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Command and Control Rapid Prototyping Continuum (C2RPC) Transition: Bridging the Valley of Death

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Preface & Acknowledgements

During his internship with the Graduate School of Business & Public Policy in June 2010, U.S. Air Force Academy Cadet Chase Lane surveyed the activities of the Naval Postgraduate School's Acquisition Research Program in its first seven years. The sheer volume of research products—almost 600 published papers (e.g., technical reports, journal articles, theses)—indicates the extent to which the depth and breadth of acquisition research has increased during these years. Over 300 authors contributed to these works, which means that the pool of those who have had significant intellectual engagement with acquisition issues has increased substantially. The broad range of research topics includes acquisition reform, defense industry, fielding, contracting, interoperability, organizational behavior, risk management, cost estimating, and many others. Approaches range from conceptual and exploratory studies to develop propositions about various aspects of acquisition, to applied and statistical analyses to test specific hypotheses. Methodologies include case studies, modeling, surveys, and experiments. On the whole, such findings make us both grateful for the ARP's progress to date, and hopeful that this progress in research will lead to substantive improvements in the DoD's acquisition outcomes.

As pragmatists, we of course recognize that such change can only occur to the extent that the potential knowledge wrapped up in these products is put to use and tested to determine its value. We take seriously the pernicious effects of the so-called "theory–practice" gap, which would separate the acquisition scholar from the acquisition practitioner, and relegate the scholar's work to mere academic "shelfware." Some design features of our program that we believe help avoid these effects include the following: connecting researchers with practitioners on specific projects; requiring researchers to brief sponsors on project findings as a condition of funding award; "pushing" potentially high-impact research reports (e.g., via overnight shipping) to selected practitioners and policy-makers; and most notably, sponsoring this symposium, which we craft intentionally as an opportunity for fruitful, lasting connections between scholars and practitioners.

A former Defense Acquisition Executive, responding to a comment that academic research was not generally useful in acquisition practice, opined, "That's not their [the academics'] problem—it's ours [the practitioners']. They can only perform research; it's up to us to use it." While we certainly agree with this sentiment, we also recognize that any research, however theoretical, must point to some termination in action; academics have a responsibility to make their work intelligible to practitioners. Thus we continue to seek projects that both comport with solid standards of scholarship, and address relevant acquisition issues. These years of experience have shown us the difficulty in attempting to balance these two objectives, but we are convinced that the attempt is absolutely essential if any real improvement is to be realized.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the Acquisition Research Program:

- Office of the Under Secretary of Defense (Acquisition, Technology & Logistics)
- Program Executive Officer SHIPS
- Commander, Naval Sea Systems Command
- Army Contracting Command, U.S. Army Materiel Command
- Program Manager, Airborne, Maritime and Fixed Station Joint Tactical Radio System

- Program Executive Officer Integrated Warfare Systems
- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
- Deputy Assistant Secretary of the Navy (Acquisition & Logistics Management)
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We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this Symposium.

James B. Greene, Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor

Panel 4 – Improving IT Acquisition

Wednesday, May 11, 2011	
11:15 a.m. – 12:45 p.m.	**Chair: Michael McGrath,** Vice President, Systems & Operations Analysis, Analytic Services, Inc. ***IT Acquisition: Expediting the Process to Deliver Business Capabilities to the DoD Enterprise*** Jacques Gansler and William Lucyshyn, University of Maryland ***Making Acquisition Measurable*** Kevin Buck and Diane Hanf, The MITRE Corporation ***Command and Control Rapid Prototyping Continuum (C2RPC) Transition: Bridging the Valley of Death*** Nicholas Gizzi, PMW 150

Michael McGrath—Vice President, Systems and Operations Analysis (SOA), Analytic Services, Inc. Dr. McGrath became the vice president in October 2007. He leads ANSER's operations in the Science and Technology, Enterprise Systems and Planning, and Operations Analysis and Management mission areas. He is responsible for developing and delivering services that enable the clients of Analytical Services, Inc., to address critical challenges in national security and public safety, and to improve the effectiveness of public-sector programs. Dr. McGrath leads a workforce whose expertise spans a wide range of technology and application domains in research, acquisition, information systems and defense operations.

Dr. McGrath served as Deputy Assistant Secretary of the Navy for Research, Development, Test, and Evaluation from February 2003 to September 2007. His role was to aggressively drive new technologies from all sources across Navy and Marine Corps platforms and systems and to develop programs to bridge the gap in transitioning from science and technology to acquisition. He was also responsible for integrating test and evaluation with the evolutionary acquisition process. His leadership was key to the restructuring of the Future Naval Capabilities program, the success of the Rapid Technology Transition program, and the establishment of the Navy Enterprise T&E Board of Directors and the Navy Lab and Centers Competency Group.

Prior to his return to government service in 2003, Dr. McGrath spent five years as vice president for Government Business at the Sarnoff Corporation, a leading R&D company with both commercial and government clients. He was responsible for developing programs to meet government needs for innovative dual use technologies in sensors and microelectronics, networking and information technology, and bio-technology.

Dr. McGrath's previous government experience includes weapon system logistics planning and management at Naval Air Systems Command, acquisition policy in the Office of the Secretary of Defense, and several technology management positions. He was the first OSD Director of the Computer-aided Acquisition and Logistics Support program. At DARPA, he managed programs in Agile Manufacturing, Electronic Commerce Resource Centers, and Affordable Multi Missile Manufacturing. He also served in leadership positions for several DoD-wide initiatives to improve manufacturing and reduce the cost of defense systems. As the Assistant Deputy Under Secretary of Defense (Dual Use and Commercial Programs), he directed the Commercial Technology Insertion Program, the Commercial Operating and Support Savings Initiative, and the Department's Title III industrial base investments.

Dr. McGrath holds a BS in Space Science and Applied Physics (1970) and an MS in Aerospace Engineering (1972) from Catholic University, and a doctorate in Operations Research from George Washington University (1985). He was an adjunct associate professor at GWU in 1987–1988. He is active in several industry associations and study groups, including studies by the Defense Science Board and the National Research Council.

Command and Control Rapid Prototyping Continuum (C2RPC) Transition: Bridging the Valley of Death

Nicholas Gizzi—Assistant Program Manager, Science and Technology (APM for S&T) at the Space and Naval Warfare Systems Command (SPAWAR) Command and Control Warfare Program Office (PMW 150). Mr. Gizzi is responsible for managing programmatic issues pertaining to Science and Technology (S&T) developments, including the coordination of all experimentation efforts and operational demonstrations. He has been a government employee for over 20 years, has held several project management positions, and leads the PMW 150 Command and Control Rapid Prototyping Continuum (C2RPC) effort. [Nicholas.Gizzi@navy.mil]

Abstract

Technologies developed under the U.S. Navy's science and technology (S&T) umbrella have historically had only moderate success transitioning to Navy Command and Control (C2) programs of record (PORs). The primary reason for the limited success rate stems from the different missions of the two program sponsors. S&T, consisting primarily of research scientists and technologists, has a mission to "foster and encourage research" as related to future naval power whereas the C2 Program Office is focused on "providing and updating communication and information technology systems" for the C2 of the maritime forces. This difference in mission, with the corresponding separate funding sources, complicates communication and coordination between these two communities as each strives to achieve its respective goals and objectives. If S&T funded programs are to solve C2 operational shortfalls, there needs to be close coordination throughout the total acquisition cycle with the Program Office directly involved in the S&T development program.

