

## Saving an Estimated \$1.2 Billion with a Design-to-Cost Methodology

Raytheon Systems

**Raytheon**

The U.S. Navy points to the AIM-9X missile as a flagship program for its design-to-cost initiative, estimating that a savings of \$1.2 billion has been achieved in the development and procurement process. Previous missile programs have been hit with large cost overruns that, in some cases, have doubled their cost. To prevent it from happening again, the joint Navy procurement team in charge of the AIM-9X program puts contract incentives in place to achieve target cost goals and insists contractors consider reducibility metrics and risk management in the design process. To meet the Navy's challenge, engineers from Raytheon Systems (formerly Hughes) and Galorath Incorporated jointly develop a software package. Design engineers can quickly evaluate the cost of a wide range of design alternatives and estimate the risk of cost increases in various subsystems.



Jim Charlton, Raytheon's Affordability Manager for the program, says, "The software allowed the design team to treat a dollar the same as an ohm, a kilogram, or a newton, ensuring cost was considered in virtually every design decision on the program."

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The AIM-9X Evolved Sidewinder is the latest member of the AIM-9 short range missile family currently in use by more than 40 nations throughout the world. A few months ago, the first air launch was successful. The

AIM-9X is in the engineering and manufacturing development (E&MD) phase and is roughly one year from production. It's a shortrange, launch-and-leave air combat missile that uses passive infrared (IR) energy for acquisition and tracking, and complements the Advanced Medium Range Air-to-Air Missile (AMRAAM).

The agile airframe, coupled with other advanced features, gives fighter pilots a significant tactical advantage in the dog fight area. AIM-9X provides:

- 1) full day and night capability
- 2) resistance to countermeasures
- 3) increased off-bore sight acquisition and launch capability
- 4) increased maneuverability and
- 5) improved target acquisition over the current inventory.

AIM-9X is a joint U.S. Navy and U.S. Air Force program with the Navy designated as the executive service. The Air Force plans to buy 5,080 and the Navy 5,000 missiles over a planned 17-year production run.

### **Making a Fixed-Price Commitment**

Charlton is designated affordability manager for the AIM-9X program mainly because of his work on the program to build the seeker for the Advanced Short-Range Air-to-Air Missile (ASRAAM), produced by Matra BAE Dynamics. In that program, Raytheon had to give a firm fixed price for a total package that included development and production of a fixed quantity of seekers. Taking this program on a fixed-price basis presents a significant risk and Charlton and other Raytheon engineers manage it by

developing a series of Excel macros to help engineers consider cost during the design cycle.

The macros provide a convenient method for summarizing four different types of costs:

- 1) material quotes from vendors,
- 2) internal estimates of labor costs for fabrication and assembly,

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- 3) rework of components that failed to make first-pass inspection, and
- 4) internal support expenses.

The macros allow engineers to enter estimates for any desired level of detail, from subsystems to individual components, and quickly roll up the costs to provide an overall program benchmark.

The tool proves to be a success in keeping the costs for this program under control. Mel Broder, Manager of Cost Tools and Processes, wants to take advantage of the lessons learned on the AIM-9X, but believed this tool isn't completely up to the task of providing design-to-cost input for the much larger program.



"The first problem," says Broder, "was that the Excel-based tool was deterministic-it generated a single number for the cost of the program based on the assumptions entered by the design engineers. What was lacking was a way for engineers to take into account the uncertainty involved in the design process."

Broder continues, "For example, what if a new technology we were planning on using to save money failed and we had to go back to an older, higher-cost approach. In any program, there are many such risks and we wanted to take them into account so that we would have the opportunity to choose a slightly more expensive, but less risky approach. Another problem with the spreadsheet was that it is inherently subject to errors. Entering a number in the cell next to the one where it should be could throw the cost estimate off by millions of dollars. We knew the complexity of the AIM-9X program would have resulted in a big spreadsheet and it would be impossible to prove its accuracy. Finally, if we had stuck with the spreadsheet approach, we would have had to support and upgrade it ourselves. This would be difficult because its authors wanted to pursue independent career paths within the organization."

