

New Simulation Methodology for Dynamic Simulation Modeling of Construction Activities for Risk Based Scheduling

Abhilash A. Jangalve¹, Hemant H. Salunkhe²

^{1,2}Department of Civil Engineering, Savitribai Pune University, D.Y.Patil Institute of Engineering, Pune, Maharashtra, India.

Abstract – Use of simulation has proven to be very beneficial for many sectors like manufacturing, Healthcare as well as in construction however there is not enough simulation methods available apart from Monte Carlo simulation for construction schedule simulation. Currently 3D simulations are used but these simulation only shows the defined timeline and 3D visualization of the model. In this paper a new Modeling method is proposed for construction activities scheduling which considers the risk of the project as well as calculated the budget for the project based on the risk based scheduling along with leveling the resources.

Key Words: Flexsim, Construction schedule Simulation, Simulation Modelling

1. INTRODUCTION

Scheduling of construction activities is very complex process and many factors needs to be taken into account for accurate schedule. A critical problem with the traditional scheduling approach of optimization-based scheduling is that it requires that all the data be fully known and deterministic. To protect against delays, the scheduler must buffer with some combination of extra time, or capacity; all adding cost to the system. Simulation-based extends traditional scheduling to fully account for the variation that is present, and provides the necessary information to the scheduler to allow the upfront mitigation of risk and uncertainty.

Flexsim is the software program which is used for various types of simulation operations and has been shows greater results in the sector of healthcare, transportation, manufacturing etc. this paper will focus on its applications in the construction sector.

1.1 Need of the study

Simulation is being used in construction for many activities but it has not been prominently used in the development of schedule. There as be very less research on this topic. Also the simulation modeling is used very effectively in manufacturing and other industries. But it is not very often used in the construction industry.

1.2 Literature review

a) "Simio: A New Simulation System Based On Intelligent Objects," Dennis Pegden

This paper describes the new modeling system Simio™- which is used for simulation modeling. The paper describes the advantages of the new system, how the simulation modeling has changed form process oriented to an object orientated modeling. The paper gives the brief introduction to the Simio framework

b) "3D Simulation Analysis of Patras New Port Operations in SIMIO Platform Environment," Mandalaki, Manesis

In this paper the application of simulation using Simio software for the preparation of the schedule of activities at the Patras port has been documented. The results shows that there has been a benefit of using this simulation modeling as it was able to reduce the waiting time for the passengers and the vehicles. The paper gives brief methodology for the development of the model. And the results that are obtained after the simulation run has been show.

c) "Adaptive Real-Time Tracking and Simulation of Heavy Construction Operations for Look-Ahead Scheduling," Linguang Song

This paper is about real time tracking and simulation of the heavy construction operations for preparation of the schedule during the construction operations. For development of the model continues data of the construction activities has been collected using tracking sensors and this data has been used as input for the simulation model. Because of using real time data it allowed schedule to be modified according to the real time situation and develop most accurate look ahead schedule.

d) "Identifying Cost Reduction and Performance Improvement Opportunities through Simulation," J. E. Brown and D. Sturrock

This study shows how the simulation for the production lines of the HVAC manufacturing unit has been benefited. Using Simio based simulation it was possible to increase the outputs and decrease the operation cost. Through the use of Simio and its analysis the Deloitte team has discovered the opportunity to improve throughput by 41% and reduce the work in process by 36%.

e) "Simio Applications in Scheduling," Renee M. Thiesing C. Dennis Pegden

This paper focuses on the applications of the Simio simulation in the scheduling. The paper shows how the mathematic based simulation differs from the simulation models. The paper gives the brief information about the type of schedules generated from the Simio software. Various terms used in the report that is generated after the simulation runs.

f) "A Flexsim-based Optimization for the Operation Process of Cold Chain Logistics Distribution Center" X. Zhu, R. Zhang, F. Chu, Z. He and J. Li

In this paper flexsim software is used to find out the bottleneck and idle resources for the cold- chain logistics distribution process. This paper provide measures to make the turnover rate of the cold chain goods & using rates of equipment and workers increase greatly.

