

Raytheon integrates systems & software processes to reduce defects, improve predictability

Headquartered in Lexington, Massachusetts, Raytheon is a \$17 billion defense and aerospace systems supplier with 76,000 worldwide employees. Raytheon is an industry leader in defense, government and commercial electronics, space, information technology, technical services, and business and special mission aircraft. Strategic mission areas include precision engagement weapons, missile defense, homeland security, and intelligence, surveillance and reconnaissance.

Citing the significant benefits of a 15-year legacy of corporate-wide software and systems process improvement and integration programs, Raytheon businesses and programs continue to mature and integrate their processes for systems and software engineering, product quality, and program management.

The company has measured significant gains in lower development costs and product defects, improved schedule predictability, and increased customer satisfaction levels resulting from its software process improvement programs. Business leaders forecast continued gains as Raytheon further integrates its systems and software disciplines within its corporate processes.

Raytheon uses an integrated, three-part process strategy to ensure that its corporate business goals map to its product development, program management, and customer satisfaction measures (see figure). The overarching element of this strategy is Raytheon's corporate-wide, tailored implementation of the popular Six Sigma quality methodology (in a variant named "Raytheon Six Sigma," or R6σ).

The philosophies and guidelines of R6σ are further instantiated in the more detailed Integrated Product Development System (IPDS), used as the corporate guide for all aspects of doing business, developing products, and serving customers. Raytheon's corporate-wide commitment to the

Capability Maturity Model Integration (CMMI[®]) framework serves to solidify the integration of systems and software engineering prescribed in the company's IPDS methodology and also helps to measure progress in IPDS and R6σ.

'Systems of Systems'

In several large "systems of systems" programs, Raytheon is using high-maturity, commonly shared processes to enable consistent practices among dispersed, multi-team development programs. The company also credits the shared use of

mature processes as a key management approach to maximizing the effectiveness of tool environments, metrics programs, and management practices throughout its development teams, supply chain, and customer organizations.

All of Raytheon's leading businesses and programs are working to implement the Level 3 activities described in the CMMI. The company is equally committed to corporate-wide implementation of full CMMI Level 5 operations once Level 3 is attained. Fulfillment of these aggressive goals is facilitated by an extensive body of assets and expertise derived from a legacy of integrated process improvement and product quality initiatives.

Consortium training courses, action planning workshops, assessments, appraisals, and other forms of consulting

IPDS, CMMI, and R6σ Work Together



Programs integrate R6σ, IPDS, and CMMI into their plans

Raytheon integrates its own tailored version of Six Sigma, its Integrated Product Development System, and CMMI processes to wield an all-inclusive approach to quality engineering.

*CMMI is registered with the U.S. Patent & Trademark Office by Carnegie Mellon University.



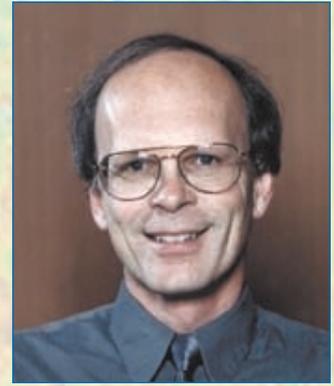
Dr. Peter Pao

Corporate Vice President, Technology



Jack Kelble

President, Raytheon Space & Airborne Systems



Dan Nash

Corporate Engineering Director of Software

services are being tapped at the corporate and business level and on key programs such as DD(X), NPOESS, and others. DD(X) is the U.S. Navy's 21st Century surface combatant ship; NPOESS (National Polar-orbiting Operational Environmental Satellite System) is the nation's next generation environmental/meteorological satellite system.

Consortium offerings and expertise are also being used in a variety of CMMI implementation programs throughout Raytheon's businesses, including Space and Airborne Systems, Missile Systems, Network Centric Systems, and other companies.

Given Raytheon's extensive experience in a variety of process improvement frameworks over the last 15 years, Consortium personnel act as peer-to-peer partners with Raytheon process experts, serving to bring additional 'arms and legs' to the task of process integration and inculcation throughout the company and its supply chain.

R6σ, IPDS, CMMI

Raytheon Six Sigma (R6σ), a company-tailored version of the popular approach to total product quality, serves as the overarching framework through which Raytheon communicates and integrates industry best practices into its development programs.

In turn, R6σ provides the guiding philosophy for Raytheon's Integrated Prod-

uct Development System (IPDS), a comprehensive methodology used as a common process for the entire engineering and product development life-

cycle throughout the company. Raytheon uses the CMMI to provide guidance for creating, measuring, managing and improving systems and software engineering practices within the R6σ and IPDS environments and to measure the overall progress of its integrated process strategy.

"Our process initiatives have significantly improved our program performance on a year by year basis," says Greg

Shelton, Vice President of Engineering, Technology, Manufacturing and Quality. "With Raytheon Six Sigma, IPDS, and frameworks such as the software CMM and the CMMI, our programs perform at a more predictable fashion, defects are sharply reduced, and our customer satisfaction grows."

Early Adopters

Raytheon was one of the first companies to embrace what became known as the software CMM. In 1987, both the Raytheon Equipment Division (now part of the Raytheon government and defense organization) and Raytheon's Fullerton Operations performed assessment of their software development

Consortium training courses, action planning workshops, assessments, appraisals, and other forms of consulting services are being tapped at the corporate and business level

process using the Software Engineering Institute's capability assessment questionnaire. Raytheon Fullerton Operations was the first organization in the world to attain software Level 3 maturity, reaching that milestone in 1990. In 1991, Raytheon Electronic Systems also achieved Level 3.

