Beyond Agile: Construction Cost Minimization through Optimal and Informed Risk Management, Contractual Agreements and Negotiations

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Abstract

Construction industry is in continuous need for improvement. Likewise, methods and techniques used for decision-making need improvement. Traditional approaches are not meeting the needs of fast-changing industry. In many cases issues start right from the contractual agreements and agreed terms that parties accept without truly understanding the feasibility aspects. These lead to multiple complications during the projects as well as towards the end of the project. To overcome such difficulties new approaches are developing as Agile with an expectation that targeting the project in smaller increments may help in reducing the possible negative outcomes. It works if the project can be delivered in smaller increments while for construction industry or others it may not always be feasible. Project Design-Build delivery method can be paralleled to some extent with Agile approach where the team works on the requirements and navigates over the phases of project development together. In practice even such approaches leave the stakeholders unhappy, because the terms and conditions of a project often change and lead to disagreements. In fact every project is a unique deliverable and very fragile if not managed properly. In this paper an innovative modeling technique named **Fragile**©, which goes beyond Agile approach, is proposed to help to deliver the project with its most efficient way from the given point on and especially for the conditions that may change in future.

Introduction

In real life project management is much more complicated compared to conceptually analyzing the difficulties about project management. If follow PMBOK then the management of projects can be easy to navigate and keep structured. Yet, the actual problems that arise during the project can be difficult to handle as it involves multiple aspects including goal and scope, owners and other stakeholders, engineers and architects, contractors and subcontractors, suppliers and vendors, specifications and drawings, contracts and agreements and much more.

The most important thing in the process of management is to keep in mind the objective of the project in whichever capacity and preference it will be decided by the involved parties. In general the objective for any involved party is to maximize their return on their invested efforts and resources. From the perspective of the owner the objective can be to get the project completed within minimum timeframe and budget with maximum quality while for negatively involved party for the same project the goal would be the project's interruption or simply limitation of project's scope or conceptual issues defined by the owner and other involved parties. When taking such approach each involved party may practice the negotiations techniques in order to proceed with the project with the least resistance and find commonly acceptable terms and conditions that can also be stated in the contracts. All these complications bring to the idea for the need of analyzing projects step by step which in some sense can be described in terms of breaking down the project into smaller increments wherever possible. This partition of projects is much easier in IT projects. This is where Agile Manifesto comes in and it was initially developed to help with the incremental approaches. Yet, in other industries it can be challenging to divide the project into smaller deliverables that can be effectively considered and understood by the owner or other stakeholders. Construction projects well be one of the types of projects that is not always possible to deliver the project in increments and assure its smooth completion through Agile techniques.

Methodology

To be able to elaborate the complexities of Agile approach it is important to present the principals of how Agile approach works, analyze its practicality then propose the new technique that may potentially be adopted for projects that might not be easy to manage with Agile. Some may find the proposed method good in combination with Agile method as it can also complement

it if necessary other than completely replacing it. As documented by Beck et al. (2001), the Agile Maifesto is structured around 12 principles when implemented on software industry projects:

1. "Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly" (Beck et al., 2001).

Straçusser, G. (2015) presented the potential application of Agile Manifesto on construction projects and still many questions can be asked about its wide and practical applications on other construction project types when incremental and segmental approach may not work. In particular Straçusser, G. (2015) discussed a project for constructing a Nuclear Power Plant and analyzed application of Agile on research, development and demonstration (RD&D). While for a project that is as large, complex and utilized 169 companies from total of 28 states to support RD&D construction, manufacturing and operations activities and during construction added more than workforce by totaling it to more than 1,100 workers, it would be reasonable to divide it into increments and segments to deliver it to the owner gradually and getting the approval for the next step. Yet, if there was an opportunity to analyze the possible outcomes of brainstorming before and even during the construction stage to keep it consistent with Agile Manifesto while keeping in

mind that not only the owner needs to be happy and satisfied, but also other involved parties should be happy the outcome of the management process and the success rate of completing the project on time and within budget might be even higher. In fact all projects are fragile and require careful management to be successful. Any project management is full of risks and it can be wisely evaluated.