2. METHODS

For the modeling of the project the construction activities of the operation theater in NuLife Geriatric Hospital, at Kamshet, Pune has been studied as in the construction of Operation Theater there are many critical activities and it's not possible to carry out two or three activities at a time.

For the data of the activities has been collected from site. Where three types of durations for each activity is recorded. Each activity duration is recorded as a most likely required time for the completion of the task then optimistic duration required and the pessimistic duration of the activity by the experts in the field.

Figure 1. Shows the details flow chart of the simulation model which is used for the simulation modeling of operation theaters.

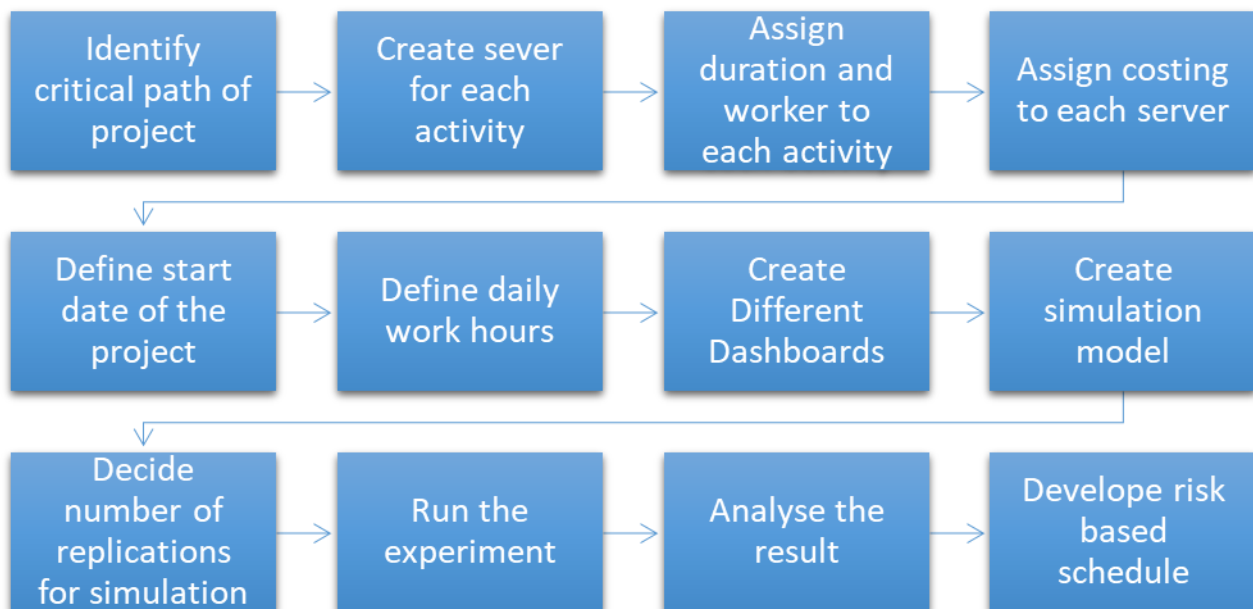


Fig - 1. Simulation methodology

2.1 Simulation modeling process

Using the list of critical activities the detail simulation model is created in Flexsim software. In this model the ach server is represented as a single activity. And for every server the respective duration of the activity has been given in the format of triangular distribution. Then all the servers as connected to each other in the sequence of the critical path. For every activity the respective worker is assigned. When the model runs the worker will go and perform his work which ever activity is available first.

Time of the simulation to be started is defined in the model and test run is performed with constant random variable of the triangular distribution. After the first run if there are any errors in the model are identified and resolved. Once the model is finished the simulation is run with random variables multiple times to consider the risk in the project. And the results are studies for the optimization of the schedule and for the risk considerations.

