Effect of Scope Creep in Software Projects – Its Bearing on Critical Success Factors

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ABSTRACT
Quality software is developed only when project management techniques are meticulous followed. Various metrics are introduced by the industry experts to execute perfect project management. The success rate of the projects is very meek when compared to efforts and expertise of the technical experts. Various reasons pitch in the scenario when the project failure reasons are searched. Scope creep is considered as one of the important factor which influences the success of project. The influence of the scope creep on its peer factors such as time, cost, personnel, etc is also noticeable. However, Applications which are developed in the industry are categorized as critical and non critical applications. This paper presents an investigation carried out on two important domains namely health care representing critical application and retail from a non critical applications back ground. This research has proven that though there is an impact of scope creep on both the categories of applications investigation analysis indicates that the impact of scope creep on critical applications is quite noticeable than upon the other. This knowledge works enable one to formulate effective scope creep management strategy in both the domains and more specifically in critical applications.

General Terms
Project Scope, Scope Creep, Project Management.

Keywords
Software Engineering, Project Management Process, Software Quality, Scope Creep, Software Development Life Cycle.

1. INTRODUCTION
Project Success and Quality Assurance is the definitive Project Success and Quality Assurance is the definitive objective of any software organization. Chaos Chronicles has declared that only 34% of IT projects developed in the Top companies are declared as successful project [3]. The reputation and success of the organization is deemed with customer satisfaction and quality project development. Hence, in the viewpoint of project success, the identification and prevention of project failure is deemed to be an important factor [4].

The strength of the company depends on the various factors such as organization maturity level, domain competency of the organization, and the project management competency such as human resource, technology development process, cost, time, scope, defect count, use case, function points etc [20]. Software Engineering Institute (SEI) proposed the Capability Maturity Model Integration (CMMI) to the software organizations which desire to develop high quality software with proper project management skills [5]. Quality assurance and standards are the part of the process which is implemented with the software certification such as CMMI [6].

In the current software industrial scenario project management has become an important part of any successful project. Project management involvement towards the project success has forced in development of various project management techniques. Software industries have witnessed a major change in the role of project management and project manager from the past decade [1].

The practices and expertise level of an organization in terms of technology development, project management and Quality Assurance are important factors of project success [6]. Human involvements as witnessed in the roles of project managers, technology developers, and quality team are also considered as important aspects of project success [7]. The important aspects to look in to the human involvement would be their skill set competency in both technical skill and soft skill, number of people involved and hands on experience of the people in both technology and domain.

Technical personnel have various roles to play in the project with their effective communication and intellectual skills in managing the project activities [8]. Thus, Soft skill is very much essential for project personnel in addition to the technical skills. In the recent past human skills has an important role to play in the project management strategy [16].

Additionally, software process is further identified as one of the most important factor of the project management [2]. Projects in software industry are developed using Traditional process approach or/and Agile process approach. On the basis of the facts stated above, the factors involved in the project management can be categorized as Organization Component [OC], Human Component [HC] and Technology Component [TC][20].

The Organization Component [OC] is deemed with the factors related to the organization such as maturity model, organization standards and domain proficiency of the organization. The Human Component [HC] is formed with all the human related factors of the project such as skill set of the personnel which includes both soft skill and technical skills, experience of the developers, Number of people involved in the project. Technology Component [TC] is comprised with factors such as project domain, time allocated for the project, cost allocated for the project, software process model, technology used for the development of the project, function points, Use case, Defect Count, etc,.

Project management experts have declared that the project management triangle has three vertices namely cost, time and scope [10]. Changes in the project scope demands the team to

have a good hold on customer requirements, which may result in scope creep in case of failure [21]. However this paper aims to analyze the impact of scope creep on project success factors and leading towards project success.

2. LITERATURE REVIEW

The experts in the software industry have introduced various Project Management practices which results in The experts in the software industry have introduced various Project Management practices which results in software quality development which directly influence project success. As discussed above the project success is considered to be a result of three components such as Organization Component, Human Component and Technology Component. The most invasive approach to successful project management is when the important factors like organization, planning, project control and other important factors are undoubtedly part of system process [12]. Success of project is achieved through the best practices followed in the project management [4].