A majority of Raytheon's leading businesses have attained software CMM Level 5, and most have also been advancing their systems engineering maturity pursuant to SE capability models and Raytheon's own IPDS, which serves to integrate the systems and software engineering disciplines. Raytheon leaders see the systemic use of IPDS throughout the company and its synergy with CMMI guidelines as key enablers of their rapid implementation of CMMI Level 3 activities.

"We continue to modify IPDS as we become more familiar with the higher levels of the CMMI framework," says Dr. Peter Pao, Corporate Vice President of Technology and Raytheon's representative on the Consortium Board of Direc-

tors. "IPDS is the way we do business, and is always growing to reflect new best practices and lessons learned. At full adoption, IPDS is a CMMI Level 5 engineering process."

"Since IPDS processes comply with CMMI requirements in areas

where they overlap, our use of IPDS expedites reaching high CMMI maturity levels," agrees Dan Nash, Corporate Engineering Director of Software. "IPDS has served as a foundation for integrating

"Our process initiatives have significantly improved our program performance on a year by year basis."

the engineering cultures of companies acquired by Raytheon in the 1990s and for integrating our systems and software activities in a manner consistent with the CMMI.”

Process ROI

Raytheon’s 15-year experience with advancing its software maturity has created wide awareness throughout the company of the benefits of higher-maturity systems and software processes. The return-on-investment from process improvement is measured qualitatively—in improved morale and customer satisfaction—and quantitatively, in measured gains in defect reduction, productivity, reduced rework, and cost and schedule predictability.

Company leaders anticipate even further gains as Raytheon continues to embrace the CMMI framework. “One of

the biggest benefits I see coming from the CMMI will be even greater predictability in our development processes,” says Jack Kelble, President of Raytheon Space and Airborne Systems in El Segundo, California. “Extending our mature software development practices to embrace other disciplines and life-cycle activities means a more orderly

“One of the biggest benefits I see coming from the CMMI will be even greater predictability in our development processes.”

product and program development process, which translates into greater reliability in meeting our customers’ cost and schedule targets. By further solidifying Raytheon’s ‘past performance’ track record, we continue to generate new business.”

Raytheon Network Centric Systems (NCS) in Fullerton, California, cites substantial productivity gains accruing from Level 5 software practices (see figure). “We’ve worked hard over the last ten years to identify and fix software defects in the lifecycle phase where they



Hope Miller
California Engineering Director
Network Centric Systems

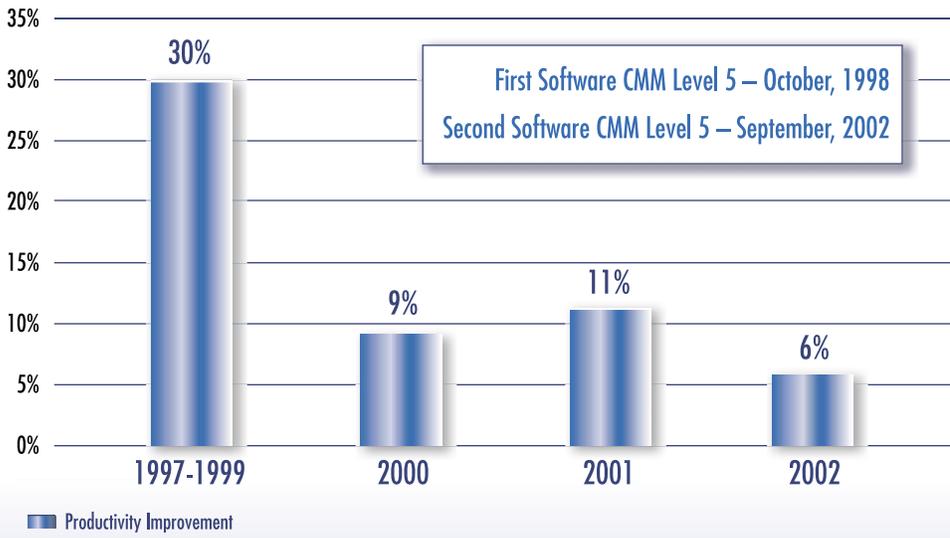
were first introduced into the lifecycle,” says Hope Miller, NCS California Engineering Director. “Fixing defects early in the process is much cheaper than later in the lifecycle, and contributes significantly to increased productivity and far less rework.”

Similar gains have been measured throughout the company. “At the Raytheon Integrated Defense Systems Tewksbury Software Center, we’ve determined that the use of statistical process control and the R6σ process helped to double our defect containment rates,” Nash says. “The Tucson Missile Systems Software Center improved its organizational productivity by a factor of 2.5x as they advanced their software maturity. Raytheon’s Northeast Software Engineering Center has reduced its Cost Performance Index variability by 36% and its Schedule Performance Index variability by 70%, thanks to deployment of Level 4 and 5 software processes.”

“Reducing our cost and schedule variability has been key to improving our programs’ performance,” says Ray Gingras, Engineering Process Senior Manager, NCS Northeast Software Engineering Center. “Using Raytheon Six Sigma to implement CMM Levels 4 and 5 was a natural fit. In fact, I see our use of CMM Level 4 and 5 processes as equivalent to performing ‘Six Sigma for software.’”

“These improvements represent significant gains,” Nash says. “When your actual cost and schedule performance is what you estimated it would be, you’re bidding much more competitively and accurately, which is of great value to your customer.”

