



# Multi-Mission Maritime Aircraft Acquisition Planning: Requirements Development and Maturation

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**T**he Multi-mission Maritime Aircraft Program will recapitalize the Navy's capabilities for Maritime Patrol and Reconnaissance currently provided by the P-3 Orion fleet. The P-3 has performed a variety of missions, including armed surveillance and reconnaissance tasking, for more than 30 years. Although onboard systems capabilities have been upgraded continually through the years, the aging P-3 fleet will soon reach the end of its fatigue life. Faced with a limited development budget, rapidly diminishing P-3 airframe life, and the need to field replacement aircraft in the 2012–2014 timeframe, the program has focused on modifications to existing military or commercial airframes. The systems engineering strategy has emphasized developing, refining, managing, and translating affordable, technically achievable requirements as a primary objective. Establishing systems engineering processes that seamlessly link requirements from Defense Planning Guidance to performance specifications and collaborating with industry partners to mature system requirements are hallmarks of the program philosophy.

## INTRODUCTION

For over 30 years, the Navy P-3 Orion has performed a variety of missions including anti-submarine warfare, anti-surface warfare, mine warfare, intelligence gathering, and other maritime surveillance and reconnaissance tasking. Its onboard systems capabilities have been upgraded through the years; however, the P-3 fleet is rapidly running out of operational airframe life.

The goal of the Multi-mission Maritime Aircraft (MMA) Program is to recapitalize the fleet capabilities of the search and attack functions currently executed by P-3C aircraft. Those primary requirements are to sustain and improve

- Armed surveillance and reconnaissance in maritime and littoral areas
- Collection, processing, and dissemination of environmental data and acoustic signals, imagery, communications, and electronic intelligence
- Evolution into a network-centric environment<sup>1</sup>

To ensure that an affordable, technically achievable set of system requirements was attained, the program demanded an immediate focus on systems engineering and requirements traceability throughout the development process. APL was engaged by the MMA Program Manager (PMA-290) to provide a range of analysis and

program development activities. Requirements development efforts included sessions in APL's Warfare Analysis Laboratory with Fleet users to validate needs and representations within analysis scenarios, validate key operational requirement parameters, and collaborate with industry and government partners to refine performance specification requirements for the design phase of the program.

## REQUIREMENTS GENESIS

The P-3 aircraft will soon begin to reach the end of their airframe fatigue life after having undergone significant material degradation over their years of operation. In the past 10 years, the aircraft have also experienced a steady decline in mission-capable rates (the ability to perform a particular mission, driven largely by equipment maintenance readiness).

Recognizing the need to field a follow-on system to the P-3, in 1998 and 1999 the Navy conducted a Mission Area Analysis using Strategy-to-Task "Quality-Function-Deployment" methodology and a Short-falls Analysis, respectively. A Technical and Economic Feasibility Analysis of several potential aircraft alternatives was conducted as well. Referred to as the Multi-mission Maritime Aircraft, this preconcept exploration work supported development of a Broad Area Maritime Surveillance (BAMS) and Littoral Armed Intelligence Surveillance and Reconnaissance Mission Need Statement that was validated and approved by the Joint Requirements Oversight Council (JROC) on 29 February 2000, enabling a Milestone 0 decision and entry into the concept exploration phase. (The current DODI 5000.2, issued on 12 May 2003, now defines Milestone A as entry into the analogous technology development phase.)

## IDENTIFYING THE DESIGN TRADE SPACE

The Deputy Chief of Naval Operations for Air Warfare (N78) sponsored an analysis of alternatives (AoA) that was executed by the Center for Naval Analyses beginning in June 2000. The MMA AoA Phase I examined a broad range of potential solutions including manned and unmanned aerial vehicles (UAVs) and satellites. Viable options identified from Phase I included a new-production P-3 derivative, a medium-sized commercial derivative based on the Boeing 737 or Airbus A320, a large-sized commercial derivative based on the Boeing 757 or Airbus A321, and a military derivative based on the Nimrod MRA4. Phase I was completed in December 2000, concluding that a core element addressing the Mission Need Statement should be a land-based manned aircraft. Aircraft with the necessary characteristics included both commercial- and military-derivative platforms.

Revised AoA guidance in 2001 required the analysis of several additional concepts in the Phase IIA study:

the U.S. Air Force Common Wide Body concept based on the Boeing 767 or Airbus A310; an organic, carrier-based solution of both manned or unmanned options; and an unmanned land-based concept. Phase IIA provided additional analysis of the candidate manned aircraft alternatives and Phase IIB, also in 2001, examined the role of adjunct sensors and platforms. Phase IIB analysis identified a potential role for UAVs in meeting some of the Maritime Patrol and Reconnaissance mission requirements. A subsequent decision by N780 required that a separate study be conducted to examine alternatives for satisfying the UAV role in BAMS. Study results are expected to be completed before MMA enters system development and demonstration (SDD) in 2004.

