OPTIMIZING WORKFLOW FOR SHELTER REHABILITATION PROJECTS IN REFUGEE CAMPS

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ABSTRACT

Optimizing workflow is a goal for lean construction implementation. Applying lean thinking on projects managed by the United Nations' (UN) agencies is challenging due to limited resources, harsh living conditions and political turmoil.

This paper will study the construction workflow for the "Camp and Shelter Rehabilitation" project sponsored by the United Nations Relief Works Agency for Palestinian Refugees in the near east (UNRWA), and funded by the European Union. The project aims to rehabilitate 736 shelters in refugee camps located in Lebanon using a new approach called "Self-help." In this approach the families are involved directly of their shelters' rehabilitation under the continuous supervision of UNRWA engineers. Rehabilitation work proceeds under a harsh working environment and extreme constraints such as: short time interval (8-14 weeks), limited budget, limited space, unstable security and poor safety.

This paper will focus on a section of the project involving 30 shelters, study the causes of disruption in workflow and recommend possible methods to improve project performance. Using process modeling and simulation analysis, different scenarios were examined to optimize construction workflow taking into account the various constraints. The ultimate goal is to increase the value delivered to the beneficiaries of the project.

KEY WORDS

Construction Workflow, Self-Help, Refugee Camps, UNRWA projects.

INTRODUCTION

Refugee camps are considered one of the biggest challenges in Lebanon. These camps weren't designed for long-term habitation, and since their construction in 1948, camp inhabitants suffer from extreme poverty, lack of organization and clean water supply. Camps started only as tents, and over time they were replaced by concrete block shelters with zinc roofs. Later in the 1950s, they were replaced by concrete roof shelters (Masad 2009, Samhan 2008).

According to the latest UNRWA statistics in the Middle East, there are 4,797,723 registered Palestinians. According to the latest reports, there are 436,154 registered

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refugees in Lebanon (UNRWA 2012). The Palestinian population suffers from extreme poverty and unemployment; out of 120,000 work force 57 % are jobless (Chaaban et. al 2010, ANERA 2012, UNRWA 2011,). Moreover, Lebanese law prohibits Palestinians from working in any profession that requires registration with government syndicates or professional association.

Official refugee camps are established on lands that are partially or wholly leased by UNRWA (Masad 2009), the owners of these lands are the government or in some cases private owners.Thus, camp borders are limited, horizontal and vertical expansions are prohibited and construction materials are not allowed into the camp. The limited land space is creating a major problem as the number of refugees is increasing year by year.

SHELTER REHABILITATION PROJECTS

According to the latest socio-economic study done by UNRWA and the American university of Beirut (AUB), there are 4,127 camp shelters in bad condition that need rehabilitation (Figure 1) (UNRWA 2011, Chaaban et. al 2010). The study also showed that these shelters are major contributors for chronic illnesses among camp inhabitants (Chaaban et. al 2010). Even though many rehabilitation projects were performed, the numbers of rehabilitated units were relatively small compared to the need due funding limitations. To cope with this challenge UNRWA implemented a pilot project (41 shelters) funded by the Swiss Agency for Development and Cooperation (SDC) in Ein El Helwi camp based on a new approach called self-help. In this approach the families are involved directly in the rehabilitation process under supervision of UNRWA engineers.

Figure 1-Damaged building, Spalling concrete

This approach is advantageous because: the unit cost per shelter decreased drastically compared to the traditional contractor approach, family members are learning small crafts and are involved in the decision making process acting as owners and contractors. Although this approach offers many advantages, it doesn’t take into consideration that some families do not have members capable of accomplishing the work themselves, or the skills to deliver the required job quality.

Although “Self Help” is a novice approach, it has a promising future. It can be used in several countries to address similar issues in camps and slums.

IFS-PROJECT

After the success of the pilot project, a new project “IFS-Instrument for stability” using self-help approach started .This project is targeting 736 shelters distributed in all camps except Burj el Shemali and Nahr El Bared. The project is targeting the poorest families. Thus UNRWA had to use a scoring system to select the beneficiaries. This system was based on the socio-economic study performed by UNRWA and AUB in 2010.

