OPTIMIZATION OF SUPPLY CHAIN FOR SMALL AUTOMOTIVE PARTS

Case: Avtoframos plant, Moscow

Sergey Kotenko

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JYVÄSKYLÄN AMMATTIKORKEAKOULU
JAMK UNIVERSITY OF APPLIED SCIENCES

JYVÄSKYLÄN AMMATTIKORKEAKOULU
JAMK UNIVERSITY OF APPLIED SCIENCES

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Tutor(s) VAUHKONEN, Petri NIEMINEN, Sanna
Assigned by OAO Avtoframos

Abstract

OAO Avtoframos faced the necessity of changing the way of supplying the certain batch of parts, which are small automotive parts PPA, to the Avtoframos production plant in Moscow. The objective of this research was to provide the most efficient and cost-effective solution taking into account all the involved processes within the plant.

The closer look to the current supply mode was described with its drawbacks and reasons why it had to be optimized. Those included growing stock, ineffective storage of parts at the warehouse, lack of space in the warehouse, and sufficient amount of lost or damaged parts. The research was conducted to optimize the warehouse premises according to new supply method of parts, to organize the distribution and storage of parts at the line side, to create the new distribution route for operators according to current developments, and to see which changes had to be applied at the reception.

The results were seen in decreasing stock and six times more free space in the warehouse, convenience of storing of parts, less occupation of operators distributing the parts, less inventory circles, as well as more free space at the reception and a fewer number of lost parts. All these were significant to OAO Avtoframos when considering whether to implement the optimization steps proposed in this work.

Keywords Automotive industry, supply chain, warehousing, inventory control, stock control.

Miscellaneous

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Terminology

CPL	Centre de Preparation Logistique (*Fr.:* Logistics Preparation Centre)
DLAR	Demande de Livraison en Raison Actuel (*Fr.:* Request for Delivery by Actual Need)
DLC	Demande de Livraison á la Consommation (*Fr.:* Request for Delivery due to Consuming Capacity)
DLQJ	Demande de Livraison Quotidienne par Jour (*Fr.:* Request for Daily Delivery enough for a Day)
MAPU	Mise au Point (*Fr.:* Installation Point)
PPA	Petites Piéces Automobiles (*Fr.:* Small Automotive Parts)
SFKI	Sofrastock International
TGP	Technicien de Gestion de Production (*Fr.:* Production Management Technician)
VBQ	Visserie, Boulonnerie, Quincaillerie (*Fr.:* Thread parts, Fastening parts, Hardware parts)

1 INTRODUCTION

1.1 PURPOSE OF THE STUDY

This thesis covers a study on how an automotive company Renault in Moscow had made a decision to switch from one supply mode to another and the most suitable solution to start the process of switching proposed by the author in cooperation with professionals in the field. The topic was chosen during the author's practical training period offered by the head of Upgrading logistics processes' effectiveness office. The project is critical for the company due to organization's policies and factors discovered further in this thesis. In order to minimize costs and risks in continuing production, it required a careful study and planning of all the involved processes: warehousing, line side organization, inventory and reception. The author did a research and calculations on how and which warehouse premises would be re-organized and how much space would be needed. As well, the author committed three audits to the conveyor to analyze the situation with arrangement of parts on the shelves and checked out which parts to use for the first batch when DLC supply mode would be implemented. The author proposed an optimized inventory handling method and studied if and how computer application at the reception would need to be changed.

The Renault case clearly shows how supply handling is carried out in a manufacturing company and what the prerequisites are to change its supply methods. This case includes many different logistical, both theoretical and practical aspects to state a current situation and find the necessary solutions for the existing issues.

1.2 COMPANY'S PROFILE

The story of Renault in Russia goes back to almost one hundred years. As far back as the beginning of twentieth century, a joint-stock company "Frese & Co." used to deliver to Russia Renault cars, which also were present in a car fleet of Emperor

Nicholas II. However, after the formation of USSR the story of Renault in Russia discontinues up to 1980s. In 1998, the company widely enters Russian market starting with assembling Megane and Renault 19 automobiles. Defining moment in the history of Renault in Russia was opening of Avtoframos plant in 2005 with production of national model Renault Logan. In 2010, Renault doubled its capacities and procured new robotic equipment increasing the productive capacity from 60,000 cars per year to 160,000 cars per year. Currently, there is a simultaneous production of Logan, Sandero, Fluence and Duster models at Renault plant in Moscow.

Production phases include body shop, paint shop and assembly shop. The first phase, body shop, is held by modern robots allowing increase the production capacity from 15 to 30 vehicles per hour. Robots are used for welding sidewalls and suspended elements of a vehicle body. The next phase, painting and enamel laying, has also been robotized. In a new paint shop there is established eight robots, which arrange laying of secondary couch, enamel and lacquer. Overall, one vehicle requires 22 kg of mastic compound and 10 kg of paint. On exit from every shop, there is a 100% quality control. Moreover, once a week vehicle bodies are tested: a test sample is completely destroyed and the properties of crashing are analyzed. As all Renault plants, Avtoframos is certified according to the international standards ISO 140001. This is the best demonstration of company's responsibilities for the environmental protection and reduction of harmful impact to the environment.

1.3 SMALL AUTOMOTIVE PARTS

Small automotive parts PPA are supplied solely by Renault SFKI. PPA also include the parts that used to be known as VBQ: Visserie, Boulonnerie, Quincaillerie (*Fr.:* thread parts, fastening parts, hardware parts). They can be defined by the next criteria:

- peculiarity: small non-specific packages, of a standard size;

- size: possibility to stock on the line boxes for at least 2-day consumption in a packaging that allows manual handling;
- consumption: fairly regular consumption with no critical variability and frequently changing parts;
- durability: unbreakable components or in a hard packaging.

PPA are the components consumed by several plants and used at several work places on a plant. All the plants of Renault Group are the clients of Renault SFKI. Reports that Renault SFKI sends are of DLC or DLAR type. All the plants of the group, motor, assembling (no matter which informational system is installed), have to use one single procedure for supplying their PPA working with Renault SFKI.

1.4 RESEARCH PROBLEM

Renault plant in Moscow made a decision to change the way of supplying certain batch of parts according to its policies. The forthcoming challenges had to be analyzed and a detailed planning for switching from existing supply mode to a new one had to be developed and proposed for implementation.

1.5 RESEARCH QUESTIONS

1. How to re-organize in the most effective way:
   a. warehouse
   b. line side
   c. inventory control
   d. and reception?
2. How to prevent stopping the line during the switch to a new supply mode?

