Supply Chain and Inventory Management through Intermodal Logistics Analysis

by

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ABSTRACT

More collaboration is needed between transportation (trucking and rail) and industry. Often transportation requests are last minute decisions made by manufacturers many times with the expectation that trucks and/or trains are always available. The problem is made worse because the manufacturer has usually known weeks in advance of the need. As a result, this leads to increased logistics costs, reduction in efficiency, and can cause avoidable delays. Logistic costs increase due to the last minute requirement of finding drivers. Experienced, professional truck drivers are a vanishing breed. Efficiency is impacted because the options (all truck or truck and rail combinations) to meet the customer's needs are greatly reduced and if the logistic company cannot allocate the necessary resources, delivery delays are certain. In addition, customer inventory management policy also has an impact on supplier operations. For example, if a customer only checks the levels of certain raw materials once a month. The customer adversely, causes a demand spike for their supplier and the supplier must man their system to handle these instances.

This project develops a web-based system (software and hardware) to help reduce costs though collaboration between trucking, rail and industry for domestic transportation. To achieve this, the concept of Vendor Managed Inventory (VMI) will be applied to the liquid and dry bulk freight industry. A software system called eVMI is developed to help decision makers alleviate the fore mentioned issues with labor by reducing the number of long haul drivers required, reducing logistics cost by providing the logistic companies with data in a timely manner, improve safety by relying on rail for long distance transfers as opposed to using trucks, and help to smooth both logistic requirements and supplier demand patterns. The project also provides a case study that illustrates how the toolset can be applied in a real setting.

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We would also like to acknowledge our industrial partners who helped us understand the operations of domestic intermodal transports. In particular we acknowledge: Doug Smith and Steve Haskins from Miller Intermodal Logistic Services (MILS) sharing their expertise in domestic supply chain operations in the liquid and dry bulk industry and trucking logistics and other MILS partners for their expertise in rail transportation.

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INTRODUCTION

More collaboration is needed between transportation (trucking and rail) and industry. According to a survey conducted by the NEXTRANS Center at Purdue University only 28% of freight carriers often or very often collaborate with rail carriers, suggesting that collaboration between rail and truck carriers remains relatively limited [1]. Often transportation requests are last minute decisions made by manufacturers many times with the expectation that trucks and/or trains are always available. The problem is made worse because the manufacturer has usually known weeks in advance of the need. As a result, this leads to increased logistics costs, reduction in efficiency, and can cause avoidable delays. Logistic costs increase due to the last minute requirement of finding drivers. Experienced, professional truck drivers are a vanishing breed. The long-haul driver leads a solitary, mobile life full of stress and inconvenience. The profession requires dedication and experience, but few fleets offer apprenticeships, modified schedules or other enticements to attract young people. As a result, the average age of over-the-road drivers has climbed to 55 in recent years. The American Trucking Associations assert that the current shortfall of 30,000 truck drivers could widen to a gap of 200,000 in the next ten years [2]. This results in increased labor costs to obtain and keep willing employees. Efficiency is impacted because the options (all truck or truck and rail combinations) to meet the customer's needs are greatly reduced and if the logistic company cannot allocate the necessary resources, delivery delays are certain. In addition, customer inventory management policy also has an impact on supplier operations. For example, if a customer only checks the levels of certain raw materials once a month. The customer adversely, causes a demand spike for their supplier and the supplier must man their system to handle these instances.

OBJECTIVE

The objective of this project is to develop a system to help reduce costs though collaboration between trucking, rail and industry for domestic transportation. To achieve this, the concept of Vendor Managed Inventory (VMI) will be applied to the liquid and dry bulk freight industry. A software system will be developed to help decision makers alleviate the fore mentioned issues with labor by reducing the number of long haul drivers required, reducing logistics cost by providing the logistic companies with data in a timely manner, improve safety by relying on rail for long distance transfers as opposed to using trucks, and help to smooth both logistic requirements and supplier demand patterns.

The following sections will describe the general problem being addressed, give a description of VMI and define how VMI can be applied to the liquid and dry bulk freight industry. A set of software tools is also described to help analyze and optimize intermodal transportation decisions.

BACKGROUND

Bulk commodities, such as petroleum, grain, oil, and gravel, are consumed as part of many manufacturing processes. As with many other commodities, liquid and dry bulk freight often relies on intermodal connections. In fact, approximately 22.8% of all truck fleets in the nation are liquid and dry bulk type body trucks [3]. The majority of US customer shipments are transported and manufactured on schedules that are driven by customer ordering methods and the manufacturer ends up being reactionary. This results in lost efficiency and additional costs for customers, suppliers, and logistics companies.

Typically, customers track their own inventory levels of bulk commodities periodically *(e.g.; daily, weekly or monthly)*. This inventory period is customer defined based on current policies and company history. When the inventory level for a given bulk good reaches a reorder point (also customer defined), a renewal order is placed with the corresponding supplier via email, fax, phone, etc. The customer is given a lead time for the renewal order, which includes the manufacturing time plus the transportation time. This process often results in unacceptable lead times, which has negative impacts on everyone in the supply chain. These impacts include: expedited shipments, order spikes, and underutilized intermodal transportation opportunities.

The unacceptable lead times require suppliers to contact the logistics company and request expedited shipments. Expediting leads to partial shipments just to meet customer requirements. The truck/mile cost is the same whether the truck is fully loaded or partially loaded. Also since rail usage is not a viable option due to travel time requirements, this results in longer truck hauls which adds to congestion on the interstate system and increased safety concerns.

The lack of visibility of end customer demand causes a number of problems. Firstly, the Forrester effect becomes evident, due to the structure of the ordering decision with its lead-time for deliveries. The retailer as a result of forecasting customer demand introduces extra fluctuations into the pattern of demand. The distributor, whose forecast is based on the orders of the retailer, then increases these variations further. This effect continues up the supply chain, resulting in a significant distortion of the actual customer demand by the time the factory receives orders [4]. This production cycle results in many order spikes creating extra costs to pay overtime on some days, and idle workers on other days. Also, these peaks cost the supplier extra for a stockpile of raw materials or finished goods large enough to compensate for this demand. For the transportation company, these order spikes could result in a lack of trucks available to handle the transportation demand. All of which are avoidable delays.

Subsequently, all the customers act independently of each other. They are concerned about their specific order needs and not what other customers purchasing the same bulk commodity may also need. These customers could be co-located in the same city or geographic area resulting in transportation inefficiencies caused by partial loads and uninformed scheduling decisions. The impact is particularly tangible when the shipment strategy calls for a consolidation program where several smaller deliveries are dispatched as a single load, realizing scale economies inherent in transportation [5]. In addition, all of the previously discussed factors cause a significant underutilization of the rail network, which could provide a transportation cost savings for the total supply chain if properly realized. “A single intermodal freight train can displace as many as 300 intercity trucks from the highways, and reduce fuel consumption by 75% in the process” [6]. The key to being able to employ a more balanced use of both truck and rail is improved inventory coordination between customers and suppliers.

METHODOLOGY

Vendor Managed Inventory

For several years, the retail-distribution sector has successfully employed what is termed a “Vendor Managed Inventory” (VMI) strategy. This approach typically draws upon advanced information systems to provide both retailers and distributors access to up-to-date inventory information, so that the “bullwhip” effect is minimized. As a result, several famous case studies have been published where total inventory levels are reduced, transportation costs are reduced, and service levels are increased. “This type of relationship is perhaps most famously utilized by Wal-Mart and Proctor and Gamble … dramatically improving P&G’s on-time deliveries to Wal-Mart while increasing inventory turns [7]”. Based on interviews with industry experts, the aforementioned VMI type approach does not exist commercially for the liquid and dry bulk freight domain. To work, all involved parties (supplier, customer, and logistics company) must share data of their respective business needs as it relates to the bulk commodity desired. This data includes manufacturing lead time requirements, loading capabilities for transportation modes, storage capacity, historical demand data and data for unique demand situations. The next section will discuss how VMI could be applied in the liquid and dry bulk freight domain.

Application of VMI

The objective of this project is to develop a web-based VMI software system to help logistics companies, customers and suppliers reduce costs through collaboration between trucking, rail and industry for domestic transportation. This system is developed for the liquid and dry bulk freight industry drawing upon a strong private sector partnership.

In order to understand the architecture of the VMI software system, the proposed type of intermodal network needs to be introduced. This network is shown in Figure 1 and is briefly described in the following narrative.