In FY 2009, the Office of Naval Research (ONR), in collaboration with Program Executive Office for Command, Control, Communications, Computers, and Intelligence (PEO C4I), initiated a modified S&T development process designed to deliver new capabilities for the Navy's Maritime Tactical C2 (MTC2) POR. This new initiative is the C2 Rapid Prototyping Continuum (C2RPC) and is jointly funded by ONR and PEO C4I. In this relationship, new technology prototypes are assessed in an operational environment at the Commander Pacific Fleet (COMPACFLT) Headquarters in anticipation of transition, in whole or in part, to PEO C4I's Command and Control Program Office (PMW 150) for incorporation into the next generation operational C2 POR.

C2RPC has streamlined the S&T phases of the acquisition process, coupling emerging technology requirements, development, testing, and integration phases into a continuous agile software development model. PMW 150 concurrently facilitated the early introduction of the new capability prototypes to the *Rapid Integration and Test Environment* (RITE), established by PMW 150 for test and evaluation of maritime C2 software. RITE has an established information repository which allows prototype developers to share a common development infrastructure and to communicate and collaborate directly with POR test and integration engineers. By engaging with the POR early in the prototype demonstration phase, the selected capabilities are well positioned for successful transition as they reach the requisite technology readiness levels (TRLs) needed for full development.

This paper presents the C2RPC development and transition processes, using a rapid incremental development model that aligns with the new information technology (IT) acquisition cycle and bridges the software transition valley of death. It presents early prototype experimentation and demonstration results and provides a projection of remaining activities planned to meet the next generation of maritime C2.

Introduction

PMW 150 has embarked on a new strategic initiative focused on dramatically enhancing the functional capabilities of the Navy's maritime C2 systems while fundamentally changing its software acquisition processes. New processes are needed to meet rapidly changing operational requirements and to take advantage of new technology enhancements. These processes use an evolutionary approach to deliver an accelerated development cycle while achieving cost reductions through programmatic efficiencies and the elimination of redundant processes. The C2RPC is delivering on the strategic initiative by providing new technology prototype development for the C2 POR.

C2RPC Implementation

The Command and Control Rapid Prototyping Continuum (C2RPC) combines emerging science and technology (S&T) development, advanced prototypes, and experimentation processes to employ new maritime C2 capabilities. The C2RPC serves as an incubator for technology and "proofs of concept" to produce capabilities that can be transitioned into future Command and Control (C2) programs of record (PORs). Development of the C2RPC follows the "build a little—test a little" philosophy, employing a series of incremental capability "drops" to demonstrate the prototypes and gain user feedback. The first capability drop (Drop 1) was implemented at COMPACFLT in March 2010. Drop 2, and each successive drop, builds upon existing capabilities to provide additional C2 functionality. The C2RPC process allows for

- rapid and continual technology insertion (e.g., continuous integration);
- continuous prototype development and experimentation cycle;
- development of individual smaller development components/increments, therefore reducing overall C2 program risk; and
- closer alignment of S&T investment to POR requirements, increasing the probability of successful transition.

Navy Command and Control Strategy

The U.S. Navy is undergoing a major IT transformation to meet changes in its operational commitments and to ensure that necessary operational and intelligence information is delivered to the "right person, at the right time, and in the right way." Historically, Navy C2 systems have simply provided "who and where" information to battle commanders' situational awareness. Future C2 systems need to fulfill Operational Level of War (OLW) requirements, and will be required to provide timely *what, when, why* and *how* information, in addition to *who* and *where*. This new C2 strategy is codified in the Naval Warfare Publication 3-32 on "Maritime Operations at the Operational Level of War (OLW)" (DoN, 2008) and the Navy Planning, Naval Warfare Publication (NWP) 5-01 (DoN, 2007).

Four Functional Pillars

PMW 150's maritime C2 strategy developmental roadmap is built around the four functional pillars of C2 Mission Management as shown in Figure 1. The four pillars are Planning, Execution, and Assessment; Intelligence and Collection Management; Intelligence, Surveillance and Reconnaissance (ISR) Data Fusion; and Force, Unit, Network Capabilities and Readiness.

A representative example of the initial capabilities that are being developed by C2RPC in support of these four pillars is also shown in Figure 1. There is an additional "invisible" pillar in the C2RPC's approach. This invisible pillar is User Facing Services (UFS) and it is depicted by the center of the figure. This is where the majority of the C2RPC user interactions are performed. It is important to note that PMW 150 is only responsible for providing the functionality associated with the Planning, Execution, and Assessment Pillar and the User Facing Services. Therefore, PMW 150 must rely on external organizations for the services and database repositories that are resident within their respective pillars.

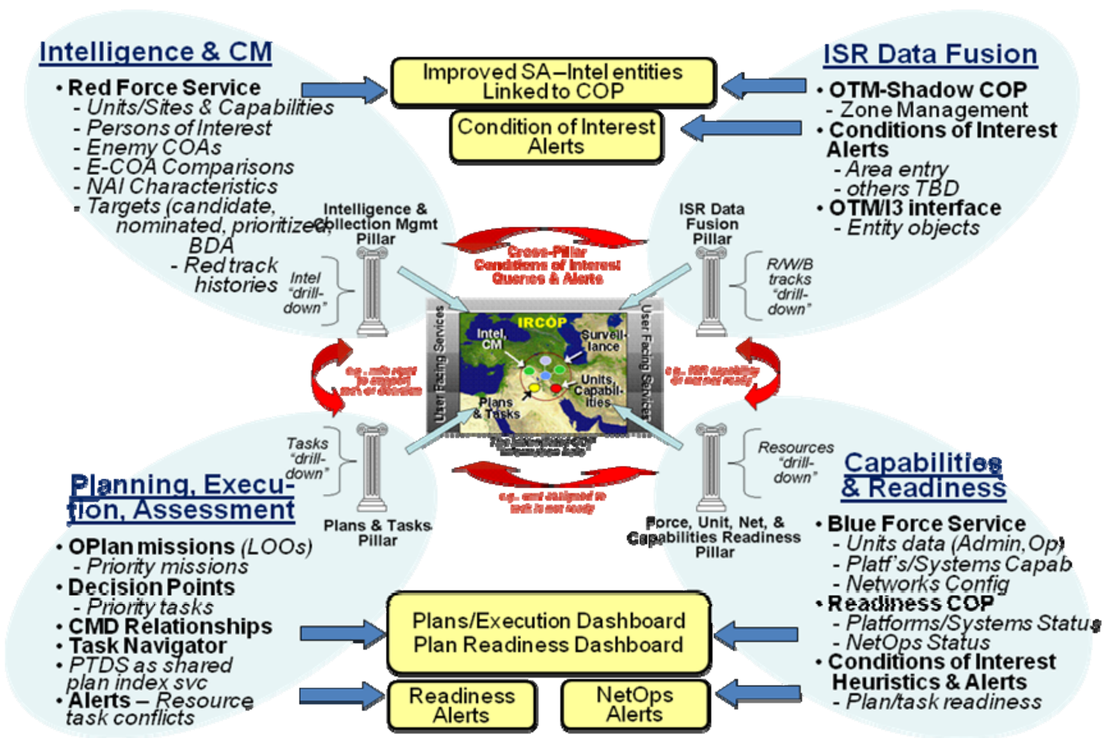

Figure 1. Functional Pillars of C2 Mission Management

C2RPC Incremental Functionality

PMW 150 has adopted a *component portfolio approach* to C2 system software acquisition. Incremental development is a key element of PMW 150's system software component strategy and requires close collaboration among developers, evaluators, and end users (warfighters). Each component of capability provides a militarily useful and supportable operational capability. These components are iterated over time and delivered when mature. The system's architecture is designed to support these incremental deliveries and enables additional components, or higher-performing implementations of existing components, to be added periodically to the core Navy C2 architecture.

