any further services of the supplier. Of course these SCC-forms can in a later stadium also be implemented, but as was already said, it is recommended to first focus on only a few SCC-forms and then decide on which form has the best potential for DAF.

4.5 Conclusion

This chapter consists for a large part of defining terms and concepts involved with supply chain collaboration . To start with supply chain, it was defined according to the summary definition of Lummes and Vokurka (15) as:

> "*all the activities involved in delivering a product from raw material through the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all these activities".*

Supply chain collaboration (SCC) was defined as *"when two or more independent companies work jointly to plan and execute supply chain operations with greater success than when acting in isolation"* (17) . Discussed was that SCC can result in, among others, service level improvement and inventory level reductions.

SCC for DAF will be based on a dyadic approach (collaboration with an immediate partner) and will have the character of a collaborative configuration; thus objectives must be defined by DAF and the supplier together, thereby making decisions centrally based on information shared between the partners in the SC-chain.

Several forms of SCC exists. In this chapter the most common forms described in literature were discussed from which appeared that Vendor Managed Inventory (VMI), Consignment Inventory (CI) and Supplier Owned Inventory (SOI) are best suitable for a first collaboration and thus will be focused on in the remaining chapters of this report.

5 Characteristics for Supply Chain Collaboration

This chapter further elaborates on the collaboration forms described in the previous chapter, and discusses under what conditions the chosen SCC forms (VMI, CI and SOI) can contribute to the aim of reducing inventory costs. This will be done by discussing which characteristics the potential supplier should have, which the characteristics of suitable article groups are and which characteristics DAF should employ or improve in order to enable a successful collaboration.
The research questions that will be answered in this chapter are:

2a. Which characteristics should a potential supplier have in order to make him an interesting partner for collaboration with DAF Eindhoven?
2b. Which characteristics should a spare part article group (e.g. value, demand rate) have in order to be valued as a potential article group?
2c. Which characteristics should DAF Eindhoven have or further develop in order to have a successful collaboration with suppliers?

As it was indicated in chapter 4, with collaboration a vertical collaborative configuration is meant between DAF and a supply chain partner. Because of this vertical collaboration, for DAF this supply chain partner is thus a supplier, as has already been mentioned from the beginning of this report.

5.1 Characteristics potential supplier

The research of Valentini and Zavanella (7) concerning consignment inventory indicated that a partner involved in a consignment inventory (CI) project must be among one of the most active and critical suppliers, starting from considerations on the type and/or quantity of pieces supplied together with the economic relevance of their supplies (7). Thus finding a partner for the SCC starts with analysing the articles of the suppliers. Since in this project the focus is on inventory costs, the article analysis of each supplier was aimed at identifying the total (current) inventory value that supplier represents. Thus the first selection criterion for a potential partner is that the supplier concerned must represent a **significant total inventory value**.

Secondly is it important that DAF already has a **good relationship** with the supplier and contact on a regular basis, preferably also on a personal level. Larsen et al. (43) indicate that collaborations based on information-sharing relations require a great deal of coordination and face to face meetings. Hence, the partners must **trust** each other as well since trust between the partners is a key element of the relationship (44) (37). Trust can be defined as ‘‘*the ability to reliably predict the actions of the other party in the relationship and the belief that the other party will not act opportunistically if given the chance to do so*” (23).

On a practical level the parties must be **(technically) able to share information** among each other. This can be via e-mail, a shared webserver or by creating an interactive connection via SAP between DAF and the supplier. As was already indicated in paragraph 4.3.4 communication via EDI resources has a positive effect on collaboration effectiveness, so communication via an ERP system like SAP or via databases on a shared webserver (26) have the preference over traditional communication ways such as telephone or fax. Moreover, information exchange via a shared webserver requires fewer initial investments than adjusting the EDI programs at both the parties. Nevertheless, at the beginning of the collaboration it must be explored how information is going to be exchanged, so that it can be arranged in short-term with acceptable costs for both parties.

Selection criteria that evaluate the supplier himself are offered by Kahraman (45), who developed criteria for measuring important aspects of a supplier's business largely independent of the product or service sought. Kahraman (45) mentions that some criteria may be impractical to evaluate during selection and that the firm's criteria should be appropriate to its planned level of effort. For this situation two of these aspects are used for DAF to evaluate a potential partner, since these two aspects give valuable information and are easily to be recovered. The mentioned aspects are "financial strength" and "globalization and localization", and will be described next.

Financial strength: From a financial point of view the supplier should have a solid financial position, which can be an indicator for long-term stability (45). DAF's department "Control Purchasing" analyses the financial strength of (potential) suppliers in two ways: first, analysis takes place on basis of the annual report of the supplier that he must submit to DAF, and secondly, DAF relies on an externally made analysis, called the Dun & Bradstreet (D&B) rating. This is an objective risk-indicator that evaluates financial strength and the risk that is involved inherent with doing business with the particular company involved with having transactions with that company (46). The D&B rating will in this report be used, since this also includes the financial strength of a company. Risk is evaluated on a scale from one to four, which describes the risk as follows; 1: Minimal risk, 2: low risk, 3: More than average risk, 4: significant risk (46). A potential supplier must be evaluated on the score one or two, otherwise DAF should not get involved in a collaboration since risks of not succeeding is then too high.

Globalization and localization: With this aspect risks such as shifts in national policies and currency fluctuations are recognized. Holweg et al. (21) define this aspect on a more practical level, they state that the smaller the distance between the partners is, the easier it is to implement supply chain collaboration. Accordingly, a short distance would be advantageous for the chosen forms of SCC since then articles can be delivered quickly when needed, without the need for DAF to store and handle all articles in the warehouse. The distance between DAF and its partner must not be more than 250 km (measured by a route planner like for example Google maps), since this is considered to be the maximum distance over which an article can be delivered quickly (at least within four hours). Next to that, it is assumed that globalization will not further play a role, since political aspects will not be very different considering the relatively short distance between DAF and potential partners who are hence located in the Netherlands or in one of the neighbouring countries. Thus political aspects are about the same.

5.1.1 Supplier selection

In this paragraph we will apply the selection criteria for a potential partner as they were discussed in the previous paragraph. The first criterion was that the supplier must represent a significant total inventory value in DAF's current inventory. For this reason data from SAP (from 2006 to 2009) is evaluated in order to select suppliers who represent a large financial inventory value (relative to total inventory value). For each current supplier (meaning a supplier of whom at least one article is in current inventory) it is calculated how much inventory, in terms of total value, he represents of the current inventory. Resulting from this was a list of current suppliers, and the total value they represent, in a descending order. As was described in paragraph 3.2 there are 600 suppliers. Because the first criteria for a supplier was that he must represent a significant total inventory value, not all suppliers can fulfil this requirement. One way to make sure that the supplier concerned does represent a significant inventory value is to always take the supplier with the biggest inventory value. For that reason the first few (seven to be exact) suppliers with the biggest inventory values were selected, and evaluated on the second criteria, thus establishing the relation DAF has with that supplier and the level of trust DAF has in that supplier. This was done by discussing those suppliers with the manager of MMP, my DAF supervisor, a maintenance material planner and head of purchasing “non-production goods”. When none of these suppliers would have fulfilled the second requirement, then the next suppliers on the ranking off the previously mentioned inventory value list should be discussed.

For those seven suppliers the outcome of the evaluation on these two criteria, the total inventory value and the relationship between DAF and the supplier and the level of trust DAF has in that supplier, is summarized in table 5.1.

Supplier	**Total value SKU’s currently in inventory (€)**	**Comments from interview**
SCHEIB ELEKTROTECHNIK GmbH	1.139.019,-	Very good relationship, trust in partner. Supplier is able to answer technical questions; contact on a personal level.
BIESHEUVEL BV	980.344,-	Only little trust in that they would be a good partner since experiences with them were not always good. This mainly concerned issues where technical support (e.g. questions about article specifications) was not as good as expected.
BOSCH REXROTH BV	916.250,-	Relationship medium. In the past it occurred several times that questions concerning orders were not treated very well (for one order, questions had to be addressed to several departments of that supplier). This has been improved lately, but it is still not good enough to be considered as a good partner for close collaboration.
GEREEDSCHAPMAKERIJ	595.068,-	Internal party of DAF; therefore not a potential partner for this project (their material, except for the raw material such as metal sheets etc., are stored in the MMP warehouse and is controlled by MMP)
BURKHARDT & WEBER	531.458,-	Machinery constructor; articles currently in inventory are those that came with the new machine. When consumed these will be replenished from another supplier. Therefore not considered as potential partner for collaboration.
ATLAS COPCO BELGIUM BV	488.148,-	Good relationship, trust in partner.
SCHWABISCHE WERKZEUG	323.826,-	Machinery constructor; articles currently in inventory are those that came with the new machine. When consumed these will be replenished by another supplier. Therefore not considered as potential partner for collaboration.

Table 5.1 Result of supplier selection criteria 1 and 2.

First to notice is that some of these suppliers are rejected from being potential partners for reasons other than mentioned before. These suppliers concern machinery constructors. From the interviews it appeared that in general articles of those suppliers are only stored within the period of a contract of guarantee. Once that contract has expired those articles are in the most cases bought from another supplier. For that reason are these suppliers not selected as potential partners for a long term collaboration. Furthermore, one party is not considered as a potential partner since they are an internal

DAF party, called "Gereedschapmakerij". This is the department that designs and manufactures tools and machinery. Their warehouse is especially dedicated to the storage of sheet metal, and next to that they use the MMP warehouse. Thus a SCC-form with them would not lead to more efficiency in the supply chain and is therefore no candidate for being a SCC partner.

Now that these external factors have been discussed, it can be continued with the selection criteria as they were described in paragraph 5.1. Of course the mentioned suppliers all fulfil the requirement of representing a large inventory value, since these are the suppliers that represent the largest inventory values of all current suppliers DAF has. From the four suppliers that are left of this evaluation round, two fulfil the second and third criteria, namely that DAF has a good relationship with them and has trust in them. From these two, Scheib Elektrotechnik GmbH is chosen in order to further analyse their suitability. When one of those requirements is not fulfilled Atlas Copco BV will be analysed on these criteria. When they would also not pass the criteria then must be returned to criteria one and select the next supplier from the inventory value list.

Scheib Elektrotechnik GmbH (later referred to as Scheib) is located in Düsseldorf (Germany). They are specialized in solutions for all electrical and electronic industry requirements (47). Scheib mainly delivers electrical- motors and modules to DAF. This supplier will be further evaluated on the characteristics as described in paragraph 5.1.

Financial strength:
As has already been pointed earlier the financial strength of a supplier will be determined with help of the D&B rating that is made for each of the DAF suppliers by an external party. Scheib's overall score on the D&B rating is equal to 1, which means that risk of doing business with them is minimal. Thus, Scheib fulfils the financial strength criterion. In appendix C the complete D&B rating report is given.

Globalization and localization: Moreover, it has already been explained that Scheib is located in Düsseldorf (Germany), the distance between Scheib and DAF measures approximately 125 km. That Scheib is an German company and DAF a Dutch company is not considered to be a problem. The currency is the same and drastic differences in political circumstances are not expected. So Scheib also passes this criterion.

Accordingly, Scheib fulfils all criteria formulated in paragraph 5.2 and can be considered as a potential partner for the SCC. A first exploratory interview with the director of Scheib revealed that they are well willing to cooperate and already have experience in the field of VMI and CI with other customers. This is reason enough to further focus on Scheib as a potential partner for a SCC-form in this report, and no other suppliers of DAF will be evaluated.

5.2 Characteristics potential article group

As was described in paragraph 4.3 and 4.4 have each of the SCC-forms their own characteristics. It therefore also depends on the characteristics of the articles subject of that SCC-form, whether or not the SCC will have its effect. Therefore will in this paragraph a method be discussed that analyses the SKU's and places them accordingly in segments assigned to either VMI, CI, SOI or no SCC. This latter allocation means that the SKU does not have the right characteristics to really profit of one of the SCC-forms and

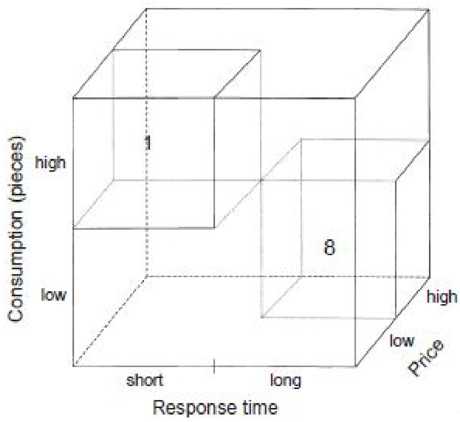


Figure 5.1 Allocation framework article group **(48)**.

thus responsibility for the control and storage of these SKU's will remain for DAF. Classifying the SKU's will be done by a framework proposed by Botter and Fortuin (48). This allocation framework characterizes SKU's on three dimensions: price, consumption and response time. These dimensions will be explained next. Botter and Fortuin recommend using two categories for each dimension: low and high. Then there are in total eight (2^3) article-segments, which is graphically represented in Figure 5.1. Article-segment 1 and 8 are displayed as an example.

The first dimension, price (or value) of the article, is important since expensive articles contribute more to the total inventory value and thus are more important for the objective inventory value reduction. The limit from which on DAF considers an article as expensive is 500 euro. (Recall from paragraph 1.2.5 that for the value of an article the purchasing price is used). To evaluate this figure we will look at the effect it has on the inventory. So far when considering inventory value, the value at a certain point in time was meant. This value of course depends on the chosen moment to monitor the total value. To have a more reliable view, a theoretical inventory value would be of more use. We therefore assume that inventory is totally replenished. In chapter 6 will be further elaborated on this choice and why is not chosen for the average inventory level as is more common in inventory management literature. Hence, the inventory level of each article is assumed to be equal to the order-up-to-level (S) of that article. Recall that within DAF this level is referred to as safety stock (SS). Selecting all articles with a value of € 500,- or more results in a deviation where 15.8% of the articles are being considered as expensive. Together they represent 78.6% of total "safety stock" value. Since this approaches the Pareto rule, it is assumed to be a reasonable deviation for distinguishing the expensive from the (relatively) cheaper SKU's, and thus will also be used as input for the allocation framework.

The second dimension is consumption because this factor also influences SCC decisions. It is likely that fast moving articles are treated differently from slow moving articles, depending on the exact aim of the SCC-form. For example, for fast moving articles handling costs can be significantly decreased, while reducing the risk of articles becoming obsolete have the biggest impact for slow moving articles. Handling costs are mainly caused by the number of order lines in an order, independent of how many items are requested of that SKU. Thus, in order to determine the border line that distinguishes between slow- and "fast-" moving, we will take a closer look at the consumption data over the period 2006 – 2009. From table 3.1 in paragraph 3.3.2 it appeared that during that period 15.192 SKU's were consumed. On the next page Figure 5.2 shows in a cumulative way in how many order lines these SKU's were requested.

