Dynamic Project Scheduling and Progress Monitoring of Engineering Phase in FPSO Conversion Project with Fuzzy Method

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Article history

Received:
11 Oct 2019

Received in revised form:
5 Nov 2019

Accepted:
4 Dec 2019

Published online:
25 Dec 2019

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Abstract

Project scheduling and progress measurement for engineering phase of floating production storage and offloading (FPSO) conversion project always faces uncertainties which frequently require re-scheduling when variance between plan progress and actual progress is too large. This research studies the dynamic nature of project scheduling of engineering phase for an FPSO conversion project where correlation of variables of number of deliverable in Master Deliverable Register (MDR), Manhours (MHR) and project duration against project progress are analysed using the regression method. The projection of these correlations against project progress are results to a Three-Dimensional surface plot of project progress at a chosen control variable of either MDR, MHR or duration.

Keywords: *Fuzzy Linguistic; Fuzzy Membership Function; Progress Measurement; Resource Management; Regression;*

1. Introduction

Project scheduling, risk analysis and project tracking are key parameters determining a project's success or failure [1]. This study features aspects of project planning on project control and tracking for detail engineering. Project scheduling and resourcing are necessary in the initial stage of the project, where the schedule denotes the completion date of a particular project. Duration of activities in project network often has ambiguity and precise estimation of them is difficult [2] . In an FPSO conversion project, engineering is the first phase to start before procurement and construction activities. Therefore, any delay in engineering will significantly cause carry over delays to both procurement and construction phases in the project.

An S-Curve is a measurement tool for planning and controlling that illustrates project cumulative progress throughout the duration of a project. When detailed information for a project is available, the traditional approach to S- curve estimation is analytical and based on a schedule of planned activity times [3]. Once project baseline schedule is developed, a cumulative measurement of work effort is compiled for activities within the schedule to develop a planned S-curve. During execution of engineering phase, the actual progress is being compared to the Planned S-curve over a particular engineering duration and Project Managers will

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be able to tell the current health of the project by comparing actual and planned progress. The use of graphics and the visual intuitiveness provided by enables project managers, schedulers, owners and construction personnel to better visualize the plan of action and more easily communicate the plan to everyone involved in the project [4]. However, there are some risks in using S-curves to establish the progress target for project control [5].

As engineering phase progresses, schedule will be updated based on action work completion and activities which are yet to be started will be forecasted and given a new dateline. Dynamic project scheduling in this research refers to project tracking at each time interval whereby, if the project performance is not at a satisfactory level, corrective rescheduling is required. In this research, variables of manpower, design deliverables and progress will be measured to obtain expected project completion date.

During engineering phase of project execution, complexity of decision making arises from project uncertainties as well as inability for Project Managers to obtain accurate data – thus leaving room for Project Managers to make assumptions based on experience and judgements. Fuzzy logic is applicable at most in two cases: firstly, if the phenomenon being studied is very complex and secondly if there is not enough information about the case. It is appropriate to use fuzzy approaches in areas where uncertainty is dominant [6]. Regression analysis is a statistical method that is used to model relationships between variables and to predict future data [6]. This research will take into account fuzzy method as well as linear regression to develop a tool with FPSO project as a base case for future project monitoring.

2. Dynamic Scheduling

Dynamic scheduling refers to the three dimensions of project management and scheduling: the construction of baseline schedule and the analysis of the project schedule's risk as preparation for the project control phase during the progress of the project. [1]. This dynamic scheduling implicitly assumes that the reliability of a baseline schedule of a project is rather restricted and operates only as a point of reference in the development of a project. A project schedule should thus be considered in general as a forecasting model that can be used for allocating efficiency calculations, time and cost risk analyzes, project monitoring and measurement of performance.

Vanhoucke [1] have developed a project performance and schedule risk information during project tracking using monte carlo simulation. The two methods obtained by Vanhoucke uses earn value method and schedule risk analysis. Earned value will not work unless accurate actual costs for project is obtained [7].

In this research, the application of dynamic scheduling applies to wide range of scenarios of manpower management and deliverable targets leading to project progress changes at a particular engineering execution stage which provides flexibility of project rescheduling or to maintain the baseline schedule.

3. Fuzzy Method

Fuzzy set theory can be used to deal with imprecision, uncertainty and fuzziness in group decision making. Fuzzy set theory has been developed to solve decision making issues where descriptions of findings are imprecise, vague and uncertain. A fuzzy logic system can be considered as a mapping from crisp inputs to crisp outputs [8]. Fuzzy set theory can be used in group decision making to deal with imprecision, uncertainty and fluidity.

