

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

ISTT ZAMBIA

MSC SUPPLY CHAIN MANAGEMENT

SEMESTER TWO EXAMINATION 2018/2019

PHYSICAL SUPPLY CHAIN MANAGEMENT

MODULE NO. EBU 7002

Date: 27 April 2019

Time: 3 Hours

INSTRUCTIONS TO CANDIDATES:

There are two parts to this exam paper.

Part A is for 40 Marks and is Compulsory Question.

Part B has FOUR questions and Students must Answer ANY TWO questions. Each question is for 30 marks.

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PART A: COMPULSARY CASE STUDY QUESTION – (40 Marks)

CASE STUDY - Make-To-Order Automobiles at GM's Gravataí Plant

In December 2007, seven years after the launching of the Chevrolet Celta, Roberto Tinoco, the plant director, proudly recalled the inauguration of the Gravataí plant in mid-July 2000, an event that caught the eye of professionals and academia both in Brazil and abroad. The core notion was: to sell cars made-to-order for final consumers. The project, known internally by the handle "blue macaw," was considered to be a true landmark for the world's automotive industry. The Gravataí plant brought about a true revolution in how cars were made, from its concept to the direct-sale model, through its production management system.

Please kindly follow the Case study provided in the class and answer all the questions as below.

- (a) Based on the case study, what are the key benefits of supplier presence on the GMBG site and having social interaction of families within the site?
[10 Marks]
- (b) What are the key drawbacks and issues with the auto purchasing system adopted within this case in other markets such as that of China, India and US.
[10 Marks]
- (c) What are the advantages and disadvantages of customer ordering directly with the manufacturer? What are the effects of this practices on dealers and suppliers from the Supply Chain context?
[10 Marks]
- (d) Is GMBG a JIT facility? Why or why not?
[10 Marks]

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PART B: ANSWER ANY TWO OUT OF FOUR QUESTIONS

Q1. Supply Chain Operations and Services

- (a) There are seven steps in the strategic Sourcing Methodology. Name at least FIVE and chose TWO to critically analyse them in more detail. [15 Marks]
- (b) Define and Discuss the FOUR basic types of E-Commerce Business Models used in Procurement and Sourcing within SC. [15 Marks]

Q2. Managing Supply Chains

- (a) Discuss Dependent versus Independent Demand as related to Inventory within SC. [15 Marks]
- (b) Discuss the elements of carrier selection, and how it differs from mode selection. [15 Marks]

Q3. Information Technology in Supply Chains

- (a) Critically describe and analyse the attributes of information quality and how they impact supply chain decision making. [15 Marks]
- (b) What is the role of Enterprise Resource Planning Systems in Supply Chain Management? [15 Marks]

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Q4. Strategic Challenges and Sustainable Supply Chains

(a) Critically analyse the changing role of supply chain professionals evolved in past decade. What skills will managers need in the future to succeed in this profession?

[15 Marks]

(b) Present a crucial evaluation of the key strategies that you would suggest to an organisation pursuing to combat the SCM talent shortages.

[15 Marks]

END OF QUESTIONS

PART A CASE STUDY IS FROM PAGE 5 ONWARDS

PAST EXAMINATION PAPER

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MAIN CASE STUDY

Make-To-Order Automobiles at GM's Gravataí Plant

Introduction

In December 2007, seven years after the launching of the Chevrolet Celta, Roberto Tinoco, the plant director, proudly recalled the inauguration of the Gravataí plant in mid-July 2000, an event that caught the eye of professionals and academia both in Brazil and abroad. The core notion was: to sell cars made-to-order for final consumers. The project, known internally by the handle "blue macaw," was considered to be a true landmark for the world's automotive industry. The Gravataí plant brought about a true revolution in how cars were made, from its concept to the direct-sale model, through its production management system. The lessons learned during the experiment were relevant because they contributed to the establishment of a new production model, helping put the world's automotive industry on a new path. The plant was working at full capacity especially during the first years, and the production during this period is shown in the table below. The extraordinary increase in production in the last seven years is evident. The idea was to deliver a car assembled as per the consumer's own specifications in the shortest possible time, at a cost lower than that of the traditional make-to-stock mass-production system.

