

**Understanding the Automotive Supply Chain:
The Case for Chrysler's Toledo Supplier Park and its Integrated Partners
KTPO, Magna, and OMMC**

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The purpose of this document is to describe the supply chain that produces automobiles and light trucks from the perspective of the assembly plant, which controls the tempo of production and coordinates actions of the upstream supply chain beginning with tier one suppliers of chassis and auto bodies and the downstream distribution system that ends at the dealership. The automotive supply chain is a large, complex operation that requires sophisticated management techniques, substantial information technology expertise, and close coordination to reduce throughput time and eliminate non-value added activities. This document specifically examines the Jeep Wrangler which is produced at Chrysler's Toledo Supplier Park.



Background

The value chain for making automobiles, light trucks, etc. transforms basic materials (e.g., sand to make glass, iron ore to make steel, and petroleum to make polymers) into finished product in the dealer's showroom that have advanced electronic and GPS capabilities, video entertainment systems, and sophisticated safety systems including rearview cameras and collision sensors. This value chain is enormous in size with hundreds of companies making thousands of parts and components that ultimately are funneled into a single plant that performs the final assembly. The correct, high quality parts and components must arrive at the right time, in the right quantity, and in a coordinated manner so the assembly can be done quickly and efficiently. The value chain is global in nature because low technology parts and components with high labor content, that are also inexpensive to ship, are sourced from low wage countries. The value chain is incredibly complex so automotive companies have organized the supply chain so it can be managed easily and effectively. This has been accomplished by

(1) establishing a tiered supply chain to reduce the number of firms with direct contact to the assembly plant, thereby putting more responsibility on first tier suppliers and (2) treating suppliers differently depending on the need for interaction. For example, the level of interaction with the suppliers of sophisticated braking components is higher than the level of interaction needed with the suppliers of hoses and belts.

The Evolution of Supply Chains

The concept of a supply chains in one form or another has existed for centuries. The industrial era began because improvements in engineering capabilities, metallurgy, equipment design, transportation, and power generation allowed the production of goods to be concentrated in fewer, larger facilities. As this was done, organizations achieved significant economies of scale, which accelerated the shift to even larger facilities. During the industrial era, companies focused on (1) maximizing the output and efficiency of the worker through automation and (2) controlling the supply chain through vertical integration. With vertical integration, a company owns and directly manages all or most of the assets, which may be managed by departments and divisions of the company. These departments and divisions provide raw materials and produce the parts and components needed to make the final product. Vertical integration provides the ultimate in control by ensuring the supply, quality, and price of component parts and subassemblies. It is also viewed as a way to maximize profits because each segment of the supply chain has a predictable and dependable set of orders from the next segment in the supply chain. As a result, the company makes a profit at each step in the chain. Most firms that produced consumer goods implemented this strategy because it was thought to reduce risk and increase return. The ultimate in vertical integration was Ford Motor Company's River Rouge complex near Detroit, which was capable of building a car from start to finish in only a few days. The complex, which employed 40,000 people at its peak in the 1940s, included a steel mill, a float glass plant, engine production, fabrication and machining operations, and an assembly plant. Henry Ford could bring iron ore, sand, and other basic materials in one end of the complex and out the other end rolled new cars.

Manufacturing firms have moved away from vertical integration towards supply chains that involve many different organizations. The shift began as supply chains became longer, more complex, difficult to manage, in part because the products demanded by customers became highly differentiated. When companies are required to produce different products rather than a single standard product and the degree of difference increases, production runs become shorter, changeover and setup cost increase, scheduling becomes more complex, inventory expands, and the number of decisions expands dramatically. Manufacturers found it to be profitable to outsource certain components because suppliers would be able to cope with part of this complexity, could achieve economies of scale, had technology expertise, and had lower labor costs and more efficient work rules and labor practices. In many cases, the manufacturers received better service from external suppliers than from internal suppliers. In some cases, companies outsourced to take advantage of global trade.

Firms with complex products, increasing product variety, and long supply chains with many branches and feeders found it difficult to manage the entire supply chain with a hierarchical structure, which allows decisions to rise up the organization until a person with enough authority is found to make the decision. This process is costly, and it delays decision making. As products became more complex and product variety increased, the hierarchy demonstrated its inability to make good decisions quickly and in some cases to make any decision at all. As hierarchies became larger and larger to address more complex problems, costs soared, productivity declined, profits evaporated, and more agile foreign competitors grabbed market share. This shift to supply chains accelerated as firms began to examine the cost of managing and controlling these vertical organizations. In essence, the shift to outsourcing and supply chain management allowed companies to replace a command and control mechanism with market forces that depend upon competition and shared benefit to drive the actions of a supplier towards outcomes that benefit the entire supply chain

Nature of Competition

Competition is no longer company versus company rather it is supply chain versus supply chain. That is true whether it is the automotive industry, the personal computer industry, or the communications industry. The production, marketing, and delivery of product are a team effort. When customers buy a product, customers choose the output of the entire supply chain and pay all of the participants. To be successful, the lead company must be able to design, organize, and execute supply chain activities. That does not mean ownership or even direct control, but it does imply actions and mechanisms that influence decision-making and impact performance.

A key to understanding this change is reconciling the statement: When customers buy the final product, customers choose the output of the entire supply chain and pays all of the participants. Customers want the best value from the supply chain. Therefore, this is a system wide rather than a company specific process. Many times businesses in a supply chain are concerned about which firm holds inventory or which company absorbs a cost. Final customers are not concerned with either who hold the inventory or who bears the costs; they care when total inventory or total cost in the supply chain are too high because these extras drive final costs and prices paid higher. The final customer is concerned when any unnecessary action is taken in the supply chain regardless of which company takes it. From this perspective, it makes sense for manufacturer and the suppliers to focus efforts on reducing the amount of inventory in the supply chain rather than creating mechanisms that shift inventory to lower the cost of one supply chain participant. This systemic view also implies that it would be wise for companies to share not only information, but to share capabilities with other organizations.