Initial Operational Capability

The focus of the initial C2RPC prototype was in support of the Fleet's ability to conduct high-priority missions and plans within the COMPACFLT area of responsibility (AOR). Figure 2 depicts the initial capabilities that are projected for MTC 2 Release One.

The figure includes a core, or "central capability" (Applications Support, Data Management and Enterprise Services abstraction), that C2 components will be integrated into and interact with. These core capabilities are shown in the bottom set of boxes in Figure 2. The additional capabilities align with the four functional pillars discussed previously and are shown in the color-coded boxes. There may be unfamiliar acronyms shown, but the specific functional definition is less important for the purposes of this paper than the methods used for rapid development and demonstration. This phased delivery is designed to add increased overall C2 functionality with each successive drop achieving a new objective (e.g., Readiness and Maritime Operations Centers (MOC) established in Drop 2 will be Enhanced in Drop 3). The successive drops are additive and the proven, operator-validated capabilities from the collective set will represent the C2 capabilities carried forward as MTC2 Release One. In all, there are four drops planned before the "capability cut-off" later this year. At that time, the aggregate release set of capabilities will transition to POR funding and go through additional hardening and developmental testing (i.e. unit, regression, etc.) before entering a formal Development Test and Operational Test (DT/OT) program. It is important to note that individual components, although based upon an initial set of capability objectives, are dynamic. The final component functionality is a product of the baseline warfighter objectives and modifications approved as a result of the prototyping process and direct feedback from operational users.

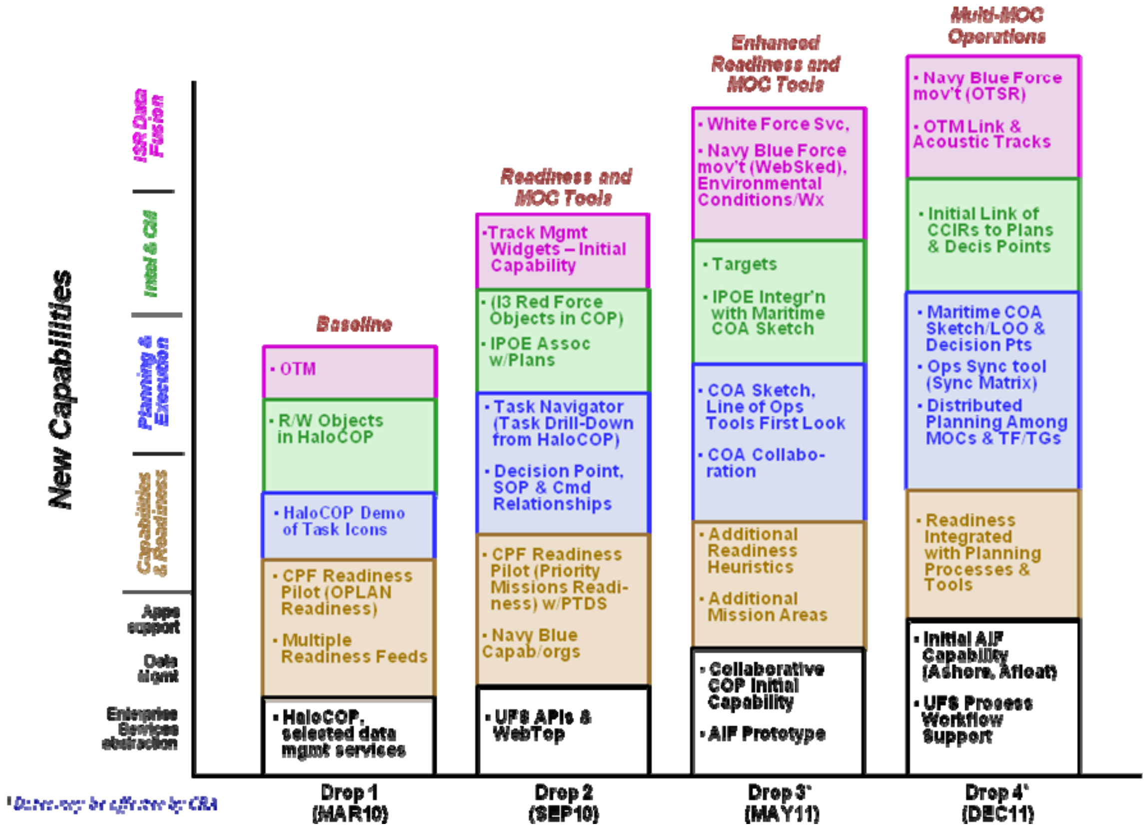

Figure 2. MTC2 Release One

Prototyping Continuum

Under the C2RPC initiative, the development and maturing of new technology is ongoing and will continue using additional S&T funding after the capability cut-off for Release One. Figure 3 represents a listing of potential C2RPC capabilities proposed for future prototype development. Again, the specific components and their respective acronyms are not as important as the method used to continually address new technology development for achieving additional C2 functional objectives. In the future drops, the objective is to support operational units expanding from the ashore MOCs to the afloat Navy (e.g., task force, TF, and task group, TG, level ships). The final set selected for MTC2 Release Two will be derived from the continually evolving set of mission-oriented requirements and maturing prototypes.

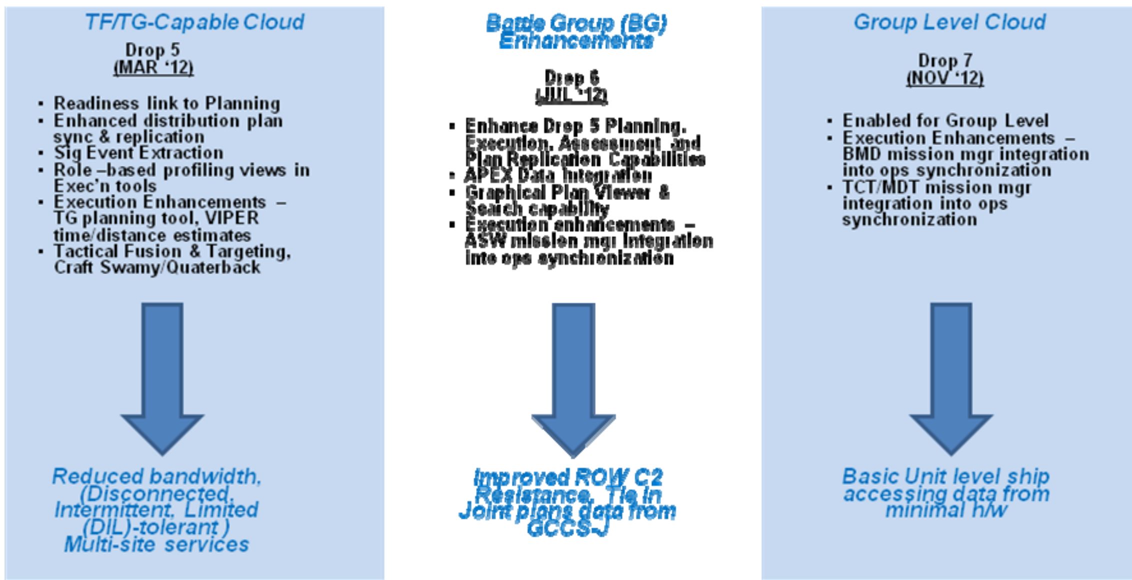

Figure 3. Proposed Navy Planning, Execution, and Assessment Services

C2RPC Prototype Development and Experimentation Methodology

The C2RPC team is comprised of "thought-leaders" in situational awareness, navy planning and assessment, Fleet readiness, and MOC operations. This collection of experts is paired with subject matter experts (SMEs) in C2 systems development and together they work closely with Fleet representatives to demonstrate rapid technology prototypes and gather operational feedback. This working relationship has led to enhanced C2 functionality in the early prototypes. This section will present the methodology employed by the C2RPC to develop, mature, and transition C2 components in an incremental and continuous development approach.