With this idea in mind the proposed approach named Fragile is to utilize the applications of well-known and possibly well underestimated power of game-theoretic mathematical modeling that allows developing tools of application for such analysis to evaluate the possible outcomes of decisions made for the projects. Game-theoretic mathematical modeling had been and currently is widely utilized in other industries such as energy, oil and gas, sustainable infrastructure development for decision-making, market behavior analysis and much more. It can definitely be successfully adopted by Project Management society and bring the successful completion of projects one or even more steps closer to reality.

The flexibility of options in game-theory provides the luxury for setting up the relationships between involved parties in any project. In game theory the parties involved in the game which is the project are called players. These players make decisions for the project. They are the owners or other stakeholders, engineers and architects, contractors and subcontractors, suppliers and vendors and most importantly from project or program management perspective the Project or Program Managers. Within the flexibilities provided by game-theoretic setup the relationships can be defined as flexibility of number of players, simultaneous or sequential decisions or also known as moves in the game, random moves, presence or absence of perfect or complete information, presence or absence of communication between parties, cooperative or non-cooperative actions.

To represent the proposed approach in this paper it is useful to analyze couple example setups with few participant for decision-making process. Assume there is a large project as discussed above for Agile Manifesto discussion. Large projects in many cases are delivered in multiple packages other than granting it to a single entity. Large projects also bring many changes during the project realization. If analyze from owner/s or stakeholders perspective it can be seen as a bidding and negotiation process for deciding with which contractor to proceed. If consider the contractor perspective it will be hard to decide with which subcontractor to proceed. Depending on item under consideration either from stakeholder, contractor or subcontractor perspective when dealing with suppliers it will be hard to decide with which supplier to proceed. If consider a choice or an option for the project from stakeholders perspective it can be hard to find a point that all will agree on a certain choice. All these and any other scenarios can be structured as game with few participants either they decide together, in sequence, with perfect or imperfect information, with gain and loss consideration and more.

Details – Part 1

Given the above information the proposed approach can be narrowed down to a hypothetical example. If assume there are two contractors and they have different options to deliver unit output to the owner and stakeholders based on the technology they implement how should the contractors manage their strategies to get more orders from the owner and make more capital? Owner wants to go with lowest cost option. Other stakeholders/investors for this project have different opinions and perhaps based on other parameters may decide to go with not the least cost option. What should be the contractors' strategy be to maximize their chance of getting the additional amount of work for the project, keep the stakeholders satisfied and committed? To better analyze this situation assume there are three (A, B, C) different technologies that can be used for

delivering the same output. Each comes with a different cost that can be offered by each contractor to the owner and stakeholders. Each contractor charges its own prices per unit. Option A can be delivered for $20.00, option B for $40.00 and option C for $50.00 per unit. For the low price trade there is 40,000.00 units of demand for each month by the owner directly and if both contractors bid with the same low price the amount of work is split between them. Based on the changes in the project it is expected that stakeholders will decide that there will be additional 60,000 units of total amount of work. Surely strategy by any of the contractor can possibly be to try to undercut the other contractor by bidding for the lowest price it can. Yet, it can be not wise if consider the payoff matrix. If payoff matrix is calculated then it will be easy to sort things out without difficulty.

If Contractor I charges $20.00 per unit and Contractor II Charges $40.00 per unit then Contractor I will get the 40,000.00 units form the owner and with probability of 50% chance it will attract 30,000.00 units from other stakeholders, resulting to 70,000.00 units to be completed with $20.00 by returning total of $1,400,000.00. Other 30,000 units (50% of 60,000.00 units) will go to the Contractor II who charges $40.00 per unit resulting to $1,200,000.00. Table 1 provides all payoffs per option in 1000s of dollars. First column second raw of Table 1 depicts results of sample calculation above.