2 CURRENT SUPPLY MODE OF SMALL AUTOMOTIVE PARTS

The supply chain is a concept that focuses on managing processes which involve other companies in managed relationships to bring activities fulfilling the process. It is easy to trace that no firm alone can do well at everything, and it is hardly possible to fulfill the complete process of meeting market demands due to strong competition and growing customer requirements. (Skjott-Larsen et al. 2007, 17)

Skjott-Larsen et al. (2007, 22) state that the supply chain has several interpretations from the management perspective. Logistics, manufacturing and corporate strategy provide different explanations of what forms the supply chain. Logistics role in the supply chain is to have an immediate connection between a company and its suppliers and customers. Logistics tools are transportation, inventory and information. The major endowment of logistics has been the concept of product flow. Different resources enter organizations, after that they go through production process, and finally are delivered to end users. As shown in Figure 1, the process crosses functional boundaries, influences and is influenced by other functional areas.
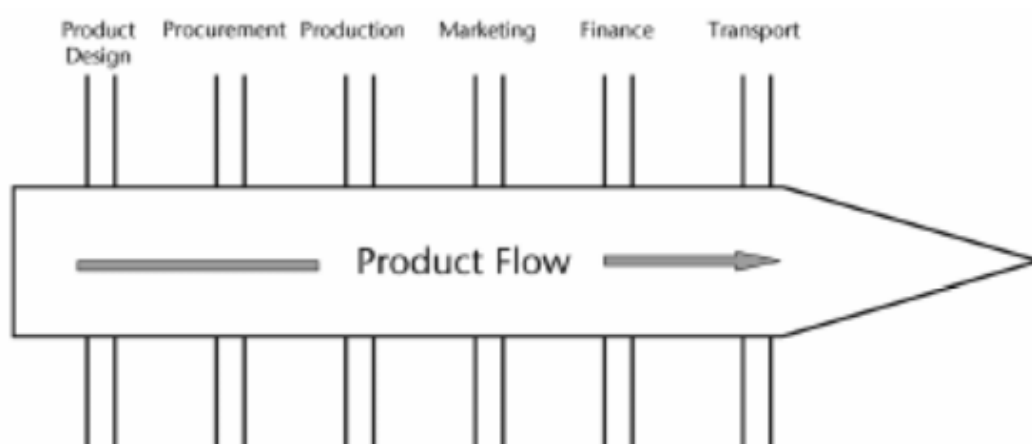

FIGURE 1. Product Flow in Logistics (Skjott-Larsen et al. 2007, 23)

Through interaction with every area of the firm, logistics brings the question of how to get over the barriers preventing productive relation of these functional areas (op. cit. p. 23).

The challenge of supply chain management in markets is organizing and handling a process in scope of global supply and networks that provide a huge variety of products and services for customers. The successful organization of these networks is base on strategic decisions comprising procurement, production, distribution, transport, telecommunication and information systems. (Op. cit. p. 42)

2.1 SUPPLYING THE PARTS FROM SOFRASTOCK

As was told in introduction, small automotive parts (further – PPA) are supplied to all Renault plants from Sofrastock warehouse, located in France. Sofrastock International was founded in 1971 by the Renault Group and is specialized in Supply Chain Management. To reach Avtoframos plant in Moscow PPA need to go through a distributor warehouse in Dacia, Romania. Normally it takes three weeks by trucks for the parts to reach the plant in Russia. In case of emergency situations, purchasing specialists TGP order the parts by plane, which takes not more than a day to fulfill the requirements of harshly lacking parts.

2.1.1 Inventory control

At the plant itself, the inventory of the parts present on the line is done every day. As Mercado claims (2007, 35 – 36), without precise inventory records, it is hardly possible to run an effective replenishment system. It is not easy to visually screen a group of items, and definitely not viable to follow a huge amount of items in inventory. That is the reason why we should use records, which show the real picture in the warehouse and shop floor. There are two principal purposes of inventory control: knowing quantity on hand for planning orders and following the cost for accounting analysis. That is when the necessity to monitor inventory items appears. To make it happen, the company assigns unique part numbers (SKU), which can use for different tracking purposes.

At Avtofamos, Moscow, each part has its own reference number (Figure 2). Those references (8200 884 332, Figure 2) differ from supplier's ones (718851 443, Figure 2), which, on their own, differ from manufacturer's as well. Nevertheless, when the necessity to manage the inventory arises, it is applied using the plant's reference numbers.

FIGURE 2. Avtoframos Part Reference Number 8200 884 332

PPA are spread among the whole assembly shop (Figure 3). Five CPL operators deliver the parts from the warehouse to the shop floor in three eight-hour shifts each day. They, themselves, do inventory twice per shift, six times per day with the radio terminals Motorola MC9190, which are standard for all Renault Group plants. Each operator has his own zone for distribution of parts and inventory control. According to the inventory records, in the warehouse the operator collects all the necessary parts on a trolley and takes to the line. If any alert occurs as a consequent of missing parts on the line, those are delivered immediately to prevent stopping production process.
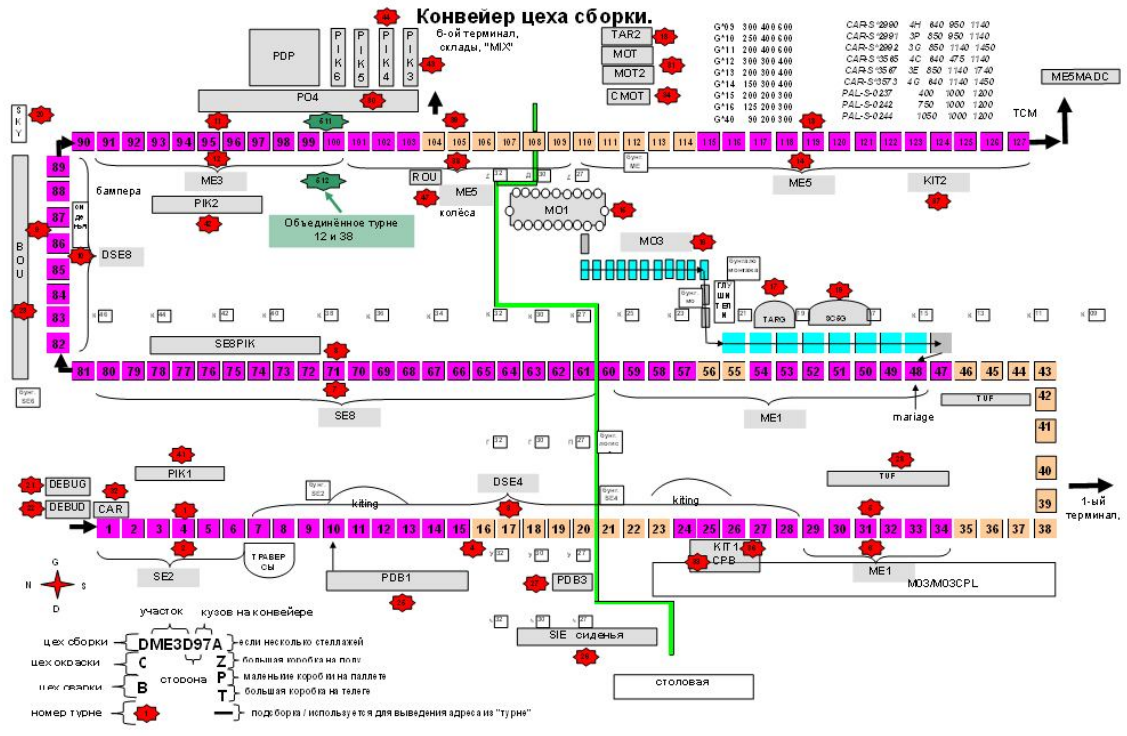
FIGURE 3. Assembly Shop Layout

Mercado (2007, 55 – 56) states that in order to identify the amount of inventory for operations, first it is necessary to find the actual reason for the demand. Preceding factors should be clear to be able to determine the actual quantity of parts to order.

Each day at the plant, the results of inventory are delivered to TGP, where they correct and manage the orders according to current needs.