## MMA ACQUISITION STRATEGY

The MMA Program is structured on an evolutionary systems replacement approach that aligns the processes employed for requirements definition, acquisition strategy, and system development into a dynamic and flexible means to attain the strategic vision for tomorrow's naval forces.

The method used for MMA requirements definition has capitalized on an iterative process with industry and the Fleet. It promotes evolutionary growth in capabilities while providing a transformational product to the users. Matched with this requirements definition process is the evolutionary acquisition strategy. For MMA, this strategy focuses on delivering the first increment in capability to the users in the earliest, most cost-efficient manner to address the Navy's inventory issue. Concurrently, the program will pursue increases in system capabilities through a spiral development process that allows the system to keep pace with emerging technologies and the strategic requirements of both the Navy and Joint forces. The spiral development process will address capabilities in well-defined blocks of functionality. In Block 1, the MMA Program will focus its resources on the development of an innovative systems architecture that will promote system growth and flexibility. This will be accomplished by basing the design of the mission system on an open systems architecture that will allow system evolution through the spiral development process and provide increased capabilities through future incremental block upgrades. The results will be the rapid delivery of a transformational system to the Fleet via the initial (Block 1) capability.<sup>2</sup>

## REQUIREMENTS MATURATION STRATEGY

The acquisition strategy was firmly rooted in a systems engineering philosophy embraced from the earliest days of the program. Developing, refining, managing, and translating affordable, technically achievable requirements was a primary objective. Instituting a framework

and process for achieving that objective depended on a number of early systems engineering philosophies and actions that have guided the program:

- Ensure that mission needs and operational requirements are linked to top-level operational Joint requirements (e.g., Defense Planning Guidance) and are further traceable to Navy warfighting requirements. This was implemented primarily by Design Reference Mission operational and tactical situations as well as Mission Area Analysis crosswalks (attributing unified Joint and Navy task lists to required MMA operational capabilities). A key feature of this process included validation by a Fleet user team of the requirement set analyzed for MMA.
- Conduct the derivation of requirements through analysis. Use both documented information and leverage domain experts from the Fleet and supporting organizations, both military and industry. This was implemented by the MMA Platform Performance Assessment Tactical Situations Analyses Summary, which identified potential key performance parameters and potential performance issues.
- Involve industry early and often in both the derivation and maturation of requirements by enabling iterative participation throughout the requirements development process. This was implemented by maturing draft requirements and specification documentation in collaboration with industry.
- Stimulate industry offerors with potential desirable capabilities, including those in the science and technology roadmap, to enable cost-as-an-independent-variable (CAIV) trades and planning for affordable upgrades for future blocks. This was implemented by providing draft threshold and objective technical values to define the trade space for affordable requirements. Also provided was science and technology information on potentially applicable government efforts to ensure that industry was aware of the full range of concept possibilities.
- Establish an open systems architecture framework to enable affordable, efficient upgrades to capabilities to allow the MMA system to meet requirements over the expected 25–30-year life of the airframe. This was implemented by providing the MMA Avionics Architecture Definition guide, which described technologies, widely accepted standards, and design philosophies.
- Establish a process for capturing and managing requirements to ensure stability and heritage with both parent and child requirement documentation. Maintain records of changes, justifications for changes, and authorizations for changes. This was implemented by employing a requirements management system to ensure traceability from top-level warfighting requirements to system-level specifications.