### **Developing a Custom Software Tool**

"We created a functional specification for a commercial tool to incorporate our algorithms while providing risk analysis and auditing capabilities," Broder says. "We looked at what was available in commercial cost models and after a rigorous source selection, the SEER for Manufacturing (SEER-MFG<sup>™</sup>) software package from Galorath Incorporated ([www.galorath.com](http://www.galorath.com)), El Segundo,

California, was declared the winner. SEER-MFG has excellent risk management tools and the capability of accepting custom cost models as plug-ins."

Raytheon engineers supplied their spreadsheet-based algorithms to a Galorath team led by Karen McRitchie, Vice President of Development. McRitchie's team encapsulated each model in a plug-in, taking advantage of the SEER-MFG architecture that provides the framework to easily integrate custom models. Each plug-in is built as a separate executable using a dynamic link library (DLL) that carries a database with process information. The program can access external databases in almost any format. Raytheon currently takes advantage of this capability to provide an updated copy of a database containing standard information such as material cost factors and labor rates along with each copy of the program.



Raytheon engineers use the software from the beginning of the AIM-9X program. In the early stages of the project, engineers enter estimated costs for each of the missile's five subsystems. In previous missile systems, and nearly every defense program of all kinds, designers have taken the basic approach of designing to the requirements and then trying to reduce the cost to make the budget. The problem with this approach is that cost isn't considered until the design is largely fixed, when it's too late to have a major impact.

Another problem in the past was that engineers often accepted every new technological development that came along while the program was underway, primarily because they had no way to determine its impact on meeting cost objectives. Finally, with cost as only a minor consideration, risk isn't considered at all. The result is a tendency to gamble on uncertain technologies whose failure in midstream would make it necessary to fall back on much more costly alternatives.

### **Budgeting Cost among Subsystems**

"The availability of a tool that allowed for both cost and risk to be considered from the start of the program allowed the Raytheon AIM-9X team to take an entirely different approach," Charlton says. "At the very beginning of the program, engineers begin entering data into the SEER-MFG

tool to estimate the cost of design alternatives. As expected, in the beginning engineers simply estimated the cost of the five major subsystems of the model. Even this high level estimate is extremely useful at the start of the project in getting engineers to think what sort of budget each subsystem would bear."

"The approach that they use, which is unlike any missile program that had preceded

it, is to allocate the budgeted cost among the various subsystems. This forces them to make necessary tradeoffs, including thinking about ways requirements could be removed or performance constraints relaxed while still meeting the overall program objectives. This basic process was repeated, at increasingly finer levels of detail, as the project continued," says Charlton.

"As the program moves down the development pathway," Charlton says, "the modeling grows in complexity, but maintains the same basic framework. This makes it possible to use higher levels of detail in some parts of the project and lower levels of detail in others in the same model. The original algorithms, by the way, incorporate learning curves, permitting the engineers to separately estimate the production price for each of the 20 lots planned for the program, each corresponding to approximately one year's production. The ability of the model to handle risk is a key factor in holding down the costs of the project."

For each subsystem or component, engineers enter an expected cost, lowest possible cost, and highest possible cost. These figures are automatically rolled up at the subsystem and program level. This simplifies focusing attention on the areas of the program with unusually high levels of risk. In some cases, they go with the more costly, but less risky technology while, in other cases, additional engineering resources focus on the component or subsystem to reduce the risk factor.

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The power of the cost estimation tool is readily apparent, leading Navy program managers to request and receive regularly updated copies of the model so they can closely track engineering design-to-cost efforts. Charlton says, "The net result is something many people involved in the procurement process thought they'd never see. The development process is nearly completed and the development and production cost estimates made four years ago haven't changed." Navy Commander Mike Skratulia, Deputy Navy Acquisition Reform Executive, points to the AIM-9X program as the greatest success to date in the Navy's cost as independent variable (CAIV) program. If Raytheon is able to maintain the original cost estimates through the program's 20-year life cycle, the savings could be much higher than the \$1.2 billion figure Skratulia has publicly cited as the savings.

The success of this project has firmly established the design-to-cost concept and the custom software tool called RAYCOST as an essential part of the engineering process at Raytheon. In fact, Raytheon has expanded the tools applicability to include parametric estimating using weight-based inputs.



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