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Study on Critical Success Factors Estimation in IT System Development

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Abstract

The success of IT system development largely depends on the System Requirements Definition (SRD) phase. Researches on Critical Success Factors (CSFs) in the SRD phase are very few. This paper aims to make clear the CSFs in the SRD phase of IT system development. To achieve this, first, interviews to discover "difficult items" in the SRD phase were executed to participants who were engaged in three highly advanced IT system developments. Second, major difficult items were extracted from the interview results. Third, CSFs estimation was executed from the extracted major difficult items. Then, the estimated CSFs were compared to those obtained from the interviews. As a result, CSFs were found to be almost the same between those estimated and interviewed. Through this research, it can be concluded that 1) Customer/User Involvement, 2) Clear project goals, and 3) Technical skills of the project team are the major CSFs in the SRD phase.

Keywords: IT system; critical success factors; system requirements definition; system development

1.0 INTRODUCTION

It is well-known that IT system development success largely depends both on the clearness of the ordering side system requirements and on the trustee side skillfulness of making the system requirement definition [1], [2]. There are many reports on system development delay due to long times to complete system requirement definitions [3], [4]. However, there are no reports which analyses the causes of time losses in system requirement definitions. Time losses are thought to originate both in the ordering side and trustee side. Unclearness of the system requirements of an ordering side is one of the causes of time delay. Lack of trustee side skills is another cause of time delay, for example, the skills to use the most advanced package software required by the ordering side. One of the best ways to make clear the cause of time losses is to interview about difficult items, problems and their solutions to the engineers who have experience being engaged in the SRD phase. The solution for each of the difficult items and problems will lead to the CSFs. About the IT system development, the Standish CHAOS Report from 1994 has illustrated that top 10 factors found in successful projects [5]. There are many researches for Critical Success Factors (CSFs) in IT fields [6], [7], [8]. However, Researches on Critical Success Factors (CSFs) in the SRD phase are very few. This paper aims to make clear the CSFs in the SRD phase of IT system development through interviews to engineers who were engaged in three different kinds of advanced IT system developments.

2.0 RESEARCH METHODOLOGY

To make CSFs in the SRD phase clear, the research was conducted as in the following:
1) To know the difficult items, interviews were executed to the engineers who were engaged in the SRD phase of the three systems whose characteristics are shown in Table 1.
2) Major difficult items were extracted from the difficult items. Through analysing the difficult items, the CSFs were estimated.

Table 1 Targeted three system characteristics

Items	System 1	System 2	System 3
1. Number of functions to be realized (small, medium, large)	Small	Medium	Large
2. Degree of the processing function complexity (small, medium, large)	Small	Medium	Large
3. Mutual dependence between the processing functions (small, medium, large)	Small	Medium	Large
4. Use of the latest middleware (Yes, No)	Yes	Yes	Yes
5. Cooperation with external systems (Yes, No)	Yes	Yes	Yes
6. Number of user interface screens (small, medium, large)	Small	Medium	Large
7. Number of user input items (small, medium, large)	Small	Medium	Large
8. Processing function change corresponding to the user inputs (small, medium, large)	Small	Medium	Large
9. System development size (Man-Month)	21 MM	63 MM	566 MM

■3.0 RESEARCH RESULTS

Design of Interview Items

The interviewees were engineers who were engaged in the development of the three systems shown in Table 1. The question items were designed from the viewpoint that elicits the difficult items in the SRD for the three systems. Also, they were designed so that an estimation of the CSFs became easy from the analysis of the answers obtained from the interview.

1) Did the ordering side have clear requirements for the development system?
   If they did not, what did you do?
2) How well is the support from the top management of the trustee side?
   If you were not supported or were not supported enough, what did you do?
3) What difficulties did you encounter during the SRD phase?
   When did you encounter the difficulties? What is your solution for the difficulties?
4) Did the trustee side engineers have enough skills or experiences for SRD?
   If they did not, how did you overcome it?
5) Was it necessary to ask for help from cooperating companies and consultants outside of the company?
   In what kind of situation was it necessary, and how was the result?
6) Was it necessary for you to evaluate the middleware software which the ordering side requested to use?
   If it was necessary, why was it necessary to evaluate it from the trustee side and what was the evaluation result?

