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The Ogden Air Logistics Center Develops Software That Automates the Minuteman III Messaging System

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Without the Higher Authority Communications/Rapid Message Processing Element (HAC/RMPE) developed by Detachment 1, Ogden Air Logistics Center (ALC), the Minuteman III missile crews would be forced to resort to manual message decoding and processing. Instead, Detachment 1's software automatically collects communications data and displays it on computer screens, including duplicate suppression, error correction, and message formatting. The software reduces errors in incoming message formatting and speeds up processing.

The software program maintained by Detachment 1, Ogden Air Logistics Center (ALC) to support the Higher Authority Communications/Rapid Message Processing Element (HAC/RMPE) automatically codes and passes information for the Minuteman III missile crews into a Weapons System Control Element, which has the computer system that fires the missiles. Detachment 1 of the Ogden Air Logistics Center codes the software based on requirements from the Joint Chiefs of Staff and the Commander in Chief, U.S. Strategic Command. This allows the Minuteman III missile crews to receive changes that keep the missiles using the same Single Integrated Operational Plan (SIOP) as the manned bombers and Submarine Launched Ballistic Missiles (SLBMs).

Formerly, those change messages had to be manually handled. They were received over various communications systems printed out in the capsules, then processed individually by hand. The HAC/RMPE software collects incoming messages and displays them on the missile crews' computer screens, including conducting duplicate suppression, error correction, and message formatting. The crews are then able to do any alterations necessary and automatically feed the information into a Weapons System Control Element, the computer system that fires the missiles.

The HAC/RMPE software reduces errors in incoming message formatting and speeds up processing. No operational time has been lost due to failure in the system. "It is a project that successfully handles unpredictable volumes of changing requirements," notes Capers Jones, a Top 5 judge. "It received very high usability scores from users and had very good user satisfaction."

Another judge agrees. "This project had a perfect customer rating and appeared to perform flawlessly in all important customer respects," says Watts S. Humphrey.

These accomplishments were made despite the fact that the HAC/RMPE operational system is very antiquated, and severely limited in available memory for the additional functions. Yet, despite this limited memory, the Detachment 1 engineers and programmers, led by Toni Estes, Programming Team lead, have never had to decline a new requirement based on technical limitations. In fact, just last year they developed new techniques to allow even more HAC/RMPE messages to be utilized.

The Delivered Product

Staff loyalty is the big thing that contributes to the project's success, stresses Capt. David Selnick, detachment commander. "I can't emphasize that enough. It's a high-pressure environment with short deadlines." In fact, he says that some of the equipment is so old, they are the only ones in the country still using it; mechanical upkeep is time consuming and difficult as no commercial/private sector languages are used in the operations.

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Selnick adds that the team does not get predefined requirements documents. They have to figure that out themselves. "We get information on the fly like everyone else in the SIOP community. We determine the effect on the missiles, and what the software has to do to meet it -- all within weeks of the deadline."

Despite the many professional drawbacks to working on this project, Selnick credits the "esprit de corps, importance of the mission, and personal dedication to that mission" for job retention. "More than half of our employees have been here since before 1997 -- proving that people are not just marking time or counting the days until they can move to a more marketable position."

Estimation efforts are made based on research, design, and coding time alone. Size is not a factor unless the change request being considered would require alteration of an extreme number of files or use an excessive amount of system memory when operational (since the HAC/RMPE system has very little memory on which to draw). In that case, an estimate of memory usage would be made based upon the amount and type of data to be stored.

A Unit Test Procedure Sheet (UTPS) is used to document all steps that will be taken to test the change. It also doubles as a record of the actual test, as each test step is presented in checklist format.

"David Shaw and SrA Joshua Babcock comprise the detachment's software testing team. They use a system Test Procedure Sheet (TPS), which is similar to the UTPS on on a system-wide level. They also update the electronic TPS database, which was created to reutilize similar test procedures as well as provide a history in case the entire system ever needed to be re-qualified. The test report includes the completed TPS form, as well as written documentation of everything that occurred during system testing, including any new or preexisting but undiscovered problems. Diane Moen, configuration manager, then releases the Software Version Description to highlight differences between the last release and the current one."