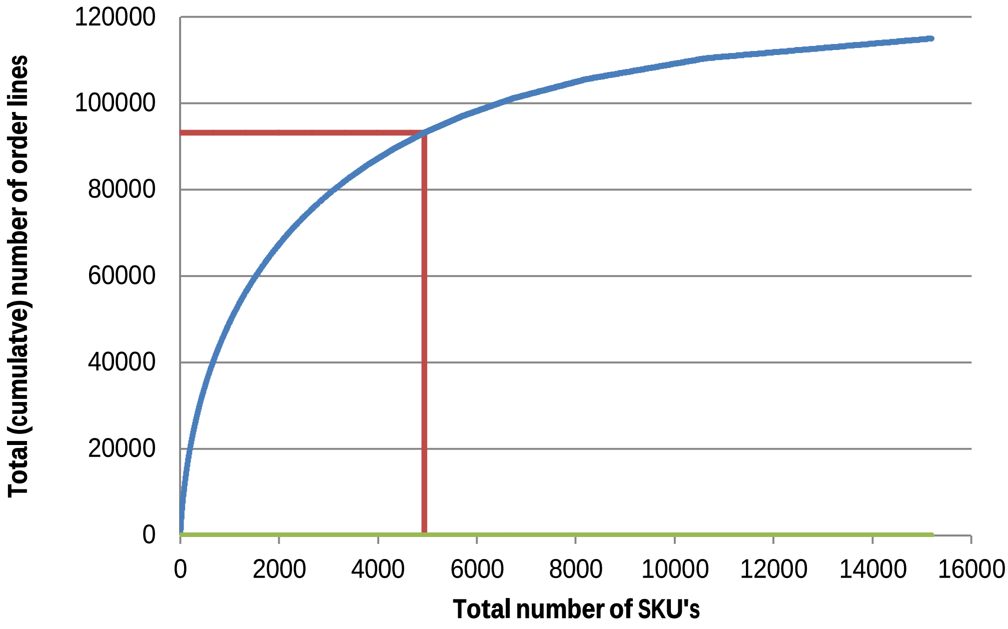


Figure 5.2 Cumulative number of order lines over the period 2006 - 2009

The rectangular lines in Figure 5.2 show that 32.5% of the SKU's with the highest consumption rate count for 81% of the total number of order lines. It appeared that this consumption rate was equal to a consumption of 6 times over four year, thus equal to 1.5 times per year. Although this would normally not be considered as fast moving, it will be in this report since it suites the consumption pattern for the spare parts at DAF.

The last dimension is response time, defined as the time that is allowed to provide customers with service parts (48). This dimension is very important since it is used to give an indication of criticality. Criticality of DAF spare parts are evaluated to some extent, but only by the relation they have with class A or C machines (from the ABC analysis where class B is not used). An article is considered critical when that article is related to a class A machine, and not critical when related to a class C machine. According to Huiskonen (49) an ABC-analysis is an insufficient control tool since the impact of a shortage of a critical article may be a multiple of its commercial value (49). Moreover it could be possible that the failure of one article on a class A-machine has a whole other effect than when another article on that same A-machine fails. However, Huiskonen also indicates that determining downtime costs of an article failing is very difficult. He proposes a practical approach of relating criticality to the time in which the failure has to be corrected, which can be compared with the dimension response time in the allocation framework as was discussed in the beginning of this paragraph. In contrast to the other dimensions (price and consumption), response time cannot be calculated based on available SAP data. These required data must be derived by having interviews with maintenance engineers and maintenance mechanics. The maintenance engineer have a good insight on the criticality of certain machines or even production lines, while the mechanic has the knowledge about all practical matters, such as time needed for replacing an article or if a failure can be fixed with a temporally reparation. Which engineers and mechanics must be interviewed depends on in which production groups the article is used.

The response time directly influences how fast an article has to be delivered. First we consider two segments, as was proposed by Botter and Fortuin. These segments divide the articles in those that can be delivered via the normal ordering procedure, and those articles that are needed faster. We will refer to these categories as long- and medium response time respectively. The thereby belonging time boundary is eight business days, chosen considering the worst case scenario where the article fails at Tuesday. Then the MRP-run in the night of Monday to Tuesday creates an ATB only on the Tuesday in the next week (thus 5 business days later) after which the supplier sends it to DAF by its regular transport way, which is assumed to last at most three days (and thus should also be agreed upon with the supplier), considering that the supplier is within a range of 250 km from DAF as was already discussed.

This does not perfectly fit the situation DAF faces, since considering only those two response time categories would mean that for many articles storage at the supplier is not an option (and thus not suitable for CI or SOI). Therefore, a third option is added, by means of the possibility of having emergency supplies. Since an emergency supply (by courier or taxi) is a lot more expensive than a normal replenishment, it is thus only lucrative for expensive slow movers. This is why it is chosen to add a third segment to the response time category, called short response time, for expensive articles, which results in having in total 10 segments. This changes also the other segments. The new dimension, short response time, is for all articles that have to be delivered within four hours with an emergency supply (recall that a potential supplier is always within a range of 250km from DAF). For this four hour boundary is chosen in deliberation with the spare parts material planner. Theoretically some articles have to be replaced immediately. But the practice shows that also in the current situation this is not realized. A mechanic who needs an article to repair a machine must first order the part via a computer on a central point, and then has to go to the warehouse to retrieve the article. This process is time consuming and never realized directly. The medium response time category changes such that it fits between the short- and long- response time. Articles in this category are replenished by normal courier delivery services, within 24 hours.

To summarize all three response time categories will be defined next, where the first two categories, short- and medium response time, are combined in one category for the low value articles.

Response time categories:

- Short response time: The article is needed as fast as possible (within 4 hours). Thus the article must be stored in the DAF warehouse or delivered via an emergency supply. In this category it is important that the failed article is ordered immediately, so that while the mechanic is operating on the machine to disassemble the defective article, the new article is on its way.
- Medium response time: The article is needed fast, but continuity of production is not harmed if the delivery of the article takes a bit longer (between 24 hours and 8 business days). This would be the case when a buffer of already produced goods can feed the rest of production for a while or when another machine can be used as a replacement for the machine that is not functioning due to the failure of the article. Upper bound for this category is 24 hours since a courier (without the need for emergency supply can pick up and deliver the article within 24 hours considering the maximum distance of 250 km. When an article has a response time of about 3 days, and thus is categorized in this segment, it will thus be delivered within 24 hours, even though this is not necessary.
- Long response time: Eight business days or more. Production is not directly influenced by the defective part because the machine can continue producing after a temporary repair . The new article can be ordered via the normal procedure (as it would be done in case of replenishing the safety stock). This may take at most eight business days considering the worst case

scenario where the article fails at Tuesday. Then the MRP-run in the night of Monday to Tuesday creates an ATB only on the Tuesday in the next week (thus five business days later) after which the supplier sends it to DAF by its regular transport way, which is assumed to last at most three days (and thus should also be agreed upon with the supplier), considering that the supplier is within a range of 250 km from DAF as was already discussed.

In theory, a fourth category exists, namely a response time equal to the delivery time as it is given by the supplier. This would be the case when the need for a new article would not be urgent (waiting time for the new article can be equal to the delivery time as given by the supplier, say about 1 to 3 months), for example when the uptime of the machine can be extended by temporary mending, or when wear of the article is observed early enough but the article still functions correctly. For these cases there is no need for a SCC-form and the article can be ordered at the moment in which it is established that it is needed. Since there is no SCC-form established, there are also no agreements made considering the minimal service level the supplier should offer. He therefore does not have to have the article in stock and once the supplier receives a request for the article he can order it (or needed raw material) from his suppliers (further up the supply chain). This scenario is out of scope for this project since for all articles considered it is already decided that a safety stock is required, and that there can never be waited as long as the delivery as denoted by the supplier.

With these three dimensions, value, consumption and response time, each article can be evaluated and assigned to a segment. But before the allocation framework can be used some other criteria have to be fulfilled. Firstly, the article may not be DAF-specific. That makes a big difference for the supplier since with a DAF-specific article he cannot apply a risk-pooling strategy. When the article is more general, he probably will have more customers who buy that article from him. With a DAF specific article he could no apply this risk-pooling effect.
The next requirement is that the three dimensions are known for each article of the supplier where the collaboration is initiated with. In this way the articles can be assigned to the segments and decided on which SCC-form is the best and which SCC-form will be initiated. For articles that already are part of the current inventory the value- and consumption dimension are already known from historical data. The response time however must be established via interviews (as was already mentioned earlier in this paragraph). For those articles that are new to DAF there is no historical data available. Hence, data must be gathered via information which should be given by the supplier and by the Maintenance Engineers within DAF who are able to assess the response time per article. Consumption rate must then be estimated based on a forecast made by the Maintenance Engineer that is responsible for the machine in which the article is placed. Another option is to trust in the reliability specifications given by the supplier.
Whether there is a form of SCC that is best suitable for a segment and which SCC-form this would be depends on the exact objective DAF strives after. Recall (from paragraph 2.3.1) that there are three objectives for implementing a SCC-form, namely:

1. Reducing inventory value.
2. Reducing handling and thus also handling costs.
3. Reducing needed storage space and thus holding costs.

For each segment it will be discussed which SCC-form can contribute to which objective. How each SCC-form in general can contribute to the objectives of DAF was already discussed in chapter 4, and can be summarized as is given in table 5.2.

SCC-form	Contribution to objective
VMI	Reducing handling (costs)
CI	Reducing inventory value
	Reducing needed storage space and thus holding costs
SOI	Reducing inventory value
	Reducing handling of the order process (thus order costs)
	Reducing needed storage space and thus holding costs (in case inventory is stored at the supplier)

Table 5.2 Summary of the contributions of the SCC-forms

Segment 1: *low price, medium response time, high consumption*.
In this segment the medium response time creates the need to facilitate the storage of the articles close to the work floor or that arrangements concerning emergency supplies must be agreed upon with the supplier. The low value of the articles in this segment makes SCC-forms such as SOI or CI expensive relative to the value of the article considered, thus it should only be considered when emphasis lies on reducing occupied storage space. Since transport costs of emergency supplies are also high compared to the value, the articles in this segment can best be stored in the DAF warehouse. Considering the high consumption, outsourcing inventory control via VMI to the supplier, who, as was discussed in the previous chapter, is able to do this more efficiently because of his experience with his “own” products and the ability to estimate future demand, it would be lucrative for DAF since handling costs for DAF would decrease (objective 2).
Due to the low value this segment will not contribute to objective 1 (inventory value reduction). If DAF solely strive for objective 3, storage space reduction, then CI would be the best SCC-form. Overall, it is concluded that all factors combined lead to the conclusion that VMI is the most efficient solution for this segment, whereby inventory cost savings can be achieved since handling costs decrease due to the ability of the supplier to arrange this more efficiently.

Segment 2: *Low price, medium response time, low consumption.*
The only difference with segment 1 is that the degree of consumption is lower, therefore this segment is not suitable for contributing to a significant reduction of handling costs. The potential savings are too low to counterweight the needed extra expenses involved with a SCC-form. DAF can therefore better keep inventory control itself, and thus does not have to engage in a SCC-form for the articles in this segment. Even though CI would contribute to storage space reduction (objective 3) this is not recommended since it would not yield further major benefits or improve efficiency in the supply chain.

Segment 3: *Low value, long response time, high consumption.*
Considering the long response time it becomes more lucrative to allocate the articles at the supplier’s or 3PL’s warehouse since transportation cost are not different from regular transport tariffs. Since the values of the articles are still low, contribution to inventory value reduction (objective one) will be low as well, and thus not worthwhile the extra costs. For the same reasons as with segment one would VMI be a good option to contribute to the second objective, reducing handling costs. CI could only moderately contribute to the third objective, since the values of the articles are low, and thus are also the costs of holding the inventory in the current situation. Accordingly, VMI is the best solution for this segment.

Segment 4: *Low price, long response time, low consumption.*
The only difference between this segment and with the preceding one is that the consumption is lower. Whereas segment three was suitable for VMI, for this segment this is not as efficient since consumption is lower. Again CI could contribute to the third objective, but further efficiency improvements will not be significant.
Thus for this segment SCC is not significantly more efficient than the current situation and thus DAF should keep inventory and control of it to herself.

Segment 5: *High price, short response time, high consumption.*
This is the first segment where the values of the articles are high. Please recall that for the high value segments all three response time categories exist. The other difference with the low value segments is that now the segments could possibly contribute to objective 1 (inventory value reduction) when CI or SOI would be implemented. For this specific segment it is required to have the inventory close to the work floor or to have an emergency supply agreement with the supplier, since the response time is direct. Whereas for previous segments this possibly needed (expensive) transport option was not an option considering the only moderate savings, the high value in this segment accounts for this since potential savings are higher. In this case preference is given to SOI, because it contributes both to inventory value reduction for DAF (objective 1) and handling is taken over by the supplier (objective 2) who can do this more efficiently and therefore the more expensive SOI (compared with VMI) is beneficial. Since consumption is high it is more efficient to store the articles at DAF premises; therefore, the SCC-form SOI with storage at the customer is the most efficient form for this segment. For the same reason this segment is not suitable to contribute to the objective of reducing occupied storage space.

Segment 6: *High price, short response time, low consumption.*
Compared to segment 5 the consumption in this segment is lower. This means that storage of the articles can be more efficiently done at the supplier, since he can pool DAF’s inventory with those of other customers so that consumption in total is higher and can be more efficiently handled. The extra transport costs (due to the short response time) can be compensated by the fact that inventory holding costs decrease significantly due to the high values of the articles in this segment. Handling costs are relatively low because of the low consumption. So there is only a small contribution to objective 2.Consequently, considering all those aspects CI is the most suitable SCC-form for this segment.

Segment 7: *High price, medium response time, high consumption.*
This segment could be treated in the same way as segment 5, but in this segment transportation could also be done by means of a regular courier (instead of an emergency supply) resulting in extra cost savings for DAF compared to the short response time category. Nevertheless, taking everything into account, the most efficient SCC-form is still SOI with storage at DAF’s warehouse because of the high consumption.

Segment 8: *High price, medium response time, low consumption.*
Given the high value and the low consumption of articles in this segment, it would be beneficial for DAF to outsource financial ownership, but not handling because of the low consumption. The supplier can control this type of article more efficiently because by risk pooling his consumption level can be higher. So for this segment CI is recommended. The medium response time defines the need

for transportation via a regular courier when the article is requested. Thus with CI both objective 1 and 3 are strived after.

Segment 9: *High price, long response time, high consumption.*
Compared to segment 5 and 7 the only difference is the longer response time. This means that no extra transportation costs have to be made since it can be delivered via the regular transportation ways the supplier uses. Still agreements have to be made concerning a certain service level that has to be guaranteed by the supplier, thus implementing a SCC-form is also necessary for this segment. SOI with storage of articles at the supplier's site would contribute to all three objectives at once. Since potential savings are high (considering the high value and consumption) and no extra transport costs are incurred, extra costs of implementing SOI with storage at the supplier can be recovered by those savings. Together with the experience and expertise of the supplier, this segment can be managed most efficiently via SOI with storage at the supplier's warehouse.

Segment 10: *High price, long response time, low consumption.*
Considering that the only difference with segment 9 is that this segment experiences lower consumption, potential savings are less since handling costs are at the moment relatively low. However, since article values are high and the long response time offers the opportunity of no extra transport costs, CI is an efficient SCC-form. The supplier can pool those articles with the articles of other customers and thus handle them more efficiently. For this situation CI offers a suitable solution thereby contributing to objective 1 and 3.

The characteristics and conclusion for each segment are summarized in table 5.3 on the next page.

Segment	Value	Response time	Consumption	Objective*	**SCC-form per objective**	**SCC-form for most efficient overall solution**
1	Low	Medium	High	i ii iii	- VMI CI	VMI
2	Low	Medium	Low	i ii iii	- - CI	-
3	Low	Long	High	i ii iii	- VMI CI	VMI
4	Low	Long	Low	i ii iii	- - CI	-
5	High	Short	High	i ii iii	SOI (storage at customer) VMI -	SOI (at customer)
6	High	Short	Low	i ii iii	CI - CI	CI
7	High	Medium	High	i ii iii	CI VMI CI	SOI (at customer)
8	High	Medium	Low	i ii iii	CI - CI	CI
9	High	Long	High	i ii iii	CI SOI (storage at supplier) SOI	SOI (at supplier)
10	High	Long	Low	i ii iii	CI - CI	CI

** Objective:*
i: reducing inventory value
ii: reducing handling
iii: reducing needed storage space

Table 5.3 Article group segments and corresponding SCC-form

5.2.1 Article group selection

When a supplier is selected and a first exploratory discussion revealed that the supplier is willing to cooperate in this SCC, the articles subject of the collaboration can be selected. The sequence of first selecting a supplier and then selecting articles subject of the collaboration is important since in this way this is more time efficient because fewer articles need to be analysed (instead of the whole DAF inventory only the articles of that supplier have to be analysed). Since it is very time consuming but still very important to evaluate the response time of each article it is better to focus on a relatively small group of articles. At this point in time, after selecting and establishing the willingness of the supplier Scheib to cooperate in SCC, the articles of Scheib could be analysed. Since the article-analysis itself is not the scope of this project it will not be done as such in this report. However, in chapter 6 will be further elaborated on the article group selection by analysing the Scheib articles based on estimated response time values.