Raytheon Fullerton Operations Productivity Improvements from Sustained Level 5 Software Processes



Raytheon NCS (Fullerton CA) has realized significant productivity gains from software Level 5 practices over the last six years. The company measures software productivity as equivalent source lines of code developed per person-month during software design through integration, and has used standardized rules for counting source lines of code and staff months consistently throughout this timeframe. 1997 and 1998 operations were considered to be at Level 5, in advance of the successful Oct. 1998 appraisal. The company’s second successful Level 5 appraisal in 2002 was conducted pursuant to contractual requirements governing large (ACAT 1) defense programs.



John Gatti
 Director of Integrated
 Product Development



Raymond Gingras
 Manager, NE SWEC Engineering
 Process Department
 DD(X) Process Working Group

Corporate Initiatives

Raytheon's integrated process initiatives are paying dividends in many ways, according to company leaders.

"Raytheon has established many integrated mechanisms across our businesses and programs to enable and facilitate common solutions, whether in business management, product development, quality assurance, or process improvement across the entire product development life cycle," says John Gatti, Director of Integrated Product Development and program manager for RECP.

Enterprise-wide process initiatives include senior-level steering groups addressing key programs and strategic areas (including CMMI) and inter-company discipline engineering and technology councils (DE&TC) focused on five common areas specific to their respective discipline (i.e., software engineering, systems engineering): People, Process & Tools, Technology, Communication & Collaboration, and Performance Excellence.

DE&TC byproducts include company-wide engineering symposia, training, and workshops; process asset libraries and repositories; and a variety of other deliverables. DE&TC activities also include process ownership of Raytheon's Integrated Product Development System (IPDS). These products and cross-company collaboration are enabled through the Raytheon Engineering Common Program (RECP).

"The Consortium is enjoying broader exposure across Raytheon and is helping more and more of our programs."

"Through the RECP, we seek out leveraging opportunities that benefit both the respective business and the enterprise, such as common processes throughout Raytheon's product development lifecycle," Gatti says. "We collaborate with all of our businesses through the DE&TC structure to identify the common needs within Raytheon and our customers. This enables our enterprise to solve the problem and satisfy the common need once, instead of each

business having to identify, understand and satisfy those common requirements independently. RECP uses IPDS to engage the engineering and technology community and other key stakeholders to identify their needs. We then merge and synthesize these into a set of common requirements and prioritize them into a roadmap of

specific, scheduled deliverables.

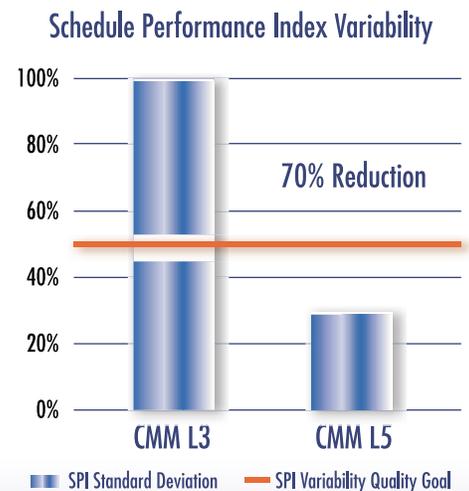
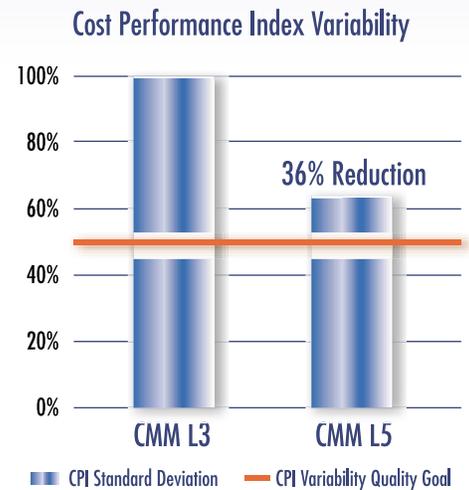
"RECP leverages subject matter experts, stakeholders, and other personnel and resources from all the businesses and from partner organizations such as the Consortium to deliver these products in a predictable way," Gatti continues. "Our activities include further development and sustainment of IPDS, sponsoring our technology network projects, fostering engineering and technology communications, facilitating CMMI implementations, and promoting engineering collaboration with collaborative product development. Each discipline engineering and technology

council provides a 'single storefront' for our customers in a given discipline, offering an intra-company community of interest through council websites, e-letters, seminars and other mechanisms. Councils also serve as 'process owners,' integrating discipline sub-processes into product development and engineering programs."

Consortium on Programs

Consortium courseware, workshops, consulting and other technologies are offered through the council structure to Raytheon program managers. "The Con-

Reducing Cost and Schedule Performance Variability, from CMM Level 3 to Level 5



Level 5 software processes have contributed to significant reductions in cost and schedule variability at the Raytheon NCS Northeast Software Engineering Center.

Raytheon supports CMMI creation & dissemination

Consistent with its early embrace of the initial software capability assessment questionnaire as a framework for advancing software maturity (administering its first self-assessment in 1987), Raytheon has continued to support the growth of process frameworks to benefit the industry at large. Bob Rassa, Systems Supportability Director at Raytheon Space and Airborne Systems, co-chairs the CMMI Steering Group that managed the overall development of the CMMI framework and product suite under the sponsorship of the Office of the Secretary of Defense (OSD) and the National Defense Industrial Association (NDIA) System Engineering Division (which Rassa also chairs).

