

How Can An Acquirer Mitigate Risks In Software Engineering Projects?

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Abstract: Competition shall provide major incentives to industry and Government organizations to innovate, reduce cost, and increase quality. It is a mechanism to obtain a beneficial price to any acquirer (buyer). In such competitive business environment, software engineering projects are moving from Time & Material (TM) contracts to Fixed Price and Time (FPT) contracts that offers less risk to the acquirer. Though, FPT contract is more risky to developer (supplier), the FPT contract offers more profit if risks are managed properly. Therefore, it is important that all the “known risks” are identified and suitable measures to mitigate those risks are undertaken by the developer. The success of a project depends on effective management of all the known risks of the project (including that of the acquirer). Failure to identify and manage the known risks by the developer also becomes a major risk for the acquirer. This paper therefore identifies some important risks and measures that have to be undertaken before and during the Request for Proposal (RFP) by the acquirer.

Key Words: Project management, software engineering, contract, cost plus, time and material, fixed price and time, risk, risk mitigation.

INTRODUCTION

There is a global recognition that competitive bidding reduces cost of projects. According to Department of Defense [1] “Competition shall provide major incentives to industry and Government organizations to innovate, reduce cost, and increase quality”. Competition is also a statutory requirement in USA [2] and in many other countries for public procurement [3]. International Funding Agencies like World Bank [4], Asian Development Bank [5] and Organization for Economic Co-operation and Development [3] demand competitive procurement of goods and services in their funded projects to reduce costs and improve quality. Further, due to huge demand for fiscal resources, fiscal constraint is a reality that all acquirers must recognize.

Once it is decided that competitive procurement will be followed for the software project, it becomes important to select the right type of contract. A contract provides reference points for entitlements to both the acquirer and developer. Different type of contracts provide different level of contractual rigidity and flexibility. Federal Acquisition Regulation, Subpart-16.104 lists various factors to be considered in selecting contract types [6].

Normally, the type of contract to be awarded to a developer is based on two major factors like:

1. The degree and timing of the responsibility assumed by the bidder for the costs of performance; and
2. The amount and nature of the profit incentive offered to the bidder for achieving or exceeding specified standards or goals

If the problem is very vague and cost estimation is not possible to a reasonable accuracy, Cost Plus (CP) contract is preferred. In CP contract, a developer claims from the acquirer, the expenditure incurred on the project plus a margin say $x\%$ of the project expenditure. It is normally not encouraged by Federal Acquisition Regulation (FAR) because there is no cost and time control.

In TM contracts, higher productivity and smaller duration would reduce the revenue and profit to the developer. Therefore, the developer has a tendency to avoid best practices in TM contracts [7]. Since, TM contract is behavioral, the acquirer needs a safeguard that the developer is not billing them more person-hours than is necessary to execute the project. So, acquirers reduce their risks by negotiating hard on the price for person-hour. Even conflict of interest is higher in CP contract and TM contract than in FPT contract because the acquirer's best interest is that the developer works as efficiently as possible to minimize the time and hence the cost. However, the developer can increase the revenue by taking more time than expected by the acquirer. In the case of unclear requirements, expanding their scope will increase developer's revenue.

In FPT contracts the developer charges a fixed fee for its services to be delivered in a fixed time. In FPT contracts the fees and time are usually negotiated before the start of the project. A developer who wants to play safe does not prefer FPT contract because the developer is totally responsible for risks due to requirement creep, interfacing requirements, attrition of skilled personnel, statutory regulations etc. Yet, mature and capable developers prefer FPT contract as they can get more profit by executing the project properly [8]. The major risk for the acquirer in awarding the FPT contract is that the developer may meet all the requirements but the quality of the service may not be superior. If the conditions of FPT contract are not met, then the contracted work may

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well end up being more costly, taking longer, and even ending in failure harming both acquirer and supplier [9].

The percentage of projects moving towards FPT contract is increasing in the software industry according to *Infosys' CEO and Managing Director, S. (Kris) Gopalakrishnan* [10]. In Tata Consultancy Services, the FPT contract is almost 44.79% of the total contracts in the financial year 2008-2009 [11].