3. Validation of the model

This modeling method is validated by cross checking using following checks using a prototype model

1. Using unit durations to each activities instead of using triangular distribution of optimistic, most likely & pessimistic duration.
2. Using Constant Random variable and performing simulation runs.
3. Comparing total duration given by this model to the traditional schedule when workers are balance and considering waiting times at constant duration of each activity.

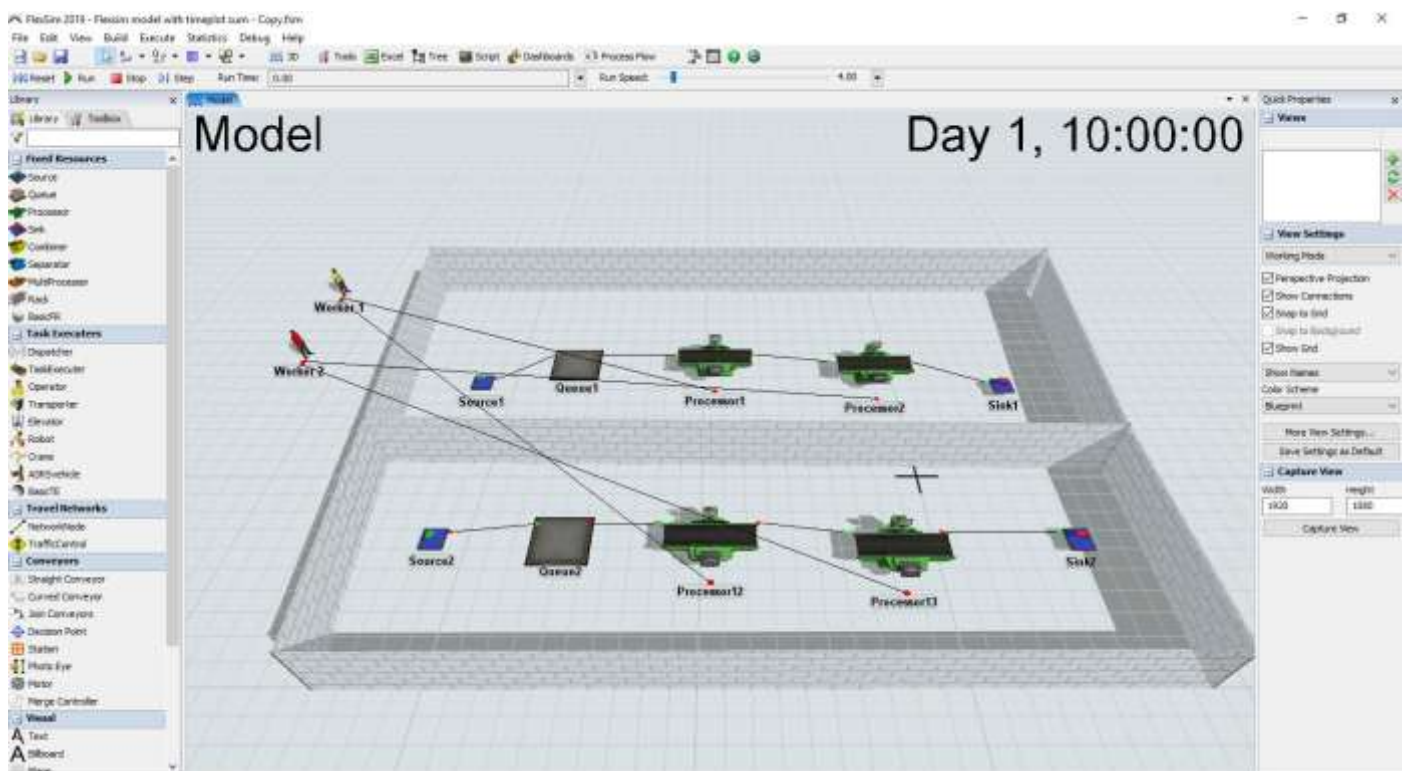


Fig - 2. Prototype Model

Model Shown in Fig -2 above has been developed to check above criteria's for the validation of the methodology. In this model two rooms are considered and each room has two processors representing two critical activities. For the completion of those activities respective workers are assigned and color coded as yellow for worker 1 and Red for worker 2.