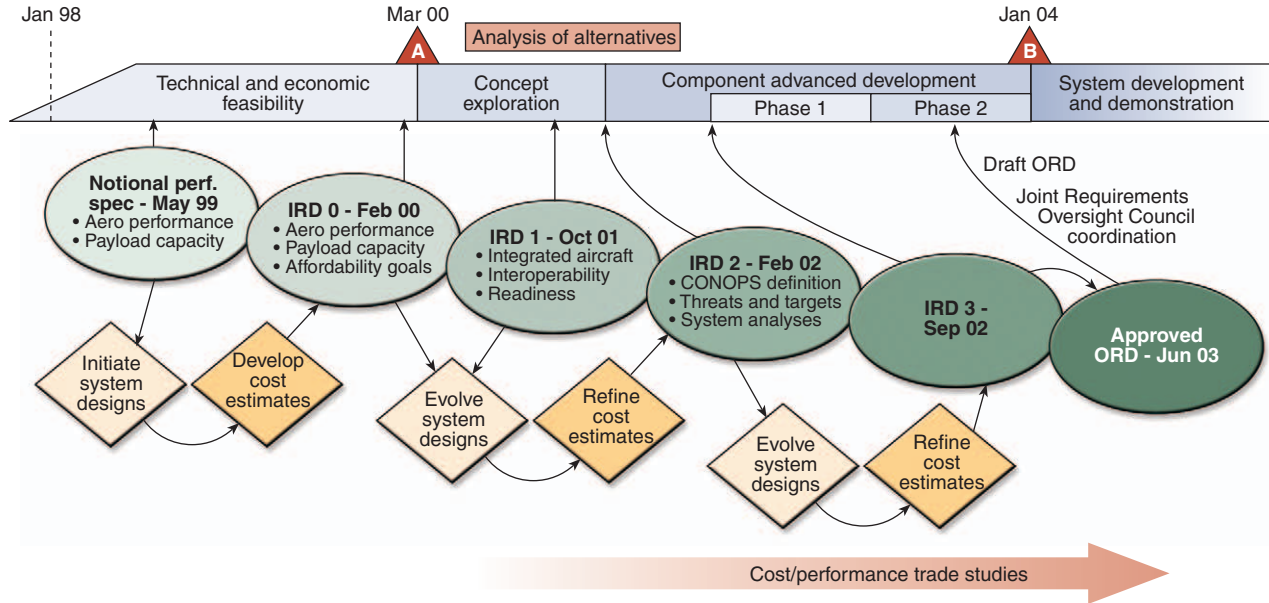
Unlike some new acquisition programs, the requirements were already somewhat defined by a need to recapitalize current capabilities, rather than to develop new warfighting functions. The preconcept feasibility studies provided critical boundary conditions for Phase 0 concept exploration and structured a firm foundation for the Mission Needs Statement (MNS). During concept exploration, the AoA and industry concept studies further refined the requirements boundaries and served as a basis for developing an Initial Requirements Document (IRD). During the component advanced development (CAD) phase, the Program Office and industry offerors will collaboratively refine the requirements and top-level specifications through the IRD and Draft Performance Based Specification (PBS). This collaboration is crucial to ensure that industry fully understands Navy customer expectations and that the Navy fully appreciates the cost and schedule impacts of the requirements on each specific industry alternative.

The requirements maturation process is represented in Fig. 1 (from a briefing by J. Landfield, PMA-290, 1 Oct 2001). The process reflects the continual interaction of government and industry partners in collaboratively maturing program definition and exchanging information to enable refinement of cost, budget, schedule, and requirements prior to entering SDD. In addition, the process will yield analytical support for performing CAIV trades in the initial requirements trade space. The refined set of needs will be reflected in the Capabilities Development Document (CDD) (previously referred to as an ORD; the revised DODI 5000.2 nomenclature for operational requirements needed for a Milestone B decision is CDD) and the PBS required for entry into SDD in 2004.

## EFFECTIVENESS REQUIREMENTS

MMA is somewhat atypical for a new development program because potential solutions were limited early on to modifications of existing commercial or military airframes. (This is very much a cost and operational constraint similar to the original P-3 acquisition 45 years earlier, which leveraged the commercial Lockheed Electra airframe.) Since MMA is a recapitalization effort, the mission systems capabilities (sensors, communications, weapons, fire control, etc.) were baselined on the effectiveness of current systems and their respective development roadmaps. For example, the performance characteristics of the P-3C Aircraft Improvement Program and Baseline Modification Upgrade Program that were projected to be at Technology Readiness Level 9 (actual system “flight proven” through successful mission operations) in 2007 were the basis for writing performance-based specifications for the mission systems for MMA.

One challenge was to specify the functional performance of systems without being overly prescriptive and



**Figure 1.** The MMA requirements maturation process reflects industry/government collaboration to refine cost, budget, scheduling, and requirements issues.

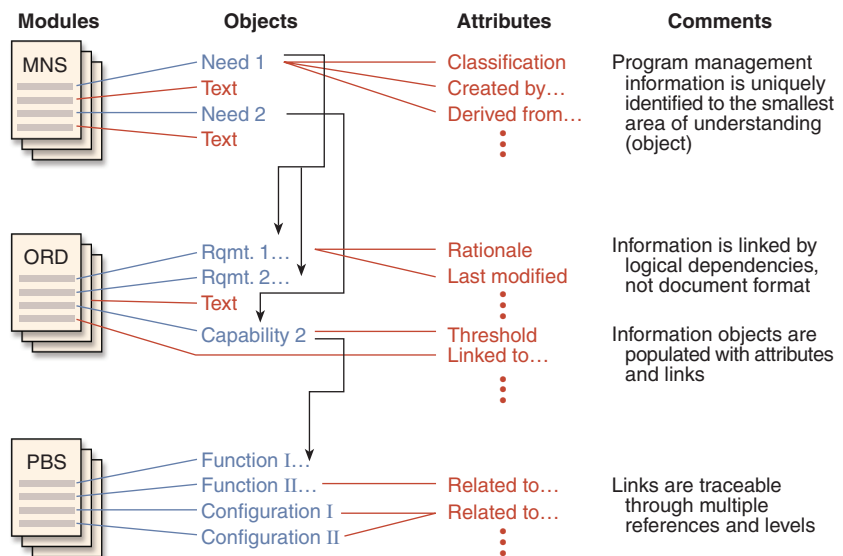
driving industry to specific existing/planned hardware implementations. Alternative systems or components that would meet the performance requirements but might offer cost savings or other desirable attributes (e.g., open systems features) were thus included in the trade space. The MMA Mission Systems Team successfully characterized the functional performance of the baselined systems and included both performance attributes and supporting analysis in information provided to the CAD phase offerors.<sup>3</sup>

