Affordability Simulation: Cost Analysis in a Simulation Environment

The Challenge

Federal systems are becoming increasingly complex. Whether homeland security, defense, air traffic control or Medicare tracking, the systems that support these programs can no longer stand alone. They are becoming, or already have become, a "system of systems." Current design methodologies have not kept pace. For the most part, systems have been designed as though they were independent of all other systems. Although it is obvious that a change in one system will impact other parts of the greater "system of systems," it is difficult to understand those impacts.

The Department of Defense (DoD) has made significant inroads into this system-of-systems approach through modeling and simulation. There are many simulation tools that can assess performance and model battlefield environments. None of these simulation environments, however, consider affordability.

What something will cost is usually left until a system design has been determined, and cost is used to optimize the design based on budget and performance trade-offs. The problem is that, by this time, the impact of cost of the system of systems is either too late to be considered or is forgotten.

Affordability Simulation strives to give designers and mission planners a means to understand cost trade-offs, while conducting early performance simulations. Although the cost calculations will not be exact, they do give decision makers enough information to determine whether the system of systems they are evaluating is affordable.

Why Now?

Historically, simulation routines have been difficult to run, because they required massive computers and extensive programming. Cost analyses have all been point solutions, because data are hard to come by and cost relationships are difficult to develop.

Over the past 10 years, significant advances have been made in both arenas. Computing power has advanced to the point at which simulations can be run more often and developed more rapidly. It is still a challenging science, but the time has come when cost factors can now be integrated into the simulation environment without adversely impacting the simulation.

Cost trends have been studied enough to understand the impacts of new technologies, and these can be modeled parametrically. With the development of open technology, no longer do cost estimating relationships have to be closed to one modeling environment. Now, these cost estimating relationships can be modeled and shared, which allows for the integration of these models into a simulation environment.

Although technology advances have made this possible, there are other challenges that need to be overcome. System-of-systems design concepts are immature. Many experts still argue about the proper metrics for modeling system of systems. Individual cost models are difficult to design, too. These models require a blended team of experts to agree on relationships that include a variety of assumptions. These two uncertainties make Affordability Simulation a challenge and are but two of the challenges faced in this area.

Figure 1

How Does Affordability Simulation Work?

The goal of Affordability Simulation is to place cost as a variable in the simulation environment. Over the past five years, PRICE Systems has completed extensive research in this arena. This research has been conducted internally and jointly with various customers. The results of this research and development fall into four areas:

- Requirements Modeling
- Visual Cost—Design-Level Cost model analysis integrated with engineering Computer Aided Design (CAD) models
- Obsolescence Planning

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An Open Framework

Each of these areas contribute to an overall open framework that allows users to interface with their existing modeling and simulation environments, as well as other traditional reporting environments. The example in figure 1 is built in an integrated Commercial-off-the-Shelf (COTS) framework using the following:

» PRICE System's TruePlanning® Framework with True S (software) and True H (hardware) catalogs
» Engineous™ FIPER Optimization Framework
» Detection Performance model built in Microsoft® Excel
» Customer-provided models representing some of the systems
» CAD models of specific systems

Other components can be added, particularly within the frameworks provided. For example, adding an additional cost model is possible—the TruePlanning® Framework allows this easily. Adding another node in the simulation is equally possible—FIPER is built for exactly this purpose. As long as the new additions are also built with an open framework, they can be added with minimal effort.

Together, these components make up an Affordability Simulation capability that is appropriate for a team of mission planners, program managers, engineers and others who are not typically part of the cost analysis process. All users need to keep in perspective the idea that this does not replace the typical cost analysis, which needs to be performed for any system. However, what it does is provide a basis for decision making that includes cost impacts early in that decision-making process, which is extremely valuable.

User-Defined Scenarios

In today's environment, mission planners are constantly evaluating different scenarios. These can be war time, peace time, centered on a specific need or strategic in nature. For an Affordability Simulation capability to be useful, it needs to be flexible. The thought process is that the scenario is typically driven by some other modeling and simulation environment, so the Affordability Simulation methodology will have the ability to apply the output from that other environment as an input. In the approach shown in figure 2, the user can define the scenario to be analyzed.

Here, the user-defined information in the node (system within the system of systems) is passed to a modeling environment, which is represented here by the Excel model. The outputs are then sent to three TruePlanning® sessions. Although shown here in series, the optimization run allows this to occur in parallel. Those TruePlanning® sessions calculate the hardware and software costs as well as the integration costs to implement the system of systems. Each run feeds these elements to a calculator producing a user output with software cost, hardware cost and a total system-of-systems cost. This is a typical scenario. The COTS products allow the user to insert various sessions, add more nodes or optimize other items.