Supply Chain Typology

Supply chain design and management is not one-size-fits-all. The relationship between a manufacturing firm, such as Chrysler, and its suppliers varies widely and depends upon what is needed by the final customer – not the next firm downstream in the supply chain, not even Chrysler – but what the vehicle

buyer at the show room wants. The final customer wants are translated to the suppliers through a series of design decisions that shape the parts and components produced throughout the supply chain. In some cases, the driving force is innovation. In others, manufacturing costs and productivity are determining factors. In still others, transportation costs and inventory costs define the relationship. As a result, the supply chain is more than a manufacturing and distribution network that moves parts and components to the assembly line; it is also a complex design process that is spread across dozens, even hundreds of companies through all tiers in the supply chain. The following structure is a way to classify supply chain design and management decisions to cope with the diversity of requirements in a supply chain.

1. Strategic Partners work closely with Chrysler on product design and development. These partners are introducing new technologies into the vehicles that provide market differentiating service that could be related to safety, convenience, or performance such as integrated, hands-free mobile phone service and music selection or navigation systems. These require a high level of interaction, usually involves high cost products, and often means keeping inventory low, so these products are provided just-in-time.
2. Operating Partners also work closely with Chrysler in production, but not so closely on product design and market changing ideation. These partners are working hard to take cost out of the system by improving quality, lowering transaction costs, and eliminating non-valued added steps. This includes activities like sequenced part delivery and pay as built systems. Sequenced part delivery has the supplier providing components in the precise order needed by the vehicle traveling down the assembly line. Pay as built systems streamline the accounting and invoicing activities, which add no value to the product and should be done as simply and accurately as possible. Operating Partnerships are often used on large bulky parts, such as passenger seats, that are extremely costly to inventory.
3. Arms-Length Relationships tend to be used to procure standard products that are not differentiated, have limited value as customer incentive, and are expected to be highly reliable. Items like power steering pumps and alternators are essential products where cost and quality are critically important but where product differentiation is unimportant to customers. Here the relationship between the supplier and Chrysler are limited. The product must function as expected, i.e., deliver the needed power, and it must be physically compatible with the other components in the engine compartment. So, the level of interaction is minimal
4. Open Market Relationships tend to involve products that are commodities such as fastener, oils, and lubricants. There are often industry standards and products can be purchased through e-catalogs with access through the internet.

Automotive Supply Chain Overview

At its Toledo location, Chrysler has two assembly plants. The Toledo North Assembly Plant was built in the late 1990s and produces the Jeep Liberty and the Dodge Nitro (Toledo North). The other facility, the Toledo Supplier Park, was completed in 2005 and produces the Jeep Wrangler, which is based on the famous Jeep utility vehicle used in World War II. The description of the assembly plant, its suppliers, and its distribution systems covers the plant built in 2005. An overview of the supply chain that feeds Chrysler's Toledo Supplier Park and the distribution network that moves finished product to the dealer network is provided in Exhibit 1.

This assembly plant is a leader in supply chain management and integration as well as a leader in productivity and efficiency. This facility has received the Harbour Award as the most efficient assembly plant in North America for the past two years. Recent ratings by the Harbour Report, that measures automobile manufacturing productivity, show that it takes only 13.57 hours to build a Jeep Wrangler in Toledo, which is 1.5 hours faster than the nearest competitor in North America. It is unique among automotive assembly facilities in North America and worldwide because of the close links between the Chrysler's assembly plant and three key suppliers, KUKA Toledo Production Operations LLC (KTPO), Magna, and Ohio Module Manufacturing Co., LLC (OMMC). No other plant in North America has this tightly integrated relationship with suppliers, and only one other plant worldwide, the SMART Assembly Plant in Hambach France, is integrated in this manner.



KTPO, Magna, and OMMC

The manufacturing facilities for these suppliers are located on the Chrysler campus, known as the Toledo Supplier Park (TSP), and they have direct and uninterrupted flows from their assembly to Chrysler's assembly line. See Exhibit 2 for an aerial photograph of the complex. The assembly process at the integrated Chrysler facility actually begins in the KTPO and OMMC facilities where the body of the vehicle is assembled and the drive-train and axels (undercarriage or chassis) are assembled, respectively. The body, assembled by KTPO is painted and prepared by Magna before the body and the drive train, which includes the engine and transmission, are joined at the beginning of the Chrysler assembly line. There is no loading and unloading of bodies and frames onto a truck or other device. The exit for KTPO is the entry for Magna. And the exits for Magna and OMMC are the entries for the Chrysler facility where the car is fitted with seats, glass, dash panels, and other items to finish the vehicle. The sequence of vehicle production in each of the four facilities has a coordinated sequence so handling of components to maintain an appropriate sequence is minimal. The conveyance systems move the components from one building to another without human interventions, in other words seamlessly.

The assembly lines in all four facilities are physically connected, centrally scheduled, and move at a contracted rate or cycle time, which is the rhythm or pace of assembly. The contracted rate, which is 35 vehicles per hour, is the rate at which KTPO, Magna, and OMMC must deliver components to the Chrysler final assembly operations. KTPO's, Magna's, and OMMC's assembly lines have the ability to move at a slightly faster pace than Chrysler's assembly line to provide some flexibility to "catch-up" if there are problems. Chrysler's demand for components can be satisfied from a small buffer inventory that builds up because the suppliers operate at a slightly faster pace than Chrysler. These four facilities operate with minimal buffer inventory between assembly lines usually one-two hours. For example, between KTPO and Magna there is up to two hours of buffer inventory, and OMMC holds up to one hour of buffer inventory prior to the Chrysler assembly line.

KTPO, Magna, and OMMC have a set of suppliers that provide components, parts, suppliers, and services. For KTPO, this includes many companies that provide stamped steel parts, produce sheet steel, mine iron ore, make spot welding equipment, etc. For Magna, it would include companies that produce paint, make spray painting equipment, and other items. For OMMC, it would include firms that produce brakes, assemble engines, make axels, and other parts. Most of these suppliers, who are located throughout North America and in some cases Europe and China, are scheduled and coordinated by Chrysler or third party logistics providers (3pls) such as Ryder. This coordination allows the supplier in the 2nd, 3rd, and 4th tier to adjust production quickly to respond to a change in demand at Chrysler. Centralized, real time information flow allows suppliers to avoid the bullwhip effect, which is caused by delayed communication of batched orders that sequentially move down the assembly line.