2.1.2 Warehouse organization

Warehouses are an essential component of today's supply chains. Managers are strictly required to improve productivity and accuracy, reduce cost and inventory, and at the same time pay a lot of attention to customer service. (Richards 2011, 7 –

8) "In today's market with expensive land, buildings, labour and energy costs, together with the introduction of concepts such as just in time (JIT), efficient consumer response (ECR) and quick response (QR), companies are continually looking to minimize the amount of stock held and speed up throughput." (Op. cit. p. 8)

Richards says (2011, 71) that, when it comes to a warehouse layout, it closely operates with a pallet storage area and an individual pick area. Whether they come along or are separated relies on the number of SKUs and free floor space for picking locations. The most effective picking system is arranged taking into account the next data:

- size and weight of the product and packaging;
- product group (hazardous, temperature sensitive, etc.);
- total number of SKUs by class (ABC);
- total number of orders in a time range;
- total number of deliveries;
- mode and average number of lines per order;
- mode and average number of units per line;
- picking sessions per SKU;
- item, case or full-pallet picks by SKU;
- typical family groupings;
- items often sold together.

Richards continues saying (2011, 150 – 151) that the design of a warehouse needs paying attention to details and collection of all necessary data. When redesigning a warehouse seems to be essential, such factors as growing of production or change of part types should be taken into account. The main floor areas that need to be calculated in the warehouse are receiving area, reserve storage area, carton-picking area, item-pick area, value-adding services area, packing area, dispatch area, cross-dock area, empty pallet and packaging storage area, material handling equipment (MHE) charging areas, warehouse offices and restrooms.

In cases when there is lack of space in the warehouse, there are several option, such as expanding the warehouse, renting additional place, organizing more space within the current premises. Another solution would be to reduce inventory levels. (Op. cit. p. 161)

PPA at Avtoframos plant are within several warehouse premises. The major number of parts, though, is in CPL M04 Warehouse placed on the gravity-fed shelves (Figure 4).
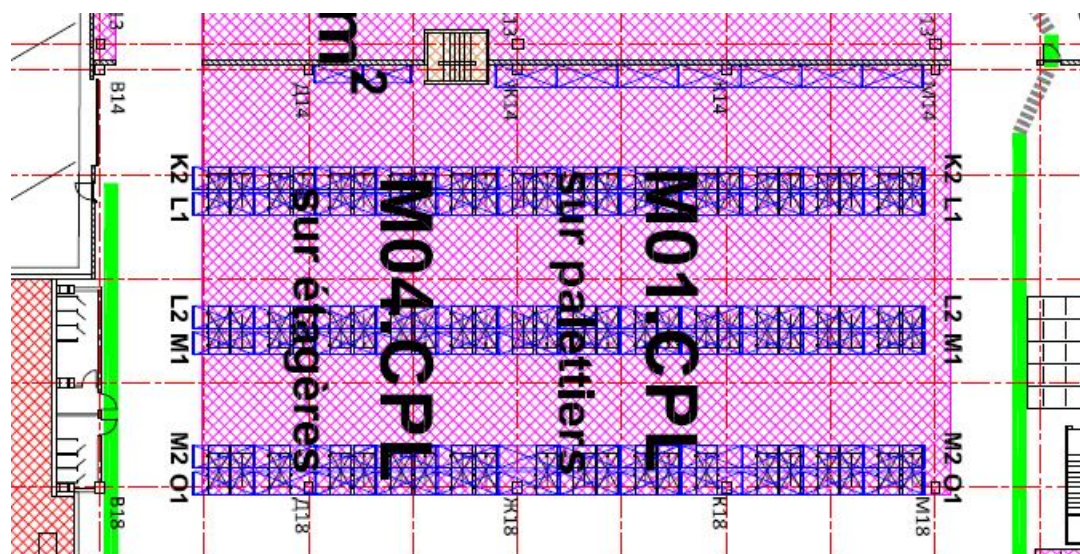
FIGURE 4. CPL M04 Warehouse layout. Avtoframos plant, Moscow.

Gravity-fed shelving or flow rack is a type of storing the items where they are loaded at the back of the shelf and as soon as the packaging is emptied it is covered with a new one. This notably increases the picking process. (Richards 2011, 71)

Packages are added at the upper side of roller lanes, and slope down under the force of gravity when a package is taken from the picking side. The rollers can be adjusted to hold packages of different size, and usually the brake system is set to prevent frail items from breaking. (Op. cit. p. 91)

Picking products from the warehouse is the critical activity as this is when the orders are defined. As well, picking is usually a manual and cost-critical activity. Those are the most important criteria for picking operations: 1) travel times; 2) product location; 3) planning; 4) service level; 5) accuracy. (Emmett 2005, 97 – 98)

Emmett then states (2005, 100 – 102) that the methods of picking depend on the number of lines/SKUs, picks per line/SKU, quantity per pick, numbers of orders, and etc. The key characteristics of picking methods are discussed next.

- *Basic order picking* is where the picker travels to take the items in the warehouse using the necessary handling equipment. The picker reaches the items with single order and picks line by line from the product stored in racking. The travel routes will vary due to level of consumption of each item.
- *Batch picking or pick by line* is where several orders are grouped into small easy coped batches. Pickers travel to take all orders in the batch, one line at a time.
- *Zone picking* is where the picking area in the warehouse is divided into zones with pickers responsible for delivery of parts from each individual zone.
- *Wave picking* is where all zones are picked at the same time and the goods are then divided by the individual orders.

CPL operators at Avtoframos use Batch picking method when collecting the parts on pallets in the warehouse. They use the daily inventory lists to pick the required parts. These same operators are responsible for sorting and shelving the parts in the warehouse after receiving process. It is very important to do it smoothly and carefully to avoid defects of the packaging, when the parts drop from a package and are lost and are not adequate for further utilization in production. Unfortunately, as always there is human factor which impacts the effectiveness of the process. The management tries to stand it up by establishing long-term relationship with the employees on mutually beneficial conditions.

2.1.3 Reception

They say that how the receiving goes determines the whole efficiency of the activities and operations in the warehouse. Mistakes made here will affect on every part of the warehouse, or even on the customers. (Emmett 2005, 91)

Richards also points out the criticality of the receiving process and claims (2011, 44 – 45) that the receiving issues should be solved in advance before the arrival of goods when it is late to make improvements.

He then continues (op. cit. p. 56) saying that there is a need to record product data right after unloading and, if necessary, checking. Product code, description and quantity are collected and registered in the system. The perfect way for data collection is barcode scanning.

When the packages with parts arrive to Avtoframos warehouses, they are registered in the company's reception system PSFv. Part reference number is scanned and information regarding the part, e.g. description, quantity, supply code, is saved into the system. PSFv is a specially designed application used at the plants of Renault group for keeping and processing data of arriving parts. This data is then synchronized with PSFp system in purchasing department, where the part consumption is followed up and according to needs purchasing specialists make new timely orders.

Reception specialists have least responsibilities for incoming parts. This is because their only function is to register the parts and save them in the system. They are not responsible for checking the parts for damages. Right after the part is unloaded from a truck, the responsibility from logistics provider passes to Avtoframos, and the forklift operators from reception have to evaluate the condition of packaging and including parts.

