POLITECNICO DI TORINO

Laurea Magistrale in Ingegneria Gestionale LM-31

Network Optimization and Cost Reduction in Overseas Packaging. The FCA Case Study

Supervisor: Anna Corinna Cagliano

Corporate Supervisor: Luca Vittorio Roero [FCA]

Author: Giacomo Ghirardi

Academic Year: 2018/2019

Index

Ringraziamenti

Alla fine di questo periodo didattico è fondamentale ringraziare tutte le persone che durante il mio periodo universitario ho avuto modo di conoscere e con cui ho scambiato attimi di professionalità e amicizia.

In primo luogo, è doveroso ringraziare la Prof.ssa Anna Corinna Cagliano che mi ha aiutato passo dopo passo nello strutturare al meglio delle mie possibilità questo progetto di tesi. Grazie al suo continuo sostegno, è stato possibile realizzare un lavoro diligente e decoroso.

Un ringraziamento sentito va alla Divisione IRF dell'azienda FCA e particolarmente al tutor aziendale Ing. Luca Vittorio Roero per avermi dato la possibilità di introdurmi al mondo del lavoro tramite un'esperienza di tirocinio che mi ha permesso di iniziare a capire le logiche lavorative di un ufficio di un certo calibro. È stato un periodo altamente formativo sia dal punto di vista professionale che da un punto di vista umano in cui ho riscontrato non poche difficoltà, ma mi ha fatto capire quanto sia necessario lavorare duramente per poter conseguire risultati degni di nota. Mi sono trovato in un team di lavoro cordiale e felice composto da persone altamente competenti, a partire da Flavia Mieli e Marco Doria che hanno avuto una pazienza incredibile nell'aiutarmi quotidianamente e hanno sempre cercato di farmi capire come bisogni lavorare da una prospettiva di alto livello per poi andare a scindere i compiti di lavoro minuziosamente, a Francesco Marro, Marco Franzolin e Maria Pia Nugnes che mi hanno dato consigli di rilevante importanza professionale al di là delle mansioni che dovessi svolgere, a Valter Dapas e Antonio Ferraro che mi hanno sempre sorretto nei momenti difficili in cui ero scoraggiato.

Una dedica speciale però è dedicata alle tre donne della mia vita, ovvero mamma Vilma, sorella Maria e nonna Pieralda, e a mio zio Mauro che non solo mi hanno aiutato economicamente in modo da concludere gli studi, ma mi hanno sempre incoraggiato a non desistere, senza dimenticare l'appoggio dei miei zii Elide, Andrea e Bruno e dei miei cari cugini Fabrizio e Stefano.

Infine, vorrei ringraziare di cuore tutti quei miei amici, colleghi e non, che, comprendendo lo sforzo che stavo sostenendo, hanno sempre tifato per me e mi sono state vicine in questi anni di università.

Index of Figures

Index of Tables

Introduction

This present thesis concerns the subject of packaging that has now assumed a key role along the entire supply chain of the product. Today packaging has entered a mature phase and it is at the centre of fundamental distribution and communication issues because on one hand its size and shape must be standardized across multiple products to optimize the shipments and on the other packaging can communicate how has to be used, stored, recycled, or even disposed it. In addition to this, the packaging system is also becoming considerably important in the issue of minimizing environmental pollution. Therefore, the global companies need a packaging process which is optimized in order to not incur in high costs and lack of efficiency.

The thesis focuses on the experience of internship at FCA Inter Regional Flows (IRF) Division from the last working week of December 2018 to the end of May 2019. IRF manages the overseas flows from Italy to the plants around the world. Particularly, the thesis derives from the work carried out by IRF Packaging team that has the duty of studying and trying to implement different policies and techniques aimed at lowering costs of packaging and making its transport as efficient as possible. In fact, the study will be developed around two main issues, Network Optimization and Cost Reduction, which will be adopted for demonstrating how the FCA operations can be improved, determining an important economic return.

The thesis starts with a literature research regarding the work issues and the potential future opportunities viable by packaging system. The literature will provide an explanation of the major key factors that can affect the network and the packaging design and of the methods already studied, such as the implementation of software tools, the application of mathematical models and the usage of returnable packaging. For this reason, the research gap that this thesis would cover is the description of the methodologies implemented by FCA in order to achieve the optimization of the network design and the reduction of transport/packaging cost in overseas shipments. This first chapter is followed by a section in which are described the Company and IRF Division from operative and organizational point of views by clarifying also the duties managed by the logistics operators. Once explained the job context, the thesis will continue with the third chapter where it is explained a short excursus about FCA Packaging Process in order to introduce the five macro-area of work of IRF Packaging team (i.e. Packaging Optimization, Packaging Supplier Base Re-engineering, Network Optimization, Cube Utilization Improvement and

Returnable Rack. All these typologies of work will be introduced with a description of high level and, for some of them, the thesis will provide business cases developed from the actual situation to the analysis of the results obtained with the new solutions applied . Finally, the thesis will be closed with chapter four where conclusions will be drawn, highlighting the limits of the work, the benefits and the future researches on the findings of the thesis.

For the development of the thesis topic, it has been used data provided by the Company, personal notes, external sources and especially advices from the experienced colleagues.

1 Packaging Research in Literature

This chapter aims to describe the literature about packaging found on magazines, e.g. "Supply Chain Management: an International Journal", "International Journal of Logistics Research and Applications", "Journal of Packaging Technology and Research", "Journal of Operations and Supply Chain Management", where it is possible to find research papers, or browsing on specialized sites on Internet, such as "SupplyChain24/7", "Supply Chain Solutions", "Industrial Packaging - The Flexible Packaging Blog", "Packaging Europe - Connecting Packaging Technology". There will be described different applications of packaging process, not all linked to automotive sector for the shortage of these last ones. The literature research has been divided in four typologies of topic:

1. Network Optimization
2. Packaging & Cube Utilization Optimization
3. Cost Reduction
4. Future Opportunities

It has been decided to apply this framework in order to follow the topics treated by the business cases reported in Chapter 3. Besides the first three sub-sections which describe new solutions to improve the packaging process, it has been introduced an interesting section aimed to show some future technologies which may upset the actual system in FCA supply chain.
Starting from the first above issue, the new sub-section will illustrate a network design overview and it will go on with some examples of Optimization.

1.1 Network Optimization

Realizing a new network design for a firm in any sort of industry or business implies achieving a satisfying organization taking into consideration all elements of the supply chain like product, market, process, technology, costs, external environment and their impact. No two supply chain designs can be the same. The network established will vary depending upon many factors including location and whether the Company is looking at national, regional or global business models. Nowadays logistics managers must be able to redesign distribution networks more often to operate at the lowest costs while offering the best customer service. "As recently as the 1990s, a company would review and restructure its distribution network once every five to ten years," says Edward Frazelle, founding director of Georgia Institute of Technology's [1]. In order to create a perfect network design/redesign, the above cited logistics expert suggests following a specific process, which starting with the assessment of the current network. The second step is designing and populating a network database and creating network design alternatives. Once all the feasible and potential options are evaluated, it is necessary to develop a network model and implement it through the chosen tool. At this point Frazelle recommends testing the network structure, computing the reconfiguration costs and doing the right trade-off on them. In his opinion, it is easy to make go/no-go decisions after the execution of this process.

The most important component in supply chain design is the establishment of appropriate performance measures in order to determine how an effective supply chain design is achieved and to compare competing alternative systems. Performance measures may be categorized as either quantitative or qualitative for which there is no single direct numerical measurement, although some aspects of them may be quantified (Beamon, 1998). In fact, a proper management and an appropriate design of the distribution network allows not only to guarantee a high level of service but also to satisfy the customer's expectations, reducing the global logistics costs. The goal of the distribution network is to define the level of control over the flows, logistics links suppliers/factories, factories/markets and any relations with the logistics operators. Particularly, four features can potentially affect the configuration of the distribution network:

1. Goods characteristics (e.g. density, weight, value, perishability, obsolescence).
2. The spatial-temporal attributes of the goods utilization (e.g. location of points of origin and delivery, seasonality).
3. Service level (e.g. cycle time, availability, delivery frequency, batch size, accuracy, reliability).
4. Logistics costs (e.g. transport, warehouses, manpower, areas costs) [2].

Besides these four aspects, the network modelling provides an operating system of the entire business to lead the managements and examine the structure from a strategic point of view, considering:

1. Internal factors, such as those reported in [3]:
    - Growth plans that require a need to check the suitability of the network to support the plans

- Introduction of new revenue streams (new products, new markets etc.) and the need to design networks to support them
- Merger & Acquisitions and need to rationalize/redesign network for new entity
- Need of companies to periodically revalidate/rationalize the existing supply chain network

2. External factors, better defined by [4]:
   - Government Policies of the Country where plants are to be located.
   - Political climate.
   - Local culture, availability of skilled/unskilled human resources, industrial relations environment, infrastructural support, energy availability, etc.
   - Taxation policies, incentives, subsidies across proposed plant location as well as tax structures in different market locations.
   - Technology infrastructure status.
   - Foreign investment policy, foreign exchange and regulations.

Currently supply chain networks have become global and dispersed and so firms can gain a competitive advantage by carrying out different network scenarios, assessing and proactively applying changes in response to the dynamicity of their businesses. Once a supply chain network design is approved and implemented, there are always opportunities to improve it. The best way to obtain a competitive advantage in supply chain network strategies is well explained by [5]. This Web page teaches that first the firm must understand the competitor's capabilities, developing an industry or private benchmarking for mapping out opponent nodes as the platform. Consequently, today it is mandatory to invest in a data analysis and network optimization tool because it is not feasible over the long run working on unrepeatable spreadsheets and feeding it with new data continuously in order to have historical information and analyse what-if scenarios. The detailed daily data will be helpful to understand service levels, volumes shipped, inventory levels and transportation opportunities. Running network strategies every six months in order to decide around load units' rationalization, cross-docking opportunities, node constraints and regional distribution centre locations will be helpful to refresh the actual situation. Other tips derived from the paper are the implementation of a common software execution layer enabling to move packages efficiently and the application of a cloud-based tool capable to provide visibility to every pallet or case move with real-time inventory positioning.

Going deeper in the literature, the network design problem has been studied from many specialists and it has been established that it is possible to obtain paramount results developing the optimal trade-off between three main sub-problems:

- Facility location, i.e. the improvement of the existing network and the determination of the best configuration.
- Inventory management, setting the best inventory levels at hubs/plants.
- Routing which consists of the optimization of the flows.

Practically, it has been proposed a mixed integer programming model in order to solve the network design problem. This mathematical model categorizes the total system costs in three typologies, mentioned in order of importance:

- Strategic costs, i.e. the location costs incurred in configuring the network
- Tactical costs, i.e. filling tool, manpower and inventory costs.
- Operational costs: the transportation ones.

After several simulations and the utilization of approximative methods for large-scale problems, the suggested model provided the needed decisions on how many filling plants and hubs to locate, where to locate them among the list of potential locations, how often to replenish the products at the hubs from the filling plants, what level of working and safety stocks to maintain at the plants, so as to minimize the total system costs consisting of total location, transportation and inventory costs. In any case, mathematical models represent both location and allocation decisions of the supply chain which maximizes the total profit, optimizing the network design. (Singh et al., 2015; E. T. Serdar, M. S. Al-Ashhab, 2016)

A last important way to achieve network optimization is selecting the logistics service providers relying on the location of its warehouses. When the core competencies of a firm are not linked to the transportations of the goods, it is preferable to grant part of the business to a logistics operator. Statistical studies have been done in order to choose the logistics service providers accurately, considering structural and spatial attributes of logistics operator locations. Literature shows the logistics operations area and the employees as the more statistically representative structural features, while the accessibility to the highway network which allows fast transport services is the spatial attribute that most contributes in the choice of a logistics service provider (Rolko, Friedrich, 2017).

1.2 Packaging & Cube Utilization Optimization

The Packaging Optimization sub-section has been considered as the collection of literature extracts about the operation of improving the packaging saturation and the sea-container/truck Cube Utilization. Therefore, any potential excerpts about the reduction of packaging materials or the reduction of any possible costs in the packaging process will be described in the next Section. When it is talked about Packaging Optimization, it is referred to the increasing of the parts density in a package. Particularly, the automotive industry has been a leader in designing packaging in order to optimize space utilization by shipping more parts in the same amount of space. A General Motors team in Brazil managed to add an extra layer of parts per container, thus eliminating the necessity for 23 extra containers. In another pack they rearranged the packaging design from a linear grid to a geometric pattern, thereby reducing the shipping requirement by 38 boxes [6].

Packaging Optimization provides an excellent opportunity to generate additional cost savings and it is possible to achieve it maximizing the primary, secondary or tertiary packaging operations:

- Primary: it is not the case of the work of thesis, but it is thinkable to optimize the primary pack design because if the product ends up on a shelf, its presence will be maximized.
- Secondary: increasing the master carton density means more products per carton and consequently more products per sea-container or per truck. It is fundamental to make sure that the primary packaging is designed to nest and fill out the master carton to optimize your transport packaging, like in Figure 1.1 where other three items are inserted in the box, occupying some of the empty space.

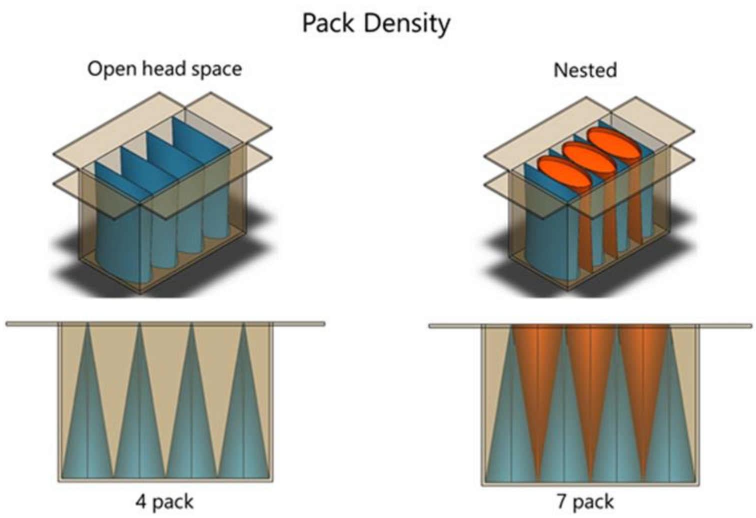


Figure 1.1 Improvement of Pack Density [7]

- Tertiary: sea-container and truck utilization remain crucial for cost savings for both full truckload and LTL (“less than a truckload”) shipments. LTL shipping allows a firm to only pay for the volume needed in the means of transport. Engineering a sea-container load configuration that utilizes the unit space (even without a pallet) without slowing down the handling processes and keeping your footprint small can minimize the cost of those LTL shipments [7].

Also selecting the right amount of protection of the package is a way to obtain Packaging Optimization. In industrial packaging it is paramount choosing the right level of packaging protection to avoid damage during transit or stacking, as shown in Figure 1.2 where it is understandable that if the package cost increases, the damaged cost decreases because the pack will be more protected.

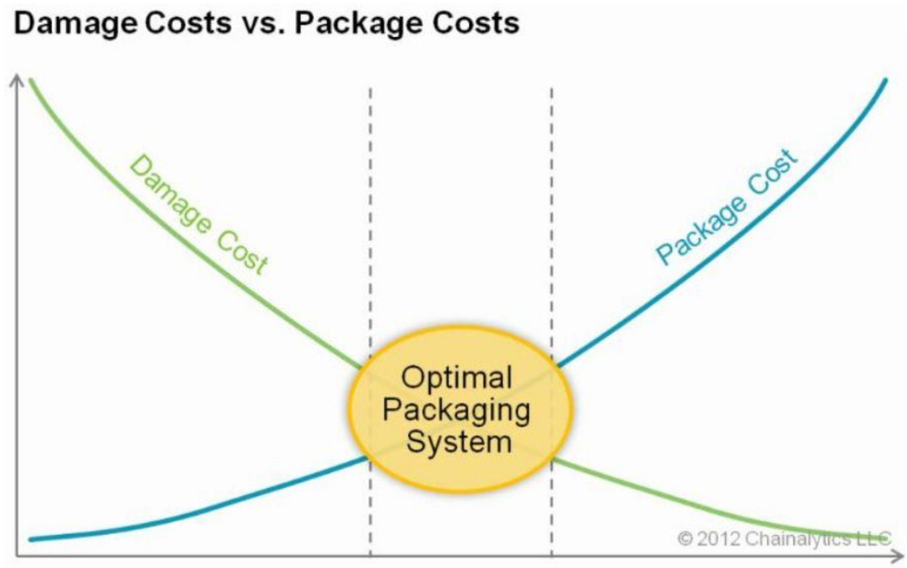


Figure 1.2 Trade-off between damage & packaging costs [8]

As Bob Fiedler says, “the best package is a robust product” [8], Packaging Optimization is also product protection. If the product is already designed to be robust, it will need minimal (or no) packaging and vice versa. Hence, in case a product is overpacked, it is possible to remove part of the internal dunnage and sometimes this reduction in auxiliary materials drives to a better saturation of the container. On the contrary it is savvy to augment the protection of the pack when there is the risk of damage for the product, even though less items per carton will be shipped. Management must guard against overpackaging and underpackaging: it is possible through overpackaging to ensure a higher degree of undamaged deliveries, while underpackaging is a package that will not protect all shipments but will protect a certain percentage of them. It can result in claims on the damaged goods, as well as lost sales, which can easily exceed packaging economies.

In turn cube utilization is not just about filling a sea-container or truck all the way to the top, but it is about using available shipping and storage space to maximize the amount of product you can move in a given transportation or storage container. The best way to achieve the maximum Cube Utilization is the adoption of a software that computes potential weights with defined priority loading rules and stacking limits. It is possible to find several types of these tools on Web. For example, Cubemaster [9] is a cloud solution able to set the optimal load plan for any kind of transportation way, such as trucks, trailers, sea-containers or wagons and even to calculate the best platform for a single footboard. The graphic interface of the software is easy to use, and 3D uses a rendering technology that allows a smooth and uninterrupted visualization of the load unit. Another method to improve the Cube Utilization of the means of transports is Consolidation [10], i.e. the combination of the goods from different shippers. So, anyone can save money for not ship anymore empty containers or uses this technique in order to purchase goods from multiple suppliers. Consolidation allows to pay a bulk rate for shipping rather than shipping all the items separately. Finally, in 2011, after an important market research, Neufarth, Haining and Moore had found that the packages with a height major than 50’’ (1270 mm) caused Cube Utilization problems every goods delivery, so they suggested the application of Super Truck with a major height always considering weight constraints. The use of these trucks allowed to pass from an averagely 80% of Cube Utilization per truck to 96%, shipping many more products in any shipments (Chan et al., 2006).

1.3 Cost Reduction

This Section will describe the methods found in literature to implement for realizing savings on transportation and/or on managing packages.

The transportation cost can be reduced implementing “the technique for order of preference by similarity to ideal solution” (TOPSIS) (D. Moon, D. Kim, E. Lee, 2015), that is a multi-criteria decision analysis method, based on the selection and the weight of quantitative (total transport distance, total transport time and total transport cost) and qualitative factors (transport service, safety and awareness). As soon as all these elements are applied in TOPSIS, this technique ranks the alternative routes and allows to establish the best one for a given shipment. Instead of using a mathematical technique, firm may reduce their transportation cost adopting creative shipping strategies, like aggregation which takes place when one shipper combines multiple orders headed to the same destination on the same day into the same means of transport or pooling that occurs when freight is consolidated or deconsolidated at a pool point, so that it spends the majority of its transit time being shipped via the most cost-efficient mode [11]. These strategies allow to fill the trucks/sea-containers to the top and to decrease the unitary cost of transport for each delivery.

Utilizing returnable packaging, that is better explained in Section 3.6, is a great way a Company may achieve savings in the packaging cost. When it is possible to implement, the end user does not discard anymore the shipping material and does not repurchase it for the entire packaging life cycle time. This reduces the amount of packaging per unit that a given business will need to purchase and this will reduce environmental costs by reducing the amount of waste per-unit that is being shipped off to a landfill [12]. When the returnable packaging is adopted in large business in which many suppliers are implied, it is possible to implement also a strategy that permits of sharing the containers. This method allows to reduce more the cost of the entire supply chain as compared to the case in which each supplier uses its own container. Since the packages can be shared between the suppliers of different areas, the transportation cost of the empty packages is reduced. If the demand between areas would be balanced, there would not be any need to transport empty container and so the transportation cost reduction could achieve the maximized value (Qinhong et al., 2015). Packaging cost may be also affected by the design of the unit load and consequently to the design of the product itself. In fact, García suggested “the need for the design of products and packaging to occur at the same time, including the logistics angle", meaning that all the entrepreneurial areas related to the packaging must work together and should create a product/packaging design team in accordance with the Concurrent Engineering approach (J. García-Arca et al., 2008). Practically, it is necessary to identify the packaging guidelines and grouping products into families and, as usual, with the adoption of an optimization algorithm, it is possible to determine the best packaging dimensions from the product ones. In addiction material consumption is calculated and if required the algorithm is also able to compare the packaging materials saved (Betancur-Muñoz et al., 2014). Finally, unnecessary packaging is an unnecessary cost factor, especially in high-volume distribution channels. So, it is also possible to lower packaging cost:

- eliminating excessive packaging with the removal of abundant components without compromising the quality of the pack
- finding the way to do not re-apply packaging into the next step of the supply chain for transport reasons.
- Light-weighting / down-gauging, i.e. maintaining the similar inner dimensions while decreasing the external dimensions of packaging, offering the same or an enhanced strength. This activity may be realized in three specific manners:
    1. reducing the thickness of the original material used
    2. not using high impact packaging materials (such as steel and aluminium) by substituting them with a more lightweight alternative
    3. building a lightweight composition through the combination of flexible materials (Worrell et al., 2013).

1.4 Future Opportunities

At the end of 2017, the worldwide automotive packaging market is worth around 3.7 billion dollars with a growth of 11% from the previous year. The automotive packaging industry is also involved in many electronic devices which are more and more common in cars, so this significant increase will drive the packaging market up to 7 billion dollars in 2023 (Azémar, 2018). In a context of continuous improvement, traditional packaging is no longer enough because of the most recently initiatives towards fostering a circular economy and minimising the carbon footprint of manufactured products. Given the shortage of resources in society today, business units develop and use green packaging materials and easy recycling packaging materials for proper packaging. Hence, it is born the concept of "Green Logistics" with the aim of reduce environment pollution and consumption of resource and consequently the term of "green package" which can be circle or used more than once. In a nutshell, green packaging is the appropriate packaging that can be reused, recycled or degraded during the product life cycle. At firm level, logistics managers should improve their operation towards green materials which not only reduce pollution, but also replace some of the expensive resources in order to reuse waste resources, making efforts to adopt measures to achieve ISO14000 certification requirements of green packaging (Gao et al., 2012).