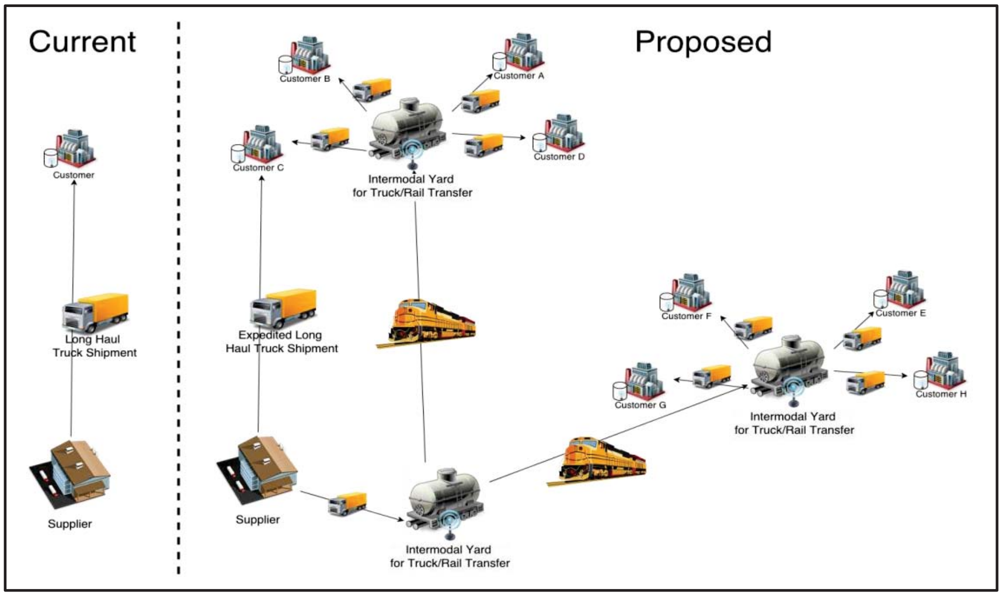


Figure 1: Commodity Flow Diagram

Today when customers need a specific liquid and dry bulk commodity most are shipped from the supplier to the customer via long haul trucks. In the proposed intermodal shipping network, liquid and dry bulk storage will be integrated into strategic intermodal rail yards. This liquid and dry bulk storage will be utilized to quickly fill customer demand. So, when customers need a specific commodity, they submit an order to the supplier. If the requested commodity is available at a local intermodal yard, the commodity is shipped via truck to the customer. If required, the tank holding the commodity at the rail yard is then replenished from the supplier. The supplier ships the commodity via a rail car and delivered to the intermodal yard where the tank is replenished. On rare occasions, when a customer needs a liquid and dry bulk commodity expedited, long haul trucks will still be utilized.

In order to effectively manage implementing VMI into the liquid and dry bulk commodity domain an advanced information system that provides access to up-to-date inventory information is needed. As shown in Figure 2, this system will access sensors at customer sites and within the liquid and dry bulk storage at the intermodal rail yards to automatically access up-to-date inventory information. The system will also allow for inventory control managers at the customer site to interact with the software. This will allow them to manually update inventory levels, set customer safety stock levels, or force replenishment due to demand increases or emergency situations. The VMI system will take the inventory data from the customer and analyze it to determine logistic reorder points. Logistic reorder points take into account the lead time needed to deliver the commodity before the customer's defined safety stock level is reached. When commodity replenishment is required the system will schedule a delivery from the liquid and dry bulk storage at the intermodal yard close to the customer. The VMI system will also monitor the inventory levels at the liquid and dry bulk storage at the intermodal rail yards to determine their logistic reorder points. When replenishment is required the system will place an order with the supplier and schedule the necessary intermodal transportation.

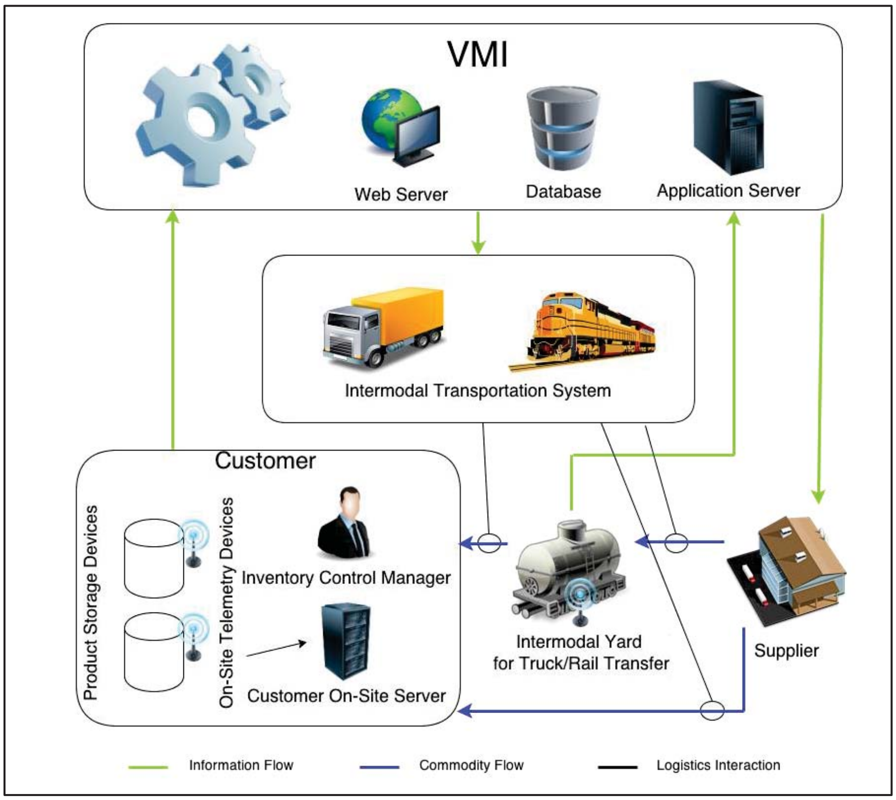


Figure 2: VMI System Diagram

EVMI SYSTEM

Overall Architecture

To apply the VMI concept, software tools and hardware components were needed to support the decision making process. These components include telemetry hardware, main system database, web-based eVMI application, and a logistic analyzer. Figure 3 shows these components and their relationship to each other and the following sections describe the details of these pieces of the eVMI system.

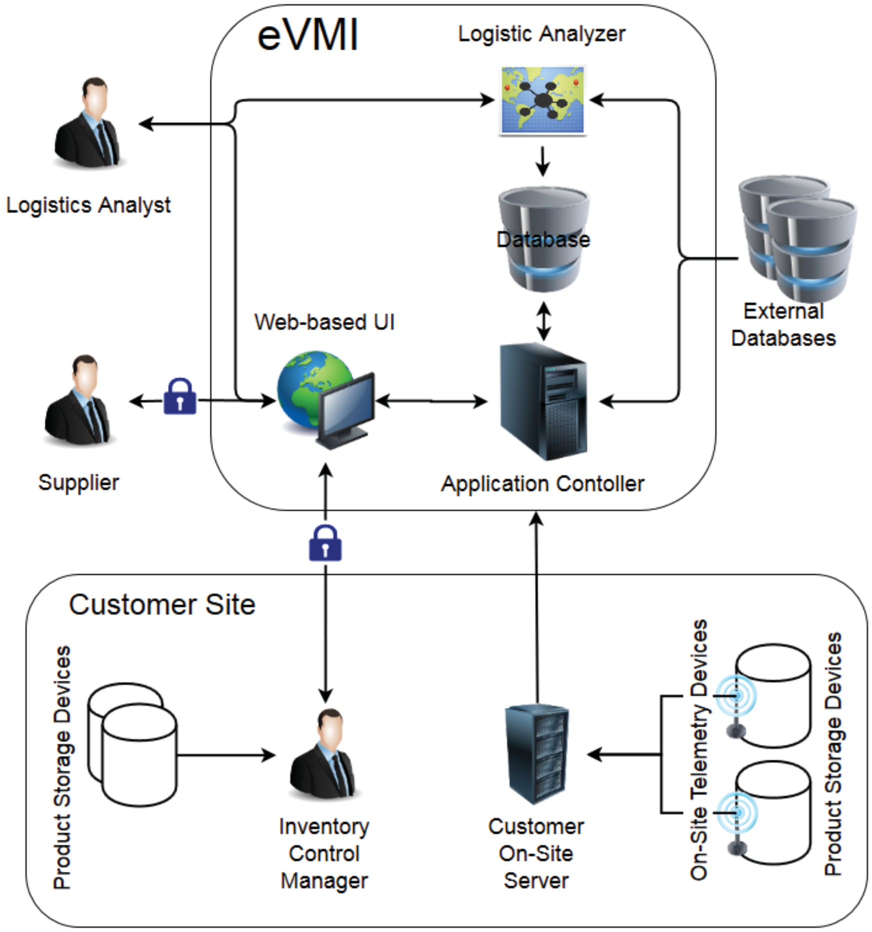


Figure 3: eVMI System

Telemetry Hardware

In a VMI system having up-to-date reliable data to make decisions is a necessity. As part of this project, MILS partnered with Level Devil [8] to develop telemetry units that could be deployed in various environments. The telemetry units can be used in structured environments (readily available network connectivity), ad-hoc environment and even in-transit. The telemetry units can also be utilized with highly corrosive products such as HCl acid and sensitive products such as food additives. These telemetry units are used to collect and transmit up-to-date inventory information.