Year	2000	2001	2002	2003	2004	2005	2006	2007
Production	24,007	91,407	109,916	115,304	136,114	135,097	140,994	192,272

The Background of the Brazilian Automotive Industry

In the '90s, three big experiments were done in Brazil. The Gravataí GM complex (GMBG), the Ford Camaçari complex and Volkswagen plant in Resende, each with specific characteristics. The Ford and GM plants manufactured passenger cars and Volkswagen made light trucks, also built-to-order like Gravataí plant. In this case, Volkswagen put all the suppliers responsible for the assembly of their components on the same assembly line. The only participation of the company was the final inspection, a necessary step for the approval and payment of the suppliers. Until 1990, the entire Brazilian automotive industry revolved around four major auto-makers (GM, Volkswagen, Fiat and Ford) who controlled the whole supply chain. At that time, car makers tended to concentrate all the intellectual product development work, limiting outsourcing to the production of low-complexity individual parts, produced according to strict specifications. Car makers also used many efforts to push down the prices of parts, both by means of invitations to bid and by encouraging competition among suppliers of a given item.

With the lifting of trade barriers in the early 1990s, from a market with few choices, high prices, no credit, and known for its technologically obsolete products, Brazil became the world's newest automotive phenomenon, turning into a region of potential sales growth for all automakers. The competition started in a more aggressive way and at the same time, the buying power of the people also increased resulting in more Brazilian sales as shown in the table below.

Year	1990	2004	2005	2006
Production	914,466	2,317,227	2,539,840	2,611,034

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The Gravataí Automotive Industrial Complex

Worldwide, GM was divided into smaller operations, a constellation of plants focused on market niches. This is the case with GMBG, charged with making compact cars for an entry-level South American market. Despite the fact that the Brazilian operation answers for less than 5% of GM's global business, it has gained strategic importance and become an innovation centre, opening very flexible plants and rapidly releasing new products.

The Gravataí Automotive Industrial Complex (GMBG) project came to be as a result of an idea by General Motors Brazil (GMB) top management to build a plant where the assembly line and the Internet-based sales system were connected and were led by a single conductor: the customer. The entire plant was to operate synchronously like clockwork. Recently, the capacities have increased by 30% and the number of employees by 40%. GMB began setting up its team of suppliers in 1995, when 17 of them were selected to work alongside the company in connection with the development of the product and process of the future GMBG. In order to come up with this team, Roberto Tinoco sponsored an international bid that had 70 companies running. The enterprise required global investments of U.S. \$554 million, borne by GMB, module suppliers, and the Rio Grande do Sul State Government, employing 2,700 people at first. The fact that system members and GM were in the same building made everything work like a single unit. The plant opened on July 19th, 2000, but car sales started on September 17th. Table 1 displays some general quantitative data on the plant. The supply-chain for the Celta, which is assembled at GMBG, brings new concepts to bear on the global automotive industry: cars are sold over the Internet, a single price applies, lead-time is minimal, and all suppliers are responsible for modules, instead of parts, in addition to being co-investors in regard to the entire enterprise. The Celta is a popular car launched with a 1,000cc engine whose project (platform and style) was specially designed for the Brazilian market, and has few variations. There is a choice of five colours, of which silver was the best-seller (40% of sales), and three models:

Table 1	General information on the plant
Location	Gravataí, Rio G. do Sul
Total Area	3,868 million sq. Meters
Building Areas	192,000 sq. meters used in plants
Capacity	245,000 cars per year (3 shifts)
Activities	Car manufacturing Automotive development
Employees	3,800 employees (only 40% are GM's)

The basic one and two better equipped ones, with different options packages. There were, therefore, 15 possible model/colour combinations and few hassles for the maker, as can be seen from Table 2. The strategy of limiting the number of possible options was adopted by GMBG in order to more quickly respond to customers' orders. Consumers don't have the option to change these three basic configurations, and almost all further customizations are provided by 20 accessories that can be added directly at the dealer.