The parts are delivered to their places as data is processed in the system and operator receives the information about the parts.
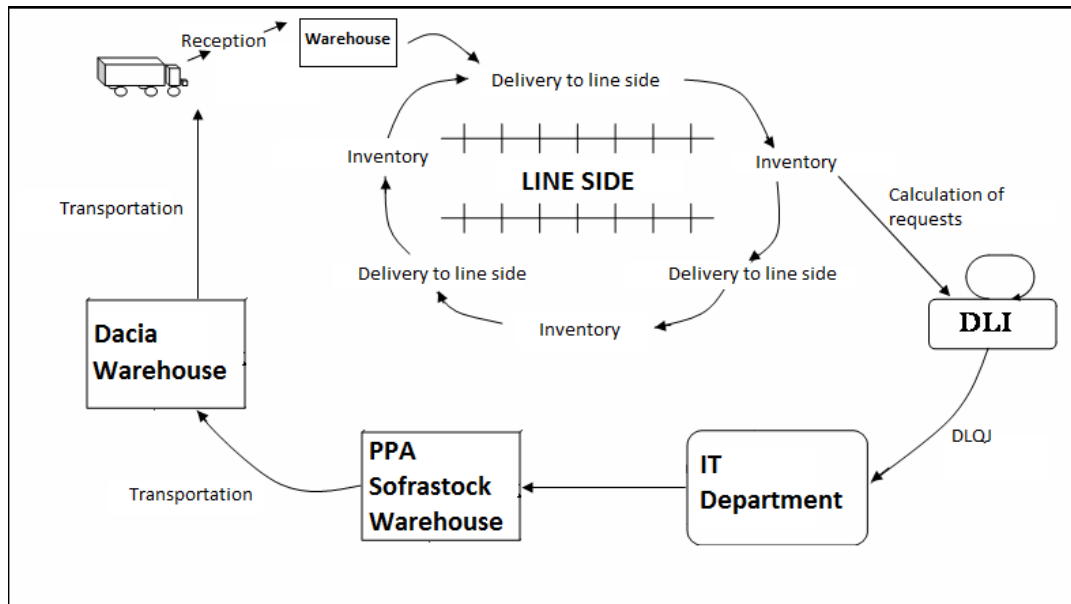
FIGURE 5. PPA supply cycle in DLQJ mode

2.2 BENEFITS AND DRAWBACKS OF THE SYSTEM

Renault Moscow has used this type of supplying small automotive parts during whole time since start of production back in 2006. It has been a good and proven method, but a fast growing production caused by a rising customer demand requires more and more parts and thus more space in a warehouse. As the plant is located in the capital of Russia, rebuilt on the ruins of Moskvitch plant, there arises the challenge of free space and effectiveness of use of the existing one. The plant has expanded at maximum and now there is almost no alternative on how to organize new space. That brings the top managers of the company to find the ways to optimize the existing premises according to the current situation at the production.

2.2.1 Benefits

One major benefit would be that the system is established and long present at the plant. Everybody is aware of the process, works consistently and capably. There is no need to arrange numerous trainings for new or current employees to provide them with the necessary information about the workflow. If any problem, e.g. lost parts, occurs, there is a proven method to solve it (priority aviation delivery as for the lost parts).

Another relevant benefit is the sufficient stock of small automotive parts. This greatly minimizes risks of suddenly running out of parts in production and brings about realization of the plan of automobiles manufacturing. There is a lot of work for inventory managers, though, to count the safety stock most precisely as the growing consumption of parts has to be taken into account.

Then there is a line side. Now there are kept parts only in capacity of 3-5 boxes according to consumption of each (or even 1-2). CPL operators replace them continuously and, because of that, the stock on line side is minimal. This is very important in the production, as the pathways in the premises must be spacious and the shelves – easy to reach.

2.2.2 Drawbacks

When it comes to drawbacks, first that has to be mentioned is the discussed above growing stock. It is getting really huge and harder to control. It requires more floor and shelf space in the warehouse premises. And the space question is critical at Avtoframos as at every other organization. That is why it is necessary to have an adequate stock.

This also causes ineffective storage in the warehouse. The case is that the parts are stored in several different warehouse premises. The main warehouse designed for small automotive parts is long time ago full and cannot be extended currently. This

is costly when it comes to operator picking who needs to spend more time traveling between these premises to fill the pallets.

Another drawback is a big amount of lost parts. Packaging for small parts is thin and not firm enough, and the packages are moved several times within the warehouse before they are finally delivered to the assembly shop. Therefore, due to human factor, it often happens that they are torn and spread all over the floor. No one will then crawl and sweep bolts and screws back into the package. It is currently a relevant problem at the plant.

2.3 CONCLUSION

Growing production volumes, big customer demand and company policies brought Avtoframos managers to the decision on optimizing the current supply chain of small automotive parts. During the research period author took an active part in preparing the planning of the switch from one supply mode to another, distinctly studying and organizing all involved processes within the plant.

3 RESEARCH METHODS

Research process begins with choosing and carefully defining a research problem. A researcher selects the problem and formulates it in an intelligible way to do a research. Generally, this problem is obtained from a difficult theoretical or practical situation in the experience of the researcher, who looks for a solution to it. The research problem requires the researcher to discover the best possible solution and to propose the scope of actions that will lead to meet the objective. (Kothari 2004, 24 – 25)

Appannaiah et al. (2010, 35 – 36) state that the research is about application of research methods to discover the necessary solution to a current problem. In a business, there are many problems that are not solved, and in the academic research, the researcher faces this list of problems to be studied and select the one. It is very important to clearly study and state the problem, as it is halfway to its solving. Before looking for facts for the research, it is necessary to know what the problem is, by precise definition of the situation, and why a solution is needed, by the determination of means to which the findings can be applied.

For collection the information for the thesis quantitative and qualitative research methods were used.

Figure 6 represents two large overlapping content fields of scientific research and statistics, which form a sub-field Quantitative Research. This intersection is a symbiosis of research design, analysis, and measuring. The numerical data is gained by the process of measuring which is a part of the study plan. This data goes through statistical analysis to describe numerical distributions, test research questions, models, present results, and form the conclusions about the research object.
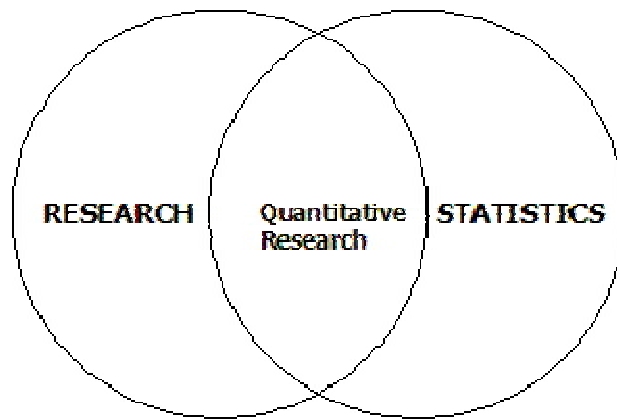
FIGURE 6. Statistics and Research intersection defines Quantitative Research
(D. Johnson et al., 2007)

Quantitative data is a numerical record that is obtained from a measurement
process and when basic mathematical operations can be applied (Singh 2007, 123).
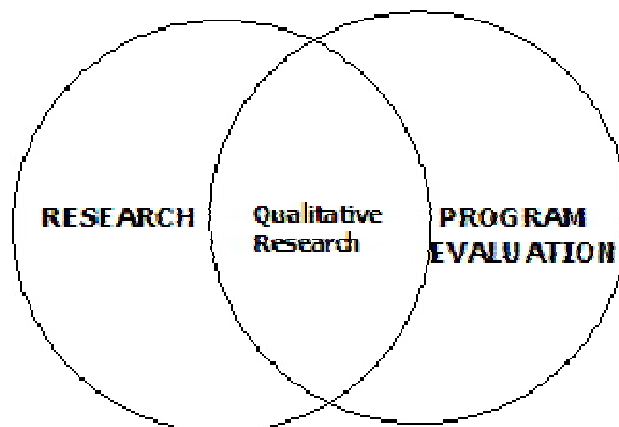
FIGURE 7. Program Evaluation and Research intersection defines Qualitative
Research (D. Johnson et al., 2007)

Qualitative research is usually considered reflecting its philosophical foundation. Figure 7 shows the concept of Qualitative Research as the result of confluence of scientific research and program evaluation. Qualitative research goes back to such social sciences as anthropology, sociology, history, psychology, and philosophy. This research is conducted in natural settings where subjects behave naturally and data is collected by different kinds of direct observation. Qualitative research gives the opportunity to speak up to those who have always been represented as a collective group, never individual opinion. This allows making a deeper research on the pressing problem. (Creswell 1998, 23 – 27)

Qualitative data, in comparison to quantitative data, measures actions which are not calculable and is represented by images or words. Another name of qualitative data is categorical data, as it can be divided into categories such as class, individual, or object. (Singh 2007, 123)

4 ORGANIZATION OF A NEW SUPPLY MODE DLC

4.1 DEFINITION

The principle of delivery of PPA components is to supplement them as soon as they are consumed. It means supplying parts (in packages) in an amount necessary to compensate the actual consumption of the customer and making it possible to hold out until the next delivery.