The telemetry system can be setup in a variety of ways. Figure **4** shows the possibilities. The readers are located on the tanks. These readers can be connected to the server via a cellular network, wireless signal, or an Ethernet cable. The server is local to the customer and serves two purposes. The primary purpose is to collect and consolidate the data from the telemetry units. The secondary purpose is to handle exceptions caused by connectivity issues with the eVMI system (i.e. if the eVMI system goes down or the network between them fails, the local server will store data until the connection is restored to ensure data integrity).

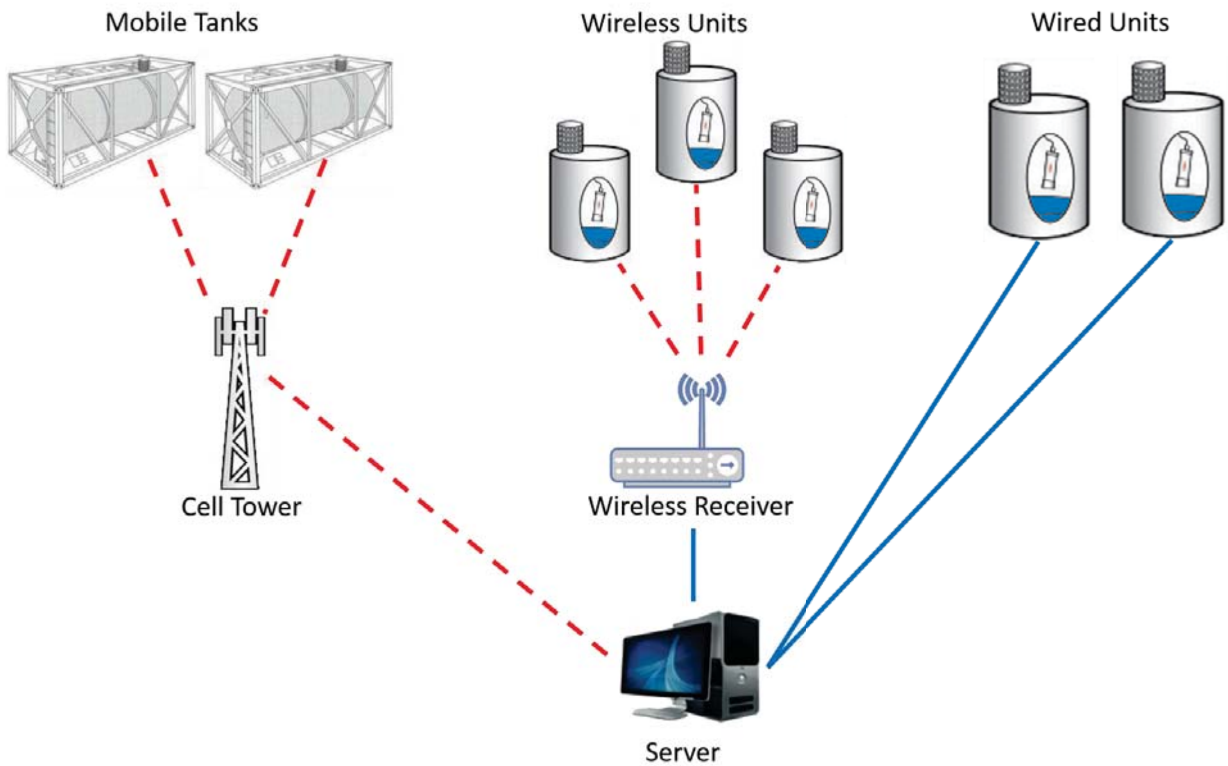


Figure 4: Telemetry Network

If the unit is fully self-contained, it transmits the data from the reader across a cellular network to the server. No other components are needed in this case. Mobile tanks, like ones moving on railways, will most likely utilize this type of setup since they are typically in motion and not stationary. Reader units, like the one found in Figure **5**, that act as "Slave" units must transmit the data using a built-in wireless transmitter to a nearby "Master" receiver unit that is directly connected to the customer's network via an Ethernet cable.

Figure 5: Telemetry Unit

Figure **6** shows how a transmitter and receiver would be setup. The reader unit located on the tank in the left of the figure must be within range of the wireless “Master” receiver unit located on the right side of the figure for the data to be transmitted successfully.

Figure 6: Telemetry Unit and Data Collector Locations

Reader units that do not have a wireless data transmitter must be directly connected to the server using an Ethernet cable. The telemetry units also have power supply options. The units can receive power from a NiCad battery or a hardwired power supply. A slave unit installed on an indoor used oil tank with a hardwired AC power supply can be seen below in Figure **7**.

Figure 7: Used Oil Tank

Units setup outside can have an optional solar panel mounted to charge the on-board battery. Figure **8** shows a slave unit installed on an outdoor influent tank with a solar panel and battery power supply.

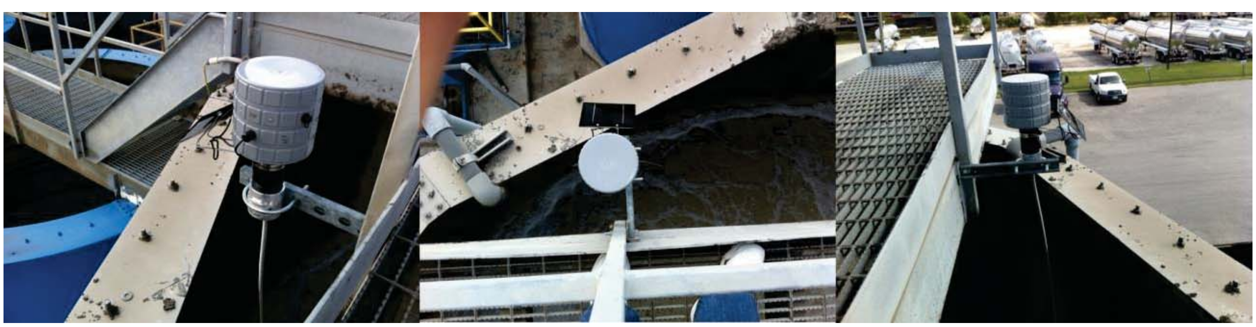


Figure 8: Influent Tank

Main Database

The main database for eVMI is responsible for storing all data associated with the system. The overall structure of the database can be seen in Figure 9. Key data that is stored in the main database includes the following:

- General Customer/Supplier Information – customer/supplier data.
- Customer/Supplier Site Information – specific site data for customers and suppliers (i.e. customers can have multiple sites).
- Equipment Information – includes information about the tanks and telemetry devices available at the various sites.
- Transport Information – includes information about the modes of transport including transport type, identifier, status, and expected pickup and delivery dates for a current order.
- Order Information – information focusing on pending, in process and completed orders including quantity, order status and expected processing dates.
- Inventory Information – tracks the status of all tanks for all customers and suppliers including last read value, forecasted consumption rate, and projected fill value (this considers any product currently in transit).
- Product Information – description of the various bulk and dry goods to be tracked and moved. This includes any restrictions for transporting a given product such HCl acid.
- Enumerations – list of units of measure, product families, product type, equipment types, etc.