5.3 Characteristics DAF for collaboration

In the previous two paragraphs the characteristics for potential articles and potential suppliers were discussed. The characteristics are especially of use for identifying potential suppliers and articles for a collaboration form. So far, characteristics for the actual collaboration were not discussed. How successful the collaboration will be depends on how the supplier and DAF work together. In order to select a supplier who is capable of collaborating and building a long term relationship, the selection criteria discussed in paragraph 5.1 must be fulfilled. Moreover, DAF should adapt in such a way that the collaboration stands the biggest chance of success. In order to do that DAF should try to avoid the potential pitfalls of collaboration such as they are mentioned in literature. The work of Saccani and Perona (50) summarizes the pitfalls that are described by several authors. These will, together with how DAF can avoid them, be discussed next. After that it will be elaborated on the characteristics DAF should already have or further develop so that they are able to avoid the pitfalls.

Potential pitfalls of collaboration (50) and how DAF can avoid them:

- *Lack of trust:* It was already mentioned that trust is an important factor. Thus it is very important that DAF selects a supplier whom they trust (as it is also considered in the supplier selection criteria). Once the collaboration is implemented DAF should maintain this trust in the supplier and in his capabilities. This may be done by evaluating the performance of the supplier. When the supplier does perform well in this collaboration he proofs that he deserves the trust given by DAF.
- *Different cultures / values:* Also this pitfall can be avoided by following the criteria for selecting a supplier. Since it was recommended to select a supplier relatively close to the DAF facility, it will thus be a supplier from the Netherlands or from one of the neighbour countries were culture and values of the companies are probably not very different.
- *Lack of managerial commitment:* Both the management of DAF and the supplier's management should support the collaboration. Also this issue can be prevented by following the supplier selection criteria. It was indicated that the management approach of the supplier must be comparable with the management approach of DAF. To further enhance this aspect and thus avoid this pitfall, the management of DAF should enter into negotiations with the management of the supplier before the collaboration actually starts. During these negotiations it must be agreed on objectives and agreements of the collaboration.
- *Size of buyer/supplier, available resources:* Both the customer and the supplier should have resources so that they are able to collaborate. This concerns employee skills, equipment, information systems etc. (51). By following the supplier selection criteria DAF can focus on selecting a supplier whose resources fit DAF, for example an information system that fits the system of DAF so that information can be easily shared without the need of (expensive) investments in the system. When a supplier does not fit all the resources requirements, DAF can also offer additional/special support to the supplier, thereby the supplier is trained and does fit DAF's requirements at a later point in time.

- *Lack of shared goals, mismatched perceptions of the collaboration:* This pitfall can be avoided by DAF in the same way as the pitfall "lack of managerial commitment": objectives and agreements must be clearly specified before establishing a collaboration.
- *Unsuitability of the purchased good:* This can be avoided by strictly following the characteristics for the potential article group as discussed in the previous paragraph.
- *Lack of benefit/risk sharing:* It is important that DAF does not strive after cost savings or the transfer of risk to the supplier for purely personal gain. Not only will additional costs sooner or later be passed on by the supplier to DAF, but it also risks the collaboration. DAF can prevent this by focusing on the reduction of costs and risks throughout the complete supply chain.
- *Resistance to information sharing or to access to knowledge:* DAF should share information with the supplier. Not only does this enhance the collaboration, but the supplier can also perform better when he has access to all needed information, such as the current inventory levels and possibly made forecasts (in case of DAF this only concerns preventive maintenance) and when articles are disposed or new articles are needed (e.g. for a new machine bought by DAF).
- *Loss of bargaining power, high dependence on the other party:* This is the third pitfall that can be avoided by jointly agreeing on objectives of the collaboration and making agreements on how to collaborate, so that power is not unequally divided among the partners. This should preferably be done by the management, since then several of the mentioned pitfalls are avoided (besides this one, also "lack of managerial commitment" and "Lack of shared goals, mismatched perceptions of the collaboration" are avoided).

Now that each potential pitfall and a way for DAF to avoid them has been discussed, it will next be focused on the characteristics DAF should have or employ in order to best cope with these pitfalls. Thereby, we will actually answer research question 2c. (*Which characteristics should DAF Eindhoven have or further develop in order to have a successful collaboration with suppliers?).*

Characteristics of DAF necessary for a successful collaboration:
- *Trust in the supplier:* To check whether or not this trust is justified DAF should monitor the performance of the supplier.
- *Visibility:* DAF should share information with the supplier. Besides that this shows that DAF has trust in the supplier, sharing information is also essential for collaboration. This can be done by giving the supplier direct access to SAP or by sending periodically (e.g. at the end of each day) an overview of current inventory levels by e-mail.
- *Management support:* special attention must be paid to the start-up phase of the collaboration during which the objectives for both parties are defined and agreements are made. The management of the MMP department must play a significant role in this, which is also good for the long term relationship with the supplier.
- *Strive after optimization for the whole supply chain:* As was already indicated, it is of no use to strive after cost or risk reduction only for DAF since this negatively effects the collaboration, and thereby in the long run the supplier will probably compensate this for example by charging higher purchasing prices.

5.4 Future SCC projects

In this report we only consider SCC with one supplier and the articles delivered by that supplier. Considering that this would be a first SCC project for DAF, collaborating with only one supplier instead of multiple suppliers does not unnecessary complicate matters. In the future, SCC projects can be performed parallel to the SCC with Scheib. Also for those projects the supplier selection criteria and the allocation framework, as they were discussed in this chapter, must be used. The supplier selection criteria dictate that the supplier that is a potential partner for SCC represents a significant inventory value. When there are in the future several SCC projects initiated, it will for every new project be harder to realize the selection criterion that the supplier must represent a large inventory value. Then another option is to research the possibility to allocate articles that are at the moment bought at several suppliers, to one supplier. Thereby enlarging the total value that that supplier represents. Such a project to research this possibility could be combined with DAF's intention to reduce the number of suppliers (as was already mentioned in paragraph 3.2).

5.5 Conclusion

In this chapter research question two is answered. First the characteristics for a potential partner were discussed. It appeared that it is very important that DAF has trust in the supplier and has already established a good relationship with them. Furthermore, the supplier must have a solid financial foundation which can be demonstrated by the Dun & Bradstreet rating and must represent a significant inventory value in DAF's inventory. Further, the supplier must be located within a range of 250 km from DAF such that deliveries can be done in a relatively short time frame. Finally it is important that DAF and the supplier can communicate (information exchange on expected demand, inventory levels) during the collaboration, in that aspect it is important that the supplier has the technical capabilities to do so. When a supplier is selected, the articles delivered by that supplier can be analysed with help of a model called the allocation framework. This framework assigns SKU's to segments based on three dimensions: value, consumption and response time. Ten segments resulted from this, whereas for two of those segments it was recommended not to apply a collaboration form. The other segments were suitable for either a VMI, CI or a SOI collaboration form. To let those collaboration forms succeed, DAF should participate active in the collaboration, but also in the preparation phase of the collaboration. This requires management support for the collaboration, creating visibility in the inventory levels to the customer and defining objectives and good agreements with the supplier. For a first SCC project the supplier Scheib was selected as the best candidate for being a partner in SCC. For future projects the supplier selection criteria can be repeated to select a new partner for a (parallel) SCC project. When the largest suppliers are evaluated and possibly selected, it can also be explored if it is possible to allocate those SKU's to one of the large suppliers, which also contributes to DAF's goal to reduce the number of suppliers, such that also those articles can become subject of SCC.

6 Savings on inventory associated costs

Please recall that the problem statement of this project is:

> "*How can DAF apply collaboration in the supply chain such that inventory costs are reduced?*".

Thereby inventory costs were briefly introduced in the assignment description, but not yet further explained. In this chapter all costs associated with the inventory are discussed and how these costs will change for DAF when one of the SCC-forms would be implemented. To do this some assumptions are made which will be discussed and explained throughout this chapter.

6.1 Elements of inventory associated costs

With handling and storing inventory several costs elements are involved, these are:

- Order costs (52). The costs of the administrational process of preparing an ATB, releasing the ATB by material planning, placing an order by purchasing at the supplier, checking the order status by material planning , and once the articles are received booking this retrieval into SAP such that order status and inventory levels are adjusted, and finally actually paying the invoice by purchasing.
- Transportation costs: The cost of moving the inventory from the supplier's to the customer's warehouse. In the current situation the supplier incorporates the transportation costs into his article price, and then delivers according to the Incoterm Delivered Duty Paid (DDP). This only holds for regular shipments, in case of an emergency supply transport costs are for DAF (transport is then arranged via a FCA (Free Carrier) incoterm arrangement). The transportation costs could also be brought under the order costs (52). Nevertheless, in this report they are considered separately since it depends on the SCC-form and the response time of the article whether or not transportation costs influence the potential savings.
- Handling costs: Handling the material starts with receiving the materials by the DAF expedition department and transporting it internally to the MMP warehouse (in case that the supplier does not directly deliver to the MMP warehouse). Handling costs that are incurred by the MMP warehouse are checking the order (are the right articles delivered?) and stocking them in the right location (if no location exists creating one). Then storage of materials requires handling since they must be cleaned and inventory levels are randomly checked by having cycle counts such that inventory reliability can be monitored (as was already described in paragraph 1.2.5). Finally the article will be picked and given out, which is the last element of handling costs.
- Inventory carrying costs: Inventory carrying cost (or called holding costs) are dependent on the amount of inventory stored and consists of (10):
    - Capital costs / opportunity costs: There is an opportunity cost to holding inventory, as the money invested in the inventory could be used elsewhere to provide a return on capital.
    - Inventory service costs: Taxes and fire and theft insurance paid on inventory held.
    - Storage space costs: (Fixed) costs associated with the storage facilities (company-owned warehouse).
    - Inventory risk costs: Charges for obsolescence, damage and relocation of inventory.

- Information costs: costs incurred as part of setting up, maintaining and using the information systems which enable the administration of transferring inventory in and out of the warehouse (10).

Each party in the supply chain, customers and suppliers, can incur these inventory associated costs. In general can be expected that the supplier incurs in total less inventory associated costs since he can handle inventory more efficiently (as was already indicated in chapter four) and the value of an article is lower since a supplier is upstream in the supply chain. But this does not mean that it is the aim of this collaboration to just move the inventory and the control of it upstream the supply chain. Aim is to more efficiently handle inventory in the supply chain and decrease the thereby belonging costs. When inventory and or control of it is transferred from the customer himself to the supplier, the supplier will incur extra costs. These costs have to be compensated by the customer, this could be done via a monthly fee paid by the customer to the supplier. Aim of this chapter is to give insight in how the inventory associated costs change for DAF with each of the three SCC-forms due to this higher efficiency. This information can DAF use in the supplier negotiations on the fee to be paid.

6.2 Inventory associated costs at DAF

In this paragraph will be discussed what the costs, as they were mentioned in the previous paragraph, are for DAF such that can be determined how the inventory associated costs change for DAF when involved in SCC. Not all cost elements are defined as such, so in order to determine the change of the cost elements caused by SCC, sometimes data was adapted or assumptions were made such that these cost elements could be used after all for determining the change in costs. If this is the case then the derivation or assumption will be declared.

We will start with the **handling- and order costs.** DAF has not defined these costs as such. Instead, they have incorporated these costs in an average annual costs saving figure per article. They assume that when a SKU does not need to be handled anymore this realizes a saving of € 329,- per article over a year for active articles, and for in-active articles € 51,- (the data source for these figures is given in table 1 in appendix D). An in-active article is defined as an article that has not been used in the last 24 months. Note that this is only used for calculating savings instead of actual costs of holding inventory. Before this figure can actually be used for calculating the financial effect of SCC, this general savings figure has to be divided into order- and handling costs separately, as is also common in current literature. This is done in two steps:

1. An expert opinion is asked concerning the ratio between order- and handling costs. This was estimated on the ratio 75:25, order- and handling costs respectively, because the larger part of handling an order is the order process itself (this process was already discussed in paragraph 3.1).
2. This average yearly figure will be converted to costs per order or per order line. This will be done by examining the number of orders (and orderliness) over the observed period of 2006 till 2009, and the number of SKU's that were concerned in these orders. Thereby only focusing on those SKU's that are, according to the allocation framework discussed in paragraph 5.2, suitable for one of the SCC-forms with the supplier Scheib and the SKU must have an active status. This is necessary since the focus is purely on inventory cost reduction realized by SCC with that supplier, and in-active article do not generate order- or handling costs. (This is not completely correct, since some in-active articles did show consumption in the first two years of the observed period. But then again an in-active SKU can be replaced by another SKU, which would then also lead to incorrect data. Therefor is chosen to neglect in-

active articles). Combining this data together with the order- and handling cost definition used by DAF will lead to the order cost and handling costs per order line.

Applying those two steps resulted in the following analysis. Of the 1180 Scheib articles in current inventory, 498 articles can be assigned to one of the three SCC-forms (67 to VMI, 397 to CI and 34 SKU's to SOI). Of these 498 SKU's only 186 can be classified as an active SKU. Determining the order- and handling costs via the DAF terminology would lead to the conclusion that these costs are € 61.200 (186 SKU's * € 329,- handling- and order costs = € 61.194,-). Analysing the consumption data of these active SKU's showed that they accounted for 436 orders. With that information we can now decide on the order costs per order and handling cost per order line by dividing the annual costs for these two aspects as defined by DAF (as was just mentioned this was € 61.200,- combined for the 186 SKU's) by the number of orders (436 orders). The resulting € 140,- from this simple calculation are thus the average costs for handling one complete order (consisting of order costs per order and handling costs per order line). According to the ratio discussed in step one, order costs are thus € 105,- per order (75% * € 140,-) and handling costs are € 35,- (25% * € 140) per order line.

Since these cost calculations are based on a limited amount of data the found results are compared with literature to validate the outcome of order- and handling costs determination. These costs vary per company and there is not one correct figure. Nonetheless did Visser and van Goor give an indication by arguing that order costs can be € 100,- or more per order (52). Since this is comparable to the value calculated we assume that our findings (for both the order as the handling costs) are realistic and will be used as such.

The **transportation costs** for the current (traditional) are at the expense of the supplier (in fact, these will be incorporated in the purchasing price. When SCC will be implemented the transportation way will depend on the exact SCC-form and on the characteristics of the SKU. How this is exactly influenced will be elaborated on later in this chapter, but there are three scenarios:

- Normal delivery: The supplier delivers the articles via his own transportation way, just as is done in the traditional way. There are no extra costs involved for DAF.
- Delivery per courier: The article must be delivered faster than normally, and thus will be send by a courier. With such a regular courier shipment the article arrives within 24 hours. Costs for this delivery are € 35,- based on the criteria that a supplier is located within 250km of DAF and thus cannot be located in a country outside Europe. These costs are at the expense of DAF. For more information on conditions for this courier delivery see appendix D.
- Emergency delivery: This delivery way will be used when an article has to be delivered within 4 hours. Such an emergency supply will cost € 0,99 per transport kilometre and again are based on a supplier within a 250km range of DAF. Also these transport costs are at the expense of DAF (see appendix D for the exact explanation).

Inventory carrying costs are defined by DAF just as was done in paragraph 6.1, and are per article considered to be 10% of the purchase price of that article per year. (The DAF data source for this is given in table 1 in appendix D). A year equals 52 working weeks since during production stops maintenance continues. Normally one would assume an average inventory level when considering inventory carrying costs. However, based on two characteristics of the inventory at DAF there is chosen to do this differently. Firstly, because many articles are characterized by only little (or even no) consumption, which means that most of the time their inventory level is equal to the order up to level. Which brings us to the second reason, DAF considers the SS as the order up to level and each

time a SKU is consumed it is ordered in the next MRP run. The result of these two factors is that mostly all SKU's are stored in an amount equal to the SS (as defined by DAF). For that reason we will consider the inventory as just being replenished (and thus equal to the SS) since this is closer to reality then when considering an average inventory level.
Another point that has to be addressed here is that inventory carrying costs are in current literature considered to be higher. Winston (53) for example indicates that most firms assume that their annual inventory carrying costs is 20% - 40% of the unit purchase price. Management of MMP is aware of this difference, but holds to the 10% as agreed by DAF because this is done for all DAF projects and would otherwise result in an unfair comparison. For that reason this will also be done in this report.