The integrated facilities constructed by KTPO, Magna, and OMMC were designed in cooperation with Chrysler, but they were financed by these suppliers, who invested about \$1 billion. This is money that Chrysler would have invested under a conventional manufacturing approach, but now it can invest in developing new products. Also, Chrysler was able to accomplish two things, (1) reduce the amount of Chrysler's invested capital because the suppliers provide the money and (2) reduce the subsequent operational and financial risk. It reduces Chrysler's risk by transforming the fixed costs associated with plant and equipment into a variable cost by purchasing painted bodies and undercarriages from KTPO, Magna, and OMMC. So, when demand is low, Chrysler buys fewer of these components, thereby cutting its costs. As demand fluctuates, Chrysler's profits and losses are dampened by this arrangement. When demand is below its reduced breakeven point, part of the loss is being shared by these suppliers who have committed capital to the project. Chrysler did not invest capital to build these assembly and painting facilities, and does not have overhead costs and other fixed costs. Chrysler only pays for components from these suppliers when the components are needed to fill demand. In effect, Chrysler has turned fixed costs into variable costs. When demand is above the breakeven point Chrysler's profit is somewhat lower than it would otherwise be because the purchase price given to the three suppliers pays for debt service and provide a return on investment for the three suppliers.

Exel Organizes Inputs and Feeds the Chrysler Assembly Line

Exel is a leading contract logistics provider in the Americas. It designs and implements supply chain solutions for market-leading companies in a wide range of industries. For the Chrysler Assembly Plants, Exel is a critical interface between the Chrysler Assembly plant and many suppliers who provide parts and components. Exel receives shipments from suppliers, breaks those shipments down, and organizes and sequences the shipments that flow to the Chrysler assembly line to ensure timely arrival, minimal handling, and low work-in-process inventory. In some cases, suppliers are not shipping through Exel, Kuka, Magna, or OMMC; they ship directly to the Chrysler assembly plant. This is illustrated in Figure 1 by the dotted line around Exel. The reasons for direct shipment will become clearer later in the discussion.

Chrysler Toledo Supplier Park for the Jeep Wrangler

The Chrysler Assembly Plant, which trims and finishes the Wrangler, is the heartbeat for the entire supply chain. Chrysler, like all automobile industry companies, attempts to set its output to meet customer demand. It is very difficult to do this by changing cycle time, which is the rate at which vehicle are produced, because changes in cycle time require shifting work among people and work stations, which drives changes in plant layout and equipment location. So, assembly plants adjust output by altering the number of hours worked through overtime or adding or removing a second or even a third shift. Currently, the facility is running a two-shift operation (normally 16 hours) with a contracted production rate of 35 vehicles per hour. The two shift target output is 519 vehicles, which is usually met. The actual available work hours are 7.41 per shift or a total of 14.82 hours accounting for paid breaks.

Inbound to the Chrysler Assembly Plant for Trim and Finish

As the painted bodies from Magna via KTPO and chassis from OMMC are received at the Chrysler facility, bar code scanners log each item and ensure the proper sequence for assembly. The body is affixed to the chassis and finishing work is performed such as the installation of seats, instrument panels and other trim work. The vehicle identification number (VIN) is used to track the painted bodies and chassis during assembly. While the sequencing provided by KTPO, Magna, and OMMC reduces Chrysler's need to handle parts, Chrysler's final assembly process still requires many other parts to trim and finish the vehicle. As a result, Chrysler receives approximately 135 trucks per shift or 270 trucks in about 16 hours of operation through 30 receiving docks. Docks are assigned using a computerized dock assignment system which optimizes the aggregate capacity of the dock system. The Chrysler plant, like the KTPO, Magna, and OMMC operations, does not receive any inputs by rail directly. Exel does receive some, but these are broken down and shipped the final mile or two by truck.

These 270 trucks deliver components that come from around the corner and around the world. Exhibit 3 is a map of the suppliers that are closest to the Chrysler assembly facility because these firms provide components, which are bulky and expensive to transport and that are engaged in sequence part delivery. These suppliers are, at most, a few miles from the Toledo Supplier Park site, so travel time is measured in a few minutes up to 20-30 minutes. To explore how the sequence part delivery system works when the supplier is not located on the Chrysler campus, Chrysler's relationship with Toledo Mold and Die is discussed in a later section.

Exhibit 4 is a map of suppliers that are located in North America and supply parts and components to the Chrysler campus including KTPO, Magna, OMMC, and Exel. About 44% or 488 parts are from within 200 miles. All of this is shipped by truck and normally requires less than 24 hours day. About 27% or 304 parts are from more than 700 miles. Many of the parts sourced in the Southwestern US and in Mexico are shipped to Exel by train. The travel time by rail is normally 7-10 days. Truck travel from this segment of North America is 2-3 days. The shipping time for the components coming from beyond 200 miles but less than 700 miles is 1-2 days by truck. Little, if any, of this is shipped by train.

Exhibit 5 is a map of suppliers that are located in Europe, which is part a holdover from Chrysler's former relationship with Daimler-Benz. There is a diesel engine option for the Wrangler. The engine is designed and produced in Italy. The manual transmission is produced in Germany. There are a few other items that are shipped from Europe. The gasoline engines and the automatic transmissions come from Trenton Michigan. The components from Europe are shipped to the US via water and enter at the Port of New York-New Jersey or the Port of Quebec. The last leg of the journey is completed by truck with the engine and transmission going directly to OMMC where they are assembled into the chassis.

The number of deliveries by truck to Chrysler (270) is substantially less than the number of parts shown in the exhibits (about 1,200) because some of the part shipments arrive at KTPO, Magna, OMMC, and other suppliers that then in turn ship to Chrysler. Also, multiple parts may be produced at one facility

and shipped on one truck or the shipments may occur every other day rather than every day for some parts. Also, when shipments are less than a truckload, Chrysler can use integrated logistics centers (ILCs) at selected locations. Trucks then follow standard “milk routes” moving parts from the ILCs to the Chrysler Assembly facility. The trucks are packed to enable the dunnage to be reloaded onto the trucks for return trips to the ILCs, thus eliminating any wasted (empty) loads.

Outbound from the Chrysler Assembly Plant for Trim and Finish

As the finished Wrangler exits the assembly line, it is inspected and driven to an on-site shipping yard. Two shipping yards are electronically organized first by transportation mode (rail or truck), and then by shipping destination. A schematic of the distribution system from the assembly facility to the dealers is provided in Exhibit 6, which shows a satellite image of the plant including in-bound truck bays and out-bound shipping yards and rail sidings. The shipping mode of the vehicle is known even as the vehicle is assembled and is associated with the VIN. Vehicles are moved to the ‘rail’ yard within one hour following final assembly. Approximately 65% of the vehicles, or about 337 vehicles, are shipped using rail each day. With about 10 vehicles per rail car, the facility has about 34 rail cars per day ready for shipment by rail. The rail cars are consolidated and organized by destination, and the trains depart when a full train is available. There is not necessarily a full train load of product that leaves the facility each day.