For the first time in its 76 years' operating in Brazil, GMB brought its main suppliers and their employees into an industrial site. Suppliers came from different nations: Germany, Belgium, Brazil, the United States and France, with differing cultures and management processes, as can be seen in Table 3. All now take active part in the Celta's engineering, design, logistics and quality. They are called module suppliers, because they provide whole parts, or modules, for the car instead of separate parts. Also, a system member is more than a supplier, acting as a "partner" in the enterprise. All suppliers provide their modules exclusively, there is no competition over the modules

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supplied. They all have precise awareness of the pace of sales and receive a sales forecast daily, which covers the next six months. They all maintain a contingency inventory at the plant, estimated at about 7 days' worth of parts. At the industrial site, some suppliers make their own modules, while others just carry out assembly operations; a few of them simply receive the parts from their headquarters and store them. These suppliers are responsible for 80% of the car's material costs, while the other 20% fall to GMB, who manufactures the Power Train (engine and transmission).

Table 2		Configuration information									
3-door 1,000cc Celta variants	Options*										Dealership customization items: Stickers, air-foil, roof antenna, break light kit, electric cables, side moldings, tail lamps, pedal support, exhaust system end, bumper protective sticker, rocker inner molding, sport wheels, side and rear skirt, seat cover, carpets, power locks, power windows.
	A	B	C	D	E	F	G	H	I	J	
Basic											
Package # 1											
Package # 2											
*Description of options available											
A ¼ Plain colors (white and green) B ¼ Metallic colors (silver and blue) C ¼ Pearly (red) D ¼ Engine and oil-pump protection E ¼ Tinted windows and tinted windshield F ¼ Rear-window defogger						G ¼ Rear-window wiper/washer E ¼ Windshield wiper timer H ¼ 42 Ah battery I ¼ Warm-air defogger and ventilation system J ¼ Air conditioning Source: GMB					

The suppliers are set up at the site according to a planned order. The layout was developed by locating module suppliers at the closest point to their module's attachment on the assembly line. Each supplier has its own dock to offload parts onto the assembly line. Everything was conceived in such a manner as to ensure agile logistics, low production costs and high productivity. Suppliers have on-line connections to GMBG and have an in-depth knowledge of the assembly line's needs. Five suppliers have been replaced by others, leaving a total of 17 suppliers on the assembly line. These are shown in Table (3), along with the modules they supply.

Payment to each module supplier is made at 6 PM of the current day, when cars are cleared for invoicing by GMBG's quality control. At Gravataí, GMBG was able to secure a special tax authority regime, under which, instead of issuing a bill-of-sale for each product deployment, records are made on-line at the computer network that connects GMBG and the suppliers. With this special regime, the entire movement can be added up at the end of the day, issuing a single bill-of-sale per supplier. This process reduces the inventory management responsibility of GMBG to zero. GMBG picked EDS as the IT support provider for Gravataí. The technology centre of the head office at S. Caetano has a remote connection with the Gravataí plant, enabling development of products and manufacturing processes in less time and with an attractive cost-benefit ratio. EDS supports and manages the required IT infrastructure, as well as the services related to its use, integrating from product engineering to manufacturing process engineering to reduce GM's time to market.

Table 3		Member suppliers listing
No.	Suppliers	Modules
1	Valeo Térmico	Engine cooling system
2	Lear Corporation	Seats and Upholstery
3	Emcon	Exhaust system
4	Indústrias Ardeb	Lighting systems
5	Bosal-Gerobrás	Tool-kit
6	Continental	Instrument panels
7	Goodyear do Brasil	Tires and wheels
8	Delphi Chassis	Suspension
9	IPA-Soplast	Fuel tank
10	Ti Automotive	Brake- and fuel-lines
11	Saint Gobain	Windows
12	Pelzer Systems	Injected plastic parts
13	Gestamp	Pressed parts
14	Inyibra	Carpeting and insulation
15	Sogefi (Fram)	Air-filters
16	Zamproгна*	Cut-to-size steel plates
17	Rieter	Roof coverage, insulators
18	AVM	Engine assembly (dress up)

*The one supplier located outside the Industrial Complex

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Inbound Logistics

GMBG uses some logistics providers to perform the transportation and receiving functions of components for the site. There are three different logistics needs:

1. **On-site Operation:** CEVA Logistics performs the logistics within the complex; they collect parts from suppliers and deliver direct to the assembly line;
2. **Off-site Operation:** pertains to all collections made from outside facilities. Currently, Ryder is responsible for the milk run operation and Cargolift is responsible for the line haul operation.