Main Project milestones are as follows:

- **Beneficiary Selection**: The beneficiaries were selected based on assessment grades, and then placed on a priority list arranged in descending order.
- **Detailed Survey:** after selecting the eligible beneficiaries from the priority lists. Surveys, sketches, design drawings, and bill of quantities will be produced.
- **Preparation of the self-help agreements Scope of work**: Once detailed surveys are finished, contracts are created for each shelter. Each of these is signed by a project manager and the family members.
- **Supervision:** UNRWA engineers and social workers will supervise the ongoing works and will ensure the implementation of design drawings.
- **Evaluation:** The project is evaluated by meeting beneficiaries before, during and after implementation. Figure 2 demonstrates the changes after rehabilitation.

Figure 2-Shelter Before, during, and after rehabilitation

This paper will focus on 30 shelters out of 736 shelters in Burj el Brajneh camp which is located in Beirut area. Rehabilitation works are facing many challenges including: permits for entering materials, limited working space, and the limited number of contactors available. In order to improve the construction workflow on the project, process modeling and simulation analysis will be performed. The input for the simulation is based on actual field data. Given the situation at hand, can simulation modeling help optimize workflow and reduce the overall waste generated in this project making it more lean?

METHODOLOGY

There are several approaches that enable system analysis; however this requires a full understanding of the system at hand. This paper employs computer simulation to mimic the real system, perform several improvement scenarios, and analyze their impact on the overall process.

Simulation modeling is an effective tool that helps in decision making. Focusing on construction processes, the model takes as input many variables such as activities, resources and the project overall environment. Process simulation aims at making the system more lean by identifying waste and removing impediments of flow. Thus it results in decreasing project costs, reducing project schedule, and optimizing resource usage. Consequently, the same project can be delivered more efficiently in a manner that increases stakeholder satisfaction (Abourizk 2010, Hamzeh et al. 2007). Simulation modeling has several qualities that facilitate system understanding and analysis (Sacks et al. 2007). In simulation one can compress and expand time then check the variations generated. Simulation provides the ability to control the sources of variation. In addition, the modeler can control the level of detail/complexity of the created model. After running the model and based on the output, one can assess the project, make reliable management and process improving decisions (Fishman 2001).

Aiming to mimic reality as much as possible, real data regarding activity durations were collected from the construction site by the help of a site engineer. These data were then inputted into a software tool called *Expertfit* from which the best distribution representing the data was extracted. Moreover, cost parameters were taken from the site engineer and inputted directly in the model.

The type of simulation modeling implemented in this study is discrete event simulation. By discrete event we mean that time progress is essential with substantial changes occurring at discrete time instances. Moreover, this type of model is stochastic, meaning the model has an element of randomness at all occasions that include undertaking random decisions. Consequently, the model will represent the randomness of real-life decisions by giving different results every time we run the model. This characteristic makes discrete event simulation very valuable since it establishes a feel for the variation in the system. Accordingly, in order to assist the need of modeling resources, randomness and variability of processes discrete event simulation software is used in this study. Experiments on the model are performed using Ezstrobe in order to analyze the system. Simulation using Ezstrobe offers a visual and a numerical understanding of the simulated model, and provides answers to the desired goals. After running the simulation experiments, the data collected will be analyzed to have an insight on how to optimize the workflow of system at hand making the system "Lean". Analyzing the simulation model provides an understanding of the system, its performance and limitations (Dooley 2002, Schruben and Schruben 2005).

As a summary, the methodology undertaken in this study is the following:

- Understand the system at hand and develop a corresponding process model.
- Data collection and fitting, obtaining cost parameters.
- Simulation using Ezstrobe then analyzing the system

MODEL EXPLANATION

The UNRWA project undertakes a combination of constructing and repairing 736 houses. However, our focus in this study is merely on 30 houses in Burj El Barajne refugee camp. Specifically, the main objective of the process modeled is the construction of 12 houses and repair of 18 houses. The project has two major resource constraints. The first constraint is that there is only one material supplier with one transport truck that can serve only one house at a time for funding purposes. The other constraint is that only contractors within the camp can initiate works.