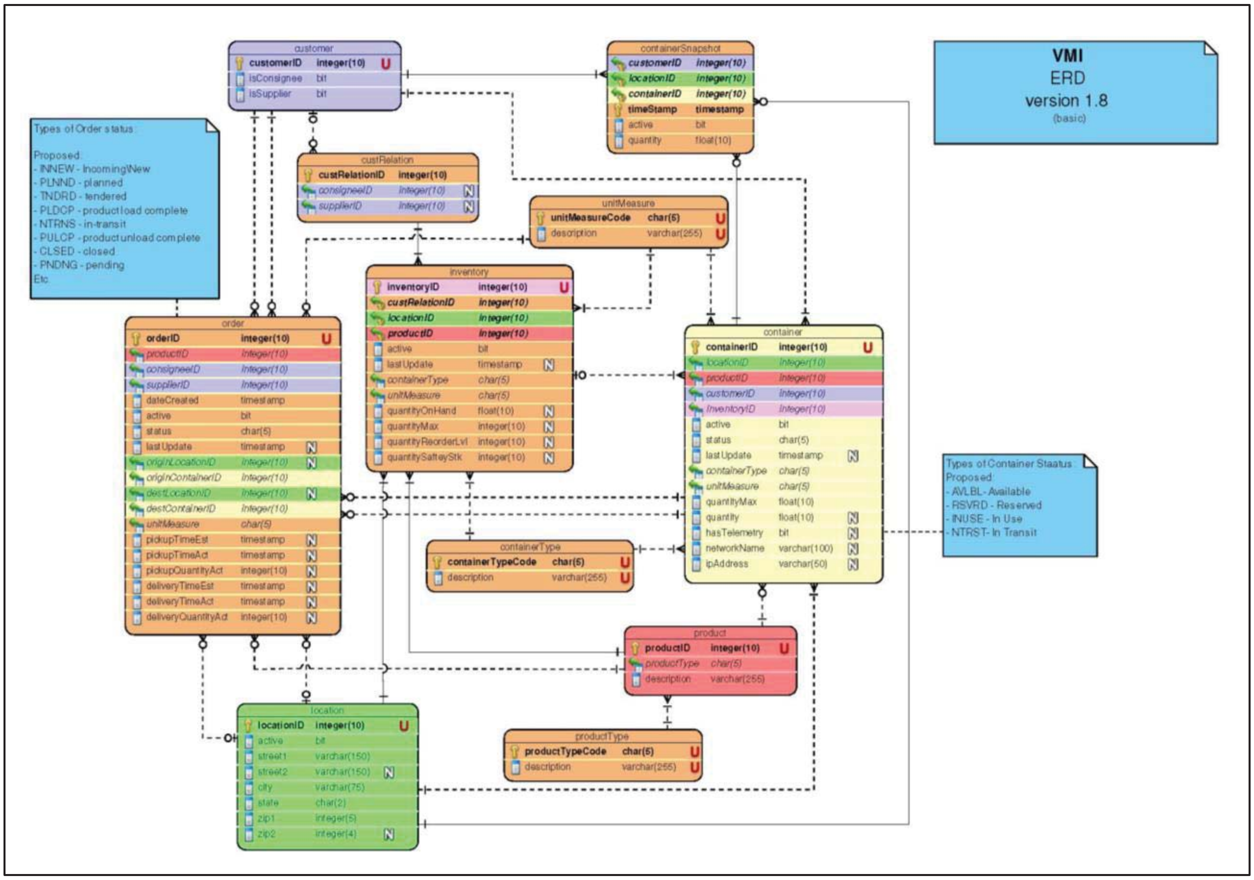
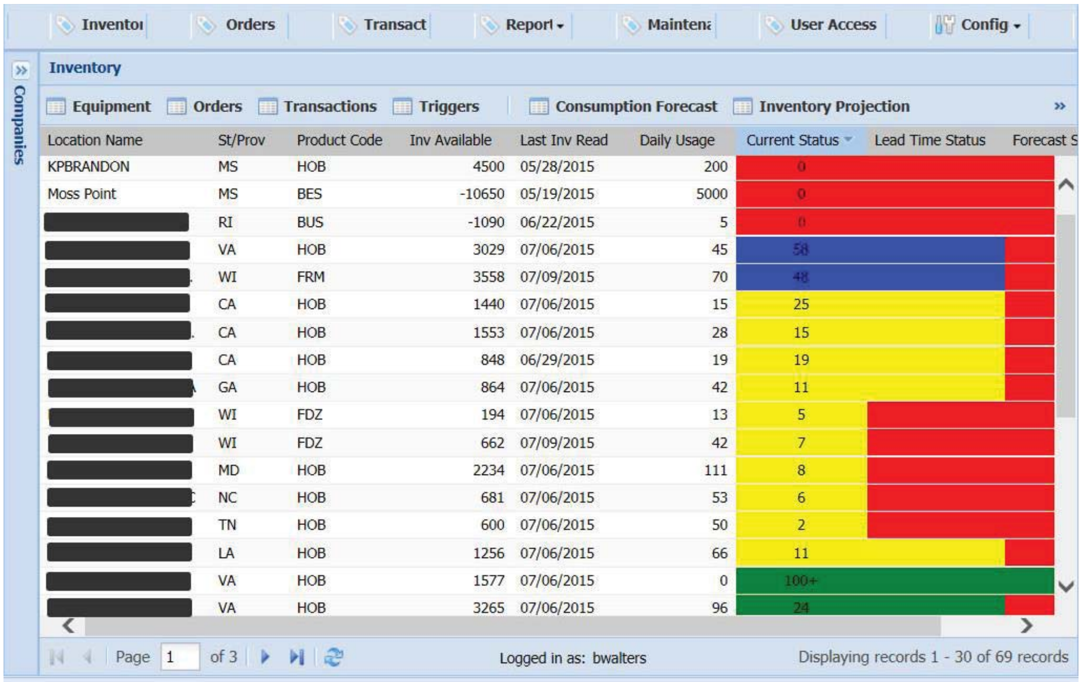


Figure 9: Entity Relatsionship Diagram

In addition, the eVMI system will eventually accesses key information from external data sources such as TMW fleet management software and other logistics and regulatory data sources.

Web-based eVMI Application

The eVMI application is a web-based data acquisition and management system that aids logistic specialists in evaluating supplier and customer inventories to ensure the customer never starves for a given bulk commodity. The tool also helps in making intermodal transportation decisions with the goal of reducing time and costs. The main dashboard, shown in



Inventory | Orders | Transact | Report | Maintena | User Access | Config

Companies

Inventory

Equipment | Orders | Transactions | Triggers | Consumption Forecast | Inventory Projection

Location Name	St/Prov	Product Code	Inv Available	Last Inv Read	Daily Usage	Current Status	Lead Time Status	Forecast S
KPBRANDON	MS	HOB	4500	05/28/2015	200	0		
Moss Point	MS	BES	-10650	05/19/2015	5000	0		
[redacted]	RI	BUS	-1090	06/22/2015	5	0		
[redacted]	VA	HOB	3029	07/06/2015	45	58		
[redacted]	WI	FRM	3558	07/09/2015	70	48		
[redacted]	CA	HOB	1440	07/06/2015	15	25		
[redacted]	CA	HOB	1553	07/06/2015	28	15		
[redacted]	CA	HOB	848	06/29/2015	19	19		
[redacted]	GA	HOB	864	07/06/2015	42	11		
[redacted]	WI	FDZ	194	07/06/2015	13	5		
[redacted]	WI	FDZ	662	07/09/2015	42	7		
[redacted]	MD	HOB	2234	07/06/2015	111	8		
[redacted]	NC	HOB	681	07/06/2015	53	6		
[redacted]	TN	HOB	600	07/06/2015	50	2		
[redacted]	LA	HOB	1256	07/06/2015	66	11		
[redacted]	VA	HOB	1577	07/06/2015	0	100+		
[redacted]	VA	HOB	3265	07/06/2015	96	24		

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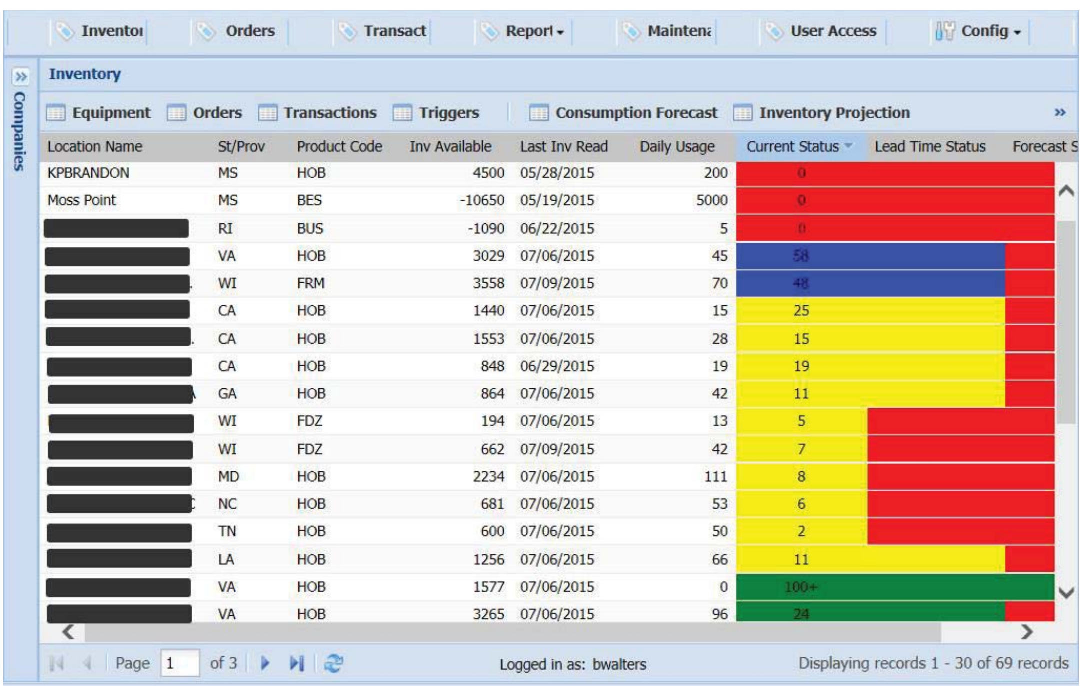
Figure **10**, is the primary view for the logistics specialists. The dashboard informs the logistic specialist of the status of each customer's inventory.