Several other Raytheon personnel assisted in development of the CMMI framework. Gary Wolf [Raytheon Northeast] helped with development of the model and formal training materials; Jane Moon [Fullerton CA] helped during CMMI development and was instrumental in building Raytheon's internal appraisal program; and Ben Berauer [Raytheon St Petersburg] helped with development of the improved version 1.1 of SCAMPI.

"The software CMM has remained unchanged since its current version was released in June 1991, and the ensuing decade saw a growing recognition of needed improvements and expansions," Rassa says. "The Pentagon came to the NDIA with the initial idea of a 'CMM Integrated' framework to widen the process improvement focus to include the systems engineering

realm. We agreed on the value of this approach and took on the task of populating the CMMI development teams with industry representatives.

"Throughout the process of growing the software CMM's 18 process areas into 22 CMMI PAs, we strove to make the CMMI equally usable by industry and government," Rassa explains. "We ensured that the Standard CMMI Appraisal Method for Process Improvement [SCAMPISM] included government evaluation methodologies as well as those used in industry.

"We achieved near-total upward compatibility of all software CMM activities, and also worked to ensure that the CMMI remain adaptable and tailorable for smaller companies in the commercial sector—approximately 80% of those adopting the software CMM have been commercial companies. Additionally, the 'software-only' version

published last year is targeted to companies who don't feel they need the full systems engineering content.

"We've also worked hard to ensure the stability of the framework to ease the task of transition to the CMMI," Rassa adds. "While we welcome suggestions for future enhancements to the model, the CMMI Steering Group view is that the CMMI be stable for at least three years, and possibly five, depending on user feedback."

SCAMPI is a service mark of Carnegie Mellon University.



Bob Rassa
*Systems Supportability
Director, Raytheon Space and
Airborne Systems*



Jeanmarie Scire
*Manager of Engineering Communications
and Technology Networks*

sortium brings a lot of depth and experience to help augment our experience and accelerate our lifecycle engineering," Gatti says. "The Consortium is enjoying broader exposure across Raytheon and is helping more and more of our programs."

"Our collaboration with the Consortium is increasingly corporate-wide," notes Jeanmarie Scire, Manager of Engineering Communications and Technology Networks for RECP. "We're tapping their support both internally and externally, in service to our suppliers and customers. Consortium participation in our CMMI Steering Committee, technology networks, and engineering councils help us so share knowledge and lessons learned, assess how we compare to industry at large, and improve the way we collaborate with other Raytheon business units, our suppliers, and our customers. The Consortium has been an excellent source of expertise for our internal series of workshops and symposia."

Raytheon's leadership communicates the value of Consortium offerings throughout their divisions and programs and invites their development teams to make wider use of Consortium technologies through course attendance, service usage, visits to the Consortium's "For Members Only" website, and other technology transfer mechanisms. "We encourage greater involvement with the Consortium by our various businesses, and are having increasing success getting the Consortium onto particular programs like the DD(X) and NPOESS," says Blake Ireland, Raytheon NCS engineering staff.



Blake Ireland
Raytheon NCS Engineering Staff



Jack Cronin
Raytheon Vice President for DD(X)



Sylvia Courtney
Director of Sensor Systems, DD(X)

“We’re also fostering greater collaboration between the Consortium and our internal process experts and infrastructure,” Ireland continues. “I think we’re all finding out that, once we get in a room together and start rolling up our sleeves, there are a lot of advantages that each organization can gain from what we’re doing together.”

The DD(X) Program



The Consortium is playing a central process improvement and communication role on one of Raytheon’s leading ‘systems of systems’ programs, the DD(X) next-generation surface combatant ship. In partnership with DD(X) prime contractor Northrop Grumman, U.S. Navy customers, other National Team partners (Lockheed Martin, Boeing, and others), and a distributed network of teams throughout its own companies and supply chain, Raytheon is the systems integrator for all DD(X) shipboard electronics, mission systems engineering, software development, and test and evaluation systems.

Raytheon will build and test a dual frequency radar suite, an integrated solid-state communication system, an integrated anti-submarine and mine warfare system, a revolutionary missile vertical launching system, and a multi-mission total systems computing environment. The engineering development models produced for DD(X) are expected to form the technological basis for the ships that will be built starting in 2006.

“In the DD(X) program, Raytheon is creating a transformational system to harness the full power of 21st century network and systems technology,” says Jack Cronin, Raytheon Vice President for DD(X). “The DD(X) represents a unique opportunity to really think through our development and management processes, systems and software architecture, tools, collaborative and distributed development environment, and bring everything we’ve learned in the last 30 years of building software to bear on a major new program. It’s an awesome program, really—and by far the best job anyone could give a systems engineer.”

“It’s the kind of program that most people go their entire careers without having the chance to work on,” agrees Sylvia Courtney, DD(X) Director of Sensor Systems. “It’s new technology, a new ship design, with transformational technology in every functional domain—it’s a clean slate, and an engineer’s dream.”

The Consortium is playing a central process improvement and communication role on the DD(X).

Open Architecture

In its systems and software architecture design, Raytheon is applying best-of-breed methodologies and approaches, maintaining an open, non-proprietary philosophy throughout. In order to create a systems and software architecture easily accessed by other members of the DD(X) development team and

program customers, development teams are using a tailored version of the George Mason University systems architecture design process methodology and are following the precepts of the DoD Joint Technical Architecture and the

Navy Open Architecture.

