

United Health Services: Transportation Optimization

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Abstract: This project is based off the desire to improve the efficiency and customer service of the United Health Services transportation departments to minimize fuel costs, turnaround time, mileage, and duplicate deliveries by May 2019. United Health Services, a medical care provider in southern New York State, has two delivery and transportation departments that service 60 facilities. Materials Handling has two drivers and a weekly schedule and oversees the delivery of various medical supplies such as bandages, syringes, and crutches. External Transportation is staffed by 12 drivers and delivers time sensitive, patient-oriented supplies such as clean and used linen, specimens, and mail, utilizing a daily schedule. The goal of the project is to merge the two departments, focusing on route schedules and the loading and unloading processes, to improve the information flow and product flow of both operations.

Keywords: Vehicle Routing, Transportation, Optimization, Healthcare

1. Introduction

United Health Services (UHS) is a medical care provider in southern New York State. They have offices that include primary care, cancer centers, imaging centers, physical therapy, general hospitals, and pharmacies. Most of UHS services are localized in the Greater Binghamton Area, although they have branch clinics that extend further into New York State.

United Health Services has two delivery and transportation departments that service over 90 UHS facilities and external clinics: Materials Handling and External Movement. Materials Handling oversees the delivery of various equipment for UHS locations including medical supplies such as bandages, syringes, and crutches and is staffed by two full time drivers. This schedule is on a weekly basis, as not all the clinics must be stopped at every day. New equipment is dropped off and inventory for future orders is recorded as routes are completed by the drivers. The other department involved in this project is External Transportation. This department has 12 drivers that deliver time-sensitive, patient-oriented supplies such as clean and used linens, specimens, and mail. External Movement has a repeated daily schedule for drivers consisting of 17 routes, as each location must be stopped at every day.

UHS tasked a team of five student engineers to optimize the transportation systems of these two departments. The scope of the project involves the routes of each department, the drivers involved in them, and the main locations being operated out of by both External Transportation and Materials Handling. Problems that these departments have frequently encountered include overlapping routes, redundancy in work completed, and communication lag. The student team is asked to analyze these systems and develop a solution that will minimize or reduce the current problems. UHS is currently seeking to merge these two delivery services. Merging these operations has the potential to reduce fuel costs, mileage, and the wear and tear on vehicles. In addition, the productivity of the drivers and dispatchers may increase, which can be measured in the turnaround time of each route. Overall, the objective is to improve the information flow and product flow of both operations which will result in a system that is more easily managed and with fewer costs.

2. Problem Statement

The Materials Handling and External Transportation Departments within UHS are requesting to be optimized due to the high number of redundancies between the two. The departments both currently meet the customer (clinic) demands, but there is potential to improve the efficiencies in terms of turnaround time, time spent at a location, vehicle wear and tear, vehicle fuel, labor, and costs associated with these metrics. According to a personal communication with Kurt Weir who oversees the Materials Handling department of UHS, there is an issue of siloed departments within the health service provider and in healthcare in general.

The managers of the transportation departments are in regular contact and are both in agreeance that there are overlapping routes and business processes. However, neither have adequate time to work together to reconstruct the delivery system for the hospitals and clinics. The lack of adequate time of the current staff to address this issue is why the Binghamton University team was recruited. The proposed design idea is to merge the operations of the two departments. Both have similar job processes and high-level workflows; therefore, the employees of either department would not have to relocate or undergo extensive retraining. This design is tied into the Process Improvement sector of UHS and most closely relates to the educational curriculum of the Systems Science and Industrial Engineering Department in Watson School of Engineering at Binghamton University. So, the project team selected to work on this consist of those studying Industrial and Systems Engineering.

A primary issue that the team focused on is scheduling of transportation routes at UHS. The two departments service all the same locations, although the frequency of delivery and pick up varies. The team incorporated all locations for each delivery type, medical supplies and specimens and linens, within respective timeframes.

A secondary issue that the team encountered was the decision of how to incorporate the loading and unloading routine for each department. Materials Handling operates out of a warehouse on Lewis Road in Binghamton, in which the drivers load the vehicle once in the beginning of the day and deliver to all the appointed stops before returning. External Movement operates out of Wilson Memorial Hospital in Binghamton, where the drivers may load the vehicles, complete a route, then return and reload to complete another route during that same day.

3. Technical Description

3.1 Project Definition

Initially, the team of students began meetings with the UHS professionals to define the scope of the project and to understand the expectations. This allowed the team to define the system and business requirements, as well as the primary, secondary, and tertiary users. Business requirements are necessary objectives of a project or design that help achieve the overall objective. They are typically high level and outline the goal of a project from a large-scale business perspective. System requirements outline the components to the design that will directly support the overall objectives of a project. Table 1 is a portion of the defined business requirements. Once the requirements were complete and approved by both the UHS professionals and the engineers, they underwent a Gap/Fit Analysis, to determine where potential risks may occur. Those requirements that may not be fully satisfied by the design highlighted a potential problematic area.