In the warehouse:

- The goal is to go without stock;
- PPA consumption stock is at the workplace on the shelf;
- Safety stock is also on the shelf on line side. This stock must be equal to a minimum amount below which it cannot go, and which is necessary to compensate the possible lack of parts (the change of production rate, delayed deliveries, etc.).

Request/delivery cycle:

- Separation of the line side to sectors (1 or more);
- Inventory and needs for each sector;
- Transfer of the requests;
- Delivery.

There is no need to track suppliers in DLC in contrast to the standard mode DLQJ, as well as customer (Avtoframos) requests concerning the early or late delivery. Renault SFKI itself works with backlogs and undertakes to deliver the missing parts in the shortest possible time. At the same time, Renault SFKI never delivers the components ahead of time.
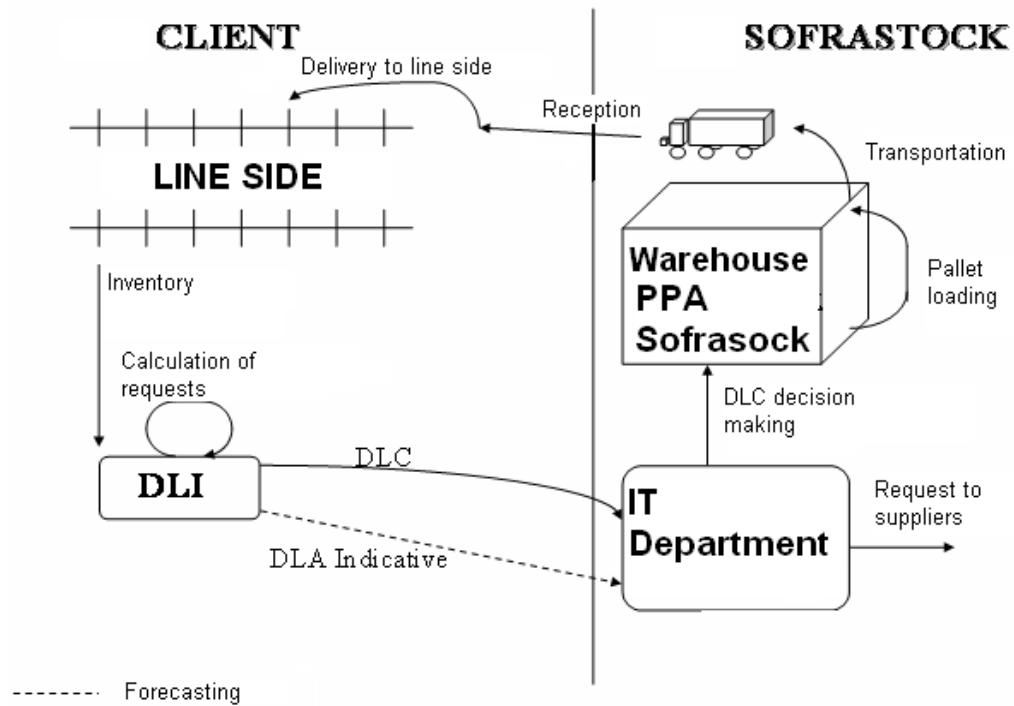
FIGURE 8. PPA supply cycle in DLC mode

Forecasting is done separately for each reference. A preliminary request is calculated for a reference consumed at all its workplaces. A preliminary calculation is done every week. The results of this calculation are sent to Renault SFKI, which allows them to prepare their own supplies.

4.1.1 Calculation of supplement

Before the inventory, it is necessary to determine the supplement for reference per working place. This amount can be calculated once a certain period of time, and depending on the pace of production. This supplement is documented separately for each localization.

TABLE 1. Calculation of supplement

Days	D1	D2	D3	D4	D5	D6			
Consumption	C1	C2	C3	C4	C5	C6			

Delivery period =
= 4 days

The supplement is calculated as the greatest number. Weekly consumption is multiplied by delivery time; the result is rounded off to the number of packages. An additional number of packages calculated for each reference (safety stock) is added to the result. See the below formula:

SUPPLEMENT = Max consum. * Consum. period + Num. of extra packs

Example:

Max consum. = 2 packs/day.

Consum. period = 2 days between two deliveries.

Num. of extra packs = 2 packs.

Then Supplement equals to 6 packages.

TABLE 2. Definition of terms in Supplement formula

Terms	Definition
Max consum.	Maximum daily consumption of reference per working place, calculated every week.
Consum. period	Maximum period of consumption on line side between two deliveries. Delivery time is expressed in terms of days.
Num. of extra packs	Necessary safety stock for each working place.
Supplement	Expressed in terms of packages.

The archive of the quantities ordered constitutes a good basis to check the amount of supplement. If the quantities ordered are close to the supplement, the situation with supplies becomes tight, and the risks of failure are great. Supplement must be increased. If, however, order quantities are very low, supplement can be reduced.

4.1.2 Calculation of parts to order

The system compares the result of the inventory with the supplement for reference per workplace. It is always necessary to take into account the time between the request and delivery of parts. This difference is expressed as the period multiplied by maximum consumption minus surplus of obtained parts. If the supplement is added to this difference, then the number of parts to order from Renault SFKI is calculated by the below formula:

Num. of parts to order = Supplement + Period * Max consum. – (Inventory + Num. of packs)

Example:

Supplement = 6 packs.

Period = 5 days.

Max consum. = 2 packs/day.

Num. of packs = 5 packs.

Inventory = 7 packs.

Number of parts to order is then 6 + (2*5) – (7+5) = 4 packs.

TABLE 3. Definition of terms in Parts to order formula

Terms	Definition
Period	Number of days between the request and delivery of parts.
Max consum.	Maximum daily consumption of reference per working place, calculated every week.
Supplement	Number of packages at workplace, calculated for each reference per workplace.
Num. of packs	Number of packages not delivered in time.
Inventory	Number of full packages at workplace.

Renault SFKI regulates delays unless they are caused by Avtoframos.

4.1.3 Request of parts

After the inventory is done, the number of parts to order is calculated in PSFp. In case of an exceptional situation, it is possible to change manually some number of parts under the responsibility of TGP before the message is validated. After validation, this number of parts will be sent to Renault SFKI by DLC. This message must contain the necessary number of parts for each reference per

workplace. The message contains data from the supply calendar and the code of pallets. This allows arranging components on a pallet in the order of distribution.

Frequency of requests is derived from frequency of inventory. DLC message must be sent before a specific time of day depending on customer-supplier protocol. It should be noted that the customer should not reduce DLC message to zero if the requested number of parts is zero for reference per workplace.