About 35% of the vehicles, or about 182 vehicles, are shipped using truck each day. Shipping distance determines this decision because for long hauls, rail is a far less expensive than truck. Some loads go by truck as far as Iowa. Trucks have the capacity to hold nine Jeep Wranglers, which means about 20 trucks per day departing from the Chrysler Facility.

Distribution

Once the assembly is complete, the finished cars are moved from the Assembly Plant by train and by truck. The vehicles moving by truck usually go directly to dealers that are close to the assembly facility. Those going by train go to distribution lots, where other brands from other Chrysler Assembly Plants are stored. From these distribution lots, a mix of vehicles can move by truck carrier to dealerships. In the case of low volume dealers, one truck carrier will stop at two or more dealers to deliver vehicles.

Some people may view the handling that happens at the distribution lots as unnecessary costs, but in fact, costs are reduced. The distribution lots are an essential step for two reasons. First, automotive assembly lines, in general and not specific to Chrysler, do not have sufficient flexibility to produce all the different models that are available for sale. The distribution lot provides a place to mix vehicles. The natural question is; why not ship directly from the assembly plants to the dealers? That leads to the second point. The shipment from the assembly plant to the distribution lot is usually by train, which has a much lower cost than shipping by truck. In addition, the number of trips required is lower when a distribution lot is used. For example, if there are five assembly plants, ten distribution lots, and 1,000 dealers, there are 50 trips (5 plants multiplied by 10 distribution lots) from the plants to the distribution

lots and 1,000 trips to the dealer by truck transport for a total of 1,050 trips. Each dealer is served by distribution lots which are regionally located. If the distribution lots are eliminated, each plant must ship to each dealer, probably by truck, for a total of 5,000 trips (5 plants multiplied by 1,000 dealers). Remember, the 50 trips from the plants to the distribution lots are handled by rail, primarily, which is cheaper than truck transport.

KUKA Toledo Production Operations LLC: Chassis to Magna

KUKA Toledo Production Operations LLC., (KTPO) is a first tier supplier of Jeep Wrangler auto bodies to the Chrysler Assembly facility at the Toledo Supplier Park. Auto bodies are large fabricated assemblies made up of many different metal stampings such as fenders, grills, body-side and door panels, brackets, and gussets. They take a lot of space and are expensive to hold in inventory and to ship because of their size. These factors cause components like auto bodies to have a high ratio of shipping and inventory costs to selling prices. OEMs have historically fabricated and manufactured auto bodies within or very near to their assembly plant facilities. This process involved batch production, or “setting up” fabrication equipment and arranging specific stampings in preparation for long production runs of a particular auto body (i.e., a four-door Jeep). This resulted in the accumulation of large work-in-process (WIP) inventories as auto bodies awaited the next discrete operation such as the assembly to the chassis and drive train. This approach proved to be costly and impeded flexibility to produce a high variety of automobiles quickly. As such, Chrysler set out to develop a new approach to these processes by outsourcing the manufacture of auto bodies needed for the Toledo Supplier Park Assembly operation.

KTPO was selected as the auto body supplier and began operations in the Toledo Supplier Park in 2006. In this role, KTPO operates a 342,000 square foot highly automated production facility with 245 KUKA robots and approximately 250 employees running two, eight-hour shifts. In doing so, the operation produces a contracted 35 auto bodies per hour or around 135,000 per year under a normal two-shift operations. Eight different variations of the auto body units are produced by KTPO consisting of two door, four door, right hand drive, left hand drive, full door and half door models. These units are produced in sequence as determined by Chrysler. In other words, single units are produced sequentially, meaning that it is possible to have a two door full door unit followed by a four door half door, followed by a two door half door, and so on, as opposed to batch production which would provide for say 100 two door full doors left hand drive, followed by 100 four door full door left hand drive, followed by 100 two door full door right hand drive units. This approach is referred to as Sequenced Part Delivery (SPD).

KTPO’s operating window is approximately two (2) hours from notification, which is called the broadcast that determines the final configuration of the requested auto bodies, until the auto body is delivered to Magna for painting. A broadcast is sent every 88 seconds facilitated by an Electronic Data Interchange (EDI) system which connects Chrysler and its tier-one suppliers. Two key EDI reports are released by Chrysler; an 830 Weekly forecast build schedule, and an 862 Daily forecast build schedule. The weekly EDI report allows suppliers such as KTPO to plan the upcoming production which is not fixed, or locked in, until shortly before delivery is required. This period, from the time that the order is locked in,

produced, and delivered to Chrysler, is referred to as the *frozen rope* and is indicated by D3 status in the communication flow table in Exhibit 7. The two hour lead time creates a frozen rope of approximately 100 units. KTPO is in a race to manufacturer and deliver a 100% defect free auto body to the paint shop operated by Magna, just-in-time to be painted and delivered to Chrysler for final assembly with the chassis in the right sequence.

For KTPO, the shipping batch size is one auto body. So, all of the parts needed to make the auto body must be on hand. There is no time to order parts. Chrysler works hard to make sure that KTPO has the consigned parts it needs. Over 235 stampings are required to produce the eight different varieties of auto bodies. Chrysler owns all of the materials (stampings, etc.) needed in the production of the auto bodies with the exception of the sealers and adhesives. This allows KTPO to keep the inventory of incoming parts low because its suppliers are organized and coordinated simultaneously like a conductor of an orchestra with many musicians. This is primarily facilitated by Chrysler's EDI communications. Each day, KTPO receives 37 truck loads from its suppliers. The shipping origin of this inventory resides throughout the Midwest United States and Canada -- 30% arrives from Ontario, Canada, 52% from Michigan, and 9% from Ohio. The remaining inventory (approximately 9%) arrives from Maryland, Pennsylvania, Kentucky, Illinois, Wisconsin, and Missouri. Inventory received from Canada, Michigan, and Ohio are received by dedicated lines (full trucks), while the remaining 9% is received on a less than truck load (LTL) basis. In terms of dollar value, the total value of the material coming into the KTPO daily is approx \$540,000.00. Of this, 49% of the total value is sourced from Canada.