One of the advantages of fuzzy logic is that it uses language variables to model vagueness inherent in human cognitive processes. In many real world project scheduling applications, duration times of activities are uncertain and they can be modeled in the framework of fuzzy sets [9].

In principle, the development of a fuzzy logic model consists of the following steps: building fluid membership functions, developing fuzzy rules and determining the fuzzy inference system.

Membership function properties consist of the universe of speech, the number of language terms, the shape of membership functions, the numerical distance of each language term and divergence across each membership function. In this study, four membership functions are namely, duration, project progress percentage, engineering deliverables in Master Deliverable Register and Manhours. Duration of activities is uncertain in many real world project scheduling applications and it can be modeled in the context of fuzzy sets.

Fuzzy inference is the process of using fuzzy logic to formulate the visualization from a given input to an output. Then the visualization provides a basis for making decisions or discerning patterns. In this research Matlab software will be utilized to operate the fuzzy method with Fuzzy Logic Toolbox. Fuzzy Inference can be conceived as containing a base of knowledge and a processing stage. The knowledge base provides the processes' necessary membership function and fuzzy rules. In the processing stage, numerical crisp variables are the system input which are carried into a fuzzification stage in which they are converted into linguistic variables, to become the inference engine's fuzzy input [10]. The inference engine rule transforms this fuzzy input into fuzzy output. Then these linguistic results are transformed into numerical values that become the output of the system by a defuzzification stage.

4. Project Control and Measurement

In this study, data collection from past FPSO engineering project was conducted whereby manpower, document deliverables and progress percentage are obtained from Schedule updates which were derived from Master Deliverable Register (MDR). Master Deliverable Register is a project documentation which enlists all engineering deliverable required to be approved and completed in stages within a planned date.

During the initial stage of the project, a baseline schedule will be developed on the deliverables in MDR list and will be the basis of project monitoring through project S-curve which is developed to monitor progress percentage against project timeline. Project S-curve is plotted based on the cumulative progressive progress of each activity in the schedule against project duration.

As the project progresses along the project timeline, project schedule and MDR are constantly monitored and updated where actual project progress is recorded along with manhours spent and completion of detail engineering deliverables periodically. A new forecasted project S-curve will then be developed from activity updates within the schedule. Figure 1 illustrates the comparison of revised schedule

S-curve against baseline schedule. In this case, schedule has been revised and progress of the new schedule has been re-forecasted. Conflicting schedules caused by shared resources or other constraints across projects are the major issue to be resolved in order for the whole schedule to be practical [11].

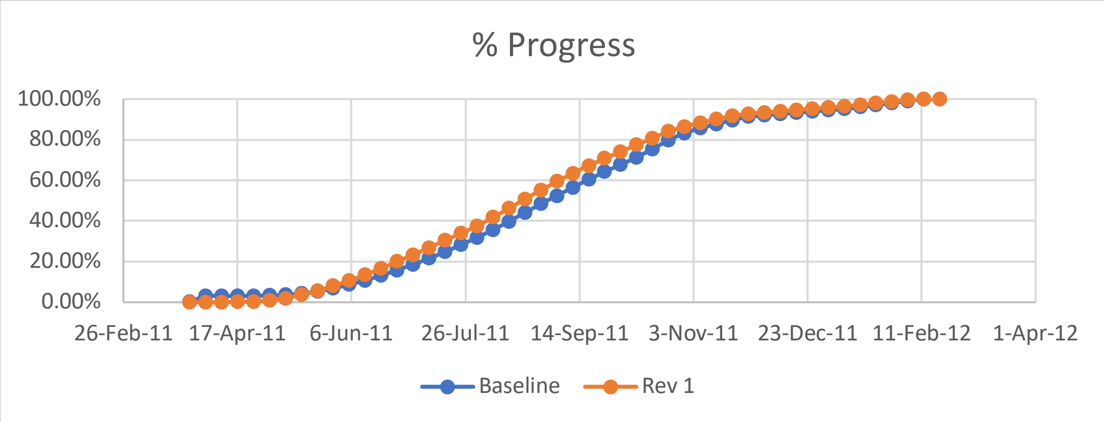

Figure 1. S-curve comparison between baseline and revised schedule.

5. Research Model

Data collection will be based on compilation of project progress from baseline and series of forecasted S-curves and MDR information as well as project manhours histograms. The data will then be extracted and tabulated into rows of project progress, MDR document completion, manhours spent and project duration.

