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USING SIMULATION TO EVALUATE SITE TRAFFIC AT AN AUTOMOBILE TRUCK PLANT

Joseph C. Hugan

Forward Vision Services
16840 Newburgh Road
Livonia, MI 48154, U.S.A.

ABSTRACT

Recent trends in automotive manufacturing have increased the focus on the Just-In-Time (JIT) delivery of automotive components. By requiring smaller batches of parts delivered more frequently, automobile assembly plants now need methods for handling and understanding how the increased traffic will effect the safety and operation of their overall site. This paper focuses on the use of discrete event simulation to address the many traffic related issues brought on by this more aggressive inventory method. The model considered factors such as plant schedule, gate staffing, vehicle production, truck size, travel time, vehicle speed, loading time, and marshalling requirements. The results of the project have helped vendors understand how much time to allow for travel within the General Motors site once the truck arrives with its parts. The paper will also discuss the role 3D simulation played in validating this model and communicating specific simulation results.

1 BACKGROUND

The trend in automotive manufacturing is to require vendors to ship parts to the end assembly plant in the order required for assembly on to the vehicle. The order of these vehicles is referred to as sequence. Since there are many different vendors that must supply parts, the plant issues a broadcast to all of its vendors. A broadcast is the order that the assembly plant intends to use when building its vehicles. From the broadcast, vendors can tell what color the truck will be, what kind of seats it will have, how big the tires need to be, and if it requires a sunroof. This, in turn, allows the vendors to place the parts on their trucks in the proper order.

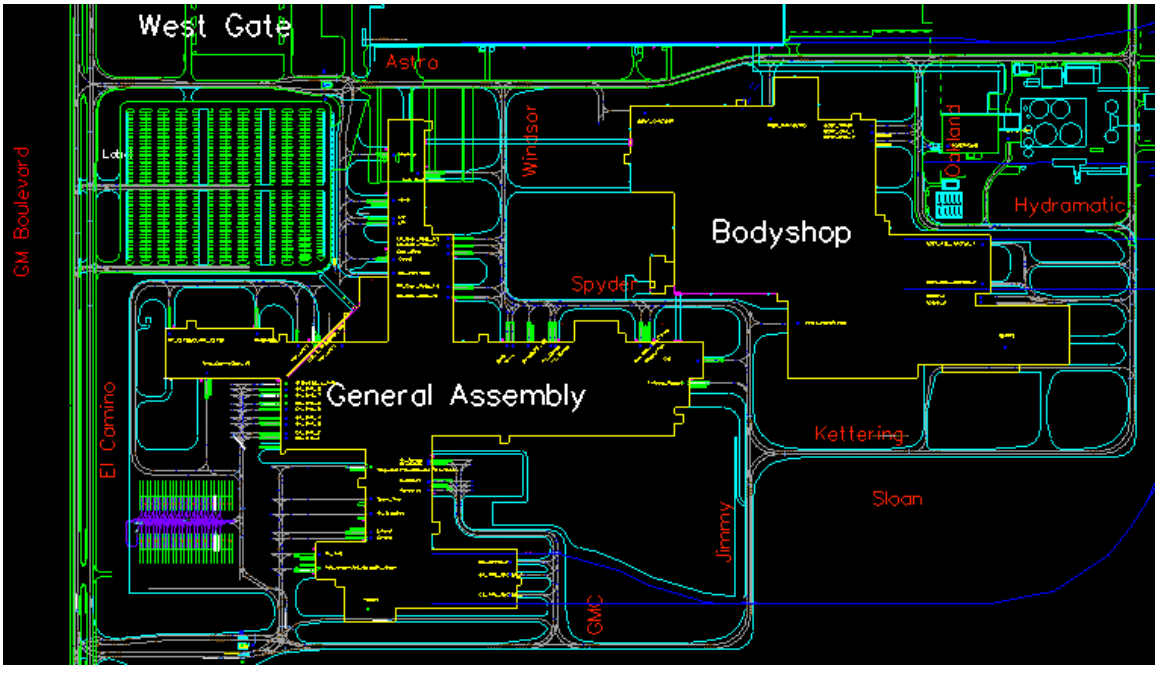

Figure 1: General Motors Truck Plant – Shreveport Site

The vendor's job is complicated by the fact that they only know this sequence a very short time before the vehicle is going to be built. The time that the vendor has from the time the sequence is set until their component is installed in the vehicle is called the broadcast window. During the broadcast window, the vendor must create the components, load them on the truck in order, and drive to the end customer's facility.

Short broadcast windows are often only a few hours. For this reason, it is important to vendors to know how much time their truck driver may spend once on-site. The time to check in a truck and drive to a dock could affect how many parts should be planned for each truck and how many trucks should be used between the two facilities.