From an innovation perspective, instead, in recent years packaging should accommodate an array of additional consumer needs and many terms, such as active packaging, intelligent packaging or smart packaging have emerged in literature. In order to not crease misunderstandings, below are reported their three definition:

1. **active packaging**: a packaging in which additives are incorporated with the objective of maintaining or extending product quality and shelf-life.
2. **intelligent packaging**: a packaging system which performs intelligent functions (e.g. sensing, detecting, tracing, recording and communicating) to make easy extending shelf life, improving quality, enhancing safety and providing information
3. **smart packaging**: a packaging that owns the capabilities of both intelligent and active packaging.

In active packaging usually are inserted ethylene scavengers, flavour and odour absorber/releaser, antimicrobial and antioxidants, while in intelligent packaging hardware components (e.g. time-temperature indicators, gas detectors, freshness indicators and radio frequency identification (RFID) systems). Having these two-fold functions, smart packaging is the best solution because on the one hand monitors changes in the environment (intelligent) and on the other performs on these ones (active) (D. Schaefer et al, 2018).

Smart packaging has a wide variety of potential application from the monitoring of food safety and drug use, tracking the postal delivery of items through security tags inside the pack, to the fundamental identification of supply chain inefficiencies. In fact, it permits to track and trace goods during the lifecycle, to control the environment inside or outside the package in order to inform any actors of the supply chain on the product's condition in any moment. Nowadays, always more companies are implementing these types of packaging in order to improve the visibility of the containers throughout the supply chain. The technology mainly used is the RFID and it is on the market in two typologies [13]:

- Passive RFID System: it consists of a reader, a tag and antenna. The tag is made up of an antenna coil and electronic chip. As the name implies, passive tags wait for a signal from an RFID reader. The reader sends a RF wave to RFID tag's antenna which converts it into energy. The energy moves from the tag's antenna to the microchip powering it which generates a signal back to the RF system. This is called backscatter and stands for the change in the electromagnetic or RF wave. In this way the signal is detected by the reader (via the antenna), which interprets the information. This technology has no internal power source such as batteries and derive their electrical power from time varying radio frequency waves generated by the reader.
- Active RFID systems: it includes also a reader, tags and an antenna. Active RFID tags have an embedded DC battery power source that allows the RFID tag to continuously send out a stronger signal and it last averagely in 3/5 years.

Active RFID tags have a greater read range (up to 100 meters) than passive ones, its RFID reader is cheaper, they offer a 1000 times greater memory to collect data and unlike passive RFID tags has a Read/Write technology. Active RFID is capable to read multi-tags simultaneously faster than passive one and provide a Real Time Location System capability, while passive RFID only gives a snapshot of nearby tags at a given time. Finally, active RFID tags are capable of restricting access so that a user must to use a password to view the information stored and have also sensing capabilities that allow them to collect data related to temperature, pressure, etc. On the contrary, their implementation requires more expensive computer software and most of all active RFID tags are far expensive than passive ones (from 20-150 dollars to 0.2-3 dollars).

Hence, radio frequency identification technologies could improve the management of returnable containers but could also update continuously both inventory and locations data and with this information firms might know in advance the number of containers that were fabricated, scrapped and lost (Maleki et al. in 2011).

All the information founded in literature research does not provide an exhaustive and practical treatment of the methodologies to implement in order to improve the actual design of a supply chain and its associate packaging process. The work of thesis would cover this research gap with the purpose of giving a true outline to take for achieving these enhancements.
Therefore, this thesis will be focused on two main topics:

1. Network Optimization with the adoption of the Direct Shipment .
2. Cost Reduction through Packaging Optimization and Cube Utilization procedures.

They will be analysed from a technical perspective, always accounting the economic aspects for showing the saving obtained with the implementation of the new solutions.

2 The FCA Group

In this Section, the objective is describing as best the Company and the office organisation where all this work of thesis has taken place.

2.1 FCA Corporate Structure

FCA was born on October 12, 2014, from the merger of two of the largest automotive conglomerates: FIAT N.V., founded in Italy in 1899 by a panel of businessmen, including Giovanni Agnelli, and Chrysler Corporation, an important American car Company created by Walter P. Chrysler in 1925. The Group is a public company with limited liability, formed under Netherlands Regulation. It has its corporate seat in Amsterdam and the place of effective management is in the United Kingdom. At the beginning of 2014, the Fiat Group's stake in Chrysler's Group rose to 100% and the new Company is listed on the New York Stock Exchange ("FCAU") and the Milan Stock Exchange ("FCA"). On January 3, 2016 the spin-off of Ferrari from FCA was completed, after being listed on the New York Stock Exchange. Ferrari remained under the control of the Group Holding, Exor N.V. 2016 is also a crucial year in terms of autonomous driving: FCA announced a collaboration with Waymo (formerly Google Self-Driving Car Project) and the production of 100 Chrysler Pacifica Hybrid. Consequently, in 2017, FCA signs a memorandum of understanding with BMW Group, Intel and Mobileye for the development of an innovative autonomous driving platform. On July 21, 2018, Michael Manley was appointed Chief Executive Officer of FCA, replacing an outstanding manager named Sergio Marchionne. On October 22, 2018, FCA announced the definitive selling agreement of Magneti Marelli business to CK Holdings Ltd, with a transaction of nearly € 6 billion that is expected to close in the second quarter of 2019 [14][15].

The main shareholders, on February 20, 2019, are:

- Exor N.V. (28.98%) with around 450 million of shares
- Tiger Global Management LLC (5.25%) with more 81 million of shares
- Harris Associates L.P. (3.81%) with almost 60 million of shares

Today the company occupies the eighth place in the world classification of automotive groups.

Figure 2.1 FCA Logo [FCA file]

As known, the Company follows the entire life cycle of the vehicle and markets it around the world, providing at the same time to its customers it after-sales services, components, spare parts and production systems. In addition, the Group's car business provides retail and dealer financing, leasing and rental services through subsidiaries, joint ventures and commercial arrangements with third-party financial institutions and that's where FCA Bank comes to life: it is an online bank created by the joint venture between Fiat Chrysler Automobiles and Credit Agricole. Finally, FCA is also active in other sectors ranging from publishing to real estate.
At the end of 2018, FCA boasts:

- More than 40 Countries where it has an industrial presence
- More than 135 Countries in which the Group manages trading relationships
- 102 Manufacturing Facilities
- 46 R&D Centres
- 199.000 workers
- 4,8 Million units sold
- Nearly € 110 Billion in Net Revenues
- €3,5 Billion in R&D Investments
- 14 Brands, that are divided into two broad groups:
    1. "Automotive Brands", in turn divided into subgroups:
        - Market brands (Chrysler, Dodge, FIAT, Jeep, Lancia, Mopar, RAM, FIAT Professional, SRT)
        - Luxury brands and sports (Maserati, Abarth, Alfa Romeo)
    2. "Components and Production Systems Brands":
        - Comau
        - Teksid

2.2 FCA Operative structure

The Company operates to support distribution and sale of mass-market vehicles in four areas, shown in Figure 2.2, through five segments:

1. NAFTA: in United States, Canada, Mexico and Caribbean islands, primarily under the Jeep, RAM, Dodge, Chrysler, Fiat, Alfa Romeo and Abarth brands.
2. LATAM: in South and Central America, especially under the Fiat, Jeep, Dodge and RAM brands, with the largest focus of business in Brazil and Argentina.
3. APAC: in the Asia Pacific region (mostly in China, Japan, India, Australia and South Korea) through both subsidiaries and joint ventures, under the Jeep, Fiat, Alfa Romeo, Abarth, Fiat Professional, RAM and Chrysler brands.
4. EMEA: in Europe (which includes the 28 UE members and the members of the European Free Trade Association), the Middle East and Africa, under the Fiat, Fiat Professional, Jeep, Alfa Romeo, Lancia, Abarth, RAM and Dodge brands.
5. Maserati: Company sells and distributes its luxury vehicles worldwide.

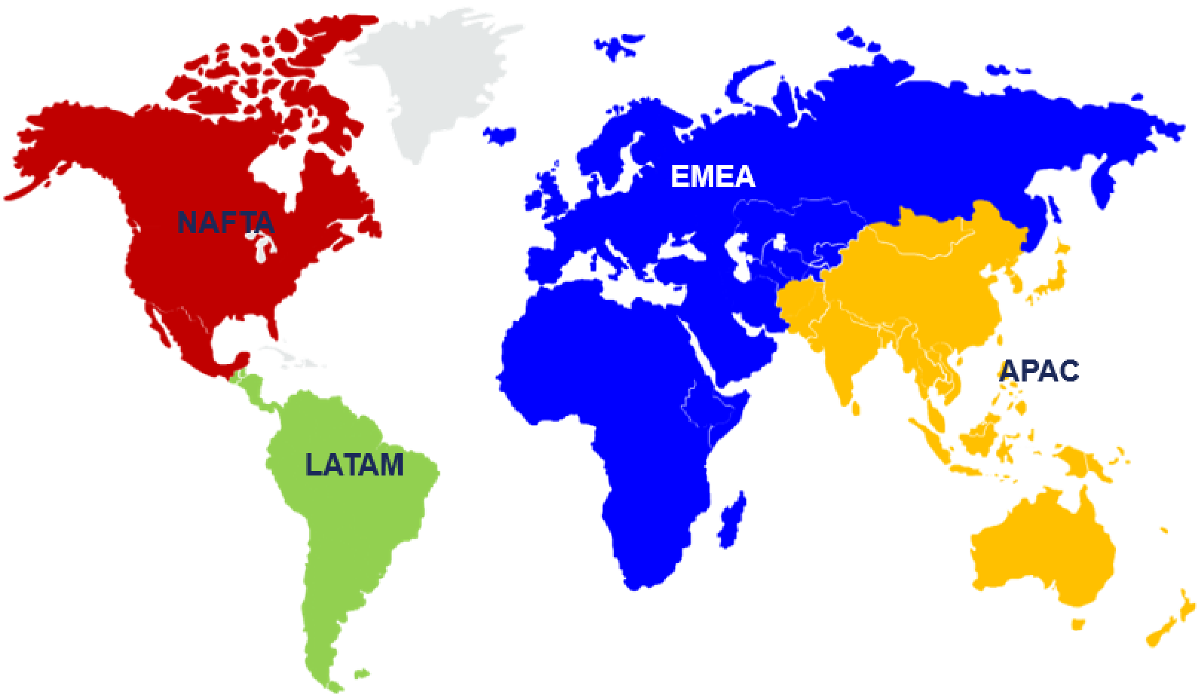
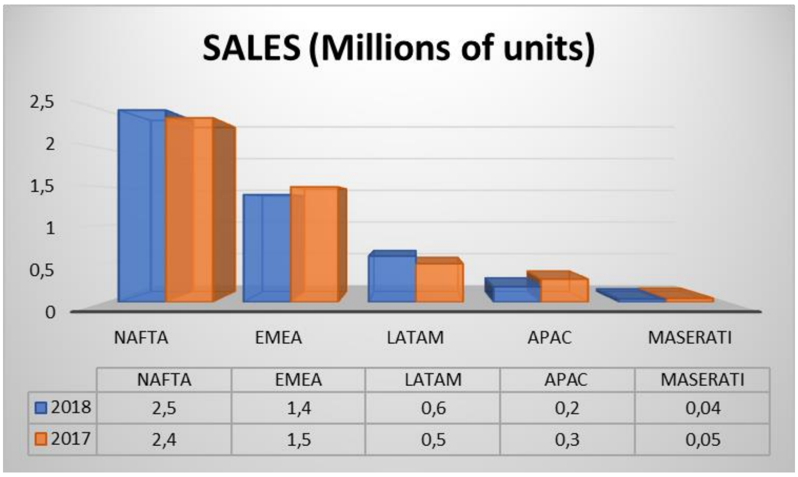


Figure 2.2 FCA Regions [FCA presentation]

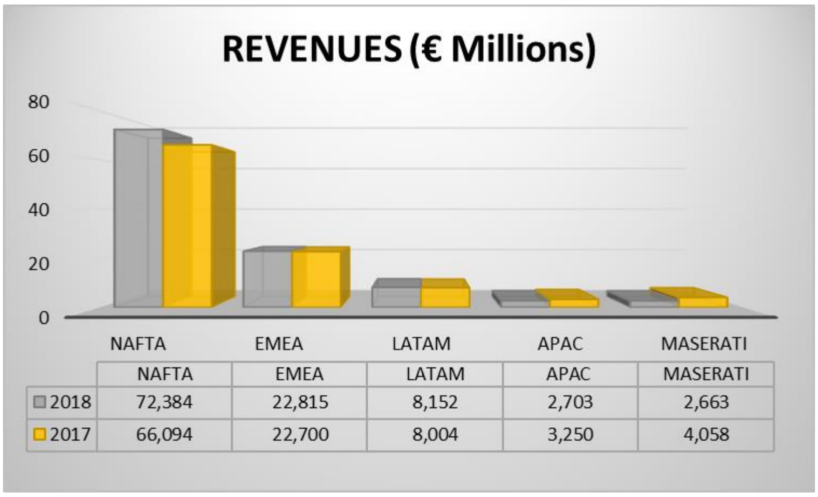
2.3 Sales & Net Revenues graphs

Analysing data represented in Figures 2.3, 2.4, 2.5 divided for segments, NAFTA contributes more than others in both terms of Sales and Net Revenues, followed by EMEA. Together, they exceed more than 80% in both categories. It is still important to note a strong percentage decrease from the end of 2017 to the end of 2018 for APAC and Maserati, but even more critical is the contraction in Sales in EMEA area[16].



	NAFTA	EMEA	LATAM	APAC	MASERATI
2018	2,5	1,4	0,6	0,2	0,04
2017	2,4	1,5	0,5	0,3	0,05

Figure 2.3 FCA Sales 2017-2018 [Personal processing of FCA data]



	NAFTA	EMEA	LATAM	APAC	MASERATI
2018	72,384	22,815	8,152	2,703	2,663
2017	66,094	22,700	8,004	3,250	4,058

Figure 2.4 FCA Revenues 2017-2018 [Personal processing of FCA data]

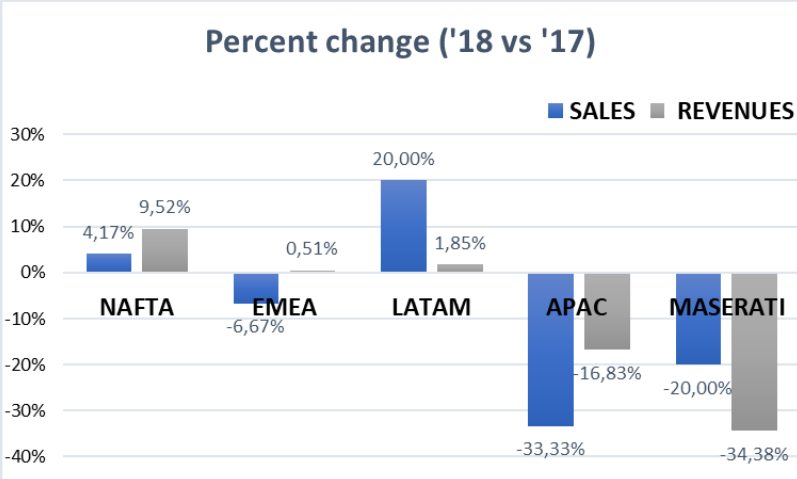


Figure 2.5 FCA Sales & Revenues Percent change [Personal processing of FCA data]

2.4 Management

FCA is managed by two executive directors:

1. The Chairman, John Elkann
2. The Chief Executive Officer, Michael Manley.

The board of directors is composed by other ten people:

1. John Abbott
2. Andrea Agnelli
3. Tiberto Brandolini D'Adda
4. Glenn Earle
5. Valerie A. Mars
6. Ruth J. Simmons
7. Ronald L. Thompson
8. Michelangelo A. Volpi
9. Patience Wheatcroft
10. Ermenegildo Zegna

Chairman and CEO have the responsibility for the day-to-day management and strategy of the Company, whereas Directors do not, but they must be prepared for any Board of Directors and

Shareholders meetings. During 2018, there were nine meetings of the Board of Directors and the average attendance was approximately 95 percent. On certain key industrial matters, Manley carries out his job taking advantage of the GEC (Group Executive Council), a decision-making body, formed by four principal structures, articulated to regional areas of operation, brand, industrial process and corporate functions support.

To summarise:

1. The first one is managed by Chief Operating Officers (COOs) whose have the responsibility for the economic results, for managing the resources and of the productive and commercial activities. To be recovered is Pietro Gorlier who has succeeded Alfredo Altavilla in the role of COO of EMEA area.
2. Brand Structure is focused on Marks, that are stood by a Brand Leader, liable for the implementation of business and marketing strategies for each Region.
3. The third one is made up by Industrial Leader which coordinate industrial processes, standardizing methods and tools across the Regions.
4. The fourth structure consists of Corporate Support and Process Leaders [15].

2.5 IRF Inter Regional Flow Division

The internship has been occurred in Mirafiori complex, located in the south of Turin, in the Supply Chain Management (SCM) department which is managed by Enzo Potenza. This department is in turn composed of several divisions: Finance, Human Resources, Advanced Supply Chain & Network Engineering, Capacity Management, Customs Governance, Demand & Production Planning, Logistics Services Contracting, Process & Methods, Supplier Delivery Risk Management, Vehicle Distribution, Supply Chain Planning Project, i-Fast Automotive Logistics, i-Fast Container Logistics, Poland SCM, Serbia SCM, Turkey SCM, Business Centre Supply Chain, Plant Logistics and last but not least Inter Regional Operations, guided by Marco Zanna.

The Inter Regional Flow is a business model implemented by the four Regions (NAFTA, LATAM, APAC & EMEA) to manage and standardize the flow of the components between them.

The IRF's purposes are those as arranging the procurement, packaging, shipping and invoicing of components built by a supplier from a specific Region to the customer plant placed in a different

Region, standardizing intercontinental supplies with a targeted level of service, quality and cost, managing the direct flow of material at a global level and developing logistical processes for new international initiatives.

To have a better understanding of what IRF deals with, you should imagine it as a virtual plant: the office buys components from suppliers in the EMEA Region, uses logistics operators to "transforms" these components and resells them to FCA plants located outside the EMEA Region. All this "transformation" resides entirely in the packaging. The Figure 2.6 explains what has just been said.

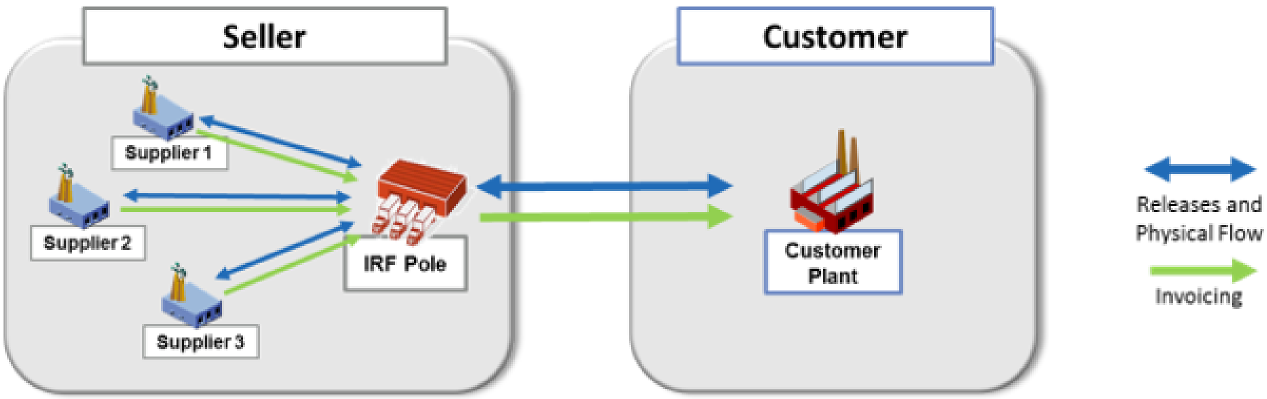


Figure 2.6 IRF Logistics Flow [FCA presentation]

In many situations, the suppliers of the components are the same as those who provide items for Italian plants (e.g. Termoli, Verrone, Melfi, Cassino, etc.) and, because of this reason, they had subscribed supply contracts in which certainly the packaging standards aren't tailored for overseas trips. So FCA, with a technical support of a third-party logistic provider, uses a specific packaging that can preserve the integrity of the product even after trips of more than two months. In addiction IRF ensure to its customer plant that both packaging and sea containers will always have a minimum saturation of 80%. In this manner, the transport unit price will be reduced to a minimum value by optimizing the cube utilization of the containers. These two activities add value to the packaging and let IRF be a self-sufficient division, thanking to the reselling of components with an additional mark-up.

It is also important to remember that in 2014 FIAT, with the acquisition of Chrysler, became a global Company and so the number of plants to handle skyrocketed. FCA has always had the idea that its vehicles should be built in the same way worldwide and for this reason it was decided that every car produced outside Europe should have sourced from the same suppliers used by EMEA plants. In this context, IRF was born with the goal of overcoming the cultural barriers between Regions and with the intention of not burdening suppliers with the complex activities of changing packaging and optimizing container saturation for overseas trips, allowing them to focus on their core business.

Figure 2.7 shows the behaviour of the plants without the coordination of the IRF, i.e. the plant buys and imports directly all the components from the suppliers located all over the world and managing the components flows in this way could be very complicated.

Figure 2.7 Components flow without IRF poles [FCA presentation]

Instead, Figure 2.8 shows the components flow with the implementation of IRF poles. The plant buys the components from the IRF poles which become the only counterpart for the import of material from a different Region and the flow management becomes lean and easier to handle.