“We want to publish all of our interfaces in an open architecture model and let our partners and suppliers develop their own best solutions to leverage those interfaces,” says Bob Martin, Director of the Total Ship Computing Environment (TSCE)

and Software for the DD(X) program. “The DD(X) program has a different approach to computing. Rather than have everybody show up with their own computers, displays, interfaces and architectures, we want to fit into the total ship architecture from the outset, where we can each show up with compatible network protocols and software—not stovepipes.”

“We’ve developed a catalog we call ‘TSCE Lite’ where we describe our hardware, software, and infrastructure products and interfaces,” says Carrie Smith, Manager of Software Management Operations Environment. “Our philosophy is to avoid proprietary approaches and ensure that the DD(X) sails in 2050 as well as 2010.”

The DD(X) shipboard information infrastructure will be one of the most functional and complex combat environments currently in development. A tiered systems architecture will provide multi-faceted visibility of human, hard-

“Our philosophy is to avoid proprietary approaches and ensure that the DD(X) sails in 2050 as well as 2010.”

ware, software, and informational components and interfaces, promoting rapid situational awareness and effective resource management while enhancing maximum scalability and modularity.

Distributed Development

In addition to its DD(X) National Team partners, Raytheon's distributed development network also includes other Raytheon businesses around the U.S., each providing various components of the TSCE. The TSCE provides a shared, virtual development infrastructure that will evolve into the final shipboard information system.

"Through our virtual collocation and our shared use of the TSCE tools and databases, we're fully replicating the systems infrastructure that will actually go to sea," Cronin says. "Our first releases of code will be into an environment that's virtually identical to the ship's system, with full requirements traceability and simulation-based validation capability of all systems."

Common Processes

As is true throughout Raytheon, the company's R6σ and IPDS are uniformly applied within DD(X) program development teams, which also share the corporate goal of attaining CMMI Level 3 this year.

Consortium assistance to Raytheon on the DD(X) program is both strategic and tactical, from helping to define the overall software process, risk mitigation strategies, and managed evolution of the systems infrastructure, to intensive training, consulting and evaluative services to ensure Raytheon's suppliers also meet the program's rigorous process maturity requirements (software CMM Level 3 is required for all DD(X) software subcontractors by August 2003). Program managers also plan to task the Consortium with development of a CMMI transition plan for the entire DD(X) National Team in 2004.

Consortium offerings in process improvement and industry best

"With their overall systems process qualifications... the Consortium has been a terrific asset to our team."