3.1 Check 1: Using unit durations to each activities instead of using triangular distribution of optimistic, most likely & pessimistic duration.

For this check each activities has given constant duration as for

Room 1:- Processor 1: 5 days Processor 2: 10 days

Room 2:- Processor 12: 5 days Processor 13: 12 days

After assign the durations the simulation model is run and total duration is crosschecked if it comes to be total 15 days for Room 1 & 17 days for Room 2. For this check workers are not assigned to the processor so that there is no waiting time for any processor considered in calculations.

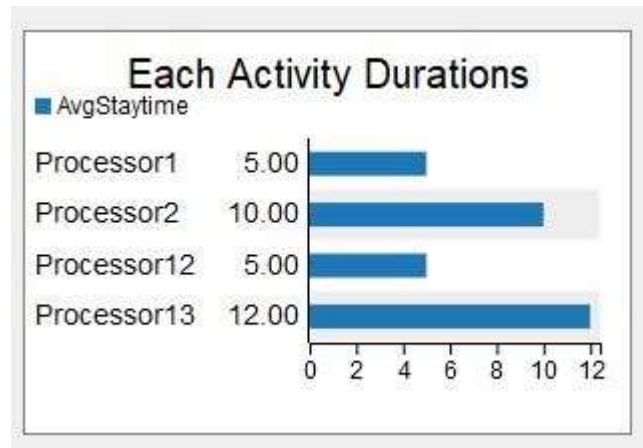


Fig - 3. Duration of the each activity from dashboard

As shown in Fig- 3 It has been verified that model gives accurate results for the durations assigned to each activity. And we can further use the triangular of beta distributions for the each activity durations input.

3.2 Using Constant Random variable and performing simulation runs

The random variable is kept constant in order to identify the errors in the model when some changes are made. By using content random variable it has been cross checked that the simulation model gives same results after performing multiple runs.

For this check the optimistic, most likely and pessimistic durations has been assigned to each processor representing construction activities of the two room.

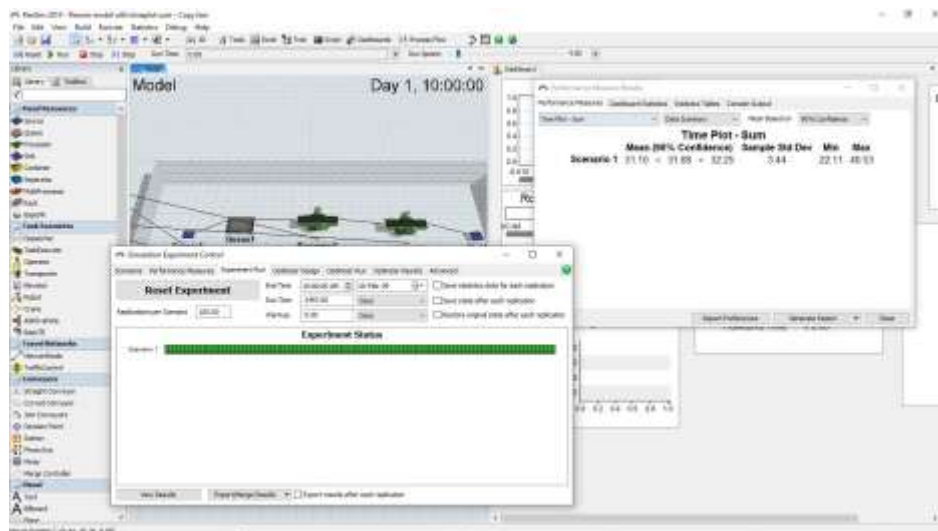


Fig - 4. Simulation run with fixed random variable

Then the simulation model is run multiple times and check if there are any changes in the result and found that there is no change in the model hence the model has no errors.

