Establishing the Analytical Foundation: Multi-Mission Maritime Aircraft Platform Performance Assessment

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A significant challenge in both defining the future requirements for a Multi-mission Maritime Aircraft (MMA) and assessing alternative proposals is understanding the performance of the current P-3C aircraft platform. Two critical elements are: (1) a set of operator-approved tactical missions, and (2) the capabilities of the legacy subsystems and P-3C aircraft in those missions. The objectives of the MMA Platform Performance Assessment were to develop a methodology for bounding performance parameters for MMA and to lay the foundation for future alternatives and force-level assessments. This article describes the assessment methodology, tactical situations used in the analysis, and resulting observations and recommendations.

OPERATIONAL CONCEPTS

The Multi-mission Maritime Aircraft (MMA) Program addresses the need to sustain and improve maritime and littoral intelligence, surveillance, and reconnaissance (ISR) capabilities for U.S. naval forces in traditional, Joint, and Coalition roles to counter changing and emerging threats. The MMA is intended to participate in missions involving armed maritime and littoral surveillance, sea control and access, land targeting and strike, and command and control tasks assigned to the Naval Air Patrol and Reconnaissance community.

PMA-290, the MMA Program Office, tasked APL with performing an assessment of the capability of the legacy P-3C aircraft sensor subsystems meant for the baseline MMA. The MMA Platform Performance Assessment was conducted over a yearlong period commencing in October 2001. The purpose of the assessment was twofold: (1) to provide an analytical basis for deriving critical system characteristics and key performance parameters for inclusion in the MMA Operational Requirements Document (ORD), and (2) to provide a framework for conducting trade-offs among design and technology options during the MMA Component Advanced Development phase.

The task involved developing operational situations (OPSITs) and tactical situations (TACSITs) for use in conducting operational analyses in support of the MMA Program in general as well as providing the basis for the platform assessment. Example missions focused on anti-submarine and surface warfare in addition to mining and maritime surveillance. Although land targeting was considered in the scenarios chosen, it was specifically excluded at the sponsor's request from the initial analysis. The OPSITs were derived from various existing DoD-approved scenarios and covered the spectrum of warfare from prehostilities to a major theater war in a variety of geographic and environmental conditions. A subset of these warfighting snapshots or vignettes covering a specific operational task or occurrence (usually conducted over a 24-h period) was approved for further analysis. These snapshots were designed to examine specific mission performance parameters and requirements in typical missions involving a reasonable threat and other Joint assets.

Methodology

As the methodology was to identify legacy P-3 aircraft systems and platform performance parameters to establish a baseline, existing analytical tools were assessed and selected for suitability in performing mission analysis. Test cases based on scenario vignettes (TACSITs) were developed from the selected MMA TACSITs to describe operational requirements for the MMA. The results were interpreted to identify qualitative insights and quantitative performance parameters for the ORD and the Performance Based Specification (PBS).

Analytical Assumptions

The following analytical assumptions were used for the assessment:

- The MMA would replace the current P-3C, and the aircraft's primary missions would be anti-submarine warfare, anti-surface warfare, mine warfare, and ISR.
- Fewer aircraft carrier–based aircraft would be available to perform these missions in the MMA initial operational capability time frame.
- Unmanned aerial vehicles (UAVs) as MMA adjuncts, either land- or carrier-based, were not considered in the analysis, but potential uses for UAVs were noted in analytical observations.
- Changes in doctrine were not deemed to be significant owing to the use of legacy subsystems in the analysis. Current tactics from the P-3C Tactics Manual were used.
- Command and control for the MMA would be network-centric for both naval and Joint operations, but specific communications loading factors were not considered.
- The potential for loss of bases due to political changes and sensitivities in host countries was assumed, and alternative bases were considered.
- Logistics on demand (including tanker availability) was assumed to be available, but MMA as a tanker was not considered.

Baseline Aircraft

The initial version of the MMA was assumed to utilize current/legacy P-3C subsystems. For the purpose of this assessment, specific sensor and weapons systems were identified as the components of the MMA equipment suite. The sponsor approved these systems as a baseline for analysis and assisted in obtaining performance data.

Although various types of aircraft were being considered as potential replacements, including both propeller and jet types, current turboprop aircraft aerodynamics were used to establish baseline performance thresholds.