Table 1. Payoff Matrix of Contractor I and II accordingly

	A - $20	B - $40	C - $50
A - $20	$1000, $1000	$1400, $1200	$1400, $1500
B - $40	$1200, $1400	$2000, $2000	$2800, $1500
C - $50	$15,00 $1400	$1500, $2800	$2500, $2500

From this payoff matrix it can be observed that the least favorable option for any of the contractors is to proceed with $20 option because all other options are preferable by both and there

is no incentive for any of the contractors to call that price. Therefore it can be eliminated from the matrix to simplify the payoff and reduce the game (Table 2).

Table 2. Reduced Game Payoff Matrix of Contractor I and II accordingly

	B - $40	C - $50
B - $40	$2000, $2000	$2800, $1500
C - $50	$1500, $2800	$2500, $2500

From here it can be observed that $40/$50 option is not preferable for any of the players and they have an incentive to deviate from such choice by knowing there is better option for them to make 2,000,000 if they both call for $40. There is also the better option if both call for $50 per unit, but since this is a simultaneous game there is big risk that the other Contractor would play $40 per unit game and get 2,800,000.00. Therefore both would preferably stay on $40 option to make $2,000,000.00 each. In reality it will be really rare that neither contractors nor the owner or owner's representative will do this calculations to understand what is actually happening. If Project Manager adopts this strategy they can serve the client better during any stage of project management through better negotiations and knowing there is a calculated room for a better low cost option if already proceeding or deciding to proceed with one of the contractors. Likewise, the game can be Nash equilibrium with non-cooperative setup. In other instances some players in the game will have more power than others, will act as leaders and others as followers in the market by making it Stackelberg game (Avetisyan et al., 2013, 2014, 2015, 2017, 2018). The above example is surely oversimplified situation, but at the same time very common situation in projects leading to wrong decisions. There is a lot more analysis completed for this project, but not all of it is presented here due to space limitations and intellectual property issues.

Details – Part 2

To give a better understanding what else goes into the proposed method that also addresses some drawbacks of Agile principles it is important to address the importance of prioritization process of small increments in a project if follow Agile Manifesto. How things are evaluated and categorized for the sprints and stages is one of the most important things to do correctly to be able to proceed with Agile system. This is impossible to do without providing a proper approach for prioritization such as suggesting Analytical Hierarchy Process. Even after the right setup of priorities of small segments the flow in the process considering the highest priority items to be completed first may not be efficient. Here is how it happens and what can be done to make sure that projects can benefit. If consider a classic problem setup from Operations Research the concept would be easy to follow. Let's consider a production problem with two products where the producer can make $300 profit per unit from producing product one and $200 profit per unit from product two. Each product uses resources and there are resource limitations. Product one uses 2 units of resource one and product two uses one unit of resource one. For resource two product one is one unit and product two uses one unit. If now impose the resource and market limitations the manufacturer should decide which product and how many to produce to maximize the profit. Resource one is available up to 100 units and resource two is available up to 80 units. Product one can be produced for maximum of 40 units and no market cap on product two. If follow the Agile approach for managing this process then the manufacturer should produce the highest profit product first as much as possible then proceed with the second product after that. In fact "cherry picking" is not the best strategy in this situation. If utilize the resources and produce product one first with maximum 40 units possible by generating $12,000.00 profit then only after that produce product two 20 units based on left resources by generating $40,000 units the maximum profit that can be expected would be $16,000.00. This is similar to the Agile Manifesto approach as high

priority items will be completed first by allocating all the forces and resources on it. Yet, if we do simple calculation then we can quickly notice that producing 20 units of product one and 60 units of product two the expected profit can be $18,000.00. The difference of $2,000.00 of profits as a result of not going with highest priority item first, but doing things in parallel and allocating the resources properly. This is just due to calculating it and not changing resource availability or usage. If we think of millions of dollars for large projects the difference can be unimaginable. The same thing can be translated into the schedule savings or any other aspects of decision-making process.