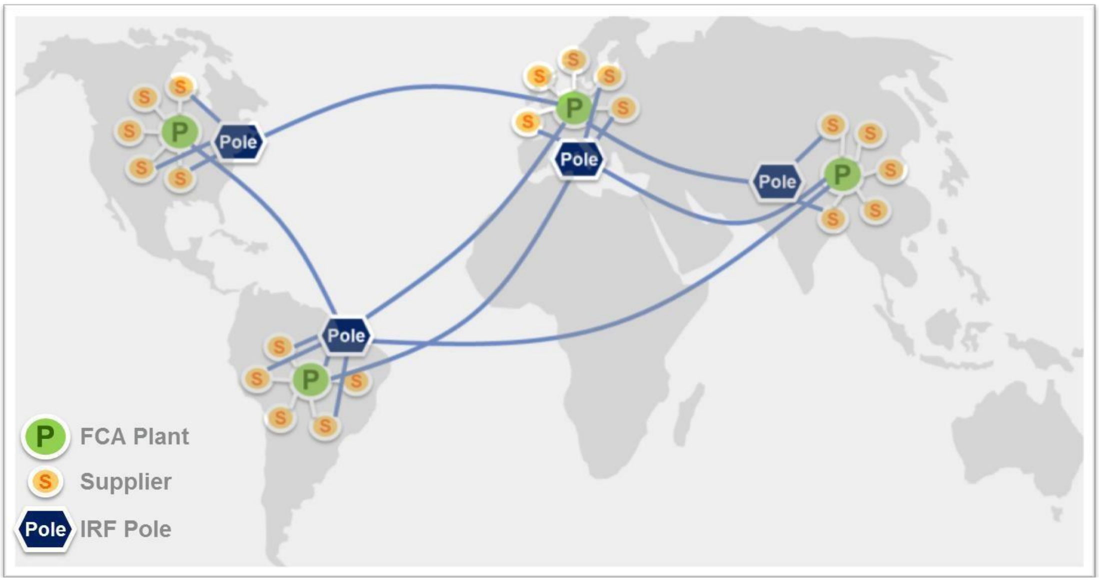


Figure 2.8 Components flow with IRF poles [FCA presentation]

All around the world there are seven IRF poles, three in EMEA region (Italy, Poland and Turkey), one in NAFTA Region, one in LATAM Region and two in APAC Region (China and India).

Figures 2.9 shows the volumes managed by EMEA IRF towards other regions in export and the volumes overseen always by EMEA IRF from other regions in import in May 2019.

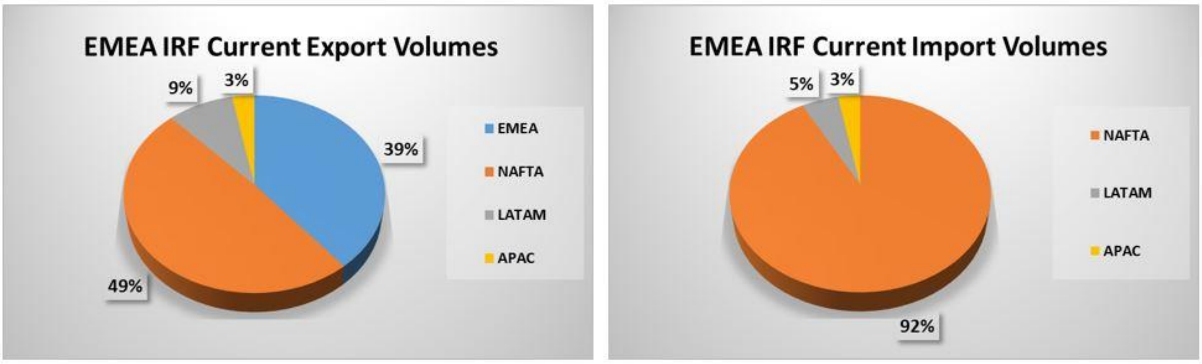


Figure 2.9 EMEA IRF Current Volumes per Region in Export & Import [FCA file]

It is possible to figure out that almost half of the flows in export is due to NAFTA Region, but, as concerns import operations towards EMEA, its contribution is here total. To give an indicative numerical value, the Italy polo manages almost 12000 items for a total of about 1.4 million cubic meters per year in export from EMEA to a different region and about 0.4 million cubic meters per year in import from any region to EMEA plants through the Consolidation Centres of the third-party logistics provider due to around 1000 components. For EMEA Region, the Saltillo flow (Mexico) is the more important with around 0.5 million cubic meters per year shipped.

2.5.1 IRF Divisions

The Inter Regional Flow department is divided in four Divisions:

1. IRF Program Management
2. IRF Operations
3. IRF Quality
4. IRF Packaging

2.5.1.1 IRF Program Management

This team represents the first interface of the supply chain for IRF flows and works in an autonomous way. It is composed by three program managers, four people who work on preseries and change management and two people in charge of KPI & Process Management ("Key Performance Indicators").

IRF Program Management coordinates the set-up activities of international flows and launches new import/export projects with inter-functional and inter-Region teams, drawing up "the Master Import List"; it validates production capacity, costs and packaging. In addition to these activities, the division deals with the continuous monitoring of projects and coordinates improvements and developments of IT systems.

2.5.1.2 IRF Operations

IRF Operations, instead, is a business unit that supervises the procurement, consolidation, shipping and invoicing of materials from EMEA suppliers to plants outside Italy through a series of standardized processes. The division is divided in two branches, one for import operations and one for export operations. The second one is composed by five groups, separated for the market they serve.

The activities of IRF Operations are based on the management of the flow of information and material and so the division has to prioritize incoming vehicles in case of emergencies, assigning packaging priorities for urgent materials, to support the Consolidation Centre in solving all problems that prevent packaging from proceeding (e.g. overstocks, unsaturated packaging authorisations, etc.) and finally to indicate the mode of transport of the material, if different from the predefined one, as explained in Figure 2.10.

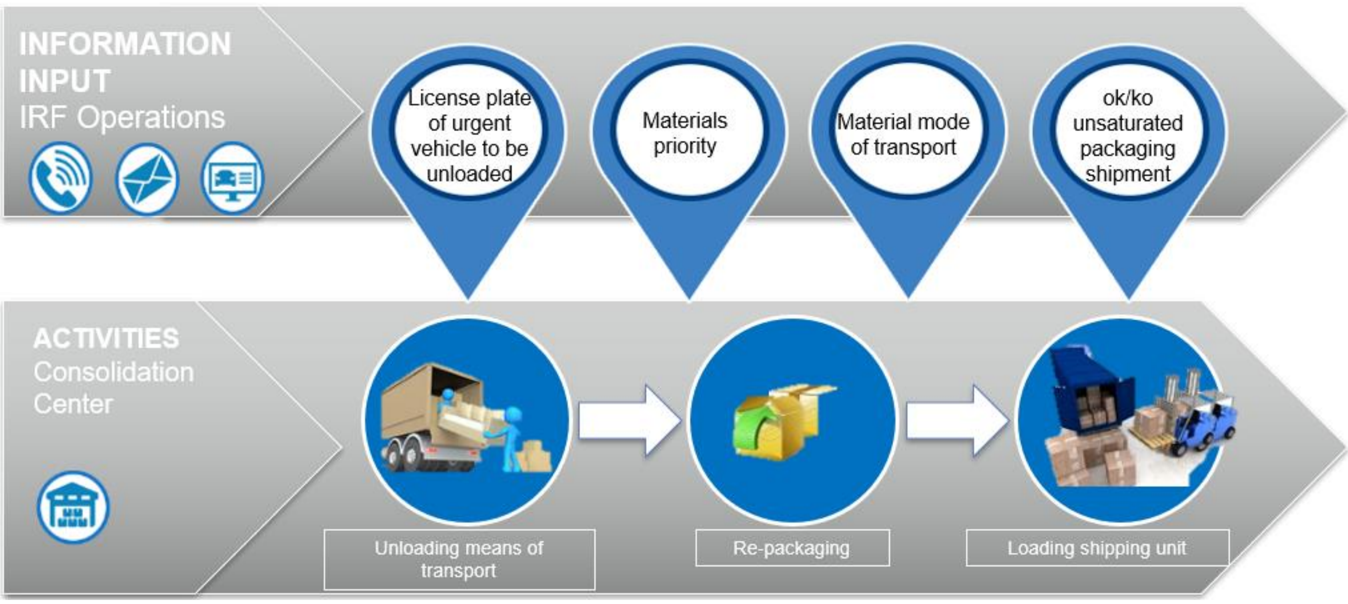


Figure 2.10 IRF Operations input information & activities at Consolidation Centre [FCA presentation]

Depending on the plant's location and therefore on the lead time needed to deliver the material, different modes of transport can be adopted. Mainly, ship is the most used means of transport as indeed occurs for Turkey, NAFTA, LATAM or APAC, instead for Serbia and Poland shipments are made by rail. Lastly, when the customer plant needs the material in less time than was planned with the ordinary mean of transport, IRF Operation uses shipments by air or road.

2.5.1.3 IRF Quality

The third group is the IRF Quality which has the responsibility on the conformity of the items which are shipped from EMEA to the other Regions. The Division is formed by four people who manage quality issues for a specific market and by a quality specialist.

Mainly, the activities carried out by IRF Quality can be considered of two types, the preventive and the corrective ones. The former ones are intended to prevent any problems at destination once the goods have been delivered, such as: Input Controls, Compliant Packaging, Suppliers Management, Regulations & Standards, Compliance Audits and set-up of KPIs for constant control of logistics operators. On the other side, the control activities are divided into: Root Cause Analysis, Action Plan, Packaging Overhaul and Complaint Management.

Control activities begin with the receipt of the goods at the Consolidation Centre: here it is checked by the logistics operator who, in the case of a quality KO, sets up a block of the received material and quarantines it; by this point, goods are checked by a FCA quality specialist who assesses the return to the flow, the return of the package to the supplier or the scrapping.

In the case you really wanted to get past the problem, direct actions are taken at the root of the quality issue and these problems can be addressed to the management, methods and processes of production by adopting a series of clean points.

In the case of complaints, these can occur as a result of different situations such as damage to the packaging or damage due to transport or handling, damaged materials inside the packaging or divergences in the quantities received than ordered.

In extraordinary cases, AUDITs are carried out at the two logistics operators to evaluate the structure, equipment and processes. FCA prepares an assessment check list on which the logistics operator will be measured and if the total indicator is high, his performance is considered optimal, if below 90% there is an intermediate performance for which corrective action is necessary and finally if the value is low, the operator's business is at risk.

However, the problems can be of a logistical or production nature, but once the liability for the damage is established, the cost is charged to the supplier, carrier or logistical operator and it is turned to the customer.

2.5.1.4 IRF Packaging & Network

This is the Division where the work of thesis has been developed. The team is composed of four people that are the focal points for the IRF export flows and of one person in charge of managing the IRF import flows. In addition to these specialists, there are two other people liable respectively for the Packaging Cycles Validation and for the update of IRF data systems.
So overall, the Division is responsible for:

1. Define and develop packaging solutions to ensure FCA's quality standards by following cost reduction targets;
2. Optimize the packaging cycles, operated by logistics operators in the activities carried out at the Consolidation Centre;
3. Improve the conditions of supply by suppliers, in collaboration with the Purchasing department;
4. Support other IRF departments in the development of the network;
5. Implement and monitor environmental sustainability projects, shown in Figure 2.11

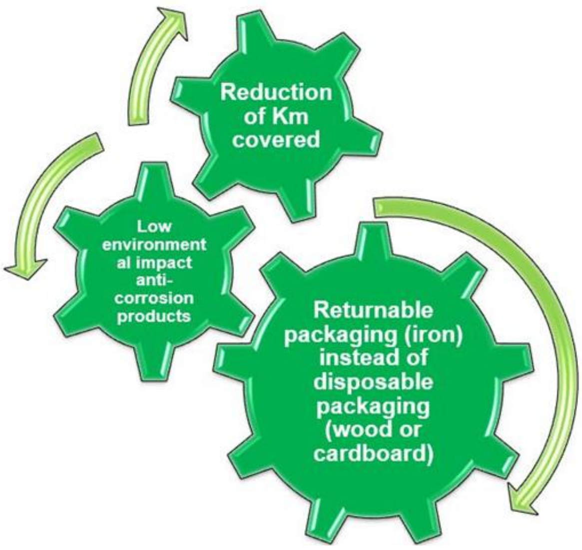


Figure 2.11 IRF Packaging solutions for sustainability projects [FCA presentation

By doing all these activities, many benefits of Packaging Optimization and consequently of the packaging cycle will be deriving and will have a significant impact on:

1. Improvement of the quality of the components packaged and shipped to destination with a significant reduction in the risk of damage;
2. Reduction of the packing cost through the optimization of the saturation of the components for each single packing;
3. Reduction of the transport cost by increasing the saturation of the packaging.

2.5.2 IRF Clients & Suppliers

IRF Clients are the assembly plants in the four Regions worldwide. IRF's logistics costs are passed on to the customer plants without any recharging.

Figure 2.12 below represents the plants in the other Regions where the IRF flow is carried out.

Figure 2.12 IRF Clients [FCA file]

Instead, Figure 2.13 shows the IRF flows from Italy polo to customer plants worldwide.

Figure 2.13 Italy polo flows [FCA file]

The following are the different cars produced in the factories of the other Regions, indicated in the above list:

- Argentina: Nuova Palio
- Brazil: Renegade, Ducato, Toro, Strada, Uno, Grande Punto, Palio, Siena, Doblò, Mobi, New Jeep C-SUV
- Mexico: Ducato, New Jeep Cherokee
- USA: New Jeep Cherokee
- China, GAC: Viaggio, Ottimo, New Jeep Compass
- India: Linea, Grande Punto, New Jeep Compass.
- Japan: 124 Spider, Fullback.

As concern suppliers, they can be classified into two typologies:

- The first ones are those who supply to FCA the items needed to assembly vehicles
- the latter have the task of providing a logistical service to the Group and they are the third-party logistics providers that we have already mentioned in the previous paragraphs and which we will discuss in more detail in the next Section.

Suppliers of items can be further classified into two categories:

- internal suppliers: they are owned by the Group and are the same plants located in Italy, such as Verrone, Cento, Pratola Serra or Termoli;
- external suppliers: they source FCA with every kind of vehicles component, for example SAPA, BOSCH, VALEO, PRIMA, MAHLE, DENSO, RAICAM, GKN, etc.

In the following graph (Figure 2.14) are reported the major suppliers regarding a wider range of components supplied. The first position is occupied by ITW LYS FUSION SRL.

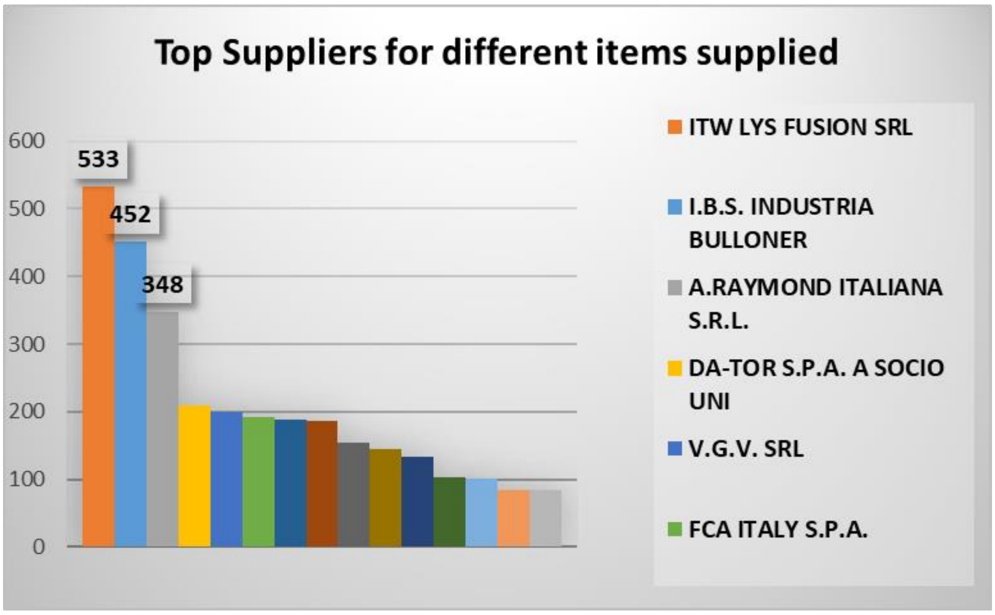


Figure 2.14 FCA Top Suppliers for different items supplied [Personal processing of FCA data]

2.5.3 Logistics Service Providers

In EMEA area there are five Export Consolidation Centres (Figure 2.15) respectively one in Poland, one in Turkey and three in Italy. Italian IRF Pole carries on his own business through two major third-party logistics providers, named BCUBE and Arcese-Syncreon, this last born from a joint venture between the carrier Arcese and the American company Syncreon, leader in warehouse management and integrated logistics. BCUBE and Arcese-Syncreon manage the items coming from the suppliers in their Consolidation Centre respectively at Villanova d'Asti (AT) and Cerratina (PE). According to the location of the customer's plant and to the specific needs of the items, logistics operators prepare the final loading unit, going to modify the packaging when necessary. In Nola (NA) there is also a Consolidation Centre which is used to store items, but it has a very small square footage when compared to other warehouses.

Figure 2.15 FCA Exportation Consolidation Centres in EMEA Region
[FCA Presentation]

In the following pie graphs (Figure 2.16) are shown the volumes shipped at the end of 2018 by the two logistics operators and it is possible to note that BCUBE sent more than half of the components inside EMEA Region, while Arcese-Syncreon operates almost only for NAFTA Region.

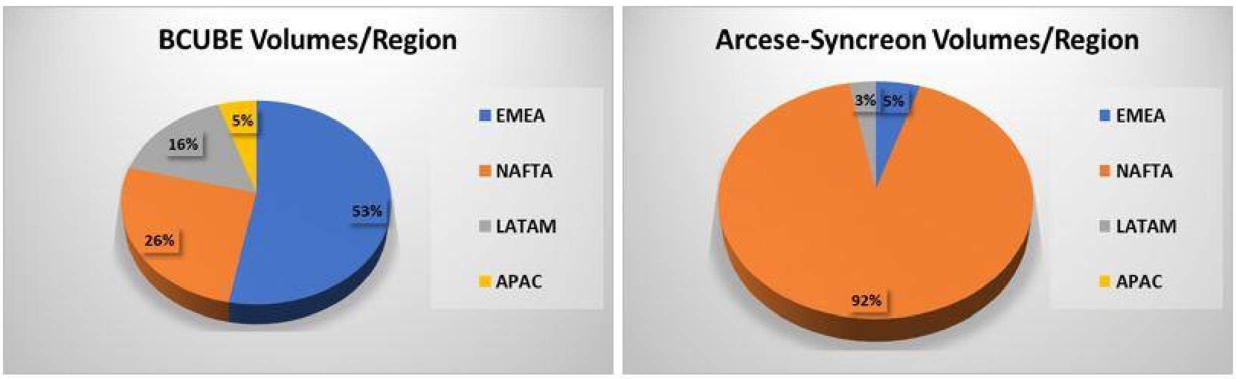


Figure 2.16 Volumes shipped per Regions by logistics operator [FCA presentation]

The activities carried out by the logistics operators are defined by the packaging cycles which are always validated by a specialist of IRF Packaging Team. A packaging cycle is always mono product: this means that the price for a single item is calculate supposing to put only one product inside a container. In practice logistics operators insert different items inside a rack because of the shortage of the volumes of some products and to prevent issues of insufficient saturation of the containers.

The purpose of the packaging cycle is to define:

- the operating mode, through detailed instructions and when possible with the presence of photographs or descriptive videos (the aim is to make sure that any operators can complete a packaging cycle, facilitating and accelerating the executives work);
- the processing times: it is fundamental to establish them because these times with the quantities of auxiliary materials define the total cost of re-packing a component. Sometimes an IRF technical expert goes to the ground and verify the packaging cycle through real empirical tests;
- the auxiliary materials used by the logistics operator for the creation of the packaging.

On these assumptions, FCA recognizes a cost to the logistics operator.

Logistics operator can exploit different processes to prepare the loading unit to be shipped to the customer's plant and they will be ordered from the one that brings a greater economic return to fall:

- **REPACK**: logistics operator intervenes on the product sent by the supplier, since the supplier's packaging is not structured for overseas shipment and therefore does not guarantee qualitative protection of the packaging. In this case, an ad hoc packaging is created for the shipment or simply the one sent by the supplier is completed with the addition of auxiliary material. Through contractual agreements, it has been established that every time the logistics operator carries out a repack on a package, the total responsibility for the quality of the package lies solely with the logistics operator. When we talk about repackaging, we should think that it is the activity that generates more cost because the supplier packaging is subjected to strong manipulation. The cost that FCA recognizes to BCUBE or Arcese-Syncreon is composed by the **handling** of the operators (calculated as the minutes spent to realize the packaging divided by the parts put in it), **materials** (the quantities of materials used for doing the package multiplicated for the specific cost established in the price list divided by the number of parts in the package) and **volume** (precisely the unit volume which is determined by the outer volume of the package divided by the number of parts in the package).

- **RACKING**: it is the transfer of the box into a specific cage (Figure 2.17), which can be made in metal or in wood. In this case, the types of cages can be divided into two main types: disposable, i.e. their task ends when they reach their destination, or returnable, i.e. they have the task of carrying out several round trips. In this transfer operation, the original box sent by the supplier is always kept and, this time, FCA recognizes to BCUBE or Arcese-Syncreon a cost which is only composed by **materials** and **volume.**

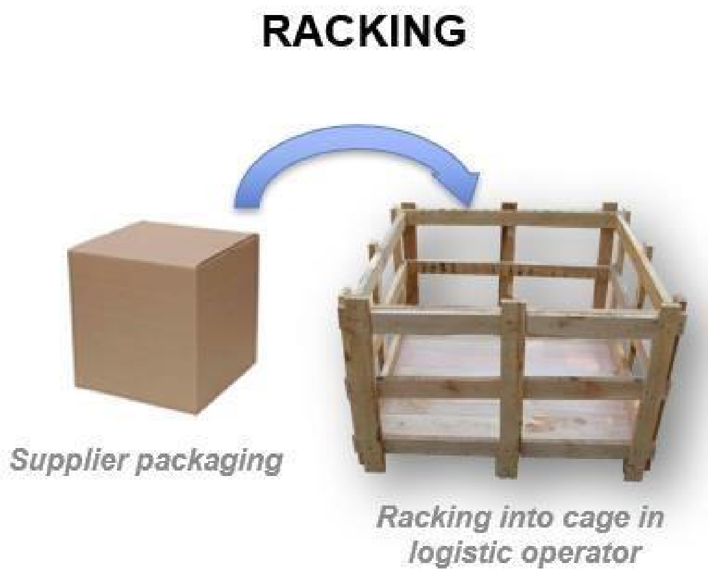


Figure 2.17 Example of Racking [FCA presentation]

This kind of process can be divided in four categories:

1. **Racking of Supplier Boxes**: it is the operation of putting the box made by the supplier into a cage of the logistics operator to be stored; this is the case where the supplier is equipped to ship the parts in a primary packaging suitable for overseas but it doesn't have high enough volumes to fill a cage and certainly not a container. In fact, in most of these situations, the boxes as they arrive from the supplier are transferred into a cage but together with other boxes from other suppliers in order to bring the cage to maximum saturation.
2. **Racking into Boxes:** this activity is conducted when the logistics operator takes the supplier's box and inserts this box into a larger box which in turn is inserted into the cage to be stored; the difference from the previous type of racking is that the supplier in this case is not equipped to provide primary packaging suitable for overseas so the logistics operator must take the boxes from the supplier and put them in a larger box designed by the logistics operator himself and clearly suitable for overseas.