With SCC the cost element **information costs** is introduced to the inventory costs, as could already have been seen in paragraph 5.3 where was established that information sharing is an important aspect for collaboration, and that the supplier must have insight in the inventory levels for some of the SCC-forms. It is assumed that information is exchanged via a shared webserver. At DAF this can be implemented in SAP (according to the SAP-administrator at DAF). The supplier must at least be able to read this. Since SAP can also export data to for example Excel spread sheets it is assumed that this is possible. Costs for implementing this are based on an estimated 15 hours programming by the SAP system administrator. Labour costs at DAF are defined by them at € 40,16 for operators and € 54,- for technicians (table 1 in appendix D). For the employee needed for this SAP programming, we assume that his labour costs are equal to an technician and thus € 54,-. Setup costs for information exchange are thus 15 * € 54,- = € 810,- Besides set up costs information sharing causes also operational costs, because the customer has to update the supplier on his inventory levels. To do this the customer is assumed to make and upload an overview of current inventory (for the articles concerned in the SCC-form) and the supplier will have to analyse those overviews and decide whether or not to replenish. Each party is assumed to be occupied one hour per week with that. Labour costs for this employee are assumed to lie within the two just mentioned salary scales, and is assumed to be equal to € 47,-.

6.3 Change in inventory associated cost per SCC-form

Now is discussed what the inventory associated costs are, and how these are defined for DAF, we can determine what the results are for each SCC-form, VMI, CI and SOI, concerning the inventory associated costs for DAF. For being able to do that we simplify the situation by applying the following two assumptions:

> **Assumption 1:** The supply chain considered is a two level supply chain. We will consider DAF and its direct suppliers.
>
> **Assumption 2:** The articles offered by the suppliers are "made to (central) stock" (54) and bought by DAF as finished goods.

The change in inventory associated costs will be determined for the SCC-forms VMI, CI and SOI with the supplier Scheib, who was selected (in paragraph 5.1.1) as the partner for collaboration.

The articles delivered by Scheib will be analysed and placed in the segments as they were discussed in paragraph 5.2, such that they can be linked to the most suitable SCC-form. For assigning the articles to the segments, data for the dimensions value and consumption are derived from SAP. The dimension response time must be analysed by assigning a project team and discussing the response time per article. Since this is very time consuming it would be practical when one conclusion would hold for multiple articles. This can be accomplished by first evaluating the relations the articles have with the machines in the several factories. When one or more of these machines are evaluated as being critical, then it holds for all of the articles that have a relation with that machine, that response time is short or medium. Whether it is short or medium only depends on how long it takes to disassemble the article from that machine. When this can be done fast (e.g. with an electrical module, V-belt) it is considered to have short response time. When more labour is required (e.g. with bearings, electrical motors etc.) the article can have a medium response time. This can thus be decided on per article group, and thereby multiple articles are evaluated at once. Although this is more efficient than evaluating each article at a time, it is still very time consuming and therefore out of scope of this project to really do so. Assigning the articles to segments is therefor done based on the two known dimensions (value and consumption) and the number of articles in each response time segment are estimated in deliberation with the MMP manager and assumed to be as follows:

Assumption 3: Response time of the articles are according to the following ratio:

- Long response time: 1% of the articles. Expected is that only few articles have a long response time. Therefore only 1% of the articles are assumed to have a long response time.
- Medium response time: 29% of the articles. The expectation for the several response time categories was mainly based on the expectation for the long- and short response time. So the medium response time is the result of the estimation for the other two response time categories.
- Short response time: 70% of the articles. It is expected that most of the articles have a short response time, which can be seen from this percentage.

The response time is an important classification for the transport decision, and is because of that especially needed for SCC-forms where inventory is not stored at the DAF warehouse, but at the suppliers (or possibly a 3PL) premises. Therefore will the before assumed division of the response time only be used when the articles concerned are stored at the suppliers warehouse.

Categorizing the Scheib articles to the consumption and value segments leads to the categorization as shown in table 6.1 on the next page. Here the joint segments (that are created because the response times are not known yet) are given together with which SCC-form performs best for the articles in that (joint) segment. Thereby is also summarized how many Scheib SKU’s it concerns and what the safety stock is (in both amount as value). Recall that DAF uses the SS as the order up to level and we assume that all articles are just replenished. This leads to the theoretical inventory value of almost € 950.000,- of Scheib articles currently in the DAF warehouse. (Notice that the inventory value of Scheib articles mentioned earlier in this report was higher, this means that for many articles there are more SKU’s on stock then actually should).

Joint segments	SCC-form	SKU	Safety stock (in DAF terms) (#)	Total value SS
1,3	VMI	67	230	€ 13.772,96
2,4	-	682	854	€ 110.352,07
5,7,9	SOI (at supplier)	34	53	€ 84.096,44
6,8,10	CI	397	407	€ 735.698,66
SUM		**1180**	**1544**	**€ 943.920,13**

Table 6.1 Scheib SKU's classified in the segments of the allocation framework.

Based on the just mentioned categorizations the change in inventory associated costs will be determined, which will be done based on the assumptions described in the previous paragraph. As was already explained the costs are determined based on figures defined by DAF which focus on calculating savings, and not on the actual costs. We will therefore only focus on the differences in inventory costs caused by a certain SCC-form. Thus it is not the intension to represent the actual inventory costs of a certain collaboration form.

6.3.1 Change with VMI

From table 6.1 can be seen that VMI is the most efficient SCC-form for the segments 1 and 3, which are in total 67 SKU's with a total value of about € 13.750 (as is shown in table 6.1). VMI contributes to more efficiently handling inventory in the supply chain. For the cost savings estimation we assume that DAF outsources handling of those 67 SKU's to the chosen supplier for SCC, thus Scheib. The costs Scheib incurs for handling the inventory will be charged to DAF via a monthly fee. How much the supplier charges will follow from the negotiations prior to the cooperation. As was already explained, the change in inventory associated cost as they will be calculated in this chapter can be used by DAF as input for these negotiations. DAF then knows the turning point when a collaboration also results in savings on inventory costs.

Order costs:

The order costs for DAF decreases partly since DAF no longer has to arrange the ordering of articles themselves because the supplier arranges that. The only part of the order costs that remain for DAF are the administrative tasks that come along with paying the suppliers invoice for the articles delivered. Since this is handled by only one department (purchasing) this is far more efficient for DAF than handling a complete order. Based on that we estimate that with VMI the part of the order process that remains, and thus also the costs, is equal to 20% of the original order costs. With other words, inventory cost reduction with VMI is equal to 80% of the total order cost. Over the observed period (four years) 167 orders were created in the VMI segment, considered over a year this would be 41,75. Thus yearly savings are the product of these orders with the order costs of € 105,-.

Thus with VMI order costs for DAF decreases with:

$$number\ of\ orders * ordercosts$$

$$41{,}75\ orders * (80\% * €\ 105,-)$$

$$= €\ 3.507,- \approx\ €\ 3.510,-$$

Handling costs:
With VMI the supplier takes over inventory handling from DAF, thus DAF no longer incurs handling costs with VMI, which are € 35,- per order. This involves all 167 orders in this segment, thus on average 41,75, orders per year, and thus contributes to a saving of:

$$number\ of\ orders * handlingcosts$$

$$41{,}75\ orders * €\ 35,-$$

$$= €\ 1.461{,}25\ per\ year \approx €\ 1.460,-$$

Transportation costs:
With VMI, Scheib will have to visit the warehouse of DAF at least once a week to handle the articles stored in the DAF warehouse. This means that there are never extra supplies (e.g. emergency deliveries) needed since articles are already at the warehouse. Thus with VMI DAF does not incur any transportation costs, just as in the traditional situation, and therefore there are neither savings nor extra costs on this cost element. For the supplier transportation costs will increase, and thus these will possibly be incorporated in the monthly fee the supplier charges DAF for VMI.

Inventory carrying costs:
With VMI DAF remains financial owner of the inventory, and thus inventory carrying costs do not change compared with the costs incurred in the traditional situation. Neither do they change for the supplier.

Information costs:
When involved in VMI Scheib will have to visit DAF each week. It would be possible for Scheib to monitor inventory levels during that visit, and replenish when needed from the articles they then have to bring every week. But when DAF would share information concerning their inventory levels this reduces chances on backorders since outliers concerning consumption would have been noticed before Scheib visits DAF. Thus information sharing is recommended, in such a way as explained under assumption three. Then DAF will be occupied with information sharing for one hour per week (at a price of € 47,-). Per year (based on 52 weeks, as explained earlier) this is equal to € 2.444,- Thus with VMI information cost increase with € 2.444,-, rounded to € 2.440,-

Total inventory cost savings with VMI:
Recall that at this point of time is not decided yet on the fee DAF has to pay to the supplier for a collaboration form (in this case VMI). As was already explained (in paragraph 6.1) can DAF better negotiate on this fee when they know how much inventory costs change because of VMI. This is equal to the summation of the change of each inventory cost element as they were discussed in this paragraph. Excluding the monthly fee and the one time needed setup costs for information sharing, annual savings with VMI are for DAF equal to:

$$order\ costs\ savings + handlingcosts\ savings - information\ costs$$

$$€\ 3.510 + €\ 1.460 - €\ 2.440$$

$$= €\ 2.530,-\ annual\ savings\ on\ inventory\ costs$$

6.3.2 Change with CI

The main contribution of CI to inventory costs savings is the decrease in inventory value for DAF, and thus inventory carrying costs decrease. Next to that also the handling costs decrease since articles are stored at the supplier. The order decision remains with the customer thus those costs do not change. With CI the inventory will be stored at the supplier. Thus depending on the response time of the article the transport costs can now also change. When an article is needed with a short- or medium response time characteristic, it has to be delivered to DAF via an (emergency) supply at the expense of DAF. This in contrast with the traditional situation where all articles are delivered at the expense of the supplier. Further must also in this segment information be shared, thus those costs also increase.

As could be seen from table 6.1, in segments 6, 8 and 10 are those articles that are best suitable for a CI collaboration. This segment contains 397 SKU's representing a total value of over € 700.000,- For deciding on the potential inventory costs reduction it is assumed that DAF enters in a CI collaboration with Scheib with those 397 articles, that are then stored at Scheib. Because of this latter reason, the assumed response time distribution (as described under assumption five in the beginning of paragraph 6.2) will also be used. Scheib will, just as with VMI, charge a (yet to be negotiated) monthly fee for her services such that costs that will rise will at least be covered for them.

Order costs
Order costs do not change with CI, and thus DAF does not incur extra costs but does also not gain any savings.

Handling costs
With CI the articles are stored at the supplier, who therefore is also responsible for handling these articles. Of the 397 articles in this segment 283 articles were not used during the four years observed, and thereby were also 29 articles not used in the last 24 months of that period (recall that these are referred to as in-active articles by DAF definition). Thus handling costs reduction can be based on 312 (283+29) in-active articles and 85 active articles. Recall that we considered that the contribution of in-active articles concerning the handling costs are nil, and thus are neglected. The active articles were ordered in 126 orders, which is on average 31,5 orders per year. Handling costs will thus decrease because the active articles do not need to be handled anymore (at a costs of € 35,- per order), and savings are equal to:

$$number\ of\ orders * handlingcosts$$

$$31{,}5\ orders * €\ 35,-$$

$$= €\ 1.102{,}50 \approx €\ 1.100,-$$

Transportation costs
Where in the traditional way transport costs were in general at the expense of the supplier, these can now transfer to DAF depending on the response time of the article concerned. Again we use the division that 1% of these articles have long-, 29% medium and 70% of the articles have short response times.

Transportation costs for the **long response time** segment do not change for DAF since these will still be delivered by the supplier, just as is the case in the traditional situation. Thus for 1% of the CI segment transport costs do not change (considering the assumption that 1% of the articles have long response times).

Transportation costs for the **medium response time** segment are based on transport via regular courier services, paid by DAF. With a regular courier shipment the article arrives within 24 hours. Costs for this delivery from Scheib to DAF (about 125 km) are € 35,- (for more information on conditions see appendix D). Also the moment at which the articles are shipped changes in this situation. In the traditional way orders were placed once a week by DAF, and thus the supplier receives an order maximum once a week, where one order could contain multiple order lines. With the new situation, needed articles are ordered directly and must be shipped directly by the supplier. Thus the total number of deliveries per year increases. To estimate the transportation costs for this situation we will estimate future demand, and thus the number of needed deliveries, based on consumption data over the period 2006 – 2009. In contrast with the handling cost calculations now both active- as inactive articles are used since this is the best representation of actual consumption. Over these four years concerned 239 articles were consumed. Thus annually we expect 59,75 articles to be consumed and thus 59,75 deliveries would be needed on a yearly basis for all articles in the CI segment. This means that specifically for the medium response time segment, which are 29% of these orders, 17,3 deliveries per year would be necessary.

Thus on average 17,3 times per year an article that is stored under a CI agreement at Scheib, and that has a medium response time, is expected to be requested by DAF and has to be delivered by a courier at the expense of DAF. Total annual costs for this are:

$$number\ of\ deliveries * transport\ cost\ regular\ courier$$

$$17{,}3 * € \ 35,-$$

$$= € \ 605{,}50 \approx € \ 610,-$$

Transport costs for the **short response time** segment can be derived via the same way as is done for medium response time. The only difference is that we have assumed that of the CI inventory 70% (from assumption five described at the beginning of paragraph 6.2) has a short response time and transport is done via an emergency supply which costs € 0,99 per transport kilometre (see appendix D for the exact explanation of this assumption). The expected total number of emergency supplies are thus 70% of the 59,75 expected orders in the CI segment, which are 41,8 deliveries.

Thus on average 41,8 emergency supplies are expected each year to fulfil demand for articles that are stored under CI at Scheib and have short response times. In those cases transport is assumed to cost € 148,50 (see appendix D) based on transport costs per kilometre and distance between DAF and Scheib. Expected annual emergency supply costs for DAF are:

$$number\ of\ deliveries * transportcost\ emergency\ supply$$

$$41{,}8 * € \ 148{,}50$$

$$= € \ 6.207{,}30 \approx € \ 6.210,-$$

With a CI arrangement the transport costs for DAF are thus expected to increase with:

$$transportcosts\ articles\ medium\ response\ time \\ + \ transportcosts\ articles\ short\ response\ time$$

$$\approx € \, 610,- \; + \; € \, 6.210$$

$$\approx 6.820,-$$

Inventory carrying costs:
With CI Scheib remains financial owner of the articles in this segment until they are requested by DAF. This means for DAF that inventory carrying costs for all the 397 articles (with a value of € 735.698,66) in this segment are completely taken over by Scheib, which results in an annual decrease of inventory carrying costs of:

$$inventory\ carrying\ cost * value\ articles\ in\ CI\ segment$$

$$0{,}10 * € \, 735.698{,}66$$

$$= € \, 73.569{,}87 \approx € \, 73.570,-$$

However must be noted that this saving is not actually made possible by the SCC-form, but is mainly accomplished due to the large amount of articles that are stored in this segment. From these nearly 400 articles are less than 25% of the articles active (85 to be exact). So when the decision would be made to no longer keep those articles in stock, a large part of this saving would have been realized without any form of collaboration with a supplier. So, in order to compare the SCC-forms in a fair way, we will only consider the active articles, because these have to be on stock (at DAF or at the supplier). The total inventory value of these 85 active articles is € 176.884,37.

Thus inventory carrying costs for the active articles are:

$$inventory\ carrying\ costs * value\ active\ articles\ in\ CI\ segment$$

$$0{,}10 * € \, 176.884{,}37$$

$$= € \, 17.688{,}44 \approx € \, 17.690,-$$

Information costs:
Since in a CI collaboration DAF remains responsible for the order decision, there is no need for information sharing between DAF and Scheib and there are also no extra information costs incurred by the parties. Thus Scheib coordinates the inventory control based on service level agreements agreed upon with DAF prior to the collaboration.