Consequently, only 12 contractors are available and responsible for the 30 houses under study.

The construction/repair process begins by checking 30 contracts, if any modifications need to be done the contracts undergo amendments were they get accepted directly if the modifications were minor or get full revision if the amendments were severe. After checking and revision, all contracts get a notice to begin works. Upon gaining the notice to start, transporting the material needed specific to the type of works (whether construction or repair) takes place. For the transport to take place a supplier with a supply truck is required. After serving one house the supplier is ready to serve another house. As soon as the material gets delivered the contractor can initiate works. After finishing, the contractor is ready to work on other projects upon request. Figure 3 demonstrates the simple process model.

The objective of building a model that simulates this process is to optimize the system's work flow. This is done by making sure all the resources are properly utilized leading to optimum project cost, duration and resource utilization.

MODEL DESCRIPTION

The simulation model encompasses the following activities:

- **Contracts:** represents the act of looking upon house contracts and directly giving them approval to start works incase no amendments need to be done. Usually 15 contracts are looked upon per day.
- **Contract amendments:** represents the act of looking into the non-approved contracts and checking if minor adjustments need to be taken. If the adjustments are minor these contracts get adjusted and approved directly. Otherwise, these contracts are channeled to full revision. The rate of Contract amendments is one contract per day.

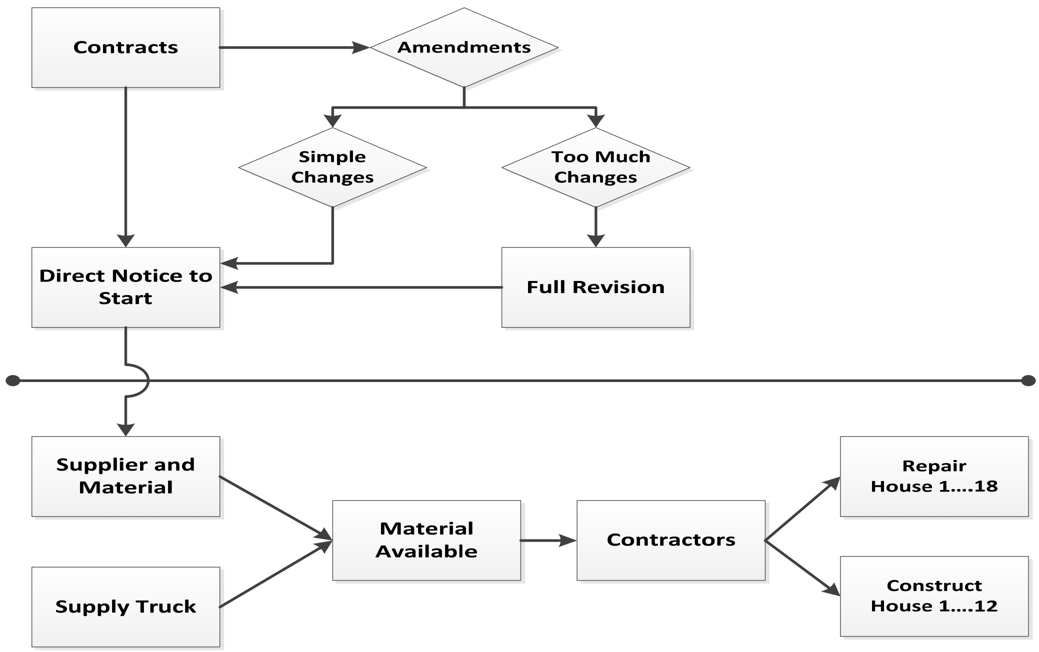

Figure 3: Simple process model representation

- **Revision:** represents the act of fully revising non-approved contracts, and adjusting all the terms for re-approval. This activity takes a week for each contract.
- **Re-hand contracts:** represents the act of re-handing contracts that had full or minor adjustments. This activity takes about one day.
- **Randomize:** this activity is responsible for randomly choosing the type of works that will take place, whether it is a house that needs repair or construction.
- **Construction ensure, Repair ensure:** since the Randomize activity chooses randomly the type of works based on a probability, the model might not choose 12 construction and 18 repair works. Thus, these two activities are made to ensure that if one type of works is fully done, the randomize activity seize to take place, and rather the following works will be from the other type of works. These two activities ensure that only 12 construction and 18 repair works take place.
- **Construction material, Repair material:** represents the act of obtaining the required material from the supplier based on the type of works and delivering it to the contractor. The duration of repair material delivery is 1 day, while for construction it is 2 to 3 days; both durations are based on a uniform distribution.
- **Construct house, Repair house:** represents the process of constructing or repairing a house. The duration of repairing a house is taken to be 3 to 9 days based on a uniform distribution. The duration of constructing a house is taken to be 11 to 17 days based on a uniform distribution.
- For Ezstrobe Full Model : **https://www.box.com/s/azy3fg2rajukpsgedhv4**

MODEL PARAMETERS

The costs associated in this project are the following:

- **Repair House:** $6000 per house, this includes the cost of repairing works and the material needed to perform these works.
- **Construction House**: $12000 per house, this includes the cost of the construction works and the material needed to perform these works.
- **Transportation:** $120 per day, this is the rental cost of the supply truck that is responsible of delivering the material.