Reliability and Quality

While the technical challenge of this project appears to be typical, the reliability and quality parameters dictate otherwise. "The operational issues and highly sensitive nature of the application appear to make this a demanding technical project," says Humphrey.

Testing is performed on a HAC/RMPE console that is identical to the consoles in the missile capsules, as well as a simulator for a related system called the Weapon System Control Element (WSCE), which is also located in the capsules. Other test equipment includes a message generator that can mimic message traffic from any of the three communications platforms with which HAC/RMPE is designed to communicate, as well as several PCs and two protocol analyzers. Humphrey also gave the ALC high marks in quality assurance. "The Ogden process is comprehensive and the activities described are important. The broad use of measurements is impressive and the organization appears to be following a well defined and stable process."

First, peer reviews are conducted for every product produced. These are documented, and metrics are kept on number of defects, type, and rework time. Second, the configuration management program ensures that all release products are monitored, tracked, and documented throughout the entire software development process.

TSgt Scott Sorenson, the software quality assurance (SQA) representative, regularly audits the products for compliance; recommends changes or improvements; and keeps work time, requirements stability, and other relevant metrics. The software process improvement team, which meets as often as needed but at least quarterly, addresses issues that will enhance the simplicity and effectiveness of the software process. This team has at least one representative from every employee work area (process management,

has at least one representative from every employee work area (process management, programmer/engineering, CM, SQA, and testing) to ensure that everyone's point of view is considered.

Capt Selnick, a Project Management Professional certified by the Project Management Institute, provides project oversight. Finally, a combined design review is performed with representatives from General Dynamics who are working on a version of the HAC/RMPE system to be used with a new type of survivable radio communications system. This combined review ensures that nothing "slips between the cracks."

When determining its effort metrics throughout the process, the detachment defines its versions of cost performance index (CPI) and schedule performance index (SPI) in a manner that best suits their needs. When measuring CPI, cost is assessed in terms of man-hours only. This is similar to the traditional definition of SPI. Goal is 1.0. CPI = 0.79.

The interpretation of this is that the estimate was within acceptable tolerances -- due to the high volatility of the team's work, anything between 0.75 and 1.2 is considered within control. Capt. Selnick explains that the introduction of late requirements and the deletion of existing requirements at the last minute frequently play havoc with this metric. (Detachment 1 must account for actual hours expended on tasks that were not originally planned for, and it must discount hours spent on tasks that the customer decides at the last minute they do not want).

Regarding SPI, the percentage difference between planned and actual completion dates are computed slightly different than the traditional definition of SPI. Detachment 1 assesses the percentage difference between planned and actual in terms of calendar days. It calculates the length of time from project start to the actual milestone date, and divides it by the length of time from project start to estimated milestone date. In order to get a percentage difference, subtract this number from 1, and multiply by 100. This is a much more important measure to Detachment 1 than is CPI, because its end date is non-negotiable. Therefore, it can tolerate more variation in man-hours than it can in actual date slippage. This metric is calculated at three major milestones: delivery of SIOP Software Specification Matrices, delivery of engineering version of software to The Boeing Company, and delivery of final product to the field. The goal is zero or higher. Positive variation (delivering early) is good; negative variation (delivering late) is bad. All of last year's numbers were either zero or positive (on time or early).

The Cost per Stage is measured in man-hours. The different stages of the process are assessed in terms of their overall contribution to the total cost of the release. This metric does not include higher-level testing, since these dates and workloads are fixed by external agencies, and the team has little control over them. This historic data allows it to improve its estimation process.

What is the result of all these efforts? Operators have never encountered an error that would require them to stop using the software. No mission time has ever been lost due to a HAC/RMPE software error. SIOP interdependence means the software release date cannot be missed. While mandatory requirements are often introduced or changed months after they are supposed to be finalized, Detachment 1 has never failed to meet a date, and, in fact, often releases early. Required software functionality has never been reduced in order to meet the deadline.