3. **Racking with Extra Protection:** here the logistics operator opens the box that the supplier has sent, adds auxiliary protection material, closes the box and inserts it into the cage to be sent. This is the typical case where the supplier is not equipped with the appropriate auxiliary material to return an overseas package. Several times it happens that the cost required by the supplier to insert the auxiliary material is much higher than the cost of the same auxiliary material inserted by the logistics operator for a matter of economy of scale.
4. **Racking of Supplier Pallet:** this kind of racking requires that logistics operator puts the box made by the supplier and equipped with pallets inside the cage; the supplier can supply a totally overseas packaging with the limit that the volumes handled reach the completion of a single pallet.

- **CROSS-DOCK:** it is the activity carried on by the logistics operator when it is not necessary doing practically any work on the package supplied by the supplier, but only containerizing it in order to ship it to the customer plant. The only possible work to do on the packaging can be represented by reinforcement activities, without however intervening on the transported component, like in Figure 2.18. This is exactly the case when the supplier is equipped to create overseas packaging, but it is not able to saturate a container on its own because of the lack of programmed volumes. This is the most economic operation for FCA because, for establishing the cost to recognize to the logistic operator, the only entry is the **volume**.

Figure 2.18 Example of Cross-Dock [FCA photo]

2.5.4 IRF KPI

IRF relies on some Key Performance Indicators in order to determine to what extent its operational, tactical and strategical objectives are achieved (Figure 2.19). Among these indicators there are some standards shared at a global level and calculated by the IRF bodies of each Region; these indicators are weekly and are specific to each plant served by IRF. Then IRF also monitors more specific indicators that aim to assess in detail the criticality and impact, both immediately and in the weeks to come, on the different actors involved in the flow.

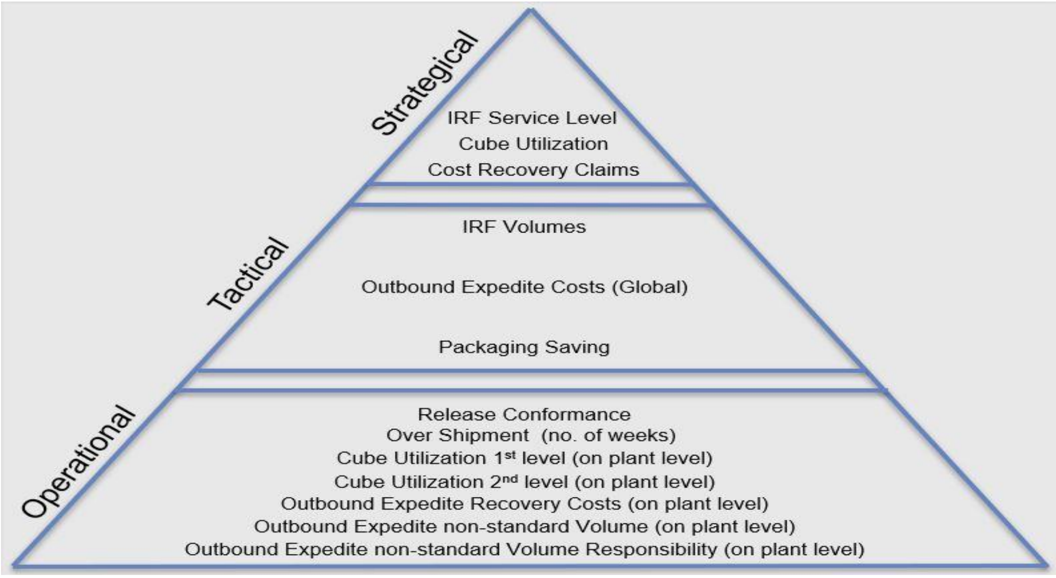


Figure 2.19 IRF KPI Pyramid [FCA presentation]

Every IRF Division monitors its own KPIs.

IRF Program Management controls:

1. **IRF Volumes & Major Clients**, tracking the shipped total volumes of each region managed by IRF monthly. Figure 2.20 shows that the major Client is Saltillo (Mexico) and, thanks to this plant, the largest volumes are shipped to NAFTA Region.

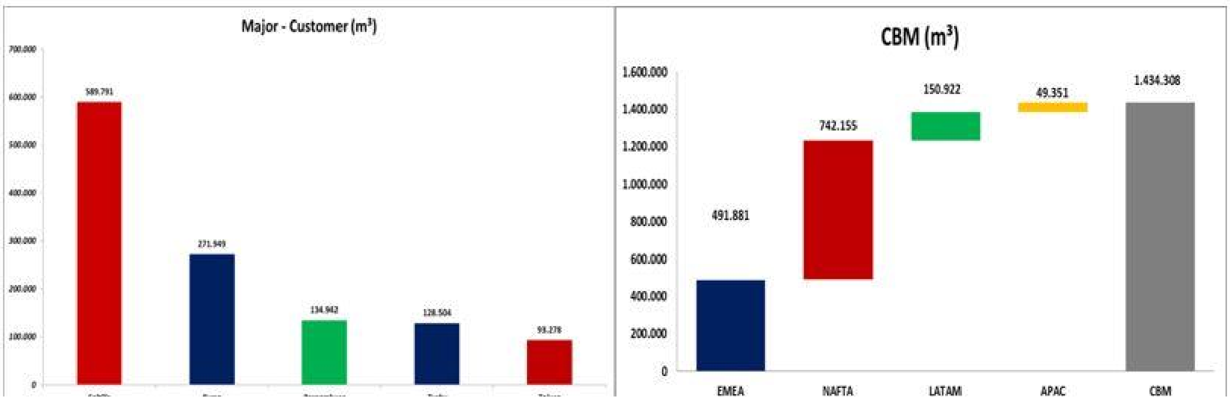


Figure 2.20 Major Clients & IRF Volumes per Region at the end of 2018 [FCA presentation]

2. **Outbound Expedite Costs**, measuring the costs for nonstandard shipment monthly, calculated for each plant supplied by IRF. Figure 2.21 allows to understand that TOFAS is the customer plant with the most frequent and higher nonstandard shipment costs.

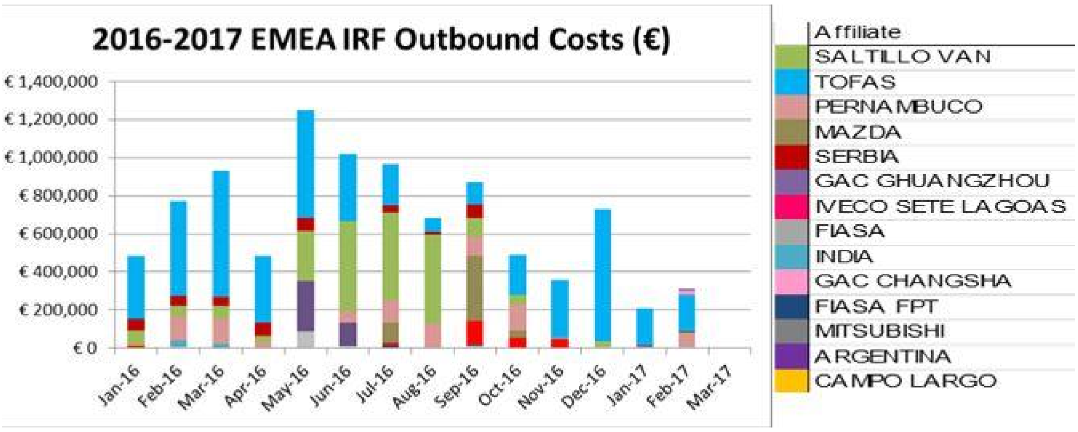


Figure 2.21 Clients nonstandard shipment costs from January 2016 to March 2017 [FCA presentation]

3. **Outbound Expedite nonstandard Volumes, Responsibility and Recovery Costs at Plant level**, monitoring the rate of nonstandard shipped volume compared to total volume shipped, calculated for the six major plants supplied by IRF monthly and considering the rate of recovered costs for nonstandard shipments that are under the responsibility of the supplier/client monthly and the Pole's ability to recover costs weekly, calculated for every single plant supplied by IRF. Figure 2.22 displays that nonstandard volumes are nearly 20% of the total shipped whose liability is due to the customer in most cases and that Pole is very skilled in recovering costs.

Figure 2.22 Responsibility for nonstandard volumes shipped and recovery costs rate [FCA presentation]

For its part, IRF Operation checks:

1. The **Service Level at Plant level**, which measures the rate of materials shipped on time compared to the materials required by the customer plant program weekly and the **Service Level at Global level**, weighted on average of the major plants managed by

IRF (6 of 25 plants responsible for about 90 % of the shipped volume) always weekly. Figure 2.23 shows that target is 80% and, in most cases, materials arrive on time.

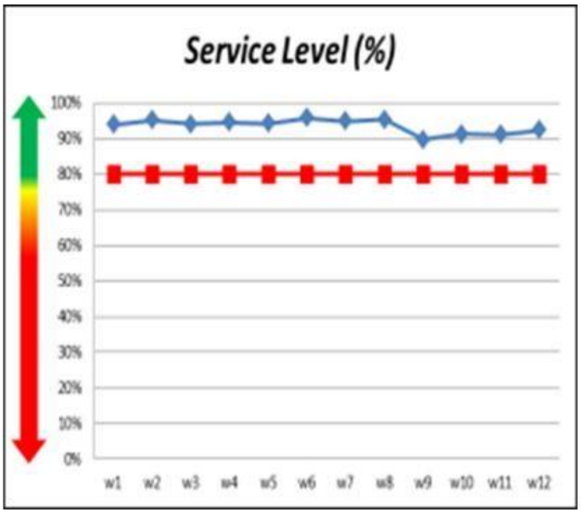


Figure 2.23 Rate of Plant Service Level [FCA presentation]

2. The **Release Conformance**, which estimates the stability of the programs sent by the customer plant weekly: it is a KPI that measures the ability of the plant to make long-term production forecasts reliable. Figure 2.24 demonstrates that it is not always easy to foresee how many vehicles plant must produce, and that demand can variate from a week to another.

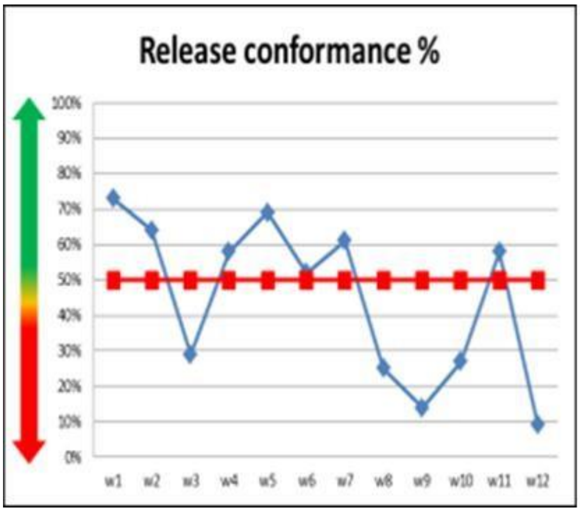


Figure 2.24 Rate of Release Conformance [FCA presentation]

3. **Over Shipments:** this KPI is a measure, expressed in equivalent weeks, of the advance in the shipment of materials to the customer plant. In the automotive sector, it is very important to receive exactly the amount of material required, because in this case the amount of capital blocked increases exponentially. Figure 2.25 explains that many times materials arrive to the customer plant sooner than necessary, creating overstocks.

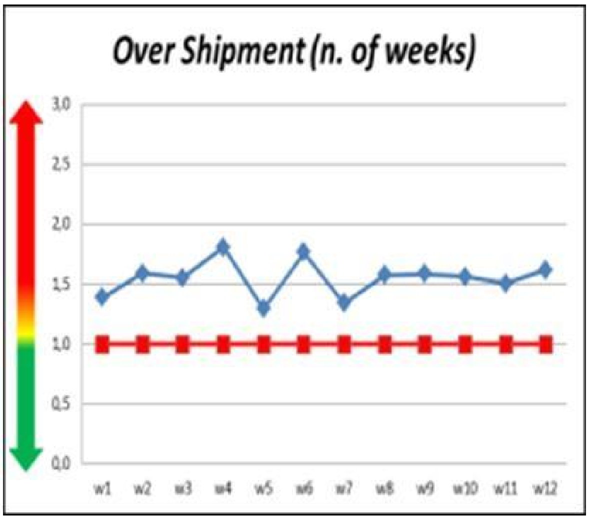


Figure 2.25 Rate of Over Shipments [FCA presentation]

Instead, IRF Quality supervises the **Cost Recovery Claims**:

1. at **Global level**, measuring monthly the rate of the value of claims against FCA suppliers issued by IRF customer plants which have been recovered by IRF team. Calculations are referred to claims issued 60 days before.
2. at **Plant level**, the same calculations were made but weekly and for every single plant supplied by IRF.

The Cost Recovery Claims calculation is composed by the **total value of claims which have been recovered by suppliers** divided per the **total value of claims issued by the customer plants** which is being subtracted from the **total value of claims which have been rejected** due to different reasons (e.g. lack of information uploaded by the customer plants..), from the **total value of claims for which the suppliers have shown to be not responsible** for the issue and the customer plants have accepted their request and from the **total value of claims not chargeable to suppliers** due to different reasons (e.g. critical suppliers). Figure 2.26 exhibits in the first pie graph that averagely more than one third of the SQP Tickets (SQP stands for Supplier Quality Performance), opened with a claim from the Client, are chargeable to suppliers and in the second graph shows that 80% of the time IRF Quality can recover costs.

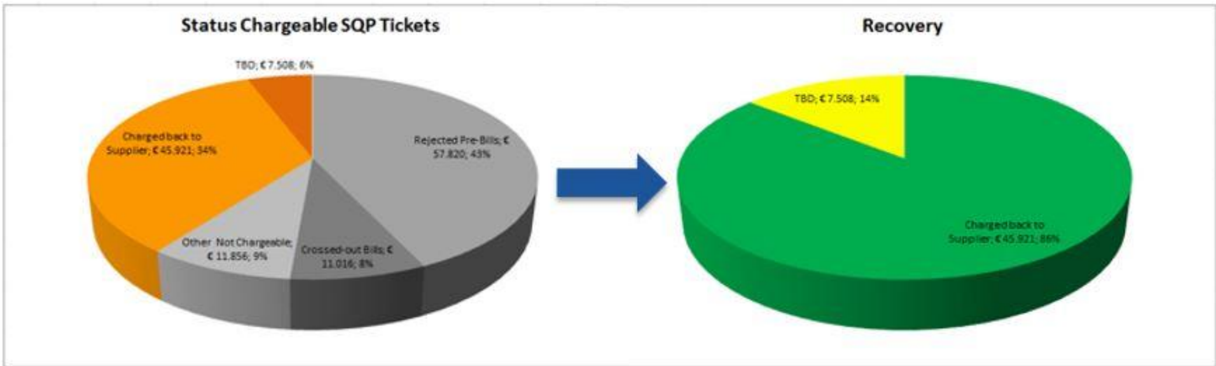


Figure 2.26 Rate of Chargeable SQP Tickets and their rate of Recoverability [FCA presentation]

Finally, IRF Packaging manages other three KPIs:

1. **Packaging Saving**, measuring monthly the effective economical saving due to improvements regarding the change of the container, the modification of the material used or even the change of packaging operation with the reduction of ECC's handling costs. It is calculated through the difference between the old and the new unitary packaging cost multiplicated per annual volumes of the item. Figure 2.27 displays the increase and the accrue of the packaging saving during the year due to the implementation of the projects, realized in collaboration with suppliers and the logistics service operation.

Figure 2.27 Cumulate Curve of Packaging Saving during the year [FCA presentation]

2. **Cube Utilization - 1st level**: this KPI is usually calculated monthly for both ship and train shipments (Figure 2.28 / 2.29) and is divided in:
   - Flow KPI, measured for each flow, is the average of Cube Utilization for each container shipped for the specific flow.

- Global KPI: average of Flow KPIs measured for each material flow weighted on volumes shipped.

Target is 90% both for Flow KPIs and Global KPI.

TRAIN						
	week	Serbia	Poland			
June	23	80,2%	46,4%			
	24	78,3%				
	25	85,8%	81,3%			
	26	83,1%	72,1%			
	Monthly Average	81,9%	66,6%			
	TARGET	**90%**	**90%**		GLOBAL KPI	81%
	Monthly Volumes	**5571**	**442**		TARGET	90%

Figure 2.29 Flow & Global KPI using train to ship materials [FCA presentation]

SHIP										
	week	Betim	Pernambuco	Guangzhou	Toluca	Saltillo	Tofas			
June	23	83,5%	85,8%		87,8%	88,9%	84,4%			
	24	90,5%	88,5%	29,6%	85,5%	89,0%	86,3%			
	25	76,7%	87,6%		88,5%	88,0%	84,5%			
	26	84,7%	86,7%		91,1%	88,5%	85,5%			
	Monthly Average	83,9%	87,1%	29,6%	88,2%	88,6%	85,2%			
	TARGET	**90%**	**90%**	**90%**	**90%**	**90%**	**90%**		GLOBAL KPI	87,9%
	Monthly Volumes	**528**	**9957**	**8,755**	**4684,557**	**48229**	**9644**		TARGET	90%

Figure 2.28 Flow & Global KPI using sea containers to send items [FCA presentation]

3. **Cube Utilization - 2nd level** shows in which way the rack is saturated (Figure 2.30). This value is manually measured by the logistics operators as the average saturation of twenty racks chosen randomly between those shipped in the considered month. The main aim is the assessment of the Logistics Service Provider on mixing supplier boxes, so the activities of cross-dock and repack are not considered, but exclusively racking. Target is 80%.

Figure 2.30 Examples of rack saturation [FCA photo]

3 IRF Work Clusters Overview

IRF Packaging team works with a continuous improvement approach and it has established five different work clusters where it is possible to enhance the performances of the IRF process. Clusters are specific macro-areas of work and are divided for the different way of obtaining savings through FCA supply chain. They are:

1. Packaging Optimization.
2. Packaging Supplier Base Re-Engineering.
3. Network Optimization.
4. Cube Utilization Improvement.
5. Returnable Rack.

Every work cluster has its own specific method to improve IRF processes, but all have in common the target of lowering the FCA costs, augmenting the parts shipped per box and per means of transport, finding new competitive suppliers, implementing returnable containers or still uncovering better routes to ship the items.

So, this chapter will be divided in five sub-sections which will start with broad descriptions of the work cluster and then some of them will introduce real business cases. For the record, the chapter will show:

1. a business case in which the primary packaging saturation will be improved for Packaging Optimization cluster;
2. some business cases in which the logistics flows of material shipped from supplier to the customer plant will be enhanced with the application of the Direct Shipment for Network Optimization cluster;
3. a business case where there will be an advantage over the cost of transport concerning Cube Utilization Improvement cluster.

However, every work cluster will be explained as clearly as possible, but before going deeper into these activities, it is still necessary to make a quick excursus aimed at describing what the FCA packaging process consists of and it will be described in the next Section.

3.1 FCA Packaging Process

Remembering that the packaging cycle is performed by logistics operators with the activities of repack, racking or cross-dock, as described in Section 2.5.3, this sub-section has the objective to clarify the procedure to be followed when proposing a change of packaging.

Usually the process starts with an analysis by market: this method identifies the part numbers on which to intervene, analysing individually the market (NAFTA, LATAM, EMEA or APAC). IRF Operation is used to receiving the production planning by the customer plant every week, so by downloading the materials data from the Enterprise Resource Planning (ERP) (FCA uses the German software SAP), it is estimated how much volume of material is shipped and how much it costs that volume itself. Afterwards it is possible to identify different macro groups of part numbers having the higher value, creating an "ABC" matrix using the Pareto technique [17]. This is the first step and serves to limit the range of action, in fact, as stated at the beginning, the IRF Division manages about 12,000 components and it would be absurd to think of building an action plan that would go to touch all the part numbers shipped.

When it is established the part number on which operating, the first step to do for IRF Packaging team is to contact the relative supplier in order to acquire the current packaging data through the compilation of the International Packaging Data Plan (IPDP) (Attachment 1). This data sheet is used to confirm shipping volumes and identify any potential concerns prior to the potential shipments. In this document there are all the information about the conditions of supply in inbound towards Logistics Services Provider or the final conditions of supply in case that supplier ships items to customer plant directly, such as:

- photos (Item, internal container and complete unit load/pallet)
- information about the component (size, weight, classification, material type and type of protection)
- primary container information (container element, container type, container dimensions, density (parts/carton), tare weight (empty carton), gross weight (loaded carton), interior dunnage material type)
- unit load information (pallet type, pallet element, pallet dimension, cartons per layer, layers per pallet, unit load density (total parts/pallet), unit load dimensions, unit load stack height (maximum), banding type).

Consequently, IRF Packaging team discusses and analyses the possible technical improvements/modifications to the present packages during the “Technical Table” meetings, which generally take place every two weeks on Wednesday, with both logistics operators, separately. If on the one hand IRF has the advantage of receiving and processing the first real feedback from the plant customers about the quality of the packaging in case of experiments and trial shipment, on the other some activities are also presented by the logistics operators because, working on the field, are those who had the most immediate feedback from the operators. Thanks to their experience, they can also provide very important information regarding the ergonomics of operations or the ease or not of manipulating components and packaging.