Inventory | Orders | Transact | Report | Maintena | User Access | Config

Companies

Inventory

Equipment | Orders | Transactions | Triggers | Consumption Forecast | Inventory Projection

Location Name	St/Prov	Product Code	Inv Available	Last Inv Read	Daily Usage	Current Status	Lead Time Status	Forecast S
KPBRANDON	MS	HOB	4500	05/28/2015	200	0		
Moss Point	MS	BES	-10650	05/19/2015	5000	0		
[redacted]	RI	BUS	-1090	06/22/2015	5	0		
[redacted]	VA	HOB	3029	07/06/2015	45	58		
[redacted]	WI	FRM	3558	07/09/2015	70	48		
[redacted]	CA	HOB	1440	07/06/2015	15	25		
[redacted]	CA	HOB	1553	07/06/2015	28	15		
[redacted]	CA	HOB	848	06/29/2015	19	19		
[redacted]	GA	HOB	864	07/06/2015	42	11		
[redacted]	WI	FDZ	194	07/06/2015	13	5		
[redacted]	WI	FDZ	662	07/09/2015	42	7		
[redacted]	MD	HOB	2234	07/06/2015	111	8		
[redacted]	NC	HOB	681	07/06/2015	53	6		
[redacted]	TN	HOB	600	07/06/2015	50	2		
[redacted]	LA	HOB	1256	07/06/2015	66	11		
[redacted]	VA	HOB	1577	07/06/2015	0	100+		
[redacted]	VA	HOB	3265	07/06/2015	96	24		

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Figure 10: eVMI - Dashboard

The system receives inventory stock readings/measurements from each customer on a given frequency. This data is updated via manual entry from the customer or from a telemetry device installed in each tank. These tanks include both in transit, intermodal yard and customer tanks. The system then uses either a customer defined consumption pattern (new customers) or a consumption pattern extrapolated from historical data (existing customers). This consumption pattern is used to predict future inventory levels to ensure timely ordering and transportation of bulk commodities. These inventory levels are represented by the colored bars on the dashboard. Green means everything is good. Yellow means these customers are candidates for order consolidation. Red means that an order must be sent immediately to ensure continued operation. The specialist identifies any customers in the red and sorts them geographically. Based on this sorting, the specialist tries to build a consolidated load. If a full load cannot be built, the specialist identifies any yellow customers that can be included to complete the load. This strives to reduce the necessity of partial loads and maximizes the use of the truck resources, optimizes the most effective route of deliveries, and results in the most cost effective delivery of goods to each customer. The specialist then places all orders, transportation requests and updates the in-transit quantities in the eVMI system. Once the orders arrive at the customer's site, the in-transit quantities are transferred to the current inventory levels.

The consolidation of multiple customer's requirements within a geographic region, also helps to identify optimum distribution site locations for that region. Once identified, an intermediate storage/distribution center can be set up to fulfill orders for that area and the supplier just needs to refill the storage center's inventory. The consolidation also helps to smooth production allowing the supplier to reduce their need for expediting and allows for more use of other intermodal transportation options such as rail, which helps to reduce costs.

Other interfaces are also provided for general data entry tasks, such as setting up customers, defining products, and modifying demand rates and inventory levels. These can be seen in Figure 11, Figure 12, Figure 13, Figure 14, Figure 15, and Figure 16. Figure 11 provides an interface to view and modify all equipment being tracked. Equipment includes mobile tanks, static tanks and liquid rail cars.

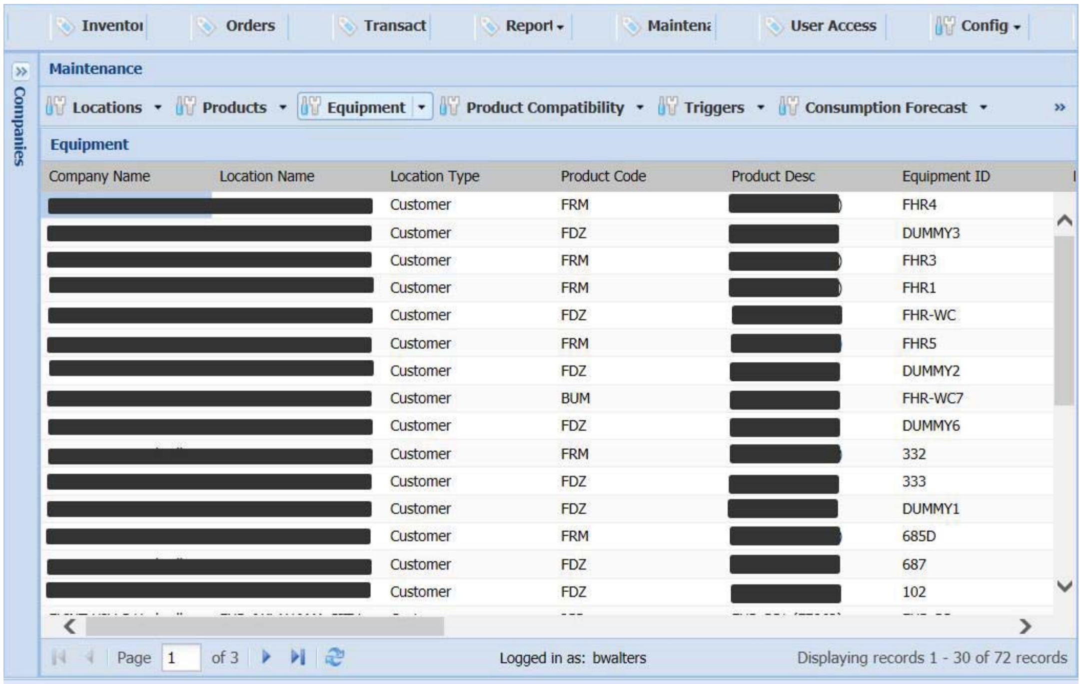


Figure 11 : Maintenance - Equipment

Figure 12 provides an interface to view and modify all products being tracked.

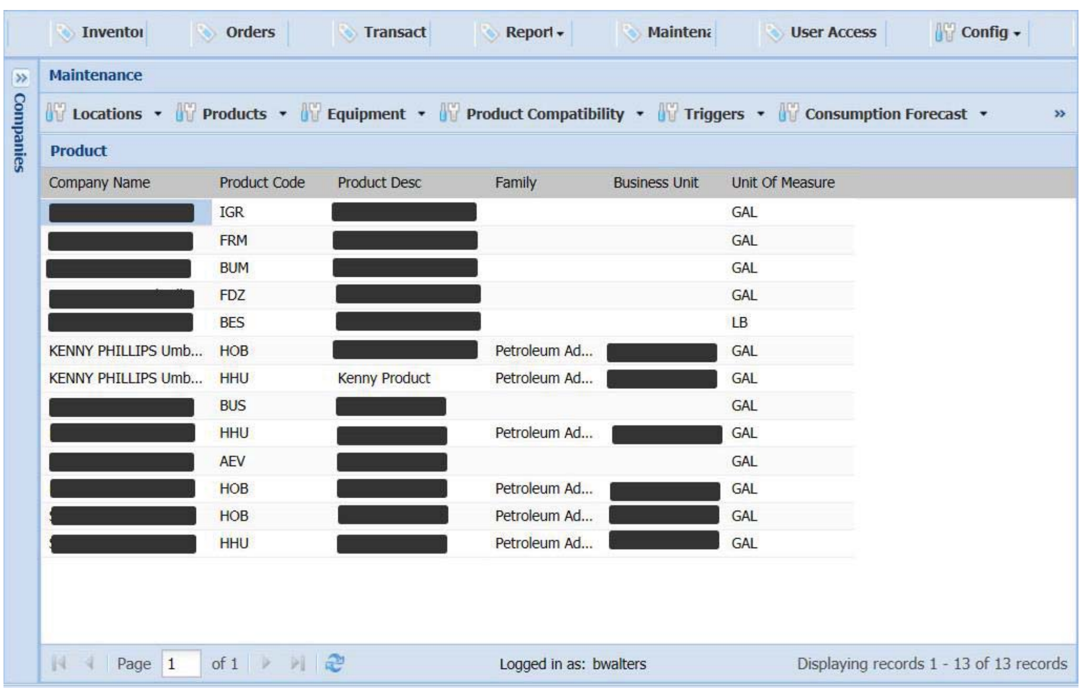


Figure 12 : Maintenance – Product

Figure 13 allows the logistic specialists to generate orders to restock customer supply from a supplier or intermodal yard or restock an intermodal yard tank for future use.

