Dynamic Project Management Using Simulations

Abstract

One of the toughest jobs of a Program Manager is to make decisions to correct the course of a program and ensure that all the projects in the program are following the defined flight path. More often than not, these decisions are based on 30% data, 30% group think, and 40% intuition that is really past experience!

In the engineering world, we have been using simulations (computer programs that mimic or model the behavior of physical systems) for years to predict and explore system capabilities and limitations. These simulations have saved millions of dollars and in many cases even lives. Applying the engineering simulation techniques to program plans can have a similar impact on the program. It gives the program manager the ability to model and view the impact of changing any given constraint on a project on the entire program and all related projects. The simulation can also give an insight into the different level of interactions between projects and the intensity of these interactions. Now without actually implementing the new course or even changing the project plans, the program manager can view the new flight path, cost, schedule and quality implications.

This paper provides an overview of how simulations assist project managers in decision making and program analysis . This paper also touches upon some leading edge simulation tools and techniques for business scenario analysis and project management that can substantially increase the overall probability of success by creating a program roadmap, managing risks , and making business decisions based on predictive analytics.

Most people in the business world expect their projects to be completed on-time, meet their quality objectives, and fall within the allocated budget. To most managers, time and money are critical factors to be carefully considered in any decision. These various factors make project management extremely challenging for organizations. Today's business leaders recognize that advanced decision making capabilities using simulation techniques can directly improve their organization's performance. To do so, however, a project has to be meticulously planned, effectively implemented, and professionally managed to optimally achieve the objectives of time, cost, and performance.

Some of the key findings from surveys conducted by different organizations are:

- 30% of organizational projects end up being cancelled midstream.
- Cost overruns are as high as 190% over the planned budget and 220% over the planned time estimates.
- Applied Data Research reported that up to 75% of software projects are cancelled.
- The Standish Group reports the average success rate for business-critical application projects is just 9%.
- In the Project Management Benchmarking Forum held in the USA, more than 50% of the Fortune 500 companies report having project management offices in place.

Many projects experience schedule slippages and cost overruns due to reasons that are both varied and numerous. As there are literally thousands of variables, both human and non-human, in a project, the only way to combat the enormous uncertainties that would be easily generated out of such large varieties is to develop sound systems to manage them.

Dynamic project management using simulation is a new trend in streamlining the management of projects. Complex plans can be analyzed by a computer and applied in many critical areas. This practice enables the project manager to address issues by simulating their impact on the project before they become problems. This allows projects of any size and complexity not only to be planned but also modeled to answer 'what if?' questions.

HOW SIMULATION HELPS IN PROJECT DECISION-MAKING

Simulation modeling is useful in project decision-making by looking at problems as a whole and articulating the complete set of relationships, interactions, and uncertainties. A business simulation model can predict what may happen in the physical system and take necessary steps beforehand, so that the physical system can maintain equilibrium despite various disturbances from both within and outside. Project planning and simulated models can be exploited to provide real-time information, as well as linking to risk-analysis, time recording, costing, estimating, and other aspects of project control. Decision makers can virtually explore future direction opportunities in a safe, cost-effective forum without having to experiment on a real system. This helps in moving from traditional "rear-view" analysis to the ability to see the predictable future, control it, and take actions today to attain tomorrow's goals. Benefits include providing critical business insight into the project, reducing time, resources and risks; increasing the quality, utility and supportability of systems; and enabling integrated product and process development.

In all instances, project work is a dynamic system. However meticulously the model is drawn, it will soon outlive its purpose unless it is continuously updated by obtaining feedback from real life. It is advisable not to build the whole model at once but rather take a modular approach where components are added a little at a time while continuously testing and validating the outputs at each stage. Simulations are effective when you cannot predict what the effects of change will be or how the proposed line might work, when you need to further understand a line or factory, when you need to test a new or proposed system before investing in the equipment, or when you have to refine an existing process. For example, an engineering program may have a complex set of varieties. The varieties are in terms of technology, equipment, materials, people, work culture, and ethics. These varieties can be combined to create a predictive model that can be used to simulate forecasts of how the program would behave over time. The intelligence of the model comes from careful definition of the business conditions, the behavior rules of the independent varieties, the dynamics of the interactions between these varieties, the frequency of such interactions, and a whole slew of other patterns that must be programmed into the model. Dynamic simulation also helps visualize multiple organizational processes simultaneously, resulting in a quantifiable solution set that is matrixed against organizational value drivers. Consequently, organizations can derive benefits from improved strategies, policies, and risk-mitigation plans; allowing management to make proactive and intelligent decisions. Exhibit 1 explains the advantages and issues in using simulations.