OMMC Mobis: Rapid, On-time Delivery

Ohio Module Manufacturing Company, LLC (OMMC Mobis) is a first tier supplier of Jeep Wrangler chassis to the Chrysler Assembly facility in Toledo. Chassis are large assemblies made up of many different parts including drive train components such as transmissions and engines, as well as gas tanks, drive shafts, axels, and even wheel assemblies. Like other large assemblies, chassis are expensive to hold in inventory and to ship because of their size. These factors cause components like chassis to have a high ratio of shipping and inventory costs to selling prices. So, like the auto bodies, OEMs have historically manufactured chasses within or very near to their assembly plant facilities. As discussed earlier, this approach produced large WIP inventories and thus proved to be costly and impeded flexibility. As such, Chrysler set out to develop a new approach to these processes by outsourcing the manufacture of chasses needed for the Toledo Supplier Park operation.

OMMC was selected as the chassis supplier and began operations in the Toledo Supplier Park in 2006. In this role, OMMC operates a highly automated production facility with approximately 270 employees running two, eight-hour shifts. In doing so, the operation produces 41 chassis per hour, which is faster than the contracted rate. Different variations of the chassis units are produced by OMMC consisting of automatic or manual transmissions, right or left hand drive, two wheel or all drive wheel models, etc. These units are produced in sequence as determined by Chrysler. In other words, single units are produced sequentially, meaning that it is possible to have an automatic transmission right hand drive

unit, followed by a manual transmission left hand drive unit, and so on, as opposed to batch production which would provide for say 100 automatic transmission right hand drive units, followed by 100 manual transmission left hand drive unit. Again, this approach is referred to as Sequenced Part Delivery (SPD).

Deliveries are facilitated by an overhead conveyor system physically connecting OMMC and Chrysler. This conveyor moves units through a tunnel referred to as the “trestle” in which 26 units are accumulated. Thus, when OMMC ends production on any given day, 26 units remain staged in the trestle which provides a small buffer of inventory that additional Chrysler production reduces to 6 units by the time that OMMC begins production the following day. At the point at which OMMC begins production the next day only 6 units or 8 minutes and 48 seconds of inventory is available to Chrysler, leaving virtually no room for error.

OMMC’s operating window or *frozen rope* is approximately two hours from notification, until the chassis is delivered to Chrysler. A broadcast is sent every 88 seconds facilitated by Chrysler’s EDI system. The *frozen rope* is indicated by F8 status in the communication flow table in Exhibit 7. The two hour lead time creates a frozen rope of approximately 82 units. Like KTPO, OMMC is in a race to manufacturer and deliver the chassis to Chrysler, just-in-time for final assembly with the auto body and trim work in the right sequence.

For OMMC, the shipping batch size is one chassis. So, there is no time to order parts. All of the parts needed to make the chassis must be on hand, and Chrysler works hard to make this happen. Approximately 662 parts are required to produce the different varieties of chassis. Chrysler owns and consigns 200 of the parts needed in the production of the chassis. The remaining 462 parts are “directed” by Chrysler. This means that Chrysler controls the parts that OMMC purchases and which suppliers those parts are purchased from. However, OMMC has responsibility for managing and paying for the logistics involved in coordinating delivery from their suppliers. OMMC’s suppliers also receive the 830 weekly supplier EDI transmission discussed earlier from Chrysler. This allows the inventory of incoming parts to be well organized and coordinated. Once inside the OMMC facility, information about the parts and their subsequent use in manufacturing is logged using radio frequency identification technology (RFID) and bar code technology affixed to skillets which serve to transport the chasses from operation to operation during production. These RFID tags report data about the production of each unit back to a Manufacturing Execution System (MES) which logs and manages quality and other production data. Each day, OMMC receives about 40 inbound truck loads from its suppliers. The shipping origin of this inventory resides throughout the Midwest United States with the exception of diesel engines which are sourced from Italy and some transmissions sourced from Germany.

Toledo Molding & Die: Direct Ship to the Chrysler Assembly Facility (Trim and Finish)

Toledo Molding & Die, Inc. (TMD) is a first tier supplier of instrument panels and door panels to the Chrysler Assembly facility in Toledo. These components are also large items that take a lot of space and are expensive to hold in inventory and to ship because of their size. An effective way to cut costs for this

product is to minimize inventory level and shipping distance. Also, because items like these are final finish items shipping them great distances can also lead to damage.

To accomplish this, TMD works closely with Chrysler to coordinate and sequence activities. It is TMD's responsibility to make sure that the correct dash panel is delivered in the proper sequence and within the delivery window. In this SPD environment, being too early is nearly as bad as being too late.

When complex products like automobiles are assembled, SPD provides substantial improvements in delivery time and reliability, inventory levels, material handling costs, and production costs. The supplier is usually given the sequence only a few hours before the component is needed, so operations must be close by often less than a one hour drive with no at grade rail crossing and no lift bridges.

TMD's operating window (frozen rope) is just under three hours (178 minutes). There are approximately 1900 hundred different configurations, so TMD must be prepared. The vehicle that the instrument panel will go into is partially assembled at the time of the broadcast. It has an engine, axels, frame, differential, break system, and cooling module from OMMC, and it has an assembled and painted body from KTPO and Magna, respectively. TMD is in a race to manufacturer and deliver the instrument panel to the assembly line, just-in-time to be put in the vehicle. And it must get them there in the right sequence. So, the 178 minutes is determined by how much work is remaining on the vehicle from the time of broadcast to the time the part is needed. This occurs at "G Status" as shown in Exhibit 7, the Communications Flow.