Table 1. RTVM Business Requirements

Req ID	Requirement	Priority (E/C/O)	Acceptance Criteria	Traceability Upwards
BFR 1	The system shall reduce total fuel costs for Materials Handling and External Movement departments.	C	Analysis: money spent on fuel will be less	A2
BFR 2	The system shall reduce total turnaround time for Materials Handling and External Movement departments standard routes and emergency requests.	E	Analysis: Current weekly route time is less than new weekly route time	Fu1
BFR 3	The system shall reduce mileage for Materials Handling and External Movement departments.	C	Analysis: current mileage is less than new mileage	A2

Models were then developed to visualize the flow of materials and driver movement. They were developed for both Materials Handling and External Transportation, and highlight the key users, the interactions, and steps in the processes. Shown below in Figure 1, an Activity Diagram describes the users' roles and sequential actions of the delivery process. This is a high-level diagram which depicts how the material moves between the Distributor, Driver, and Inventory Management.

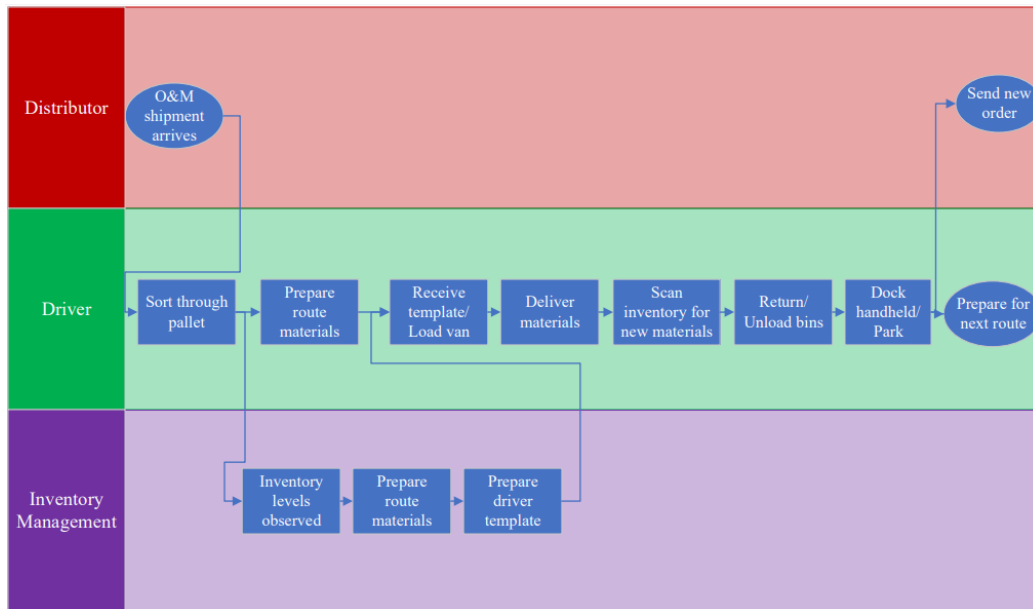


Figure 1. Activity Diagram for Materials Handling

3.2 Data Collection

Following the project scope and definition phase, the student team then began to collect data and observe the processes. There was data collected on both the internal processes of each transportation department as well as the delivery routes. Along with collection of data from the UHS team, there was also research on relevant areas of operational improvement.

Internal data was collected by several interviews with the heads of each department as well as staff members that operate vehicles and inventory for the departments. Along with this, there was also tours of the distribution center for each department which made it possible to map out the tasks required to prepare deliveries. In addition to data on internal affairs, the team also collected information on the routes of each department. Through digital files and paper route sheets that are filled in by drivers, information on each clinic, the address, route order, stop duration, and more were found. This information was deemed useful in the current state route mapping.

Research for the project was based on articles on the Vehicle Routing Problem (VRP) for single depot models. Though this type of operations research problem may be complex to follow, the team aimed to find rudimentary tips from research to take into consideration when creating new routes. Once an applicable version of the VRP is discovered a tool may be sought out to help the team create routes for UHS that reduce time and mileage.

3.3 Data Analysis

Based on the data found on the internal delivery preparations by interviewing and shadowing personnel that work at the UHS delivery departments, there were problematic findings in the daily operations. Specifically, it was discovered that certain clinics that were visited more frequently and were larger in size had a longer stop time on deliveries. This is because of the vast amount of inventory data collection that needs to be done for the larger clinics. It would shorten route time if these tasks were delegated to someone/something besides the drivers so that the routes would not be delayed as much.