Fragile Approach

Once having some of the concepts discussed earlier for the developed methodology the following can be considered to improve the management and decision-making process and potentially improve the project management and successful completion of projects. Figure 1 gives graphical representation of the developed process, which is presented with limitations due to space requirements as well as due to intellectual property issues. Project is treated in Stages and each Stage analyses the current State conceptually similar to Dynamic Programming. Then at each Stage the State of the project is evaluated from multi-angle perspective including game-theoretic models, earned value management, schedule impacts and resource allocation and other additional pertinent limitations or risks. Tools are developed to assist in each type of analysis in each Stage. Stage is defined by the user that can be owner, owner's representative, project/program manager, contractor or anyone else who wants to make informed decisions for the project. If any of the ***Fragile***© processes in Figure 1 is missing or not analyzed properly the projects' optimal and efficient completion is questionable and mostly impossible given the number of variables involved

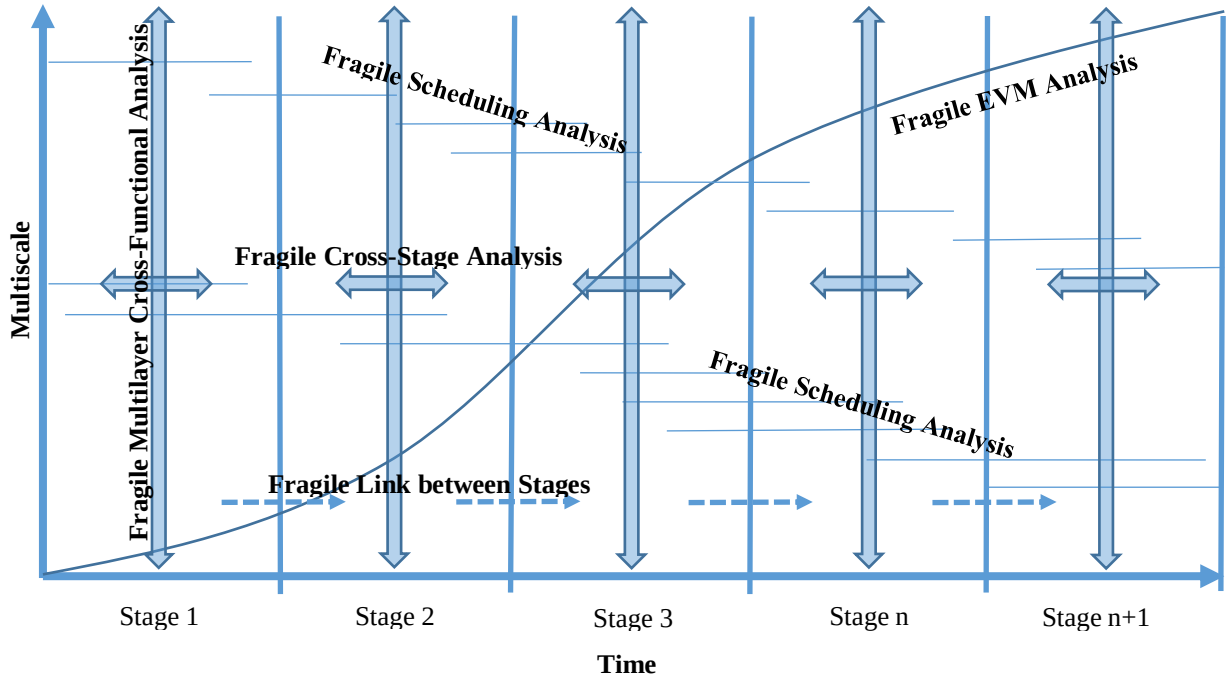

Figure 1. Graphical representation of Fragile Approach©.

Conclusion

As much as Agile is challenging to apply beyond Software and IT industry ***Fragile*** is easy to apply in projects and programs in other industries. Each project and program is very fragile and if not managed properly or issues not captured as early as possible projects and programs fail. ***Fragile*** is an approach suggested to evaluate projects at every stage very carefully, take actions as necessary for optimally managing it instead of just feasibly managing it. Is assists in avoiding unnecessary risks and even developing better contract terms. The question that can be answered by Fragile Approach is that if there is any better way of doing things while keeping all involved parties to its possible highest level of satisfaction.

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