Proceedings of the 2001 Winter Simulation Conference
B. A. Peters, J. S. Smith, D. J. Medeiros, and M. W. Rohrer, eds.

DOW CHEMICAL DESIGN FOR SIX SIGMA RAIL DELIVERY PROJECT

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ABSTRACT

Dow Chemical needed to find a solution that would enable them to meet the forecasted increase in demand for a line of products. In order to find the most cost effective solution that met all project criteria, Dow Chemical implemented Six Sigma principles. By utilizing the Six Sigma methodology combined with discrete event simulation, Dow was able to devise a solution that would allow then to meet the increase in demand with a savings of $2.45 MM in capital expenditure. This paper outlines the steps that Dow took to complete the project, as well as, a discussion of the simulation models and project results.

1 EXECUTIVE SUMMARY

Dow Chemical was faced with designing a rail delivery system to meet the forecasted production increase for a plant at one of their large manufacturing sites. By 2005, Dow expects the plant production volume to increase from one-half billion pounds to nearly 1.5 billion pounds annually. The existing logistics infrastructure does not have enough capacity to load and ship the forecasted rail volume. A Design for Six Sigma Project (DFSS) was initiated to create a new supply strategy to:

- handle increased volumes while minimizing capital costs
- manage freight costs
- improve delivery performance for rail customers.

A simulation model was developed to assist in designing the new supply strategy. The two main concepts captured in the simulation models were loading and shipping of railcars from the manufacturing site and marine transporting of bulk products to contract terminals. The models addressed six product families comprised of 35 unique products.

The initial facility plans developed by Dow called for building additional storage and loading facilities at a cost of $3.2 MM. Through the use of six sigma tools and simulation models, Dow was able to meet the forecasted rail demand through re-engineered work processes using the current physical assets with a capital investment of $ 0.75 MM. The project delivered savings of $2.45 MM in capital expenditure and a re-engineered work process to satisfy both plant and customer requirements.

2 INTRODUCTION

Dow Chemical, a leading science and technology company, was faced with growing demand in a key product line. They were concerned that existing loading and shipping infrastructure would not meet the forecasted increase in demand. The current site rail infrastructure had not been significantly upgraded since the 1950's. Current shipping practices and business policies would not be able to keep up with the increased demand. Dow needed to find a way to meet or exceed the forecasted increase in demand using the least amount of capital. The business forecast predicts demand will increase to more than twice its current levels by the year 2005.

This project was chosen by Dow to be one of the first projects to initiate Design for Six Sigma (DFSS) Methodology. DFSS methodology defines specific process steps to be followed. By executing these steps the best possible solution will be achieved. The process steps to complete this project are Define, Measure, Explore, Develop, and Implement, which is defined by the acronym DMEDI.

Each of these steps will be described in greater detail. Also included in this summary is a description of the simulation created for this Six Sigma process along with a discussion of the applicability of simulation in Six Sigma projects.

3 PROBLEM DESCRIPTION

Dow needed to address an increase in demand for a critical product line. The increase in demand resulted in increased production at the facility, necessitating increased product storage requirements and loading infrastructure. Production was forecasted to increase by a factor of 2 plus by the year 2005. Existing storage and loading infrastructure at the site would not handle the increase in production volume. In addition, the large manufacturing site was already congested with railcars. The increased congestion due to additional railcars would be nearly unmanageable. In order to handle the increased production, Dow would need to develop a solution to handle the increase in demand with the smallest capital investment possible.

4 DEFINE

The Define phase has three key deliverables:

- define the opportunity
- determine the scope,
- develop project plans.

The opportunity is that Dow expects the demand for a given product line to more than double. A new storage and loading design will enable Dow to capitalize on the increase in demand. The project goal was to load and ship increased demand while continuing to provide an excellent level of service to customers. Additionally, the solution should be achieved with the lowest overall capital expenditures.

The project scope consisted of the loading and storage logistics of the production facility. The actual manufacturing of the product was considered out of scope for this project. The Define phase also included the development of a multi-generational plan to complete and implement the solution. For this project, the multi-generational plan defined milestones for the gradual ramp-up of shipping the forecasted demand. This phased approach allows Dow to ramp up the shipping and loading infrastructure as the demand increases over the following four years. Also, at this step, the project team was identified. Once the Define phase was complete, all aspects of the Define stage were reviewed with stakeholders. Upon completion of the define phase, Dow had a focused goal and was able to begin working to find a solution. The additional time spent defining and planning will save time in later phases of the project.

5 MEASURE

Once the problem was identified in the Design phase, the next step was to gather information pertaining to the project to assist in finding the best solution. At this point, the Six Sigma team interviewed and led focus group sessions for individuals directly impacted by the project to identify their concerns and requirements. The team also collected and analyzed historical information relating to the storage and shipping of each product family. Benchmarking information was collected to understand industry best practices.

Out of the measure phase, the Critical Customer Requirement's (CCRs) were determined. The four requirements are listed below:

1. The cost per pound shipped should be below a defined maximum cost.
2. The number of on time deliveries must be greater than a defined target percentage.
3. The improved loading and shipping operations should be able to ship the forecasted product with a 20% margin for forecast error.
4. The new design should be able to handle excess inventory.

