Save Six Man-Months per Proposal with Estimation Process

Lockheed Martin Mission Systems

Two primary launch ranges support U.S. Government (DoD and NASA/JPL [Jet Propulsion Laboratory]) and other government-sponsored launches and missions in the continental United States. Vandenberg Air Force Base (30th Space Wing), located in southern California, north of Santa Barbara, is responsible for all Department of Defense space and missile launch activities on the West Coast. The Eastern Launch Range at Cape Canaveral, Florida (45th Space Wing), supports similar missions, and is also responsible for launching the world-renown Space Shuttle. Both ranges launch a myriad of expendable vehicles including the Athena, Atlas, Delta, Pegasus, and the Titan, as well as support Air Force development and evaluation of all intercontinental ballistic missiles.

Two ranges are needed to avoid launching near populated areas. The orbits in which they launch satellites distinguish the two as Vandenberg launches satellites destined for near polar orbits, while Cape Canaveral launches for equatorial orbits.

Background on the Launch Ranges

Both serve as vast tracking, telemetry, and command complexes. Their electronic and optical tracking systems collect and process launch-related data for a variety of users. Prior to launching a spacelift mission, the trajectory of the vehicle or missile is carefully analyzed to determine the limits of a safe launch. Sensors are deployed around the world to track progress of the launch vehicle and the generated data is delivered over a wide area network to mission command. Mission controllers carefully track the progress of the launch vehicle and destroy it when it moves outside safe boundaries.

In the early 1990s, surveys of spacelift launch facilities at both locations indicated a need for extensive repairs and replacements of many supporting elements. A great deal of hardware made it difficult to operate and maintain.

The Need for the New Estimation Process

In 1993, the Air Force initiated the Range Standardization and Automation (RSA IIA) Program, a long-term effort to modernize the nation's two spacelift ranges and, more specifically, the complicated high-tech tracking and data systems known as the Spacelift Range System (SLRS). In late 1995, Lockheed Martin Mission Systems in Santa Maria, California, was chosen to conduct the RSA program. The goal was to provide safe mission execution and staunch customer support, standardize designs and interfaces, and improve flexibility, capacity, and responsiveness of the SLRS.

To reach this goal, Lockheed Martin implemented a structured software cost estimation process that saved an estimated six man-months per proposal. With up to three proposals submitted per year, the savings are substantial. Most of the time savings came from the new cost estimation process providing a consistent method that was understood and accepted by the customer, the Air Force Space and Missile Systems Center. This reduced the need for discussion and rework of estimates. The estimating process offered more efficiency because the new method automated the large amount of manual data entry and calculations.

Previously, each product team had the option of selecting its own cost estimation method, which required a considerable amount of explanation when presenting estimates to the customer and frequent changes. By implementing the new method, each product team estimated the size of its project and helped determine parameters for estimating productivity using a knowledge base of

completed programs. This method was recently accepted as a best practice in the company, which will lead to broader use.

Previous Cost Estimation Method

The RSA IIA program required several major software proposals a year, each began with the development of a technical solution. Typically, six product groups might be required to participate: for example, flight analysis, which models the successful launch boundaries; flight operations, which tracks the launch vehicle; and networking, which transports data from the sensors to mission control. In the past, each of the product groups used its own estimating method. Some would make an engineering judgment call by directly estimating the number of hours that would be required. Some would base the estimate on the size of the team needed. Even when two groups used the same approach, the details of their methods were different so estimates were not comparable. The teams spent a lot of time calculating estimates on spreadsheets. Before presenting the estimates to the customer, management reviewed the estimates and often requested changes, sometimes multiple times. It took a large effort to reconfigure and check the spreadsheets when redoing them.

After management signed off, teams compiled estimates into a proposal and presented it to the customer. Since the different pieces of the proposal were generated by different methods, there was room for discussion on why one method was used in one part of the proposal and another method elsewhere. Often the assumptions used by the different product groups were not fully documented.

The meeting usually involved six to 12 people, lasted a full day, and ended with the client requesting another iteration of the estimate from some or all of the product groups. Several

people from each of these groups spent a couple of days collecting information, revisiting their assumptions, and recalculating their spreadsheets.

The revised quotation would go back through the management review chain. It would be presented at another meeting the following week, occupying the same participants for another day. Typically three or four such meetings would be required to finalize the proposal. This also required days of effort from the product teams for re-computing their estimates.