In the case of this facility, the end customer utilizes a marshalling area to get trucks in and out of the site quickly for certain high volume shipments. The marshalling area at Shreveport was intended to primarily service the Central Market Area (CMA). The CMA handles the arrival of most parts that are not sequenced into the facility.

Since the parts for the CMA are not sequenced, the trucks often show up before the plant opens for the day. This surge of trucks is best handled through marshalling. Figure 2 shows a picture of the eight docks used for unloading the trucks for CMA. These eight docks are continually fed from trucks in the marshalling area. Once trailers are dropped by vendors in the marshalling area, it is the job of dedicated switcher trucks to move these trailers from the marshalling area to the CMA docks.

2 PROJECT OBJECTIVES

This project had four main objectives, 1) determining the best routes for each type of truck to alleviate congestion, 2) estimating time required for each commodity to reach its dock once it has entered the site, 3) determining the size of the marshalling area required to support the planned production, and 4) determining the number of switchers required to service the marshalling area.

3 MODELING ASSUMPTIONS

The main focus of the model was the process of routing trucks to the appropriate dock, unloading the truck, and sending the truck out of the site on the best route. The trucks were classified as sequenced or non-sequenced parts. Trucks with sequenced parts had a special lane for entering the facility. This carded gate allowed these trucks to enter and exit the site quicker than a truck that was delivering non-sequenced parts going to the CMA or trucks that carried for the cafeteria or supplies for the shipping area.

Trucks were given a constant velocity within the site (8 mph) and were required to follow all traffic lights and stop signs within the site. Trucks also had to cross railroad tracks that were used to ship completed vehicles. These rail crossings were made unavailable during specific times in the day based on a set shipping schedule.

The model also included estimates on employee traffic. Forty-five minutes before a shift was set to start, employee cars would start to arrive based on a distribution provided by General Motors. The model also had allowances for the fact that over 70% of employees arrived from the East. This imbalance made it difficult for sequenced trucks arriving from the east during any kind of shift change.

The model also accounted for the fact that certain types of components were actually consumed directly from the truck. This meant that the unload rate was a function of line speed. These docks operate in pairs. One trailer provides the sequenced parts for delivery directly to the line while the other trailer gets the empty racks that must be delivered back to the vendor to be refilled. At Shreveport, seats, instrument panels, powertrain modules, and wheels all follow this dual dock philosophy. Due to the size of these components and the additional time for the trailers to empty, these are the most critical docks with the least room for problems with their arrival.

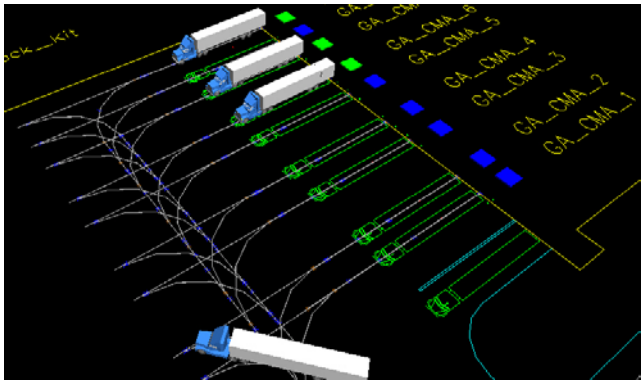

Figure 2: CMA Dock Area

The model does not include the actual unloading process within the facility. The early phase of the model prohibited us from knowing how the facility would be staffed for unloading trailers. Each type of truck was assigned a conservative time for unloading based on the experience of team members.

4 MODEL OVERVIEW

The model was constructed using AutoMod from Brooks Automation. The modeling began with an AutoCad file showing the site and surrounding areas. Conveyor was used to model the roads. The trucks in the model are actually parts in the AutoMod scheme.

The model is driven by a series of data files that make experimentation easier. One file describes the arrival of vehicles base on their contents. Another file defines the path taken in and out of the site through a unique method of numbering intersections.

Each intersection in the site was given a number, an inbound path was defined by listing a series of intersections for the truck to follow. Rerouting trucks was as simple as reordering numbers in a data file. This allowed for easy experimentation on possible routes that may alleviate congestion. The same method was used for directing trucks to exit the site.

5 MODEL VALIDATION

The two main methods used to validate the model were meetings with expert from Shreveport and the use of deterministic data. The model was developed with input from these experts over a period of three months. During the validation phases of the project, the paths, rules of the road, unload times and commodity sizes were refined many times. The model output also included time stamped event files that could be used to walk through the model on a step-by-step basis. Once the model was validated, distributions were used for all operations that involved stochastic operations. The run results shown were a summary of 10 replications using different random number streams.

6 SIMULATION RESULTS

The project was designed to address the specific objectives outlined here. The first objective focused on alleviating congestion. By referring to Figure 3, the project team was able to reroute non-critical components through less traveled intersections that may take the truck longer but lend to better overall traffic flow.

