

## Measuring the Impact of Changing Requirements on Schedule Variance: An Empirical Investigation

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**Abstract.** It is well acknowledged phenomenon that requirement volatility has significant impact on project performance. In particular, literature shows that change in requirements has major impact on cost overrun and schedule overrun in software projects. In our study we have identified those factors that can significantly contribute towards the estimation of variance in schedule of software project. In this paper a detailed impact analysis is also performed to derive an equation to compute the variance in schedule of a software project due to change in requirements. This equation is derived by performing Correlation and Regression analysis on the change request data collected from 9 different Software projects of Pakistan Software Industry. This analysis is based on conceptual model for schedule variance presented in this paper.

**Keywords:** Requirement Change, Schedule Delays, Change Attributes

### 1. Introduction

Due to the changing needs of stakeholders and work environment the requirements usually keep on changing during the development of a software project. Although changing requirements are considered as major risks to software projects in the context of schedule delays or budget overruns and one of the major difficulties of software development [2], but to meet customer expectations and to satisfy their changing needs, change should be allowable.

This paper demonstrates our findings based on empirical investigation of requirement changes and its impact on the estimated schedule of the Project. Initially the schedule is developed to complete a particular project on the basis of opening requirements provided by the client. Usually the clients add or modify requirements at later stages of the project development life cycle, due to which more tasks and activities are needed to add to the predefined scheduled tasks to accommodate those changes. To perform each task some additional effort in terms of working hours is required, these increased working hours extend the project duration and lead to delays in the initial estimation of the timelines.

This empirical Investigation also identifies those requirement change attributes which are the potential factors for the estimation of schedule variance by suggesting a conceptual frame work. In this paper, a generic equation is derived to compute the schedule variance by using Correlation and regression analysis.

This paper provides information on the related work that has been done in this area (section 2) and then describes the research methodology that has been used to derive the equation for the computation of schedule variance and the detail description of each step (Section 3). On the basis of the lessons learned from this empirical study conclusions are drawn (Section 4).

## 2. Review Of Literature

Zowghi et al. (1998) defined different types of Requirement Volatility i.e. requirement volatility in early and later phases of software development life cycle [9] and they finally concluded that requirement changing in later phases are more destructive because it affects the quality of software. They also identified that conciseness of requirement definition, the type of system development methodology used, software components, poor communication between user and developer are those factors that contribute to Requirement volatility [6].

Barry et al. (2002) analyzed the relationship between project duration and project effort by developing and evaluating a two-stage model [7].

To demonstrate the impact of requirement instability on project performance Pfahl et al. (2000) used the simulation models [11].

Nurmuliani et al. (2006) investigated the impact of Requirement Volatility on development effort that is total working hours to implement a change. Their findings reported that if new requirements are added in the later phases during software development it would be a high risk because it will cost the organization in the form of schedule delays or budget overruns. [5]

To determine the impact of a requirement change on software development Neal et al. (2001) presented impact analysis method based on requirement traceability. They created classes of requirement changes by identifying attributes of different work products and traces. Then they prioritized those requirement classes according to their potential impact.[4]

Damian et al. (2005) reported that there is a positive relationship between improved requirement engineering process and software productivity. According to them a mature requirement engineering process improves overall software development [10].

Bhatti et al. (2010) analyzed the impact of requirement change with respect to the development phase of a software project. They reported that changes can be proposed during any development phase however more changing are proposed by customer during maintenance phase. Also concluded that changes proposed in requirement phase and changes proposed in Design phase have significant relationship [1].

## 3. Research Approach

Fig. 1 describes a novel approach which is used to derive an equation to compute the schedule variance that came into being due to proposed changes.

