The Multi-Mission Maritime Aircraft Design Reference Mission

Trena C. Lilly and Bruce R. Russell

A Design Reference Mission (DRM) defines the specific projected threat and operating environment baseline for a given force element, which may range from a single-purpose weapon system to a multi-mission platform to a multi-system, multi-platform system of systems. The Multi-mission Maritime Aircraft (MMA) DRM provides a notional description of deployed operations for the future MMA. It is primarily an engineering/design tool to support systems engineering activities by identifying significant design-driving operational elements and characterizing them to the level of detail necessary to assess design impact. The DRM is intentionally modular to allow the U.S. Navy to tailor or modify the scenario and its components over time in order to update aircraft operating and warfighting requirements and prospective solutions. To this end, the DRM is envisioned as an evolutionary document that can be revised throughout the acquisition process.

INTRODUCTION

A common, authoritative threat and operating environment baseline is critical to efficient and successful systems engineering. The Design Reference Mission (DRM) provides a common framework to link systems engineering efforts and help to ensure an "apples to apples" comparison of analytical results. This article describes the DRM developed for the Multi-mission Maritime Aircraft (MMA) Program.

Multi-mission Maritime Aircraft Background

The Navy needs a multi-mission, responsive, deployable, long-range capability to replace the functions now performed by the P-3C Orion and EP-3E Aries aircraft. These aircraft entered service in the early 1960s and are approaching the end of their service life. Therefore, the intent of the MMA Program is to develop the next generation of Maritime Patrol and Reconnaissance aircraft that will substantially reduce total ownership costs while improving capability, availability, and supportability.

As stated in the MMA Initial Requirements Document (IRD), the MMA will respond to missions that range from peacetime to major theaters of war (MTW). These aircraft will be fielded in block increments that incorporate technology improvements to provide increasing operational capabilities. The initial

production blocks will require an overall mission system capability no less effective than the baseline configurations being replaced in order to conduct legacy missions and those deemed feasible in the future.

Legacy missions encompass a mix of anti-submarine warfare (ASW); surface warfare (SUW); command, control, and communications (C3); information warfare (IW); intelligence (INT); command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); command and control warfare (C2W); and other mission areas and specialty tasks. Maritime Patrol and Reconnaissance aircraft conduct detailed reconnaissance, surveillance, and ASW sanitization in the operational area (OPAREA) in advance of the arrival of naval forces. They provide effective over-the-horizon surface surveillance and mid- and outer-zone ASW defense of expeditionary strike groups and detachments. Likewise, when an aircraft carrier is not conducting flight operations, these aircraft provide similar services for the carrier battle group.

The MMA Program addresses the need to sustain and improve maritime and littoral ISR capabilities for U.S. naval forces in traditional, joint, and combined roles to counter changing and emerging threats. Satisfying this need permits the Navy to enhance performance by sustaining and improving the collection, processing, and dissemination of intelligence, including acoustic, imagery, and electronic intelligence; conducting surveillance and reconnaissance in maritime and littoral areas above, on, and below the surface of the ocean; and supporting the evolution into a network-centric warfare environment.

Design Reference Mission Background

The primary objective of a DRM is to characterize the specific projected threat and operating environment that will serve as the baseline for a given force element, which may range from a single-purpose weapon system to a multi-mission platform to a multi-system, multi-platform system of systems. This objective is common across the variety of systems acquisition policies used by the Navy.

A DRM is primarily an engineering/design tool to support systems engineering activities (i.e., requirements definition and refinement, concept development and evaluation, trade study analysis, design, test and evaluation) by identifying significant design-driving operational elements and characterizing them to the level of detail necessary to assess design impact. Operational situations (OPSITs) are developed to feature selected operational characteristics, or combinations thereof, in operationally viable combat environments. Inputs and reviews from the acquisition, operational, and intelligence communities ensure valid, realistic, and useful representations.

There are three types of DRMs: Warfare Area, Platform, and Battle Force. Warfare Area DRMs focus on the application of single and multi-warfare platform types to a specific warfare area. Warfare Area DRMs are developed to enable exploration of the entire warfare domain, which includes portions of other Platform DRMs. Platform DRMs focus on a variety of warfare operating environments that might be encountered by a single multi-warfare platform. Platform DRMs cover only a subset of Warfare Area DRMs, where the operational environments must be consistent. Battle Force DRMs focus on a multi-warfare, multi-platform system-of-systems operating environment that provides a venue for cross-warfare, cross-platform, and interoperability analyses.[1]

As discussed in Ref. 1, the evolving DoD systems acquisition process heightens the need for the strong threat and operating baseline provided by the DRM. The traditional acquisition process, i.e., one in which a government team develops detailed system specifications that are then provided to industry to guide system development, has been modified to involve industry earlier in the process. Industry now functions as an integral member of the systems engineering team or may even replace the government in the development of systems concepts and specifications.