National Defense Authorization Act of 2010 Alignment

In 2010 Congress passed, and the President signed, the National Defense Authorization Act, becoming Public Law 111-84. This law defined a new acquisition process for IT systems. Conventional DoD acquisition processes are too long and cumbersome to fit the needs of IT systems that require near continuous change. This new process is to be based upon the recommendations provided in the March 2009 Report of the Defense Science Board (DSB) Task Force on Department of Defense Policies and Procedures for the Acquisition of Information Technology (hereafter referred to as DSB-IT; USD[AT&L], 2009).

The DSB-IT recommendation was for a new acquisition process for IT, as shown in Figure 4.

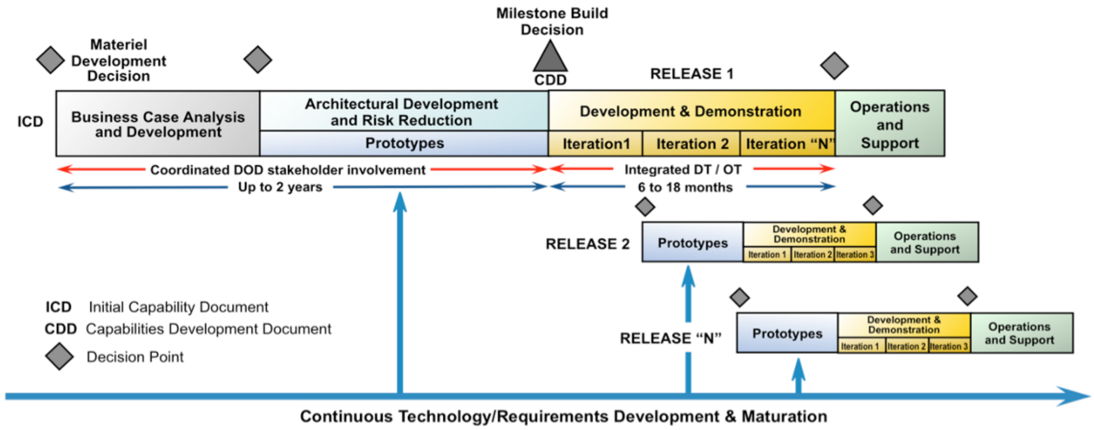

Figure 4. DSB-IT Recommended Acquisition Process for Information Technology

The process shown is geared toward delivering meaningful increments of capability in approximately 18 months or less, and it leverages the advantages of modern IT practices. Multiple, rapidly executed releases of capability allow requirements to be prioritized based on need and technical readiness, allow early operational release of capability, and offer the ability to adapt and accommodate changes driven by field experience. The new process will include

- early and continual involvement of the user;
- multiple, rapidly executed increments or releases of capability;
- early, successive prototyping to support an evolutionary approach; and
- a modular, open-systems approach.

The C2RPC methodology has all of these attributes and is described in this section.

C2RPC Implementation Roadmap

A notional C2RPC implementation roadmap with its various programmatic stages is shown in Figure 5. The graphic shows the relationships between the stages, including the planned transition of new C2RPC technologies to the MTC2 POR after completing "Early" and "Late" Stage prototype development cycles. The roadmap aligns with both traditional DoD Acquisition Life Cycle milestones required in DoD Instruction 5000.02 (USD[AT&L], 2008) and the processes recommended in the DSB-IT.

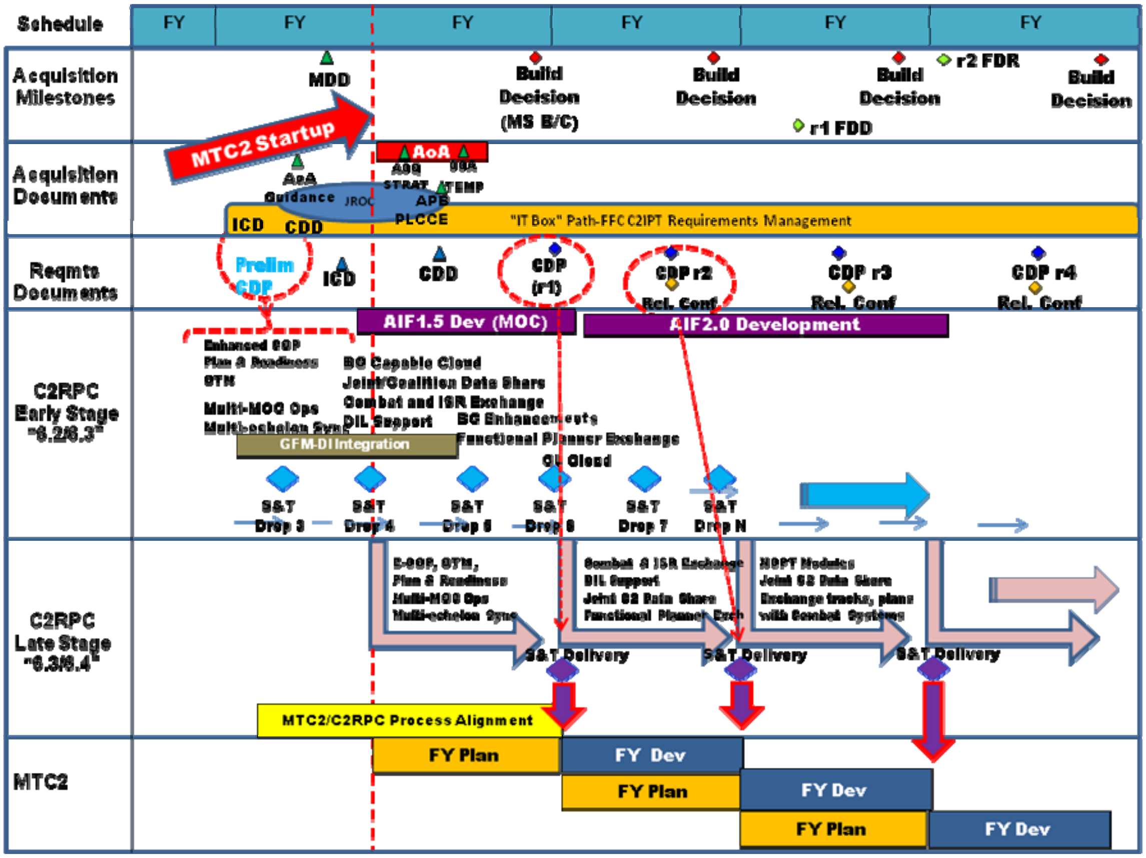

Figure 5. Notional C2RPC Implementation Roadmap

C2RPC Capability Requirements Definition

C2RPC employs a modified approach for the identification and assessment of C2 capability objectives. A C2 independent product team (C2IPT) consisting of SMEs from ONR, working along with PMW 150 and COMPACFLT, meet in periodic workshops at COMPACFLT Headquarters to identify and prioritize operationally relevant C2 objectives. These 2–3 day forums are held every 3–6 months and normally coincide with increment drops, so that the users have the opportunity to express their ideas and provide input to the software developers directly. The workshops are chaired by ONR but include representatives from all stakeholders.