PROS	CONS
• Allows experimentation with a model of the system • Allows identification of problems, bottlenecks, and design shortfalls before building or modifying the system • Allows comparison of alternate designs or policies • No disruption to the existing system • Animated or visually appealing • Allows uncertainty in modeling	• Don't get exact answers, only approximations, estimates • Hard to obtain data (if it is a new system) • Simulation results may be difficult to interpret • Simulation modeling and analysis can be time consuming and expensive • Challenging to master

Exhibit 1. Pros and Cons of Using Simulation

SIMULATION MODELING VS SPREADSHEET ANALYSIS

The use of spreadsheets is very common in analyzing data and creating "what-if" scenarios. Although spreadsheets are very useful and a powerful tool for analyzing data and creating forecasts, use of simulations provides a distinct advantage when trying to model and predict the behavior of complex programs and business scenarios. Also once the system is correctly modeled, the power to look into the future can only be provided by simulation. Following are some of the key advantages of using simulation techniques over spreadsheets.

- Spreadsheets use averages to represent schedules, activity times, and resource availability
- Spreadsheets cannot accurately reflect the randomness and interdependence present in reality with resources and other system elements
- Spreadsheets are static and can only provide a quantitative result for one moment in time, where as simulation replicates the dynamic business reality (the power to look into the future)
- Spreadsheets do not have the flexibility of animation, where as simulation can clearly provide visibility to the effects of a local change on a global system

EXAMPLES OF HOW SIMULATED DATA CAN BE USEFUL TO THE DECISION PROCESS

Consider a manufacturing firm that is contemplating building a large extension onto one of its plants. Company leaders are not sure whether the potential gains in productivity would justify the various costs associated with the expansion. It certainly would not be cost-effective to build the extension and incorporate it into their business plans and processes only to remove it later if it does not work out. However, a careful simulation study could shed some light on the question by simulating the operation of the plant, as it currently exists and as it *would* be *if* the plant were expanded. Along with the more apparent issues, there are also less visible – but extremely important – concerns to be identified and factored into the overall equation. How would the workforce be structured and what would be the make-up of the team? What would be the optimum mix of in-house talent and outsourced resources? What types of communication strategies would need to be in place? What types of system dynamics would need to be taken into account? What would be the impact of using various options? What kinds of risks are associated with even the best of scenarios? Traditional process analysis or project planning does not address these types of behavioral issues, and the usual way to resolve them would be to run the actual process, create detailed plans, and observe the consequences - which would prove to be a costly experiment if it failed. In this case, simulation can assist in decision making in the following areas:

Requirements management - Simulations can be a major help in pinning down the requirements early in the product lifecycle, particularly for examining temporal behavior. This method is more accurate than costing models. Simulation can also account for dependencies between tasks, finite capacity resources, and delays resulting in rework loops.

Project management - Simulations allow managers to make more accurate predictions about the schedule, resources, and the accumulated costs associated with a program or a project by creating a robust project design. This starts with establishing a framework for modeling and scenario analyses of the program plan. The framework is put into place prior to the detailed planning and WBS sessions.

The project template is designed with particular emphasis on the products or deliverables, the goals or tasks as they relate to the products, the complex information and re-work dependencies between goals, the first definition of project phases and any high-level dependencies that may exist between them, and an understanding of the work effort that is required to achieve the goals that are defined in the model. This first simulation result is not necessarily accurate or optimum, but points out areas of design that need clarification or change to correctly reflect real-life conditions and relationships.

The next phase begins with the creation of specific baseline models and simulations for the program and each of the sub projects leveraging the templates and specifications from the first phase. Also, a strategy is considered for the scope of scenarios once these sub projects are combined into a common program model. The most compelling scenarios are then explored and multiple “what-if” questions are asked, modeled, and simulated. The forecasts show the bottom line cost, duration, and risk of the overall program and the sub projects given these different scenarios.

The biggest advantage is that very early in the planning phase the executive team can get a more definitive understanding of the inter-goal or inter-phase dependencies, an understanding of the possible organizational revisions or flexibility that is possible, awareness of the capabilities and talents of the teams that are involved, knowledge of changes or requirements in goal priorities that are possible, and a clear understanding of the work process and the ability to modify it.

Training - Simulation sensitizes managers to the consequences of instabilities resulting from badly designed organizational processes. Processes can be identified, improved, and rolled-out to staff with few surprises.