Implementing a Structured Approach

Greg Braun, manager, RSA IIA Process Engineering and Metrics, originally responsible for the structured software cost estimating process for Lockheed Martin's Western Development Labs in San Jose, was asked to establish the same process for the RSA IIA program. "There are several basic advantages to the structured approach," Braun said. "First, providing a consistent and systematic method that is understood and agreed to by everyone involved in the process eliminates the need to revisit methods and assumptions for every proposal. Second, the use of a standardized approach makes it possible to implement software that can substantially reduce the time otherwise required to enter data and manipulate spreadsheets."

Braun said that there were several commercial tools available for structuring cost estimates, but this project's customer made it clear it preferred SEER-SEM™ from Galorath Incorporated (www.galorath.com), El Segundo, California. SEER-SEM's advantage was its database of thousands of completed projects from client/server, embedded, distributed, and stand-alone systems, varied MIS applications, graphics, and signal processing environments. This database made it possible to immediately begin generating accurate estimates, even when little or no historical records are available.

The process that Braun developed for the Space Support Systems operation in Santa Maria worked as follows: Each product group started by producing a technical description that was broken into the smallest pieces possible at this early stage. Then the engineers provided three estimates for the size of each block of code: most likely, optimistic, and pessimistic.

The engineers were also responsible for determining SEER-SEM's parameters to estimate the productivity rate for the project. One such parameter measured the level of formality of the program. A manned space flight, for example, required a very formal program run to military standards so that high-level designs, detailed designs, and test plans were shown at standup presentations requiring heavy-duty preparation.

The majority of military programs now use high-grade commercial standards that involve technical interchange meetings demanding less preparation. Other included input parameters in the software estimation model were the application type, language, application complexity, development method, and experience level of the project team.

Users entered probability levels for each parameter so that the risk of changes in these parameters could be incorporated into the final cost estimates. The parameter settings were reviewed over the entire proposal to ensure the accuracy and relativity to others for each component.

Understanding the Risk Involved

Next, SEER-SEM accessed its knowledge bases to identify programs similar to the ones needing an estimate and generated productivity rate predictions. These included a probability range for the potential rate based on the uncertainty factors entered by the estimators. The estimates, along with the estimates for the

size of the project generated earlier, were entered into a Crystal Ball, a Monte Carlo simulation program for performing statistical analysis on the estimate to determine the range and probabilities of all possible outcomes of the model.

The results showed an overall probability distribution for the simulation. For example, management might learn the program has a 50% level of confidence of taking 20,000 hours or less, a 90% level of confidence of taking 25,000 hours or less, and a 100% level of confidence of 32,000 hours or less.

The SWEM produced a Software Bid Summary summarizing the categories and size of the required SLOC along with the productivity rates from the Monte Carlo Simulation. At this point, management determined how much risk to assume in making the estimate. After rewarding the contract, the SWEM re-ran periodically throughout the development lifecycle. During this period, early estimates of size, product complexity, and team composition were placed with actuals and/or more accurate estimates. The updated model supported management assessment of the effort to date plus the estimation for completing the project.

"This new approach has dramatically improved the efficiency of the cost estimation process," said Ed Butt, RSA IIA program director for Lockheed Martin. "Both our program managers and our customers understand the process and have confidence in it, so there is not much to discuss," he said. "The only areas that typically come into question are the input parameters and the program size estimates. We can make changes in these areas and rerun the model in less than an hour. The result is that we nearly always come to an agreement in the initial meeting, saving something on the order of six man-months that would otherwise be involved in additional meetings and reworking the estimates."

Ralph Tourino, vice president of Mission Systems' Space Support Systems, said, "This process represents a significant step forward in the acceptability of software bids by our customer, and also in our ability to accurately predict program performance. That's why we have approved this method as a best practice within Lockheed Martin. We are already in the process of implementing it in other divisions," he said.

For more information contact:

Galorath Incorporated
222 Sepulveda Boulevard, Suite 1700
El Segundo, CA 90245 USA
Telephone +1 310.414.3222 Fax: +1 310.414.3220

www.galorath.com info@galorath.com

Galorath International Ltd.
Suite 10
Basepoint Business Centre
Andover
Hampshire
SP10 3FG
United Kingdom
Telephone +44 (0) 207 788 9042 Fax: +44 (0) 207 138 2642