After the user has defined the scenario, the Affordability Simulation environment kicks off an optimization routine to analyze the best mix of systems within the scenario. Each mix is then broken into components of hardware, software, communications and data links. Then each is processed through a series of cost models to determine the hardware and software costs for each system, as well as the overall system-of-systems cost. The optimization routines help the user focus on a specific set of variables that could include budget, performance, time, size of the system and other factors.

People who run optimization routines often understand that an effective optimization may take several hours. This Affordability Simulation allows the user to define whether they want a quick run (few optimization checks) or several runs (well-refined optimization). This flexibility allows the user to have rough order of magnitude affordability answers quickly and more precise answers when time allows.

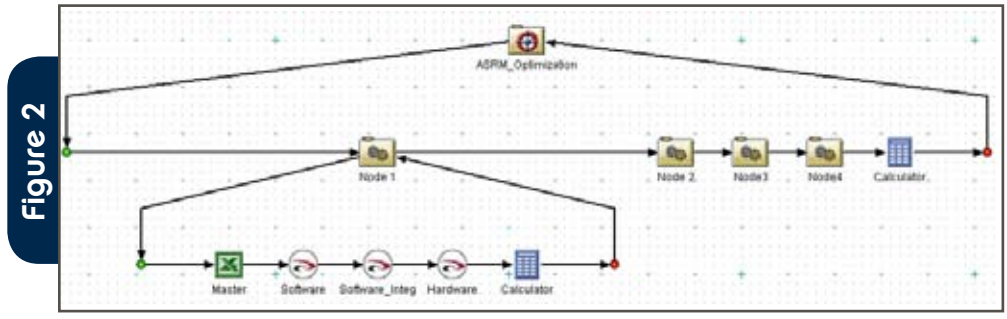

Figure 2

Affordability Simulation strives to give designers and mission planners a means to understand cost trade-offs, while conducting early performance simulations.

