Delivering Engines Just-In-Time sequenced from 10,000 km away

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ABSTRACT

This paper describes how International Engines South America has set-up a logistics operation to supply six North America Truck plants from Brazil with Engines with more than 100 different configurations line set sequenced. The first part of this paper has some background information about the project. In the following parts present the roadmap developed to support the decision-making process and implementation process. In the conclusion, the results and lessons learned.

Key words: JIT sequenced, Postponement, International Logistics

ABOUT THE AUTHOR

Carlos E. Panitz took Civil Engineer at UFRGS, Business Administrator at PUC-RS and took his Master Degree in Industrial Engineering at Post Graduate Program in Production Engineering – PPGEP/UFRGS. He is responsible for the Material Planning and Logistics of International Engines South America and professor of Logistics and Transportation at Unilassale for the Graduate and Post Graduate Programs. As responsible for implementing the export operation of the V8 7.3L Engine built in Brazil for North America, he lived in USA between 2001 and 2002.

1. INTRODUCTION

In 1999, International Truck and Engine (ITEC) entered into a joint venture with the Iochpe Group to produce diesel engines for the North American truck Market. Located in the south of Brazil, the Iochpe Group was producing diesel engines for agricultural applications and the Mercusol market. By February of 2001, ITEC purchased 100% of the joint venture and named the company International Engines South America (IESA).

By the end of 2000, ITEC decided that the Brazilian Plant would be part of the transition plan to allow one of the US Plants to change over its Assembly Line to another family of products without compromise deliveries. IESA would be responsible for providing V8’s to four Trucks facilities in USA and two in Mexico. Three facilities would receive 100 different configurations of the 7.3L T444E Diesel Engine line set sequenced and the other one would receive three different models of the 7.3L Econoline Diesel Engines. Both Mexican plants would each receive a single part number.

The plan would require moving production of several models of the 7.3L V8 Engine to the Brazilian plant. The Brazilian plant has been assembling one of the models of this engine since January of 2000 for one of the Plants in Mexico.

The challenges of this new project were to prepare the supply base and the assembly plant to a volume 60-70% higher and to find a logistics framework to support deliveries of more than 100 different configurations in a Just-In-Time Sequenced operation from an offshore plant located 10,000 km away.

In addition to changing the supply and manufacturing processes, the outbound logistics process would require a completely new approach. The Indianapolis Plant is 1 to 2 days from its customers and uses the truck mode to make the deliveries. The Canoas Plant is 5 weeks from these...
customers and is 7 weeks from 35% of its supply base, also located in US. Transportation have to be multi-modal with customs and transloading operations (at least one in Brazil).

Since customers are used to providing 6 months of aggregated forecast, 2-3 weeks of frozen period and 3-4 days of line set sequenced schedule, the 1-2 days transit time permitted the Indianapolis Plant to run its Master and Material Schedule Process in a timely manner. As IESA has a much bigger pipeline on both sides – inbound and outbound – the traditional closed loop, which involves the Master Production Schedule – MPS – and Material Requirement Plan – MRP, wouldn’t fit for its business model. It was clear that the tactical planning process would have to be more complex.

The geographic dispersion of the customers required a wide range analysis of different scenarios for the network configuration. Variables such as routes, site location and capabilities were part of the Problem Solving and Decision Making – PSDM - Process.

In the next section we will present the steps of the decision-making process as follows network analysis, operations requirements deployment, planning process, implementation and final remarks.

2. DEFINING THE NETWORK CONFIGURATION

To define the network configuration, an aggregate logistics model was applied. The cost modeling included both inbound and outbound transportation costs, warehousing costs, start-up costs and inventory carrying costs. As the applied model was an analytical framework and not an exhaustive search approach, the potential scenarios were chosen based on the project assumptions and the experience of the analyst. The advantages of using analytical aggregate models are extensively discussed by DAGANZO (1991), DAGANZO et al. (1985) and PANITZ (1996). The original assumptions of the project were:

- One or two warehouses near ITEC or Customer facilities. This market positioning approach (LAMBERT, et al. – 1998) was convenient since one of the major objectives was to ensure 100% customer service level. As there were 5 potential site locations, the number of alternatives was \( \binom{5}{2} + 5 \) or 15 alternatives;
- Shipments to the Mexican facilities could be made from a US facility or directly from Brazil, due to the low volumes demanded by the plants;
- Containers could be loaded under US highways weight regulations to be delivered directly in the warehouses or could be fully loaded until the US ports and then transloaded to trailers for the in land portion of the trip.