Process improvement - By applying simulation modeling to static process information flows, such as value stream maps, it is possible to analyze potential new scenarios in a virtual world. Process simulation can help make intelligent change decisions when trying to understand the impact on the organization from restructuring and outsourcing strategies by simulating work process changes or resource pooling.

Once a static representation of the process is ‘brought to life’ in the virtual world, individual activities, resources, times, bottlenecks and other independent variables can each be made to behave and interact as desired so as to create anything from a gradual to a radical change in the original process. The predetermined performance indicators can be continuously calculated to evaluate the behavior of proposed changes to the process.

There are primarily two powerful advantages of using simulation for process improvement analysis. First, these virtual process models present an opportunity to evaluate the pros and cons of multiple options before deciding on a final process to evolve to. Further, more than one option can be connected in series as a way to understand a phased approach for achieving the desired final state. This leads to the second advantage of simulation which is the dynamic capability of running the model by simulating time itself. The ability to study the impact of the independent variables on the process over a period of time can provide very useful insights with regards to potential bottlenecks in the future or other unforeseen events or outcomes.

Risk management - Models can be developed to examine the potentially complex interactions of different variables and the impact of different risks on the overall system. Mitigation strategies can be developed that will lessen the impact of unanticipated and disruptive events. It also helps management focus on the most critical risk areas rather than all the identified potential risks.

STEPS IN PROGRAM ANALYSIS USING SIMULATIONS

The first step is to **Identify** the key business conditions and the organizational breakdown for the assignment of goals. Also, identify the product breakdown and determine the proper level of work breakdown that will achieve the desired forecast accuracy for the project. Typical data and information that is required to achieve rapid progress in this phase are: available resources (numbers, talents, etc) and their possible locations, hourly rates, work schedules, reporting relationships, the basic work process, product vision, and work deliverables. This is the phase of the process where the background of the initiative is defined - participants discuss the organizational makeup, vision of the project, and high-level objectives. Key financial accounts are also identified and an activity-based costing model can be developed if required.

Next, a **Model** that provides a hypothesis based solution is formulated. This is the phase of the process where the specific initiative roadmap is built with particular emphasis on the products or deliverables, the goals or tasks as they relate to the products, the basic dependencies between goals, the first definition of project phases, any high-level dependencies that may exist between them, and an understanding of the work effort that is required to achieve the goals. It starts with the construction of a program roadmap at the top level and then develops detail in the area being studied. The key is to collect data on the system of interest, though only enough to capture the essence of the targeted system, and use it to estimate input parameters and to obtain probability distribution for the random variables used in the model.

After Identification and Modeling, the next step in the process is to visualize multiple project scenarios simultaneously through **Simulation**. Factors involved in this step include - validation and verification, sensitivity or 'what-if' analysis, optimization, and uncertainty analyses. This is the part of the process where the project team examines the initial results, outline areas for improvement, decide on changes, and perform multiple simulations that result in an acceptable and likely outcome for the project or program.

Information required for this phase includes – a more definitive understanding of the inter-goal or inter-phase dependencies, an understanding of the possible organizational revisions or flexibility that is possible, awareness of the capabilities and talents of the teams that are involved, knowledge of changes or requirements in goal priorities that are possible, and a clear understanding of the work process with the ability to modify it.

The final step is **Documenting** the assumptions that went into the simulation and **Implementing** the results of the study in the actual business situation. This is the final phase of the process where the results of the multiple scenarios are analyzed and where one or more that meets the needs of the organization is selected. The key to this selection is the clear understanding of the actions that are necessary by all to achieve the end objectives and the recognition of the impacts on the project results by unforeseen events or inadequate progress on specific goals.

SIMULATION TOOLS AND TECHNIQUES

Simulation can be used to tackle many problems from initial design and proof-of-concept studies through operation and validation. Selecting the appropriate tool depends on the level of detail required for the model and the questions being answered. Some leading edge techniques include continuous simulation, program design, discrete-event simulation, combined discreet-continuous simulation, and the Monte Carlo simulation technique. Less than a decade ago, simulation was developed using textual coding of the model. Today, graphical simulation tools are available. They are robust, reasonably inexpensive, and allow for rapid model development with a reduced margin for error. They are also easier for non-technical staff to understand and require less training to learn to use than more complex tools.

CONCLUSION

Simulation refers to the broad collection of methods and applications to mimic the behavior of real systems. Today, we have the ability to use simulation techniques for creating a project roadmap and evaluating different options to achieve our end objectives. This activity, done in the early stages of the project, can help us create more realistic project plans and control processes. Figure 1 shows the process for creating models and using simulations for better forecasting.