Analytical Tools

Several different analytical tools/techniques such as existing studies, spreadsheets, and models and simulations (including tactical decision aids) were examined for applicability to the MMA Platform Performance Assessment. These tools were employed to simulate the use of subsystems and implementation of tactics and operating parameters defined in the current P-3C tactical and operational manuals and instructions. The acceptability criteria utilized to evaluate each potential tool on its applicability to the MMA mission capability being evaluated included

- Level of resolution, i.e., the degree to which the model emulated real-world performance
- History/pedigree, i.e., the use of other similar studies and assessments that the tool had been employed to support
- Verification, validation, and accreditation, i.e., the process for ensuring the accuracy and reliability of a model or tool and activities required to certify a simulation as credible for a specific application

In addition, the availability and applicability of databases were examined to verify the validity and fidelity of both the tools examined and the MMA assessment.

MISSION ANALYSES

Nine TACSITs were selected as test cases for this assessment. Each was broken down into basic operational tasks. The mission threat/target that the MMA was tasked with detecting and/or attacking was characterized, as were any threats to the MMA itself. Subsystems were identified that were essential to mission accomplishment. Operating and alternative bases were identified, and flight routes to operating areas were planned. An aircraft mission profile based on sensor and weapons altitude limitations was used along with a tailored aircraft stores loadout to assess aircraft performance and endurance. Environmental impacts were considered for both winter (February) and summer (August) conditions. Specific operational parameters examined were

- Effective time on station (ETOS): the length of time that the aircraft can remain on station performing its mission (Note that current doctrinal crew rest requirements limited maximum sortie length [continuous operation] to 12 h.)
- Stores load: the total amount of sensor and/or weap-

ons stores required for mission accomplishment

- Operational range: the one-way range from bases to the closest point in the operational area

In addition, issues requiring further analysis were noted, and qualitative issues and observations resulting from the analyses were identified.

Port Protection

The MMA was tasked with defending a U.S. guided-missile destroyer (DDG) that was providing area ballistic defense of a key port city. A threat diesel submarine was attempting to close and attack the port area. The MMA had to detect, localize, track, and attack the submarine before it achieved torpedo range on the DDG.

Three aircraft subtasks were identified (Fig. 1): a defensive mining operation using air-dropped mines (described in the next section), an acoustic search using sonobuoys (improved extended echo ranging) in deep water, and a radar periscope search in a shallow-water area with heavy commercial shipping traffic and poor acoustic performance predictions. Issues and observations included the following:

- If primary bases are not available, in-flight refueling and multiple aircraft/crews may be needed to accomplish the mission owing to time of flight from the secondary bases and required aircrew rest limitations.
- The number of frequencies that can be monitored by one aircraft system may be a limiting factor for a large sonobuoy field.
- The uncertainty of nonacoustic classification and poor environmental conditions may make classification using weapons (e.g., use of a torpedo to cause the submarine to react) more effective than use of sensors alone, but this would require additional weapons stores.
- In a high clutter environment due to shipping and in weather conditions that would impact radar periscope detection performance, hold-down tactics with radar at altitude (use of the radar as a detectable potential threat to the submarine) may be equally effective and allow more time on station (TOS).

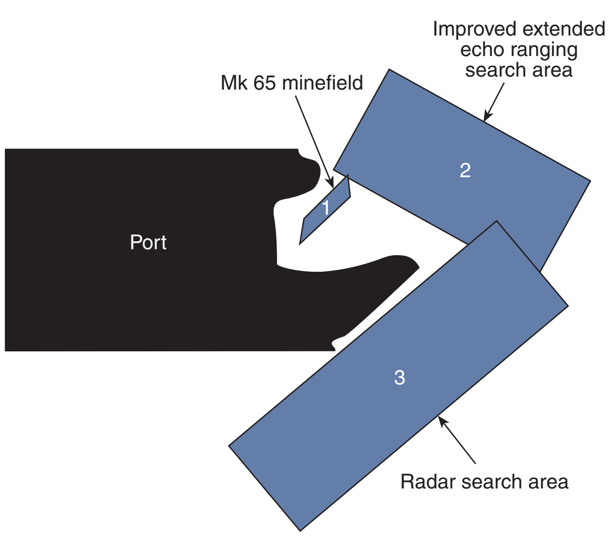

Figure 1. This port defense mission included a defensive mining operation, an acoustic search, and a radar periscope search.