The route data collected for the External Transportation and Materials Handling departments have been analyzed for stop time averages and location redundancies. The routes have also been mapped using MapQuest to provide a visual layout. This service also provides an approximate fuel cost for each route while taking into consideration the vehicle in use, which can be used to compare the before and after routes. Below in Figure 2, an example route is shown using MapQuest, which details a previous route of External Movement. In addition, the External Movements schedule has been analyzed to best incorporate the stops of Materials Handling.

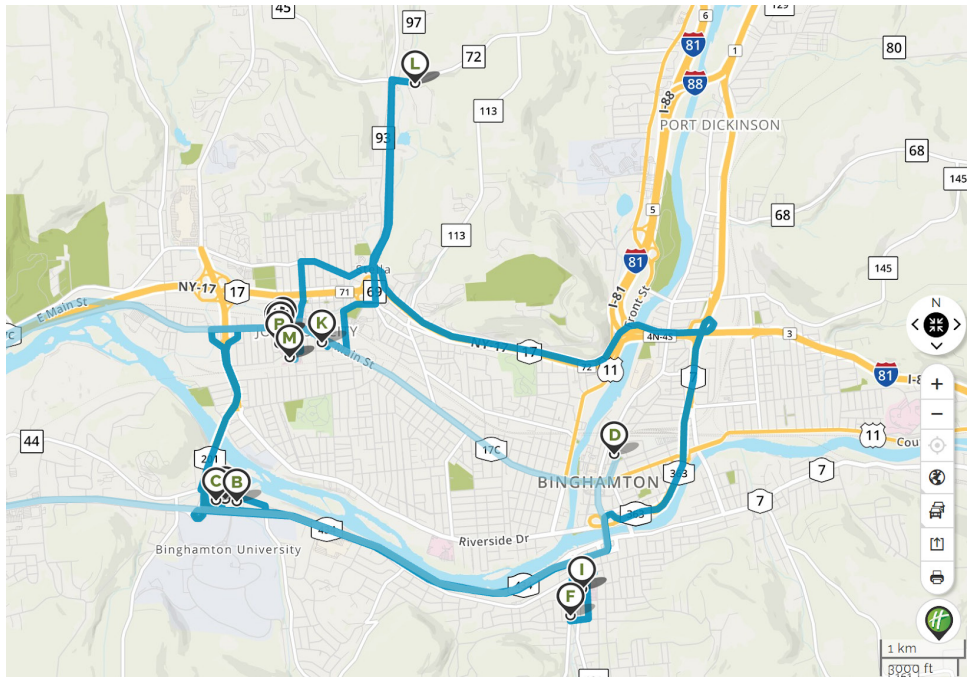


Figure 2. Example Route

From preliminary research on the Vehicle Routing Problem, a better understanding of delivery systems in healthcare were sought. One rudimentary tip found from research on the VRP was that touring is better than sweeping (Pillac, 2013). This means that it tends to be more optimized for routes to base delivery patterns on clustering stop that are close by as opposed to covering more ground across a geographical region. Through VRP research, there also was an open-source software found that was applicable to the UHS transportation problem. This was used to find improved routes for the healthcare transportation departments.

3.4 Solution and Implementation

The Binghamton University team provided a three-alternative solution to the UHS team in order to improve the transportation system. These alternatives are based on the analysis of route driving and stop times collected from route records and route mapping. Each alternative will have a different level of adjustment to the current system.

Alternative 1 was the most basic compilation of the two existing transportation departments. Materials Handling stops were added onto External Transportation routes. A second stop was added to each of the routes in the beginning that went to the Materials Handling warehouse to pick up necessary materials to deliver. The selection of which route to add the stop to were done in order of descending average Material Handling stop length and each stop was assigned to the shortest route that was able to visit the applicable clinic for the Materials Handling stop. This procedure was followed until each Materials Handling stop was assigned to a route. Any route that was then measured to take over 7:45:00 then needed to be divided. At the conclusion of Materials Handling stop assignment, a new route was created that visited the longest stops that were over the 7:45:00 threshold so that no new routes were expected to receive overtime pay.

Alternative 2 follows the same procedure as Alternative 1, but with the addition of two inventory workers. The inventory workers would be assigned to work at the two complexes that had the longest Materials Handling stop times. It was then assumed that whenever there was a stop at any location with an inventory worker, the stop time would not exceed a fixed time of 15 minutes as the drivers would have less tasks to complete at those stops. This removed the need of the additional route as none of the newly configured routes were calculated to last over 7:45:00.

Alternative 3 is the most invested alternative of the three. This alternative is based off Alternative 2. In addition to the inventory worker, the routes would also be analyzed using a VRP software to find any improvements to the route stop orders that would save time. Also, this alternative would have one combined warehouse for both departments at the External Transportation warehouse so that there would not have to be a second stop at the current Materials Handling warehouse.