Total inventory cost savings with CI:
Calculated in the same way as with VMI, the inventory costs savings are with CI equal to:

$$savings\ handling\ costs - transportcosts + savings\ inventory\ carrying\ costs$$

$$€ \, 1.100 - \; € \, 6.820 + \; € \, 17.690$$

$$= € \, 11.970,- \text{ per year}$$

6.3.3 Change with SOI

In chapter five was already explained that SOI can contribute to a change in three inventory cost elements, namely inventory value reduction (thus inventory carrying costs), handling costs and order costs. The number of Scheib articles that are suitable for being implemented in a SOI collaboration is small (only 3% of all articles delivered by Scheib). Inventory cost reductions will be discussed for the case where all of these 34 SKU's will be outsourced via a SOI collaboration to Scheib, and articles are stored at the warehouse of the supplier (thus Scheib).There is chosen for storage of the articles at the supplier since it is expected that the small number of articles in this segment does not compensate for the costs that would be made when the supplier would have to visit DAF's warehouse at least once per week.

Order costs:
Just as it was the case with VMI, order costs for the customers decrease when involved in a SOI collaboration since the supplier handles the inventory. The order decision remains with the customer, thus the part of the order costs that remains is dealing with the invoice send by the supplier when articles are ordered. Recall (from paragraph 6.2.1) that this part was assumed to be 20% of the total order costs. Thus order costs (of € 105,- per order) for DAF decreases with 80% for all of the 143 orders (35,75 per year) in this segment. This is equal to an annual saving of:

$$number\ of\ orders * ordercosts$$

$$35{,}75\ orders * (80\% * € 105,-)$$

$$= € 3.003,- \approx € 3.000,-$$

Handling costs:
Just as with CI the articles are stored at the supplier premises, thus also for the articles in this segment the handling costs decrease. Difference with CI is that in this segment all articles are active since it concerns high consumption articles. In total there were 143 orders (35,75 per year) in this segment, and thus handling costs reduction in this segment is equal to:

$$number\ of\ orders * handlingcosts$$

$$35{,}75\ orders * € 35,-$$

$$= € 1.251{,}25\ per\ year$$

Transport costs:
Just as was the case with the articles in CI, in the SOI segment the transport costs are expected to increase. Again the expected number of deliveries are based on consumption data over the period 2006 – 2009. For the articles in the SOI segment is expected that annually 96,75 SKU's will be consumed and thus have to be delivered immediately. Also the assumption concerning the response times is equal to the assumptions made with the CI segment, and thus is assumed that 1% of the articles has long response times, 29% medium and 70% of the articles short response times.

Transport for the SOI segment where articles have a **long response time** can be done via the regular way as is also the case in the traditional way. And thus for that segment transport costs do not change for DAF.

Transport costs for the SOI segment where articles have a **medium response time** are based on outsourcing transport to a courier, on expense of DAF. Expected number of deliveries can be calculated based on the data mentioned at the beginning of this subparagraph, and are 29% of 96,75, thus 28,1 deliveries per year.

Costs per delivery are the same as was the case with CI and are thus € 35,-. Annual transport costs for the articles with a medium response time are thus expected to be:

$$number\ of\ deliveries * transport\ cost\ regular\ courier$$

$$28{,}1 * € 35,-$$

$$= € 983{,}50 \approx € 980,-$$

Articles that face a **short response time** within the SOI segment have to be delivered by an emergency supply whenever they are requested by one of the customers. Recall that we assumed that 70% of the articles in this segment have a short response time. Just as done for the medium response time the expected number of deliveries can now be calculated, and are 70% of 96,75, thus 67,7 deliveries per year.

Recall that emergency supplies costs € 148,50 per delivery based on the distance between DAF and Scheib, and thus annual transport costs for DAF for articles in the short response time category are:

$$number\ of\ deliveries * transportcost\ emergency\ supply$$

$$67{,}7 * € 148{,}50$$

$$= € 10.053{,}45 \approx € 10.050,-$$

Thus total transport costs in the SOI segment increase with:

$$transportcosts\ articles\ medium\ response\ time + transportcosts\ articles\ short\ response\ time$$

$$€ 980,- + € 10.050$$

$$= € 11.030,-$$

Inventory carrying costs:
Since with SOI the financial ownership lies with the supplier he also incurs the inventory carrying costs. Thus with a SOI collaboration DAF does not incur any inventory carrying costs anymore over the 34 articles, which have an aggregate value of € 84.096,44. Savings on inventory carrying cost are thus:

$$inventory\ carrying\ cost * value\ articles\ in\ SOI\ segment$$

$$10\% * € 84.096{,}44$$

$$= € 8.409{,}64 \approx € 8.410,-\ per\ year$$

Information costs:
Just as with VMI it is also with SOI essential that the supplier has insight in the inventory levels of the customers. Costs for this are also in a SOI collaboration € 2.440,- per year.

Total inventory cost savings with SOI:
A summation of all inventory handling costs changes results in the annual savings of:

$$savings\ order\ costs + savings\ handling\ costs - transportcosts + savings\ inventory\ carrying\ costs - information\ costs$$

$$€\ 3.000 + €\ 1.250 - €\ 11.030 + €\ 8.410 - €\ 2.440,- = -€\ 810,-$$

Thus instead of saving on inventory related costs, an SOI collaboration would costs DAF money since the savings made do not account for the extra costs, mainly on the costs for emergency supplies.

6.3.4 SCC-forms combined

Although it is not recommended for a first SCC, the three forms discussed in the paragraphs preceding can be combined. Even though it is not to be expected that the forms will be combined for a first collaboration, it will be considered here to give a complete overview. The total savings when Scheib and DAF would implement all three SCC-forms at once are then the summation of the savings of each form separately. This is given in table 6.2, where the SCC-forms discussed in this chapter are summarized, because those are the input for the potential savings when multiple SCC-forms were used at once.

	Changes with VMI	Changes with CI	Changes with SOI	Changes SCC-forms combined
Total # of (active) articles:	*67*	*85*	*34*	*186*
Average number of orders per year	*41,75*	*31,5*	*35,75*	*109*
Safety stock value	*€ 13.770*	*€ 735.700*	*€ 84.100*	*€ 833.570*
Change in order costs:	- € 3.510	0	- € 3.000	- € 6.510
Change in handling costs:	- € 1.460	- € 1.100	- € 1.250	- € 3.810
Change in transportation costs:	0	+ € 6.820	+ € 11.030	+ € 17.850
Change in inventory carrying costs:	0	- € 17.690	- € 8.410	- € 26.100
Change in information costs:	+ € 2.440	0	+ € 2.440	+ € 4.880
Total change per year (negative amount is saving):	**- € 2.530**	**- € 11.970**	**+ € 810**	**- € 13.690**
Change per order: (negative amount is saving)	**- € 60**	**- € 380**	**+ € 20**	**- € 130**

Table 6.2 Potential inventory cost reduction for Scheib SKU's

6.3.5 Extending the SCC

Discussing the potential savings, as is done in this chapter, gives in indication of the potential savings. But it depends on the article characteristics what the financial results are, and therefore can vary per supplier. Therefor will in this paragraph the same method be used in order to determine the potential savings per SCC-form when the five biggest suppliers will be used. These suppliers are besides Scheib: Biesheuvel B.V., Bosch Rexroth, Atlas Copco B.V. and MAG Maintenance solutions. The result of this is given in table 6.3 underneath.

	Changes with VMI	Changes with CI	Changes with SOI
Total # of (active) articles:	*543*	*1054*	*61*
Average number of orders per year	*362,25*	*66,75*	*89,5*
Safety stock value	*€ 87.860*	*€ 2.210.390*	*€ 176.770*
Change in order costs:	- € 30.430	€ 0	- € 7.520
Change in handling costs:	- € 80.260	- € 4.430	- € 6.140
Change in transportation costs:	€ 0	+ € 5.430	+ € 6.140
Change in inventory carrying costs:	€ 0	- € 221.040	- € 17.680
Change in information costs:	+ € 2.440	€ 0	+ € 2.440
Total change per year (negative amount is saving):	**- € 108.250**	**- € 220.040**	**- € 22.760**

Table 6.3 Potential inventory cost reduction for SKU's of the five largest suppliers

With this overview must be stressed that this is excluding the costs the supplier will charge for his service. Since this will probably be a significant part of the potential savings, we cannot yet conclude on the savings that can really be realized by SCC. But again, this gives in indication for DAF of the breakeven point for SCC, with this information DAF can deliberate whether or not to engage in SCC.

6.3.6 Sensitivity analysis of the response time distribution

Most of the data used for calculating the potential savings that can be realized by SCC, are based on historic consumption data and article characteristics, which are both known. However not all needed information was known and therefore some assumptions were made throughout this chapter. The assumption that has the greatest impact on the calculated potential savings is the assumption on the response time distribution. Although the effects on the end results are big, this assumption only influences the transportation cost, because it directly influences the decision in which time frame an article must be delivered to DAF, and thus also the thereby belonging costs. In this paragraph a sensitivity analysis will be performed on this assumption, such that is evaluated to what extend this influences the end result, and potentially the end conclusion. For that matter we will use the scenarios depicted in table 6.4, which will be declared next.

Scenario	% of SKU with **short** response time	% of SKU with **medium** response time	% of SKU with **long** response time	Potential Savings
Distribution as is expected for DAF(and used as such in this chapter)	*70%*	*29%*	*1%*	*€ 13.690*
Scenario (100,0,0) **Lower bound** potential savings:	100%	0%	0%	€ 8.300
Scenario (75,0,25)	75%	0%	25%	€ 14.110
Scenario (50,0,50)	50%	0%	50%	€ 19.920
Scenario (25,0,75)	25%	0%	75%	€ 25.730
Scenario (0,0,100) **Upper bound** potential savings	0%	0%	100%	€ 31.540

Table 6.4 Sensitivity analysis response time assumption

The distribution of the article response times as was used in this chapter for calculating the potential savings is given in the second row of table 6.4. With this sensitivity analysis we want to establish how this distribution has influenced the end result, thus the calculated savings of € 13.690. In the rows underneath several scenarios are given. To start with (in row three) the first scenario where all articles are assumed to have a short response time, which is the lower bound of the potential savings. The reason for this is that the lower-bound of the potential savings can be found by considering the situation with the highest transport costs. This would be when all SKU's had to be delivered by emergency supplies (the most expensive way of the three delivery ways considered) and thus all SKU's would have to have a short response time (because then an emergency supply is necessary). This first scenario we will call scenario "(100,0,0)", representing the response time distribution. In the same way the upper bound for the potential savings is determined, visualized in the last row of table 6.4. For this scenario we assume that all articles have a long response time, since then DAF incurs no extra transport costs and thus potential savings are the highest for DAF. This is scenario (0,0,100). Further scenarios that are examined for this sensitivity analysis are evenly distributed between the lower- and upper bound of the potential savings as they were just discussed. The extremes of the potential savings are only influenced by the short and long response time categories. Therefore the medium response time will not change and the other scenarios will be (75,0,25), (50,0,50), (25,0,75), which is also depicted in table 6.4.

From this sensitivity analysis we conclude that although the potential savings vary, it is not considered to have a big impact on the end conclusion. Whichever situation is considered, the inventory costs can always be reduced for DAF, and thus the conclusion does not change depending on the chosen division for response times. More importantly, the variation between the lower- and upper bound follows a linear function, and thus can be derived for every situation. Based on that we conclude that this assumption does not affect the conclusion and thus can be used for giving an indication of the potential savings that can be realized.

6.4 Conclusion

The savings on inventory costs SCC can realize are calculated in this chapter for the scenario where would be collaborated with the supplier Scheib. It appeared that the savings are not significant, in fact, when the fee that Scheib will charge for his services will be included, it is not expected that there will be any savings on inventory related cost for this scenario. The reason for DAF to initiate a SCC project will therefore not be on financial grounds, but for the increase in efficiency for DAF's inventory control.

Although SCC does not directly contribute to significant inventory cost savings, it can prevent unnecessary costs for the future. For example, at the moment many articles in stock must be classified as in-active, due to the very low consumption rate. Inventory carrying cost for these in-active Scheib SKU's are over € 60.000 per year. This can be prevented in the future when DAF would be involved in a SCC since together with the knowledge and experience of the supplier reliable forecasts can be made, something which is not done at the moment. The inventory can then better match the consumption pattern such that then less unneeded articles are stored. And in this lies the biggest benefit for DAF. The potential savings are not that high, especially not when compared to the inventory value it concerns. At this stage it might be more important for DAF to optimize its inventory control, and thereby improve the KPI's as they were discussed in paragraph 1.2.5. SCC can be very helpful with this (as was shown in paragraph 4.1) and when it also results in savings on inventory costs it is of course very good. But even when DAF would have to pay more to the supplier then the savings can realize, it is recommended to engage in a SCC with Scheib. Since it is important to start with only one collaboration at a time, we recommend starting with CI, mainly because this concerns the articles with low consumption rates. It seems from the many non-movers and in-active articles that this is a difficult segment for DAF, and some extra expertise from the supplier could be very helpful in optimizing the inventory control at MMP. This can also be concluded from the potential saving analysis for the largest five suppliers. Although we cannot conclude how much the savings would be after the fee to the supplier is paid, it is clear that in the CI segment the potential for savings is the highest.

7 Decision Support Tool

In chapter five was discussed what characteristics a potential supplier must have in order to be a potential partner for a SCC form with DAF, thereby also focusing on the characteristics of DAF and the article group that together create good opportunities for successful collaboration. When the supplier is selected, the SKU's of that supplier have to be analysed according to their characteristics as was descriped in paragraph 5.2. The decision support tool (DST) can be used for this, since this tool uses the allocation framework to analyse the article. This tool will be further discussed in this chapter.

The decision support tool can be used in two ways. First to give the user of the tool insight which SKU's are suitable for SCC and are thus helpful in realizing one of the three SCC objectives for DAF (as discussed in paragraph 2.3.1). Thereby indicating what potential savings on inventory costs can be realized. This can be used by DAF as input for negotiating with the supplier on the fee that that supplier will charge for the services he offers in the SCC-form. And in case this fee will be higher than the savings, DAF can consider if it might be worthwhile after all in order to optimize its inventory control.

The second scenario in which this tool can be used is for future situations when DAF attracts a new supplier for spare parts and there must be decided on how inventory control should be accommodated for the articles of that new supplier. Also for this scenario holds that the tool does not only give the specific SCC form to be applied, but also how much savings can be realized in relation with the traditional way of inventory control where all articles would be stored and handled by DAF internally.

For both ways about the same approach can be followed, only input information for the consumption dimension differs. Where for the first scenario consumption is known (number of demand request over a certain period) this has to be estimated for the second scenario (where the articles are new to DAF). Input for this latter scenario could be MTTF (Mean Time To Failure) data of the SKU given by the supplier or having demand forecast made by DAF Maintenance Engineers.

The decision support tool requires input from the user. This input is data concerning the characteristics of the articles of the supplier the user would like to evaluate, where after the articles are analysed according to the scheme as is shown in Figure 7.1, which is in fact the allocation framework as discussed in paragraph 5.2. Each SKU is analysed on the three dimensions as they were discussed in paragraph 5.2, consumption, response time and value, and are than assigned to either no collaboration, or to one of the three SCC-forms chosen in this report, VMI, CI or SOI.

The potential savings that can be realized are determined in the exact same way as was done in paragraphs 6.3.1 till 6.3.3. Depending on the result given by the DST the user can decide whether or not to implement the recommended SCC-form.