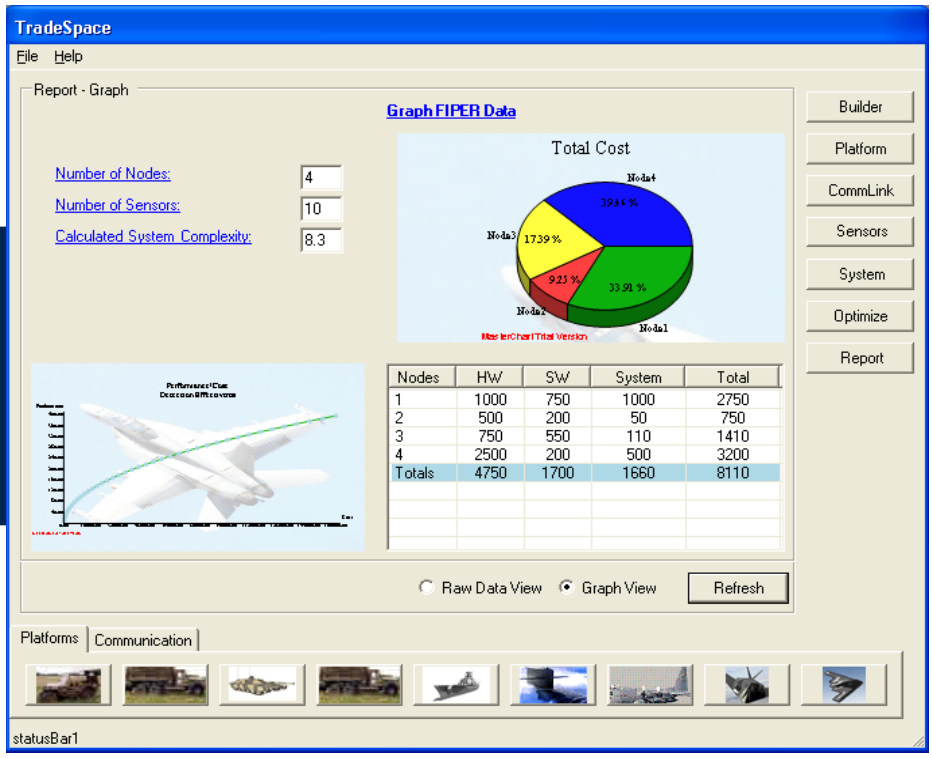

Figure 3

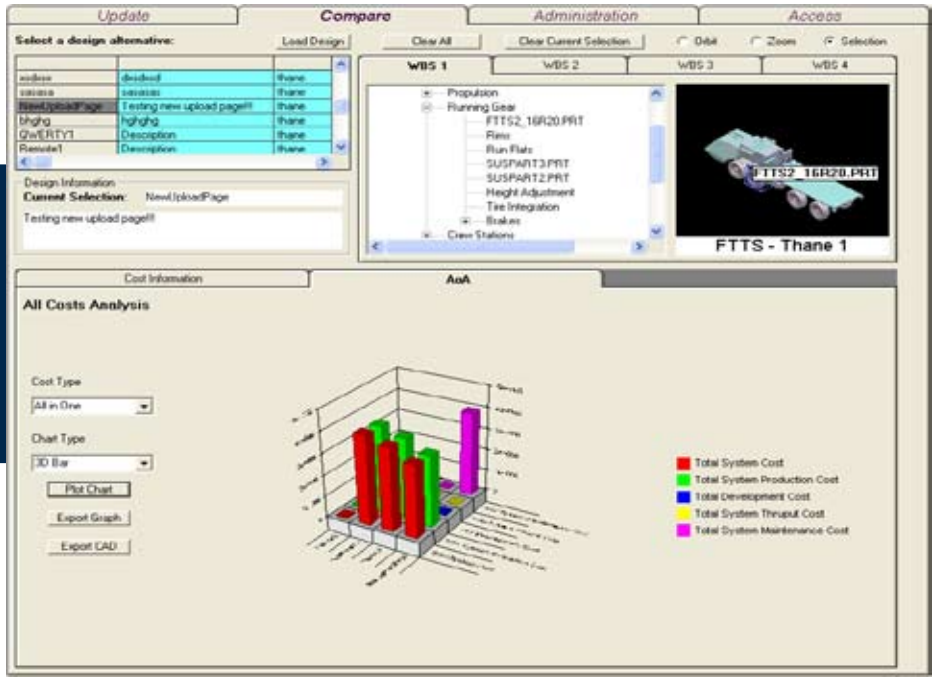

Figure 4

Results

The Affordability Simulation outputs are varied. For this effort, a quadrant chart approach (figure 3) was taken to allow the user to see multiple outputs at one time. By selecting even just one of the outputs, the user can obtain more information. This is where the value of Affordability Simulation is first recognized. The user can analyze this information to determine whether different scenarios offer better performance for a given situation. Also, users can determine the performance per dollar they are willing to pay and work the analysis backward to determine what the optimal system of systems will be.

Further Affordability Analysis

Assuming users find a simulation run they like, they then can begin to perform what-if analyses on the individual systems within the system of systems. This is performed with the Visual Cost Module or the Obsolescence Module. Figure 4 shows a user analyzing a future tactical truck with the Visual Cost Module. This is where both production and lifecycle costs are calculated, and a user can make piece-part changes at the work breakdown level and perform additional analyses of alternatives.

What Is Next for Affordability Simulation?

Affordability Simulation is just now becoming a reality. Research has shown that Affordability Simulation is possible and practical. Technology has advanced to the point at which it doesn't take a major investment to build a simulation environment. Current frameworks are available off the shelf. As with any solution, though, modifications are needed and enhancements for specific users will be required. DoD is investing money into these areas and, soon, commercial vendors should be in the position to develop a marketable package.

Today's budgets and needs require planners, engineers and developers to accurately assess overall costs early in their concept development and throughout the lifecycle of the program. System-of-systems models are being developed to allow trade-offs within the overall system and determine impacts on each of the components of the system. Affordability needs to be a part of that assessment, and with Affordability Simulation, it can be and it should be. It's time to implement such an approach.

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For more than 30 years, PRICE Systems has remained dedicated to a philosophy of continuing to be the premier commercial provider of cost research. Today, our global network of experts performs independent research and information gathering throughout the aerospace, defense, government, civilian and commercial sectors. This continued philosophy results in three significant contributions to our customers:

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» PRICE Systems KnowledgeNetwork®. This repository for metric benchmarks of actual projects continues to grow as increasing numbers of projects are added. Software and Information Technology projects are the most recently added. The data come from our customers, purchased databases and independent research.

» PRICE Systems Custom Models. Engineers and analysts can develop custom models rapidly and accurately using a common technology and methodology to define functional components, structure, activities, cost drivers and processes. Additionally, PRICE Systems analysts and programmers build custom modeling environments for our customers that meet their specific needs. The Affordability Simulation modeling environment described in this paper is a custom environment built by PRICE Systems and JKJ Engineered Technologies under contract to DARPA. JKJ Engineered Technologies provided the system performance research and analysis that was integrated into the solution.

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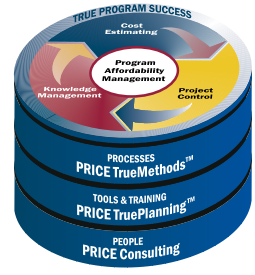

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