For TMD, the shipping batch size is 40 panels (20 panels in each container or rack). Two containers will fit on a tractor-trailer. TMD has a cycle time of 80 seconds, a bit faster than the Chrysler cycle time of 88 seconds. (Cycle time is the time interval between finishing a panel and finishing the next panel.) So, it takes about 53 minutes to assembly these 40 instrument panels ($80 \text{ second per unit} \times 40 \text{ units} / 60 \text{ seconds/minute}$). Over 400 SKUs are required by the instrument panel assembly process. About 80% of the parts coming into TMD are managed by Chrysler and are on consignment to TMD. Another 12% are managed by Ryder. About 8% are ordered and controlled by TMD, primarily sourced from two TMD sister facilities located within a 90 minute travel radius. This allows TMD to keep the inventory of incoming parts low because its suppliers are organized and coordinated largely by Chrysler. To ensure fast and reliable delivery, TMD located its operations about two miles from the Chrysler Assembly Plant. Each day, TMD receives 13-16 trailer loads from its suppliers and it ships 12 - 13 loads to Chrysler, 6 loads per shift. Remember, each instrument panel in each load is in the sequence that Chrysler specified because they are assembled by TMD in that sequence. Even though TMD is a couple of miles away, it is an extension of Chrysler's assembly line separated by a sequenced buffer inventory of only 3 hours or about 120 instrument panels.

Advantages of Sequence Part Delivery and Pay as Built Systems

While this may seem like a lot of effort, the savings are substantial and the coordination is very effective. First, it forces all companies, particularly suppliers to the OEM to make quality, right the first time, a

very high priority. A quality defect at TMD or its supplier can shut down the entire assembly process very quickly. In addition to the quality discipline, it also creates a culture where TMD makes what is needed and ships what is needed. This system creates substantial disincentives for making and shipping parts that are needed tomorrow or another day. It also forces TMD to find ways to reduce production time so it can respond to Chrysler's broadcast with 100% on-time delivery of the right part. As a result, TMD invests engineering, management, and operator time and talent to find ways to do the work better and faster.

For Chrysler, the savings maybe larger than the savings at TMD. A traditional manufacturing operation would have received a truck load of parts and followed the following process.

1. Unload the containers/racks from the truck and place them in the staging area.
2. Check the parts against the invoice to make sure what was ordered is what was shipped.
3. Determine which items are needed immediately on the assembly line and take those parts to the assembly line
4. Take the parts that are needed another day and put them into inventory.
5. Record that information into the inventory management system.
6. When those parts are needed, send a worker to pick them and take them to the line.
7. Whether the items got to the assembly line from the staging area in item 3 or were picked from inventory, someone at the assembly line must sequence them so they are installed in the correct vehicle.

With SPD, Chrysler has to do the following.

1. Unload the containers/racks and take them directly to the assembly line
2. The assembler takes the items in sequence and installs it. A bar code on the part is read automatically to determine that the sequence is correct. It is nearly every time.

It does not require in depth analysis to understand the significant benefits that result from streamlining this process. There is no staging near the unloading docks nor inventory space to hold items that will be needed on a later day, so space requirements are lower, which drives down both operating and construction costs. No one has to check the parts to make sure they have arrived because Chrysler uses a Pay as Built (PAB) system. When the vehicle drives away from the assembly line and passes final inspection, it must have an instrument panel. So, Chrysler issues payment for that instrument panel based on the terms it has negotiated with TMD. As a result, the entire invoicing, billing, and payment system is simplified. There is no inventory of instrument panels at Chrysler, so no one has to manage, pick, and deliver from stock to the assembly line.

In summary, SPD and PAB systems provide the following benefits.

1. Improve quality
2. Smooth line feeds and eliminates swings in production through Just In Time single piece flow.

3. Less floor space needed per unit of output
4. Less material handling and consequently less damage
5. Fewer containers/racks to hold the part because there is less inventory
6. Share technology with suppliers
7. Long-term supplier relationships
8. Streamlined receiving systems
9. Reduced costs in accounts payable
10. Increases discipline in the flows of information and goods among the partners
11. Inventory reduction
12. Lower transportation costs
13. Less rework and returns because they get it right the first time
14. Paperless systems

There are a number of components, similar to the instrument panels produced and delivered by TMD that use SPD and PAB systems to simplify and error proof the process and lower costs. Other interior components such as seats and consoles use these systems to improve performance.

Summary & Wrap Up

Chrysler's Toledo Supplier Park with its tightly integrated partners, KTPO, Magna, and OMMC, and its well organized supply chain is the most productive plant in North America. Following are some key points to consider.

1. It shares operating and financial risks by having these suppliers build with their capital and operate their employees, facilities that are usually part of the OEM's span of control. They share the profits with Chrysler when demand is strong because these suppliers receive a payment per unit that covers variable material and labor costs and contributes to overhead and profit. When demand is high, this relationship is profitable for all. When the economy is slumping, they share the loss with Chrysler because Chrysler buys only what it needs to meet consumer demand. Chrysler has less invested capital and therefore lower fixed costs.
2. Even though Chrysler is at the end of the assembly process, it coordinates the supply chain by providing demand information to not only first tier but second, third, and fourth tier suppliers. This process of spreading information about product demand often, quickly, and simultaneous provides the supply chain members with up-to-date information that greatly reduces/eliminates fluctuation in demand usually seen by suppliers, commonly known as the bullwhip effect.
3. Sequence Part Delivery and Pay As Built systems are commonly used by OEMs and their supply chains to simplify transactions, reduce transportation cost, slash inventory, and improve efficiency. These systems work very well when the components being shipped are bulky and take much inventory space, can be easily damaged, and are expensive to ship.

OEMs and their supply chains must continue to innovate if they intend to maintain and improve their competitive position in the global market place for vehicles.

Exhibit 1: Overview of Chrysler's Toledo Supplier Park Complex (Wrangler Production)