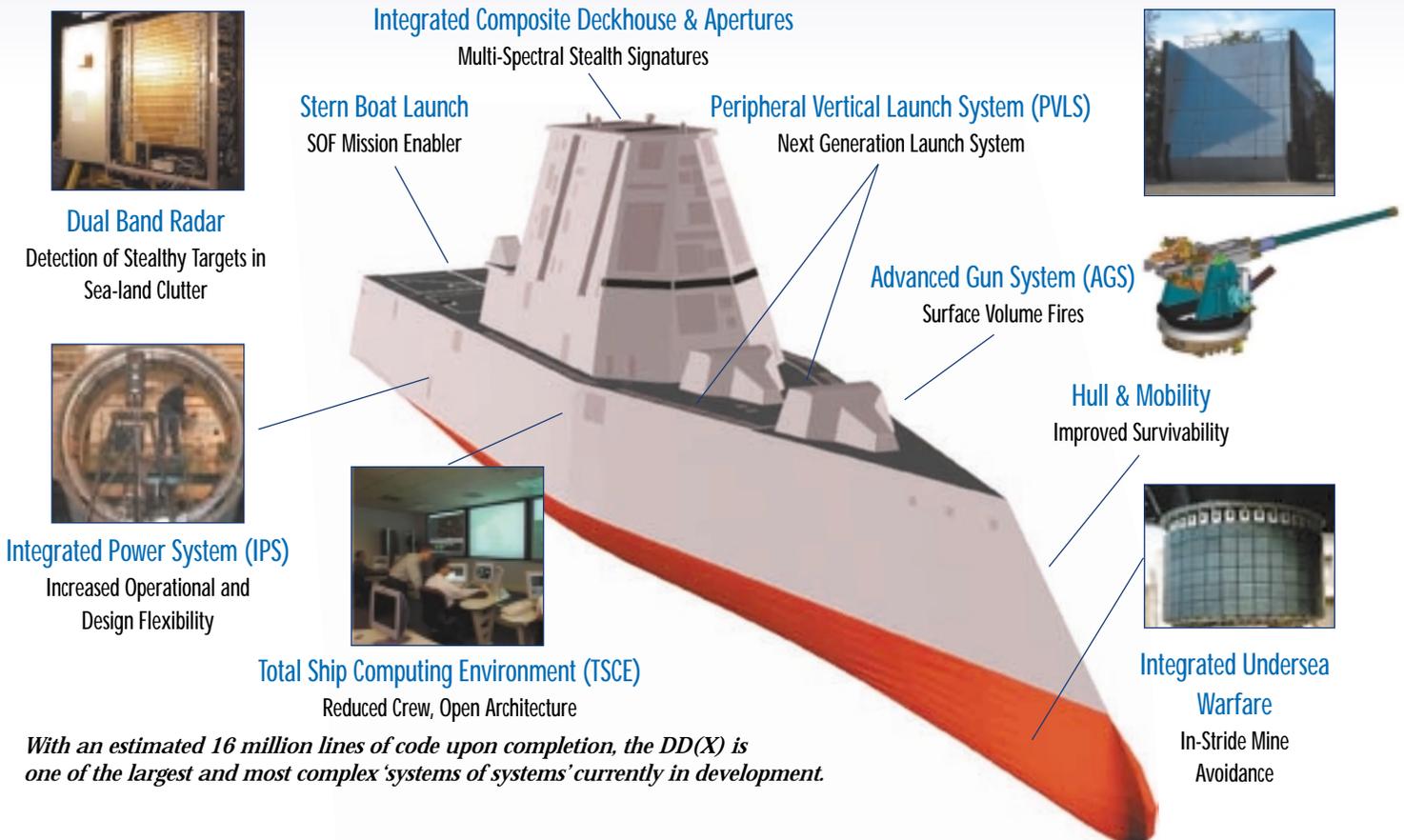


Bob Martin

Director of the Total Ship Computing Environment (TSCE) and Software, DD(X)

practices are also helping to manage Raytheon's DD(X) distributed development teams. "The Consortium brings us a consistent set of processes we can all use across our teams, and their knowledge of industry trends and best practices is also extremely important," Cronin says. "With their overall systems process qualifications, risk management, managed evolution, software subcontractor selection and management, the Consortium has been a terrific asset to our team."

DD(X)—Transforming Mission Effectiveness



With an estimated 16 million lines of code upon completion, the DD(X) is one of the largest and most complex 'systems of systems' currently in development.



Carrie Smith
*Manager of Software Management
 Operations Environment*



Mike Keebaugh
*President, Raytheon Intelligence &
 Information Systems*



Mike Mader
*Raytheon Vice President &
 NPOESS Program Director*

CMMI: Broad & Deep

“As Jack Cronin told us at the outset, our biggest challenges on this program would be in process and communication,” says Sylvia Courtney. “I remember Bob Martin and I looking at each other and both saying, ‘CMMI.’ CMMI establishes a broad and deep paradigm to subsume all process and communication, subcontractor management, configuration management, systems engineering, metrics—the entire gamut. We’re all champions of the culture of operational discipline embodied in the CMMI.”

“The contract award on the DD(X) was extremely competitive, and the Consortium’s process improvement plans played a key role in our proposal,” Bob Martin says. “The Consortium helped us develop and implement a solid process improvement strategy across the program, a particular challenge for such a large, geographically dispersed development team. They really did an awesome job.”

The NPOESS Program

The Consortium is providing Raytheon with process improvement, training and trouble-shooting assistance on another large ‘systems of systems’ program, the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

Managed by a tri-agency Integrated Program Office (IPO) utilizing personnel from the Department of Commerce National Oceanic and Atmospheric

Administration (NOAA), Department of Defense and NASA, NPOESS is the nation’s next-generation environmental satellite system, converging existing civil and defense satellite systems into a single national program. In addition to the cost-effectiveness of this consolidated approach, NPOESS will increase the timeliness and accuracy of severe weather event forecasts, reducing the potential loss of human life and property resulting from severe weather.

Raytheon Intelligence and Information Systems (IIS) is developing the NPOESS ground system in support of prime contractor Northrop Grumman. The ground system will include command, control and communications; mission data processing; system engineering support; and other functions and services.

“The Consortium’s engagement with us on the NPOESS program has been of significant benefit,” says Mike Keebaugh, President of Raytheon IIS. “The Consortium’s extensive training courses, workshops and evaluations helped get the whole proposal team to CMM Level 3.”

“The NPOESS software architecture will deliver massive amounts of data at much lower latency than current systems to produce near real-time environmental and meteorological products in support of operational forecasting, scientific research, and climatological users,” says Mike Mader, Raytheon Vice Presi-

dent and NPOESS Program Director. “The system will process up to a terabyte of data per satellite per day to put needed information into the forecaster’s hands in less than 15 minutes over 75% of the time—versus today’s architecture that averages about two hours.”

The completed Raytheon ground system will include approximately 4 million lines of code, approximately 60% of which will be reused from existing Raytheon ground systems and related products. “We embraced object-oriented development approaches at our Aurora [Colorado] campus in the early 1990s and have been aggressively pursuing software reuse since that time,” says Linda Martz, NPOESS Ground Segment Chief Software Engineer.

Level 3 operations

The majority of the Aurora organization was assessed at software CMM Level 3 prior to the NPOESS award. Consortium assistance was used to evaluate software processes being used by the Aurora campus and to transfer those processes to four other Raytheon businesses serving on the NPOESS development team. Consortium consultations and assessments were used to ensure that software Level 3 operations were in place throughout Raytheon’s dispersed NPOESS development teams.

“The Consortium indicated that this was probably the first time they had assessed such a diverse group of geographically-dispersed units in one assessment,” Mader says. “I believe this also set a milestone for Raytheon, having five separate locations all assessed at Level 3.”

“The contract award on the DD(X) was extremely competitive, and the Consortium’s process improvement plans played a key role in our proposal.”



Bob Kern
Vice President of Engineering
Raytheon Space & Airborne Systems

“Our joint assessment was important, because we want all five facilities using the same processes across all locations,” Martz explains. “We’re all using the same tools, processes, and metrics. In a sense, we have to *be* as one, so we wanted to be assessed as one.”

“We were advised after our assessment that the systems and software development and test procedures we’d already implemented in our Integrated Product Teams represented giant strides toward the CMMI,” Mader adds. “We in fact were not far away from the CMMI just by the way we were already doing business.”

