Maritime Domain Protection Task Force

Project Update

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MARITIME DOMAIN PROTECTION TASK FORCE

The Maritime Domain Protection Task Force was formed in January 2004 at the Naval Postgraduate School in Monterey, California. Formed and structured after guidance from the Office of the Assistant Secretary of Defense for Homeland Defense, the Task Force researches and investigates issues surrounding protection of the United States, its vessels, and citizens against terrorist threats originating from the maritime domain.

The work of the Maritime Domain Protection Task Force (MDP-TF) will provide essential input in the national effort to prevent terrorists from exploiting the world's oceans to attack the United States.

This multi-year effort will pursue multiple research initiatives in order to define, design, and aid implementation of a national Maritime Domain Protection System. The envisioned system will provide capabilities to deter, interdict, or defeat threats as far from U.S. borders as possible, and will be based on a concept of multiple lines of defense and domains, coordinated through a national command and control system.

The Task Force has already attracted over sixty NPS faculty, students, and staff with experience in fields ranging from intelligence to information science to systems engineering. In the months since its formation, the Task Force has reached out to several agencies involved in developing our nation's policy and capabilities in Homeland Defense against terrorist threats. Currently, over two hundred federal, state, and local government agencies, along with several private contractors and naval allies such as Canada and Mexico are contributing to and participating in the work of the Task Force.

The Task Force schedule includes research on a process for improving current vulnerability versus capability assessments and an initial description of the current national system by this Fall. Concurrent efforts will include work in system design, advance capabilities in Maritime Domain Awareness (MDA), the establishment of a classified Maritime Domain Homeland Defense database and reference library , and the creation of a classified Maritime Domain Protection war gaming facility to provide a "test bed" for local, state, federal, and DoD concept of operations development.

MDP System Architecture Design Process - Systems Engineering and Integration

Systems Engineering Design Integration (SE&I) is one of three primary independent efforts that form the core of this Maritime Domain Protection research project.

The multi-year Systems Engineering and Integration effort focuses on the delivery of a proposed architecture on which to base future process and technical design. This project is a collaboration between several NPS faculty and students from the Navy, Coast Guard, Northern Command, and other MDP project participants from various government agencies.

MDP Architecture Engineering Process

As depicted in Figure 1, the MDP architecture engineering process consists of three main processes executed in an iterative manner: Needs Analysis, Alternative Architecture Definition, and Architecture Ranking and Selection. All boxes in Figure 1 are called processes, and bolded phrases denote names of the processes.

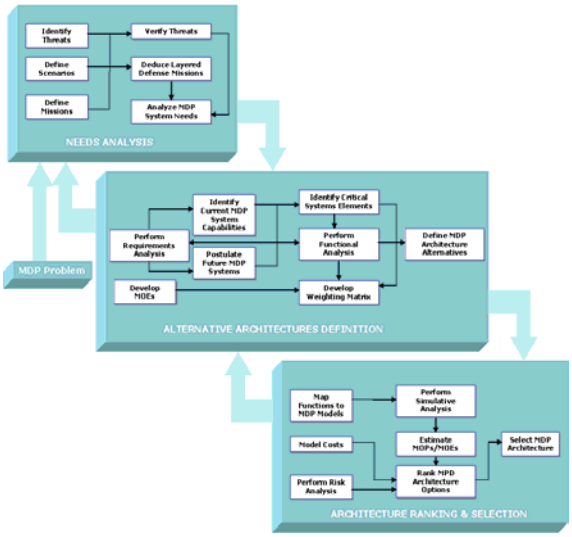

Figure 1. MDP Architecture Engineering Process

Needs Analysis

The MDP problem sets the Needs Analysis process in motion:

- *Identify Threats* and *Define Scenarios Processes* - Identify threats and scenarios.
- *Define Missions Process* - Defines several MDP missions; requires consultation with the various stakeholders involved in the defense against terrorists.
- *Verify Threats Process* - Utilizes the results produced by the MDP-TF Threat and Vulnerabilities Assessment research to verify the identified threats for accuracy and reasonableness.
- *Deduce Layered Defense Missions Process* - Based on the scenarios identified by Define Missions, the Deduce Layered Defense Missions Process then defines missions for different layers of defense. Again, consultation with the stakeholders is required for realism.
- *Analyze MDP System Needs Process* - Taking into account the confirmed threats and the missions undertaken by the different layers of defense, this process ascertains what functions an MDP system must perform to execute the MDP missions.