- **Relocation:** $15 per day, this parameter represents the cost paid by the camp residents to rent an apartment in the camp.
- **Idle Cost:** $100 per day, this parameter represents the cost incurred by the contractor when idle.
- **Inflation Rate:** 6% per year which equals 0.02027% per working day.

MODEL REMARKS

- The material supplier and his supply truck serve both types of works construction and repair. However in the model, the material supplier is divided into two resources one for construction and the other for repair works. This is done to simulate the fact that the transportation durations for these activities differ.
- The durations of each activity is obtained from the site. The engineer onsite collected numerous durations for each activity which were then fitted into the best representative distribution using a program called ExpertFit.
- The probabilities present in the model are obtained from the real system with the help of the engineer onsite.
- The idle cost is calculated as 10% from the total project cost (Blattner, 2008).
- The inflation cost is calculated based on working days in Lebanon (297 days), (Byblos Bank, 2012).

MODEL LIMITATIONS

One fact not modeled is when the supply truck needs repair. This instance might have a substantial impact on the project's duration, cost and work flow.

SIMULATION ANALYSIS

The objective of this simulation exercise is to determine the areas of waste in the system and impediments to flow. Upon identifying the sources of inefficiencies, several scenarios are exercised to determine the optimum scenario which results in the best balance between total project cost, resource utilization and project duration.

In order to determine the optimal balance between the specified factors, the number of material suppliers and supply trucks is varied in the simulation along with the number of contractors. Consequently, the simulation is expected to demonstrate the effect of varying both the number of material suppliers, supply trucks and the number of contractors. The impact of varying these resources on the model results are examined closely and is demonstrated for comparison purposes.

The scenarios examined are the following:

- The original model (T1 C12) with only one material supplier, one supply truck and 12 contractors.
- 1st: (T2 C12), 2 material suppliers, 2 supply trucks and 12 contractors.
- 2nd: (T2 C13), 2 material suppliers, 2 supply trucks and 13 contractors.
- 3rd: (T3 C12), 3 material suppliers, 3 supply trucks and 12 contractors.
- 4th: (T3 C13), 3 material suppliers, 3 supply trucks and 13 contractors.
- 5th: (T4 C12), 4 material suppliers, 4 supply trucks and 12 contractors.
- 6th: (T4 C24), 4 material suppliers, 4 supply trucks and 24 contractors.
- 7th: (T30 C30), 30 material suppliers, 30 supply trucks and 30 contractors.

The seventh scenario is done as an extreme case just for demonstration purposes.

SIMULATION RESULTS AND DISCUSSION

The original model was simulated for 100 trials with different seeds and the average duration was found to be 59.7, when compared to the first 30 trials the average duration was found to be 59.5 ,thus the difference is 0.335% which is negligible. Consequently, the different scenarios were simulated 30 times each. Table 1 displays the average results of the trials done. In the original model, the total duration is found out to be 59.5 days, the total cost is $301900, and the average idle contractor time is 10.4 days. The fact that there is 10.4 days on average of idle contractor time is alarming; this means that on average contractors sit idle for 10.4 days in this project rendering an inefficient workflow pattern. Consequently, the intuitive conclusion is that the material supplier and his supply truck are the bottle neck in this project and tackling this problem makes the system less wasteful and thus more lean.