In the technical table, IRF Packaging and the Logistics Services Provider evaluate the technical and economic feasibility of the proposal and the timing and modalities of implementation and for each change of packaging, logistics operator compiles the Quick Kaizen form agreed, inserting both the technical and the economic information for the old and the new packaging solution highlighting the relative saving, which is divided between the parties as declared from contractual agreements.

Finally, IRF Packaging informs the Procurement Department of the saving obtained and the new quotations of auxiliary materials to negotiate with BCUBE or Arcese-Syncreon, mentioned in Section 2.5.3.

As regards the development of new packaging solution, there are five phases to implement:

1. DESIGN: the initial design is derived by using both product math data and physical parts to create a CAD drawing. Standard export and import packaging guidelines are used to establish a baseline packaging footprint. Packaging is designed in order to protect the part, be ergonomically friendly and fully utilize the shipping container.

2. PROTOTYPING and PART FIT: during this operation the physical prototype is built, and physical parts are tested for fit prior to creating the tooling for production packaging, as shown in Figure 3.1.

Figure 3.1 Example of item fitting [FCA photo]

3. TESTING: Prototype packs are subjected to static tests at supplier warehouse using various machinery designed to simulate the transportation environment. The "Shake Table" as can be seen in Figure 3.2 is one of the most common tests used which simulates the truck and ocean transit. Other tests include the impact compression tests to determine stacking and load capability and shock tests to assess drop and impact during handling.

Figure 3.2 "Shake Table" test [FCA photo]

4. CUSTOMER SIGN-OFF: before doing the test shipment, there is a review of the packaging between provider and the customer in which the parts are pack out to ensure the design meets the customer requirements (safety, quality, ergonomics, line-side and delivery). Therefore, the provider gives to the customer the Unit Load Data (ULD) Sheets with load

and unload information. This phase allows for all parties to be involved and provide feedback before production.

5. VALIDATION: the prototype packaging is loaded at the supplier and shipped to the customer plant. Any parties involved in the process, such as the packaging provider, supplier, program management or quality are encouraged to attend the review from the customer plant through a check list (Figure 3.3). Any issues noted are corrected and evaluated prior to establishing the tooling for production packaging. For validation, FCA requires the success of three test shipments with different containers.

#1 Check-list (Customer Plant)			**Case nr.:**	
Question	**YES**	**NO**	**Remarks**	**Validated by**
Rusted material		X		
Collapsed material		X		
Material with dent, deformation, damage		X		
Package collapsed without affected material		X		
Package in wet condition		X		
Others (issue description)		X		

Figure 3.3 Example of Validation check list [FCA file]

This process is followed every time to ensure part protection and cost effectiveness.

After this general overview on FCA packaging process, five paragraphs will be introduced in order to explain broadly the activity carried out in the work cluster and according to the circumstances a business case will be inserted and specified.

3.2 Packaging Optimization

Packaging Optimization is achieved with the aid of the Logistics Service Provider, conducting technical evaluations:

- on the auxiliary materials, used for realizing the package and sometimes in order to fortify it, finding cheaper solutions on the market or removing them when they are not mandatory for the safeness of the package;
- on the packaging dimensions, trying to find a standardized solution that could be used for multiple items. The dimensions should be chosen in order to maximize the number of items insertable in the packaging, respecting the weight constraint;
- on the packaging materials, switching from cardboard to wood or from wood to plastic or metal. This action could bring optimization in the weight of the packaging solutions;
- on the type of the activity performed by the logistics operators during the packaging cycle (repack, racking or cross-dock), trying to switch from the first activity to the last one to lower the cost that the FCA must recognise to them;
- on the handling time, spent from the operators to make the units to shipped, verifying with a technical expert if the times declared in the packaging cycle file from the logistics operator are real, taking account of a certain tolerable variation with a maximum of 5%;
- on overseas protections, considering the significant temperature and humidity variations that might occur throughout the logistic flow, because when a component must be sent from a Region to another, with long shipping times, could reached the customer plant, ruined by corrosion/oxidation phenomena.

In the next subchapter, it will be introduced a business case in which the IRF Packaging team attempted to increase the number of components inside a package in order to increase second level saturation.

3.2.1 External Upper Front component

This action of packaging improvement is born during an inspection at BCUBE Consolidation Centre in Villanova d'Asti. IRF Packaging team was located at the logistics operator's warehouse in order to check the duration of a packaging cycle, when it has been noticed that the box saturation could be augmented and, consequently this packaging upgrade, it will be possible to obtain an economical convenience and a better saturation of the packages.

3.2.1.1 AS IS situation

The business case regards two parts shipped from Mirafiori plant in Turin to Saltillo plant in Mexico. In Villanova they arrive inserted in a normalized metal container of dimensions 2210x1700x880 mm with a density of 52 parts. The items cross BCUBE Consolidation Centre and they are processed through a repack activity, because for example they need an addiction of extra protection material like VCI or desiccant bag for an overseas transportation in order to not reach the customer plant with problems of corrosion. Here, the components are positioned in a disposable cardboard box, called 50010294, of dimensions 2260x1143x1280 mm with a density of 36 parts. Figure 3.4 shows how the items are arranged in the racks and the pace between each of them.

Figure 3.4 Placement of parts in the box [FCA photo]

Nowadays the packaging cycle conducted by the operators is:

1. opening the Inbound container and checking the status of the items;
2. obtaining the necessary material for packaging: n°1 cardboard box and n°1 wooden footboard;

3. applying on the side of the box an envelope containing coupons and poster (lot, reference, destination);
4. cutting a sheet of polythene VCI of dimensions 5500x3600 mm from the reel enough to cover the cage and cover it internally, as it is possible to see in Figure 3.5;

Figure 3.5 Laying of a VCI sheet into the box [FCA photo]

5. picking up and placing items in the locations of the racks inside the packaging;
6. cutting to cage plane size and inserting a VCI sheet of dimensions 980x2250 mm above the components, as exhibited in Figure 3.6;

Figure 3.6 Laying of VCI sheet above the items [FCA photo]

7. closing the polythene by taping;
8. opening the upper box, removing its panel and positioning it at line edge;

9. storing the opened upper box on the lower one and inserting items as done with the lower box, as displayed in Figure 3.7;

Figure 3.7 Placement of upper box [FCA photo]

10. relocating the panel in the inserts;
11. cutting and placing n°1 sheet of black polythene of dimensions 2600x1800 mm and scratching it on the lid;
12. taping the lower edge of the black polythene on the cage;
13. positioning protection angles and carrying out n° 2 vertical strapping;
14. applying envelope containing coupons and poster (lot, reference and destination) on the side of the box;
15. Cleaning and tidying up of the workplace;

After having outlined a technical overview of the packaging cycle, it is important to describe how the saturation calculations have been made up. These mathematical steps will be utilized also for the next business cases in Sections 3.4.2 and 3.5.1. In any cases it has been helpful to assess the best way to load the secondary packaging in the tertiary one (these two concepts are well explained in Section 1.2).

In all Tables of Section 3 which will show how many packs can be load in sea-containers or in trucks, calculations have been achieved with two arrangements which are shown in Figure 3.8:

A. Loading the secondary packaging lengthways in the sea-container/truck
B. Loading the secondary packaging crosswise in the sea-container/truck

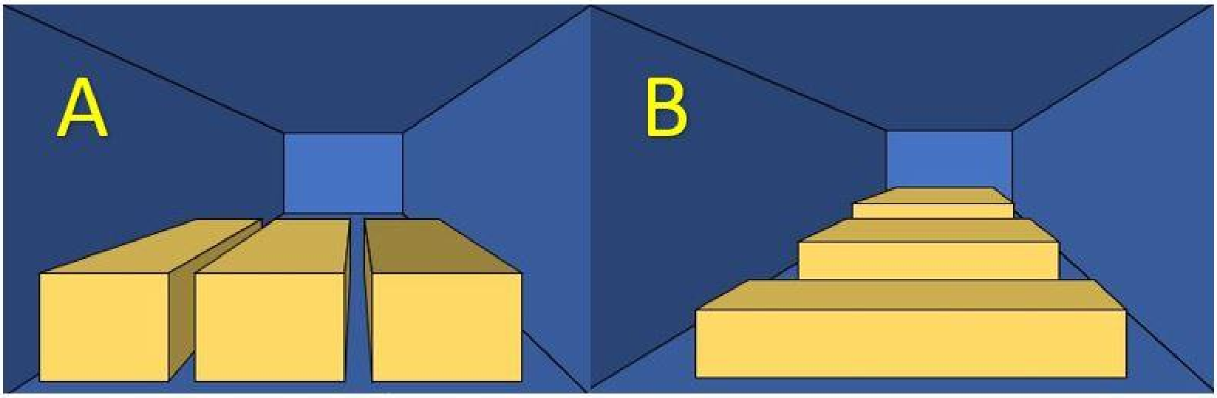


Figure 3.8 Loading modes

In Table 3.1 are calculated the potential boxes for sea-containers with dimensions of 2350x12000x2580 mm (Width, Length, Height).

Table 3.1 Potential boxes inserted in a sea-container [Personal processing of FCA data]

	Width (mm)	Length (mm)	Height (mm)	BOX / SEA-CNT
A	2350	12000	2580	**20**
	2260	1143	1280	
	1,0398	10,4987	2,0156	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOX / SEA-CNT**
	2350	12000	2580	**20**
	1143	2260	1280	
	2,0560	5,3097	2,0156	

The Table calculates how many boxes can be inserted in a sea-container, loading the boxes in the ways explained before and approximating the findings per defect. The findings are the same with either of the two arrangements, i.e. 20 boxes per sea-container, and so 720 items can be shipped.

The analysis is made on the price list that IRF pay to the logistics operator for the packaging and today the activity carried out by BCUBE is repack. As explained in Section 2.5.3, the total unitary cost of the parts is determined by the sum of:

1. the volume cost, which is calculated with the external dimensions of the pack (for 50010294 boxes is 2.260x1.143x1.28 m = 3,3065 cubic meters) and this value is divided by the number of the items into the rack (36 parts). In this way it is possible to get the value of the unitary volume in cubic meters that must be multiplied with two fix prices specified in the contract with the logistics operator, that for reasons of secrecy it is not possible to describe in detail into the thesis;
2. the material cost, which is calculated multiplying the total number of materials that are used for doing the package and the cost of this material specified in the price list of the logistic operator;
3. the handling cost, which is calculated multiplying the total time (in minutes) used for doing the package and the hourly rate specified in the contract with the logistics operator and dividing the entire expression by 60 for changing the rate in minutes.

For AS IS situation, the unitary cost is taken from the price list directly and it is worth 7.84 €/part. To these typologies of cost, it is necessary to add the expense for the transport. The transportation cost is established by FCA in agreement contracts with carriers. The Company has arranged a value for any routes and for every means of transport used. So, considering this new cost, it is necessary to take the established one for Saltillo route from BCUBE and dividing it per the total items shipped in a sea-container (720). The final part price is the sum of these two values, and it is 11.94 €/part. Table 3.2 illustrates the calculations already stated.

Table 3.2 AS IS Calculations [Personal processing of FCA data]

CLIENT	ACTIVITY	PART / BOX	BOX / CNT	PART / CNT	€ / PART (HANDLING + AUXILIARY MATERIAL + VOLUME)	€ / PART (TRANSPORT)	TOTAL € / PART
SALTILLO	REPACK	36	20	720	7.84	4.10	11.94

3.2.1.2 TO BE situation

IRF Packaging team and logistics operator have decided to reduce the original step of 115 mm between components because they believed that it was possible of inserting more items in each pack. Given the shape of the parts, the main issue was to establish a step that would have allowed to insert and extract the parts without them touching each other during the packaging cycle, but also in the transport. Noticing the line drawn on the cardboard, as displayed in Figure 3.9, IRF Packaging team proposed a packaging with a step of 80 mm in order to insert the maximum number of items in the box, while logistics operator a step of 95 mm aiming to be more prudent.

Figure 3.9 Dimensions of the original step between items [FCA photo]

Hence, the supplier has been contacted and has realized the two prototypes proposed. When the packaging has been realized by supplier and delivered to Villanova d'Asti, IRF team with one BCUBE executive tested the new packaging and it has been established that the prototype with a step 80 mm do not cause any quality problems to the parts inside of it.

In Figure 3.10 it is possible to see the difference of the steps in the old and in new agreed solution.

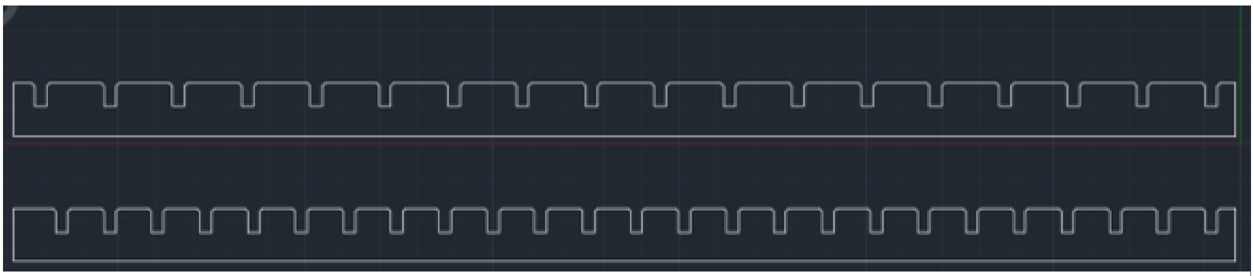


Figure 3.10 Steps Math [FCA file]

As exhibited above, the number of parts inside a box passes from 18 to 25 with the improved step and so the quantity of items increases from 36 to 50 in the complete packaging.

Assuming always the usual dimensions for the sea-container, the saturation of the first level improves from 720 parts a sea-container to 1000 items, given the 20 boxes loadable.

The total unitary cost of the parts is always achieved adding the usual three entries of cost:

1. the volume cost, which is always calculated multiplying two fix prices specified in the contract with the external dimensions of the rack, obtaining a value which is divided by a major number of items inside the box (50 parts). In this way, there is a reduction of the volume cost;
2. the material cost, which is supposed to be constant concerning the old solution and so there are not cost reductions;
3. the handling cost. During the relief, the activity of putting an item inside the box has been timed and its average duration is 0.3342 minutes. The calculation starts using the old cost multiplied per 36 items and, adding to this, the time measured multiplied per 14 items and per the hourly rate divided by 60 for changing the rate in minutes. Finally, the entire expression is divided per 50, that are the number of items inserted in the new packaging.

For TO BE situation, the unitary cost is composed by the three entries already explained added together for a total 5.68 €/part. The transport cost, as in AS IS situation, is a confidential data and it cannot be shared in the work of thesis, but it is calculated on the total of items shipped in a sea-container (1000). Also, this typology of cost is decreased compared to the AS IS situation because of the increasing of parts shipped. The final part price is the sum of these two values, and it is 8.63 €/part. Table 3.3 exhibits the calculations already described.

Table 3.3 TO BE Calculations [Personal processing of FCA data]

CLIENT	ACTIVITY	PART / BOX	BOX / CNT	PART / CNT	€ / PART (HANDLING + AUXILIARY MATERIAL + VOLUME)	€ / PART (TRANSPORT)	TOTAL € / PART
SALTILLO	**REPACK**	**50**	**20**	**1000**	**5.68**	**2.95**	**8.63**

3.2.1.3 Analysis of Results

With the implementation of the new solution, IRF Packaging team achieves a growth of 38.8 % in the saturation of the box and consequently also in the saturation of the sea-container because the boxes loaded do not vary. Given the potential reduction in the transportation cost, this business case could also represent a Cube Utilization work, but it was explained in this Section because the major saving is due to the Packaging Optimization. In fact, concerning numerical terms, the increasing of items shipped involves a reduction of 1.15 €/part in the transportation cost (outbound) and a saving of 2.16 €/part regarding the activities carried out by the logistics operator. Adding up the last two values, the final total gain is worth 3.31 €/part with a reduction of the total cost of 38%. Considering that the planned quantities of the two components involved are nearly 50 thousand at year each, the potential cumulated saving can reach around 330,000 €. Splitting up the saving, already calculated, it is realized a packaging saving of 216,000 € and transportation saving of 115,000 € that usually is turned to the region of the customer plant.

Finally, it is important to remember the timing of the project in order to comprehend the duration of the tasks. It is started at the end of January 2019 and during February the supplier has realized the prototypes. At the beginning of March IRF Packaging team with the support of supplier and logistics operator specialists has tested the new packaging with optimal results. Afterwards the packaging is shipped to the customer plant. The delivery in sea-container from Italy to Mexico lasts a month and FCA usually undertakes a new packaging to three test shipment with different sea-containers. The customer plant evaluates the quality of the items and gives back to IRF a technical feedback. In case all the tests should fit, IRF will show the proposal to the Purchasing and Contracting departments which revise the new proposal under an economical prospective. At the end of May, no feedbacks were yet going back to IRF and considering the summer holidays, it is possible that the project will be achieved not before than the end of September.

3.3 Packaging Supplier Base Re-Engineering

Packaging Supplier Base Re-Engineering is activity conducted by IRF Packaging team along with the Purchasing department at firm macro-level in order to identify competitive solutions and savings opportunities. The scope of this work cluster is developing a Market Analysis through the design of the current competition of Direct Procurement Packaging which is the purchasing of packs in large quantities from a group of suppliers at the best possible cost and quality [18].

Usually it is carried out through long-term projects, scheduled in four phases:

1) RFQ, i.e. request for proposal to several competing suppliers to obtain offers of services for which, in any case, not only a quotation but also other technical details identifying the object of the supply are required. During this phase is defined the scope of the work, are established Line Up meetings, in which parties can clarify any doubts, is occurred the concept development and is stipulated a preliminary quotation by suppliers and, lastly, FCA does his own cost analysis and creates an associate supplier list.
2) During the following phase a selection of suppliers, that meeting FCA parameters, build the prototype, tries to fit the relative reviews and consequently conducts tests on the prototype and its trail shipment. As been said in Section 3.1, if the affiliate feedback result to be positive, there is the packaging validation.
3) The next step of the project is Sourcing. It is not only operational but also strategic. One thing is to buy with the aim of spending little, another is to buy well, i.e. to understand the purchase as a complex process and an integral part of the corporate culture. During this phase, supplier recommends and selects what is best for FCA which in turn creates contracts in order to approve the flow. In addition to these prerogatives, supplier provides all the information and data required by SAP system of FCA and, only then, the issuance of the purchase order occurs with types, quantities and agreed prices.
4) Timing which is divided between the time spent in ordering materials negotiated and the time required to deliver these to Consolidation Centre.

This work cluster will not be faced in more detail because it is not possible to describe company information of a higher level.

3.4 Network Optimization

This work cluster faces the challenge of improving the flows between suppliers and customer plants and there are two main strategic choices for changing the network:

- The modification, in agreement with the supplier and with the Purchasing department, of the conditions of supply both as regards the Minimum Order Quantity (MOQ) and about the INCOTERMS (contraction of International Commercial Terms), which are explained in Section 3.4.1. Varying these two parameters, it is possible to develop a cost saving aspect called "Milk Run" [19], a strategic delivery method for mixed loads from different suppliers, like the implemented by i-Fast. Milk Run is a concept applied in the management of raw material collection logistics from suppliers: delivery is based on a pre-established timing and not on actual use.
- The modification, with the availability and the aid of the supplier, of the packaging. Thanks to this arrangement, it is feasible to bypass the logistics operator in the supply chain taking advantage of the so-called Direct Shipment which is a delivery scheme that reduces transportation and storage costs but requires additional planning and administration. This is the case in which, through several years of experience, the supplier makes himself available to create a package dedicated to overseas shipments in such a way as to eliminate a passage of the supply chain (i.e. the transition from the logistics operator) and an important cost saving is induced. This type of solution, however, depends also on the volumes that the supplier can send to a specific customer plant because the cost saving conditions are created only in cases where the supplier is able to constitute a perfectly saturated whole container.

The main benefits of switching from normal flow to direct shipment are:

- Reduction of transport costs: clearly there is no savings on the main transport cost (e.g. EMEA-NAFTA) but a saving in the internal transport cost since the items have not to pass through the logistics operator anymore.
- Elimination of double movement of the components with consequent reduction of quality risk: among the variables that must be numerical, there is also the percentage of discarded parts because of the various movements.

- Elimination of handling costs: once direct shipment is implemented, FCA does not pay anymore the normal activity carried out from the logistics operator.

Nowadays IRF Division has implemented several direct shipments from EMEA to all other regions, instead of using the normal flow through the Consolidation Centre. The percentages of these two typologies of shipments are indicated in Figure 3.11:

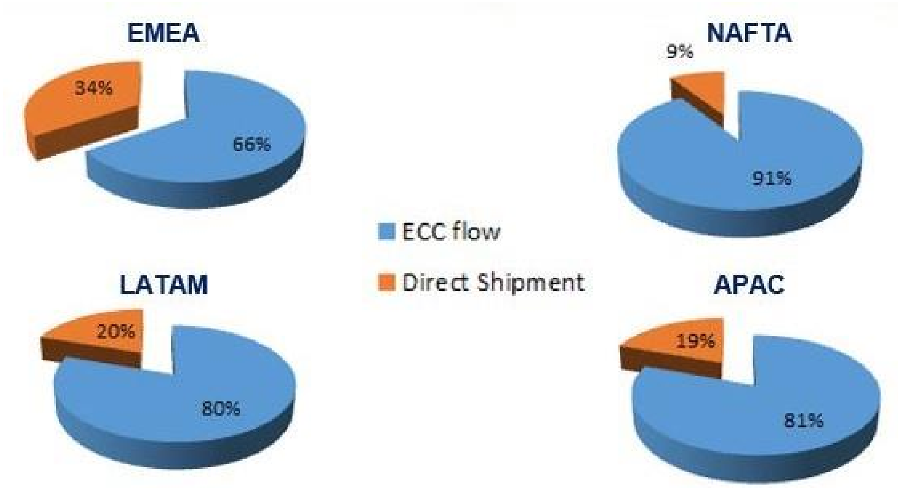


Figure 3.11 Consolidation Centre vs Direct Shipment Flows [FCA presentation]

At macro level, instead, Direct Shipment is implemented for the 19% of the materials shipped from IRF Italy polo against the 81% managed through the logistics operators, precisely a 43% of materials is shipped by BCUBE and the remaining 38% by Arcese-Syncreon.

Since INCOTERMS were previously mentioned, let's open a short parenthesis on them precisely because they are varied in the two business cases of Direct Shipment, outlined in Section 3.4.2.