**REQUIREMENTS TRACEABILITY**

To maintain a seamless track of the lineage of requirements from top-level warfighting guidance through the weapons system specifications to industry, APL chose a Dynamic Object Oriented Requirements System (DOORS)-based Requirements Management System from subcontractor Holmes-Tucker International. Used successfully in the analogous phase of the Joint Strike Fighter Program, the Requirements Management System employs a DOORS database of requirements objects that enables linking of requirements objects in various documents. Figure 2 describes the traceability of requirements between documents. The database is used to record decisions, actors in the decision process, supporting documentation or analysis, changes to requirements objects, and pointers to

subsequent changes that may be required in other documents that have been linked in the DOORS database. The Requirements Management System also allows rapid notification of the range of impacts that might occur as a result of a change requirement.

Because all requirements are linked in a common database containing all pertinent documents, orphan requirements or gaps in requirements flow-down are readily identified by gap analysis. And since related objects are linked in the database, changes that occur in one document may readily be attributed to another. This is particularly important when requirements language is common or similar across many documents (e.g., CDD, PBS, Test and Evaluation Master Plan, etc.). In addition, the system



**Figure 2.** Requirements Management System traceability enables a seamless track of lineage requirements from top-level warfighting guidance to industry specifications.

offers significant configuration control qualities across many engineering and acquisition documents.

## MATURING THE MMA REQUIREMENTS

As previously mentioned, potential industry offerors were involved in concept studies from the beginning to help bound the technical and affordability dimensions for the MMA Program. In 2002, the Navy conducted a competition to select industry partners for the CAD phase. As a result, Lockheed Martin and Boeing were awarded contracts to further develop MMA concepts. Both offerors were given draft requirements and performance-based specifications to conduct baseline analysis for their respective concepts; to comment on the cost, schedule, and technical features of the requirements set; and to offer proposed changes to the requirements which provided lower cost or less risk for achieving a compliant design. Since both offerors selected for CAD also employed DOORS for their respective systems engineering requirements tracking systems, a common set of objects was used to communicate the requirements to both.

## EFFECTING REQUIREMENTS CHANGES

The benefit of employing a rigorous requirements management philosophy was realized early in the acquisition program. Shortly after the award for CAD Phase I contracts, the Navy deleted the requirement for a Signals Intelligence (SIGINT) variant of MMA (i.e., EP-3E replacement), choosing to focus on the search and attack (i.e., P-3C) variant only for the initial produc-

tion block of MMA. (SIGINT functionality will now be addressed in a separate APL-led study examining alternatives for recapitalizing the EP-3E capability.) Because all of the requirements for both original aircraft variants were captured as linked objects in the DOORS database, the transition to both requirements and specification documentation for a search and attack-only version was realized with relatively little additional effort. In addition, because all specification objects were linked to parent requirements in the IRD, changes were rapidly accomplished, enabling minimum turnaround of both the IRD and Draft PBS to industry offerors for CAD Phase II analysis. CAD Phase II will precede downselect to a single industry partner for SDD in 2004.

## SUMMARY

The MMA acquisition program employed an early focus on analytically supportable, affordable requirements and provided a process to ensure traceability of those requirements from Defense Planning Guidance to system-level hardware and software specifications. The Requirements Management System's ability to involve industry in the derivation of affordable, technically achievable requirements has been crucial to program progress.

## REFERENCES

- <sup>1</sup>*Broad Area Maritime and Littoral Armed Intelligence Surveillance and Reconnaissance Mission Needs Statement*, Joint Requirements Oversight Council, Washington, DC (2000).
- <sup>2</sup>*Multi-mission Maritime Aircraft Acquisition Strategy*, Maritime Surveillance Aircraft Program Office, Patuxent River, MD (2001).
- <sup>3</sup>*Multi-mission Maritime Aircraft Performance Based Specification*, Maritime Surveillance Aircraft Program Office, Patuxent River, MD (2001).

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