It is the duty of the organization to implement the best practices for quality improvement of the project [13]. Continuous improvement models are assuring for a notable improvement on quality, productivity and resources [13]. Introduction of the maturity models are removing the fear for both management and employees [13]. From the year 2000 software companies have adopted Capability Maturity Model popularly known as CMMI [14].

The skill of the technical personnel and their attitude toward the project is one of the key factors for project success [11]. The human resources can be visualized as the major impact on the project success. At this point, it is always worth to identify project management as one of the significant technique to deliver successful projects [9]. The project management technique which is popularly used today can be carried out successfully or can be implemented successfully only with the help of project manager [16]. The experience and expertise of the project manager influences a lot on the effectiveness of team members. Assessing the strength of his team members and efficiently utilizing their skills also plays an important role in successful development of quality product. The skill set of the HO includes both the technical skill and the soft skill [8]. According to the author of [8] technical skill of the developer is definitely utilized hundred percent only when the project manager has the proficiency in both technical and people skill.

The customer evaluates the reputation of organization based on their strength such as quality and project success. Company strengths are evaluated basing on the quality and project success. The technical development phase of the project is always crucial part of the project development [10]. The various facts to be noted in the development of project are the domain of the project, technology used for project development, software process in which the project development will take place, time, cost, function points, scope, use case, defect count etc.[20], However, author of [18] insisted that the technology such as operating system and programming language used for development always has a significance in development of successful software. Further the author introduced five generations of programming languages such as machine code, assembly language, high level language, very high level language or 4GL and 5GL, used from 1950 to the late 1990 for software development in the industry [18].

With reference to the Author of [4] complexity of the project is also considered as project success factor [4]. The author of [8] suggests the complexity of the project to be determined by the requirements of the project [8]. They further state that quality of requirements management has an impact on success of the project [8]. They therefore assured that 93% of success prediction to be accurate when the requirements management is perfect.

However, authors of [22] feels that project managers compromise with customer and accept new requirements which add changes to the scope of the project often called as scope creep [22]. Based on the nature of the project the development can be broadly classified in to critical and non critical applications. In today scenario critical application is not only for the high secured organization but also applicable for the individuals in the society are using it [19]. Authors of [23] have proven that that the projects which are developed using Agile approach does not have impact of scope creep towards project success. Further the authors have proven that scope creep has an impact on projects that are developed in traditional approach. Therefore this research has directed towards analysing the impact of scope creep on various type of projects which are developed in the traditional process.

3. RESEARCH METHODOLOGY

Success of the project is influenced by the factors such as methodologies and best practices implemented by organization. This work has focused on the factors of various components such as OC, HC, and TC which leads the project success. This research includes various survey conducted in software companies to understand the impact of factors on project success. The survey also includes reference to various technical papers, research articles, white papers, interactions with the IT counter parts and the industry experts opinions. The mode of communication and and data collection with our peers in the industry happened through interviews, mails and face to face communication.

4. CASE STUDY

This case study includes study made on software industries of various production capabilities such as service based and product based industries. However, this research restricted towards CMMI level 4 or CMMI Level 5 organizations. The critical factors influencing project success that are analyzed in this investigation include scope, time, cost, number of developers, use case, technology, experience etc. Further, to resolve the intrinsic complexity in research, this investigation constrained to study projects which are developed with different programming languages namely COBOL and JAVA. Investigation focused on a deep survey on various range of projects which span between critical and non critical domain applications.

Limitation 1: All the software organizations considered in this research are CMMI and domain proficient.

The sampled projects are from CMMI level 5 company and the standards of CMMI are implemented. The personnel selection is happening on the basis of skill rating and scale of the human resource department. The skills considered for the experts are both technical and soft skill. To overcome the various complexities and challenges this research formulated hypothesis in order to progress further.

Hypothesis 1: All projects are classified as critical and non critical applications based on the domain.

All the sampled projects are from both critical and non critical applications. The factors considered for critical and non critical applications are same. The data depicted in Table1 and Table 2 are randomly selected projects from the vast data and only the critical success factors are depicted in Table1 and Table2. The data of the sampled projects is given in terms of expected and actual from the various factors considered for project scope.