3.2 Comparing total duration given by this model to the traditional schedule when workers are balance and considering waiting times at constant duration of each activity.

For this check the same model has been developed in Microsoft project and total duration of the project is calculated as 27 days. And after the simulation model run it has been check that the simulation model gives same result as 27 days for completion as show in below Fig.5 & in Fig 6

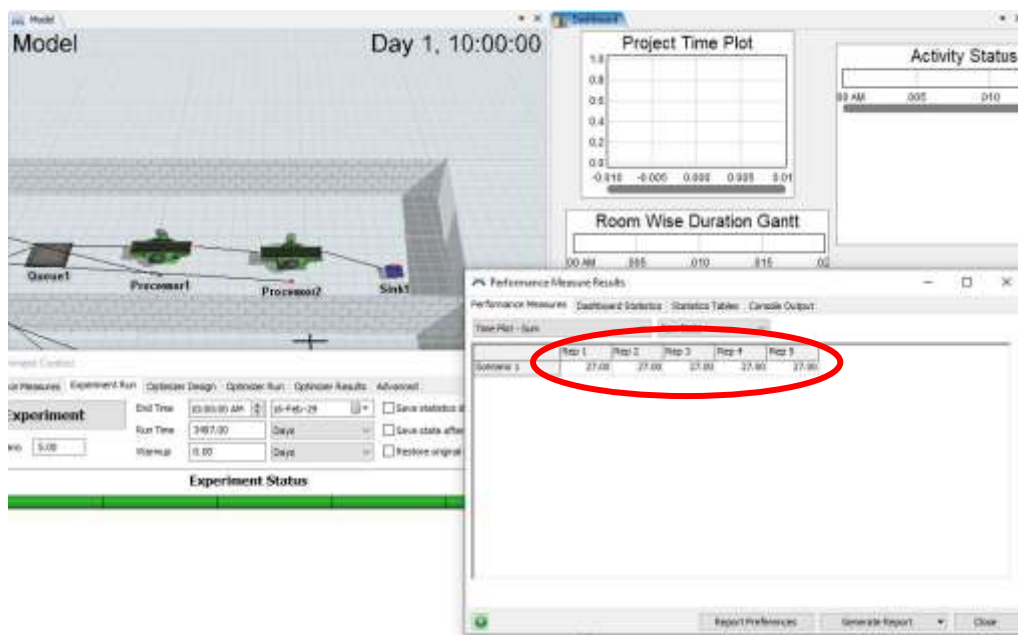


Fig - 5. Total duration given by simulation model

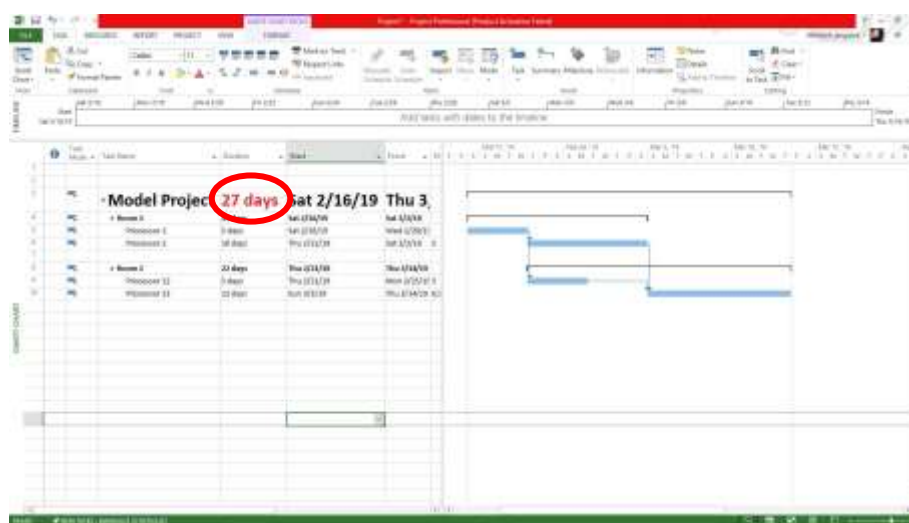


Fig - 6. Total duration given by traditional schedule

4. Development of Operation Theatre model

Once the method is verified Three Operation theatre model of Gagan Nulife Hospital, Kamshet has been developed based upon above methodology. For this model 14 critical activities are find out from traditional schedule. And from the experts the data has been corrected as optimistic, most likely and pessimistic durations. These durations are then assigned to each activity.