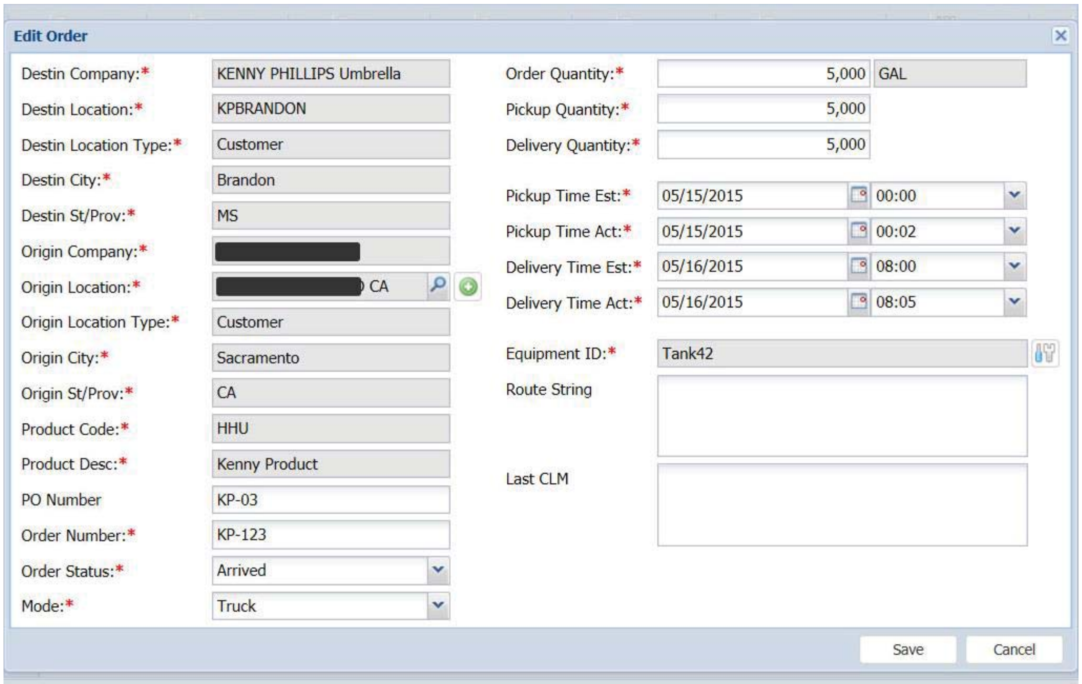


Figure 13 : Edit Order

Figure 14 shows the ability to modify a customer’s base consumption rate to add time-based spikes and lull in a given products usage.

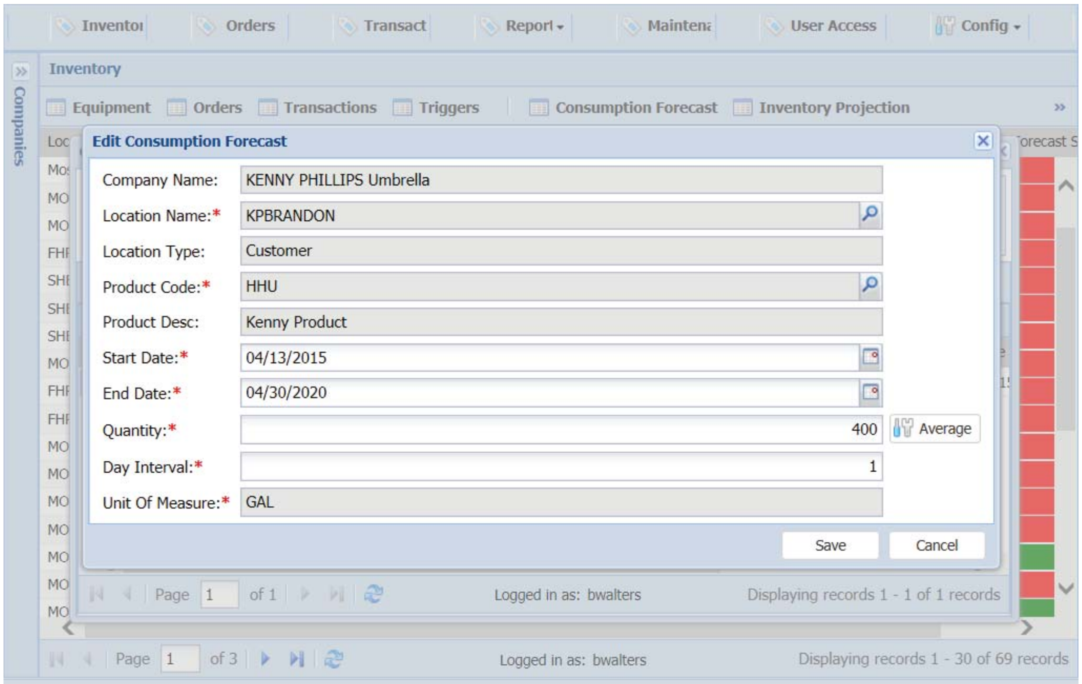


Figure 14 : Edit Consumption Forcast

Figure 15 shows that ability to define the limits (triggers) for each tank that controls the status

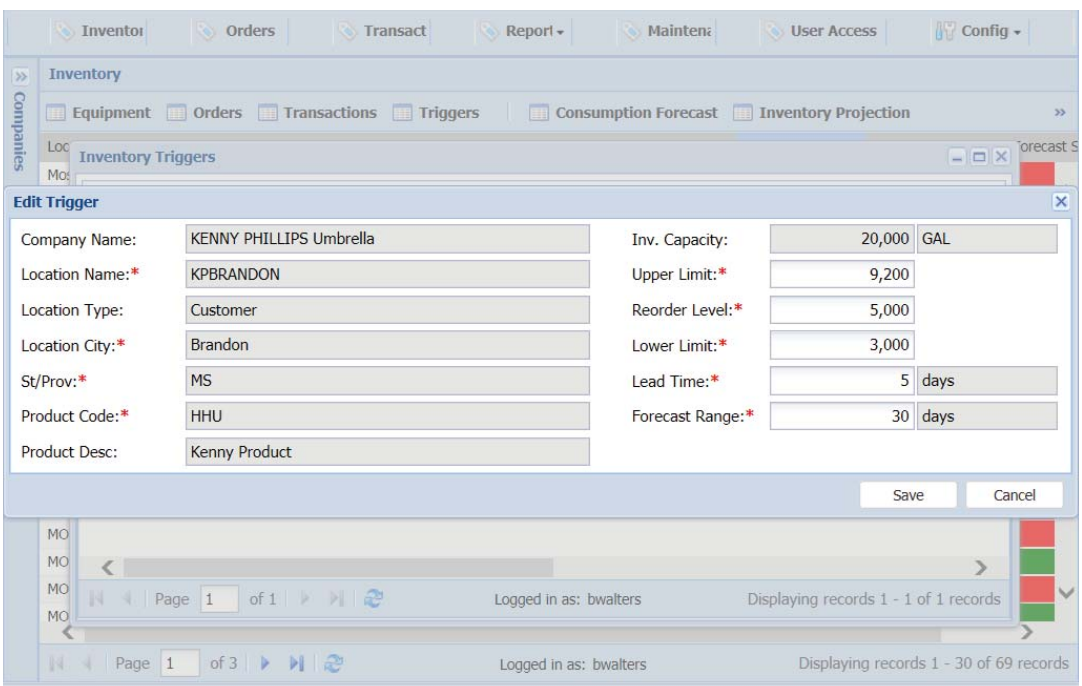


Figure 15 : Edit Trigger

Figure 16 allows users to add tanks and define their capacities, types, and waste amount to the system for monitoring and forecasting.