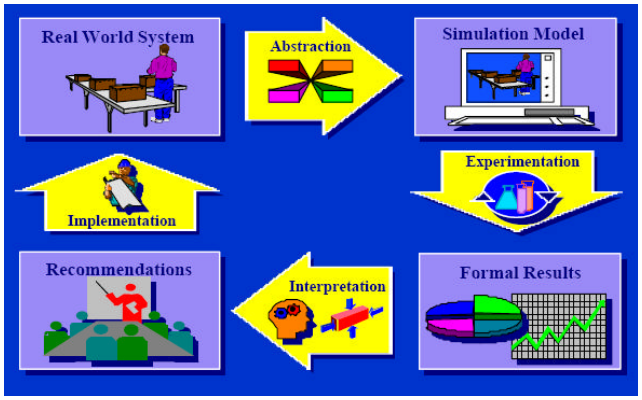

Figure 1: The Simulation Framework

In conclusion, all simulation analysis for any situation shares the common elements of scenario comparison, risk identification, and tradeoff evaluation. Some of the benefits of using simulation include - **Comparison of Operating Alternatives** by evaluating two or more alternatives, **Time Compression** by evaluate several different operating scenarios over a simulated period of time, **Simulation and Optimization** by imitating several situations with multiple levers and then optimize only a few that yield the best results, and **Risk Management** by developing mitigation strategies that will lessen the impact of unanticipated and disruptive events.

Some important things that need to be considered while using simulation techniques are:

- Level of detail (remember the forest vs. trees). More details means more time, more bugs, and more parameters. It does not mean more accuracy.
- Invalid Models: model vs. reality. Enough time should be spent in thinking about the kind of models that need to be created and would be useful in mimicking reality.
- Too short simulations. Create the simulations for the right intervals.
- Inadequate level of user participation. This is a common problem for all planning exercises!
- Obsolete or nonexistent documentation on requirements or past project plans.

The use of simulation techniques in projects increases the overall yields and quality of the project to which they are applied. It also lowers the total program costs. Though it is a simplification of the real world, it is not a panacea as the predictive power of simulation is strongly dependent on how well the models are validated. Every project has risk and uncertainty associated with it. Dynamic Project Management using simulation is a new trend that assures results by minimizing those risks and uncertainties through use of predictive models. Knowledge of the different techniques and their application can help a project manager to use predictive analytics to forecast future probabilities with a far more acceptable level of reality vs. traditional methods.

If applied correctly it can help save many projects from disaster.

REFERENCES

Choudhury, S.
Project Management, *New Delhi: Tata McGraw-Hill Publishing Company Limited*

Khwaja, Aref
Business Simulation Models – Weapons for Decision Making, *Retrieved 07.10.06 from CGN & Associates*, Sep. 2005, http://www.cgn.net

Kleijnen, Jack P.C.
Supply chain simulation tools and techniques: a survey, *International Journal of Simulation & Process Modeling*, Volume 1, 2005

Moser Bryan, Milthemer, Hajo
Planning in the Global Economy, *Global Project Design LLC*, Feb. 2003

Mukhles Zaman
Predictive Analytics; the future of Business Intelligence, *published in Business Intelligence Research Center,* Nov. 2005

Oren, T.I, Zeigler., B.P., Elzas, M.S.
Simulation and Model-Based Methodologies: An Integrative View, *Published by NATO Scientific affairs Division*, 1984

Product Development Institute Inc.
Doing it Right-Winning with New Products, *Retrieved 07.28.06 from Synergest*, 2001, http://www.Synergest.com

Dr. Robert G. Cooper
Formula for Success in New Product Development, *Retrieved 07.27.06 from Stage-Gate, Inc.,* Apr. 2006, http://www.stage-gate.com

The Teamport™ Roadmap Design Process: Global Project Design, http://www.gpdesign.com

HOW CGN HELPS

CGN is a Business Performance Consulting firm that works with Fortune 500 companies to help them identify ways to achieve 'Superior Business Results' by increasing leader visibility to cost, quality, and yield management. CGN solutions are built around key levers that can help organizations achieve and deliver both short term and long term improvements, ultimately leading to breakthrough growth.

TO LEARN MORE

If you would like to understand how you can take advantage of The CGN Way℠ to overcome your businesses challenges or pursue new opportunities, please contact us at 1-888-RING-CGN or visit us at www.cgn.net.

Key Words: Simulation Analysis, Forecasting, Predictive Modeling, Program Management, Requirements Management, Process Improvement, Risk Management, Optimization, and Time Compression