Design of Critical Success Factors

The CSFs were designed by referring to the CSFs proposed by the papers of Bradley [9] and Imtiaz et al. [10] as shown in Table 2. In the two papers, 15 CSFs were proposed by Bradley including 10 CSFs proposed by Imtiaz. So, new CSFs in the SRD phase were designed which consist of 15 CSFs proposed by Bradley and 5 CSFs proposed by Imtiaz et al.
New CSFs were designed in such a way that they cover a wide range of system types.

Table 2 Design of critical success factors in SRD Phase

#	Critical Success factors	Meaning
1	Detailed formal plan with well- defined tasks	There should be project management planning of well-defined tasks and accurate estimation of required effort [11].
2	Clear project goals	Ding et al. (2008) noted that the goals are set in accordance with the requirements of the customer [12].
3	Time budget, manageable workload	Reasonable distribution of workload on the staff of coordination is very high artistic work [13].
4	Analysts with knowledge of both business and technology	Obtain “business” analysts. One of the critical workforce requirements for the project was the ability to obtain analysts with both “business” and technology knowledge [14].
5	Technical skills of project team	They possess the necessary technical skills and have adequate technology to perform their tasks [15].
6	Selection and management of consultants and staff	Reel (1999) noted that building the right team means getting suitable people in the team. Well organized team would be doing good job which outcome the good result [16].
7	Third parties fill gaps in expertise and transfer knowledge	Howells (2006) referred that actors (third party) fill gaps in information and knowledge in industrial networks [17].
8	Problem solving with vendors	They had IT personnel with knowledge and experience performed better in problem solving than a project group without them [18].
9	Top management support	Fortune & White (2006) referred that this factor can be affected by the general state of the economy; a lack of this factor can lead to project failure [19].
10	Top management is engaged, not just involved	Brown et al. identified this CSF is the first of five factors in ERP implementation project [20]
11	Management communication, education and expectations	Expectations at every level need to be communicated. Management of communication, education and expectations are critical throughout the organization [11]
12	Establishment of trouble shooting mechanism	Trouble shooting is an important independent variable and project success categorized by project phase [21].
13	Change management hand in hand with project management	Brown et al. identified this CSF is the fourth of five factors in ERP implementation project [20].
14	Monitoring and feedback against initial plan	Adequate monitoring and control is important for the quality of the project [19].
15	Redesign of business processes	Many companies “go to war” with the package and try to make it meet their process requirements [14]
16	Leadership	Many research studies have discussed the importance and/or style of project leadership [22] Leaders should have strong technical and relational skills [23].
17	Team Work	Cross-functional team and cooperation between members of team and team work was described as a CSF for IT projects [24].

18	Customer/User Involvement	Park et al. (2011) identified Customer/user involvement in application design is necessary and the lack of it can result in IS project failure [25].
19	Risk Management	Fortune & White (2006) also referred that In a successful projects risk analysis was done at the start of the project and risks that arose were handled successfully, whereas in the failed project no risk analysis was done [19].
20	Adequate Requirement	Ding et al. (2008) also studied this factor that although difficult to gather is very important for the success of the system; inadequate requirements usually lead to a failed project. [12].

Extraction of Major Difficult Items from the Interview Results

Two engineers of the leader and the sub-leader of the SRD for each of the three IT systems were interviewed. They were selected as the best engineers as they knew all the progress and problems of the SRD. Through the interviews, many difficult items and solutions were answered as shown in Appendix A. Major difficult items were extracted from the difficult items answered by removing the less important answers. They are shown in Table 3.