The research model consists of 3 packages encompassing steps of information transfer starting from data collection to Regression Packages which generate coefficients relationship of independent variables. These coefficients will be used in Fuzzy Package where fuzzy inference rule is being established and transferred to User Interface Package. Then, fuzzy progress surfaces at selected control variable will be generated by the User. The research model is illustrated in Figure 2 whereby the datasets are processed through a series of regression packages, fuzzy packages and user interface package. One way to approach the problem of regression using fuzzy rules is to transform it into an ordinal classification problem in which the output variable is discretized by intervals [12].

The first package in the model consists of regression package to analyse the relationship between MDR, manhours and duration against project progress as coefficients which will then be used to generate equations for Fuzzy inference.

SPSS software regression analysis model summarises output as well as report table of coefficients where linear equation is developed based on the computed independent variables of progress of MDR, Manhours and duration being independent variables against the dependent variable of progress percentage. Table 1 depicts the coefficients table which is the output from SPSS analysis.

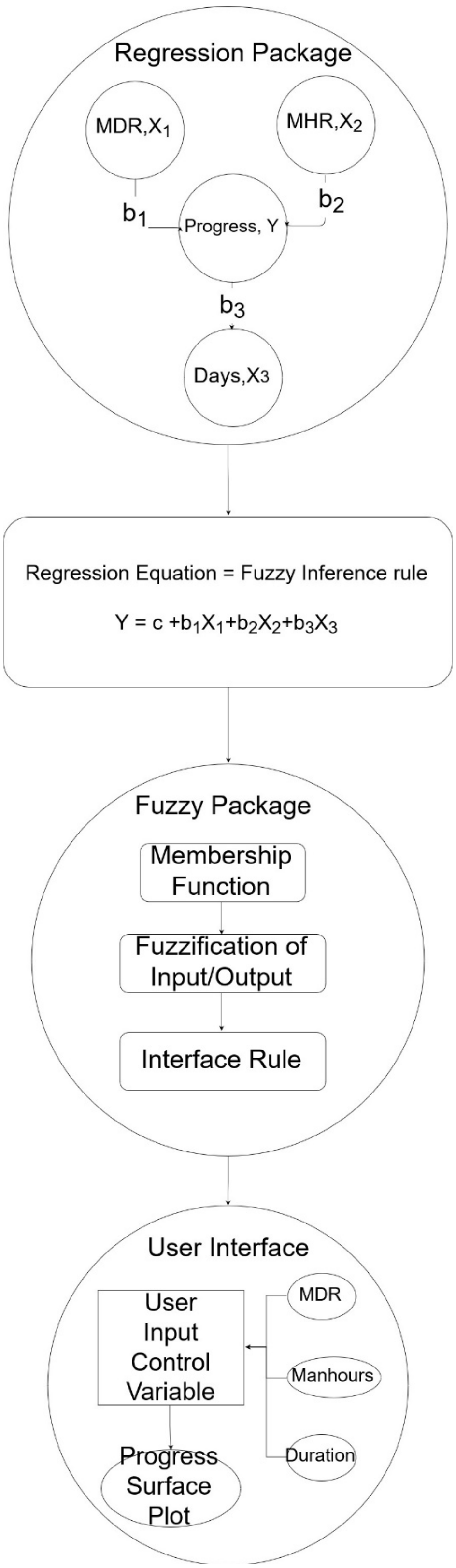

Figure 2. Research Model consists of 3 packages – Regression Package, Fuzzy Package and User Interface Package.

Table 1: Coefficient table from SPSS software

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.243	.626		-3.582	.000
	MDR	.004	.001	.107	4.591	.000
	MHR	.001	.000	.918	58.164	.000
	Days	-.008	.005	-.029	-1.661	.097

a. Dependent Variable: Progress

Based on the coefficient table from SPSS, the relationship between independent variable and dependent project progress is produced through equation (1):

$$\text{Progress} = -2.243 + 0.04\text{MDR} + 0.001\text{MHR} - 0.008\text{Days} \quad (1)$$

The equation generated by the SPSS regression package will then be used for developing fuzzy inference in the fuzzy package. The fuzzy package is first developed by defining the membership function of input and output variables in Matlab fuzzy toolbox as illustrated in Figure 3.