Identifying idle time as one source of inefficiency in the system led to developing different scenarios to optimize performance. In the 1st scenario, the number of suppliers and supply trucks were increased from 1 to 2 while keeping the number of contractors at 12. The outcome of the first scenario is that the total duration dropped by about 20 days, the cost decreased to $286997 and the average idle contractor time decreased by about 6 days. The first variation showed significant improvements in all the parameters. Therefore, the 2nd scenario was undertaken to understand more what is happening in the system. One contractor was added to the previous scenario resulting in 2 suppliers and supply trucks, and 13 contractors. However, no obvious improvement was detected, since the total duration stayed rather the same, the total cost increased and the average idle contractor time increased. This led to the conclusion that the number of suppliers and supply trucks are still the bottle neck in this model, and that adding contractors will only make the system more wasteful.

Table 1: Results for different scenarios each simulated 30 times

	Scenario	Total Duration (days)	Total Cost ($)	Idle Time (days)	Unit price ($)	Production rate (unit/day)
T1 C12	Original	59.50	301900	10.4	10063	0.504
T2 C12	1	39.36	286997	4.65	9567	0.762
T2 C13	2	39.08	288094	5.35	9603	0.768
T3 C12	3	32.55	283486	2.72	9450	0.922
T3 C13	4	32.78	285056	3.55	9502	0.915
T4 C12	5	30.99	285292	2.24	9510	0.968
T4 C24	6	28.51	301484	7.56	10050	1.052
T30 C30	7	20.05	351052	11.65	11702	1.50

The 3rd scenario demonstrates the effect of increasing the number of suppliers and supply trucks to 3, while keeping the number of contractors as 12. As a result, the total duration decreased by around 7 days more than the initial decrease of the first scenario, the total cost decreased to $283686 and the average idle contractor time decreased to 2.72 days. The 4th scenario demonstrates the effect of increasing the number of contractors by one resulting in 13 contractors, while keeping the number of suppliers and supply trucks as 3. Like the 2nd scenario, the total duration did not change, the total cost increased and the average idle contractor time increased. Therefore, the bottle neck is still the number of suppliers and supply trucks.

The 5th scenario demonstrates the effect of increasing the number of supplier and supply trucks to 4 and keeping the number of contractors as 12. The total duration decreased to become around 31 days, the total cost became $285292 and the average idle contractor time became 2.24 days. The 6th scenario demonstrates the effect of keeping the number of suppliers and supply trucks as 4 and increasing the number of contractors to 24. The decrease in total duration (from 31 to 28.5) is very shy compared to the increase in total cost (from $285292 to $301484) and the idle average time increased from 2.24 days to 7.56 days.

The 7th and last scenario demonstrates an extreme case, were 30 suppliers and supply trucks are available as well as 30 contractors. This scenario means that almost all works can begin at the same time with the contract approval/revision as a limiting factor. The total duration dropped to 20 days, the total cost increased to $351052 and the average idle contractor time became 11.65 days.

Now that all possible variations are made, one can notice several trends. The first trend is that when the number of material suppliers and supply trucks increased, holding the number of contractors constant, the total duration decreased as well as the contractors' idle time thus enhancing the system's workflow. The second trend one can observe is that when increasing the number of contractors, while keeping the number of material suppliers and supply trucks constant, the total cost is increasing along with the contractors' idle time, and the total duration change is barely noticeable thus increasing waste in the system. These trends are demonstrated in figures 4 and 5.

The final trend obvious in figure 4 is the project duration reduction due to the effect of increasing all 3 resources the suppliers, supply trucks and contractors. Time reductions become less and less significant after adding these resources and reaches a vertical asymptote at day 20 were no matter how much resources added, the only thing changing is the total project cost which increases till infinity. As for the data presented in figure 5, one can deduce that addition of contractors have a negligible effect on the project duration, and the average idle contractor time increases when contractors are added to the project.