Table 3 Major difficult items obtained by interviews

System #	Major difficult items
1	1) Insufficiency of knowledge about the middleware which the ordering side required to use
2	1) Insufficient information about the system requirements from the ordering side
	2) Insufficiency of knowledge about the middleware which the ordering side required to use
	3) Lack of project management
	4) Difficulty in direct communication with the ordering side
3	1) Insufficiency of knowledge about the middleware which the ordering side required to use
	2) Insufficient information about the system requirements from the ordering side
	3) Engineer skills mismatching for the SRD phase
	4) Difficulty in direct communication with the ordering sides
	5) Lack of cooperation with the ordering side
	6) Lack of methodology for the current system development with the ordering side and partner System Integrator.

Estimation of CSFs from the Major Difficult Items

The CSFs for each of the three systems were estimated from the extracted major difficult items via the possible solutions as in the following:

CSFs Estimated for System 1:

1) CSF-5: Technical Skills of Project Team and CSF-7: Third parties fill gaps in expertise and transfer knowledge

The major difficult item is “Insufficiency of knowledge about the middleware which the ordering side was required to use”. The possible solutions for this are to add engineers with sufficient knowledge and to assign the third party engineers filling the knowledge gap about the middleware. Thus, the CSF is estimated to be “Technical skills of project team” and “Third parties fill gaps in expertise and transfer knowledge”.

CSFs Estimated for System 2:

1) CSF-2: Clear Project Goals and CSF-18: Customer/User Involvement

The first of the major difficult items is “Insufficient information about the system requirements from the ordering side”. This results in a long period to complete SRD, which causes developmental delay. This can be solved only by the ordering side. The possible solutions for this are to request the customer more involvement and to ask the partner System Integrator to jointly get the ordering side requirements. Thus, the CSF is estimated to be “Clear project goals” and “Customer/User involvement”.

2) CSF-5: Technical Skills of Project Team and CSF-7: Third parties fill gaps in expertise and transfer knowledge

The second of the major difficult item is “Insufficiency of knowledge about the middleware which the ordering side was required to use”. The possible solutions for this are to add engineers with sufficient knowledge and to assign the third party engineers filling the knowledge gap about the middleware. Thus, the CSF is estimated to be “Technical skills of project team” and “Third parties fill gaps in expertise and transfer knowledge”.

3) Detailed formal plan with well- defined tasks and Monitoring and Feedback Against the Initial Plan

The third of the major difficult items is “Lack of project management”. This refers to changes such as the project formation change from the initial cause development delay. The possible solution for this is to replace the project manager. Thus, the CSF is estimated to be “Detailed formal plan with well-defined tasks” and “Monitoring and feedback against the initial plan”.

4) CSF-18: Customer/User Involvement

The fourth of the major difficult items is "Difficulty of indirect communication with the ordering sides". This arises so often from the multi-layered development project formation on the trustee side. In this case, the interviewee was engaged in the SRD under the control of a prime contractor. The possible solution for this is to remove the intermediary. This means customer involvement directly. Thus, the CSF is estimated to be "Customer/User involvement".

CSFs Estimated for System 3:

1) CSF-5: Technical Skills of Project Team, CSF-7: Third parties fill gaps in expertise and transfer knowledge, and CSF-11: Management communication, education and expectations

The first of the major difficult items is "Insufficient knowledge about the middleware which the ordering side is required to use". The possible solutions for this are to add engineers with sufficient knowledge, to assign the third party engineers filling the knowledge gap about the middleware, and to make the training fulfilling the knowledge. Thus, the CSF is estimated to be "Technical skills of project team", "Third parties fill gaps in expertise and transfer knowledge", and "Management communication, education and expectations".

2) CSF-2: Clear Project Goals and CSF-18: Customer/User Involvement

The second of the major difficult items is "Insufficient information about the system requirements from the ordering side". The possible solutions for this are to request the determination of the requirements by the additional staff, to request the customer more involvement, and to ask the partner System Integrator to jointly get the ordering side requirements. Thus, CSF is estimated to be "Clear project goals" and "Customer/User involvement".