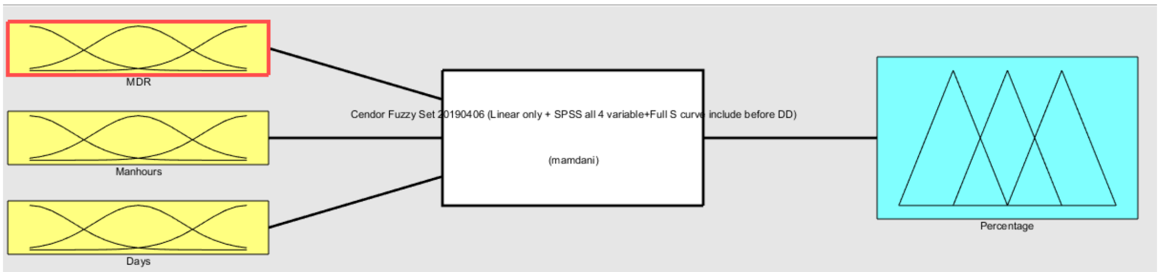

Figure 3. Matlab toolbox function for Fuzzy Package

A logic set consisting of "IF AND THEN" sets of rules will be generated with the linguistic terms. The series of linguistic inputs for the three variables for MDR, Manhours and duration with 7 linguistic terms can be organized using the following flowchart in Figure 4 where:

i = the fuzzy linguistic term for MDR

j = the fuzzy linguistic term for MHR

k = the fuzzy linguistic term for Duration

Y*n* = the stored percentage linguistic term for *n* number of scenarios

The fuzzy rule base process involves fuzzification of calculated progress percentage from the regression equation calculation with the peak value of each input variables. The value of progress at each constant independent variable will then be converted into linguistic terms with reference to the progress membership function.

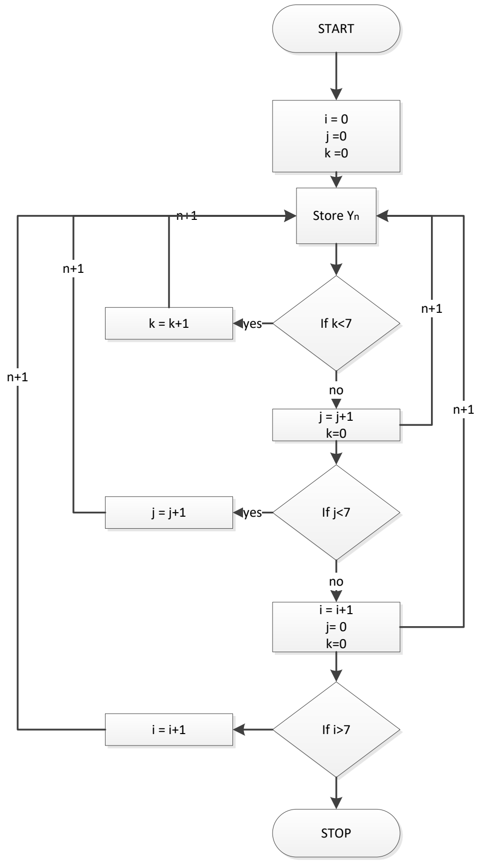

Figure 4. Number of set rule series for fuzzy inference

6. Results

The result the research model is a series of progress which forms a layer of contoured surfaces which predicts the expected progress based on input conditioning. The user will only be required to key in one control variable of either manhours, MDR or Duration to visualize the fuzzy progress surface with the other 2 variables as independent axis in the surface plot as illustrated in Figure 5, Figure 6 and Figure 7.