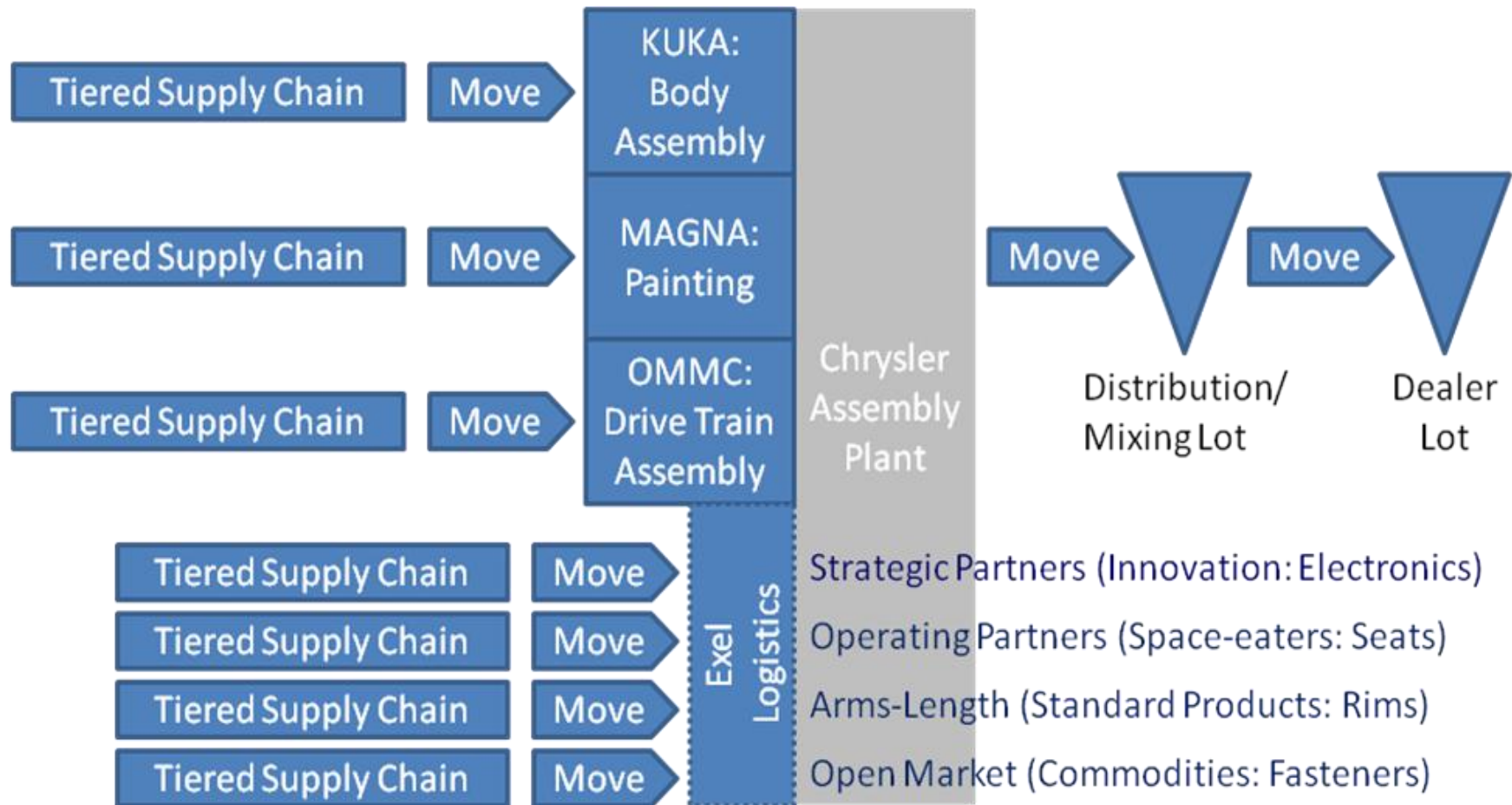


Exhibit 2: Aerial Photograph of Chrysler Toledo Supplier Park Complex (Wrangler Production)

Chrysler
Final Assembly

OMMC/Mobis
Chassis

MAGNA/TPF
Paint Shop

Kuka/KTPO
Bodyshop



Exhibit 3: Map of Sequence Part Delivery to Chrysler's Toledo Supplier Park Complex

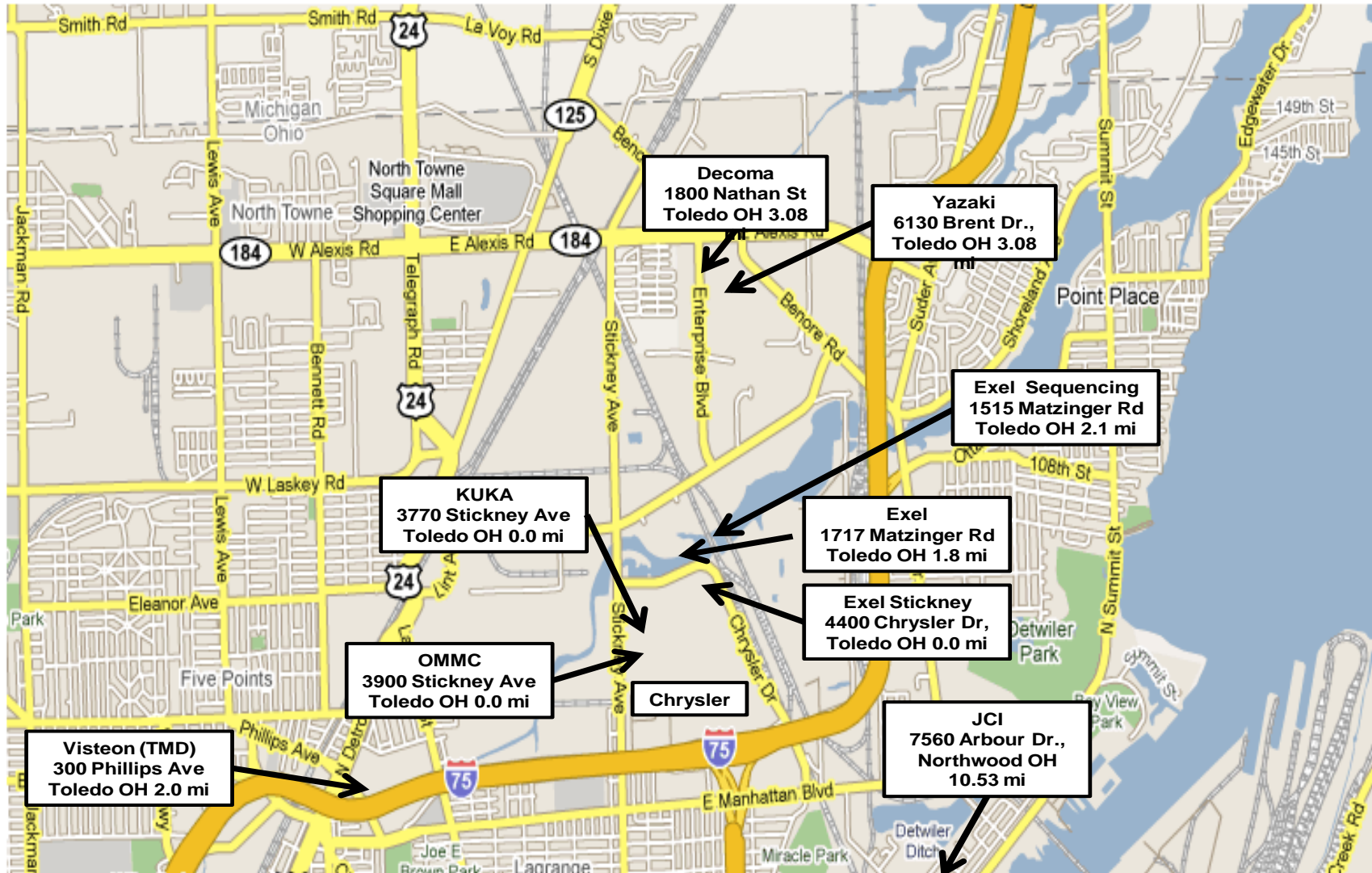


Exhibit 4: Map of Supplier Delivery to Chrysler's Toledo Supplier Park Complex from North America