3) CSF-5: Technical Skill of Project Team, CSF-7: Third parties fill gaps in expertise and transfer knowledge, and CSF-11: Management communication, education and expectations

The third of the major difficult items is "Engineer skills mismatching the SRD phase". In case the engineering skills do not match the ordering side requirements, it took a long time to complete the system requirement phase. The possible solutions for this are to add engineers with sufficient knowledge, to assign the third party engineers filling the knowledge gap about the middleware and to make the training fulfilling the knowledge. Thus, the CSF is estimated to be "Technical skills of project team", "Third parties fill gaps in expertise and transfer knowledge", and "Management communication, education and expectations".

4) CSF-18: Customer/User Involvement

The fourth of the major difficult items is "Difficulty in direct communication with the ordering sides". The possible solution for this is to have direct communication with the ordering side. This means more customer involvement directly. Thus, the CSF is estimated to be "Customer/User involvement".

5) CSF-2: Clear Project Goals and CSF-18: Customer/User Involvement

The fifth of the major difficult items is "Lack of cooperation with the ordering side". While the ordering side required the project to get the ordering side's requirements from the document of the existing system, it took long time to complete the SRD phase without cooperation from the ordering side. The possible solution for this is to request the ordering side to replace the system. This means more customer cooperation and involvement. Thus, the CSF is estimated to be "Clear project goals" and "Customer/User involvement".

6) CSF-2: Clear Project Goals, and CSF-18: Customer/User Involvement

The sixth of the major difficult items is "Lack of methodology for the current system development". While the ordering side and partner System Integrator required to use the middleware, it took long time to complete the SRD phase without appropriate development methodology, such as concurrent engineering, developing the system design and programing at the same time. The possible solution for this is to take the concurrent engineering, developing the system design and programing at the same time. This means to be needed clear Project goal and more customer cooperation and involvement. Thus, the CSF is estimated to be "Clear project goals", and "Customer/User involvement".

Table 4 shows the Critical Success Factors estimation results from the major difficult items via the possible solutions.

Table 4 Critical success factors estimated from the major difficult items via the possible solutions

System #	Major difficult Items	Possible solutions	Estimated CSFs
1	1) Insufficiency of knowledge about the middleware which the ordering side is required to use	・To add engineers with sufficient knowledge ・To assign the third party engineers filling the knowledge gap about the middleware	CSF-5: Technical skills of project team CSF-7: Third parties fill gaps in expertise and transfer knowledge
2	1) Insufficient information about the system requirements from the ordering side	・To request the customer more involvement ・To ask the partner System Integrator to jointly get the ordering side requirements	CSF-2: Clear project goals Customer/User involvement
	2) Insufficiency of knowledge about the middleware which the ordering side is required to use	・To add engineers with sufficient knowledge ・To assign the third party engineers filling the knowledge gap about the middleware	CSF-5: Technical skills of project team CSF-7: Third parties fill gaps in expertise and transfer knowledge
	3) Lack of project management	・To replace the project manager	CSF-1: Detailed formal plan with well-defined tasks CSF-14: Monitoring and feedback against initial plan
	4) Difficulty in direct communication with the ordering side	・To remove the intermediary. This meant customer involvement directly.	CSF-18: Customer/User involvement
3	1) Insufficiency of knowledge about the middleware which the ordering side is required to use	・To add engineers with sufficient knowledge ・To assign the third party engineers filling the knowledge gap about the middleware. ・To make the training fulfilling the knowledge	CSF-5: Technical skills of project team CSF-7: Third parties fill gaps in expertise and transfer knowledge CSF-11: Management communication, education and expectations
	2) Insufficient information about the system requirements from the ordering side	・To request the determination of the requirements by the additional staff ・To request the customer more involvement ・To ask the partner System Integrator to jointly get the ordering side requirements	CSF-2: Clear project goals CSF-18: Customer/User involvement
	3) Engineer skills mismatching for the SRD phase	・To add engineers with sufficient knowledge ・To assign the third party engineers filling the knowledge gap about the middleware. ・To make the training fulfilling the knowledge	CSF-5: Technical skills of project team CSF-7: Third parties fill gaps in expertise and transfer knowledge CSF-11: Management communication, education and expectations
	4) Difficulty in direct communication with the ordering sides	・To have direct communication with the ordering side. This meant more customer involvement directly.	Customer/User involvement
	5) Lack of cooperation with the ordering side	・To request the ordering side to replace the system. This meant more customer cooperation and involvement.	CSF-2: Clear project goals CSF-18: Customer/User involvement
	6) Lack of methodology for the current system development.	・To take the concurrent engineering, developing the system design and programing at the same time. This meant to be needed clear Project goal and more customer cooperation and involvement.	CSF-2: Clear project goals CSF-18: Customer/User involvement