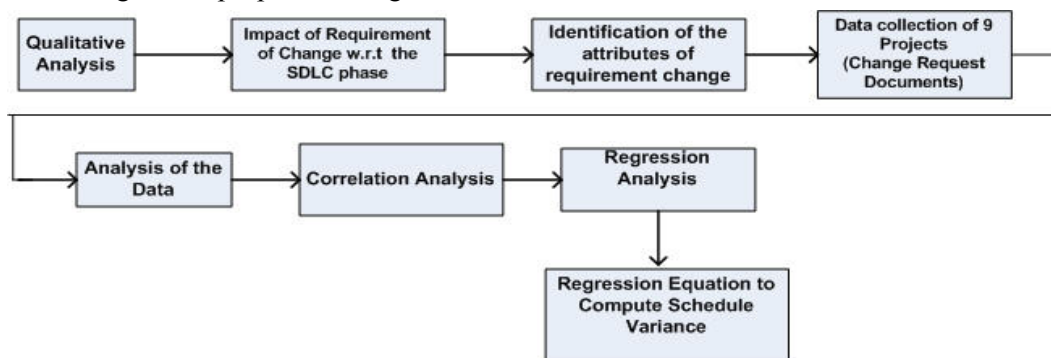


Fig. 1: Research Methodology

### 3.1. Qualitative Analysis

First step is performed to identify those potential requirement change attributes that can affect the estimated timelines of a software project. During this analysis following research questions were asked from the experts of Pakistani Software Industry.

- How changing requirements affect schedule of software?
- How the change in requirement affects the Project Scope?

- How the change in requirement affects the timelines of Project?? (E.g. Timelines of different phases of System Development Life Cycle (SDLC) i.e. Analysis, Design, Implementation, Testing, Maintenance)

### 3.2. Impact analysis of change

In incremental software development, a specific set of requirements is developed in each increment. In case of any change in requirements the new requirements are added to the increment while older are discarded or modified according to the change. After the change occurred, modified older requirements plus new requirements are implemented in the increment. Due to these requirements' modification more activities are added to complete the task that results in project delay.

- Changes in Requirements can lead to Expansion in Project Scope.(RV+→ Scope Creep+)
- Scope Creep can lead to Increased Project size (Enhanced Functionality).(Scope Creep+→Project Size+)
- Increased Project Size can lead to More Effort (Man Days).(Project Size+→Effort(Man Days)+)
- More Man Days can lead to Extended Project Timelines.(Man Days+→Project Duration+)
- Extend project Timelines can lead to Schedule Delays.(Project Duration+→Schedule Delays+)

### 3.3. Identification of the attributes of requirement change

In this phase, we identified significant attributes of requirement change from change request forms that can be useful in the estimation of variance in schedule due to implementation of change. The attributes are Type of requirement change (i.e. GUI, Functionality, Process, Work flow, DB Design), Software development life cycle phase (Analysis, Design, Implementation, Testing, Maintenance), Change Priority (Low, Medium, High), Effort (Man Days) as depicted in fig 2.

### 3.4. Data Collection

At this step, various change request forms of 9 different projects were collected from different organizations. Almost 100 Change IDS were analyzed against different change request types.

### 3.5. Analysis of data and Results

We analyse the data collectively which we got from qualitative analysis and change request forms to perform correlation and regression analysis to derive an equation for the computation of the schedule variance in terms of calendar days.

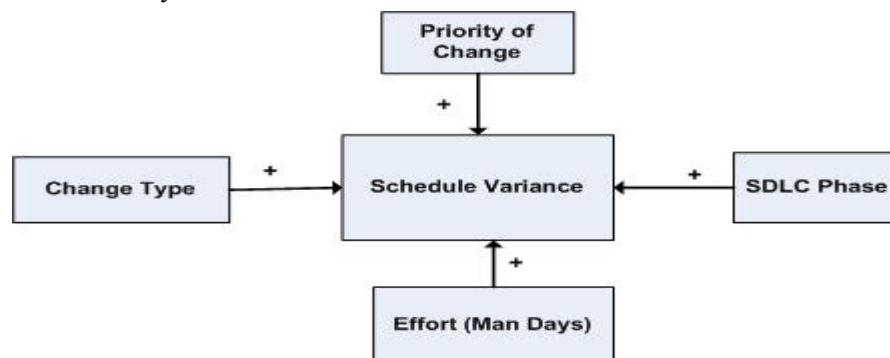


Fig. 2: Conceptual Frame work for Schedule Variance Estimation

#### 3.5.1 Correlation Analysis Results.

This statistical analysis shows that the selected change attributes are significant factors for the Schedule Variance estimation model. The statistics of tab 1 shows that coefficient of correlation between Request Type and SV (Schedule Variance) is .337.This correlation is significant at 0.01 level (1-tailed).