4.1.4 Processing the request by Renault SFKI

Renault SFKI receives two types of information, DLA Indicative coming from the customer and long-term thorough forecast done by a special application. This forecast is sent to the suppliers in the request.

Renault SFKI can handle any mode of operation (daily inventory or inventory once in three days). They send DLC message to the customers orientating by the code of pallets. In case when the code is not documented yet and the customer wishes to have the number of pallets according to the calculated number on the line side, Renault SFKI will change the data based on the consumption at workplace. It is therefore recommended that the number of requested parts is in a logical order if the customer wishes the line side to be supplied by the exact amount necessary at every workplace. Due to geographical and ergonomic reasons, the customer should keep logic in distribution routes and document pallet codes in the order of workplaces.

Pick lists are printed on pallets. These pallets are meant for each customer, a type of pallet corresponds with a certain customer. The pallets are loaded according to these lists.

PPA sent by Renault SFKI have the following features:

- Different references can be on one pallet, and the same reference can be placed on several pallets (if this part is consumed at different workplaces);

- Labels are attached to the pallet from two sides containing a specific sequence number of the pallet, the locations of start and end of distribution and the pick list (see Appendices);
- A note indicating data of request delivery, which must match the content of the pallet.

Preparation of the pallets based on the customer's order is at the last moment before the truck's departure. Hence, Renault SFKI can respond to any change of the address of workplace, which is reported by the customer by fax or phone. Packages are not labeled, but there is a pick list inside each package containing the information about all the parts in the box.

Arrangement of PPA in the vehicle is in reverse order of unloading required for the customer. Renault SFKI sends AVIEXP message based on the customer's order, which can be forwarded right after the departure of the truck, or may be delayed if the customer wishes to receive it at a certain time, or once a day if there are several deliveries daily.

Transporting of PPA is discussed and documented between the supplier and the customer. They do not pass the Center of Logistics Preparations, and Renault SFKI provides additional means especially in case of a very important order.

4.1.5 Receiving PPA

In Avtoframos case, when it takes more than a day for transporting the parts, the delivery is organized in a following way. After receiving AVIEXP message on arrival of the truck at administrative reception, the message about the paid bills is sent. There is no clear organization of receiving small automotive parts, validation at reception cancels all the requests. As stated above, the supplier does not follow up, Renault SFKI manage their delays on their own. This requires the knowledge of received amount to calculate the quantities to be requisitioned.
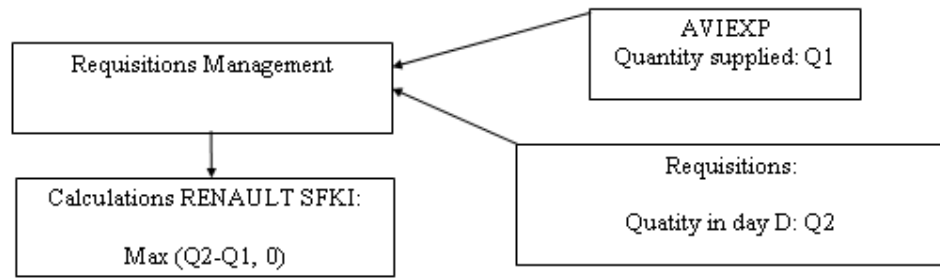
FIGURE 9. Calculation of quantities to order

At the reception, Renault SFKI trucks with DLC parts pass the next procedure:

- There is no specified document control;
- There is no control of receiving packages;
- The only taken action is a physical unloading of PPA.

This is possible if Renault SFKI is the only supplier, and this supplier has the high service level. This is the reason why controlling of unloading truck is not necessary.

Problem cases may occur while delivering the parts to the line side if the packaging is missing or the references on the note do not correspond to the parts in the pack. These cases are managed manually: an operator informs TGP about the problem, TGP contacts Renault SFKI, and they send the missing parts in packages. Packages supplied by mistake are timely returned to Renault SFKI. In case of shortage of packaging, Renault SFKI informs the customer by phone.

Supplying the line side happens during the receiving of the packaging, in the order of workplaces, as the truck is unloaded. Due to the content of pallets and allocation of packaging on them in the order of workplaces, delivering to the workplaces and the distribution is simple. It is during the opening of packaging when the operator can check that the including parts match up the note. Marked empty pallets are

stored in a warehouse, after which are sent back to Renault SFKI according to the protocol between the customer and the supplier. Renault SFKI manages this transportation.

4.2 PACKAGING

The small automotive parts in mode DLC arrive in big 3P packages, 1150x1000x1200 mm³. Every package contains several references more or less according to one area on the line side. Renault SFKI is responsible for arranging the small packages within 3P in accordance with data received from the customer, Avtoframos. As told above, there is no information about the parts attached to 3P package. All the necessary details are on the pick list inside the box.

What is marked on the box is the day for which it is consigned. The packages with all the needed parts for the exact day arrive every day. So, if today we consume parts for 20th of July as of this date, in stock we have the parts for 21st of July, and today we are expecting the parts for the 22nd of July. Avtoframos had to make a decision on how many days stock they would have. After a detailed discussion, it was decided to have a two-day stock of PPA. The possibilities of three and four-day stocks were also taken into account, but the necessity of smallest volumes to keep in warehouse was the essential issue. The risk of running out of parts because of late delivery was also considered, but as Renault SFKI is the trusted supplier and claims to make impossible late deliveries, it was decided to minimize stock as much as possible.

A total number of Sofrastock references is currently 817, and a total number of workplaces where PPA are used is 1558.

4.3 SCHEDULING

First, it was planned to start the project in the beginning of summer 2012, but as there were too many ongoing projects, and the key persons were tied up with their

tasks, it was decided to postpone the switch process until the beginning of September 2012, right after the holiday time at the plant.

For the start, it was determined to order a batch of 50 references. Going through the complete list of the parts, the necessary references were chosen. Such criteria as one area on the line side, one forklift operator route, different consumption days, and references consumed from one to several workplaces, was considered. Out of 50 references emerged 69 parts at workplaces. Senior CPL operator would be responsible for receiving and delivering DLC parts to their workplaces. It was considered very important to make responsible for delivery an experienced operator who would work fast and concisely and minimize the risks of wrong placement of parts on the line.

W235	W236	W237	W238
DLQJ	DLC	Implementation	
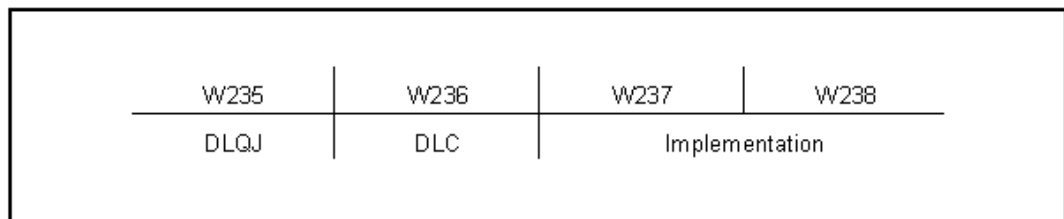
FIGURE 10. Scheduling

It was planned (Figure 10) that the switch to DLC process would start from ordering the test batch of 50 references in two weeks 36 and 37 before the arrival. Previously, before week 36 the inventory would be done to see how many of these exact references would be needed for two weeks. It was necessary to count everything and avoid extra stock when the parts in new mode would arrive. According to plan, the second batch would also consist of 50 references, and all the rest batches would be of 100 references coming each week.

In two days before the arrival of DLC parts (week 37), the line would be filled in with all the parts left in the warehouse. It is necessary to be sure that the number of

packs of parts is enough not to stop the production process. That is why the consumption for two days was calculated for each part (Figure 11).