“We like the way we can just call the Consortium and say, ‘Could you send someone out to one of our sites and spend a few days with them, see where they are?’”



Louise Francesconi
President, Raytheon Missile Systems

Program Predictability

Mader and Martz cite enhanced cost and schedule predictability as a key benefit of Level 3 software maturity, and believe the CMMI will extend this and other benefits.

“On a large program such as NPOESS, it’s critical to understand exactly where

you are in terms of cost and schedule at any point in time,” Martz says. “Our aggressive pursuit of software reuse over the last decade served as a ‘forcing function’ for integrating our systems and software disciplines, because we didn’t just reuse software code; we reused systems architectures, requirements and design specifications,

testing procedures and algorithms, and other system elements.

“Our senior systems and software managers work together, which eliminates the traditional ‘over the transom’ handoff between the two disciplines,” Martz continues. “We see the CMMI as further erasing the barriers between systems and software engineers.”

“I also see a lot of benefits from frameworks such as the CMMI in bringing younger engineers up to speed more quickly,” Mader adds. “These frameworks show them how to fit into our organization

“When I first joined the DD(X) program, the Consortium’s ‘For Members Only’ website was one of the first places I went. I was downloading things like crazy.”



Lynn Levine
Raytheon NCS DD(X) Software
Subcontractor Manager

and makes them productive much more quickly than on-the-job training modes.”

Consortium Role

Raytheon IIS plans continued use of Consortium training courses, consulting and assessment services to help NPOESS development sites attain CMMI Level 3. “The Consortium will continue to help us improve our processes and stay abreast of systems engineering and software development environments,” Mader says. “We like the way we can just call the Consortium and say, ‘Could you send someone out to one of our sites and spend a few days with them, see where they are, and share your ideas with them?’”

“What the Consortium brings is a broader view of what’s going on in industry, whether it be the commercial or defense arena,” Mader continues. “Their broad focus on industry trends in best practices helps us continuously

improve our internal processes.”

“The Consortium is well-connected in the systems and software engineering communities within the defense and commercial arenas, and with our customers,” Keebaugh concurs. “The Consortium also provides a neutral meeting ground with our competitors,

where we can benchmark ourselves against industry at large and share lessons learned. It’s been a great relationship.”

Space & Airborne Systems

With more than 10,000 employees located in California, Texas and Mississippi, Space and Airborne Systems (SAS) develops critical space and airborne missions programs such as the STSS, Global Hawk Sensors, ATFLIR Targeting Pod, APG-79 AESA Radar, U2 Sensors, and numerous classified programs.

The company has maintained an active software engineering process group and training program for many years and uses the Raytheon IPDS as its program development methodology. "IPDS offers very extensive software and systems engineering guidelines," says Jack Kelble, President of Space & Airborne Systems. "We require its use on all of our programs and ensure that our people are adequately trained in its use."

Consortium training courses and web-based, videostream course offerings (either live or archived on the "For Members Only" secure Intranet server available to members) are also a part of Raytheon SAS training curriculum. "We use a lot of the Consortium's training programs and consulting services," Kelble says. "Their live webcasts and archived online training courses work out exceptionally well for us."

Consortium lead assessors are working at SAS to help ensure that IPDS usage complies with CMMI Level 3 guidelines. "I've been a very strong supporter of integrated approaches to systems, software and hardware since the mid-1980s," Kelble says. "In 1991, as the head of a large Raytheon engineering organization, I asked our team to create a hardware version of the software CMM. We used that to perform a full maturity analysis assessment and implement an upgrade process in all of our hardware areas. In doing so, we saw the same productivity benefits from this approach to hardware as I'd grown accustomed to seeing in software."

"I'm consequently delighted with the CMMI initiative," Kelble continues, "because it helps us extend the same kinds of process maturity discipline and training to systems engineering, program

and subcontractor management, and hardware engineering activity areas."

"We do a lot of measurement and cost estimating to track our actual costs to our predictions," says Bob Kern, SAS Vice President of Engineering. "We've learned to measure the effectiveness of improvements we've made to our software processes so we can adjust those processes to make further productivity gains."

"As one example, we've been tracking defects in our various life-cycle phases, and have made significant progress in eliminating defects in-phase," Kern continues. "We're getting problems out of the way early in the lifecycle, which saves us untold time and money. Our system test phases are becoming increasingly anti-climatic."

Consortium benefits

Kern and Kelble cite the Consortium's industry-wide membership and the wide body of practical knowledge created by interactions with this diverse group of companies and government agencies as key benefits of membership.

"We get an excellent return on our Consortium investment through their direct services and training courses, and also through the interchange of knowledge of industry and management trends," Kelble says. "We can leverage the work the Consortium has done and learn what's been tried before, what works and what doesn't. It builds our confidence to know we're engaging in activities that have proven to be successful for other companies in our class."

"We encourage all of our employees to take advantage of Consortium training resources and website assets," Kern adds. "There's a great opportunity to gain knowledge through the Consortium website to see what's going on with other members and benchmark ourselves against the industry at large."

"What the Consortium brings is a broader view of what's going on in industry, whether it be the commercial or defense arena."

Missile Systems

A \$3 billion business, Raytheon Missile Systems designs, develops and produces missile systems for critical requirements, including air-to-air, strike, surface Navy air defense, land combat missiles, guided

projectiles, and directed energy weapons. Company products include the AMRAAM, Javelin, Excalibur, TOW, Stinger, Tomahawk, and other major missile systems. The company is headquartered in Tucson, Arizona, with development sites also located in Kentucky, New Mexico and California.