The key statistic in this analysis was the average time spent on -site by each type of arriving commodity. Figure 4 shows the final table of times for selected commodities.

ZONE	# TRUCKS	ZONE	# TRUCKS
American_Way-East_Gate	1908.0	Leland-Scrap_Entrance	258.0
Marshal_Area-600_Docks	1586.0	Lelend-Hydramatic	273.0
Marshal_Area_Entrance	1802.0	Leland-Astro	315.0
CMA_Dock_Entrance	1162.0	Astro-Oakland	235.0
American_Way-GMC	353.0	Atro-Windsor	546.0
Jimmy-Kettering	319.0	Astro-West_Gate	722.0
Kettering-Blanks_Exit	129.0	Astro-Body_Dock	151.0
Leland-Blanks_Entrance	281.0	Leland-Paint_Dock	130.0
Leland-Scrap_Exit	263.0	Hydramatic-Tank_Farm	4.0

Figure 3: Validation Table for Quantity of Trailers Passing Key Intersections

Road-Gate: Time as measured from a point 1000 ft from arriving gate
Gate-Dock: Time as measured from the entry gate to the dock
In-site transit: Sum of Road-Gate and Gate-Dock times
Avail transit: Available transit time as defined in POU sheet
Avail offsite transit: Available transit time from supplier to a point 1000 ft E/W of the gates

Part Name	# of daily trips	Avg. IAT (min)	Road-Gate (min)	Gate-Dock (min)	In site transit (min)	Avail transit (min)	Avail offsite transit
Main_body_harness	21.0	57.1	3.4	0.8	4.2	20.4	16.2
Headliner	29.0	41.4	3.2	0.2	3.4	28.9	25.5
HVAC	9.0	133.3	3.3	0.4	3.7	20.0	16.3
I/P	23.0	52.2	2.9	0.5	3.4	17.6	14.2
Carpet	19.0	63.2	3.4	0.7	4.0	24.0	20.0
Steering_column	25.0	48.0	4.3	1.0	5.3	21.4	16.1
Frames	49.0	24.5	4.9	1.0	5.8	16.9	11.1
Exhaust	34.0	35.3	4.1	0.5	4.6	25.2	20.6
Power_train	38.0	31.6	5.0	1.5	6.5	27.7	21.2
Rear_bumper	13.0	92.3	5.5	2.2	7.7	31.8	24.1
Seats	21.0	57.1	3.6	1.1	4.7	20.0	15.3

Figure 4: Selected Commodity Times for Point-to-Point Travel

These times originally showed occasional problems with the arrival of instrument panels, frames, and seats. Once the average available time exceeded ten minutes, the team was comfortable that the shipping schedules were achievable.

The model was also used to size the marshalling area to service the CMA. This area saw a maximum utilization of 70% during the course of experimentation. The area allocated was deemed sufficient for the marshalling requirements.

The last objective was to determine the number of switchers required to service the marshalling area and CMA docks. Manual calculations of pickup time, travel distance, and drop-off time estimated three switchers would suffice. However, the simulation showed that congestion in the entry to the CMA and in the marshalling area itself, dictated that four switchers would be required.

As is the case in many simulation projects, another important characteristic of the site was determined during the modeling process. The East gate would often have non-sequenced part trucks waiting when the gates opened each morning. These trucks, numbering 35-40 some mornings, would backup on to the single lane service drive that led into the facility. This meant that sequence trucks often had no way of getting to their dedicated lane until many of these trucks had entered the facility. This discovery prompted the city to add of a second lane on the service drive well ahead of the scheduled opening of the new operation.

7 THE ROLE OF 3D SIMULATION

There were two main areas of the project that were greatly enhanced by the use of 3D simulation, Model Validation and Model Accuracy.

During the validation process, a team of engineers reviewed the model for several hours. This led to an active discussion on potential routes that had been evaluated and the interference caused by the railroad crossings.

The 3D nature of the model also made it more accurate. Without the scaled model, the measuring congestion and determining the time for alternative routes would have been time-consuming, at best.

8 CONCLUSIONS

Using simulation to provide a framework for design evaluation and improvement is an excellent way to organize and motivate a disparate team of engineers toward a common goal. The high level of visualization encourages input from everyone on the team and gets buy-in to the model's value early on in the project. In the case of this program, This model gave the project team a common framework for discussing everything from how many guards to place at each gate to where the cafeteria should be located.

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AUTHOR BIOGRAPHY

JOSEPH C. HUGAN is President of Forward Vision Services. Forward Vision is a simulation consulting company located in Livonia, Michigan. He received his Bachelor's Degree in Manufacturing Systems Engineering from GMI Engineering and Management Institute and his MBA from Wayne State University. He has over 16 years experience in discrete event simulation including the software products AutoMod, Witness, GPSS, and QUEST.