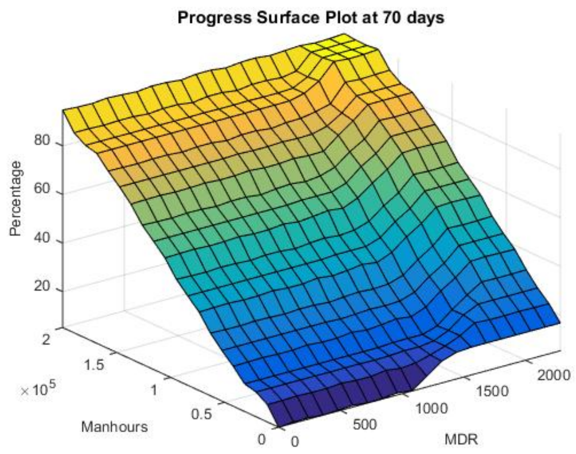

Figure 5. Percentage fuzzy surface at duration 70 days

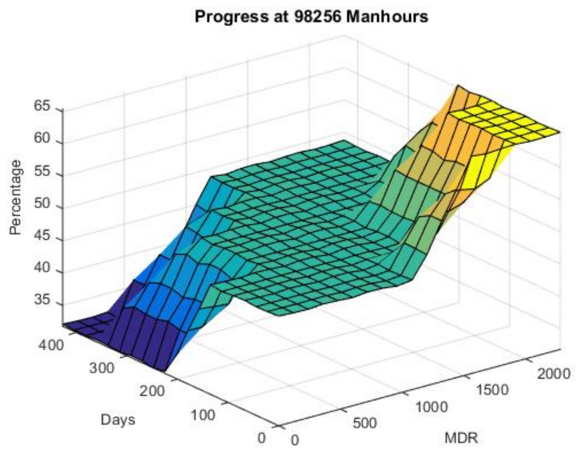

Figure 6. Percentage of fuzzy surface at 98256 manhours

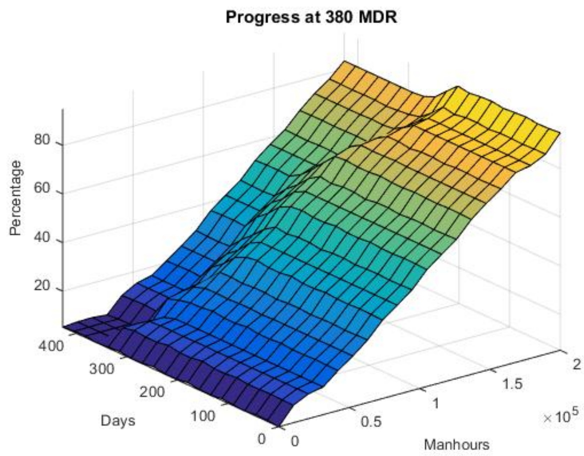

Figure 7. Percentage of fuzzy surface at 380 MDR number

The surface plot provides alternative from a conversional way of measuring project progress, whereby an S-curve is normally used in project reporting to predict the project trajectory throughout the project timeline.

7. Discussion

In an FPSO conversion project, uncertainties such as delays in drawing approval, change of existing FPSO construction scope, late input of vendor data and lack of manpower will often impact the maturity of engineering phase which will then cause a chain effect of delays in procurement phase and construction phase throughout the FPSO conversion project. The level of maturity of engineering is measured in the progress figures.

The fuzzy progress surface also provides a visual illustration for project managers to look into the productivity of the engineering team, whereby the contour surface is an indication for project managers and planners to predict the level of workforce required to catch-up with project progress at a given project duration.

In the viewpoint of fuzzy progress surface for control variable of duration, project manager will be able to view the expected manpower required to complete a certain number of MDR to meet the project progress as the engineering phase was executed at n number of days.

As for fuzzy progress surface for control variable of manhours, project managers will work out the capability of current manpower to complete a certain number of MDR within a set number of days to meet project progress.

In the fuzzy progress surface for control variable of MDR, project manager will be able to visualize the number of workforce required within a set time frame to meet project progress for a set number of MDR.

The fuzzy progress surface can be used as a baseline for project monitoring whereby, when an actual progress is monitored against the fuzzy progress surface, project managers will be able to view the gaps in either MDR deliverables, manpower commitment or durations to meet the planned progress and start to re-schedule to catch-up with the progress.

8. Conclusion

The research method presents a new approach of progress monitoring for dynamic scheduling for FPSO conversion project whereby Project Managers are able to ascertain the uncertainties based on the correlations between MDR numbers, manhours and project durations against project progress. Through the results obtained from this research, Project Managers will be able to view projection of engineering progress at a particular event of a project. The proposed method in this research will resolve issues in the conventional progress S-curve method which is quite rigid and has limitation in adjusting to uncertainties. This method of progress measurement eliminates the requirement for progress measurement based on cost and budget which is very prominent in Earn Value Method. The progress of engineering phase in FPSO conversion relies on deliverables in MDR and manhours contribution.

Through the fuzzy progress surface, project managers will be able to visualize the engineer's manpower efficiency of completing MDR deliverables within a certain timeframe. This observation will then be used as a gap measurement tool for the project manager to consider if the current project schedule is required to be revised, maintained or expedited along based on the manpower supply and MDR demand.

Acknowledgement

I would like to express my gratitude towards MISC Bhd project management team on assisting me with my data collection and sharing session on their experience of management in engineering phase in FPSO project.

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