As these last two assumptions were independent from the first one, the cost analysis to decide how the Mexican Plants would be supplied and if there would be a transloading operation were made separately. In order to reduce the number of alternatives to be evaluated, a rough analysis of the demand indicated that Conway shouldn’t be considered as an option for a warehouse due to its low demand. Comparing transportation costs from Chicago and from Indianapolis to the Customer locations also eliminated the Chicago option, since the transportation costs were always favorable to Indianapolis. As result of this filtering, the number of scenarios to be modeled dropped from fifteen to six. Table 1 presents some of the scenarios selected for the analysis. Also, to help to understand the chosen scenarios, figure 1 shows the North America Map with the plant locations.

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The cost model applied was an aggregate model that can be expressed with three simple analytical equations. Equation (1) represents the search of the lowest cost option based on the results of equations (2) and (3). Equation (2) describes the outbound logistics costs from one site location and equation (3) describes the inbound logistics cost to that location as follow:

\[ L_{opt} = \min \{ OL_j + IL_j \} \]  
\[ OL_j = \sum_{i=1}^{k} f_{ij} \cdot Q_{ij} \]  

where:

- \( L_{opt} \) → lowest cost location [$/month]
- \( OL_j \) → outbound logistics cost for location \( j \) [$/month]
- \( i \) → index that represents one of the \( k \) locations

\[ IL_j = \sum_{i=1}^{k} Q_{ij} \cdot \left( \frac{F_j}{V} + P \cdot R \left( \frac{V}{\sum_{i=1}^{k} Q_{ij}} + T_j \right) \right) + W_j \]  

where:

- \( IL_j \) → inbound logistic cost of the consolidated demand shipped to location \( j \) [$/month]
- \( F_j \) → sum of transportation costs per trip [$/trip]
- \( V \) → transportation lot size [# of units/trip]
The result of this cost modeling resulted in two warehouses to supply the four US Assembly Plants, one located in Tulsa, OK and other located in Lorain, OH. The first warehouse would supply the three Bus Plants while the Lorain warehouse would exclusively supply the Lorain Truck Plant. Figure 2 shows the final configuration of the distribution network:

After the cost modeling analysis, a PSDM process was conducted to address soft issues that could affect the final recommendation. Some of the soft issues addressed were:

- Minimum possible financial commitment. Could be a through away solution;
- High accessibility to the warehouse;
- Warehouse facility should meet all requirements regarding docking, space, layout, security and communication;
- The 3PL should have expertise with the scope of the operation required;
- Store imported engines inside available space at US Engine Plants wouldn’t be an option due to Union issues;
- Multiple points of entry are acceptable;
- Transloading operation could be a quality issue if the requirements wouldn’t be specified properly for the 3PL;
After taking in consideration these assumptions in the decision-making process, the scenario with two warehouses, one in Tulsa and other in Lorain, was confirmed. It was also decided that the Mexican Plants should be supplied directly from Brazil to avoid additional in land costs from US to Mexico and import duties that could be avoided because Brazil and Mexico had a special agreement at the time. The transloading operation was postponed in the beginning of the project besides it had been identified as a cost savings opportunity for further quality risk assessment.

The selection of the Shipping Carriers took into account, not only the freight cost per load, but also transit time and shipment frequency to the destination port.

3. DEPLOYING THE REQUIREMENTS

It was clear that to provide responsiveness from an off-shore supplier, the warehouse that would supply the Tulsa Bus Plant would require trim capability to build the 100 different configuration from a base engine shipped from Brazil. After an analysis of different configurations versus the Bill Of Materials (BOM), the Engineering group defined that three base versions could support the trim process at the warehouse.

The challenge was to identify the minimum set of base engines to avoid inventory complexity, working capital requirement and equipment investment in the warehouse.

Another important requirement was the line set sequence capability. Orders were placed by features (called Feature Based Orders or simply FBO’s) thru EDI which also informed a detailed assembly schedule (Job #, line set #, assembly day, etc.). As only the US Engines plants were prepared to support this business process, it was defined that the warehouses would use the IT applications from one of the US Engines plants. These applications were able to match the FBO’s with the high level part number of the Engine (this process was called Configure-To-Order), load the programming module of the Engine and prepare the load according to the line set sequenced established. For convenience, the Huntsville Plant was chosen to provide these IT capabilities to the warehouses.

To provide trim capability for the Tulsa site, a small assembly cell was designed with two single spindle screwdriver and one twin spindle screwdriver. All this equipment had controlled torque connected with the Engine Tracking System. A pressurized circuit provided compressed air to perform leak testing of the Engines and a Bridge System provided handling capability to move and re-rack the Engines from the wooden crates to the returnable racks.

As a consequence of the trim capability assigned to the Tulsa warehouse, it would also be necessary to set-up a planning capability to order, receive and backflush the trim parts needed to finalize the Engine dress-up. Again, it agreed that we would adopt the same IT applications of the US Engine plant.