3.4.1 INCOTERMS Overview

INCOTERMS are a series of terms used in the field of import and export worldwide and are fundamental to define in a univocal manner and without possibility of error any right and duty competent to the various parties involved in a transfer of goods among Countries [20].

Analysing FCA databases, it has been possible to understand that the INCOTERMS utilized in Company shipments are mainly these five:

1. EXW which stands for EX-Works and implies that the seller delivers the goods by making them available to the buyer at his own premises (factory, factory, warehouse, etc.). The seller is not obliged to load the goods onto the collection vehicle or to clear them for export if such customs clearance is required. The transport cost is charged on the buyer.

2. FCA, i.e. Free CArrier and means that the seller delivers by handing over the goods to the carrier or another person designated by the buyer at his premises. FCA requires the seller to clear the goods for export. The transport cost is charged on the buyer in this case too.
3. FOB which means Free On Board and may be used only for sea or inland waterway transport. It involves that the seller delivers by placing the goods on board the ship designated by the buyer at the named port of shipment. The responsibility of the risk of losing or damaging the goods passes on the buyer when the goods are on board the ship and he bears all costs from that time onwards. Like FCA, FOB requires the seller to clear the goods for export. The transportation cost is divided between seller and buyer.
4. DAP: Delivery At Place means that the seller makes the delivery by placing the goods at the disposal of the buyer on the means of transport of arrival ready for unloading at the agreed place of destination. The seller bears all risks associated with the transport of the goods to the named place. DAP, instead, requires the seller to clear the goods for export but not for import into the third country and, in this case, the big part of the transportation cost is borne by the seller.
5. DDP, i.e. Delivery Duty Paid and entails that the seller delivers the goods by making them available to the buyer on the arriving means of transport ready for unloading at the named place of destination. The seller bears all costs and risks associated with the transport of the goods to the place of destination and has the obligation to clear customs not only on export but also on import, to pay any fees for both export and import and to complete all customs formalities. With this INCOTERM the seller has the all shipment liability pretty much.

Applying the INCOTERMS logic to the supply chain managed by IRF, the seller is represented by the supplier and the client by the customer plant. In EMEA Region the transport to the logistics operator is managed by i-Fast Container Logistics, an FCA subsidiary. This Division, in fact, is responsible for running the transportation of returnable containers all around EMEA Region by road carrying out the so-called Milk Run between suppliers and customers plants.

When a direct shipment is implemented, IRF performs an operation called TRIANGULATION because the material never transits physically under the jurisdiction of FCA but only virtually.

It is as if during the physical journey leading from the supplier to the customer plant, the items made two changes of ownership instead of just one, i.e. from the supplier to IRF and from IRF to the final plant. Here Figure 3.12 is a schematization of the triangulated flows.

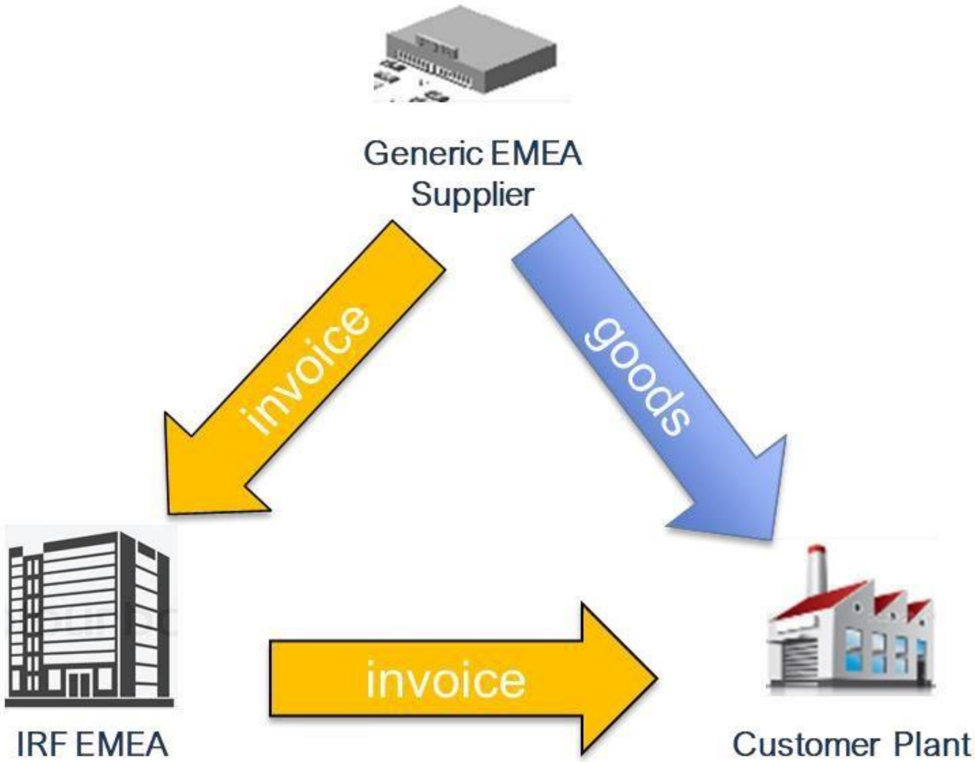


Figure 3.12 IRF Triangulation [FCA presentation]

Once understood the meaning of INCOTERMS, it is feasible going deep into business cases relative to this work cluster.

3.4.2 Merit and Continental Cases Overview

In this Section two business cases of Network Optimization through Direct Shipment will be explained:

1. Merit Case, a supplier of steering columns
2. Continental Case, a supplier of instrumental panel clusters and engine control unit.

All these suppliers are shipping items to TOFAS, an FCA plant in Turkey, precisely in Bursa. The Merit warehouse stays in Sant Vicenc dels Horts, not far from Barcelona and the Continental one is ubicated in Timisoara in Romania. The first project is started at the beginning of October 2018 and it is implemented in the first days of March 2019, instead Continental project is begun in the middle of December 2018 and it is completed in the last days of April 2019.

Many activities have been carried out for realizing a Direct Shipment:

1. Volumes Check, i.e. verifying the possibility to fill at least a truck/sea-container a week.
2. Packaging Check, i.e. verifying that current packaging allowed a cross-dock flow (No repack or racking situations because the package must be already ready to be loaded and shipped from supplier with no re-activity that usually did the logistics operator).
3. INCOTERMS Check because in case of not presence of Fiscal Representative, INCOTERMS must be DAP, so the clearance of the goods in import is on charge of the supplier. Otherwise it is necessary that the INCOTERM used is FCA.
4. Supplier quotation assessment in order to evaluate supplier calculation.
5. Business Case achievement (for potential changes to transport & packaging costs).
6. Check existing Fiscal Representative for the Countries concerned.
7. Check VAT number.
8. Involving Finance for Business Case approval.
9. Involving Fiat Service department for a major support in activities like management, taxation, labour cost, payroll, etc.
10. Involving SADI department for assistance and advice on customs systems of foreign countries
11. Involving Information and Communication Technology (ICT) department for changing parameters according to IRF Operations requirements and only this activity requires three weeks of work.
12. Checking of TOFAS logistics operator readiness.
13. Check of invoicing flow, because the items must be sold to FCA Italy and shipped to TOFAS.
14. Management of the return of empty rack, creating regularly customs’ declarations for temporary export (returnable packaging not sent back in time) because if the time period for the temporary export is exceeded, the customs’ authorities penalise the parties with fees and penalties: it has been confirmed from TOFAS that returnable packaging from the delivery of the week before will be sent back the following week.
15. Set the starting date.
16. Updating of transfer prices by Finance.

All these activities have been performed through weekly conferences calls between suppliers, TOFAS and IRF Italy polo. During them, the parties discussed in order to clarify open points and potential doubts and each time a small but constantly updated summary of what had been said was shared by email.

Clarified how the parties have accomplished the project, the two business cases will be described one at a time starting from the “AS IS” situation, going on with the “TO BE” situation and finally describing the findings obtained.

3.4.2.1 Merit AS IS situation

Nowadays Merit shipped its own items to FCA trough BCUBE which in turn delivered to TOFAS. The INCOTERM agreed in the contract was EXW and so i-Fast Logistics had the task of collecting the products from supplier premises and delivering them to the logistics operator in Villanova d’Asti. From there the items were sent to Genoa dock where were loaded on a sea-container in route to Bursa. The clearance of the goods was on charge of FCA both in export in Spain and in import in Turkey. In Figure 3.13 it is possible to see how the flow was.

Figure 3.13 AS IS Merit Flow [Google Maps]

In this situation the number of items per box was 80 and they were sent in a cardboard box with dimensions 1200x800x1100 mm (Length, Width, Eight). The transportation cost from Merit to BCUBE (Inbound) is fixed from i-Fast and it is worth 0.19 €/part. From Villanova d’Asti to TOFAS

(Outbound), instead, the transportation cost is made by FCA. Until December 2018 this package was inserted in the Ga.Fe.R 4670 that has dimensions 2250x1450x1400 mm (Length, Width, Eight). From that period the components considered were shipped per 88% in a cross-dock way without Ga.Fe.R. and per the remaining percentual part as it was delivering before. In addition to this ratio, it is also important specify that the 83% of the shipment are made in sea-container and remaining part by truck. So the calculation of the business case will be arranged to these ratios.

For determining the saturation of the first level, the following internal dimensions (Length, Width, Eight) have been arranged between the parties concerned:

- Truck: 2450x13600x3000 mm
- Sea-container:2350x12000x2580 mm

Tables 3.4 and 3.5 show respectively how many Ga.Fe.R are inserted in a sea-container and in a truck loading them in the modes of Section 3.2.1. All the calculations are made dividing the dimensions of the truck/sea-container per the dimensions of Ga.Fe.R and rounding per defect.

Table 3.4 Number of Ga.Fe.R in sea-container [Personal processing of FCA data]

AS IS GA.FE.R				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**GA.FE.R / SEA-CNT**
	2350	12000	2580	**5**
	1450	2250	1400	
	1,6207	5,3333	1,8429	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**GA.FE.R / SEA-CNT**
	2350	12000	2580	**8**
	2250	1450	1400	
	1,0444	8,2759	1,8429	

Table 3.5 Number of Ga.Fe.R in truck [Personal processing of FCA data]

AS IS GA.FE.R				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**GA.FE.R / TRUCK**
	2450	13600	3000	**12**
	1450	2250	1400	
	1,6897	6,0444	2,1429	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**GA.FE.R / TRUCK**
	2450	13600	3000	**18**
	2250	1450	1400	
	1,0889	9,3793	2,1429	

The calculations demonstrate that in the best option 8/18 Ga.Fe.R. could stay in a sea-container/truck (crosswise mode) and so the total items shipped could be respectively 640/1440.

In the same way, Tables 3.6 and 3.7 dysplay respectively how many boxes are inserted in a sea-container and in a truck loading them always with the logics of Section 3.2.1.

Table 3.6 Number of Racks in sea-container [Personal processing of FCA data]

AS IS BOXES				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / SEA-CNT**
	2350	12000	2580	**40**
	800	1200	1100	
	2,9375	10,0000	2,3455	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / SEA-CNT**
	2350	12000	2580	**30**
	1200	800	1100	
	1,9583	15,0000	2,3455	

Table 3.7Number of Racks in truck [Personal processing of FCA data]

AS IS BOXES				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	**66**
	800	1200	1100	
	3,0625	11,3333	2,7273	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	**68**
	1200	800	1100	
	2,0417	17,0000	2,7273	

Calculations demonstrate that the maximum number of boxes inserted in a sea-container is 40 (lenghtways mode) and 68 in a truck (crosswise mode). In this case, the parts sent were 3200 in sea-container and 5440 in truck.

Established the transportation cost by truck from Villanova d'Asti to TOFAS and the transportation cost by ship and not shared in the business case because there are confidential tariffs that FCA do not confess, it is necessary to split them up by the number of the total items sent using a Ga.Fe.R or a simple box in the truck/sea-container. Once there are determined the transportation costs per part in the two options, it is necessary multiplying the boxes one for the ratio of 88% and the Ga.Fe.R. one for the remaing part of percentual.

Finally, for finding the average transport cost per part occurs summing the transport cost by truck multiplied per 17% and the transport cost by sea-container per 83%. It is around 0.54 €/part.

The packaging cost for managing the items, instead, is fixed by the logistics operator and it is worth 0.34 €/part.

Adding the Inbound cost, the Outbound cost and the packaging cost, the part price is 1.07 €.

3.4.2.2 Merit TO BE situation

With the implementation of direct shipment Merit will produce, packages, containerizes and ships its own components straight to TOFAS. The new INCOTERM agredd in the contract is DDP and so the clearance of the goods will be on charge of Merit both in export in Spain and in import in Turkey. In Figure 3.14 it is possible to see how the flow will change.

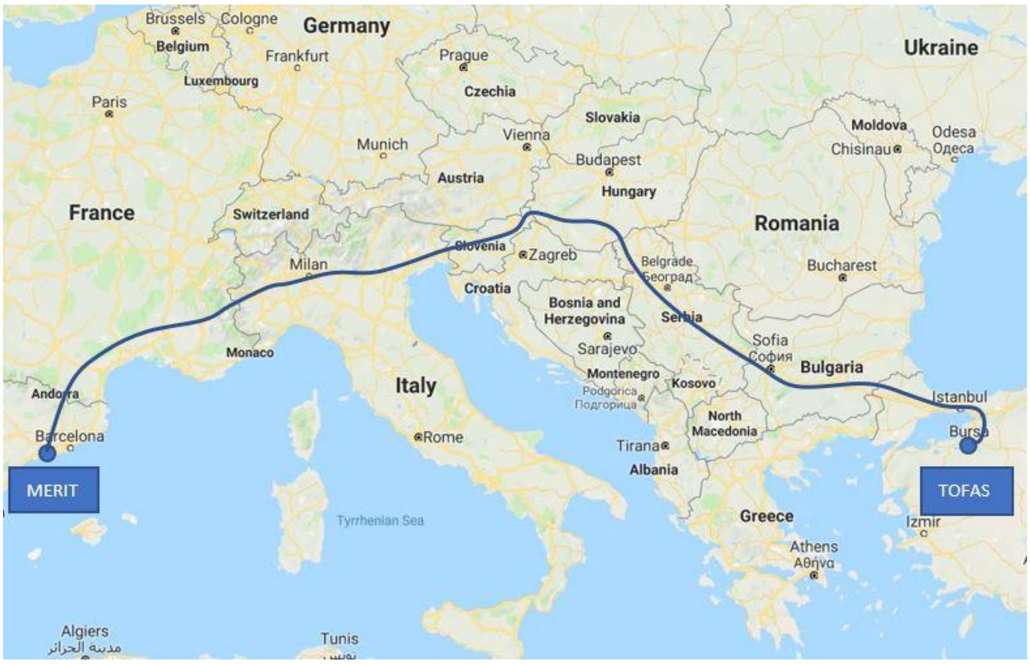


Figure 3.14 TO BE Merit Flow [Google Maps]

The items will be shipped only by truck and without Ga.Fe.R. because it is an asset of FCA, so the supplier has to use the simple box. The best saturation of the first level is already known for the "AS IS BOXES"calculations, but Table 3.8 remembers it.

Table 3.8 Number of boxes in a truck [Personal processing of FCA data]

TO BE BOXES				
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	68
	1200	800	1100	
	2,0417	17,0000	2,7273	

With this packaging configuration the parts sent are 5440.

The transportation cost in Inbound is 0 €, because trucks do not pass to BCUBE anymore.

Always for reason of privacy, the transportation cost of trucks to deliver components from Merit to TOFAS is not revealed, but it also determined dividing it for the items shipped. Instead, even though parts are not managed from the logistics operator, FCA recognize a packaging cost of 0.02 €/part to BCUBE for accounting and monitoring activities. The final price is established at 0.35 €/part.

3.4.2.3 Analysis of results

The final total gain through the implementation of this direct shipment is around 0.72 €/part, resulted from the difference between the old 1.07 €/part and the new 0.35 €/part. Afterwards assuming like X the total planned items in six months from the customer plant, it is possible calculating the parts required yearly, taking this value, dividing it per six and multiplying it per 11.2 which is the number of months of shipments in a year used by FCA, considering holidays and festivities. Therefore, the total saving among the two IRFs (Italy and Turkey poles) is determined by 0.72 * (11.2/6) * X. This number obtained could be divided in two entities:

- IRF Italy polo takes the saving consequent to the addition of the packaging saving from AS IS and TO BE situations, which is (0.34 €/part - 0.02 €/part) = 0.32 €/part, and the transport saving in Inbound towards BCUBE, which is 0.19 €/part. It results 0.51€/part and it must be multiplied with the planned items. Considering for example around 200 thousand items, IRF Italy can obtain a saving of 102,000 €.

- IRF TOFAS will obtain only the saving due to the lack of a new Outbound transport cost, which is attained from the difference of the old value of 0.54 €/part and the new value of 0.33 €/part (0.35 €/part minus the 0.02 €/part recognized to BCUBE). It is worth 0.21 €/part. As for IRF Italy polo, this number must be multiplied per the components planned. IRF TOFAS, instead, can gain a saving of nearly 42,000 €.

Globally, the saving achieved will be of 144,000€.

In the next Section the Continental case will be analysed: the procedure is around the same used to describe this last business case, but it will also be explained.

3.4.2.4 Continental AS IS situation

Today Continental shipped its own items to FCA trough BCUBE which in turn delivered to TOFAS. The INCOTERM agreed in the contract was EXW and so i-Fast Logistics had the task of collecting the products from supplier premises and delivering them to the logistics operator in Villanova d'Asti. From there the items were loaded on a truck and sent to Bursa. The clearance of the goods was on charge of FCA both in export in Romania and in import in Turkey. In Figure 3.15 it is possible to see how the flow was.

Figure 3.15 AS IS Continental flow [Google Maps]

This time the parts concerned in the business case are several and so for simplicity unit prices are weighted according to the customer plant consumption in order to create one single unit price.

The MOQ is about 512 parts and they are shipped in a specific box with dimensions 1200x1000x1240 mm (Length, Width, Eight). Each box contains a standard quantity of 80 items. The transportation cost from Continental to BCUBE (Inbound) is fixed at 0.85 €/part. The activity of cross-dock achieved by logistics operator costs around 0.11€/part.

Using the dimensions considered in Merit Case for determining truck saturation expressed in millimetres and remembering the loading modes in Section 3.2.1, it is possible to calculate it, like in Table 3.9:

Table 3.9 Number of boxes in a truck [Personal processing of FCA data]

AS IS BOXES				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	**44**
	1000	1200	1240	
	2,4500	11,3333	2,4194	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	**52**
	1200	1000	1240	
	2,0417	13,6000	2,4194	

In the best option (crosswise mode) there are shipped 52 boxes in a truck for a total of 4160 parts. Again, the transport cost in Outbound made by FCA to ship items is confidential and it is not possible sharing it, but unitarily it is worth 0.56 €. Now, adding the three entries of cost, the AS IS part price is 1.52 €.

3.4.2.5 Continental TO BE situation

With the implementation of direct shipment Continental will produce, packages, containerizes and ships its own components straight to TOFAS only by truck. The new INCOTERM agreed in the contract is DAP and so the clearance of the goods will be on charge of Continental in export in Romania and on charge of FCA in import in Turkey. In Figure 3.16 it is possible to see how the flow will change.

Figure 3.16 TO BE Continental flow [Google Maps]

The saturation of the first level do not change, using always trucks with the same dimensions.

The entries for defining the final part price are always:

- The transport cost in Inbound: 0 €/part, because the items do not cross the Consolidation Centre in Villanova d'Asti.
- The packaging cost: 0.02€/part for logistics operator accounting activities
- The transport cost In Outbound: 0 €/part.

Unlike the previous business case, this last entry has been evaluated at 0. Here the shipping cost from Continental to TOFAS has been inserted in the expense of Purchase Order. Every component made by supplier had a certain requirement from the customer and so the transportation cost of 0.62 €/part has been added to the same original value of the parts. Wanting the new final part price for a next evaluation of savings resulted, it is worth 0.64 €/part remembering the packaging cost and isolating the transport cost from the purchase order cost.

3.4.2.6 Analysis of results

In this business case, the final total gain is around 0.88 €/part, resulted from the difference between the AS IS 1.52 €/part and the TO BE 0.64 €/part. Like for Merit business case, it is possible to assume like X the total planned items in six months from the customer plant and to determine the parts required yearly, always taking this value, dividing it per six and multiplying it per 11.2 which is the number of months of shipments in a year used by FCA equivalent to 48 weeks. Therefore, the total saving among the two IRFs (Italy and Turkey poles) is determined by 0.88 * (11.2/6) * X. This number obtained could be divided in two entities:

- the packaging saving, derived from AS IS and TO BE situations, which is (0.11 €/part - 0.02 €/part) = 0.09 €/part and surely accounted for IRF Italy polo. Afterwards, this number must be multiplied per the components planned: assuming a planning of 60 thousand items, the saving obtained results around 5,400 €.
- the transport saving results to be globally positive. As concerning the Inbound transport, IRF Italy polo achieves a saving of 0.85 €/part for a total of around 51,000 €. On the Outbound side, the transport saving of 0.56 €/part is cancelled by DAP cost (0.62 €/part). So IRF TOFAS polo suffer a penalty of 0.08 €/part for a total loss of 4,800 €.

Globally, the business case proves to be successful and global saving is worth 51,600 €.

3.5 Cube Utilization Improvement

Many times, different typologies of pallet and boxes are loaded inside trucks/sea-containers causing serious problems of saturation and quality issues. In order to solve these difficulties, IRF Packaging team conducts everyday activities, like:

1. Mixed-load Optimization, which is the task of mixing packaging with different dimensions in order to improve Cube Utilization of the first level, as displayed in Figure 3.17.

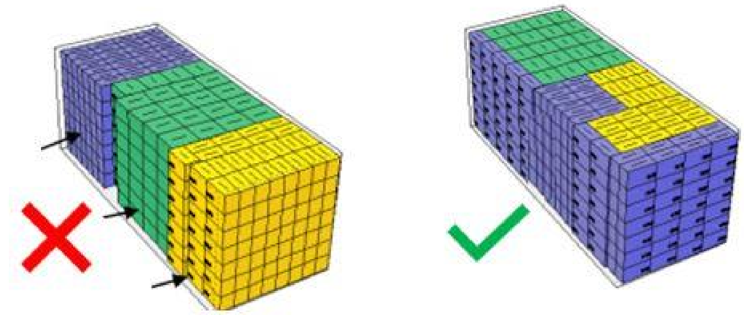


Figure 3.17 Wrong and Right placement of packages inside a sea-container [FCA presentation]

   On the left it is possible to see a sea-container loaded without any specific rules and every load is made by ECC based on experience and material availability; instead, on the right there is represented a sea-container loaded by Mixed-load logic using best practices studied and implemented (e.g. adopting overboxes that are wooden boards installed over a package in order to allow the loading of another box on the lower one) .