While looking at the graphs, it is apparent that the optimum system lies between the 3rd and the 5th scenario. While the 3rd scenario entails the lowest cost, the 5th scenario presents the minimum average contractor idle time and lowest project duration at reasonable project costs. Therefore, choosing between these two scenarios requires further analysis to justify the stakeholder preference. However both scenarios are successful in optimizing the system's workflow making it more lean.

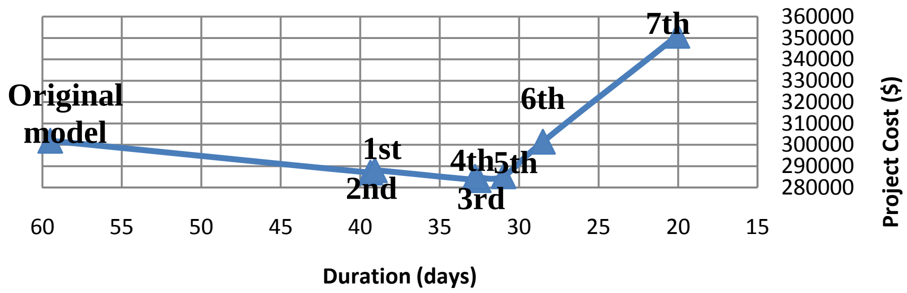

Figure 4: Result of simulation trails (Duration Vs Project Cost)

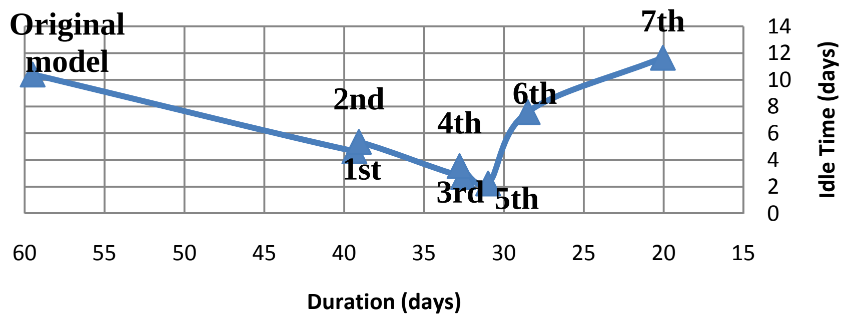

Figure 5: Result of simulation trails (Duration Vs Idle Time)

CONCLUSION

This paper has introduced the effect of using discrete event simulation modeling in construction projects. Different variations were modeled to have an understanding of how the system works.

Several simulation model scenarios were presented in this paper in order to optimize the system at hand. The results of this simulation exercise pointed out interesting outcomes. Significant reductions in cost, contractor idle time and total project duration resulted from varying resources, thus showing the power of simulation modeling in identifying sources of waste and providing alternatives to improve the system by making it more lean. Two scenarios proved to be optimal in this study. One scenario was optimal in terms of project's cost, this scenario included having 3 material suppliers, 3 supply trucks and 12 contractors. The cost reduction resulting from this scenario was $18,414. The other scenario was optimal in project duration and average idle contractor time, this scenario included having 4 material suppliers, 4 supply trucks and 12 contractors. The time reduction resulting from this scenario was 28.5 days.

Conclusions in this paper were drawn based on simulation models and some associated assumptions. Experiments and comparisons between simulated models and reality in construction projects are required for better conformation. As for the system presented and after observation and analysis, one can deduce that the current system is far from being optimal; a great deal of waste in the system is generated due to inefficient resource utilization, as is the case in most construction projects.

Simulation modeling in this paper was used to demonstrate some of its capabilities in identifying sources of waste and analyzing various scenarios for optimizing systems and making them more lean. Consequently, one can deduce that simulation modeling can be applied to improve processes and is scalable to any type of project. It should be noted that simulation modeling is not only used to asses existing systems, but also its power lies in mimicking systems that are still in design, allowing stakeholders to proactively design and improve production systems.

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