■4.0 CONSIDERATIONS

In this chapter, it is verified whether the estimation of the CSFs is correct or not. At the final stage of the interview, the engineering leaders were asked to select five CSFs from the 20 CSFs list shown in Table 2. Their selection results are shown at the right end of Table 5. Also, the estimated CSFs explained in the above section are shown in the middle section of Table 5. It can be understood that all the estimated CSFs are included in the selected CSFs. This means that the proposed estimation method by this paper is correct and useful. The reason why the CSFs are not perfectly the same as those of estimated and selected is thought to be the ambiguousness of the questions to the engineers who were interviewed. Some of the engineers who received interviews are supposed to answer the question from the general viewpoint of project management.

Table 5 Estimated CSFs and their comparison with those of interviewed CSFs selected by the interviewee

System #	Difficult items	CSFs estimated	CSFs selected by interviee (engineering leader)
System 1	1)Insufficiency of knowledge about the middleware which the ordering side required to use	**Technical skills of project team** Third parties fill gaps in expertise and transfer knowledge	Clear project goals Team work Customer/User Involvement **Technical skills of project team** Selection and management of consultants and staff

System #	Difficult items	CSFs estimated	CSFs selected by interviee (engineering leader)
System 2	1) Insufficient information about the system requirements from the ordering side	**Clear project goals** **Customer/User Involvement**	**Clear project goals** **Customer / User Involvement** Selection and management of consultants and staff Top management is engaged, not just involved **Monitoring and feedback against initial plan**
	2) Insufficiency of knowledge about the middleware which the ordering side required to use	Technical skills of project team Third parties fill gaps in expertise and transfer knowledge	
	3) Lack of project management	Detailed formal plan with well-defined tasks **Monitoring and feedback against initial plan**	
	4) Difficulty in direct communication with the ordering sides	**Customer/User Involvement**	

System #	Difficult items	CSFs estimated	CSFs selected by interviee (engineering leader)
System 3	1) Insufficiency of knowledge about the middleware which the ordering side required to use	**Technical skills of project team** **Management communication, education and expectations** Third parties fill gaps in expertise and transfer knowledge	**Customer/User Involvement** **Technical skills of project team** **Management communication, education and expectations** **Clear project goals** Risk management
	2) Insufficient information about the system requirements from the ordering side	**Clear project goals** **Customer/User Involvement**	
	3) Engineer skills mismatching for the SRD phase	**Technical skills of project team** **Management communication, education and expectations** Third parties fill gaps in expertise and transfer knowledge	
	4) Difficulty in direct communication with the ordering sides	**Customer/User Involvement**	
	5) Lack of cooperation with the ordering side	**Clear project goals** **Customer/User Involvement**	
	6) Lack of methodology for the current system development.	**Clear project goals** **Customer/User Involvement**	

■5.0 CONCLUSION

This paper aims to make clear the critical success factors (CSFs) in the system requirements definition (SRD). Through focusing on the consideration that CSFs are the solution for difficult items in an SRD process, a new method for the CSF estimation was studied from difficult items obtained by interviewing engineers who were engaged in SRD. This method is the syllogism which derives the possible solutions from the major difficulties and estimates CSFs based on the solutions.