The project team reviewed the Critical Customer Requirement's (CCR) and researched factors from the current work process that could influence the CCRs. Four main, functions were identified which influenced the CCRs. They are:

1. Inventory – any factor affecting the storage locations and storage policies
2. Marshalling – any factor that controls the logistics of obtaining, loading, staging, and cleaning of containers, as well as scheduling the loading operation
3. Transporting – any factor that affects moving the product from one location to another
4. Transferring – any factor that affects the actual transfer of product from one container to another, as well as billing and other administrative tasks

6 EXPLORE

Once the entire project was defined and all of the requirements and functions had been analyzed, the next step was to explore solutions to the problem. At this point all of the planning and research was put to work. The detailed definition together with the Critical Customer Requirements (CCRs) and functions acted as a roadmap to assist the project team in developing the best solution.

At the beginning of the Explore phase, the CCRs and influencing factors are added to a quality matrix. Then each CCR is ranked with respect to each factor. Weighting is assigned to all CCRs with respect to function, and the Critical Customer Requirements were ranked from biggest impact on overall performance to the least impact. Using the ranked list of CCRs as a guideline, the Six Sigma project team used brainstorming and pattern breaking tools to develop several high level concept designs that would allow the business to meet the defined CCRs.

After analyzing and comparing the various high level concepts, the team selected three solutions for further evaluation:

1. Single Pulls (initial solution) – Railcars would be filled from inventory to fulfill customer orders. Additional loading capacity would be added at the facility, and railcars would be loaded based on current business rules.
2. Double Pulls – Additional rail switching capability would be deployed to double the daily throughput of the loading rack, railcars would be filled and used as additional storage for the product. The full railcars that do not have a customer

order would be transferred to another location and stored. Once a customer places an order for that particular product, a previously loaded railcar would be released for transport to the customer.

3. Barge Loading – The existing loading facilities would remain intact. The excess product would be piped several miles to a marine dock and loaded into barges, transported to a contract terminal, stored in tanks, then loaded in railcars to meet customer orders.

Dow chose to use discrete event simulation as the tool to explore the alternative scenarios and assess the functional capability of each alternative. The double pulls, and the barge loading scenarios were modeled. The two models will be described in the following text.

6.1 Simulation Modeling

In order to assess the feasibility and performance of the alternatives, simulation models of the Double Pulls and Barge Loading were developed. These models included the detailed railcar loading operations and product storage capacities.

Using the simulation model, Dow was able to assess its current capability and examine each scenario to see if they met their requirements. For each of the scenarios, Dow was able to answer the following questions by manipulating the simulation inputs:

1. How many load spots are required at the production facility?
2. How much storage is required at the plant?
3. How much track is required at the plant for railcar storage?
4. How many railcars are required to ship the product?

For the Barge scenario, the following questions were also examined:

5. How much pipeline capacity is required?
6. How much marine tank storage is required?
7. How many barges / ships are required?

The results of the simulation allowed Dow to assess the overall performance of the scenarios. The key outputs used to assess the scenarios were:

1. Expected railcar cycle time
2. Number of late shipments
3. Loading spot utilization
4. Minimum, average, and maximum inventory levels
5. Number of rail cars on-site – measures site rail congestion
6. Overall cost of each scenario

7 RESULTS

After testing the different scenarios, Dow determined that both solutions would meet the criteria of loading and shipping the increased production, as well as, meet the on-time order criteria. However, the results of the simulation and other factors showed that one of the scenarios was clearly superior.

- The barge-loading scenario requires the lease of costly additional tanks at the contract marine terminal. The double pull scenario does not require additional storage tanks, and the storage track for the filled railcars is relatively inexpensive.
- The barge-loading scenario requires multi-year contracts with the terminal keeping the fixed costs high. The double pull scenario does not require long-term contracts. Since idle railcars can be used for storage, the double pull option is much more flexible to accommodate forecasting errors.
- The barge-loading scenario has a greater Environmental Health & Safety (EH&S) (environmental, health and safety) risk than the double pull scenario.
- The barge-loading scenario requires higher inventory levels in the pipeline to meet the on-time order requirement. The double pull inventory levels are lower.
- The barge-loading scenario is difficult to manage the inventories because large quantities of product are tied up in transit. Additionally, it also requires more handing and transfer of the product. Double pulls, while adding an additional handling step, is more flexible since the storage railcars can quickly be diverted or routed to a customer allowing Dow to fulfill the customers' orders quickly.

Overall, both designs meet the critical customer requirements, however the double pull option achieves the requirements at a significantly lower cost. In addition, since the double pull option uses railcars for storage, Dow can increase their railcar fleet gradually over the next four years as production increases. As a direct result of this simulation study, the project team chose the double pull scenario as the solution. In addition to solving the defined problem, the double pull simulation model is now being used as a site logistics planning tool to assist in properly executing the solution while continually looking for improvements.

8 DEVELOP AND IMPLEMENT

The final phases of the DFSS project are to design and implement. Using the results of the simulation model, Dow completed a detailed design which included detailed work process documentation. This process identified business rules and defined roles and responsibilities for the double pull scenario that will be used to guide the actual implementation of the solution. In additional an implementation plan was developed.

9 THE VALUE OF SIMULATION WITH SIX SIGMA

A critical step in the DFSS process is the Explore phase. Although there were many tools that Dow's Six Sigma project team could use to assess the functional capability of the potential solutions, simulation allowed the project team to quickly build and analyze several design concepts. In addition to being efficient, simulation allowed the complex interactions that occur with the loading and shipping operations to be examined. The simulation allowed Dow to incorporate and test complex operational rules. Complex system interactions and the effects of process variability were identified. Modeling provides the ability to test the input, review all identified options, determine the financial impacts and ultimately, prove the best option to meet the project goal in growing demand with high customer service levels while minimizing the capital required.

AUTHOR BIOGRAPHIES

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