Ryder plans all pick-ups from the São Paulo area, Paraná, and Minas Gerais, from 166 suppliers, and takes the cargo to a consolidation centre in São Paulo. CEVA has agreements with module suppliers, and even implements the milk run system with their third-level suppliers. The entire operation is carefully monitored from collection all the way through to delivery. Cargolift is responsible for the line haul, which is a direct transfer operation between the São Paulo Terminal and the Gravataí plant. Loads are optimized in express hauls towards Gravataí, which are more economic for long distances. When they get to Gravataí, the cargo is distributed among the system members.

Cargolift uses a dedicated software for its GMBG operation called TMS (Transportation Management System), a GPS-based vehicle-tracking application. The software is accessed over the Internet by users with pre-approved passwords who can make queries by part, criticality level, and the truck each part is on, in addition to track-ing the trucks' itinerary;

3. **Material Handling Operation:** CEVA Logistics is responsible for this operation which includes internal manipulation of materials. This company is responsible for the dollies that collect materials from suppliers and for transportation to a holding area in the vicinity of the assembly line.

At this point, full dollies are replaced with empty ones that are ferried back to the supplier. The dolly is, basically, a version of the Kanban packing system—a small train on wheels that is unloaded at the point of use by the GMBG production operators themselves, who also replace them with empty ones. In some special cases, production cells support an EPS (electronic pull system) device, a type of electronic marker that enables the operators to request the part needed by radio directly from the forklift operator. This system enables CEVA to monitor the lead time between placement of an order and its filling, thereby gauging its system's reliability.

Each supplier must, by force of contract, have at least one backup dolly. The notion of backup is important and implies an equipment/operator always available and accessible by radio, in the event of a problem. There were 17 routes, and 177 points of delivery, with an average frequency of 60 minutes/route. Recently, a series of improvements have made 33 routes and 153 delivery points possible, with an average frequency of 40 minutes/route. In some cases, routes have faster frequencies, such as 24 minutes. For this purpose, CEVA uses its own fleet of Toyota tractors. The tractors are CEVA's property, but the dollies are the responsibility of the module suppliers, because, among other things, there is a specific dolly for each part-type. Dollies for fenders are unlike those for, say, headlights. There is, however, standardization as regards the tow-catches, because dollies need to be exchangeable, as well as the wheels and rain covers. They represent the greatest danger in the operation, so much so that there is a proposal under which CEVA would receive the dollies under a loan-for-use agreement, taking over maintenance, which would make parts flow more reliably.

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Plant Organization

The plant has three hierarchic levels: plant director, functional managers, and super-vision, with an aim to facilitate communications and enable quick solutions to problems. Employees are 32 years old on average and fundamental schooling is a requirement, but most of them have completed high school. The number of female workers has diminished from an average of 12% to 6%. Employees change position in the line, change islands, and from time to time, change sectors. So they all know how to do everything and they are multi-functional. GMBG employees have averaged 440 hours of training in order to work at the world's most modern automotive assembly line.

Production Planning and Control

Production orders are based on customer orders received over the Internet (70%) and the traditional dealer-based sales orders (30%). GMBG only starts a car's assembly after an order is placed and paid for over the Internet. As a consequence, the operation is extremely profitable, as the company receives payment for its cars before it has to pay its suppliers. The system is close to ideal, production is aligned with demand, and relies exclusively on agility to fill consumer orders, leading to an order lead time of between 5 and 14 days, resulting in few lost sales at times of peak demand.

The Manufacturing Processes

The Press Shop

The supplier Zamprognia is the only company set up outside GMBG. They receive steel in spools and provide steel plates cut to size for GM's Gravataí press. At the press line, the number of components has increased from the original 17 to 25 now, including piece parts for other GM car models (side panels, roof panels, hoods and doors). The press is fully automated, weighs in at 5,600 tons with a speed of 450 strokes per hour, using a five-stage transfer process.

The Bodywork Shop

This is the sector where auto bodies are set up and welded. The sector is the most heavily automated in the plant with 250 robots. It is divided into several islands, each responsible for one part of the car, and parts are taken from the islands to the assembly line by an aerial conveyor belt.