At the initial workshop, held June 24–26, 2008, the first set of development objectives was established in response to COMPACFLT priorities. These included the following:

- C2 of Intelligence Operations,
- C2 of Information Operations,
- C2 of Network Operations,
- C2 of Computer Network Protection, and
- Common Operational Picture (COP) Improvement.

These agreed objectives were used to derive a set of "capability gaps" that were prioritized for the initial C2RPC C2 increment. The capabilities have since evolved and new capabilities have been added as a result of experimentation and early exposure to the operator who provided recommended modifications.

To support the requirements definition, the roadmap, shown in Figure 5, lists several requirements related documents that are important to the establishment of an upfront Technology Development Strategy, and are necessary to achieve acquisition Milestones and Build Decisions for MTC2. These documents include the following:

- *Initial Capabilities Document (ICD).* As described in the Joint Capacities Integration and Development System (JCIDS) manual (CJCS, 2009), the ICD documents the "need for a materiel approach, or an approach that is a combination of materiel and non-materiel, to satisfy specific capability gap(s)." The *ICD* defines the gap in terms of functional area; relevant range of military operations; desired effects; time and Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF); and policy implications and constraints. The outcome of an *ICD* could result in one or more DOTMLPF Change Recommendations (DCRs) or Capability Development Documents (CDD).
- *Capabilities Development Document (CDD).* The Technology Development Strategy includes a description of how the materiel solution is sub-divided into Capability Increments, Releases, and Iterations (drops). The CDD builds on the ICD and provides detailed operational performance parameters necessary to complete the proposed systems design. These requirements are prioritized and parsed into groupings to establish baselines for initial and subsequent releases. The objective of C2RPC is to develop and deploy the highest priority mission capability first and reduce the technical risk to the POR. Therefore, capabilities defined in the CDD are prioritized and, where appropriate, grouped into a limited number of time-phased releases that correspond to mission priorities. An agile approach allows for the reprioritization of requirements for each iteration and release (and for the increment as a whole) based on subsets of functionality to prevent delay and facilitate rapid development and deployment.
- *Capabilities Development Plan (CDP)—Release 1 to Release (n).* The purpose of the Capability Development Plan (CDP) is to serve as the agreement between the Program Sponsor, the Program/Project Manager (PM), and the Acquisition Decision Authority (ADA) on the activities, cost, schedule, and performance boundaries of the work to be performed for the POR and the artifacts from C2RPC are used to substantiate the reduced risk. The CDP presents topics and issues, specific to the acquisition, that allow the PM to clearly define the "body of work" that must be accomplished during each planned software release.

Continuous Prototype Development

C2RPC has separated prototype development into two distinct stages: Early Stage and Late Stage. These stages are related to overall technology maturity levels of the respective capability components and have separate S&T funding sources. The Early Stage, designated for Advanced Technology Development, is funded by 6.2 and 6.3 budgets, while the Late Stage, involving Demonstration and Validation experiments (along with approved prototype modifications and changes) conducted at COMPACFLT, is funded from 6.3 and 6.4 budgets. It is important to note that this separation of stages supports the continual progression of maturing capabilities that are available for graduation to the next level of development without unnecessary delay. For example, Early Stage capabilities that have reached an acceptable technology readiness level (TRL), as described in the *Defense Acquisition Guide* (*DAG*, n.d.) are moved to the Late Stage where they undergo relevant operational experimentation.

Additionally, as Late Stage capabilities are evaluated at the requisite maturity level, they enter the transition phase, where they receive further capability enhancements and the software hardening necessary for final transition to the POR. Lastly, this separation of development stages allows the Early Stage to serve as the incubator of new technology with new prototype components being initiated as additional requirements are identified. The capability components need not adhere to pre-determined development cycles and independently move through the development process. This methodology allows the C2RPC to provide a “continuum” of new capability components that are being routinely evaluated for transition to the POR.

Figure 6 depicts the different TRLs and indicates the separation of C2RPC and POR responsibilities, including the overlapping transition of S&T to POR. The figure also introduces the “progressive” integration approach being employed by the C2RPC to gradually introduce POR engineering processes to the various release components as they progress from Early-to-Late-to-Transition Stages. Early prototype development is often less structured and therefore the prototype, as part of the experimentation and maturing process, needs to incorporate POR best practices for items such as software configuration management and documentation. Using a wiki for content management, the development of selected documentation is developed over time by the various members of the C2RPC team. The process for this progressive integration is covered in the transition section later in this paper.

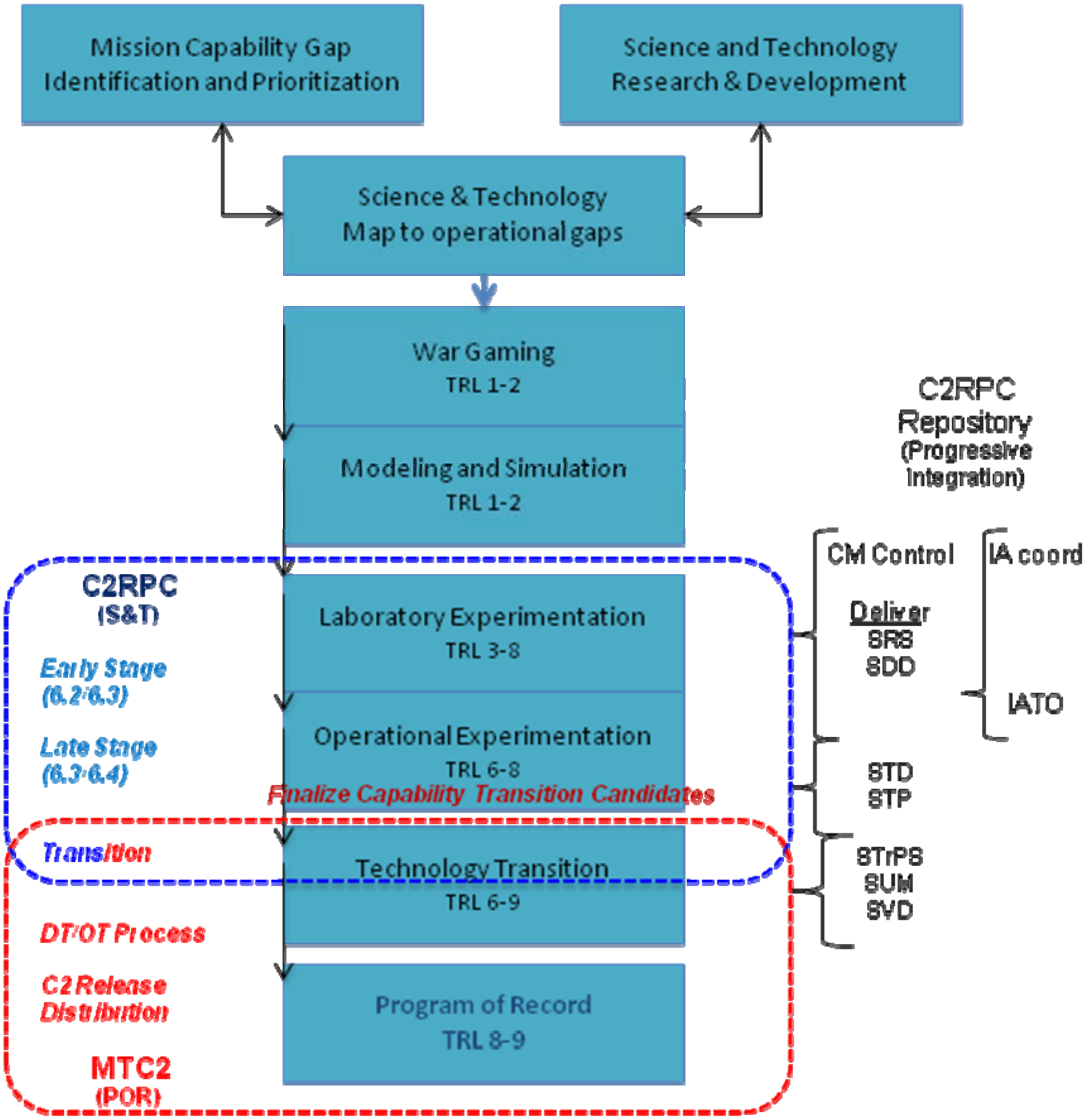

Figure 6. C2RPC and Technology Readiness Levels (TRLs)