Figure 1 illustrates the Common Systems Engineering Process. Here, the DRM is a key element of the systems operating environment definition, which establishes the foundation for systems engineering trade studies and specification development.

MMA-SPECIFIC DRM

Purpose

The MMA DRM is a platform DRM specifically designed to support the MMA Program. The DRM defines a common set of problems and questions for evaluation by both industry and government. The problems are derived from the MMA IRD and provide a systematic way to evaluate whether the MMA designs are responsive to the requirements articulated in the IRD.

Operational availability for mission-critical systems during peacetime and wartime operations is the primary measure of material readiness for the aircraft and its ability to perform missions. The DRM serves as a framework to evaluate the reliability, availability, and maintainability (RAM) characteristics of the MMA design as it evolves and to demonstrate the potential to meet the operational availability thresholds in proposal analyses and presentations. The DRM identifies stressing conditions involving the environment, threat, operational characteristics, tactics, and mission elements. It characterizes these elements to the level of detail necessary to assess the RAM impact of engineering design as well as logistic mission support alternatives and trade-offs. Additional alternative and system-level

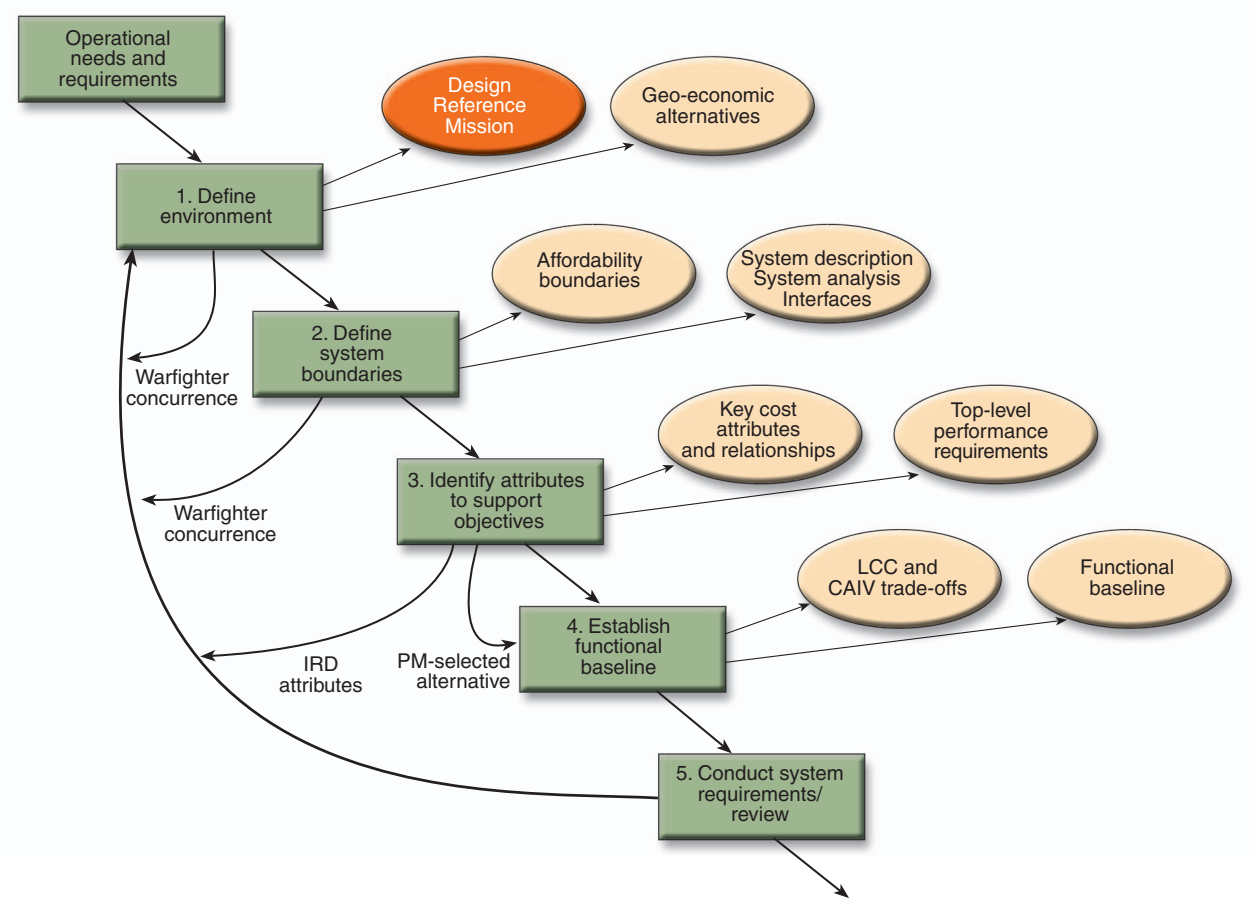

Figure 1. The Common Systems Engineering Process.[1] Process elements are partially concurrent, nonsequential, and iterative. With feedback from program managers (PMs), operators, and others, the process is revised as needed. The products of the process are shown in the ovals. (CAIV = cost as an independent variable, IRD = Initial Requirements Document, LCC = life-cycle costs.)

criteria for availability and material readiness may be developed and used for trade-off analyses. Trade-offs are encouraged to determine the optimal extended forward deployment duration relative to total ownership costs and availability requirements.