Architecture Alternatives Definition

The Architecture Alternatives Definition process uses the outputs of the Needs Analysis Process:

- *Perform Requirements Analysis Process* - Translates the MDP needs into MDP system requirements.
- *Perform Functional Analysis Process* - Iteratively refines the MDP system requirements with its outputs.
- *Identify Current MDP System Capabilities Process* - Identifies capabilities of the current MDP system, if it exists, as necessitated by the MDP system requirements. Close collaboration with the stakeholders needs to occur for this process to be effective.
- *Postulate Future MDP Systems Process* - Postulates MDP system elements that need be developed in the future, based on the existence of any gaps between the current MDP system and the required capabilities.
- *Identify Critical Systems Elements Process* - Upon completion of the previous two processes, the Identify Critical Systems Elements Process establishes critical elements of the desired MDP system.
- *Define MDP Architecture Alternatives Process* - Uses these system elements and the outputs of the Perform Functional Analysis Process to define various MDP architecture options.
- *Develop Weighting Matrix Process* - Uses the MDP critical system elements and the Measures of Effectiveness (MOE) defined by the *Develop MOEs Process* to produce the weights that will go into the Architecture Ranking and Selection Process. Again, close collaboration with the stakeholders is necessary for a robust development of the MOEs and the weighting matrix.

Architecture Ranking and Selection

The *Perform Simulative Analysis Process* now assesses the performance of each of the MDP system architecture alternatives established by the Architecture Alternatives Definition Process. The simulative analysis employs modeling and simulation, which requires modeling of the MDP system functions, facilitated by the *Map Functions to MDP Models Process*. These MDP system functions require appropriate algorithms to be implemented in these MDP models. Also, the simulative analysis will employ various simulations, either in existence here at NPS or elsewhere, or to be developed.

The *Estimate MOPs/MOEs Process*, which processes the outputs of the simulative analysis, provides the estimated Measures of Performance (MOP) and Measures of Effectiveness (MOE).

The *Rank MPD Architecture Options Process* then ranks the various MDP architecture alternatives, using the estimated MOPs and MOEs, the costs produced by the *Model Costs Process*, and the risk factors generated by the *Perform Risk Analysis Process*.

Finally, the *Select MDP Architecture Process* selects the best MDP architecture from the MDP architecture alternatives. Based on the selected MDP system architecture, the implementation phase of the MDP research will design and develop an MDP system.

This system architecture engineering process can be adopted with necessary modifications to determine architectures for any military system.

The members of the SE&I team are Drs. Tom Huynh, Orin Marvel, John Osmundson, and Gene Paulo, and Mr. Mark Stevens. Please address questions to Dr. Tom Huynh (thuynh@nps.edu).

THREAT AND VULNERABILITY ASSESSMENT

This effort focuses on the process of improving current assessments of maritime threats and vulnerabilities in order to effectively focus assets to protect people, property, and the nation.

NPS and the MDP-TF will initiate this process by hosting a Maritime Domain Threat and Vulnerability Assessment Symposium from 15-17 June 2004 in Monterey, California.

The symposium will focus on two basic sub-themes: to identify current near-term threats and to identify key vulnerabilities. Participants will be asked to help identify what is missing, what is not being addressed, and where to effectively focus limited resources.