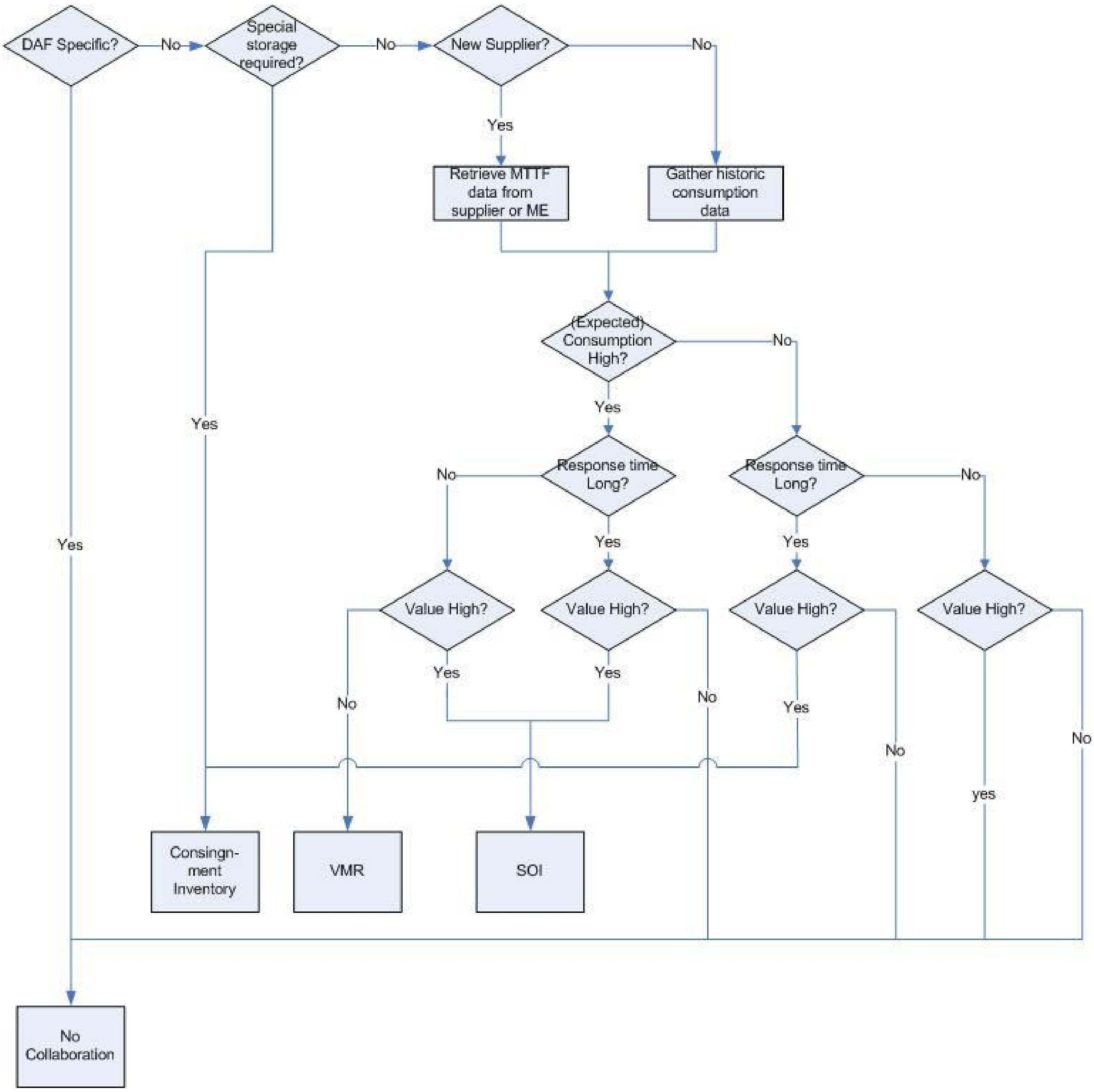


Figure 7.1 Steps Decision Support Tool for classifying SKU's

8 Collaboration agreements

SCC can only succeed if the partners of that collaboration work closely together. To realize this some agreements have to be made, and needless to say, each party must stick to these agreements. In this chapter will be elaborated on these agreements and whether or not they have to be arranged via contracts. Further the risks that evolve from the SCC are discussed, all by answering research question 5, which was defined as:

How should DAF collaborate with a potential supplier in order to let a collaboration form for an article group succeed?

a. *Which agreements should be stipulated by a contract?*
b. *For which aspects will informal agreements do?*
c. *What are the potentials risks of such a collaboration?*

8.1 Contract issues

The collaboration must be guided by contracts such that is clear what is expected from each party, and that also performance can be monitored. According to Piplani (10), who reports about a VMI implementation project at an electronics manufacturer, the agreement with a supplier is by far the most critical component of the implementation. Also it can be seen that VMI programs usually contain contractual agreements (55). Considering that collaboration is key within all SCC forms, we assume that it holds for all SCC-forms that they can best be guided by contractual agreements. The function of a contract is to facilitate trade between two parties who must make relationship-specific investments (56). On the terms and conditions, or the collaboration agreement, must be negotiated on before the collaboration begins. The agreements that are specific for the SCC and have to be arranged parallel to the regular supply contract, are concerning the following topics:

1. *Specification of decision right* (57)*:* getting involved in SCC creates a shift from decentralized to centralized inventory control. In order to successfully realize this shift, information has to be shared. How this should be done must be agreed upon in the contract. Further must the contract guide when the customer must place an order (for CI) or at which moments the supplier will replenish inventory at the customer (for VMI and SOI).
2. *Service-Level Agreements (SLA's):* In this section of the contract the service that will be provided by the supplier is described. Next to that are the rights and obligations, concerning the agreed quality level of the service, for each party denoted (58). The quality level of the performance can be defined by the following issues:
    - Lead times (57): articles with a short response time have to be delivered within four hours, and articles with medium response times within 24 hours. Thereby must be agreed on reasonable costs (as a reference the transportation costs used in chapter 6 can be used) for these deliveries (which will be at expense of DAF) and stipulated in the contract.
    - Inventory levels: This holds for a VMI collaboration since the supplier is then responsible for the inventory levels at DAF. Further can a distinction be made between SKU's needed for preventive- and for corrective maintenance. SKU's needed for corrective maintenance may only be replenished till the agreed level. But when a supplier can achieve more efficiency when he replenishes more SKU's then actually was agreed upon, this would be possible for preventive maintenance SKU since for those articles is known that they will be used in the near future, where this is for corrective maintenance SKU's not the case.

- Item fill rate: For all of the three SCC-forms discussed must hold that the supplier realizes a minimum item fill rate of 98%. This is equal to the KPI as DAF uses in the traditional situation, as was explained in paragraph 1.2.5.

3. *Procedures to be followed* (10): Collaboration between the customer and supplier requires some new procedures that have to be followed. In the contract must be stated how DAF orders an article and where the supplier has to ship the article to (e.g. direct to the MMP warehouse instead of to DAF expedition). This is especially important for articles with short or medium response times since then there is no time to waste.
4. *Quantity flexibility* (57)*:* The spare parts at DAF are used for both corrective as for preventive maintenance. This can cause large variations in the number of articles that are ordered. Since demand for preventive maintenance can be predicted, it can be arranged in a contract that large variation in the articles ordered is allowed when requested in an early stage. In this way the supplier can incorporate this information into his own production planning.
5. *Penalty agreement:* When one of the parties does not hold to the agreements made or does not achieve one of the SLA's, the consequences can be big. Consider what the (financial) consequences for DAF are when the production line comes to a stop because a needed article is not available. These consequences can never be compensated for by a (relatively small) supplier. This penalty agreement is therefore not intended to be a compensation for caused damage, but solely as a way to stimulate each party to live up to agreements made. Formal research (59) has shown that participants of collaboration forms considered penalty agreements as very strong incentives in trying to live after the agreements made.
6. *Selection of possibly used third party logistics providers* (10): When is chosen to use the services of a 3PL in the collaboration, this must together with the tasks and responsibilities of this 3PL be denoted in the contract.

8.2 Informal agreements

Creating and controlling the complying of contracts is a very specialistic and time consuming task. Thus when agreements can be made outside the contract via informal contracts, this reduces needed labour at each partner. We refer to these agreements made outside the contract as informal agreements, and assume that they are noted in a sort of procedure, and thus in a less formal and legal way as is the case with contracts.

Throughout this report it was repeatedly addressed that information sharing is a crucial factor for collaboration and that it is less important how this is exactly arranged. One could arrange this in a very formal way with a contract, but when this would be arranged based on informal agreements it creates the possibility for partners to further develop their trust in each other. The agreement on information sharing is suitable for informal agreements since it is not important how it is done as long as it is done on regular basis. DAF and the supplier must discuss how information can best be exchanged (against reasonable costs) since it depends on the current information systems at each partner's company. Contracts do more focus on hard conditions and terms, thus arranging the way of information sharing via informal agreements is also beneficial for the legal departments of each party who create the contract. Their knowledge is mainly in the field of legal terms and conditions, and not how company processes should be carried out. Thus leaving the choice of how information is exchanged to the users themselves and not via contracts will probably also result in more efficient and usable procedures.

8.3 Potential risks

There is always a risk involved with keeping spare parts on stock or by having them controlled by a supplier. Also with a collaboration-form as discussed in this report there is always a chance that the supplier is not able to realize the agreements made for this collaboration. Which risks there are and how DAF can cope with them is per SCC-form different. Therefore we will per SCC-form discussed in this report, elaborate on the risks and the potential measures that can be taken for the SKU's concerned in that SCC-form.

VMI:

Recall that with VMI low value and high consuming articles are involved. The supplier visits the MMP warehouse (minimal) on a weekly basis and replenishes articles when needed. The risk that DAF faces is that the supplier has not correctly managed one of more articles and DAF does not have an article when needed. DAF can only discover this when they need that SKU. Since the articles in a VMI collaboration are common (assumed based on the low value and the high consumption rate) and thus there will be multiple suppliers who can deliver this article and probably also from stock. So if possible the supplier sends the SKU as fast as possible with an emergency supply, and when that would not be possible the needed SKU can be purchased at another supplier and delivered via an emergency supply, even though transport costs are then very high compared to the value of the article.

CI:

With a CI collaboration the supplier guarantees (till a certain level) availability. Probably the supplier will offer the same guaranty to multiple customers while not having the articles on stock for each customer. This so called risk pooling effect creates the possibility that the supplier cannot deliver an article to the customer when more customers request the same article at the same point in time. Even though chances for this are low (considering the low consumption pattern of the articles in this segment), DAF should explore at forehand which other suppliers sell the SKU's subject of CI. In contrast with VMI, there will probably be not that many alternative suppliers due to the high value and low consumption of the SKU's in this segment. Another way how DAF can avoid the negative results of this risk is to collaborate with DAF Westerlo. This is probably not that easy, since DAF Eindhoven would not be possible to offer the same service, and thus such a collaboration is not balanced which is even for emergency situations not a good starting point. For CI it is thus even more important to have good agreements with the supplier to prevent shortages of articles in this segment.

SOI:

Recall that the articles are of high value and also experience high consumption. This makes that availability of these articles at other suppliers is better as with CI (but not as good as with articles in VMI) because there are then probably more customers who use these articles. This creates the possibility of buying these articles at another supplier when needed, and having them delivered with an emergency courier. Although it will probably require some searching for a supplier who has that article in stock, since suppliers will have less inventory of articles in this segment then in the VMI segment. Therefore is recommended to already have some potential suppliers administrated, such that when this emergency measure is necessary no time is lost in searching for other suppliers. This way DAF can cope with this risk relatively well.

So far was the situation considered where the supplier wasn't able to deliver the article. Another risk is that the supplier has delivered the wrong article. In that case this must be notified to the supplier immediately, and then the supplier must deliver a new (correct) article as fast as possible.

8.4 Conclusion

In this chapter is elaborated on which agreements should be stipulated in contracts and for which informal agreements will do. Collaboration is for each SCC-form very essential, for that reason it is important that the partners in that collaboration are aware of their tasks, and what they may expect from the partner. To accomplish that, the contract that accompanies the SCC must stipulate the agreements made on six different issues:

1. Specification of decision rights
2. SLA's
3. Procedures to be followed
4. Quantity flexibility
5. Penalty agreement
6. Selection of possibly used 3PL's

However, how certain aspects are accomplished to meet the agreements (e.g. how information will be shared among the partners) can be agreed upon with informal agreements, without the need for stipulating this in contracts which would entail a lot of effort for the legal department. Deciding on such aspects by the employees themselves (instead of the legal department that has not the detailed knowledge of procedures used in practice), creates the opportunity to use the knowledge of these employees in finding an efficient and workable solution.

Despite all carefully made informal and contractual agreements, there will always be a risk involved in such a collaboration. However, when DAF would at forehand research which companies do also sell the SKU's subject of the collaboration, these risks can be reduced to the minimum. Risks in the CI segment are higher since those articles are scarcer on the market, and therefore it is for a CI collaboration even more important to have really good agreements with the supplier.

9 Implementation plan

Now that all research questions are answered and all aspects of collaboration are discussed, we will focus on some guidelines that have to be followed in order to set up a collaboration (independent of the precise form). This will be done by defining some implementation steps. The first part is for preparing for the SCC, and the second part concerns the collaboration itself.

Preparation for SCC:

Step 1: Support creation:
Implementing such a collaboration requires quite a change on the company culture, since it could feel unnatural to outsource control of inventory, especially when it concerns critical articles. This support should be carried by the management of MMP, Maintenance Engineering and Purchasing in order to be able to spread this support over all future users. The project leader should assist in creating this support and thereby also answering possible questions that arise with DAF employees.

Step 2: Setting up a team:
A project team (of three to five persons) must be set up and one person should be the project leader. He should not only lead the project and guides its progress, but he should also be of help by creating support through the organization. Finally, he also has to be the focal point for this project. Then a mechanic should be part of the project team. This mechanic must give insight in response times and temporary mending of machinery applied in practice when a needed article is not (directly) available. The third project member must be a maintenance engineer, he also will have input for the response time and he has insight in what other articles can be used as a (temperately) replacement. Further will he be responsible for delivering most of the data (mainly machine relations).

Step 3: Select supplier:
Earlier in this report this step was already conducted to demonstrate the procedure for selecting a potential partner. In future projects this should be repeated, which is thus step 3 of the implementation. This step must be completed by having an exploratory meeting with the supplier to discuss whether or not the supplier is willing to engage in a SCC and if he has the resources for it.

Step 4: Create groups of articles:
Now the potential partner for collaboration is selected, the project team has to analyse the articles of that supplier and place them in one of the ten segments of the allocation framework. Then is known which forms of SCC are suitable and how much the potential savings are. This information is needed when is further negotiated with the supplier concerning the SCC, which is the next step.

Step 5: Negotiation with supplier:
From the previous step DAF knows what the maximum savings per article group are. It now depends on the fee the supplier charges for his services, how much potential savings can actually be accomplished. Points to negotiate on during this step are those described in chapter 8 “collaboration agreements”.

Step 6: Decide on what to do with current inventory that will be part of SCC
There are several options for DAF what to do with current inventory, depending of the type of SCC-form that is going to be implemented:

- VMI: articles in this segment will also after the implementation of VMI be stocked in the warehouse of DAF and furthermore also financially owned. What has to be done for these articles is relocate them to a separate area where the supplier has free access to so that he can manage the inventory control of those articles. At the start of the collaboration the supplier has to make sure that the inventory level of each article is at the same level as agreed upon in this negotiation. When inventory level is higher than agreed upon they don't have to be disposed. Consumption is this segment is high so it will level out automatically.

- CI: The articles in this segment have high values, it might therefore be worthwhile to sell those SKU's back to the supplier, or to the highest bidding external buyer. Due to the slow moving character of the articles in this segment this is recommended over first using the articles and then starting the SCC. It than can take a long period of time before the SCC concerns all SKU's, which is not beneficial and can cause misunderstandings between DAF and the supplier. For the bookkeeping value of these SKU's it has no big effect since DAF almost completely writes off the value of articles from the moment that they are purchased.

- SOI: The articles in this segment are of high value and consumption rate is also high. This means that these articles will still be relatively new. So just as was with the active articles in the CI segment, it is recommended to negotiate with the supplier the possibility that the supplier buys these articles back from DAF.