The Paint Shop

The paint job at Gravataí is a worldwide benchmark for GM, operating with five different colour lines according to a process that eliminates the need for rework. Investment in this process was approximately U.S. \$60 million. The modern painting process is pre-pared to use water as a solvent, as soon as the cost/benefit ratio becomes favourable. Operation of this system is still exceedingly expensive, costing 5 times more than the ordinary process. At the end of the assembly line there is an intermediate inventory of 130 bodies, which regulates the assembly line's pace. Production follows the sequence of orders received over the Internet. "This is the buffer where production says: I want a black car, or a silver one, so that the automated elevators can select a car from the appropriate drawer and send it up to the assembly line", explains the GMBG manufacturing manager.

The Modified General Assembly Line

During November 2006, a new sedan named Prisma started being produced with the same initial Celta platform. The efficiency of the assembly line is constantly being improved. The first operation performed at the assembly line is the removal of the doors, as this facilitates operations inside the car. At the end of the assembly, each door is reattached to the car. The car is then placed on a platform whose height can be adjusted according to the employee's own height and the activity he or she is performing, thereby ensuring a comfortable working position. This is an innovation in the automotive world. It improves employees' productivity and well-being. The module arrives at the assembly line at precise intervals, every 20 minutes, and a 30% improvement from the initial assembly line interval. The "T"-shaped assembly line facilitates replenishment, reducing the need

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for physical space. Inventories at the assembly line are limited to a few dollies that feed the process as needed. For more unwieldy items, such as seats, a truck is called for instead of dollies.

One of the most innovative stages found at the Celta assembly line is the installation of the Continental instrument panel module in the car in a single step, an operation that lasts about 2 minutes. Continental also provides 150 items (originally it was 65 items), including plastic and metal dashboard parts such as the glove compartment, fuse-box cover, steering column, pedal modules, steering wheel and blinker activators. In order to assemble everything, Continental receives parts from two other Gravataí module suppliers: Valeo Térmico (Ventilation box) and Delphi (suspension).

Another innovation is the installation of the entire mechanical system in one single operation, assembling the engine, transmission, brakes, fuel line, exhaust, thermal protection and rear axle. Eight components are automatically installed in a single automated operation. After the car passes a final quality check, if reworking is needed as a result of a scratch or damage suffered during the assembly, it goes to a special line for repairs, and no longer returns to the main assembly line. Tinoco states that the less than 1% of the cars produced require repairs. Nineteen checkpoints certify manufacturing quality along the assembly line. The Gravataí plant is GM's worldwide benchmark: it has one of the least turnouts of unfinished or "crippled" cars in all of General Motors. A crippled car is a car that is not completed because of missing parts or defective parts provided by suppliers. The assembly line is flexible and, if need be, could assemble a different car, up to the size of a mid-size sedan. In October 2007, the 900,000th car was produced at Gravataí.

The Distribution Strategy

When GMBG started the CELTA production in 2000, Internet sales was pioneer activity all over the world for mass production cars. The distribution strategy was based on four pillars:

- Direct Sales: to legally circumvent taxes;
- E-Commerce: to make consumers comfortable;
- Accelerated Delivery: typically four days for close-in customers;
- Same Prices and Freight Charges: regardless of distance, in an effort to do away with the negotiation process between consumers and dealers. This strategy was utilized to allow the car to reach different regions of the country. Today, 35% of sales are distributed within 1,500 km from Gravataí, while the rest are in the north and northeast (a distance of 4,000 km from Gravataí).

Under the traditional model, GMBG sells cars to dealers, who incorporate them into their inventories. Consumers go to the dealers, choose a car, negotiate with the salesperson and make a purchase. However, as competitiveness increases, car buyers the world over demand more power in terms of choice and speed of delivery. Car makers need to reinvigorate their manufacturing processes to meet these demands, competing more on service.

Under the direct Internet selling model, GMBG sells directly to consumers. Consumers enter the website and choose a configuration. The system then searches for completed cars at the Gravataí plant. The system doesn't place orders with the plant, but, rather, looks for completed cars at the distribution centre. When the configuration requested by the consumer is found, the car is set aside. The customer then makes a small down payment to secure the car. Upon receipt of proof of payment, the car is invoiced and sent to the dealership closest to the customer's address. The customer is then called to the dealership, pays the invoice and receives the car.

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GMBG controls the entire flow of both distribution channels: The traditional one and the virtual one.

At present, 30% of sales are made by means of the traditional model, while 70% take place over the Internet. Thus, 70% of the demand can be tracked on-line by GMBG, while the remaining 30% that consumers buy from the dealers are not monitored, so a doubt remains as to whether these consumers got what they wanted, or whether they bought whatever was available, or simply gave up and left.