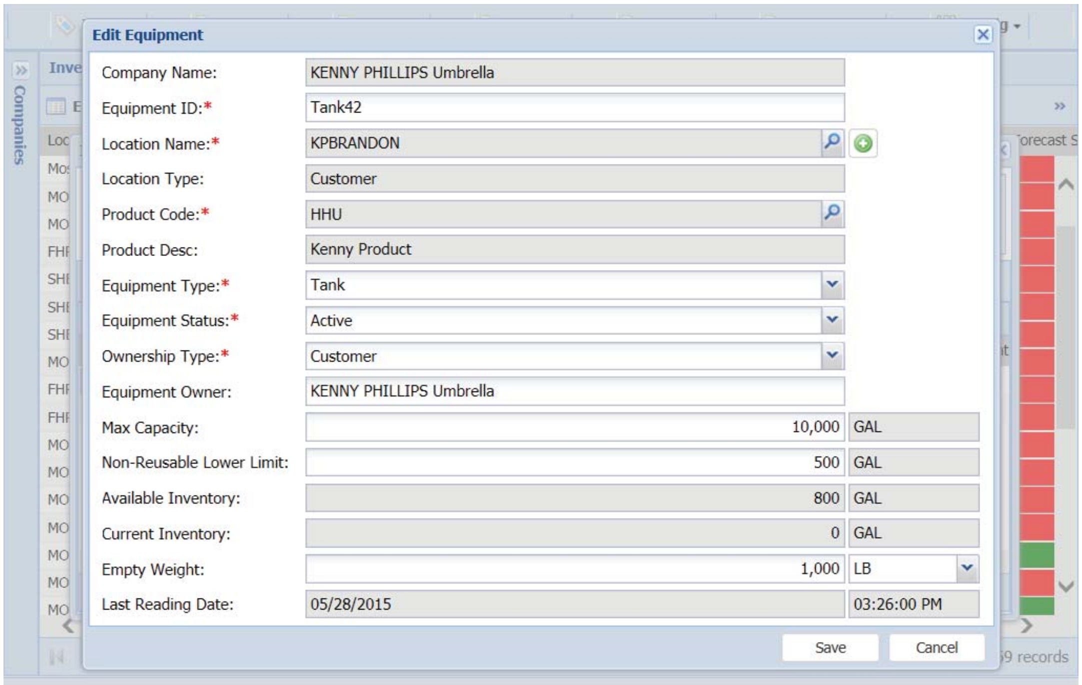
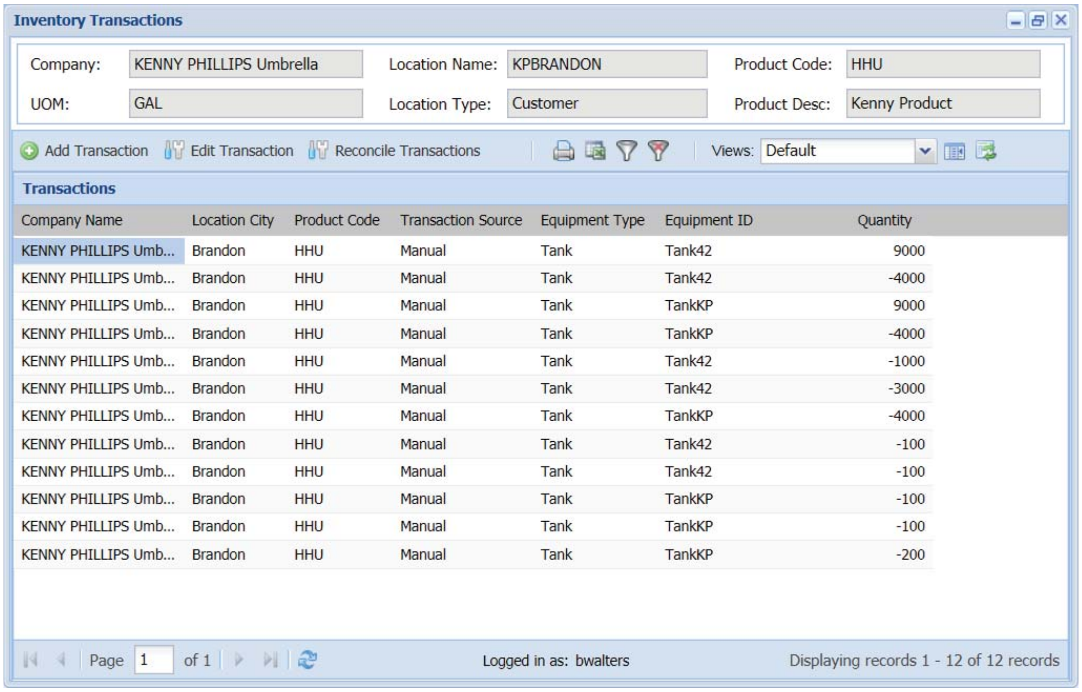


Figure 16 : Edit Equipment

The eVMI application also allows a user to see a history of every inventory transaction (usage and deliveries) made (Figure 17) and generates usage projections for a given product (Figure 18). These help to fine tune logistic decisions and help identify key transportation hubs to stage tanks to improve the efficiency of eVMI system.



Inventory Transactions

Company: KENNY PHILLIPS Umbrella | Location Name: KPBRANDON | Product Code: HHU

UOM: GAL | Location Type: Customer | Product Desc: Kenny Product

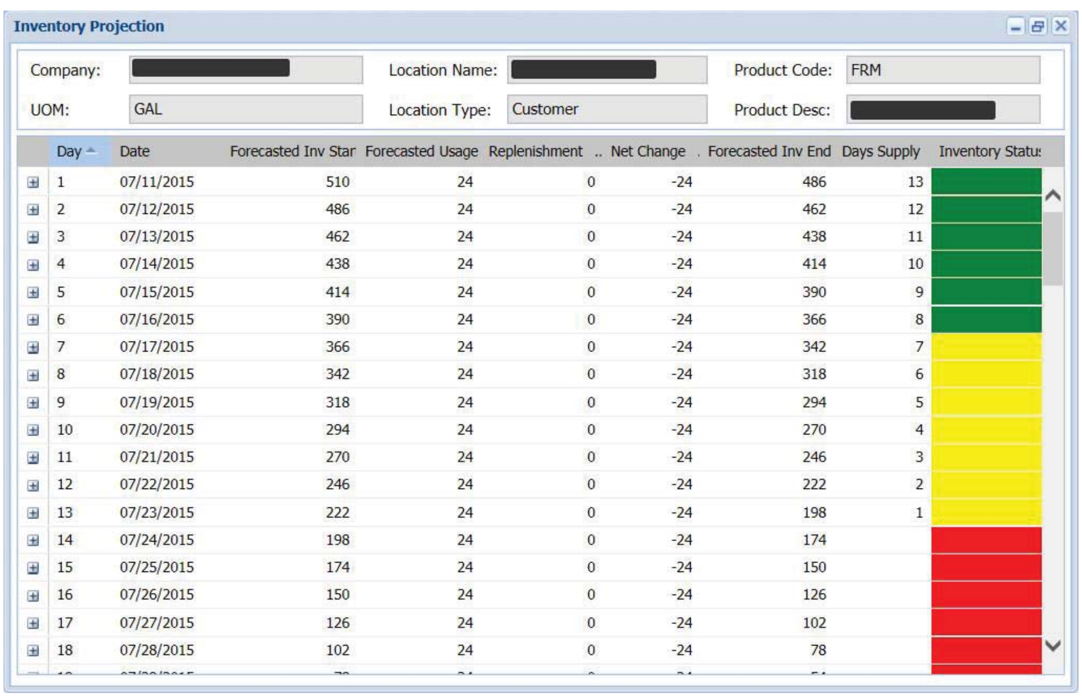
Add Transaction | Edit Transaction | Reconcile Transactions | Views: Default

Transactions

Company Name	Location City	Product Code	Transaction Source	Equipment Type	Equipment ID	Quantity
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	Tank42	9000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	Tank42	-4000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	TankKP	9000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	TankKP	-4000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	Tank42	-1000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	Tank42	-3000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	TankKP	-4000
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	Tank42	-100
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	Tank42	-100
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	TankKP	-100
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	TankKP	-100
KENNY PHILLIPS Umb...	Brandon	HHU	Manual	Tank	TankKP	-200

Page 1 of 1 | Logged in as: bwalters | Displaying records 1 - 12 of 12 records

Figure 17 : Inventory transactions



Inventory Projection

Company: [redacted] | Location Name: [redacted] | Product Code: FRM

UOM: GAL | Location Type: Customer | Product Desc: [redacted]

Day	Date	Forecasted Inv Star	Forecasted Usage	Replenishment	Net Change	Forecasted Inv End	Days Supply	Inventory Statu:
1	07/11/2015	510	24	0	-24	486	13	
2	07/12/2015	486	24	0	-24	462	12	
3	07/13/2015	462	24	0	-24	438	11	
4	07/14/2015	438	24	0	-24	414	10	
5	07/15/2015	414	24	0	-24	390	9	
6	07/16/2015	390	24	0	-24	366	8	
7	07/17/2015	366	24	0	-24	342	7	
8	07/18/2015	342	24	0	-24	318	6	
9	07/19/2015	318	24	0	-24	294	5	
10	07/20/2015	294	24	0	-24	270	4	
11	07/21/2015	270	24	0	-24	246	3	
12	07/22/2015	246	24	0	-24	222	2	
13	07/23/2015	222	24	0	-24	198	1	
14	07/24/2015	198	24	0	-24	174		
15	07/25/2015	174	24	0	-24	150		
16	07/26/2015	150	24	0	-24	126		
17	07/27/2015	126	24	0	-24	102		
18	07/28/2015	102	24	0	-24	78		

Figure 18 : Inventory Projection

Logistics Analyzer

In addition to a system that helps manage the inventories of various customer locations and intermodal transfer sites, a web-based logistics analyzer tool was developed. This tool has two primary goals. The first goal was to help evaluate a portfolio of intermodal transportation requests for a given customer. A transportation request is an intermodal contract to move product from a supplier to a set of customers. The current analysis method is primarily manual with each portfolio containing hundreds of requests. This manual process can take days to complete and only provides a limited amount of information. The second goal was to help identify candidate transfer sites that could be used to hold managed inventory closer to the customers.