	A	D	N	T	AE	AF	AK	AL	AM
1	Referenc	Designation courte	four	MAG	PDT	PDT	max # of boxes	enough place for 2 days cons (for audit parts)	consumption of one box
23	7703633008	ГАЙКА M8x1,25 С БУРТИКО	SOFRAS	M08TOL	BFERG98	BFERG98			> 8 days
24	7703602058	БОЛТ M6-50 8-8 С ШЕСТИГ	SOFRAS	M08TOL	BFERG98	BFERG98			< 2 days
25	7703602282	БОЛТ M6-20 8-8 С ШЕСТИГ	SOFRAS	M08TOL	BFERG98	BFERG98	5	OK	< 2 days
26	7703033181	ГАЙКА M6 С ШАЙБОЙ В СБ	FUTUR S	M01CPL	BFERG98	BFERG98	6	NOK	< 2 days
27	7703602206	БОЛТ M6-20 8-8 С ШЕСТИГ	SOFRAS	M01CPL	BFERG98	BFERG98	4	NOK	< 2 days
28	7705098159	ГАЙКА M10X1,5 ПРИВАРНА	SOFRAS	M08TOL	BLIN_D73U	BLIN_D73U			> 8 days
29	7703042086	ГАЙКА M6 ПРИВАРНАЯ (СТ	FUTUR S	M08TOL	BLIN_D77U	BLIN_D77U			> 8 days
30	7703042100	ГАЙКА M8X1,25 ПРИВАРНА	FUTUR S	M08TOL	BLIN_D90U	BLIN_D90U			> 8 days
31	7703633008	ГАЙКА M8x1,25 С БУРТИКО	SOFRAS	M08TOL	BOUV1N96	BOUV1N96			> 8 days
32	7703633008	ГАЙКА M8x1,25 С БУРТИКО	SOFRAS	M08TOL	BOUV4D80	BOUV4D80			> 8 days
33	7703633008	ГАЙКА M8x1,25 С БУРТИКО	SOFRAS	M08TOL	BOUV4D82	BOUV4D82			> 8 days
34	8200920077	4H-RIVET G 4,8-16 AC	FUTUR S	MX38	BOUV4G77	BOUV4G77			> 8 days
35	7703101446	9J-VIS H RDL M6X100-	FUTUR S	MX38	BOUV5D65	BOUV5D65			> 8 days
36	7703602282	БОЛТ M6-20 8-8 С ШЕСТИГ	SOFRAS	M08TOL	BOUV5D67	BOUV5D67	6	OK	< 2 days
37	8200749747	ШАРНИР СТАЛЬНОЙ	FUTUR S	M08TOL	BOUV5N71	BOUV5N71	10	OK	< 2 days
38	7703633008	ГАЙКА M8x1,25 С БУРТИКО	SOFRAS	M08TOL	BOUV6G52	BOUV6G52			> 8 days
39	7703611016	ШПИЛЬКА M6-18 ПРИВАРН	SOFRAS	M08TOL	BOUV6G52	BOUV6G52			< 2 days
40	7703602282	БОЛТ M6-20 8-8 С ШЕСТИГ	SOFRAS	M08TOL	BOUV6G52	BOUV6G52	6	OK	< 2 days

FIGURE 11. The extract from a file "Consumption of PPA"

The parts were sorted in three groups: a) consumption time is less than two days (25%); b) consumed in more than eight days (25%); c) with a consumption period from two to eight days (50%). For those parts which consumption time is less than two days, there was conducted an audit to find out how many parts could fit on the line (Column AK, Figure 11) and whether this number was enough for two days (Column AL, Figure 11). The justifiable overstock was considered of one day.

TABLE 4. Detailed planning

Mon, W236	Mon, W237	3 days before
Inventory (PSFP not entering)	1. Physical inventory 2. Define the lacking parts (order by truck)	1. Inventory. 2. Closing CPL work. 3. Define the lacking parts (order by plane) 4. Afternoon (B) shift for testing

As discussed earlier, the switch to DLC needed a precise inventory. However, the remaining DLQJ parts would not be registered in the company's system PSFp anymore. In a week before the arrival of first batch, the inventory would be conducted again, and if some parts were defined as lacking or close to be used up, they would be ordered by truck.

Finally, 3 days before the arrival during the weekend when the activities at the plant were minimized, the ultimate inventory would be done. If some parts were defined as lacking, they would be ordered in an urgent delivery by plane. References of the lacking parts would be handed to TGP specialists, who would make the order. Then the line would be fed with the parts right away. CPL operators' work would be finished, and they would become DLC operators. It was decided to call up the afternoon shift B for testing, as they are more responsible, and it is easier to control them and the process during the usual workday.

4.4 WAREHOUSE PLANNING

When starting discussions on planning the warehouse location for PPA, the first idea was to leave it in M04 Warehouse. As Sofrastock parts had been stored there before, it seemed to be logical and effective. However, when switching to DLC mode, the parts would be delivered and fill the workplaces at line side at

maximum. This is necessary to prepare the place in the warehouse for DLC packages. The problem would be the bigger number of packages in stock then the number that would fit to the line. A possible solution to the problem was proposed in a regular meeting with head of logistics department. It was suggested to use MAPU Warehouse for storing extra packages that would not have fit to the line.

MAPU Warehouse had previously been used for tuning the welding equipment, training of operators, and storing the parts for project vehicle production, not serial. As B32 Megane project at Avtoframos was frozen until year 2013, and projects H79 Duster and L38 Fluence successfully launched, MAPU Warehouse was temporary on hold.
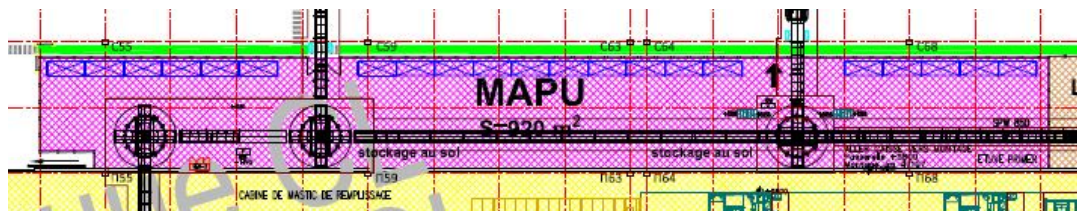
FIGURE 12. MAPU Warehouse layout

Everyday inventory of the parts in MAPU Warehouse would be conducted until it was empty. DLC operator would be responsible for that.

It was calculated that one-day consumption number of 3P packages would be 73. They would be filled approximately 80-90% due to embedding PPA packaging, and the volume of one 3P package was 0,685 m³, then the volume of parts per one 3P package would be 0,62 m³. The volume of all PPA was found out as 45 m³. Then, dividing the volume of all PPA by the volume of PPA per one 3P, the number of 3P packages was achieved. As of two-day stock, the number of packages needed to be stored was 146.

4.5 Operators' distribution route

As there were five CPL operators per shift, they would now become DLC operators. It was discussed whether it would be better to give the whole responsibility for DLC to one operator one by one, or every operator could combine CPL and DLC work while switching process. It seemed to be more reasonable to divide the responsibilities and that one operator would deliver both CPL and DLC parts, but in his own distribution zone. Workload of operators had been calculated and the results showed that it would not change drastically.

The organization of tourneys for operators and zones of distribution would be organized by one of the leaders of logistics projects at Avtoframos. This person had previously been responsible for tracking CPL operators' routes and optimizing them. Another task for him would be defining the parts within the batches for each 1-2 weeks of new arrival. The data on which defining would be based would be taken from the file "Consumption of PPA" (Figure 11).