2. Packaging Standardization through packaging re-engineering from supplier. This activity has always the main scope of enhancing the saturation of the sea-containers / trucks as shown in Figure 3.18.

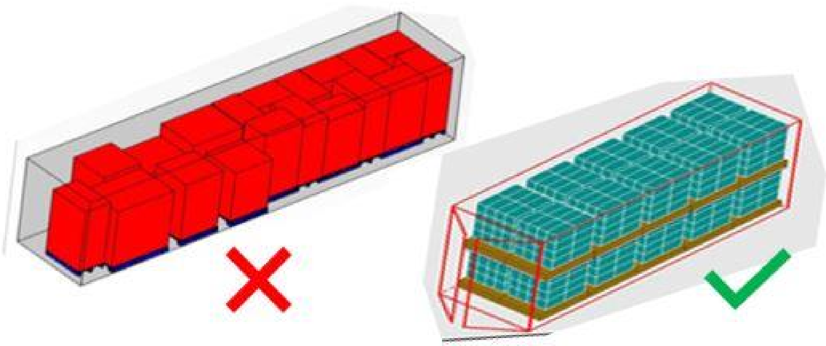


Figure 3.18 Non-Standard and Standard boxes inside a sea-container [FCA presentation]

Nowadays, FCA suppliers have its own packaging dimensions, no possibility to mix different packaging with different stackability, no target price and difficulties of sea-container saturation. The scope of this task is to discipline each supplier which must follow standardized packaging dimensions, certify stackability for each pack, use target price defined by Purchasing department in order to achieve saturation improvement. In fact, if supplier will realize overseas packaging, they must need check the parameters about VCI, % humidity, dynamic stress and temperature variation according to the International Packaging Guidelines FCA Norms.

In the following Section, a Cube Utilization business case will explain how the project has been conducted during the internship.

3.5.1 Transmission Shaft Case

GKN Poland is a polish Division of the same English Company. It is a supplier of transmission shafts and ships its components to Melfi and to Pernambuco plants through BCUBE with the activity of cross-dock with Reinforcement. The items delivered to Melfi are managed by i-Fast Container Logistics and there are not subject of the business case. Instead, the other parts are inserted in the following packaging described with their dimensions in millimetres and their volume in cubic meters in Table 3.10.

Table 3.10 Packaging Dimensions and external volume [FCA file]

PARTS	Length (mm)	Width (mm)	Height (mm)	Volume (m3)
533364200	2400	800	1100	2.112
552699480	2700	800	1100	2.376
552758480	2400	800	1100	2.112

The project follows the steps explained in the paragraph "Analysis of Results" of Section 3.2.1 and is started in the middle of January 2019. During the months of February and March supplier has realized the packaging proposals established in conference calls with IRF Packaging team and the Pernambuco plant. The delivery in sea-container from Italy to Brazil lasts around a month and the first one has occurred at the end of March 2019. At the end of April 2019, the customer plant has assessed the quality of the items and has given back to IRF a technical feedback. At the end of May 2019, the project has been turned to the Purchasing and Contracting departments which has the duty of revising the agreed proposal from an economical point of view. With this timing, it is possible that the project will be achieved within the end of June 2019.

The project carried out by IRF Packaging team in collaboration with Pernambuco team assesses the possibility to change the internal distance between items, maintaining the structure of support, while the supplier evaluated a technical proposal with the ideal dimensions for truck and sea-container Cube Utilization.

Figure 3.19 exhibits the placement of the items in the packaging and the internal structure that holds them together.

Figure 3.19 Package of length 2.4 m (left side) and package of length 2.7 m (right side) [FCA photos]

3.5.1.1 AS IS situation

Nowadays, these packages are shipped with a density of 30 parts/box, precisely with 5 parts per layer on 6 layers. They are composed by a pallet, a cardboard box, an internal dunnage and a VCI bag. In Tables 3.11 and 3.12 are calculated the quantities of boxes in a sea-container or a truck for the parts with Length of 2400 mm, while in Tables 3.13 and 3.14 the quantities for the items 2700 mm long. All the calculations are made up using always the loading modes of Section 3.2.1 and with dimensions expressed in millimetres.

Table 3.11 AS IS 2400 mm boxes per sea-container [Personal processing of FCA data]

AS IS PARTS 2400 mm				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / SEA-CNT**
	2350	12000	2580	**20**
	800	2400	1100	
	2,9375	5,0000	2,3455	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / SEA-CNT**
	2350	12000	2580	**0**
	2400	800	1100	
	0,9792	15,0000	2,3455	

Table 3.12 AS IS 2400 mm boxes per truck [Personal processing of FCA data]

AS IS PARTS 2400 mm				
A	Width (mm)	Length (mm)	Height (mm)	BOXES / TRUCK
	2450	13600	3000	30
	800	2400	1100	
	3,0625	5,6667	2,7273	
B	Width (mm)	Length (mm)	Height (mm)	BOXES / TRUCK
	2450	13600	3000	34
	2400	800	1400	
	1,0208	17,0000	2,1429	

The boxes of the parts with a Length of 2400 mm are better loaded:

- Lengthways in sea-container
- Crosswise in truck

Therefore, 600 parts are shipped by sea-container and 1020 by truck.

Table 3.13 AS IS 2700 mm boxes per sea-container [Personal processing of FCA data]

AS IS PARTS 2700 mm				
A	Width (mm)	Length (mm)	Height (mm)	BOXES / SEA-CNT
	2350	12000	2580	16
	800	2700	1100	
	2,9375	4,4444	2,3455	
B	Width (mm)	Length (mm)	Height (mm)	BOXES / SEA-CNT
	2350	12000	2580	0
	2700	800	1100	
	0,8704	15,0000	2,3455	

Table 3.14 AS IS 2700 mm boxes per truck [Personal processing of FCA data]

AS IS PARTS 2700 mm				
A	Width (mm)	Length (mm)	Height (mm)	BOXES / TRUCK
	2450	13600	3000	30
	800	2700	1100	
	3,0625	5,0370	2,7273	
B	Width (mm)	Length (mm)	Height (mm)	BOXES / TRUCK
	2450	13600	3000	0
	2700	800	1400	
	0,9074	17,0000	2,1429	

Instead, the boxes of the parts with a Length of 2700 mm are better loaded always lengthways and 480 parts are shipped by sea-container and 900 by truck. In all these cases the stackability of the boxes is always 2 (see yellow painted numbers in Tables 3.11, 3.12, 3.13,3.14).

Cube Utilization is calculated as the ratio between the total volume of the packages shipped and the internal volume of the means of transport concerned. So, considering always the following dimensions for the means of transport:

- Truck: 2450x13600x3000 mm
- Sea-container:2350x12000x2580 mm

It is possible to determine the internal volume of sea-container and truck which is respectively 72.756 and 99.96 cubic meters and in Table 3.15 are shown the actual Cube Utilizations, calculated multiplying the number of boxes with their volume and dividing for the volume of the means of transport concerned.

Table 3.15 Calculations of actual Cube Utilization of sea-container and truck [Personal processing of FCA data]

PARTS LENGHT (mm)	BOX VOLUME (m3)	SEA-CNT VOLUME (m3)	TRUCK VOLUME (m3)	BOXES / SEA-CNT	BOXES / TRUCK	CUBE UTILIZATION SEA-CNT	CUBE UTILIZATION TRUCK
2700	**2,376**	**72,756**	**99,96**	**16**	**30**	**52,25%**	**71,31%**
2400	**2,112**			**20**	**34**	**58,06%**	**71,84%**

Considering the actual Cube Utilization of sea-container and truck, IRF Packaging team believed that there were opportunities of improvement and so has provided to the supplier three new packaging proposals, thought only for the items 2400 mm long because they have been shipped in much more quantities than the longer ones.

In Tables 3.16 and 3.17 are displayed respectively the most important data for assessing the percent change of the Saturation, i.e. the number of items sent, and of the Cube Utilization in each of the proposals, always compared with the AS IS situation.

Table 3.16 Calculation of Saturation percent change [Personal processing of FCA data]

SCENARIO	PARTS / BOX	BOXES / SEA-CNT	BOXES / TRUCK	PARTS / SEA-CNT	PARTS / TRUCK	SATURATION IMPROVEMENT BOXES	SATURATION IMPROVEMENT SEA-CNT	SATURATION IMPROVEMENT TRUCK
AS IS	**30**	**20**	**34**	**600**	**1020**	**-**	**-**	**-**
CASE 1	**35**	**20**	**34**	**700**	**1190**	**16,67%**	**16,67%**	**16,67%**
CASE 2	**40**	**20**	**34**	**800**	**1360**	**33,33%**	**33,33%**	**33,33%**
CASE 3	**64**	**20**	**22**	**1280**	**1408**	**113,33%**	**113,33%**	**38,04%**

The improvements calculated are the ratios between the difference of the items shipped with a proposal solution and the AS IS packs and these last values, reporting the finding in percentage.

Table 3.17 Calculation of Cube Utilization percent change [Personal processing of FCA data]

<table>
<tr><th>SCENARIO</th><th>BOX VOLUME (m3)</th><th>SEA-CNT VOLUME (m3)</th><th>TRUCK VOLUME (m3)</th><th>CUBE UTILIZATION SEA-CNT</th><th>CUBE UTILIZATION TRUCK</th><th>CUBE UTILIZATION IMPROVEMENT SEA-CNT</th><th>CUBE UTILIZATION IMPROVEMENT TRUCK</th></tr>
<tr><td>AS IS</td><td rowspan="2">2,112</td><td rowspan="4">72,756</td><td rowspan="4">99,96</td><td>58,06%</td><td>71,84%</td><td>-</td><td>-</td></tr>
<tr><td>CASE 1</td><td>58,06%</td><td>71,84%</td><td>0,00%</td><td>0,00%</td></tr>
<tr><td>CASE 2</td><td>2,427</td><td>66,71%</td><td>82,55%</td><td>14,91%</td><td>14,91%</td></tr>
<tr><td>CASE 3</td><td>3,561</td><td>97,90%</td><td>78,38%</td><td>68,62%</td><td>9,11%</td></tr>
</table>

These improvements are calculated in the same way as the previous ones.

To sum up, are reported the findings for each proposal:

1. Case 1: the dimensions of the package remain the actual one, realizing one more layer of parts compared to the actual solution, keeping the same external dimension and changing the internal dunnage. The parts per box increase to 35 and the boxes loadable in a truck or a sea-container do not change. In this way, 700 parts/sea-container and 1190 parts/truck can be transported, and the saturation improves of 16.7% in both cases, while the Cube Utilization of trucks and of sea-containers do not change, so there are no improvements. Implementing this solution, some benefits, like a lower storage space needed and a reduction

of warehouse handling operations, could be attained, while the lifting vehicles capacity must be checked.

2. Case 2: IRF proposes the package dimensions of 2400x800x1264 mm, increasing the height of the box and realizing 8 layers of 5 parts each. With this proposal the parts boost from 30 to 40 a box. In a sea-container and In a truck can be always loaded 20 and 34 boxes, but now 800 parts/sea-container and 1360 parts/truck can be transported. The Saturation improves of 33.3% in both cases compared to the AS IS situation, while Cube Utilization of sea-container and of truck raises, respectively to 66.7% and 82.5%, with a modest increase of nearly 15% in both cases. Applying this second proposal, the same benefits will reoccur, but this time the supplier will be evaluate also the ergonomics for the operators.
3. Case 3: in this proposal the packaging dimensions are the following: 2400x1150x1264 mm. The height of the package remains the same as in Case 2, but this time is the width to be augmented in order to have a box of 8 parts per layer. Here, the number of parts increases to 64 parts/box. Considering the same internal dimensions for trucks and sea-containers, now 22 boxes/truck can be loaded, while the number of packages charged on a sea-container do not vary. For that reason, 1280 parts/sea-container and 1408 parts/truck can be shipped. Saturation of sea-container doubles, precisely it is augmented of 113%, while the truck one improves by a good 38%. In turn, the Cube Utilization of sea-container reaches the 97.9% with an incredible growth of almost 70%, while the truck one the drops to 78.4% raised only of a small 9% compared to the AS IS situation. Implementing this last packaging solution, supplier must verify all the previous open points, but he will achieve all the cited benefits too.

3.5.1.2 TO BE situation

After IRF Packaging team have sent its packaging proposals to GKN, the supplier has studied and evaluated them. Finally, they have not been approved because for a few reasons: on the one hand, the cost of creating a new box with major dimensions cancelled the gain obtained by the Packaging Optimization, on the other one, the operators encountered ergonomics problems, as shown in Figure 3.20.

Figure 3.20 An operator placing the item in the pack [FCA photo]

In fact, during the packing and the unpacking of the parts, the distance to the last part on the layer was too huge for the operator.

Afterwards, the supplier (GKN) provided to IRF Packaging team another solution with dimensions of 2400x750x850 mm, diminishing both the width and the eight of the boxes, that could be implemented also for the part of 2700 mm long. The items insertable in the new package would have been 30 too. In Figure 3.21 it is possible to see the math representation provided by GKN.

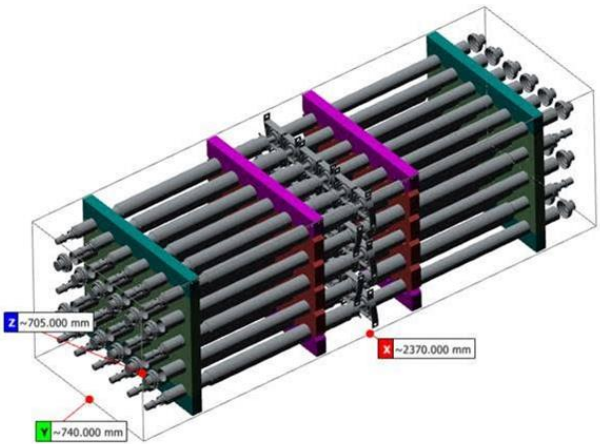


Figure 3.21 New solution math [FCA file]

Table 3.18 and 3.19 show respectively how many boxes of length 2400 mm can be transported in sea-container and in truck.

Table 3.18 TO BE 2400 mm boxes per sea-container [Personal processing of FCA data]

TO BE PARTS 2400 mm				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / SEA-CNT**
	2350	12000	2580	**45**
	750	2400	850	
	3,1333	5,0000	3,0353	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / SEA-CNT**
	2350	12000	2580	**0**
	2400	750	850	
	0,9792	16,0000	3,0353	

Table 3.19 TO BE 2400 mm boxes per truck [Personal processing of FCA data]

TO BE PARTS 2400 mm				
A	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	**45**
	750	2400	850	
	3,2667	5,6667	3,5294	
B	**Width (mm)**	**Length (mm)**	**Height (mm)**	**BOXES / TRUCK**
	2450	13600	3000	**54**
	2400	750	850	
	1,0208	18,1333	3,5294	

The boxes of the parts with a Length of 2400 mm are better loaded:

- Lengthways in sea-container
- Crosswise in truck

Therefore, 1350 parts are shipped by sea-container and 1620 by truck.

Table 3.20 and 3.21 instead show respectively how many boxes of length 2700 mm can be transported in sea-container and in truck.

Table 3.20 TO BE 2700 mm boxes per sea-container [Personal processing of FCA data]

TO BE PARTS 2700 mm				
A	Width (mm)	Length (mm)	Height (mm)	BOXES / SEA-CNT
	2350	12000	2580	36
	750	2700	850	
	3,1333	4,4444	3,0353	
B	Width (mm)	Length (mm)	Height (mm)	BOXES / SEA-CNT
	2350	12000	2580	0
	2700	800	1100	
	0,8704	15,0000	2,3455	

Table 3.21 TO BE 2700 mm boxes per truck [Personal processing of FCA data]

TO BE PARTS 2700 mm				
A	Width (mm)	Length (mm)	Height (mm)	BOXES / TRUCK
	2450	13600	3000	45
	750	2700	850	
	3,2667	5,0370	3,5294	
B	Width (mm)	Length (mm)	Height (mm)	BOXES / TRUCK
	2450	13600	3000	0
	2700	750	850	
	0,9074	18,1333	3,5294	

Instead, the boxes of the parts with a Length of 2700 mm are better loaded always lengthways.

In this case, 1080 parts are shipped by sea-container and 1350 by truck.

As stated many times before, all the calculations are made on the loading modes, described in Section 3.2.1.

Once established the number of boxes per each means of transport and consequently the parts shipped in any of these cases, exhibited in Table 3.22, it is possible to calculate the new Cube Utilizations. Table 3.23 displays the new values.

Table 3.22 TO BE Calculations of parts shipped [Personal processing of FCA data]

PARTS Length (mm)	PARTS / BOX	BOXES / SEA-CNT	BOXES / TRUCK	PARTS / SEA-CNT	PARTS / TRUCK
2400	**30**	**45**	**54**	**1350**	**1620**
2700		**36**	**45**	**1080**	**1350**

Table 3.23 Calculations of the new Cube Utilization of sea-container and truck [Personal processing of FCA data]

PARTS LENGHT (mm)	BOX VOLUME (m3)	SEA-CNT VOLUME (m3)	TRUCK VOLUME (m3)	BOXES / SEA-CNT	BOXES / TRUCK	CUBE UTILIZATION SEA-CNT	CUBE UTILIZATION TRUCK
2700	**1,721**	**72,756**	**99,96**	**36**	**45**	**85,17%**	**77,49%**
2400	**1,53**			**45**	**54**	**94,63%**	**82,65%**

The new solution results the best one compared to the three previous proposals. Considering the reduction of boxes dimensions, their stackability pass from 2 to 3 in each means of transport (see red painted data in Table 3.18, 3.19, 3.20, 3.21). For parts 2700 mm long Cube Utilization arises to 85.2% in sea-container and to 77.5% in truck, while for the shorter items it increases to 94.6% for sea-container shipments and to 82.6% concerning truck shipments.

The business case has carried the findings reported in Table 3.24.

Table 3.24 Business Case results [Personal processing of FCA data]

PARTS Length (mm)	CUBE UTILIZATION IMPROVEMENT SEA-CNT	CUBE UTILIZATION IMPROVEMENT TRUCK	PACKAGING OPTIMIZATION	SATURATION IMPROVEMENT SEA-CNT	SATURATION IMPROVEMENT TRUCK
2700	**63,00%**	**8,66%**	**-**	**125,00%**	**50,00%**
2400	**63,00%**	**15,06%**	**-**	**125,00%**	**58,82%**

The calculations are made as the ratio of the difference between TO BE and AS IS values and the AS IS values expressed in percentage. The best results are associated to sea-containers shipments with a more than 60% increase in Cube Utilization and a bigger 125% in Saturation, even though there have been also fair outcomes regarding truck. Finally, no Packaging Optimization occurred because the number of items per box has not changed.

3.5.1.3 Analysis of Results

The aim of this sub-section is to describe the saving obtained from the business case.

As already explained in Section 3.2.1 and 3.4.2, the saving is calculated operating the difference from the AS IS and the TO BE situation for every entry of cost and multiplied for the planning of Pernambuco plant.

It is divided in two main entities:

- Inbound saving gained by IRF Italy polo and due to the packaging improvement at Consolidation Centre and to the saving derived from the transport from the supplier to BCUBE by truck. In this case, the activity made by the logistics operator on these parts is a cross-dock with Reinforcement, so the only entry of cost for defining the €/part is volume. Multiplying the external volume of the box for the hourly rate established in the contract and dividing this value for the items inserted in the package, it is possible to define this value. Instead, for the transport saving, the specific transport cost of a truck from GKN to BCUBE, established by FCA and for privacy not revealed, must be divided by the relative items shipped.
- Outbound saving, as Inbound saving, is calculated onto the established transport cost of a sea-container from BCUBE to Pernambuco divided by the components in it, but it is gained by customer Region.

To be complete, doing an items average, the saving achieved on BCUBE operations is 0.1 €/part, the Inbound one is 0.45 €/part and the Outbound one is 2.65 €/part. With around 50 thousand items planned, IRF Italy polo can achieve a saving of 27,500 €, instead LATAM Region around 132,500 €. All savings achieved are based on the customer planning of one year.

The scope of the work cluster is improving the Cube Utilization; in fact, the saving associated to the transport cost of the items is around thirty times bigger than the packaging one.

3.6 Returnable Rack

This work cluster usually is represented by the activities conducted by IRF Packaging team in order to assess the implementation of returnable packaging on certain flows. During the internship IRF Packaging team carried out some analysis on items shipments from Arcese-Syncreon Consolidation Centre to NAFTA Region doing a trade-off on the usage of returnable wooden crates instead of disposable packaging for those part numbers that constitute the larger part of the revenues. One of these studies will be explained in general terms in Section 3.6.3.

First, it possible to give a definition of the typologies of packaging in order to fully comprehend their true purpose. A returnable packaging is a reusable container that will be used over multiple journeys and can take the form of bulk containers, hand-held totes, shipping racks, dunnage and even pallets. Instead, an expendable / disposable packaging is designed to only make one journey before being disposed of / recycled, commonly produced using corrugated cardboard materials.

Clarified the meaning difference between these two classes of packaging, it is fundamental to take a step back and describe a broadly IRF Packaging Overview prior to going into detail of this work cluster.

3.6.1 IRF Packaging Overview

Nowadays FCA owns a wide array of containers to carry vehicle parts to the production plant and they can be used only for logistic flows of TIER1 suppliers or FCA MAKE parts. The former are Companies that produce and supply parts directly to Original Equipment Manufacturers (OEM), the latter are the internal suppliers of the Group that produce items to ship towards customer plants in which they are assembled [21].

In FCA there are two main families of racks:

1. Special rack: a not standard-sized container, that is designed to be able to contain only defined part families (e.g. doors, tunnel, tail lamps) or precise parts.
2. Standard container: a multi-purpose and standard-sized container, that can contain different part families, with the possibility to be equipped with dunnage and supports.

Each family is composed by classes and each class is evaluated according to the five most important features that they should have: cost of the material, design complexity, durability, flexibility of use and protection of the contained parts.