Tab. 1: Correlation Matrix - Significant factors for the Schedule variance estimation model

		Request_Type	SDLC_Phase	Priority	Man_Days	SV
Request_Type	Pearson Correlation	1	-.048	-.134	.121	.337**
	Sig. (1-tailed)		.317	.093	.116	.000
	N	100	100	100	100	100
SDLC_Phase	Pearson Correlation	-.048	1	.142	.599**	.156
	Sig. (1-tailed)	.317		.080	.000	.061
	N	100	100	100	100	100
Priority	Pearson Correlation	-.134	.142	1	.132	.110
	Sig. (1-tailed)	.093	.080		.096	.138
	N	100	100	100	100	100
Man_Days	Pearson Correlation	.121	.599**	.132	1	.455**
	Sig. (1-tailed)	.116	.000	.096		.000
	N	100	100	100	100	100
SV	Pearson Correlation	.337**	.156	.110	.455**	1
	Sig. (1-tailed)	.000	.061	.138	.000	
	N	100	100	100	100	100

\*\* . Correlation is significant at the 0.01 level (1-tailed).

These results indicate that there is a positive relation between the nature of change and schedule variance i.e. a dramatic change in requirement results as intensive rework as compare to the minute change in requirements (Fig 3).

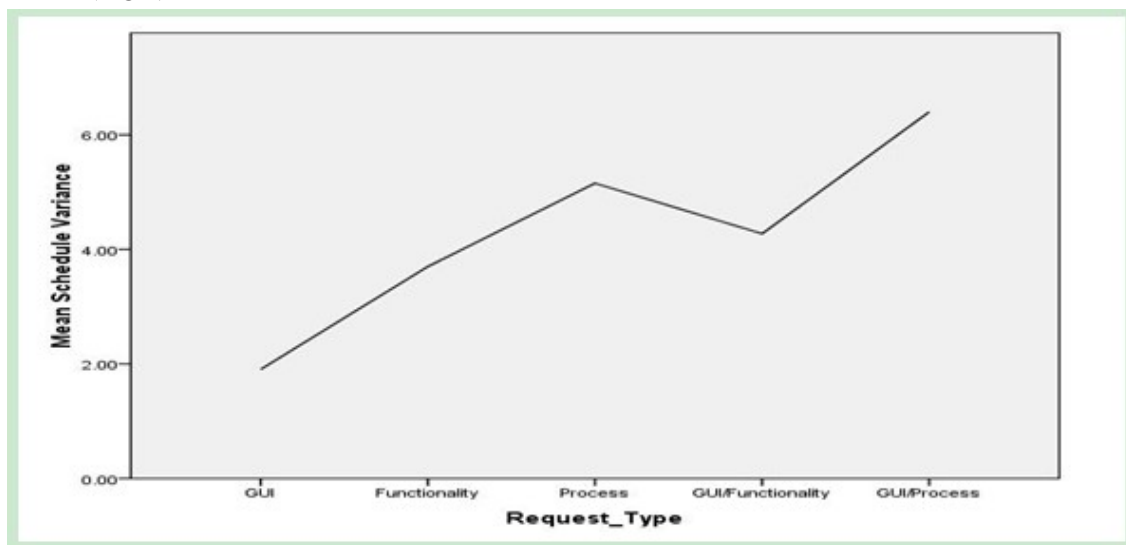


Fig 3: Request Type and Schedule Variance

More complex change types are potential candidates to increase the project scope. The increment in project scope requires more effort and time to complete the project due to which the projects usually run out of time. The coefficient of correlation between SV and Priority is .110. This weak positive correlation shows that up to some extent change Priority would affect the variance in schedule. The coefficient of correlation between SDLC Phase and SV is .156 which is weak positive correlation. The coefficient of correlation between Man Days and SV is .455 and this correlation is significant at 0.01 level (1-tailed). This positive relation indicates that Man Days significantly contribute towards the estimation of dependent variable i.e. SV (Fig4). Man days represent the working hours \* No of resources. Continuous changes in requirements directly affect the size of anticipated project because a change results as additional tasks that are needed to perform by the project development team or enhancement in project scope. To accommodate change requests more time in the context of Man Days is taken by development cycle. This is because some changes modify the existing work and some changes enhance the existing functionality of the software. Due to this enhanced functionally and rework more development time in terms of working hours is required to accommodate this