Defensive Mining

The Minefield Planning Requirements Folder, issued by the Commander, Mine Warfare Command, was used to determine the size and density of a minefield that the MMA would have to deploy. The TOS needed to drop the mines from various potential bases was determined to be a very small fraction of the two-way transit time. Various actual and potential aircraft loadouts of mines were compared to examine the total length of time and number of aircraft sorties it would take to insert the minefield. Issues and observations included the following:

- The time required to insert a minefield is a factor of the number of airframes available to perform the mission, mine stores carry capacity, and distance from base.
- The time spent at low altitude for mine deployment is a small fraction of the total flight profile for this mission.
- The number of hard points (aircraft wing stations) available to carry a large mine will determine the number of sorties and will be a major determinant of the force-level requirement for mining.
- Navigation and deployment accuracy is key to mission effectiveness.

Anti-Surface Convoy Protection

This mission involved detection and engagement of a group of enemy surface combatants threatening a convoy. A Hunter-Killer tactic was used, with one MMA providing surveillance and over-the-horizon targeting and a second providing on-call, cued weapons engagement. It was assumed that any potential air threat (enemy fighters) was being suppressed by Allied land-based fighters. The five-ship enemy group was projected to have both area and self-defense surface-to-air missile systems. The Killer aircraft would use low altitude and the Hunter aircraft would use an off-axis approach to maintain surprise and improve survivability. Issues and observations included the following:

- Electronic support measures can be significant in specific platform identification and attack tactics when fused with inverse synthetic aperture radar imaging (ISAR mode).
- Adverse weather and/or heavy, prolonged rain would degrade both ISAR performance and missile guidance/effectiveness.
- Reliable communication between Hunter and Killer

for vectoring and directing attack is essential.
- If close basing is not available, the advantage of using a Hunter-Killer tactic is reduced and the number of required sorties is increased.
- A UAV could substitute for the Hunter part of the mission if it is equipped with appropriate sensors.

Mine Clearance Protection

This mission involved participation of the MMA in a rollback campaign to clear an area of hostile missile patrol boats (PTGs) armed with anti-surface missiles prior to the arrival of mine clearance vessels. The MMA was assumed to be both a detection and weapons platform, but because of the location, i.e., near shore around islands in a potentially dense shipping environment, the preferred tactic would involve two MMA flying geographically staggered orbits (180° out of phase) to maintain detection capability. Flight profiles were designed to minimize instances of overflying land with potential anti-aircraft missile or gun systems. The tactical objective was to kill the threat craft outside of threat weapons range to the minesweeping ships by creating an exclusion or keep-out area (Fig. 2). Issues and observations included the following:

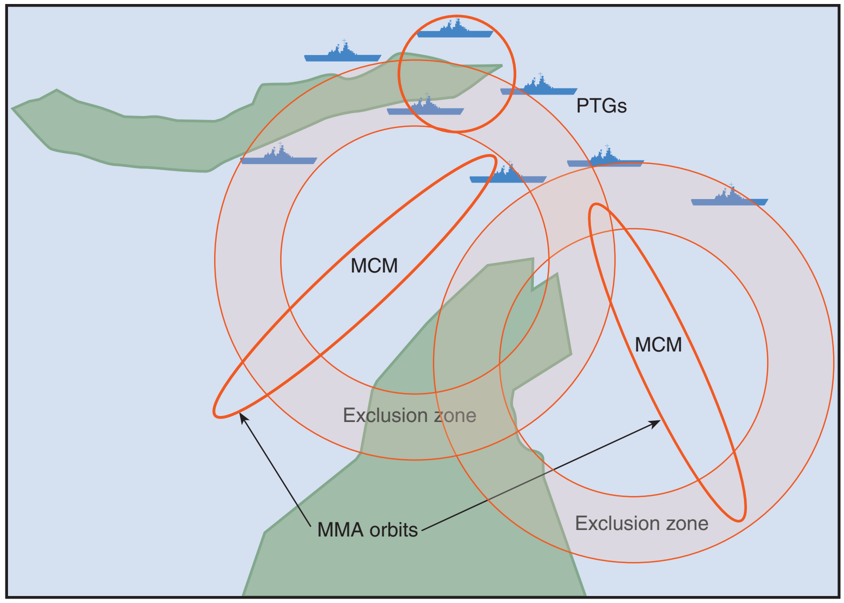

Figure 2. MMA exclusion zone tactic: protection of mine countermeasures (MCM) ships from hostile missile attack boats (PTGs).