On May 2019 items are shipped from IRF Italy polo to other regions (NAFTA, APAC, LATAM) and inside of the same EMEA Region (Serbia, Poland and Turkey) both in returnable and disposable packaging. To be exact the volumes are shipped in the proportion stated by Table 3.25:

Table 3.25 Percentual Type of Packaging per Region [FCA presentation]

PACKAGING	EMEA	NAFTA	LATAM	APAC
Carton Boxes	**8%**	**58%**	**44%**	**70%**
Wooden Cages	**8%**	**17%**	**52%**	**30%**
Total Disposable	**16%**	**75%**	**96%**	**100%**
RETURNABLE	**84%**	**25%**	**4%**	**0%**

In the table is exhibited how most of the volumes shipped in returnable packaging is through EMEA Region. This data is influenced by the volumes shipped by i-Fast Container Logistics. Also, NAFTA rate is discrete, but it is necessary to clarify that most of items shipped for example towards Toluca plant, like engines or gearboxes, are inserted in disposable packaging. Generally, in fact, more the journey is long and more it is difficult to manage a returnable flow.

Concerning only returnable packaging, EMEA Region manages different typologies of rack:

1. Ga.Fe.R., which are returnable metal cages owned by FCA, are named in this way for the Italian meaning of “Gabbie in Ferro a Rendere” and shown in Figure 3.22.

Figure 3.22 Example of Ga.Fe.R. [FCA photo]

2. RWC, which are returnable wooden crates managed at economic level between logistics operator and FCA with a financial leasing, calculated on a pre-arranged number of turnovers, are exhibited in Figure 3.23.

Figure 3.23 Example of RWC [FCA photo]

3. I-Fast standard containers, which are returnable container realized in plastic or metal according to the customer's needs, are represented in Figure 3.24.

Figure 3.24 Example of i-Fast container [FCA presentation]

4. MIX, that stands for different types of normalized and specific racks , are displayed in Figure 3.25.

Figure 3.25 Example of Special Rack [FCA presentation]

All these kinds of returnable packaging are collapsible, so in the way of return they could be knocked down occupying less space in sea-containers.

In Table 3.26 it is possible to see which specific type of returnable packaging is used by region.

Table 3.26 Percentual Returnable Packaging per Region [FCA presentation]

PACKAGING	EMEA	NAFTA	LATAM	APAC
i-Fast	**18%**	**0%**	**0%**	**0%**
MIX	**62%**	**0%**	**0%**	**0%**
Ga.Fe.R.	**20%**	**19%**	**100%**	**0%**
RWC	**0%**	**81%**	**0%**	**0%**

Analyzing the table, it is easy to figure out that APAC is supplied only with expendable packaging, LATAM shipments are managed only with Ga.Fe.R. as regards returnable packaging, RWC are only used to ship items towards NAFTA and not inside EMEA, where instead is being exploited a large number of MIX racks.

3.6.2 Returnable Rack Pros and Cons

This sub-section aims to describe which are the possible advantages and drawbacks of utilizing this typology of rack.

The main advantage of using a returnable packaging instead of disposable one is the possibility to reuse it indeed. Others potential benefits are linked to productivity improvements for operations such as handling, stocking and unpacking for several times, reducing the amount spent on additional cost in the warehouse and the relative additional space for packaging materials. The use of this kind of rack improves also the transport efficiency because FCA returnable containers are all collapsible so during the return they can be completely knocked down occupying far less volume. Also, the durability of the packaging allows to save money in the cost of purchasing and discarding packages for every shipment [22].

On the contrary, the first problem of returnable packaging is that it requires a large initial investment, additional transport costs, because the rack after the utilization needs to go back to be used again, and, consequently to this, an infrastructure for the sorting of empty container and systems for tracking it. Lastly, it is important to do not forget that returnable rack must be maintained regularly. In the worst cases, Company must consider that there is a loose percentage of the containers during shipments.

3.6.3 Overview on NAFTA Analysis

The project is still ongoing, but at the very beginning it consist of establishing the required containers to ship to NAFTA making an average calculation of the previous year's shipments in order to foresee the new demand. From this point and with many conference calls between the two IRF poles, it has been calculated the real requirement on returnable wooden crates because it had to be considered that a complete tour from the logistics operator to the customer plant and back took about 21 weeks. As discussed in Section 3.6.2, RWC is paid on the turnovers and settled eight turnovers as the life expectancy of the cage, an analysis is being carried out comparing the cost of a disposable packaging against the one eighth of the cost of the returnable packaging. This last cost is still added to the reparation cost of the same packaging (usually it is a rate from 20 to 30% of the one eight of the cost) plus the NAFTA handling cost for managing the RWC and the NAFTA transportation cost to ship back to Cerratina the packaging. The point in favour of the returnable packaging is that it can be knocked down, so for example it is possible to ship 24 RWC in outward and 80 in return with a rate of nearly 2.3 times more of shipped cages.

Therefore, IRF Packaging team and logistics operator have realized that they need more returnable crates of certain dimensions in order to accomplish the requirements of the customer plant, so several analyses have been carried out with a bunch of part numbers chosen always with Pareto method [17]. These studies consist of trying to switch items from an RWC to another with different dimensions, calculating before the saturation of the rack, then the saturation of the sea-container and the relative transportation costs always using the planned quantities from customer plants. They will not insert in the sub-chapter because are works relative to Packaging Optimization and Cube Utilization clusters.

3.7 Takeaways

The aim of this sub-section is to comprehend the findings achieved in each business cases and to draw the appropriate conclusions. The common thread which links each work cluster is determining new possible solutions in order to lower FCA costs on its entire supply chain. Every work cluster must follow a series of methodologies and technical constraints which are shared with other parties, like logistics operators, suppliers, customer plants or simply different Departments of FCA Supply Chain Division. However, projects, such as the ones developed in Packaging Supplier Base Re-engineering work cluster, require a greater level of secrecy and the information are revealed only at the right moment and in the right way and can last much more time compared to the others work clusters because there are engaged many business units of different Companies. In turn Network Optimization and Returnable Rack work clusters represent activities in which the information in most cases is a technical opinion or a necessary data to use in the business case and so it is freer to be distributed between organizations. They usually take nearly six months of work for IRF Department in which are studied the supplier, logistics operator and customer plant requirements starting from an operational/management to a logistical/strategic point of view. Finally, Packaging Optimization and Cube Utilization work clusters involve easier and quicker analyses on the actual shipments which can be realized in a variable time: there are cases in which the proposal is immediately the right one, while sometimes it may need to be revises or completely re-arranged. Though, the information shared is frequently of a lower level and if any type of issue would not occur, its tasks can be fast achieved.

The saving obtained may vary from around 50,000 € to more than 300,000 € and not always the project more complex lead to the major outcomes from an economical perspective. Obviously, when more competitive solutions for auxiliary materials or for packaging itself are founded on the market, it is possible to obtain better economical results because of the high volumes shipped from the Company. In these cases, the potential savings are generally higher than the ones achieved with the project carried out during the internship.

To sum up the economical outcomes in the business cases analyzed, Tables 3.27 and 3.28 show the savings achieved respectively in €/part and as total value (€) on the yearly planning of the plant.

Table 3.27 Projects Savings in €/part [Personal processing of FCA data]

	SAVING in €/PART		
	EMEA		CUSTOMER REGION
WORK CLUSTER	PACKAGING	INBOUND	OUTBOUND
Packaging Optimization	**2,16**	**-**	**1,15**
Network Optimization MERIT	**0,32**	**0,19**	**0,21**
Network Optimization CONTINENTAL	**0,09**	**0,85**	**-0,08**
Cube Utilization	**0,1**	**0,45**	**2,65**

Table 3.28 Projects Savings in € [Personal processing of FCA data]

	SAVING in €/YEAR		
	EMEA		CUSTOMER REGION
WORK CLUSTER	PACKAGING	INBOUND	OUTBOUND
Packaging Optimization	**216,000**	**-**	**115,000**
Network Optimization MERIT	**64,000**	**38,000**	**42,000**
Network Optimization CONTINENTAL	**5,400**	**51,000**	**-4,800**
Cube Utilization	**5,000**	**22,500**	**132,500**

All the values of Table 3.28 are conditioned from the planning of the customer plant. In any of these projects there was no possibility of choosing the parts more shipped on which make improvements, but generally it would be fundamental to work on the items with a bigger demand in order to obtain major saving.

From the tables it is possible to understand:

- the biggest saving is obtained on Packaging Optimization project and it is not composed by Inbound entry because the transportation to Mirafiori to BCUBE does not change;
- only in Continental Business Case a negative value has occurred: it is due to the DAP cost that FCA must pay to the supplier for the shipments. Generally, the outcome of the business case is positive, so the project has been implemented;

- Cube utilization project have determined lower costs for FCA at macro-level, but greater part of the savings (outbound transportation) is gained from the customer Region because of the corporate rules. However, when import projects are realized (from customer Region to EMEA), the saving achieved from the outbound transportation is earned by EMEA Region.

About the business cases studied, attaining a standardization of the packaging in order to get a major stackability in truck/sea-container allow FCA to ship more items, always considering the required quality features of the items and the weight constraints of the means of transport. In this way the transportation cost, which is the main factor examined by Cube Utilization projects, is directly shot down. Instead, Packaging Optimization takes chiefly into account the Consolidation Centre cost. It may be reduced attacking its three entries, i.e. handling, material, volume. Handling cost is usually associated to the activity of repacking by an operator, therefore, if parts were packed with a racking or cross-dock mode, this voice would be immediately cancelled because FCA must not pay this cost the logistics operator. In most cases this packaging process is mandatory and so the better way to eliminate this cost would be the implementation of a Direct Packaging which is the realization of the over-seas packaging at supplier premises. In turn material cost is lowered if potential reduction of unnecessary internal dunnage may be accomplished, while volume cost is decreased in two ways: figuring out a better placement of the items inside a box with a saturation improvement or reducing the volume of the packaging itself maintain the same number of items in the pack. Finally, Network Optimization analyses are conducted in order to find new competitive routes and new suppliers with right logistical capabilities. When this type of improvement methodology is applied, the existing supply chain becomes leaner and the main benefits are those explained in Section 3.4.

4 Conclusions

This chapter aims to summing up the benefits and the limitations of the thesis as well as providing some examples of future steps that FCA could implement to augment the efficiency of its supply chain.

4.1 Benefits

The work of thesis has had the scope of analyzing two typologies of business case:

1. Network Optimization
2. Cost Reduction

The former has allowed to understand that if a Direct Shipment is implemented, the network becomes leaner and the entire supply chain results easier to monitor. In fact, in this way, the items have only to be managed only with the regard to their accountability. In addition to this fact, all the activities relative to the packaging of the parts are carried out by the supplier and IRF must not pay anymore the logistics operator for doing these tasks. These costs are incorporated in the expenses of the components and most of the time the overall cost due to a supplier is lower than in the case the Company must pay the two different parties, as shown in Chapter 3.4.2. Furthermore, with the reduction of the actors in the supply chain, the parts and their packaging itself do not incur in redundant movements diminishing the risk of damaging or loosing. In turn, the latter has permitted to comprehend that in a world characterized by an increasingly competitive market environment and where global companies must be efficient more and more, every small improvement can make the difference because of the large volumes managed.

From Packaging Optimization project it is possible to realize that there are packaging that can be better saturated and in this way the Company can ship more items a time reducing the number of sea-container/ truck to utilize and does not spend money for shipping “air” anymore. Meanwhile, Cube Utilization project is the exact consequence of adopting a continuous improvement approach at the saturation level. Doing trade-off tests on the dimensions of the packages, the business case provided to achieve their optimal stackability in the principal means of transport used by FCA.

Finally, the literature researches have provided important suggestions for both Network Optimization and Cost Reduction topics. Speaking about efficiency, the implementation of software tools remains the best solution for monitoring and re-designing the supply chain network if it is necessary, maintaining it as efficient as possible and supervising the relative costs, but also the application of returnable packaging represents an optimal suggestion for the companies that have the objective of lowering the transportation/packaging costs, even though it requires an important initial investment. From an innovation point of view, the solutions described in section 1.4 would allow FCA to make the leap concerning its logistics operations.

4.2 Limitations

The main limitation of this work of thesis has been the long duration of the projects themselves from the identification of the opportunities to the implementation of the new solutions. The internship took five months, some projects analyzed in Chapter 3 started only at the end of January 2019 and they will last not until the end of summer 2019. Therefore, in a short experience of internship, it has not been possible to deal with projects managed between different FCA Supply Chain Divisions, such as the potential ones explained in sections 3.3 and 3.6, because of the lack of needed competencies that only a proper experience may give.

4.3 Future Steps

During the internship it has been possible to understand that there are many opportunities to explore for the Company. By analyzing cost-saving projects in more critical terms, it can be defined as these projects, besides causing a cost reduction, are also essential to stimulate the FCA itself, as well as suppliers and customers, to work as efficiently as possible, developing innovative processes that can go hand in hand with current environmental policies. Returning to Packaging Optimization project, the opportunity of increase the number of parts per box has been identified directly at the Consolidation Center of logistics operator by IRF Packaging team. This flashback has been reported for making clear that a frequent presence of packaging experts in the locals of the logistics operators and a better collaboration between parties may bring to identify new chances of saving. In the same way, improving the work relationships with suppliers helps to achieve better technical and economic results. The adoption of a common Cube Utilization software, such as CubeMaster (it is able to determine the load optimization for every means of transport used), from the supplier, but also from the same FCA and logistics operators, will permit to align the quantities to ship and do not have discrepancies between parties. Moreover, the Company should effort to implement Direct Shipment not only inside EMEA, but also between different regions in order to obtain bigger savings on transportation cost. Finally, the implementation of new technologies, such as RFID, will allow to find the better way to have a good traceability of the packages inside the flow from a logistic operator to the production plant.

Attachments

INTERNATIONAL PACKAGING DATA PLAN (IPDP)

FCA
FIAT CHRYSLER AUTOMOBILES

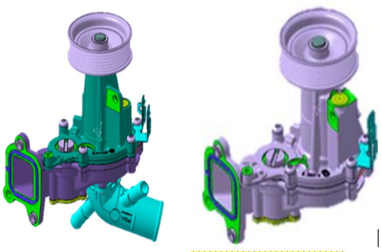
Supplier Code :	ROZEA	Part Number(s) :	708778000/708779000/708007010
Supplier Name :	PIERBURG		
Contact Person :	Guillaume Maillard	Part Description :	KL/JL/K8PHEV
Phone No :	+33 382555965		
E-mail :	guillaume.maillard@fr.kspg.com	Program Name :	HURRICANE

Date : 18/05/2018
Pilot : ☐ PVP, VP, PS
Production : ☐ V1 Launch

(May 2014)

Photograph/Sketch

(Part)



(Internal & External Container w/ Dunnage)

(Complete Unit Load w/Pallet)

4 Polyester banding + stretch film

Part Information

Part Size:	Length : 250	Width: 220	Height: 130	☐ (in)	☑ (mm)	
Part Weight:	Wgt : 2,025	☐ (lb)	☑ (kg)			
Part Classification:	☐ Hazardous Material	☐ Date Sensitive	☐ Electronic	☑ Powertrain	☐ BIW	☐ PIA ☐ Trim ☐ Hardware
Material Type:	☑ Plastic	☑ Steel	☑ Aluminum	☐ Fabric	☐ Other, (describe)	
Protection:	☐ Anti-Static	☐ Oil	☑ VCI	☐ Desiccant	☐ Other, (describe)	

Primary Container Information

Container Element:	☑ Corrugated	☐ Plastic	☐ Other, (describe)			
Container Type:	☑ Manual Hand Tote	☐ Bulk Pallet Box	☐ Custom			
Container Dimensions:	Length 600	x Width : 400	x Height : 140	☐ (in)	☑ (mm)	
Density: (parts/carton)	Pieces : 2					
Tare Weight: (empty carton)	Wgt : 1	☐ (lb)	☑ (kg)			
Gross Weight: (loaded carton)	Wgt : 5,05	☐ (lb)	☑ (kg)			
Interior Dunnage Material Type:	☐ Corrugated	☐ Foam	☑ Plastic	☐ Wood (certified)	☑ Other, (describe)	Plastic tray + VCI bag

Unit Load Information

Pallet Type:	☑ (4-way)	☐ (2-way)	Pallet Tare Weight: 15	☐ (lb)	☑ (kg)	
Pallet Element:	☑ Wood *	☐ Corrugated	☐ Plastic	☐ Other, (describe)		* Wood Pallets MUST be **ISPM-15** Certified
Pallet Dimensions:	Length : 1200	x Width : 1000	x Height : 130	☐ (in)	☑ (mm)	
Cartons per Layer:	Cartons : 5					
Layers per Pallet:	Layers : 5					
Unit Load Density: (total parts/pallet)	Pieces : 50					
Unit Load Dimensions:	Length : 1200	x Width : 1000	x Height : 830	☐ (in)	☑ (mm)	(one part number / pallet)
Gross Unit Load Weight:	Wgt : 146	☐ (lb)	☑ (kg)			
Unit Load Stack Height: (maximum)	In-transit Sea Container : 3		Warehouse - Storage:			
Banding Type:	☑ Polyester	☐ Metal	☑ Stretch-Film			

Logistic Information (for Direct shipment)

Export Location:	City:	Country:	Code:
Import Location:	City:	Country:	Code
Shipping Model:	☐ 20' ☐ 40' ☐ 40'HC		
Direct Shipment: (FCA facility)	☐ Yes ☐ No	Consolidation Point	

Supplier Acknowledgement

OEM Supplier : Date :

Title :

*NOTE: Supplier is responsible for component quality through to the point of use.

References

- Azémar J., Jolivet E., Chemisky L., 2018, “Trends in automotive packaging 2018”, Yole Développment Market & Technology report
- Beamon B. M., 1998, “Supply chain design and analysis: Models and methods”, Int. J. Production Economics, Volume 55, pp. 281-294
- Betancur-Muñoz P., Osorio-Gómez G., Martínez-Cadavid J.F., Duque-Lombana J.F., 2014, “Integrating Design for Assembly guidelines in packaging design with a context-based approach”, Procedia CIRP, Volume 21, pp. 342-347, https://doi.org/10.1016/j.procir.2014.03.173
- Chan F.T.S., Chan H.K., Choy K.L., 2006, “A systematic approach to manufacturing packaging logistics”, The International Journal of Advanced Manufacturing Technology, Volume 29, pp 1088-1101.
- Gao Q., Zhang G., 2012, “Green Packaging Management of Logistics Enterprises”, Physics Procedia, Volume 24, pp. 900-905, https://doi.org/10.1016/j.phpro.2012.02.135
- García-Arca J., Prado J.C.P., 2008, “Packaging design model from a supply chain approach”, Supply Chain Management: International Journal, Volume 13, pp. 375-380
- Maleki R.A., Meiser G., 2011, “Managing Returnable Containers Logistics & Improving visibility through using automatic identification technologies”, International Journal of Engineering Business Management, pp. 45-54
- Moon D., Kim D., Lee E., 2015, “A Study on Competitiveness of Sea Transport by Comparing International Transport Routes between Korea and EU”, The Asian Journal of Shipping and Logistics, Volume 31, pp. 1-20
- Neufarth S., Haining P., Moore T., 2011, “Order and Truck Optimization: Increasing Sustainability and Profitability”, IBM Corporation presentation.
- Qinhong Z., Anders S., Yu-Chung T., Biyu L., 2015, “Returnable packaging management in automotive parts logistics: dedicated mode and shared mode”, International Journal of Production Economics, Volume 168, pp. 234-244
- Rolko K., Friedrich H., 2017, “Locations of Logistics Service Providers in Germany - The basis for a new freight transport generation model”, Transportation Research Procedia, Volume 25, pp. 1061-1074, https://doi.org/10.1016/j.trpro.2017.05.479

- Schaefer D., Cheung W.M., 2018, “Smart Packaging: Opportunities and Challenges”, Procedia CIRP, Volume 72,pp. 1022-1027, https://doi.org/10.1016/j.procir.2018.03.240
- Serdar E.T., Al-Ashhab M.S., 2016, “Supply Chain Network Design Optimization Model for Multi-period Multi-product”, International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS, Volume 1.
- Singh T.P., Neagu N., Quattrone M., Briet P., 2015, “Network design for cylinder gas distribution”, Journal of Industrial Engineering and Management, Volume 8, Issue 1, pp. 85-109
- Van Sluisveld M.A.E., Worrell E., 2013, “The paradox of packaging optimization - a characterization of packaging source reduction in the Netherlands”, Resources, Conservation and Recycling, Volume 33, pp. 133-142, https://doi.org/10.1016/j.resconrec.2013.01.016

Websites

1. https://www.mhlnews.com/global-supply-chain/how-design-logistics-network-10-steps
2. https://www.logisticaefficiente.it/wiki-logistica/network-trasporti/logistics-network-design-definizione-rete-distributiva.html
3. https://www.thiscomplexworld.com/pt/supply-chain-network-design/
4. https://www.managementstudyguide.com/supply-chain-network-design.htm
5. https://www.inboundlogistics.com/cms/article/improving-supply-chain-network-strategies/
6. https://www.thebalancesmb.com/automotive-and-industrial-packaging-waste-reduction-ideas-2878022
7. https://www.chainalytics.com/three-tips-to-drive-cost-savings-through-your-packaging-strategy/
8. https://www.chainalytics.com/packaging-optimization-complex-role-packaging-defined/
9. http://www.cubemaster.net/Subscription/home.asp
10. https://www.shiplilly.com/blog/maximizing-space-container/
11. https://www.evanstrans.com/5-ways-reduce-transportation-costs-find-capacity/
12. https://www.nefab.com/en/insights/how-to-reduce-packaging-cost/
13. https://blog.atlasrfidstore.com/active-rfid-vs-passive-rfid
14. https://www.linkedin.com/company/fcagroup/about/
15. https://www.fcagroup.com/it-IT/group/Pages/group_overview.aspx

16. https://www.fcagroup.com/it-IT/investors/financial_regulatory/financial_reports/files/FCA_NV_2018_Annual_Report.pdf
17. http://www.businessdictionary.com/definition/Pareto-principle.html
18. https://blog.procurify.com/2013/09/25/whats-the-difference-between-indirect-and-direct-procurement/
19. https://www.allaboutlean.com/milk-run-intro/
20. https://www.searates.com/reference/incoterms/
21. http://marii.my/the-automotive-supply-chain-explained/
22. https://www.mhlnews.com/transportation-amp-distribution/logistics-issues-returnable-packaging