The MMA DRM also provides a notional description of deployed operations for the MMA. It is intentionally modular to allow the Navy to tailor or modify the scenario and its components over time in order to update aircraft operating and warfighting requirements (and prospective solutions) circa 2015. To that end, the DRM is envisioned as an evolutionary document that can be revised throughout the acquisition process.

Development

The MMA DRM was derived from a draft MMA Concept of Employment (CoE) authored by J. Orosz of the Naval Air Systems Command (NAVAIR) Warfare Analysis Dept., AIR-4.10. The CoE and the IRD were reviewed thoroughly, and a Top-Level Requirements Matrix was then developed to determine which scenarios would best serve MMA DRM development. Next, requirements were mapped to key performance parameters, minimum or threshold requirements, and goal or objective requirements. A check was placed in each cell of the matrix to indicate if the requirement affected the aircraft alone, mission systems alone, or a combination of both. Checks were then placed to show which warfare area (ASW, SUW, etc.) would be affected by the requirement, and what type of scenario would best address the requirements and warfare areas ranging from major conflict to peacetime operations.

Once the matrix was populated, a set of OPSITs and tactical situations (TACSITs) was developed at a high level based on Defense Planning Guidance scenarios, the draft MMA CoE, other related DRMs, and actual past operations. These OPSITs and TACSITs were next mapped against the requirements to ensure that all requirements would be represented at least once and that differing environmental, threat, and operational conditions would also be addressed for each requirement. The OPSITs and TACSITs were subsequently modified based on the mapping against the requirements to ensure that all requirements would be represented (Fig. 2).

On 17 May 2001, several Navy organizations held a 1-day vetting session during which the results of the Top-Level Requirements analysis were assessed and the 11 OPSITs were agreed upon and accepted for use in the