Operator would deliver 3P packages to the line side and sort them directly at a workplace. Empty 3P boxes would be removed by operators right after filling the line with PPA.

The organization of new trolleys for DLC packages was discussed with Engineering Department specialists who made new orders.

4.6 Inventory control

Inventory in DLC mode is done once a day. In this way, the operator registers the total number of full packages at every workplace of his distribution zone. One reference should be registered by one operator, no matter at how many workplaces it is consumed.

It was chosen to engage the night and morning shift operators to put the parts on the line while the afternoon shift operators' main duty would be handling inventory.

Inventory on the computer is realized in the following way. The system generates an inventory list when you request it (see Appendices), which includes a record of reference/workplace pairs. It is automatically created so that the travel distances of the operator are minimized and optimized. The operator uses this list for checking the presence of packaging at workplace, registers the number of full packages that he has checked. When all lines on the list are filled in, he goes and enters the data into computer, and the information is delivered to TGP. Two different specialists can do inventory and data entering. In that case, the one who enters the data into the system should report if he has doubts about the accuracy of the records.

4.7 LINE SIDE

613 references' consumption is less than one per day. This means that there is definitely a place for each part on a shelf at line side. Then there are 189 references with consumption volumes more than one package in a day. An audit of these references and their workplaces was organized to see how many of them would fit to the line in an amount necessary for two-day consumption when the time to implement DLC came in a week W237. As a result, 74 references were specified as non-OK, which means that there would not be enough places on the shelves to store them.

One solution could be storing the extra packages next to the shelves, as in many cases, it is just one or two packs that would not fit. However, there are also packages with consumption, for example, nine packs per day, and the availability of place on the shelf is just six packs. Then for two days, it is necessary to store eighteen packs. This is a lot, but to avoid mixing the parts by placing the packs of one reference to a neighbor place on the shelf, it is better to store them on the floor. Anyway, two days in a weekend should not become a problem and it seems to be possible to avoid a mess on the line.

Bigger challenges arise when considering the serial production. There are some parts with consumption of five, nine, or even fifteen packs per day, and the availability of place on the shelf is only for four or five packs. Solution for this bottleneck is seen in the next actions. During the business trip to Renault plant in Bursa, Turkey, the delegation saw how they managed this problem. In their plant Turkish manufacturers use long and wide plastic tubes with a scoop at the end from the assembling operator's side. These tubes perfectly fit a cell of the shelf. The parts are taken from the box and tilted into the tube. All the necessary boxes can fit the tube due to the broader use of the free space. Another good point is that there is no need to pick up the empty packages after the parts have been used in the production. The operator takes them back with 3P package right after unloading.

Unfortunately, there is one relevant drawback, which is impossibility to do inventory of these parts. Nevertheless, it could be agreed that it would be no use to do inventory, as the consumption level of these several parts is very high. Lack of them would have become immediately clear if the production volumes had increased.

4.8 RECEPTION

As for the reception, it was the easiest step in organization of DLC process. When 3P package arrives, it goes through the reception, and as there is no label attached to it but the one with the date of the day to be used in production, the pick list inside the box could be used for scanning and entering data of the parts within the box into the system. PSFv system did not have to be changed anyhow.

5 IMPROVEMENTS BY THE NEW MODE

DLC method of supplying PPA brings several great benefits to Avtoframos. It has been taken into account when making decision on changing the supplying mode. As well, it is necessary to mention any disadvantages which may appear when implementing DLC.

5.1 MINIMIZATION OF STOCK

The first to mention is decreasing of stock. DLC radically reduces the occupation of warehouse premises. Instead of storing parts on all three high shelves, there is a necessity of only three levels on one shelf for 146 3P packages. It has been already mentioned above how critical the question of free space within the plant is for Avtoframos. DLC is the perfect answer to it.

A little stock and parts usage on the exact date also minimize the engagement of operators. Their mission is now to deliver at once with several travels all the parts to their workplaces at line side, and there is no need to travel extra times like in DLQJ mode when a need of parts at line side occurs.

5.2 LESS INVENTORY

Another advantage is cost reduction through less engagement of employees in inventory control. Now responsibilities have been redistributed, and there is no need to do six inventories per day, but just one inventory round by operators of afternoon shift.

As there is now a tighter control on ordering PPA, the possibilities of running out of the necessary parts and surplus orders are gone. It is possible to normalize the production process and have a firmer control on it.

5.3 TRACEABILITY BY THE SUPPLIER

Renault SFKI takes responsibility for timely deliveries and safety of the parts. Avtoframos operators do not have to check PPA at the reception. This means time-saving and workload reduction. As well, this eases of need in extra space in the warehouse for opening 3P packages and taking out and sorting small boxes with PPA.

6 CONCLUSION

This thesis study presents the proposition of the optimization of the current supply chain of small automotive parts at Avtoframos plant, Moscow. The objective of the study was to reveal the most efficient solutions to the arising challenges during the supply process implementation, taking into account the ongoing production flow.

A detailed scheduling for implementation of DLC was prepared letting see the whole picture of the switching process on the third hand. Warehouse re-organization was carefully prepared and the operators routes were calculated taking into account their engagement and distribution zones. Inventory control was totally changed according to principles of DLC minimizing the workload of the responsible specialists. Solutions to organization of line side and reception were found out and proposed. And finally, a carefully organized scheduling of the switching activities was planned to avoid risks of stopping the production line.

As a result the next benefits were achieved: six times more free space in the warehouse due to minimization of packaging in stock; more convenient storing of parts in the warehouse; minimum number of lost parts; less engagement of operators; less inventory circles; free space at the reception as a result of no need to check parts at their arrival.

To conclude, it should be said that this research study has a practical value and the suggested means can be effectively implemented at Avtoframos plant bringing several benefits to the company improving the production process.

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APPENDICES

APPENDIX 1

Inventory list

EDITION D'INVENTAIRE DE LA TOURNEE **				JJ/MM/AA à HH:MM		
**********(DESIGNATION DE LA TOURNEE)**********						
				PAGE : xx		
LOCALISATION	REFERENCE	INDICE	DOT	QUANTITE INVENTORIEE	DESIGNATION PIECE	
**********	**********	***	***	_____	********************	*****
**********	**********	***	***	_____	********************	*****
**********	**********	***	***	_____	********************	*****
**********	**********	***	***	_____	********************	*****
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**********	**********	***	***	_____	********************	*****

APPENDIX 2

Packaging label

Destinataire
USINE PIERRE LEFAUCHEUX
MAG 6424 BP 3
78410 AUBERGENVILLE

N° document (P)   **8380**

N° Produit (P)

Lieu de livraison (2L)   **COA**

Adresse expéditeur
SOFRASTOCK 27220 SAINT ANDRE

Poids net   Poids brut (kg)   nbre boîtes
0322   0314   0033

Quantité (Q)

Produit
MAITRESSE DE MANUTENTION
Réf. fournisseur (30S)

Fournisseur (V)   **900105 80**

N° étiquette (G)

Date   Indice modification
D950929
N° lot (H)

Odette Version 1 Rev 5.0

ETIQUETTE POIDS SOFRASTOCK

USINE PIERRE LEFAUCHEUX

USINE   MAGASIN   GARE ROUTIERE
0005   006424   **GR01-390**

LIEU DE LIVRAISON
COA

de **COADD161**   a **COADD281**

LP N° 8380   **010**   0314KG 45

APPENDIX 3

Label at line side