As a result, the following conclusions were obtained:

1) To enable CSF estimation, appropriate interview items were designed in such a way that the engineers who were engaged in the SRD were able to clearly point out difficult items.
2) Major difficulty items were extracted from the difficult items obtained from the interview.
3) Twenty CSFs were newly designed based on the CSFs proposed by the preceding study results.
4) To encounter the difficult items, the possible solutions were derived.
5) CSFs were estimated so that they solve the major difficult items extracted as described above.
6) The estimated CSFs were proven to be almost the same as those selected by the interviewee.

As described above, it can be concluded that the CSF estimation method proposed by this paper is correct and effective.

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Appendix

Table A Answers Of The Interviewee And The Solutions

System #	Answers of the interviewee and the solution
System 1	1) There were no engineers in the SRD staff who had the experiences and knowledge about the use of the middleware requested by the ordering side. The solution for this were (1) to add engineers with sufficient knowledge, (2) to assign the third party engineers filling the knowledge gap about the middleware or (3) to make the training fulfilling the knowledge, *(3) This solution was not suitable since the period of the project could not afford.
System 2	1) No clear system requirement was given by the ordering side. The solution for this were (1) to request the customer more involvement, (2) to obtain business analysts, or (3) to ask the partner System Integrator to jointly get the ordering side requirements. *(2) This solution was not suitable since the business analyst of this system is a few. 2) There were no engineers in the SRD staff who had the experiences and knowledge about the use of middleware requested by the ordering side. The solution for this were (1) to add engineers with sufficient knowledge, (2) to assign the third party engineers filling the knowledge gap about the middleware, or (3) to make the training fulfilling the knowledge. *(3) This solution was not suitable since the period of the project could not afford. 3) The project manager was not properly assigned. The solution for this was to replace the project manager. 4) Existence of a meaningless intermediary caused the worst communication between the ordering side and trustee side. The solution for this was to remove the intermediary. This meant customer involvement directly.
System 3	1) There were very few engineers in the SRD staff who had the experiences and knowledge about the use of the middleware requested by the ordering side. The solution for this were (1) to add engineers with sufficient knowledge, (2) to assign the third party engineers filling the knowledge gap about the middleware, or (3) to make the training fulfilling the knowledge. *3) This solution was suitable since the period of the project could afford. 2) The ordering side did not determine the requirements. The solution for this were (1) to request the determination of the requirements by the additional staff, (2) to request the customer more involvement, (3) to obtain business analysts, or (4) to ask the partner System Integrator to jointly get the ordering side requirements. *(3) This solution was not suitable since the business analyst of this system is a few. 3) Engineers who had narrow experience about the use of middleware requested by the ordering side were assigned. The solution for this were (1) to add engineers with sufficient knowledge, (2) to make the training fulfilling the knowledge, or (3) to assign the third party engineers filling the knowledge gap about the middleware. *2) This solution was suitable since the period of the project could afford. 4) The existence of a meaningless intermediary caused the worst communication between the ordering side and trustee side. The solution for this was to have direct communication with the ordering side. This meant more customer involvement directly. 5) It was supposedly good to recommend the replacement of the current system to a new infrastructure. The solution for this was to request the ordering side to replace the system. This meant more customer cooperation and involvement. 6) The partner System Integrator took eight months to become aware of the importance of the verification of the middleware which the ordering side was required to use, resulting in a long delay of SRD. The solution for this was to take the concurrent engineering, developing the system design and programing at the same time. This meant to be needed clear Project goal and more customer cooperation and involvement.