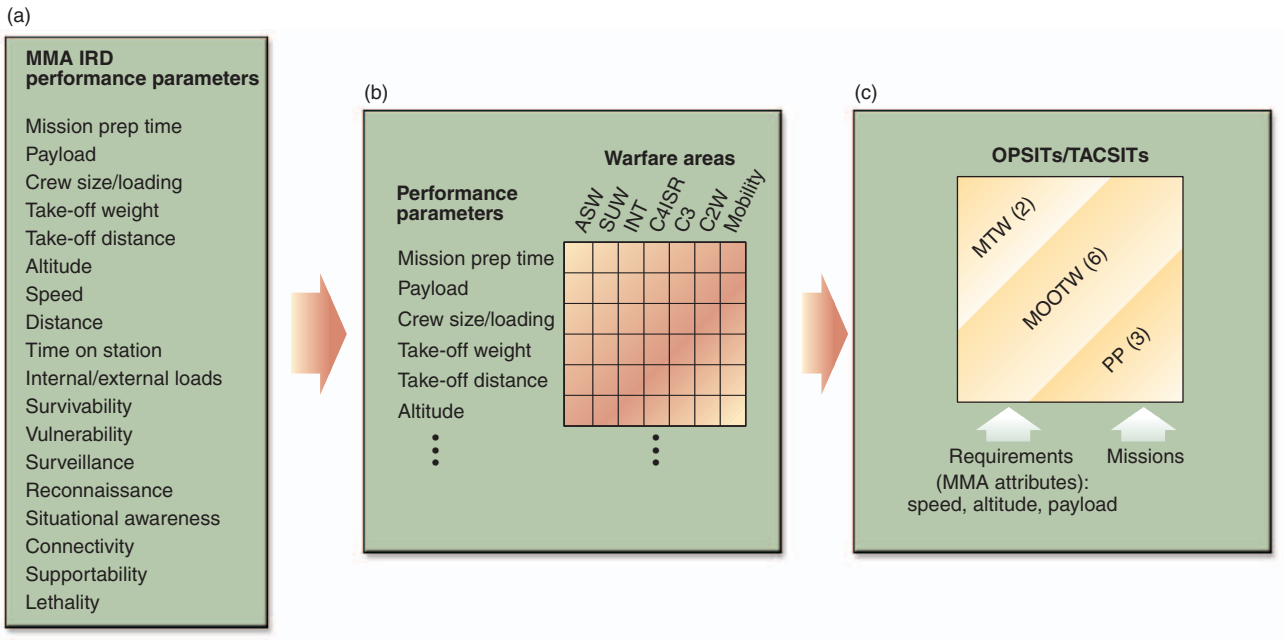

Figure 2. Development of the MMA DRM. (a) The Initial Requirements Document was reviewed and the requirements were mapped to key performance parameters. (b) A matrix was developed and checks were placed to show which warfare area (ASW, SUW) would be affected by the requirement and what type of scenario would best address the requirements and warfare areas. (c) Once the matrix was filled in, a set of OPSITs and TACSITs was developed. The OPSITs and TACSITs were next mapped against the requirements to ensure that all the requirements were represented at least once and that differing environmental, threat, and operational conditions would be addressed. The MMA DRM will be used to determine MMA attributes such as speed, altitude, and/or payload that the MMA should be expected to meet.

DRM. The OPSITs were selected based on a spectrum of conflict operations such as MTW, small-scale contingency, military operations other than war (MOOTW), or peacetime presence (PP), as well as level of threat (to protected units/platform), force structures and levels of support, intensity of activity, geographies and environments, and primary and secondary missions to be accomplished. The selected OPSITs, designed to ensure that the MMA could support all potential Joint Vision 2020 operating environments, were delivered as Part I of the MMA DRM.

Each OPSIT contained several TACSITs, i.e., the specific engagements to be studied. Aviation meteorological and oceanographic data were provided in each TACSIT. The data were based on historical conditions during the TACSIT operational time frame in the region.

On 14–15 August 2001, a team of people from various Navy organizations was briefed on the approved 11 OPSITs and 41 proposed TACSITs. The team reviewed the analyses to ensure that the OPSITs supported the development of performance parameters (threshold and objective) in the IRD and to validate specific TACSITs that described how the Navy expects the MMA to perform certain missions. The 41 TACSITs were approved by this team and are provided in Part II of the MMA DRM.

Each OPSIT covers a fairly short period of time (days). Within this period, the MMA will be subjected to specific military engagements or TACSITs, each of which will be described with a mission statement, a situation description, and a geometry description. Engagements focus on individual warfare areas as well as simultaneous multi-mission tasking. The TACSITs include more detailed information on the mission of the MMA, friendly and threat assets, physical environment, and threat tactics for the specific engagement.

Structure

The first section of the MMA DRM contains a broad description of the process by which the operational contexts were established for the MMA. These should not be considered as all-inclusive, constraining, or directive. The areas of interest are identified, stressed, and presented for subsequent analysis. The design concept provides the process, supporting rationale, and methodology for addressing issues in areas of interest within the operational context of the DRM. The robustness of aircraft design proposals will be examined by varying the conditions bounding the deployment timeline within the OPSITs. These conditions include the geographic locations of friendly and hostile forces, threat characteristics, physical environment characteristics, and aircraft operational environment. In addition, several operational constraints within the theaters of interest have been placed on the aircraft in order to focus on total aircraft system issues.

The main body of the MMA DRM document is devoted to the 11 OPSITs and supporting TACSITs,

covering the range of peacetime and conflict operations that the MMA could reasonably be expected to encounter.

A Threat Appendix was prepared to support the MMA Program with intelligence concerning current and projected threats and targets and describes the threat environment for the MMA. The purpose of this appendix is to provide a quick reference concerning the set of threats contained within the MMA TACSITs. The authoritative threat reference document, the System Threat Assessment Report, was released after publication of the MMA DRM.

Operational Situations

The MMA DRM was provided to develop an operational context to support the analytical underpinning required to determine the performance parameters that are presently described in the MMA IRD and Performance Based Specification (PBS). Operational context is established through the use of peacetime and conflict (or near-conflict) OPSITs. These OPSITs are set in real geographic locations with projected threats, but since they may contain constructs that do not reflect the "real world," the DRM may serve as a tool for engineering assessments. The operational context is designed to cover the expected range of important operational conditions to be encountered by the MMA under both peacetime and wartime conditions. The 11 agreed upon OPSITs are within range of the potential MMA airfield locations. They are geographically dispersed to account for real-world operations.