Missile Systems is software CMM Level 5 and is working toward CMMI Level 5, with CMMI Level

3 as this year's goal. In addition to its use of Raytheon's corporate Six Sigma and IPDS frameworks and methodologies, Missile Systems is also ISO 9001 registered (as are most other Raytheon companies).

As with other Raytheon businesses, a legacy of multi-framework compliance creates fertile ground for rapid adoption of the systems and software integration requirements of the CMMI.

"The integration and maturity of our processes have played a key role in our improved performance in the cost, quality, and schedules of our programs," says Louise Francesconi, Missile Systems President. "Having an integrated approach rather than a stove-piping of our processes ensures that the outputs from one process meet the input needs of the follow-on process."

"Our integration extends beyond systems and software processes," Francesconi continues. "We include all engineering disciplines as well as supporting processes, and extend on to production where the integrated approach is critical to ensure we can produce the products that we engineer."

The company plans to leverage heavily off its software, systems and ISO successes as it approaches CMMI Level 3. "We are using the SE/SW/IPPD version of the CMMI model and all our disciplines are moving forward together," Francesconi says. "We believe this will

"We use a lot of the Consortium's training programs and consulting services. Their live webcasts and archived online training courses work out exceptionally well for us."



Janet Bratton
Cross-Product Team Lead
DD(X) Software Process Engineering

give us the highest return on our investment—if it's good for software, if it's good for systems engineering, its good for the enterprise."

These expectations seem warranted based on the company's return on investment from software maturity investments. "In moving from software Level 3 to Level 4, we achieved a 6:1 return based upon reduced defects—less rework—and increases in productivity," Francesconi notes. "In moving from Level 4 to Level 5, we attained a 9:1 return. We expect to see similar returns on our CMMI journey."

The company is using Consortium training and service offerings to augment its own internal appraisal leaders as it works to attain CMMI Level 3 compliance. Future plans include continued use of Consortium offerings in attainment of CMMI Level 5 and in other technology and product development areas.

"We plan to make continued use of Consortium process improvement offerings and expand our use of their extensive training courses and lifecycle engineering technologies, to help us achieve even higher level of performance on our programs," Francesconi says. "We're particularly interested in the Consortium's work in security and collaborative development."

"We also expect to gain lessons learned from industry based on the Consortium's unique position, and to work with the Consortium and its other members to collectively define future directions and technologies."

Network Centric Systems

Raytheon NCS develops network centric solutions that integrate sensors, systems and secure communications to manage the battlespace and airspace. Major programs and products include air traffic management systems, armored vehicle fire control sensors and systems, battle-field radar, command and control/battle management systems, communication products and systems, infrared components and sensors, soldier systems and cooperative engagement capability.

One of several Raytheon companies working on the DD(X) program, NCS Fullerton (California) is developing the human interface, data-base architecture, and parts of the networking system that will integrate within the DD(X) shipboard computing system. Twice assessed at software Level 5 maturity,* NCS Fullerton is also leading the overall DD(X) software process improvement program, extending its software expertise throughout the development team.

NCS is also working aggressively to implement CMMI Level 3 operations at its major sites by the end of this year. "The Consortium is filling a vital role in helping us to meet this goal," says NCS California Engineering Director Hope Miller. "Consortium training courses, workshops, assessment and other services help extend our own process

resources. We see them as a partner in accomplishing our goals."

The company has measured significant productivity gains from software Level 5 operations (see "Process ROI," page 6), and expects continued gains from CMMI Level 3 attainment. "Over the many years that

Raytheon has pursued software improvement, we've seen schedule risks decrease by huge margins," Miller says. "By extending the same disciplined process to systems engineering, program management, our supply chain and

other program activities, we'll see much lower cost and schedule risk on our programs as a whole."

Rapid Improvement

The Consortium is currently helping several of Raytheon's DD(X) subcontractors rapidly implement software CMM Level 3 processes. "The DD(X) procure-

ment requires all software suppliers to demonstrate software Level 3 capability," explains Lynn Levine, Raytheon DD(X) Software Subcontractor Manager at NCS. "The Consortium is working with our Raytheon process specialists to create software process improvement plans to help our subcontractors rapidly advance their software maturity."

For each supplier, the Consortium offers an

interactive CMM evaluation to get an initial baseline of process maturity, then facilitates an action planning workshop to identify needed next steps. "I survey our subcontractors to see how they evaluate the services they're receiving, and the results have been very positive," Levine says. "Our subcontractors are very enthusiastic about working with the Consortium/Raytheon process team."

"The suppliers we're working with are very small companies, so the Consortium's offerings in diverse CMM environments are very useful," adds Janet Bratton, DD(X) Software Process Engineering, Cross-Product Team Lead. "The Consortium's training courses and materials, action planning workshops, process templates, and services are all ready to use, 'out of the box' assets that we can plug right into our process improvement programs." ■

*CMMI is registered with the U.S. Patent & Trademark Office by Carnegie Mellon University.

*Raytheon NCS in Fullerton, CA is one of a very few organizations that has successfully repeated a software CMM Level 5 assessment, undergoing their second assessment in Sept. 2002 to satisfy Defense contractual requirements for large (ACAT 1) programs.

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"We're particularly interested in the Consortium's work in security and collaborative development."