Hosted Centralized Repository

The C2RPC hosts a software development and transition environment to facilitate continuous development and integration. The hosted environment is centered on an information repository (IR), where all stakeholders share information and have access to a common set of documentation and development tools. This hosted environment includes a segmented build environment for each developer to control its individual source code, but allows third party (public, with limited access) sharing of libraries and associated tools that are used across multiple developmental projects. The repository allows a broader stakeholder base to interact with the components as they progress through the various development and transition stages. The services and support that are provided through the hosted environment include

- Developer Version Control,
- Communication / Tool Support,
- Quality Control, and
- Automated Testing and Integration Environment.

As shown in Figure 7, the Central Repository is actually a collection of three types of repositories. The cardinality of each repository type varies, but in the figure they are each represented as if they are single units. Each Repository can potentially be accessed by the various stakeholders (Developers, Testers, and End-Users) using a central configuration management system. The three Repositories include:

- *Application (Prototype Developer) Repositories.* Each prototype development contractor has access to its own repository for developing source code. These modules can either be standalone applications, components of a parent application, or code libraries meant for use by other products. By combining these modules with shared code and external tools and applying a build process to them, software configuration items (CI) can be produced for C2RPC use.
- *External Repository.* The external repository is a public, read-only Subversion repository for use by all participating developers. Its purpose is to contain software CIs that meet the following criteria:
    - They are required for a developer to create a software product.
    - They are publicly available and free to use (no proprietary tools are allowed).
    - They are not tied to a particular developer's project.

  Items that would be found in this repository include:

    - Compilers and interpreters (JDK, gcc, Python, Perl, et al),
    - Build tools and frameworks (ant, Maven, ivy, et al),
    - Integrated Development Environments (IDEs; Netbeans, Eclipse, et al), and
    - External application programming interfaces (APIs) and libraries.

  The external repository's primary role is to store all of the third party tools needed by developers to assemble and make ready their development environment. Because this repository is *read-only*, developers are not able to populate it themselves. In order to get the necessary tools, they must send a request to the repository configuration management (CM) team, who works with the developers to place all needed tools into the repository. This is important because the CM team will be responsible for using the developer's build instructions to exactly replicate the software for testing and eventual release.

- *Common Component Repository.* The common component repository is a public, limited-access Subversion repository which contains libraries to be used across multiple developer projects. The typical example would be a repository containing common interfaces and base functionality to be used across a set of software products. The common repository, however, is populated by code written by the developers and not by external interfaces (thus differentiating it from the code in the external repository).

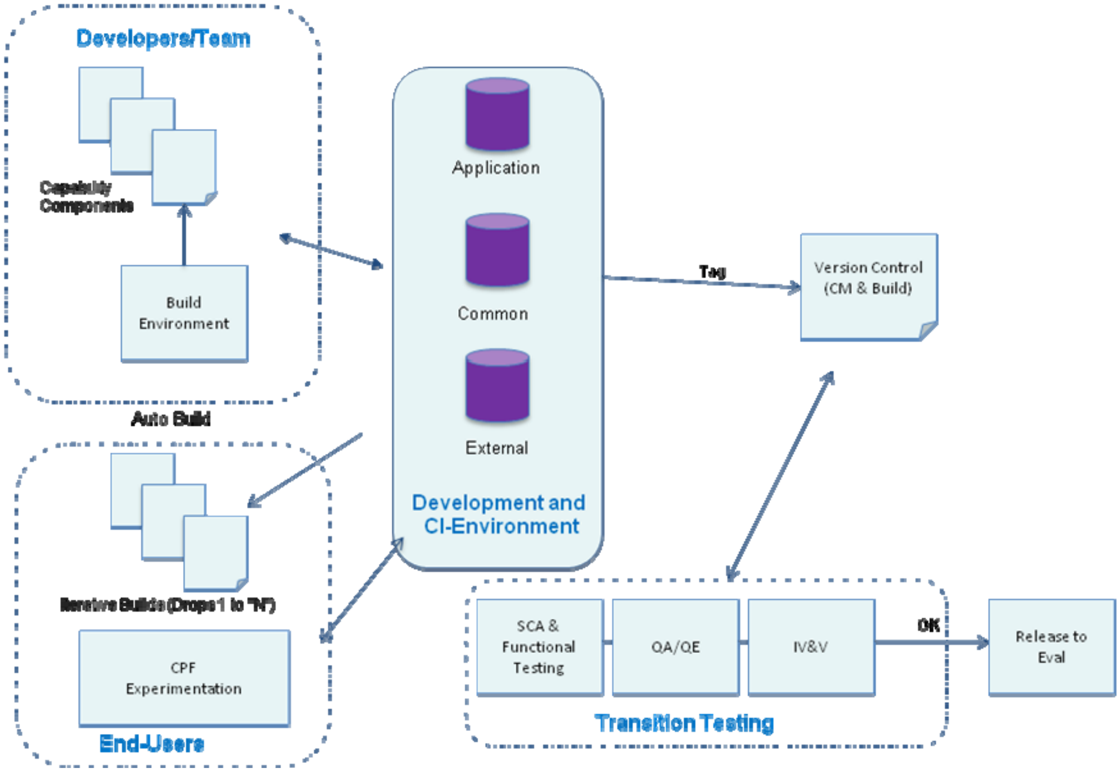

Figure 7. Repository Management, Prototype Development and Transition

C2RPC Governance

The pace of technology change and the increasing levels of complexity in C2 systems necessitate a more agile governance model for the acquisition of IT-intensive systems. One of the C2RPC's goals was to enhance the project agility and responsiveness to technological change and user requirements. The C2RPC wanted to establish a process where the Combatant Command (warfighter) had authority to reprioritize, add or delete non-key performance parameter requirements working along with the POR program sponsor and appropriate milestone decision authority. This new governance model would allow the development programs to more rapidly evolve to support changing Fleet needs. C2RPC governance includes several different activities to ensure that Fleet inputs are addressed when making programmatic changes.

- *Periodic Workshops.* As stated previously, the C2RPC conducts periodic workshops to develop and validate new C2 capability requirements and to gather operator feedback on recent capability installations. The workshops are 2–3 day forums and are normally conducted every 3–6 months, coinciding with engineer drops. The workshops are chaired by ONR but include members of the C2 IPT. These workshops have been instrumental in establishing the operational objectives for the incremental development and related engineering drops. Feedback from each successive drop has been used by the development to further enhance the C2 capabilities being installed.