- MMA survivability depends on suppression of the enemy air- and land-based, long-range anti-aircraft missile threats as a precursor to operations.
- Shoulder-held anti-aircraft missiles are a significant threat, both from enemy-occupied land and PTGs because of the altitude of the MMA during the mission and the difficulty in detecting and suppressing this type of weapon.
- The altitude chosen for orbits is key to radar and electro-optical sensor effectiveness. For radar, a shallow grazing angle (lower altitude) is needed for clutter suppression and optimum imaging. For electro-optics, both range and cloud cover/visibility will impact performance.
- Owing to the potential of white (neutral) shipping in the area, the rules of engagement may drive the MMA within visual identification range of the threat boats and degrade the advantage of long-range standoff weapons.
- Because of the difficulty in detecting small craft near shore in dense maritime traffic, use of an exclusion kill zone would provide the most effective tactic. An exclusion zone is a keep-out area centered on the defended units, delineated by the range of the threat weapons systems, in which rules of engagement would permit engagement contacts with weapons without positive identification being required.
- Use of a UAV for visual identification could be a valuable adjunct to a standoff MMA.

Anti-Submarine Quick Response

This mission examined the use of an MMA as a quick-response, or Pouncer, asset responding to an attack on an oil tanker by a hostile diesel submarine. The submarine was assumed to clear the area at snorkeling speed in order to charge batteries and purge air. Once clear of the area it was assumed to remain submerged and head for a friendly coastline at a slower, less detectable speed. Figure 3 depicts the search area growth generated by these assumptions. Issues and observations were as follows:

- A shorter mission planning time before takeoff or use of an aircraft tactical decision aid to permit planning in flight would reduce the time required to reach the search area and commence search.
- Owing to historically poor environmental conditions in the geographic area of this TACSIT, the ability to monitor more sonobuoys would provide a better probability of detection.
- Greater MMA speeds do not demonstrate a significant increase in TOS for shorter transits.
- In the shallow waters of this TACSIT, a general-purpose bomb with a hydrostatic fuse would be more effective than torpedoes in prosecuting the target.

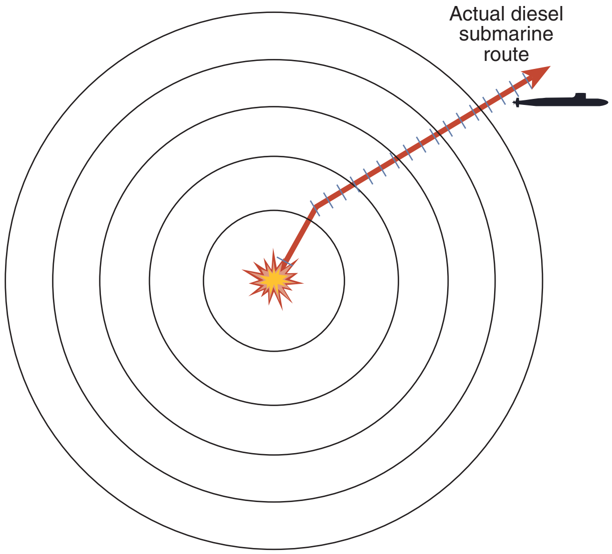

Figure 3. Search area and actual diesel submarine route for an anti-submarine quick-response TACSIT. The tick marks along the submarine's trajectory represent equal time intervals.

Small Boat Counter-Piracy

This mission examined the use of an MMA as a surveillance and targeting platform against small boats being used to attack and rob merchant vessels in a key maritime choke point. The boats were modified Zodiacs (inflatable boats equipped with outboard engines) with hand-held weapons including rifles, pistols, rocket-propelled grenade launchers, and shoulder-held anti-aircraft missile launchers. The MMA was tasked with conducting a search using its radar and electro-optic/infrared systems to locate, track, and identify potential pirate craft. Once positive identification was made, Allied aircraft would be vectored on the craft to conduct attacks. The MMA was also required to monitor merchant traffic and warn them of potential pirate attacks. Because of the presence of friendly shipping and the potential political sensitivity of the TACSIT (i.e., the effect on relations with the pirate boats' country of origin), key elements of the mission included avoiding collateral damage and collecting photographic (digital imagery) evidence of the threat craft with weapons. Issues and observations included the following:

- A low-altitude search would be required for both radar and electro-optic/infrared systems (depending on cloud cover and visibility). Only an electro-optic system sensor can make a positive identification and collect digital images of the threat craft. Radar could be used to detect groups of small boats acting suspiciously and for cueing the electro-optic system sensor operator, but not for identification owing to the small size of the targets.
- The MMA would be required to enter the envelope of shoulder-held anti-aircraft missiles, and possibly small arms, in order to identify and photograph the pirate craft. An effective missile warning system and infrared countermeasures would be essential for MMA survivability.