Exhibit 5: Map of Supplier Part Delivery to Chrysler's Toledo Supplier Park Complex from Europe



Exhibit 6: Schematic View of the Distribution System from Assembly to Dealers

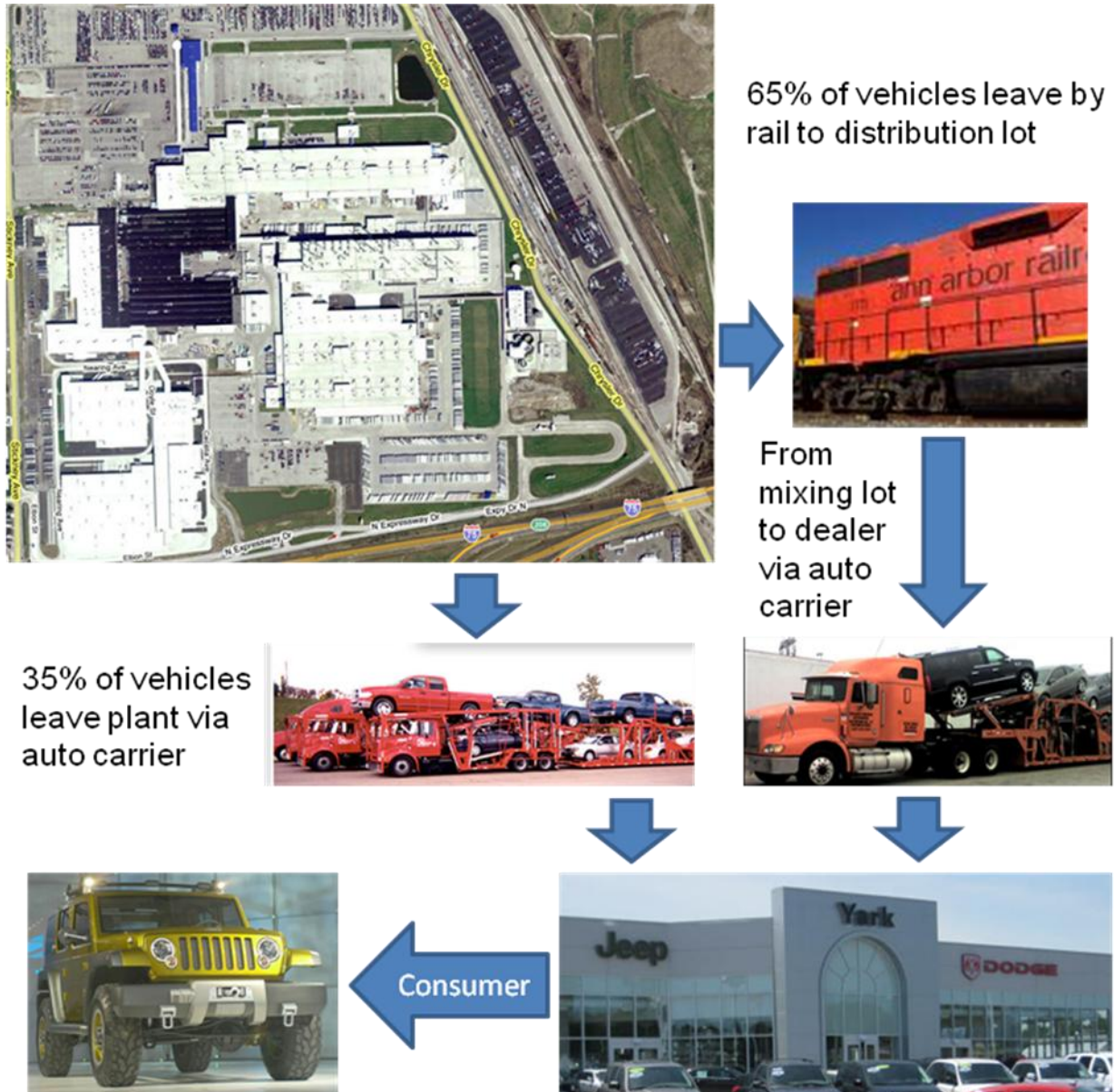


Exhibit 6: Communications Flow

4.0 Communications Flow

When	From	To	Message Type	Comments
End of Production five days before build	DCX	Kuka Hadne Mobis	GL	Initial detail of vehicle sequencing and specs, one GL per vehicle
D3 Status	DCX	Kuka	SV	Two hour lock-in
E Status	Kuka	DCX	WV	Body build is started
E9 Status	Kuka	DCX Magna	WV	Body is leaving body shop
E9 Status	Kuka	DCX	SR	How body was built
F Status	Magna	DCX Kuka	WV	Body is entering paint shop
F7 Status	Magna	DCX Kuka	WV	Body is leaving paint into sequencer
F8 Status	Magna	DCX Kuka	WV	Body is leaving sequencer into 'frozen rope'
F8 Status	DCX	Magna	SV	Release the vehicle
F8 Status	DCX	Mobis	SP	Modular build sequence
F8 Status	Mobis	DCX	SA	Acknowledgement of SP
G Status	Magna	DCX Kuka	WV	Body is transferred into DCX system
Chasis is complete	Mobis	DCX	SR	Actual build configuration
Chasis in Mobis shop	Mobis	DCX	CP	CPTS serial number data
I Status (requested by Kuka, not agreed to yet)	DCX	Kuka	SV	Vehicle is off assembly line into final line
J Status	DCX	Kuka Magna Mobis	SV	Vehicle is built and will be paid for