Each alternative was compared to the current system based on route times, mileage, and fuel cost. Along with this, each alternative was mapped out on a simulation software Simio to find the variance of each route so that the confidence of performance of each alternative may be analyzed as well.

The alternative selected by UHS will then be implemented into operation piecewise, with a pilot route being selected to observe how the changes in the system are taken by the drivers, clinics, and other stakeholders.

3.5 Results and Feedback

After finalizing the first two alternatives, the metrics of time, mileage, and gas were compared with the current state analysis. The results of this major metric comparison are shown below:

Table 2. Comparison of First Two Alternatives

Yearly Comparison						
	Total Mileage	% decrease	Total Route Hours	% decrease	Total Gas Cost	% decrease
Original	2569437.00	-	28426:43:28	-	\$319,096.44	-
Alternative 1	2,502,513.00	2.605%	26874:19:20	5.461%	\$272,633.40	14.561%
Alternative 2	2,484,846.00	3.292%	24898:10:40	12.413%	\$271,521.90	14.909%

From the results it was found that Alternative X is the most favorable solution in terms of metrics but would also require an investment of training inventory workers, merging warehouses into one location, and setting up and installing an inventory management system.

As of April 5th, results still need to be collected on the configuration of Alternative 3 and simulation analysis of each alternative that would provide a more confident analysis of routes.

4. Dependencies

UHS team 1 has met with the UHS professionals (Doctor Srikanth Poranki, Vrudenti Amin, Kurt Weir, and Terry Brown) bi-weekly throughout the course of this project. These UHS employees are representative of the Process Improvement department, which usually oversees similar projects, and from the two transportation departments being worked on. Meetings with this group were to show progress, ask questions, plan next steps, and to take any feedback that they had. They have also acted as a guide to the team to ensure that objective achievement is on track.

Another dependency of the UHS student team includes the faculty advisor for the project, Dr. Yoon. Dr. Yoon is the advisor for this project because of an adequate background in operations research methodology and an already familiar relationship with the students on the team. Meetings were every two weeks to discuss the technical aspect of the project. Dr. Yoon has recommended areas of research and adjustments to the scope of the project.

5. Risk

There are multiple risks that the team has taken into consideration during this project. Firstly, as already experienced, the scope of the project may change. Changes in the scope have been caused by changes asked by the client, infeasibility of alternatives, infeasibility of software or tools, or unattainable approved requirements.

Another risk that may be experienced is the inability of alternative recommendations. It may be realized after implementation that the new routes designed disrupt an unforeseen requirement relating to timing of route deliveries or vehicle capacity. This issue would have to be addressed with minor revisions to the routes and vehicles.

A risk that comes with merging departments is the possibility of downsizing. With the aim of reducing costs that may be related to workforce, there may be a reduction of necessary driving hours that may result in the loss of employment.

Another common area of concern when updating operations is the change engineering of the involved personnel. Those who work in the current system have grown accustomed to it and a foreign team of students recommending a variation of a work schedule that is already comfortable may lead to resistance. This may be overcome with transparency and communication in the integration process by both the project team and UHS personnel.

6. Recommendations/Next Steps

Based on the results of the alternative analysis as of April 5th, 2019, the team is able to make preliminary recommendations. It is found that Alternative 2 will save approximately 15% of transportation costs over one year with the investment of hiring and training employees to act as inventory managers at two clinic hubs. This investment would be feasible over a short term as there would be no major routing changes and the operations as a driver in the system would not become more complex. Because of this, the student team recommended that UHS implement Alternative 2 into effect. Once there has been a trial period of Alternative 2 over the course of several weeks, feedback should be collected and reviewed to make any revisions to the routes or operations.

As a long-term goal, the team recommends that components of Alternative 3 be implemented piecewise to further improve the system and reduce costs, assuming that results will show further savings from this alternative. Investments include adjustments of route orders to be more optimized, consolidation of transportation warehouses, and working with an inventory management system to improve inventory collection.

Future work of the student team includes the finalization of Alternative 3, quantifying an alternative comparison, simulation of results, and making recommendations for the UHS team. Also, there will be recommended areas of study for the UHS team to consider to further improve operations such as a Kanban inventory management system to streamline the ordering process.

In conclusion, potential improvements to a transportation system for a healthcare provider were found and measured with current state analysis, data analysis, mapping, simulation, and operations research methodologies. With the implementation of Alternative 2 for one year, UHS may realize savings of \$47,500.

7. Acknowledgements

The Binghamton University project team acknowledges and thanks the contributions of Dr. Sang Won Yoon who advised the team and provided insight on relevant areas of operations research and provided overall guidance for the direction of the project.

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