Step 7: Setting up data exchange system:
In this phase is decided on all elements and thus each party knows what is expected from him. Before the collaboration can really start an information exchange system must be implemented. Depending on agreements made this could be done via SAP or more simply via a shared webserver. The needed labour of up- or downloading, adjusting and analysing this data should be taken into procedures so that this is done on fixed moments of the week.

Step 8: Instruct the warehouse employees
The biggest change for the warehouse employees is a VMI collaboration. Then there will be a separate part in their warehouse where the supplier controls the inventory, of course the warehouse employees must exactly know which SKU's this concerns, or better, which area of the warehouse is assigned to VMI. For CI and SOI a new procedure must be followed. Where normally a requested article must be retrieved from the shelve in the warehouse, it has to be ordered at the supplier for the articles part of a CI or SOI collaboration. Since this must be done immediately these warehouse employees must be instructed that they call the supplier (or a maintenance material planner from DAF) immediately.

During the supply chain collaboration:
The previous implementation steps concerned the preparation for the SCC. Now will be focused on the collaboration itself.

Step 1: Forecasts
It is important that DAF will make more use of forecasts. As was indicated this might be hard, and therefore the experience of the supplier can be used. It is the task of the maintenance material planner to create a forecast together with the supplier.

Step 2: Keeping the data exchange with the supplier up to date
Assign a Maintenance Material Planner who is responsible for maintaining the data exchange with the supplier. This means sending the corrective maintenance forecasts to the supplier, maintaining and keeping up to date the data files the supplier has access to concerning the inventory levels and the future forecasts.

Step 3: Maintaining contact with the supplier
Since this is especially important in the beginning it is recommended that the MMP manager schedules a weekly brief discussion with the supplier and evaluates the inventory control done by the supplier of the last week. In this way possible mistakes are noticed and can be prevented for the future. This is also important for the relationship between DAF and the supplier.

Step 4: Monitoring performance and evaluate with supplier
Just as DAF does at this moment with handling inventory themselves, they should monitor fill rate of the articles of which handling is outsourced in the collaboration. Besides that it is important to discuss the results regularly, see the previous step, this is needed to evaluate if the supplier achieves the SLA's as they are denoted in the contract. Communicate the performance levels of each period directly to the supplier. The supplier needs this information such that he can further improve his services.

Step 5: Evaluate internally
Just as the performance is evaluated with the supplier, this should also be done internally between MMP management, maintenance material planners and the warehouse employees. Also for the DAF employees holds that they only can improve their work if they know what the performance is at the moment.

10 Conclusions and recommendations

This last chapter describes both the conclusions resulting from the project described in this report and also some recommendations to DAF are discussed.

10.1 Conclusions

This research project has resulted in an increased awareness of the potential of collaboration in the supply chain. Although was shown that SCC can also for DAF realize inventory costs savings, it appeared that most savings can be achieved by optimizing the inventory control at DAF. Data analysis showed that even considering the spare part characteristic of the articles used at DAF, many articles show very little (or even non) movement in the observed period of four years and one can question the need for storage of these SKU's. Nevertheless was during this research focused on the savings that can be achieved purely by SCC. Three SCC-forms were researched, how much savings they can realize is given underneath:

- VMI: € 60,- savings per order. When collaborated with the best potential partner, Scheib GmbH, a total annual saving of € 2.530,- can be realized for an article group that is suitable for this SCC-form (consisting of 67 articles), depending on the fee the supplier charges for this SCC. The mean contribution from this SCC-form would therefore not be the potential saving, but the improvement of the inventory control considering the experience of the supplier that can be used.
- CI: In terms of potential savings, both per order as for the entire article group of the previous mentioned supplier, the most promising SCC-form with savings of € 380,- per order and annually € 11.970,- for the article group concerned (in total 85 SKU's). Again excluding the fee charged by the supplier for having the articles of DAF in consignment stock.
- SOI: The articles in the SOI segment are characterized by the high value and high consumption they represent. There are only few articles within DAF's spare parts inventory that satisfy these criteria (34 SKU's). When a SOI collaboration would be initiated DAF would face high transport costs, due to the high consumption and having the articles stored at the supplier. Because of that SOI is the only SCC which would not result in savings for DAF. Cost per order will increase with € 20,-, which would annually result in extra costs of € 810,- annually.

These savings are only small compared to the total inventory value (SS value). Therefore would at this point, where DAF does not have experience with SCC, the main motive for engaging in SCC not be the potential savings that a SCC could realize, but that DAF can make use of the experience of the supplier. When DAF and the supplier combine their knowledge of the spare parts and make a forecast for future consumption, this can contribute to the mission of MMP, ensuring maximal utilization of spare parts against minimal costs. This holds especially for CI, since concluding from the many non-movers and in-active SKU's this is a difficult segment to control for DAF.

A factor where DAF can realize significant savings on inventory control costs is to research the non-movers and in-active articles. For some of these articles there was no relation with the machinery equipment administrated, which could mean that these articles will never be needed again. Carefully exploring the in-active articles on this observation could easily avoid the costs of (unnecessarily) having these articles on stock.

10.2 Recommendations

As a result of this project, the following recommendations are made to DAF:

1. For the in-active articles that do not have machine relations administrated, check the need of having those on stock. Start with the most expensive articles to realize the biggest savings.
2. Link the active or in-active status to the article description in SAP. At the moment it is time consuming to evaluate an article on the activity status.
3. Start making use of forecasts. If needed first with help of Scheib and for the articles subject of the collaboration, but expand this later to the entire inventory. Differentiate between articles used for preventive- and for corrective maintenance.
4. When these points are completed set up a CI collaboration form with Scheib. To do so, the response times of the articles have to be determined with help of a project team.
5. Negotiate with Scheib on selling back the articles subject of the collaboration to Scheib. If this is not possible sell those articles to the highest bidding external party. The collaboration has the best effect when all articles are managed by and stored at Scheib from the beginning.
6. During the first few months of the collaboration, evaluate on a regular basis (e.g. weekly) the progress. After a while this period can be extended. But to maintain the relation and personal contact with the supplier it is recommended to deliberate on the collaboration at least once a month.
7. When SCC is implemented, with Scheib or also with other suppliers, and has proven its effect, it can be researched if it is possible to bring SKU's from other small suppliers under the SCC contract. In this way the SCC can become more profitable and the number of suppliers can be reduced.
8. Future research should focus on the boundaries that were chosen in this report for assigning articles to segments. When more and more articles are subject of collaboration forms, these border lines for value, consumption and response time have to be adjusted in order to select "new" articles.
9. Future research should also cover the exact handling- and order-costs. In this report these costs are derived from the handling- and order-costs as they are defined by Paccar for DAF. This was done because interviews showed that within DAF it is not exactly known how these costs are derived. Since it is very important to have an accurate figure for one's items of expense, lies in this a potential improvement.
10. In this report DAF Westerlo was not within the scope of the research, but when SCC works successfully for DAF Eindhoven, this can be further optimized by collaboration with DAF Westerlo.

References

1. **DAF Trucks N.V.** *DAF General Presentation.* 2010.

2. **Paccar.** [Online] [Cited: 09 September 2010.] http://www.paccarengines.com/en-us/Engines.aspx.

3. **DAF Trucks N.V.** [Online] [Cited: 03 September 2010.] http://www.daf.com/EN/About-DAF/Pages/Facts-Figures.aspx.

4. —. *DAF the company.* 2002.

5. **Silver, Pyke, Peterson.** *Inventory Management and Production Planning and Scheduling.* s.l. : John Wiley & Sons, 1998.

6. **J.E. van Aken, H. Berends, H. van der Bij.** *Problem solving in organizations, a methodological handbook for business students.* United Kingdom : Cambridge university press, 2007.

7. *The consignment stock of inventories: industrial case and performance analysis.* **Valentini, Zavanella.** 81 - 82, 2003, international journal of production economics, pp. 215 - 224.

8. *Is collaboration paying off for firms?* **Daugherty, Richey, Roath, Min, Chen, Arndt, Genchev.** 49, 2006, Business Horizons, pp. 61 - 70.

9. *The inventory value of information sharing, continious replenishment and vendor-managed inventory.* **Yao, Dresner.** 44, s.l. : Elsevier, 2008, Transportation Research Part E, pp. 361 - 378.

10. *Coordination in the supply chain: Vendor Managed Inventory is the way to go.* **Piplani.** 1, 2006, Serbian Journal of Management, pp. 41 - 47.

11. *A supply chain model of Vendor Managed Inventory.* **Dong, Xu.** 38, s.l. : Pergamon, 2002, Transportation Research Part E, pp. 75 - 95.

12. *Decision Support Framework for Supply Chain Collaboration.* **Ana Cristina Barros, Ana Paula Barbosa Póvoa, Alexandra Castro.** 2008.

13. [Online] http://dafportal.eu.paccar.com/operations/departments/maintenance/dfn/machineclassificering.aspx.

14. *Realities of supply chain management.* **R.P. Kampstra, J. Ashayeri, J. Gattorna.** 2006.

15. *Defining supply chain management: a historical perspective and practical guidelines.* **Rhonda R. Lummus, Robert J. Vokurka.** 99/1, 1999, Industrial Management & Data Systems, pp. 11 - 17.

16. *Coordinated Supply Chain Management.* **Thomas, Griffin.** 94, 1996, European Journal of Operational Research, pp. 1 - 15 .

17. *The collaborative supply chain.* **Simatupang, Sridharan.** Vol. 13, No. 1, 2002, The International Journal of Logistics Management, pp. 15 - 30.

18. *Examining supply chain relationships: Do buyer and supplier perspectives on collaborative relationships differ?* **Nyaga, Whipple, Lynch.** 28, 2010, Journal of Operations Management, pp. 101 - 114 .

19. *Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead times and information.* **Chen, Drezner, Ryan, Simchi-Levi.** Vol. 36, No. 3, 2000, Management Science, pp. 436 - 443.

20. *The effect of Vendor Managed Inventory (VMI) dynamics on the Bullwhip Effect in supply chains.* **Disney, Towill.** 85, 2003, International Journal of Production Economics, pp. 199 - 215.

21. *Supply chain collaboration: Making sense of the strategy continuum.* **M. Holweg, S. Disney, J. Holmström, J. Smaros.** Vol. 23, No. 2, s.l. : Elsevier Ltd, 2005, European Management Journal, pp. 170 - 181.

22. [Online] www.logistiek.nl/dossierartikelen/id830-Wat_is_het_verschil_tussen_pl_en_pl.html.

23. *On characterizing the 4 C's in supply chain management.* **Miguel A. Lejeune, Nevena Yakova.** 23, s.l. : Elsevier Ltd., 2004, Journal of operations management, Vol. 2005, pp. 81 - 100.

24. *On the benefits of CPFR and VMI: A comperative simulation study.* **Sari.** 113, 2008, International Journal Production Economics , pp. 575 - 586.

25. *9 steps to success with cpfr.* **Harrington, Lisa H.** 2003.

26. *CPFR: an emerging supply chain tool.* **Fliedner.** Vol. 103; No. 1, 2003, Industrial Management & Data Systems, pp. 14 - 21.

27. *From a traditional replenishment system to vendor-managed inventory: A case study from the household electrical appliances sector.* **De Toni, Zamolo.** 96, 2005, International Journal of Production Economics, Vol. 2005, pp. 63 - 79.

28. *Empirical evaluation of VMI: two ways to benefit.* **Kauremaa, Smaros, Holmstrom.** 2007.

29. *Automatic replenishment programs: The impact of organizational structure.* **Sabath, Autry, Daugherty.** Vol. 22, No. 1, 2001, Journal of busines logistics.

30. *Supply chain management: a framework to characterize the collaborative strategies.* **Derrouiche, Neubert, Bouras.** Vol. 21, No. 4, 2008, International Journal of Computer Integrated Manufacturing, pp. 426 - 439.

31. *Coordinating replenishment mechanisms in supply chain: From the collaborative supplier and store-level retailer perspective.* **Lyu, Ding, Chen.** 123, 2010, International Journal of Production Economics, pp. 221 - 234.

32. *Supply chain integration in vendor-managed inventory.* **Yuliang Yao, Philip T. Evers, Martin E. Dresner.** 43, s.l. : Elsevier, 2005, Decision Support Systems, Vol. 2007, pp. 663 - 674.

33. *Vendor managed category management - an outsourcing solution in retailing.* **Kaipia, Tanskanen.** 9, 2003, Journal of Purchasing & Supply management, pp. 165 - 175.

34. *Effectiviness of vendor-managed inventory in the electronics industry: determinants and outcomes.* **Kuk.** 41, Information & Management, pp. 645 - 654.

35. *Performance outcomes and success factors of Vendor Managed Inventory (VMI).* **Claassen, van Weele, van Raaij.** Vol. 13, No. 6, s.l. : Emerald Group Publishing Limited, 2008, Supply Chain Management: An international journal, pp. 406 - 414.

36. *The Dollars and Sense of Electronic Data Interchange.* **Carter, J. R.** 31 no.2, 1990, Production & Inventory Management, pp. 22 - 26.

37. *Exploring the experiences of collaborative planning initiatives.* **Mark Barrat, Alexander Oliveira.** Vol. 31, No. 4, International Journal of Physical Distribution & Logistics Management, Vol. 2001, pp. 266 - 289.

38. *VMI and SMI Programs: How economic value added can help sell the change.* **Pohlen, Goldsby.** Vol. 33, No. 7, s.l. : Emerald, 2003, International Journal of Physical Distribution & Logistics Management, pp. 565 - 581.

39. *Impact of consignment inventory and vendor-managed inventory for a two-party supply chain.* **Gümüs, Jewkes, Bookbinder.** s.l. : Elsevier Ltd. , 2008, pp. 502 - 517.

40. *Consignment contracting: Who should control inventory in the supply chain?* **Ru, Wang.** 201, 2010, European Journal of Operational Research, pp. 760 - 769.

41. *Channel coordination in a consignment contract.* **Zhang, de Matta, Lowe.** 207, 2010, European Journal of Operational Research, pp. 897 - 905.

42. *Vendor-owned inventory management arrangments in retail: An agency theory perspective.* **Rungtusanatham, Rabinovich, Ashenbaum, Wallin.** Vol. 28, No.1 , 2007, Journal of business logistics, pp. 111 - 135.

43. *Supply chain collaboration: Theoretical perspectives and empirical evidence.* **Larsen, Thernoe, Andresen.** Vol. 33, No. 6, 2003, International Journal of Physical Distribution & Logistics Management, pp. 531 - 549.

44. *Long term collaborative business relationships: The impact of trust and C3 behaviour.* **Humphries, Wilding.** 20, 2004, Journal of Marketing Management, pp. 1107 - 1120.

45. *Multi-criteria supplier selection using fuzzy AHP.* **Kahraman, Cebeci, Ulukan.** Vol. 16, No. 6, Logistics Information Management, Vol. 2003, pp. 382 - 394.

46. **Dun & Bradstreet Inc.** [Online] 2008. http://dbnetherlands.dnb.com/Dutch/Brochures/DB_Rating_score_N.pdf.

47. **Scheib Elektrotechnik GmbH.** [Online] www.scheib-gmbh.de.

48. *Stocking strategy for service parts - a case study.* **Botter, Fortuin.** 2000 : MCB University Press, International Journal of Operations & Production Management,Vol. 20 No. 6, pp. 656 - 674.

49. *Maintenance spare parts logistics: Special characteristics and strategic choices.* **Huiskonen, Janne.** s.l. : Elsevier, 2001, International journal of production economics 71, pp. 125-133.

50. *Shaping buyer-supplier relationships in manufacturing contexts: Design and test of a contingency model.* **Saccani, Perona.** 13, s.l. : Elsevier, Journal of Purchasing & Supply management, Vol. 2007, pp. 26 - 41.

51. *Avoid the pitfalls in Supplier Development .* **Handfield, Krause, Scannell, Monczka.** Vol. 21, No. 2, 2000, MIT Sloan Management Review.

52. **Visser, van Goor.** *Werken met logistiek.* Groningen, the Netherlands : Wolters- Noordhoff, 2004. ISBN 90-207-3223-4.