From the above discussions it is clear that FPT contract appears to be in the best interests of the acquirer and developer when the risk is contained in software engineering projects. This paper lists some known risks and mitigation measures so that the risks would minimize in the projects. However, irrespective of the type of contract, it would be better if the acquirer mitigates all the known risks before the release of Request For Proposal (RFP) by incorporating suitable clauses in the contract for each risk. The responsibility for conforming to RFP clauses can still lie with acquirer or developer depending upon the type of contract. This approach would ensure as double check in mitigating the risks to the project.

KNOWN RISK FACTORS

Risk factors of software projects have been identified by Borland [12], Amrit Tiwana *et al.* [13], DIR, Texas State [14], Edmund H. Conrow *et al.* [15] and The Standish Group [16]. According to them, the risk factors vary but there are some common factors. The risk factors listed below have been identified based on study done by others and my own experience. They are ranked based on their importance. However, all of them are important and need to be mitigated before releasing the RFP. These risk factors are:

1. User involvement
2. Development Methodologies
3. Requirements
4. Interfacing Requirements
5. User and Management Support
6. Managing Innovation
7. Complexity
8. Relevant Experience
9. Skill Requirement & Team Turnover
10. Scope of work
11. Developer Selection
12. Project Management Practices
13. Training
14. Statutory and Legal requirements
15. Subcontracting/Outsourcing
16. Cost Estimation
17. Time Estimation
18. Understanding of Request for Proposal (RFP)
19. Software Tools
20. Project Information

RISK MITIGATION MEASURES

Let us consider the above twenty risks one by one for mitigation. All the risks have to be mitigated from the earliest project proposal stage through issue of RFP. Further, risks that may appear during execution of project are to be predicted, mitigation measures be planned, and tackled effectively. Most of the risk mitigation measures have been taken from the author's experience in various projects like 'Spiral Welded Pipe Plant' of Rourkela Steel Plant, Rourkela, 'Modernization of Distributed Computer Systems and Plant Wide Networking' of Kochi Refineries Ltd, Check Post Automation for Andhra Pradesh government etc in India.

1. User Involvement: In most projects, the actual users do not get an opportunity to get involved in the project from the beginning. In some cases, users' representatives will be involved. Rarely, the users and stakeholders will be involved. User involvement brings the actual needs peculiar to a country, culture etc. For example: In India, people enter date like 5-12-2009 or 31-1-2009. Most of the Banking software report this as an error with out indicating any reason. Later, after several attempts if you enter 05-12-2009 or 31-01-2009, the system accepts the input. Though, it is not a fatal error, it wastes the valuable customer time and creates irritation in their minds. Similarly, in engineering projects, electrical and automation documents provide basic design details and very less documentation on erection and installation. The reason is the constructor is assumed to be an outsider and expect them to generate documents from the basic design documents. Cable Management software could have been integrated to cater for the constructor also. By doing this, the project saves time during construction. An acquirer could mitigate many such risks by identifying key personnel for operation, maintenance etc at the very start of the project and launch regular interaction among users, stakeholders, consultants, bidders, and developers. It helps to identify the real problems. In addition, when a solution is discussed with the users, the developer gets valuable comments to improve the solution, make it more practical, cost effective and later acceptable (which is very important) during final acceptance. It is also important that the right, informed and experienced users are involved. Acquirer shall identify the users in any type of contract and further arranging users interactions can be mutually agreed between the acquirer and developer depending upon the type of contract.
2. Development Methodologies: Software development paradigms also determine the success and failure of the project in most of the cases. One can not use "water fall model" in all the projects just because it is simple and comfortable to developers. So also, one need not use "spiral model" for each and every project just because the developer has the capability and skill to adopt this model. Wrong adoption of "water fall model" to a first time project

can lead to loss of flexibility to incorporate changes during development. So also, adopting a “spiral model” to a “technology migration project” can unnecessarily increase the cost and time of the project. To mitigate such risks, the right “development model” should be chosen after a thorough and careful assessment of the project requirements stability, completion time, complexity of the project and previous experience in using the selected model etc. For example, where time is short and critical, an “incremental model” can be adopted to deliver a solution with basic functionalities in a short time and further functionalities can be added in increments. In the case of TM contracts, the acquirer should verify that the developer is selecting the right model and in the FPT contracts, the selection of development model shall be left to the developer.