The Relationship with Customers and Dealers

GMBG went from 500 customers (their dealers), to direct contact with 80,000 consumers. Customer service had to be expanded with the creation of a call-centre to provide guidance on the sale process. Today, the General Motors dealership chain in Brazil has around 470 stores. One group, representing the dealers collectively, studied all the processes proposed by GMB. Initially dealers were wary; they thought they might be left out of the deal. They had heard comments that GMB was going to sell directly. Then they understood they were not excluded from the business, that quite the opposite was true. Each dealer was to be paid a fixed percentage of the sales channelled through their respective dealership. For GMB, dealerships still play a role: servicing, buying and selling used cars, selling and installing customized items for new ones, receiving payment from customers, and delivering cars to consumers. They are very involved. Even with regards to purchases over the Internet made by consumers from their homes, they are still involved. All direct sales involve a dealer, and dealers receive a 7% commission on each unit sold. When GM started in 2000, they set up Internet kiosks in every dealership in Brazil. And each dealership had one unit for test-drives and another for show. Consumers go to the dealership to see the car, try it out, and then they can choose to buy immediately over the Internet.

The Celta Website

The Celta website allows selection of colour, configuration and additional services, payment and receipt of the car. Consumers can connect to the Celta website from their homes or from the nearest dealership. The main things attracting consumers to the website are first and foremost, the security of receiving information and sending personal and financial data for a credit check; and, secondly, the price. Over the Internet, a Celta sells for about R 800 (U.S. \$450) less than under the conventional system. GMB also aims to use the website to develop a lifelong relationship with the customer. According to its philosophy of providing service to customer's end-to-end, GMB sells the cars, provides constant information about them, and deals with technical support and maintenance. The objective is to take care of customers from the pre-sale process until selling the product in the used car market.

Lead Time

GMBG delivers Celtas to any place in the country, in a convenient lead time. The simplicity of the product is an important feature to meet this target. The lead time in a traditional plant to deliver a customized car is about 5 to 6 weeks. Aside from the Celta, only about 2% of GMB cars are built to order in Brazil.

Freight

GMBG was able to change the traditional freight concept by implementing the notion of a set freight-price for all of Brazil, due in part to the involvement of freight companies as partners from the very inception of the project. Freight companies are hired by GMB, rather than the dealer. The hauler is actually a consortium of firms under the coordination of the National Association of Vehicle Freighters (ANTV). Hundreds of trucks are involved, each carrying 11 Celtas, delivering throughout Brazil as dictated by sales.

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Changes in the Distribution Model Used by GMBG

From the beginning, the GMBG distribution model was:

1. Elimination of the discounts and bonuses for dealerships.
2. Elimination of GM's Bank incentives to finance dealers' working capital.
3. Reduced space taken up inside dealerships.
4. Reduced inventories at dealers and, consequently, the supply chain.
5. Consumers don't need to price-hunt. They can pick the car they want.
6. Consumers make their orders and receive their car in 5 to 14 days, regardless of their distance from the plant.

To make it possible, five distribution centres were built in 2000, in different regions of the country. Due to a tax system change as well as the greater agility of production and transport logistics, this system was deactivated in 2005. Today, the deliveries of all the cars are done directly from the Gravataí plant's distribution centre to dealers all over the country. The Celtas are distributed to the Chevrolet dealerships using the Day Supply (the same concept of the different models manufactured by other GMB sites). This system envisages levelling the stocks of the dealerships in order to be sufficient for the next day. So, if the monthly sales volume of a certain model is 5,000 units all over the country, the inventory of the dealerships will be 2,500 units. This quantity must be sufficient for 15 days of sales, so the distribution system works in order to equalize the stocks of the whole net of dealerships in 15 days.

The Future

Roberto Tinoco improved the efficiency in the press shop, painting and assembly departments due to investments to expand the capacity and meet demand. A new car was launched; the number of assembly combinations increased as well the number of suppliers and consequently the complexity. But Tinoco still has in mind reducing time-to-market and increasing the customization level while maintaining costs at competitive levels in a period of increasing competition among the major car makers. Always the pragmatist, he expects his team to provide ideas leading to the improvement of the logistics process.

END OF CASE STUDY