Table 1 depicts the sampled projects of the critical applications in the Health care. The projects have been developed with COBOL programming language. The scope is the number of functionalities which the design team has added. The time is the person hours estimated for the total project development, cost is estimated in the US Dollars, number of developers are the technical personnel who were working exclusively for the project.

Actual experience of developers is calculated on average years for the number of developers. Use Case and D C are computed for the project from the design to implementation phase. Complexity of the project is measured by use cases in this particular sampled company. The sampled projects in Table 2 are representative of a Retail domain.

These applications have been developed with JAVA programming language. Factors depicted in Table 2 are same as same as table 1. The sampled projects of Table 1 are named as HP1, HP2, etc., whereas the sampled projects of Table 2 are named as RP1, RP2 etc.,. The project success in Table1 and Table2 is stated in the form of percentage.

From Table 1 and Table 2 it is clearly evident that the scope is having an impact on the project success as well as on other factors such as Time, Cost, Use Case, Defect Count and Number of Developers. The impact of scope on the experience of developer is insignificant and can be disregarded.

Table 1: Factors Influencing Project Success in Health Care Domain

PF	HP1		HP2		HP3		HP4		HP5		HP 6		HP 7		HP 8		HP 9		HP10	
	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act
SC	15	18	18	21	19	22	23	27	23	27	17	23	23	26	23	28	27	33	28	32
Time (*)	1800	2340	1940	2640	2900	3350	3270	3440	3420	3640	2970	3460	3140	3360	3740	4120	3470	3790	3900	4440
Cost (**)	1484	1829	1450	1985	2164	2432	1489	1637	2743	3129	2643	3025	2349	2926	2700	3234	2743	3490	3643	4274
# Dev	12	12	9	11	14	17	11	13	11	14	14	14	11	13	12	14	11	14	14	16
EDev	5 - 6	5	6-7	6.5	5-7	6	6 - 8	7	4 - 6	5	6 - 8	6 .5	6 -7	6.5	5 - 7	6.5	5.- 7	6	7 - 8	7.5
Comp	3.5	3.5	4	4	4.2	4.2	4.35	4.35	3.2	3.6	3.2	3.7	4.2	4.4	4.2	4.6	3.8	4.2	4.3	4.5
D C	56	67	67	82	82	97	74	81	81	97	72	96	77	94	77	92	77	104	93	118
P S (%)	100	86	100	87	100	90	100	85	100	88	100	87	100	90	100	88	100	87	100	88

HP1- Healthcare Project, PF- Project Success Factors, SC-Scope Creep, #Dev-Number of Developers, EDEV – Experience of Developers, Compl - Complexity, DC – Defect Count, PS – Project Success; (*) – Measure in Person Hours, (**) – USD;

Table 2: Factors Influencing Project Success in Retail Domain

PF	RP1		RP2		RP3		RP4		RP5		RP 6		RP 7		RP 8		RP 9		RP10	
	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act	Exp	Act
SC	27	31	32	37	27	32	31	34	34	39	26	29	36	39	22	24	29	33	32	36
Time (*)	3750	4350	3780	4040	3900	4170	3340	3475	3640	3920	2640	2780	3760	4180	2600	2740	2840	2990	3320	3530
Cost (**)	2944	3432	3214	3328	3264	3482	3164	3482	3640	3784	1790	1924	3334	3729	1930	2044	2470	2615	3100	3322
# Dev	14	16	17	18	14	15	16	18	19	21	13	14	21	20	14	14	17	18	19	22
EDev	5-7	6.5	6 - 7	6.5	6 - 7	6 - 7	6 - 7	6 - 7	6 - 8	7.2	6 - 7	6.8	6 - 8	7.2	6 - 7	6.2	8	7.5	6 - 7	6 - 7
UC	3.7	3.7	4.2	4.2	4.15	4.15	4.3	4.3	4.35	4.35	3.75	3.75	4.4	4.65	3.7	3.8	3.8	3.95	3.9	4.05
D C	86	93	97	103	106	117	112	119	117	129	79	84	124	139	86	94	97	108	113	124
P S (%)	100	89	100	90	100	88	100	92	100	92	100	91	100	91	100	92	100	91	100	92