3. **Requirements:** Lack of clear and complete requirements is the next risk to a project. Acquirer can consider two major categories of projects. One category may have both hardware and software. For example, Acquirer may have a bank automation project where central servers, databases, communication networks, and software products are in the scope of supply. In the other category, Acquirer may have only software development that is to be integrated with the existing system. In the first case, system requirement should be prepared in consultation with users, so that the proposed system and software would take care of everyone’s needs. Software requirements should then be prepared from the system requirement and user interactions. Ideally, each category of user should be treated as a unique customer and their needs should be identified. The users’ need should never be combined to reduce the designers or programmers’ work. Maximum customer satisfaction is achieved when a category of users gets a report or display that contains the exact information that they wanted; rather than extracting information from a common report or display that is meant for different groups of users. The documented requirements should be reviewed several rounds until acceptance by all the users are reached and approved by competent authority. Last year, the Government Accountability Office (USA), or the GAO, looked into 95 major defense projects and found cost overruns that totaled \$295 billion. **Exotic requirements** was one of the factors for wasteful spending [17]. The requirements should be segregated as vital few and useful many. Vital few are those requirements, which do not change during the course of time, and with out those requirements the project will be in jeopardy. Functional, Operation and Maintenance requirements fall under this category. Useful many are those, which improve the features and make it more user friendly. In any project, the vital few requirements must be clearly understood, documented, reviewed and accepted by everybody. Minimum acceptance

criteria for all quality parameters and type of validations should be defined. If special performance guarantee tests are required, the constraints and resources needed from the customer should be listed and agreed mutually. Vital requirements can not be left unsatisfied while the trivial requirements can be traded-off with cost, convenience and time. In any type of contract, the acquirer shall define the acceptance criteria and performance guarantee. They would have to be negotiated for mutual acceptance with terms and conditions for carrying out such tests. In FPT contract the system and software requirement specification shall be accepted by the acquirer and developer by contractual agreement.

4. **User and Management Support:** Users support is vital for final acceptance of project. In many projects, (where users are not involved from the requirement to installation/staging) except the user every body else may feel the project to be complete and fit for transfer to operation. When final acceptance is done with the user, Acquirer will find hundreds of discrepancies with respect to their implicit needs to be fulfilled. Though many of them will be trivial and can be managed, some of them may be major issues blocking the final acceptance. This type of things cannot happen if the users were involved properly and their support is obtained regularly. Next, with out acquirer's management support, no project can complete in time. Management support is vital to get adequate resources at the right time. It is therefore important that during the project execution no change in top management would occur. Even if it occurs, a formal commitment of management support should be obtained. Management should define responsibility and authority for acquirer's program managers. They should also support program manager's (acquirer side) decisions to free developers who do not meet the quality requirements and time schedule. With out this authority, it is impossible to control a large project with many developers. The project manual (prepared by acquirer) should have a procedure or method to address these issues. The project manual should therefore consist of guidelines on how to ensure user and management support throughout the project life cycle. Irrespective of the type of contract, acquirer shall ensure appropriate project manual to the developers.
5. **Interfacing Requirements:** In projects, where the ‘proposed system’ is to be integrated with existing one, there are several possible risks. One of them is the ‘interfacing requirements’ for different types and vendors' products (both hardware and software) that are proprietary in nature. Since, the interfaces are highly proprietary nature, the vendors may quote very high price to competitors. The other risk is these vendors may also be bidding for the project and in that case they may not quote to competitors. This creates lot of rivalry among the bidders and

renders price comparison meaningless. This can end in exceeding the budget or delay in negotiating a fair deal or incomplete project. This is a serious risk in large projects with large number of proprietary hardware and software. This risk is mitigated by including a special clause “associate contractor clause” (similar to that existing in aerospace industry, USA) in the RFP. According to this class all the suppliers whose interfaces depend on other contractors would be called “associate contractors”. Associate contractors would have to submit a memorandum of understanding stating that they will cooperate with each other associate contractor in accordance with associate contractor clause. They shall jointly agree to work and one of them will be called up on to create and maintain as the integrating contractor. In a fierce competition, the integrating contractor would still need some help of the Acquirer to run the show smoothly. The system integration role can be played by one of the vendors or by the main contractor or the acquirer. It has to be decided carefully after thorough study of the project environment [18]. This applies to any type of contract.