Combat Search and Rescue (CSAR) Support

This mission examined the use of an MMA to provide surface and subsurface surveillance support to a U.S. DDG conducting a CSAR mission. Here, two neighboring countries, both Allies of the United States, had gone to war with each other. A Marine Corps aircraft was tasked with evacuating families of embassy personnel and other U.S. citizens from the capital of one of these countries when the aircraft experienced mechanical failure and crashed close to the territorial waters of the warring nations. A DDG with an embarked helicopter was sent to conduct a CSAR mission, and an MMA was assigned to provide surveillance support. Issues and observations on this mission included the following:

- Communications among the MMA, CSAR DDG, and MH-60R helicopter via voice and Link 16 are essential. In addition, the MMA needs to maintain communications with air control authorities in both warring countries and to be prepared to challenge unknown shipping entering the CSAR area on standard commercial bridge-to-bridge and/or international distress frequencies.
- Neither the MMA radar nor the electronic warfare system can provide warning of the approach of potentially hostile aircraft. The DDG is the only source for air surveillance in the area needed to provide an air picture to the MMA via datalink. Improved wider-band electronic surveillance on MMA could provide the ability to detect airborne radars.
- Weather conditions such as heavy cloud cover and rain would impact sensor effectiveness.
- Long transit distances and crew rest needs could limit TOS and increase the number of sorties required to perform this mission if closer alternative basing is not available.
- Rules of engagement would probably prohibit the use of weapons unless the MMA or CSAR units were fired upon.

Aircraft Carrier Battle Group (CVBG) Protection

This mission examined the use of an MMA to provide anti-submarine warfare support for a CVBG that was aiding a U.S. Ally in a prehostilities situation. The primary threat was nuclear and diesel submarines. The MMA was operating with other U.S. and Allied assets to provide and maintain a safe area for carrier operations. It was assumed that a mixed screening force would be established, with specific operating areas given to the various platforms. Figure 4 depicts the Joint action area (JTAA) established to

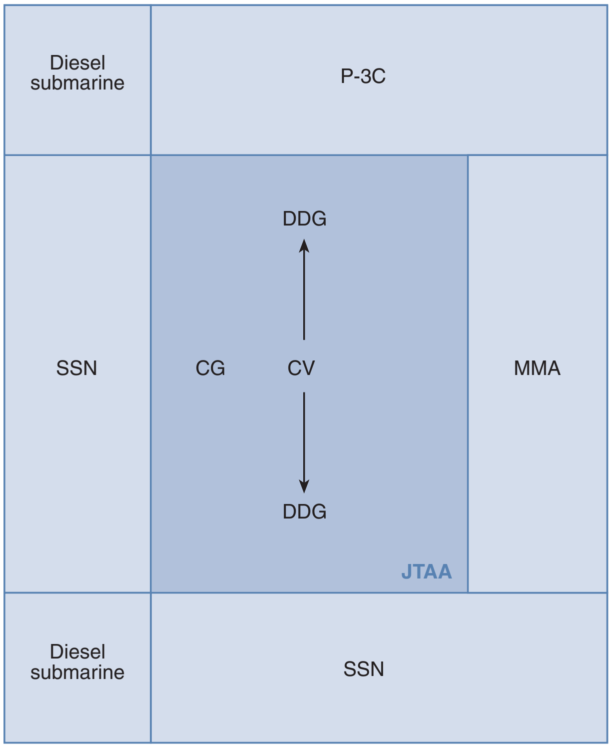

Figure 4. Joint action area (JTAA) carrier battle group screen.

protect the CVBG. Issues and observations included the following:

- The MMA will be required to communicate with other units to coordinate operations and to hand over suspected submarine contact to other platforms for prosecution.
- Coordination with other Joint or Allied intelligence gathering platforms may be required if contact is made during prehostilities.
- Because of excellent environmental conditions in the deep-water area assigned to MMA in this mission, the number of sonobuoys carried is not a stressing factor. However, it could be of significance in poorer acoustic conditions.

Port Security

This mission examined homeland defense. The MMA was tasked with patrolling an area outside a U.S. SSBN port area to counter a threat SSN that was engaged in intelligence collection. The MMA objective was to detect the SSN, coordinate with SSBN security once the threat submarine had been detected, and provide the SSN's location to the SSBN. The search area encompassed approaches to the channels for entering and leaving the port area. Issues and observations included the following:

- Coordination with SSBN base security, SSBNs entering and leaving port, and SSNs supporting the operation is essential to the mission.
- Use of two MMA to conduct the operation would provide greater effectiveness by permitting one aircraft to conduct a continuous acoustic search while the second could be conducting localization and nonacoustic search.
- Rapid deployment of a detachment to an airfield closer to the port would have increased TOS and reduced sortie requirements.