HP1- Healthcare Project, PF- Project Success Factors, SC-Scope Creep, #Dev-Number of Developers, EDEV – Experience of Developers, UC – Use Case, DC – Defect Count, PS – Project Success; (*) – Measure in Person Hours, (**) – USD;

Table 3 represents the variation with the factors with respect to both the domains Health Care and Retail. The projects in Table 3 are projected in the ascending order basing on the variation of scope of the projects. The sampled projects of Health Care domain and Retail domain are thoroughly analyzed and the variation of the actual values and the expected values of each domain are generated and the ranging of values are compared. A set of projects from Health Care and Retail which are having the nearest scope variation are depicted in Table 3 for expedient comparison.

Table 3: Variation Comparison of Health Care and Retail Domain

	HP 7	RP10	HP 10	RP 9	HP 3	RP 2	HP 5	RP 3
Scope (%)	13	12.50	14.3	13.79	15.8	15.63	17.4	18.52
Time (%)	6.5	6.33	13.8	5.28	15.5	6.88	6.4327	6.92
Cost (%)	19.7	7.16	17.3	5.87	12.4	3.55	14.07	6.68
Use Case (%)	4.8	3.85	4.7	3.95	0	0.00	12.5	0.00
Defect Count (%)	18.1	9.73	26.9	11.34	18.3	6.19	19.75	10.38
Number of Developers (%)	15.4	15.79	14.3	5.88	21.4	5.88	27.27	7.14
Project Success	10	8	12	9	10	10	12	12

The specific projects from the above table which have large variation in critical success factor has been tabulated above to draw the inference.

Inference 1: The scope creep has an impact on both critical and non critical domains.

Inference 2: Critical applications are more sensitive to the scope creep when compared to the non critical applications.

Table 3 is further visualized graphically which is as represented in Fig 1. Fig 1 infers the variation of various success factors in health care and retail domain as the scope increases. In Fig 1 the X-axis of the graph illustrate the factors such as scope, Time, Cost, Use Case, Defect Count, # of Developers and Project Success. Further, Y-axis of Fig1 is representing the scale of variation of values which are depicted in Table 1 and Table 2.

From Fig 1 it is clearly visible that the scope creep has a tremendous impact on the various success factors and further the variations are more for the health care domain which is critical application and the degree of sensitivity is high in health care compared to the retail domain.

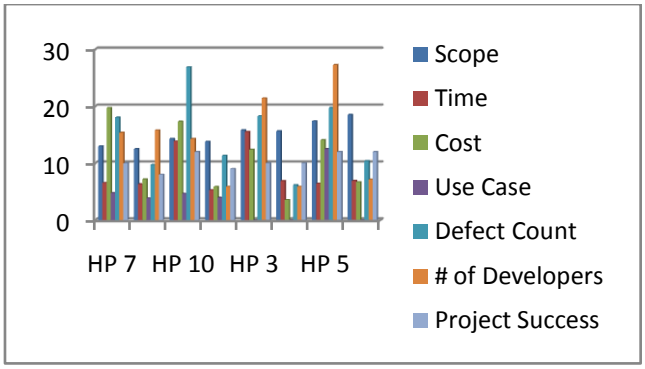

Fig 1: Comparative Analysis of Success Factors with Health Care and Retail Domains

5. CONCLUSION

Development of high quality software products is possible only by practicing the best project management practices. Nevertheless, project management practices and quality assurance techniques adopted in the industry are yet not able to achieve complete customer satisfaction. This is because success of the project is influenced by various factors such as scope creep, time, cost, personnel and their experience level, use case and defect count. Further our investigation has categorized the various success factors to fall under three different components known as Organization Component, Human Component and Technology Component. Since any project can be either a critical or non critical application based this research has lead towards comprehending the impact of scope creep on the two types of above classified projects. A case study indicating an empirical investigation of various projects developed in both the classification is put forth. The investigation results infers that the impact of scope creep is high with regard to health care projects when compared to projects is lower in retail projects. Future work of this research is to therefore to introduce an analytical model for effective scope creep management.

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