6. **Managing Innovation:** Where project involves innovation, the exact area where innovation is involved should be identified. Radical innovations should be done by separate contracts and integrated with the main project. In case the innovation fails, there should be a plan for alternate technology or product. Research and development should be done off-line and the execution of the project should go on in a systematic and planned manner. For example: A modern border check post can be planned to have on-line weighing, profile measurement, and reading number plate of vehicles. A high-resolution digital camera can be proposed to capture the front image of the vehicle, locate the number plate, identify the registration number and store those images in the computer for further processing. Considering the non-standard number plates, language, size and type of fonts used, there is a tremendous risk in identifying the number of vehicles. To mitigate the risk, initially provision can be made for manual identification and entry of the registration number. Later, if a reliable image processing software is available, the same could be integrated. This applies to any type of contract.
7. **Complexity:** Complexity is judged by such factors as the number of organizations, vendors, teams and technology that interact with each other. The size and number of variables affect the decision process in all stages of project. A large and complex project can be split in to many small projects of manageable size. Complexity could be further reduced by right kind of organization, defined roles and responsibilities, and effective communication. To mitigate risk due to complexity, it is better to use proven but not outdated technology than the latest, unproven, and skill scarce technology. This applies to both the acquirer and developer in any type of contract of very large projects.
8. **Relevant Experience:** Novel projects are hard to execute with in an estimated cost and time. Here, the risks are unknown. Yet, Developer’s prior experience in executing similar (many novel) projects and presence of those skilled persons with them would help to effectively manage risks as they arise in the project. Also, examine whether the developer possesses a good record of ‘lessons learned’ for continuous improvement of their performance in each project. This is important in FPT contract.
9. **Skill Requirement & Team Turnover:** Areas where high-level skills are required; should be identified. Further, number of experts available in each area of expertise, average years of experience, and availability of excess pool of skilled software engineers can be obtained through RFP. Adequacy of skilled persons could then be ensured. This could mitigate the risk that could arise due to shortage of skilled persons in the project during execution. Where regulations permit, (US Government contracting does not permit) the names, age, photo and qualification of such experts could be obtained to make the evaluation fool proof. The availability of right skills with sub-contractors should also be verified. Team turn over should be avoided to the extent possible during the execution of the project by suitable agreement between employer and employees. This is important in FPT contract.
10. **Scope of work:** The scope of the project should clearly define the deliverables in the RFP itself. Deliverables should include design criteria, system requirement specification, software requirement specification, hardware, system software, application software, documentation, and test records. It should explain what is to be done, what are the limits, what is not in the scope, and in case of dispute the method of resolution of conflict. Before commencement of the contract, the scope should be finalized by having several reviews with the users. Acceptance of final scope and requirements should be obtained by the acquirer from the competent authority of the client (the user for whom the acquirer is managing the project) before inviting bids. Still certain scope and requirements creeps are what the program managers (PM) need to watch out carefully to avoid additional cost and time. The RFP should explicitly define a procedure to handle such additional scope or requirements that might arise during execution of the contract. The procedure shall show a flow chart starting from what will be considered as an add-on and who will approve the ‘extra claim’ for payment of extra price and time that may be needed. With out approval of competent authority, the developer should not undertake any job that might result in dispute over extra claim. This is important in FPT contract.