For the Lorain facility, there was no line set or trim requirements; consequently the process set-up was much simpler. The three different part numbers of fully dressed engines were received in the warehouse using wireless bar code readers and were stored according to the FIFO method. Once the warehouse receives the load schedule from Ford, they started to uncrate the Engines and re-rack to returnable racks. At the same time a final quality inspection is made. The loads ready to ship are positioned near the shipping docks waiting for pick-up. After the load has been released, an ASN file is generated automatically.

From an infrastructure stand point, the Lorain site had less capabilities and the Tulsa site. This warehouse had an inspection area with leak test system and the bridge system for the handling and re-racking operations.

4. SETTING-UP THE PLANNING PROCESS

For the tactical planning process, there were three levels of planning/execution activities as follows:

- Delivery to the plants from the warehouses –a pull method based on daily shipping releases and managed by the 3PL staff with support of the Huntsville plant. The major task here was to ensure a 100% customer service level in a cost effective way;
- Shipping Plan from Brazil to the warehouses –a push method based on a weekly forecast released thru EDI and managed by the Material Planning & Logistics group in Brazil. This information would allow setting up a time phased order point approach to plan the outbound flow. This process, also called DRP (Distribution Requirement Planning) was executed prior to the MPS process. From the replenishment process stand point, the model adopted was Vendor Management Inventory - VMI, once International Engines South America was planning able to plan based on real customer demand and complete inventory visibility of the pipeline. The major task in this part of the Supply Chain was to
support the warehouse responsiveness with the lowest inventory level as possible in the pipeline;

- Production/Material Schedule (MPS/MRP) at Brazil—a push method also based on weekly forecast releases to both the local and offshore supply base. The challenge in this part of the process was similar with the distribution process because of the long pipeline that 35% of the items had. To release the order to the supply base a web-EDI application was implemented. This application, called International Engines Supplier Network – IESN, was able to support both the local and international supply base;

As the long term forecast was too aggregated to support the Shipping and the Production/Material Schedule beyond the VMI process, it was also necessary to have a forecast breakdown. To make this breakdown, a regression model helped forecast mix trends over the aggregate forecast (see figure 3). Figure 4 demonstrates why the planning process in Brazil has required additional steps in the planning process.

![Figure 3](image)

**Figure 3 – Regression Model used to breakdown the aggregated forecast in the base models of the T444E Engine**

To ensure responsiveness, IESA implemented specific strategies with exclusive items to allow quick changes in the assembly line from one model to the other. For example, from the 450 items that are part of the BOM of the Econoline Engines, the difference between them was just 4 part numbers.

Having some additional days of supply of these items allowed IESA to make changes in the Production and Shipping Schedule the following day after a demand change from the customer. Having an exception to the days of supply policy for a few items provided an important flexibility for a supply chain with such a long pipeline (5 weeks from the customer).
Finally, to ensure that the supplying process would achieve the objectives of 100% service level, responsiveness and as low an inventory as possible, a set of controls were defined to monitor the execution level. Build dates were monitored thru the Built-To-Schedule – BTS control item. Shipping, arrival, and customs clearance dates were also monitored daily. Each part number was controlled by monitoring the weeks of supply in both warehouses.

5. IMPLEMENTATION PHASE

The implementation phase started in October 2001 at the Lorain facility. The 3PL selected for this project was in charge to lease the building and provide all standard material handling equipment required. The 3PL was responsible for all receiving, storing, inspection, trimming (only in Tulsa), line set sequencing and shipping operations in the warehouses. In each warehouse, there was only a resident Quality Engineer to support the customers after the start-up of the operations.

In December 2001 the first shipment to Ford Lorain was released and in February 2002 the first shipment to the Bus plants was released with Engines built in Brazil. All IT infrastructure and trim equipment was in charge of International Engines. A wireless network solution was adopted in both sites to connect all terminals, printers and scanners used in the operation.

Implementation of the project was supported using a Project Management methodology. More than 500 tasks were created and controlled with Gantt charts and Action Items Plans to ensure that timing, objectives and budget would be achieved. A Status Report was released on a monthly basis to keep the rest of the company updated about the majors highlights and milestones of the project.
6. **FINAL REMARKS**

The evaluation phase of the project lasted 6 months, starting on April 2001. The implementation phase has lasted others 6 months, from October 2001 to March 2002. More than fifty people from International Engines in the US and in Brazil provided direct contribution to the rollout of this transition plan. The background involved also shows the complexity of this kind of project: logistics, material planning, purchasing, IT, manufacturing, quality, engineering, customer service and controlling.

Since the beginning of the project more than 80.000 Engines have been shipped to the six customers in the US and Mexico with 100% Customer Service Level. The volume exported to the NAFTA market leveraged International Engines South America to be one of the biggest export companies from Brazil and proved that it possible to meet detailed customer schedules even from such a great distance.

7. **REFERENCES**

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