- *On-site Technical Representative*. Coinciding with C2RPC Drop 1, ONR assigned a C2RPC system engineer to work on-site at COMPACFLT. The C2RPC system engineer works with the operators, trains them on C2RPC, gathers additional user feedback and interests, and helps interpret the operators' new capability requests for C2RPC deliveries. This individual interacts with COMPACFLT's operational and technical personnel to document and report recommended component changes to the developer team. In some cases, software modifications have been done in near-real time and the operator was able to experience the rapid response to proposed system changes. This has helped to foster a strong working relationship between the developers and operators and has reinforced the operators' involvement in the development process. The operators are actively engaged in providing feedback and are committed to the success of the final set of C2 components. This feedback has resulted in multiple iterative improvements to upcoming drops, with minor updates occurring daily or weekly.
- *Software Change Requests.* In addition to the periodic workshop and on-site technical representation, the C2RPC uses an online Software Bug Report and change request tool (the "JIRA" system) to submit change recommendations. A change request is a standard form for documenting what needs to be accomplished, but does not address how the change should be implemented. The JIRA "tickets" are used, in addition to the feedback received via the other methods, by the Engineering Review Board (ERB) to document longer range enhancements, re-prioritize, and to assign resources to the modifications or requested new capabilities.
- *Engineering Review Board.* The Engineering Review Board (ERB) is responsible for establishing the technical roadmap for the C2RPC as well as for setting the capability iteration cycle (drops), prioritizing the capabilities and fixes, and assigning technical resources within the constraints handed down by management for the C2RPC. Additionally, it is responsible for ensuring the configuration control of the various software increment releases and ultimately determines the selection and timing of the components for migration from Early Stage to Late Stage to nominating technologies for transition. Proposed change to the C2RPC drops gathered either through the workshops or the SCR process is reviewed by the ERB. This board is chaired by the C2RPC Chief Engineer (as designated by ONR and PMW 150) and includes representatives from each of the four functional pillars (ISR, etc.) described earlier. The ERB provides the C2RPC a level of project flexibility needed to meet the relatively short development cycle. It is necessary to have a board with this responsibility and authority if the rapid prototyping and integration activities are to meet the 4–6 month release cycles envisioned as part of the IT-intensive systems acquisition process.

  The ERB is empowered to

  - establish capability requirements and prioritization,
  - approve proposed component changes submitted through SCR process,
  - modify prototype requirements to meet operator needs, and
  - select the mature capabilities and propose them for transition.

C2RPC Transition Process

As stated previously, a significant challenge facing the C2RPC effort is transitioning the technology prototype components to the MTC2 program. The transition involves the continued maturation and hardening of the final designated capability components within Release One while undergoing a change in program funding from S&T to POR. This "hand-off" is conducted in the proverbial "valley of death" for new development programs where the "initial funding" is often fully expended before funding needed for continuity of operation is received. In this situation, it is more about management of the transition process and the close coordination needed between the two program sponsors to avoid any loss of momentum as the capability components are transitioned. There need to be shared expectations and appropriate funding levels provided by the respective sponsors. It is critical during this transition phase that the S&T funded prototypes achieve the expected maturity level planned for by the MTC2 sponsor prior to entering the transition phase. Conversely, the Program Office needs to have established the necessary program plan, schedule, and funding needed to complete the software development, testing, integration, and ultimate fielding. This program plan is generated based, in a large part, upon a specific set of assumptions and risks and the expected transition readiness of the C2RPC technology. If the C2RPC capabilities do not meet the minimum expected, the transition could fail, leaving the MTC2 program in jeopardy.

Currently the C2RPC has a Technology Transition Plan (TTP) Level A with the MTC2 POR and a start date of 2013. The initial C2RPC drop was developed in approximately 18 months. Further drops are planned at approximately four to six month intervals until FY 2012. The transition from the Late Stage development to the MTC2 POR for selected capability components is scheduled to begin in early 2012 and will be done in various steps. The transitional activities will be under the leadership of PMW 150 supported by SSC Pacific as part of its Navy C2 Software Support Activity (SSA) functions and will employ testing and integration processes established as part of the Rapid Integration and Test Environment (RITE) initiative.

Trusted Agent and Software Support Activity (SSA) Roles

SSC PAC supports PMW 150 as both the Navy C2 Trusted Agent and its Software Support Activity (SSA). These roles establish SSC PAC as a key participant in the overall C2 acquisition process. The functions performed by these two related roles are highlighted in Table 1.

Table 1. SSC Pacific C2 Support Roles

Trusted Agent	*Software Support Activity*
• Architecture Definition • Translating Requirements into Design Objectives • Engineering Support • Technical Reviews • Risk Management • Implementation of Transition Plan • Configuration Management • Deployment Planning • Schedules • Sustainment • Test and Evaluation	• Logging, tracking and analyzing Modification Requests (MRs) and Problem Reports (PRs) • Replication or verification of a reported problem, as required as part of the PR analysis • Development of options for implementing modifications • Design, development and testing of software enhancements • Design, development and testing of software corrections • Provision of Technical Assistance • Provision of Fleet Engineering Support • Provision of Maintenance Support • Performance of Software Support Risk Management • Performance of Configuration Management • Development of Technical Documentation • Acquisition and Reporting of Metrics

Rapid Integration and Test Environment (RITE) for Continuous Integration

The iterative nature of incremental component software development and the migration to net-centric operations requires a different set of software acquisition processes. PMW 150 established the Rapid Integration and Test Environment (RITE) to facilitate needed C2 testing and integration process change. RITE places increased emphasis on early and frequent software testing, as well as on necessary software engineering practices at the source code level. RITE provides an agile approach to software development, taking full advantage of technological advances and open source models to automate processes and shorten development cycles—thus increasing the maintainability of software baselines. RITE also clarifies software delivery requirements, adding engineering structure to final deliverables and reducing opportunity for misunderstanding between sponsors, end-users, and developers.

From the C2RPC, transition and integration of new, adapted, and adopted C2 system software capabilities will be synchronized into periodic C2 Releases (C2R), nominally on a six-month cycle. The transition of MTC2 Release One is expected later this year and at that time it will enter the RITE process. As the various incrementally developed capabilities reach the requisite maturity level (TRL 6-7), they will individually be evaluated and assessed for integration into the POR.