11. **Developer Selection:** Qualification of developers should be verified before issuing the RFP and it should only be sent to those who qualify. The qualifying criteria should be; financial status, key personnel's details, number of similar (type of contract, duration, value) projects executed earlier and their details like nature of job, specialty of the project, status of implementation, project closure certificate, and details of referrals. Also, ensure that the developer has used the proposed technology, process and design successfully earlier. This applies to any type of contract.
 12. **Project Management Practices:** The RFP should ensure that the developers would use PM tools like Primavera or MS Project, with many small milestones. They should include allocation of resources for all the activities. The base line schedule should be submitted after the award of contract to be approved by the acquirer. The RFP should also indicate that only major milestones will be monitored by the Acquirer's Project Office, where as mini-milestones would be monitored by the developer. The developer should also be asked to send 'conformance to schedule' report regularly. This applies to any type of contract.
 13. **Training:** All the personnel involved in the project should be given proper training for effective performance in the project. According to Project Manual and RFP, it shall be mandatory for the developers to show evidence of appropriate training and skill for different roles of the employees engaged in the project. This applies to any type of contract.
 14. **Statutory and Legal requirements:** Relevant statutory regulations and legal requirements should be listed with appropriate references in the RFP or Project Manual. The bidder should be asked to confirm that they are capable and conform to those requirements. This applies to any type of contract.
 15. **Subcontracting/Outsourcing:** The RFP should make it clear about outsourcing issues. The likely developers to be engaged in the project should be approved before placement of order. The project manual should have a procedure for approval of such developers. The procedure should include methods for risk mitigation at least for the following situations:
 - a. Problem between developers and their employees
 - b. Problems between developers and their subcontractors
 - c. Problem between subcontractor and their employees
 - d. Prime or subcontractor abandoning the project
- This applies to any type of contract.
16. **Cost Estimate:** Acquirers need not make very accurate cost estimate of project in a competitive bidding where as an accurate estimate is important in the case of CP and TM contracts. The estimate is required for the following reasons:
 - a. Budgeting and cash flow planning
 - b. Reference to disqualify bidders who quote is too low with respect to estimate (the assumption is that if the price is too low compared to the estimate, the bidder might not know the scope, complexity and other requirements of the project)
 - c. Discard 'ivory tower organizations' too high bid, from entering into bid discussions and wasting resources
 - d. To use it as a basis for price negotiation

This applies to any type of contract.
 17. **Time Estimate:** Project duration is also a factor affecting the price of the project. Due consideration shall be given for 'on-shore', 'off-shore' and 'outsourcing'. If 'off-shore outsourcing' is assumed with proper time zone difference, the project duration can be reduced considerably. Assuming worst case scenario like, everything will be done in-house or on-shore will end in longer project duration than some other optimal scenarios like 60% off-shore development, 20% on-shore development and rest in-house. There is every likelihood that part of the work is outsourced to countries like India which is almost 11 hours ahead of US central time. In such situation, the time zone difference can be favorably exploited to reduce the duration of project. Work flow should be organized to use this time zone difference. The bidder should be asked to explain the various measures that would be taken by them if they outsource some portion of the job. This applies to both the acquirers and developers in any type of contract.
 18. **Understanding of RFP:** The RFP should have a questionnaire to evaluate the developers' understanding of the project requirements. This would mitigate the risk involved in misunderstanding of the RFP. The answers should be verified and where there are discrepancies they should be sorted out between the bidder and acquirer. The questionnaire, their answers, subsequent discussions and agreed points should form part of the contract. This is important in FPT contract.
 19. **Software Tools:** A set of preferred Computer Aided SE (CASE) tools should be suggested to developers to ensure quality and uniformity. The tools should be suitable for areas like requirement management, design, testing, and configuration management. The suggested tools should have been proven for their ability to improve productivity, and documentation. However, the developer should be allowed to have their choice. This applies to any type of contract.

20. Project Information: If Acquirer need good competitive offers, they should not assume that the bidder would have the overall picture of the acquirer and the acquiring system followed by them. Lack of good information can limit entry of new contractors and give a better bargaining power to existing contractors. Instead, Acquirer should provide detailed information about the project and its (physical, business and technical) environment. For example: In a state border check post project, an elaborate write up about geographical locations, their meteorological data, check post processes and other links to local information resources shall be included in the Project Manual. This applies to any type of contract.

RECOMMENDATIONS

Enormous software projects have failed in the past that may be due to type of contract or unmitigated risks by developer. The author recommends that it is better for the acquirer to take suitable measures to mitigate all the known risks before the issue of RFP even in the case of FPT contract. This additional effort would ensure success of the project and better quality of products and services from the developers.

CONCLUSION

This paper has described the changing scenario in software engineering projects starting from competition, type of contracts and gradual maturity reached by leading Indian software industry to move towards FPT contracts. As more and more projects are moving towards FPT which is perceived beneficial to both the acquirer and developer, known risks mitigation has become all the more important. This paper has picked twenty known risks from hundreds of risks that have been identified by different agencies globally that have analyzed failures of software engineering projects. It also suggests measures to mitigate such risks before the issue of RFP by the acquirer as even in the case of FPT contract the ultimate risk is to the acquirer only.

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