53. **Winston.** *Operations Research, Applications and Algorithms.* [ed.] Brooks/Cole - Thomson Learning. 4. 2004.

54. **Heijden, M. van der.** *Sheets SCTM: Multi-echelon inventory management part 1.* 2009.

55. *Vendor Managed Inventory for single-vendor multi-retailer supply chains.* **Darwish, Odah.** 204, 2010, European Journal of Operational Research, pp. 473 - 484.

56. *Incomplete contracts and renegotiation.* **Hart, Moore.** Vol. 56, No. 4, 1988, Econometrica, Journal of the economic society, pp. 755 - 785.

57. **Tayur, Ganeshan, Magazine.** *Quantitative models for supply chain management.* s.l. : Kluwer Academic Publishers, 1999. 0-7923-8344-3.

58. **Maas, Pleunis.** *Facility management: Strategie en bedrijfsvoering van de facilitaire organisatie.* 2e. s.l. : Kluwer, 2006. 9013032052.

59. *Coordinating production and delivery under a (z,Z)-type Vendor Managed Inventory contract.* **Fry, Kapuscinski, Lennon Olsen.** Vol. 3, No.2, 2001, Manufacturing & Service Operations Management, pp. 151 - 173.

60. DHL postage calculator. [Online] www.dhl.de.

61. Rusan Transporte. [Online] http://www.rusan.de/.

62. *Der Courier.* [Online] http://www.dercourier.de/.

63. Top Courier. [Online] http://www.topcourier.de/index4.htm.

64. *Managing lumpy demand for aircraft spare parts.* **A. Regattieri, R. Gamberi, M. Gamberi, R. Manzini.** 11, s.l. : Elsevier, 2005, Journal of air transport management, pp. 426 - 431.

65. *Environmental determinants of VMI adoption: An exploratory analysis.* **Dong, Xu, Dresner.** 43, 2007, Transportation research Part E, pp. 355 - 369.

66. *Control of service parts.* **Fortuin, Martin.** Vol. 9, No. 9, 1999, International Journal of Operations & Production Management, pp. 950 - 971.

67. *A model for evaluating supplier-owned inventory strategy.* **Piplani, Viswanathan.** 81 - 82, 2003, International Journal Production Economics, pp. 565 - 571.

68. [Online] http://www.nen.nl/web/Normshop/Norm/NENENISO-90012008C12009-nl.htm.

69. **Callegro.** *Forecasting methods for spare parts demand.* Dipartimento di tecnica e gestione dei sistemi industriali, Universita' Degli Studi Di Padova. 2010.

70. **Sherbrooke.** *Optimal inventory modeling of systems: Multi-echelon techniques.* s.l. : Kluwer Academic Publishers, 2004. 1-4020-7849-8.

71. *the critical tools of the supply chain.* **Williams.**

72. *Capacity allocation using past sales: When to turn-and-earn.* **Cachon, Lariviere.** Vol. 45 No.5, s.l. : Institute for Operations Research and the Management Sciences, 1999, Management Science.

Appendix A. Glossary of terms

3PL: Third party logistics provider

4PL: Fourth party logistics provider

ATB: in Dutch: “Aanvraag tot Bestelling”, in English: request for an order

CI: Consignment Inventory

CPFR: Collaborative Planning, Forecasting and replenishment

CR: Continuous Replenishment

ME: Maintenance Engineer

MMP: Maintenance Material Planning

MTTF: Mean Time To Failure

QR: Quick Response

SAP: ERP package as used at the MMP warehouse

SC: Supply Chain

SCC: Supply Chain Collaboration

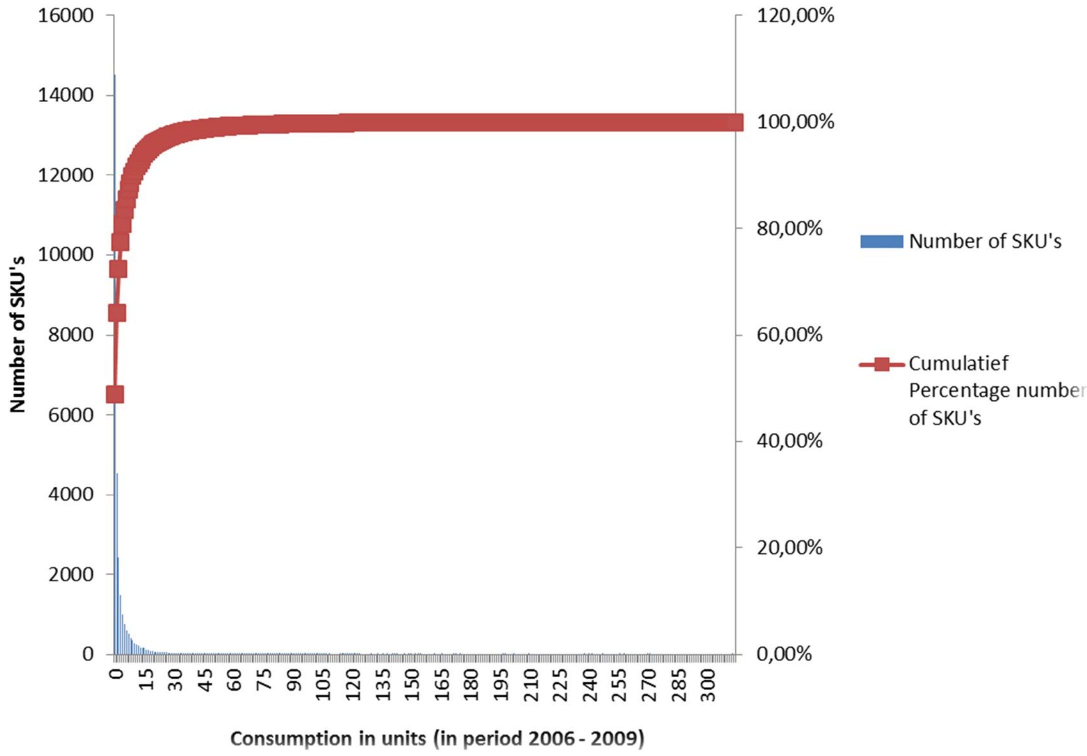
SKU: Stock Keeping Unit

SOI: Supplier Owned Inventory

VMI: Vendor Managed Inventory

VMR: Vendor Managed Replenishment

Appendix B. Consumption pattern 2006 – 2009



Appendix C. D&B rating Scheib Elektrotechnik

D&B Decide with Confidence

European Compact Report - Supplier Intelligence

Report viewed	28 Feb 2011
Subscriber Number	870-043498
Your Reference	Dhr. H. van der Aa

► Collapse All ► Expand All

Identification & Summary

Click on the Section Headings to Collapse/Expand each section TOP

Scheib Elektrotechnik Gesellschaft mit beschränkter Haftung

Risk Evaluation

D&B Risk Indicator	1
D&B Failure Score	90
D&B Maximum Transactional Credit	EUR 92.000
D&B Total Credit Recommendation	EUR 1.050.000
Days Before Terms	5
Score Override	No
Current Negative Legal Events	No
Special events	No

Associations

Parent Company	No
Number of Subsidiaries	0
Number of Branches	0

Financial Summary

Total Equity	EUR 1.481.652
Employees	47

Identification

D-U-N-S® Number	31-682-8433
Trading Style	Elektro-Bau-Scheib GmbH
Main Trading Address	Martinstr. 38 40223 Düsseldorf Postal office box no. 260255 40095 Düsseldorf Nordrhein-Westfalen GERMANY
Telephone Number	+49 211 901480
Fax Number	+49 211 9014811
VAT Number	DE119428147
Registration Number	HRB9965
Line of Business (SIC)	Mfg relays/industrial controls (36250000)
Web Address	http://www.scheib-gmbh.de/

D&B Insured ►
Powered by Euler Hermes

D&B Risk Assessment

TOP

D&B Analysis: MINIMUM Risk Of Business Failure, pays to terms.

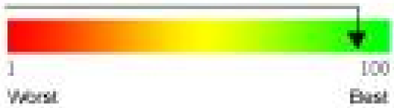
D&B Rating	1A 1	
Financial	1A	based on a net worth of

D&B Maximum Transactional Credit	€ 92.000
D&B Total Credit	

Strength		€ 1.481.652	
Risk Indicator (1-4)	1	Represents a minimum risk of business failure.	

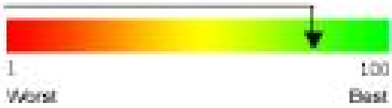
Recommendation	**€ 1.050.000**

D&B Failure Score **90 out of 100**



10% of German businesses have a lower risk of failure.

Payment behaviour - Paydex **82 out of 100**



The business is paying their bills with an average of 5 Days Before Terms.

Main Influencing Factors for Risk Evaluation

- The legal form of this company has a positive impact on the D&B risk assessment.
- The retained earnings of the company have a positive impact on the D&B risk assessment.
- The excellent paydex of the company has a positive impact on the D&B risk assessment.
- The current liabilities to net worth ratio has a positive impact on the D&B risk assessment.

Click here to receive immediate notification of changes to the level of risk or payment habits of this business

Find out about the risks of doing business in this country

Current Principals

TOP

There are currently **2** principals. There have been **0** appointment(s) in the last 12 months and **0** resignations.

Jürgen Goormann : Managing Director

Date of Birth 24 Jan 1960

Siegfried Szymanski : Managing Director

Date of Birth 09 Nov 1948

Click here to receive immediate notification of any legal filings & changes in general information.

Ownership

TOP

According to D&B database, Scheib Elektrotechnik Gesellschaft mit beschränkter Haftung has 5 owner(s).

Share Holder Name	D-U-N-S ®	Interest	Start date of interest	Type of interest	Birth date / Year of foundation	Address
Zdravko Majcenic	-	8,25%	14 Aug 2003	Partner / Shareholder	26 Dec 1947	41460 Neuss, GERMANY

Siegfried Szymanski	-	8,25%	14 Aug 2003	Partner / Shareholder	09 Nov 1948	40545 Düsseldorf, GERMANY
Jürgen Neumann	-	50,19%	14 Aug 2003	Partner / Shareholder	30 Dec 1930	40474 Düsseldorf, GERMANY
Hans-Wilhelm Laukart	-	8,25%	14 Aug 2003	Partner / Shareholder	12 Mar 1951	47802 Krefeld, GERMANY
Jürgen Goormann	-	8,25%	14 Aug 2003	Partner / Shareholder	24 Jan 1960	47877 Willich, GERMANY
Helena Goormann-Leijten	-	16,81%	14 Aug 2003	Partner / Shareholder	16 Oct 1935	41564 Kaarst, GERMANY

Click here to receive immediate notification to public registered information changes

Register Profile & Capital

TOP

Legal Structure

Legal Form	Private Limited Liability Company
Date Started	14 Jan 1964
Date of Registration	23 Mar 1964
Registered in	Düsseldorf 40213
Registration Number	HRB9965
VAT Number	DE119428147
Registered office	Martinstr. 38, 40223 Düsseldorf, Nordrhein-Westfalen, GERMANY

Capital

Ordinary Share Capital (GmbH)	EUR 510.000
Date of latest capitalization	14 Aug 2003
Capital has been increased by	EUR 250.000 from originally EUR 260.000

Click here to receive immediate notification to public registered information changes

Banks

TOP

Bank Name	ZIP Code / Postcode	Town	Bank Sort Code
Postbank	45125	Essen, Ruhr	36010043
Commerzbank	40002	Düsseldorf	30040000

Financial Summary

TOP

Financials - based on investigation

	Non Consolidated Based on Investigation EUR 2010
Inventories (net value)	423.000
Sales Revenue	9.400.000

	Non Consolidated Based on	Non Consolidated Based on	Non Consolidated Based on

	Investigation 2011	Investigation 2010	Investigation 2009
Number of Employees	47	47	47

Pls. note: Number of employees is not shown in thousands (000)

Financials - based on balance sheet

	Fiscal Non Consolidated Based on Balance Sheet EUR 31 Dec 2009	Fiscal Non Consolidated Based on Balance Sheet EUR 31 Dec 2008	Fiscal Non Consolidated Based on Balance Sheet EUR 31 Dec 2007	Fiscal Non Consolidated Based on Balance Sheet EUR 31 Dec 2006
ASSETS				
fixed tangible assets/ intangible assets	425.154	392.356	363.277	317.228
current assets	1.899.296	2.045.491	2.102.696	1.818.102
inventories (net value)	464.862	521.467	545.597	600.096
LIABILITIES AND SHAREHOLDERS EQUITY				
equity (capital and reserves)	1.481.652	1.607.433	1.333.175	1.141.827
balance sheet total	2.366.627	2.466.669	2.491.827	2.136.888

	Non Consolidated Based on Balance Sheet 31 Dec 2009	Non Consolidated Based on Balance Sheet 31 Dec 2008	Non Consolidated Based on Balance Sheet 31 Dec 2007	Non Consolidated Based on Balance Sheet 31 Dec 2006
Number of Employees	unknown	unknown	unknown	unknown

Pls. note: Number of employees is not shown in thousands (000)

Receive immediate notification if new accounts are filed

Customer Service and Support

TOP

For any queries please use our Online Assistant Service or contact us on:

e-mail Address customerservicen@dnb.com
Telephone Number 010-7109560

Please quote your subscriber number **870-043498** for any query or support.

Appendix D: Cost assumptions

Transport costs (at expense of DAF) for short- and medium response times.

Transport cost are estimated based on a courier company who operates in multiple countries. For the medium response time segment, delivery costs are given based on costs charged by DHL, a large courier company operating in several countries (among others the Netherlands and Germany). Delivery costs are given based on a package with a maximum size of 120 cm x 60 cm x 60 cm and a maximum weight of 20 kg. With these dimensions will probably not all articles in stock be covered, but certainly many of them are. Further is assumed that the article is picked up by the courier at the supplier's premises, this service is also offered by DHL, while the supplier is responsible for packing the article such that it can directly be handed over to the courier. Based on delivery within 24 hours these services will costs € 35,- (60).

For short response time articles this type of delivery is not suitable since it takes too long. For this category a direct shipment is necessary. These costs are based on the average price of three different couriers in Germany, near the selected supplier Scheib (since cost savings are based on collaboration with this supplier). Prices for this type of delivery depend on the distance the courier has to cover, being the distance from the courier to the supplier and then to DAF. Based on prices of these three couriers we assume that emergency supply costs per km are equal to the average of the price at these three couriers, and are: € 0,99 / km (61) + € 0,97/km (62) + € 1,00/km (63) / 3 = € 0,99 / km. Only those kilometres are charged that the courier has to cover from his premises, to the supplier and then to DAF. Considering a courier in the neighbourhood of the supplier (thus Scheib) total distance charged is assumed to be 150 km. Thus one emergency delivery is assumed to cost: 150 * € 0,99 = € 148,50.

Maintenance Operations 2011 Saving calculation (EUR)

Project Title:		
Project no:		
Project owner:		
Date:		
Team members:		
Savings category	**Description**	**(Fixed) Values**
Labour - Technicians	Hours per year	
Select Department	Labour cost / hour	54,-
	Saving annualized (EUR)	
Labour - Operator	Hours per year	
Select Plant	Labour cost / hour	40,16
	Saving annualized (EUR)	
Material Costs (usage) - Spare Parts	Material costs / year	
Material number(s):	**Saving annualized (EUR)**	
Material Costs - Repair Parts	Material costs / year (new parts)	
Material number(s):	Material+Repair costs / year (using repair parts)	
	Saving annualized (EUR)	
Inventories - Spare Parts	Inventory value	
Material number(s):	Spare Parts inventory rate	10 %
	Saving annualized (EUR)	
Material costs - administrative	No. of parts used per truck	
	Administrative costs / partno.	329,-
Material number(s):	Adm costs / partno. in-active article	51,-
	Saving annualized (EUR)	
SUBTOTAL SAVING ANNUALIZED		
TOTAL SAVING ANNUALIZED		
ROI (%)		
Payout (yrs)		

v. 20 Jan 2011

Fixed 2011 values

Table 1 Costs assumptions by DAF