OVERALL INSIGHTS

- Onboard mission planning (route planning, use of databases and tactical data aids, etc.) would be beneficial and is needed for some missions.
- Real-time/*in situ* measurement capability (with a bathythermogram sonobuoy, dropsonde, and refractometer) or environmental data exchange between MMA and other assets could be essential to optimize tactics selection and sensor placement.
- Littoral tactics and environmental databases such as HOD (hydrographic obstruction data) are needed since the impact of environmental and geographic factors on sensor performance varies significantly near coastlines and in shallow water.
- The use of legacy sensor systems in this assessment may have indicated that a higher force level of MMA would be required to execute individual missions. Improved sensors, weapons, survivability/self-defense systems, and UAVs need to be examined. The impact of alternative systems should be assessed in a future force-level study.
- Use of a flexible payload module/bay on the MMA to handle larger sonobuoys, nonacoustic sensors, organic UAVs, etc., may provide flexibility for future upgrades.
- Additional communications capabilities, above those in the baseline equipment suite, are required to communicate with organic/inorganic remote sensors and to provide a common tactical picture on MMA and other platforms.
- Limitations on required weapon release/launch altitude affect survivability and duration of time at low altitude. Rockets, other missiles, and guns need to be examined for effectiveness and adaptability to MMA.
- Small threat craft using shoulder-held missiles and small arms may impact MMA survivability at low altitude. The use of adjunct or organic UAVs for low-altitude search should be assessed to determine their impact on MMA vulnerability.
- In the littorals, significant density of shipping and other maritime objects (navigational buoys, oil rigs, rocks, etc.) make radar search difficult. The ability to use an electro-optical system for classification is essential.
- No existing system or combination of systems in the baseline provides adequate MMA warning against threat fighter aircraft or air intercept radars.

- Tailored, optimal stores loadouts need to be developed for specific MMA missions.
- An in-flight refueling capability provides advantages, *but* for longer transit distances the primary factor in ETOS is the crew rest limitation.
- The need for multiple aircraft for various missions is driven by
  - TOS achievable from available bases
  - Differing altitude requirements (fuel burn rates) for sensors (radar/sonobuoys)
  - Launch altitudes for weapons
  - Weapons/mines/sensor stores requirements
  - Turnaround time
  - Survivability tactics
- Future force-level analysis will be needed; the total numbers of MMA required will be driven by a variety of factors including
  - Campaign parameters (number of missions, duration, threat, etc.)
  - Bases/alternative sites availability
  - Range/base availability
  - Sensor/weapon performance/limitations
  - Transit speed
  - Stores capability (weight, form/fit, internal/external carry, hard points)
  - Use of UAV adjuncts
  - Turnaround time (facilities, handling equipment, etc.)
  - In-flight refueling
  - Survivability/vulnerability analyses
  - Tactics and doctrine changes

RECOMMENDATIONS

ETOS was identified as the key factor/performance parameter in determining mission effectiveness for both anti-surface warfare and surface surveillance/reconnaissance missions. To determine ETOS for each scenario mission, it was necessary to analyze on-station mission performance requirements (e.g., the time required to deploy a sonobuoy field to provide area clearance, etc.). Once ETOS was determined for both environmental extremes (summer and winter), a transit analysis was performed for each deployment/detachment that had been identified by the CinC Coordination Team. The amount of time required to transit to a designated mission area given a preplanned mission search-and-kill stores loadout was calculated using models created by NAVAIR. By using mission profile time constraints, airfields from the candidate list could be eliminated from the overall analysis effort. The current P-3C aircraft provided a threshold average transit speed and an average objective transit speed as a basis for determining aircraft TOS at various combat radii. On the basis of these findings, it was recommended that ETOS and interoperability be used as the only key performance parameters for the ORD.

SUMMARY

The development of a set of operator-approved missions (discussed in the article by Lilly and Russell, elsewhere in this issue) and operational assumptions involving the tactical utilization of the MMA provided the context for mission analysis to determine operational performance parameters. The employment of legacy subsystems from the current P-3C aircraft allowed known equipment performance data and existing models to be used. The result was the determination of baseline performance metrics to establish threshold values for MMA performance. These metrics provide an analytical baseline for MMA source selection and for future alternative subsystem requirements.

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