Where appropriate, specific situations and events are described with a mission or task statement, a situation description, and a set of operational and physical environments. These OPSITs have a pedigree of use and design spanning the current set of naval and joint mission contexts.

The operational context consists of OPSITs that contain the

Mission of the MMA
Friendly and threat assets
Threat characterizations and order of battle (OOB)
MMA basing
Airfield weather data
Route-of-flight information
Physical environment characterizations

OPSITs 1 and 2—non-peacetime conditions varying from prehostilities through conflict operations in MTWs—represent major conflicts involving joint forces and were designed to aid in the development of future system requirements and acquisition specifications in high threat environments.

OPSITs 3–8 involve MOOTW scenarios and reflect a variety of potential MMA missions in support of the objectives of the U.S. National Security Strategy across the full range of potential military operations. Since the destruction of the Berlin wall and subsequent demise of the Soviet Union, U.S. military forces have responded to a growing number of small-scale contingencies, ranging from noncombatant evacuation operations to peacekeeping and disaster relief. In addition to their frequency of occurrence, these operations are best characterized by little or no indications or warnings. As a result, first-on-the-scene forces often face many unknowns. The general nature of these scenarios increases the risk to early entry forces as they face either a rapidly deteriorating situation or one teetering on the brink of war.

OPSITs 9–11 (also in support of the objectives of the National Security Strategy) reflect the enduring PP situations that continue to characterize maritime patrol operations.

OPSITs 3–11, MOOTW and PP scenarios, are structurally different from OPSITs 1 and 2, warfighting scenarios, in a number of ways. Some could be preludes to war, while others are merely peacetime out-of-area operations that the United States might wish to monitor. They do not have the traditional indications and warnings/road-to-war timelines as in a full-scale OPSIT. The political/military background is not as extensive in these OPSITs compared to that given in one of the well-developed Defense Planning Guidance scenarios, but the background provided is directly relevant to the OPSIT. Where appropriate, the threat objectives have been identified.

All intelligence data are derived from intelligence materials obtained in accordance with the Office of Naval Intelligence (ONI) Scientific and Technical Intelligence Liaison Office process. A set of representative threats and targets was selected to give an appropriate range of engineering characteristics that addresses the important aspects of aircraft performance.

Each OPSIT provides the high-level environmental attributes that affect operations. The physical environment is described with emphasis on those environmental attributes that can affect MMA performance and includes information on weather, climate, and potential icing in the winter (January) and summer (July). Environmental conditions are characterized with a range of attribute values provided as appropriate for use with the DRM.

The MMA DRM enabled a number of follow-on studies such as mission, airfield, and survivability analyses and the MMA logistical analysis tool. These are detailed elsewhere in this issue.

SUMMARY

The MMA DRM provides a framework to evaluate the RAM characteristics of the MMA design as it evolves and to demonstrate the potential to meet the

operational availability thresholds in proposal analyses and presentations. The document identifies stressing conditions involving environment, threat, operational characteristics, tactics, and mission elements. It characterizes these elements to the level of detail necessary through OPSITs and TACSITs to assess the RAM impact of engineering design and logistic mission support alternatives and trade-offs. As the MMA Program matures, the MMA DRM will be used to reflect the appropriate problem space and support the evolving needs of the systems engineering process.

REFERENCE

[1]Skolnick, F. R., and Wilkins, P. G., "Laying the Foundation for Successful Systems Engineering," *Johns Hopkins APL Tech. Dig.* **21**(2), 208–216 (2000).

THE AUTHORS

TRENA C. LILLY received a B.S. in engineering mathematics from North Carolina A&T State University in 1997 and an M.B.A. and M.S. in management from the University of Maryland. As an operations research analyst in APL's Joint Warfare Analysis Department, she develops operational situations and Design Reference Missions to determine system requirements and the engineering design of systems. Ms. Lilly is a member of the Military Operations Research Society, National Society of Black Engineers, and Mathematical Association of America. Her e-mail address is trena.lilly@jhuapl.edu.

BRUCE R. RUSSELL is a member of the APL Senior Professional Staff in the Power Projection Systems Department's Aviation Systems Group. He received his B.S. in education from SUNY at Buffalo in 1974 and his M.S. in systems engineering (electronic warfare) from the Naval Postgraduate School in 1986. Mr. Russell joined the Laboratory in 1999 after serving in the Navy and in defense-related industry. He has participated in and led various analytical studies involving aircraft and unmanned aerial vehicle effectiveness. His e-mail address is bruce.russell@jhuapl.edu.