To achieve the first goal, the tool evaluates all defined intermodal (truck and rail) routes to determine the intermodal combination that results in the route which delivers the lowest monetary cost in minimal time. These costs include mileage costs based contract rates, rail transport costs and rail transload costs.

The tool uses truck and rail information to generate a weighted path network which is evaluated to determine the lowest cost path for each supplier and customer combination. To evaluate the network a modified Yen's algorithm [9] is used. The basic algorithm determines the top three lowest cost paths through the network. For this application, the base algorithm has been modified to allow for bidirectional paths and for multiple viable paths between the same two nodes. The first modification was introduced to replicate real road and rail routes which are bidirectional. The second modification was implemented to represent the possibility of transporting goods between two major cities, such as Houston, TX to Chicago, IL, which has multiple direct intermodal transportation options (e.g. transported directly using truck or rail). Figure 19 shows a small example of a network to be evaluated by the algorithm.

Figure 19: Example Network

To generate the network, city-to-city distance data, customer mileage rate data, rail transload data, and rail cost data is used to define the nodes and edges and their respective costs. The logistics specialist must also provide a supplier/customer list via an Excel file. This list represents the portfolio to be analyzed. The initial screen can be seen in Figure 20.

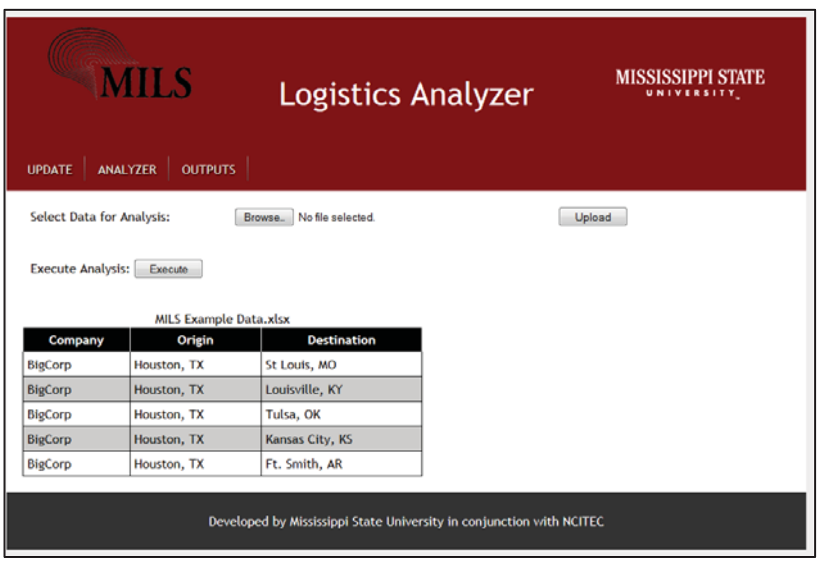


Figure 20: Logistics Analyzer - Inputs

Once the portfolio has been loaded into the system, the logistics analyzer performs the analysis and returns the truck direct route and the top three intermodal routes for each supplier-customer combination. This is shown in Figure 21. The logistics specialist can utilize these results to make better decisions on how to handle the supply chain.

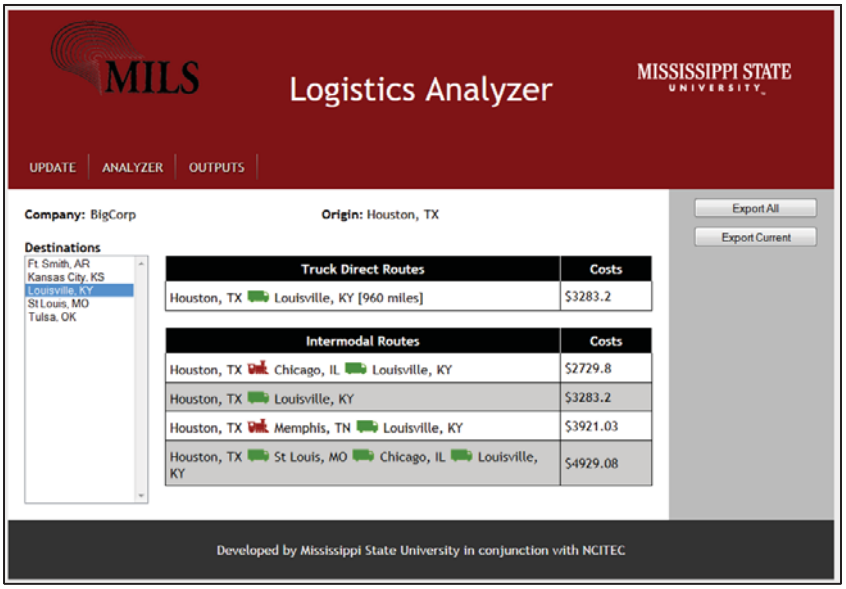


Figure 21: Logistics Analyzer - Outputs

In addition, using the top intermodal routes generated for the complete portfolio, can be utilized to help identify key transportation hubs that would be candidates for inventory holding locations to support the overall eVMI system.

CASE EXAMPLE

This case study applies the Vendor Managed Inventory methodology to the liquid and dry bulk industry and tests a web-based eVMI application to manage the implementations. This application was developed as part of a National Center for Intermodal Transportation for Economic Competitiveness project, to evaluate whether applying the VMI concept the this industry was viable and showed potential for improvements in the current system.

Two scenarios are defined which includes implementing VMI and the eVMI application and documenting the results. The first scenario is to install, configure and use the eVMI application at Miller Intermodal Logistic Services (MILS). This scenario focuses on the system's use to make better decisions regarding the methods to transport product from supplier to customer and how to consolidate loads across multiple customers to gain transport efficiencies. The second scenario incorporates a third-party to use the telemetry hardware and eVMI system to ensure suppliers and logistic specialists have up-to-date information to further improve decision making across the entire supply chain.

As a result, the case study revealed that VMI could be applied to the liquid and dry bulk freight industry. In addition, the eVMI application can be used to effectively manage such a system to improve supply chain efficiencies. Some future work is still needed to enhance the eVMI application to expand its power and usefulness.

DISCUSSION OF RESULTS

Conclusions

The eVMI system ultimately alleviates the aforementioned issues of supplier and logistic demand spikes, avoidable delays, transportation costs, logistic manager productivity, safety, driver satisfaction, and highway congestion. Supplier and logistic demand spikes will level out more due to the increased visibility of their customer's needs. This will lead to increased service levels for both suppliers and logistic companies and a reduction in avoidable delays caused by the lack of drivers during the spikes. Reductions in transportation costs will be realized due to the increase amount of time to react to customer needs that leads to making more optimal decisions about which modes of transportation to utilize and how. In addition, the system will lead to productivity improvements for logistics managers. This will lead to the ability to manage customers more efficiently and provide excess capacity to obtain more business. Safety increases with the reduction of long hauls because of the reduced time trucks are on the road. In turn, this also leads to reduced congestion on the roadways. Driver satisfaction is improved since they will only be required at the beginning and end of the chain allowing for truckers to be home more. This also aids logistic companies since hiring and retaining long haul drivers is becoming more difficult.

Future Research

Future research could include the following: expand study on real world application effectiveness, incorporate air and water transportation, and expanded to other freight types beyond liquid and dry bulk freight. Performing an expansive study on the application of the system explored in this research would ensure the systems applicability for a variety of customers and situations. Incorporating air and water freight transportation into the application of VMI in the liquid and dry bulk freight industry could allow the system to take advantage of other cost saving intermodal transportation options. Lastly expanding the VMI concept to other freight types beyond the dry and liquid bulk industry would expand the applicability of this research.

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