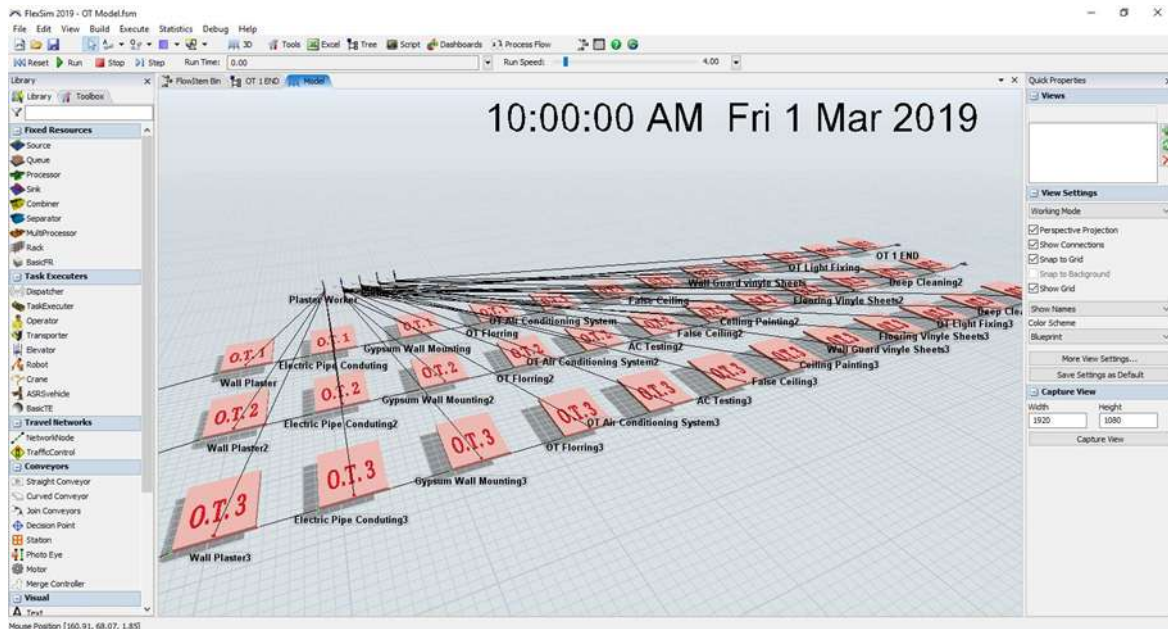


Fig - 7. Three Operation theatre model

After development of the model detailed dashboard has been developed which gives the results of the model. This model has helped the engineering team to develop risk based schedule.

5. CONCLUSION

The new methodology has been developed for risk based schedule development of construction activities. After verification of the model it has been found that this methodology gives accurate. Further this mythology has been used to develop operation theatre model which helped engineering team at Gagan Nulife Hospital, Kamshet to develop risk based schedule, to estimate the budget of the project and to prepare for the various risks in the construction. It has been found that this method can be effectively implemented on real projects and gives accurate and beneficial results. Further research can be done by developing more complex models.

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