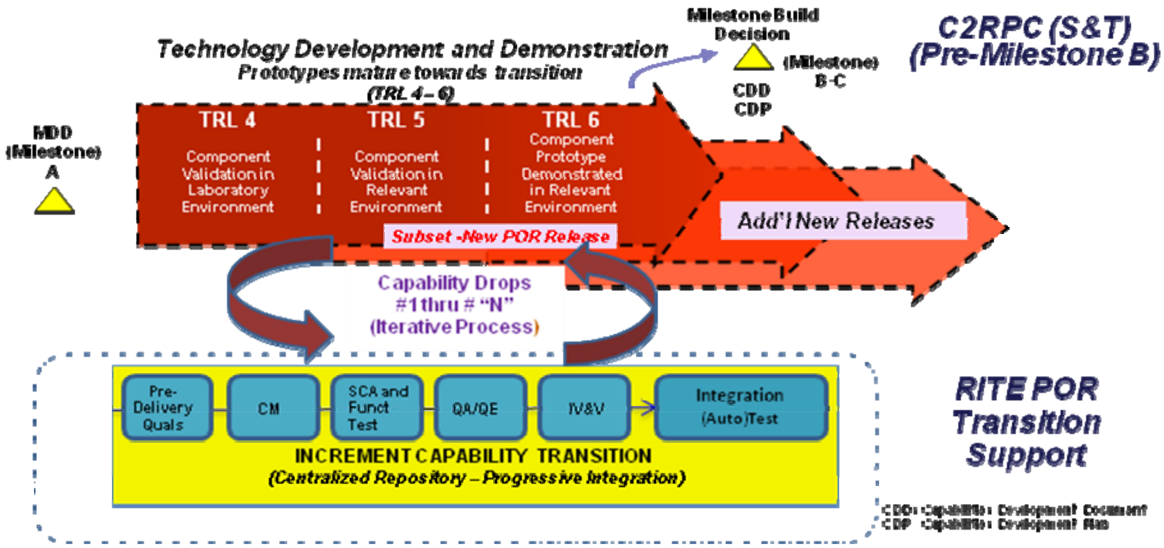

Figure 8. RITE Transition Processes for C2RPC Components

The successful transition of increments developed under the C2RPC umbrella is critical to achieving rapid Navy C2 system enhancement. Therefore, close coordination between the POR SSA and the individual prototype developers as the mature capabilities near transition is paramount. During the transition, the development program must begin adopting and implementing the software-development processes employed by the POR while it is effectively changing funding sources from S&T (6.3A, 6.3B) to POR acquisition (6.4-6.5). The RITE processes and infrastructure, as shown in Figure 8, will be used for the transition of the C2RPC. Using the centralized repository, as the selected capability increments reach the requisite TRL for transition, they will enter the RITE's testing and integration processes. These processes include completion of a pre-delivery qualification conducted by the vendor to ensure that the prototype is ready to enter a set of iterative testing and integration processes. Feedback is provided to the developer after each iteration so that issues can be corrected in a timely manner.

RITE Acceptance Process

Table 2 details the software-acceptance process required to enter the new technology product into the transition process. The process is part of the Maritime Global Command and Control, Family of Systems (MGF) Acceptance and Delivery Process and has been adapted for use in the C2RPC transition stage. RITE team members evaluate software work product deliveries to determine their suitability for integration into the POR. The objective is to ensure that developers delivering prototype source code, and other software products, for entry into the RITE do not have obvious or critical errors or omissions. The RITE acceptance and test team will work with the developer to correct any problems as part of the transition process.

Table 2. Prototype Software Transition Acceptance Process

Step	Actions	Decisions (Accept/Reject)
1	Developer delivers required software work product and other deliverables to RITE Configuration Manager. The Developer should follow the prescribed Delivery Qualification Checklist.	
2	Configuration Manager reviews delivery package against Acceptance Checklists. The acceptance checklists include the need for Information Security checks required by the relevant STIGs.	• Accept; notify Quality Engineering (QE) to conduct baseline "as is" assessment. (NOTE: This assessment [step] is ONLY conducted the first time a new developmental product is "delivered" for RITE testing and integration. For any additional drops, CM will commence at Step 4 upon acceptance of delivery.) • Reject; notify developer and specify issues identified. (Go to Step 8.)
3	QE conducts a technology baseline assessment to determine the current ("as is") state of the technology being delivered. Baseline assessment will be conducted using the Checklist provided in Appendix B.	• Upon completion, notify CM to execute build.
4	CM builds a software-executable version following build instructions provided in delivery package.	• Accept (build successful): Notify QE (Step 5), Security Engineering (Step 6), and System Integrator (Step 7). • Reject (build not successful): Notify developer of need for rework (go to Step 6).
5	QE reviews source code against requirements of the QE acceptance checklist.	• Accept; go to Step 10. • Reject; notify CM with reason for rejection. CM go to Step 8.*
6	Security Engineering conducts validation test using applicable STIGs and runs relevant automated test tools (e.g., Gold Disc) to determine IA compliance status.	• Accept; go to Step 10. • Reject; notify CM with reason for rejection. CM go to Step 8.*
7	System Integrator reviews delivery package against requirements of the Integration acceptance checklist.	• Accept; go to Step 10. • Reject; notify CM with reason for rejection. * CM go to Step 8.
8	CM notifies the Program Office and Developer of rejection and provides reason for rejection.	
9	Developer reworks software work product to correct problem(s) with delivery.	• Upon completion, return to Step 4.

10	If accepted by QE, Security, and System Integration, CM enters executable and delivery package contents into IR, establishing initial product iteration baseline.	

Note. *Rejection by Quality Engineering (Step 5) and Security Engineering (Step 6) does not automatically delay integration, but may require further work by the developer to complete transition.

Configuration Management and Documentation

The documentation identified for completion as part of the C2RPC prototype transition is developed collaboratively using a "confluence" wiki. For the development of technical reports, confluence combines online authoring capabilities and tools. Additionally, although many individuals can contribute to the document development, the Program Office retains complete control over who can create, edit, and view and export documentation. During the prototype development and transition stages, it is envisioned that different development teams, as well as end-users and testing teams, will be asked to contribute to the respective document development. Using the Wiki ensures that contributors are using the latest, up-to-date version of each document for better document configuration control. The Wiki also allows periodic releases of the documents and seamless editing as the prototypes evolve as part of the transition hardening development.

As the prototype continues to mature, required documentation is completed and filed on the Wiki for use by stakeholders in performance of their job requirements. The documents listed in Figure 8 are from MIL-STD 498 Standards (DoD, n.d.), whose purpose is to establish uniform requirements for software development and documentation. The standard and its Data Item Description (DID) are meant to be tailored for each type of software to which they are applied. Under the RITE process, SSC Pac works with the Program Office to tailor the specific standards that it wants to invoke for each specific contract. The POR will need to work closely with the C2RPC to produce the following list of documents for transition to the MTC2.

- *Software Requirements Specification (SRS).* Specifies the requirements for a Computer Software Configuration Item (CSCI) and the methods to be used to ensure that each requirement is met.
- *Software Design Description (SDD).* Describes the design of CSCI-wide design decisions, the CSCI architectural design, and the detailed design needed to implement the software.
- *Software Test Description (STD).* Describes test preparations, test cases, and test procedures to be used to perform qualification (transition) testing of a CSCI or software system or subsystem.
- *Software Test Plan (STP).* Describes the plan for qualification testing of CSCI and software systems. Describes the test environment to be used for testing, identifies tests to be performed, and provides the schedule for test activities.
- *Software Transition Plan (STrP).* Identifies the hardware, software, and other resources needed for life cycle support of deliverable software and describes the developer's plans for transitioning deliverable items to the support agency (or the Acquirer).

- *Software Users Manual (SUM).* Explains how to install and use a CSCI, a group of related CSCIs, or a software system or subsystem.
- *Software Versions Description (SVD).* Identifies and describes a software version consisting of one or more CSCIs. It is used to release, track, and control software versions, which in this case is the initial software release for transition to the POR.

Summary

The C2PRC is an initiative jointly funded by ONR and PEO C4I to develop new C2 capability components for future maritime C2 PORs. The initiative is not only supporting the implementation of a new C2 strategy focused around the four functional pillars of the *Operational Level of War* but has also pioneered new prototype development and transition processes needed to rapidly develop, test, and field new software technologies. Uniting the various stakeholders, the C2RPC has streamlined the S&T phases of the acquisition process, coupling emerging technology requirements, development, testing, and integration phases into a continuous agile software development model designed for IT-intensive C2 systems.

The C2RPC prototypes have undergone an intensive development and demonstration process, and selected components are expected to enter transition later this year. The proof will be in the ability to successfully integrate the new software into the C2 POR, but the close coordination between ONR and the Program Office throughout the prototype development has reduced POR risk and should allow the POR to field the new C2 software earlier than would have been possible following a traditional acquisition cycle.

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