proposed change. This greater effort leads to longer project duration and due to this longer duration delay is expected in the estimated schedule.

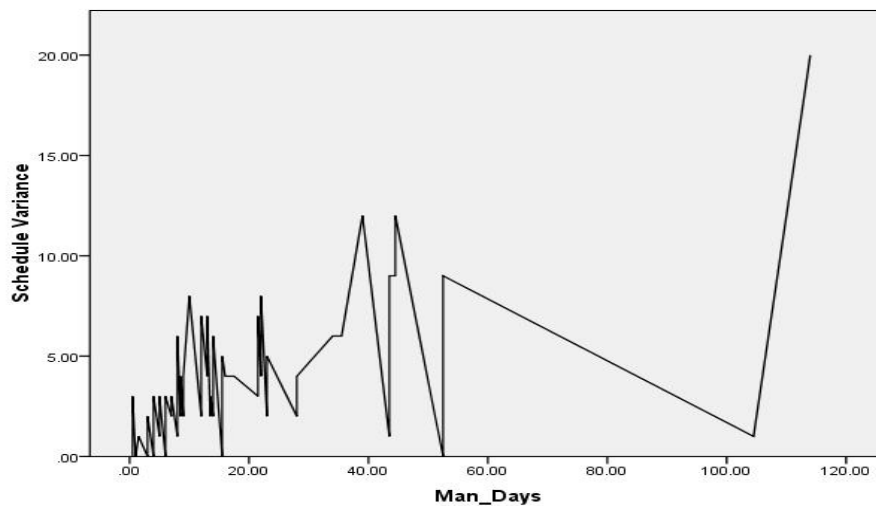


Fig. 4: Effort (Man Days) and Schedule Variance

### 3.5.2 Regression Analysis Results

This statistical analysis shows that Adjusted R-Square is 0.280 and Sig F. change is .000. Which indicates that relationship of dependent variable schedule variance is significant with independent variables Change Priority, SDLC phase and Change Type and Effort (Man Days) at 99.99 confidence interval.

### 3.5.3 Regression Equation:

Following equation is a generic equation for the computation of schedule variance against change. This equation is based on the model depicted in fig 2.

$$\text{Schedule Variance} = .661 + .807\text{Request Type} - .444\text{SDLC Phase} + .457\text{Priority} + .072\text{Man Days}$$

Where:-

Schedule Variance is the dependent variable and is computed in terms of calendar days.

Man Days=Number of Resources\* Number of working hours.

## 4. Conclusions

In this paper we have taken the data of 9 varying projects from different organization to empirically investigate and proof that the change in requirements has a strong impact on the estimated time duration of the anticipated project. This research has addressed following research questions.

RQ1. How the change in requirement affects the Project Scope?

A change in software requirement doesn't always affect project scope. Nature of change and frequency of change are the two important factors that can become the cause of scope creep.

RQ2. How the change in requirement affects the timelines of Project? (E.g. Timelines of different phases of SDLC i.e. Analysis, Design, Implementation, Testing, Maintenance)

Due to enhanced functionally and rework more development time in terms of working hours is required to accommodate the proposed change. This increase the project size as more tasks are added in the already defined tasks which in turn results to greater effort and greater effort leads to longer project duration and due to this longer duration delay is expected in the estimated timelines of the project.

This paper helps to understand the impact of a particular change on the estimated schedule of the software project and highlights the potential factors for the estimation of schedule variance.

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