A significant task for the symposium will be to work out a method for matching threats with vast number of existing vulnerabilities. This system will be needed as a way to prioritize vulnerabilities in order to facilitate the operational focusing of limited resources.

Symposium General Concept

The symposium will take place over a three-day period, devoting one day to the examination of existing threats; one day to the examination of maritime oriented vulnerabilities; and the final day to requirements necessary to address identified challenges.

Each day will consist of a series of presentations and panel-driven discussions and/or scenario-based vignettes geared toward fostering cooperation and better communication. Presentations, discussions, vignettes, panels, and any questionnaires that are part of the symposium will be captured, packaged, and delivered to participating agencies and MDP stakeholders.

Attendance is limited to approximately fifty people to ensure that a core group of experts, who can both participate and interact, is assembled. Commands presenting at the Symposium include JCS, NORTHCOM, TRANSCOM, MTAC, CNO-IP, USCG (HQs;11th District), ONI, JFIC, and COMNAVEUR, NCIS HQ.

The MDP-TF Symposium will provide the start of an iterative process to help bind together thoughts, ideas, and concepts that exist throughout various intelligence and operational communities, military commands, other government organizations, and private enterprise.

Results of the symposium will provide input for NPS Systems Engineering and Maritime Awareness working groups as well as a functioning "network of networks" that enables all MDP-related organizations to move very rapidly from assessment to operations.

This Symposium will assist in the future coordination of MDP goals and methods by providing a platform for discussion and understanding of the various MDP efforts.

The members of the Threat and Vulnerability Assessment team are CAPT Steven Ashby, USN, Professor Mitch Brown, Professor Paul Shemella, and NPS students LT Mark Steliga and LT Robert Hight. Please address questions to CAPT Ashby (sbashby@nps.edu).

MARITIME DOMAIN AWARENESS

The Identification and Documentation of the Content and Structure of Existing National MDP Data Sources

This project focuses on identifying and documenting the content and structure of the data sources of the existing national Maritime Domain Protection system, as part of the larger effort to develop a new national Maritime Domain Protection System Architecture and Information System. The understanding of these data sources will serve as the basis for integration into a follow-on system design.

One of the central challenges of MDP is the identification, tracking, and analysis of large numbers of moving assets. Not only must the volume of assets be identified and tracked in near-real time, but the number and variety of data sources is large, compounding the problem. These sources must be fused and analyzed in order to produce a timely result that can be acted upon. Thus the need to design and build a prototype MDP system that can be evaluated for its effectiveness in thwarting maritime threats.

The core of the MDP prototype is a Maritime Domain Awareness Data Warehouse. This Warehouse will contain cleansed, integrated, and structured data collected from a variety of data sources. Data analysis and mining tools will enable analysts to access the data in the warehouse to support data analysis and the discovery of useful and previously unknown patterns and relationships. A Boyd Cycle (a.k.a. OODA Loop- Observe, Orient, Decide, and Act) approach for MDP may be used for the design and development of the prototype MDA system.

This project addresses the long-term goal of designing and implementing the Data Warehouse and proposes a five-step methodology for its development. These steps consist of defining the data sources, developing the data model, cleansing and integrating the raw data, populating the warehouse, and providing data analysis and mining tools to access the data warehouse. These steps will be performed iteratively as changes to the design emerge during various development stages. NPS researchers will work closely with the Coast Guard's MDA Procurement Office.

Dr. Magdi Kamel (mnkamel@nps.edu) is the primary member of this research team.

Maritime Domain Awareness System Demonstration

The Maritime Domain Awareness (MDA) System Demonstration effort focuses on improving Maritime Domain Awareness by providing tools and portals that can be integrated into a stakeholder's existing workstation, providing the user access to faster, more accurate, and more useful MDA information.

MDA, a necessary part of any Modeling and Gaming Laboratory, will require access to applicable data sources and tools to manipulate and display data. This effort will develop that access and provide those tools.

Participants at a recent workshop on MDA developed a two-part working definition of MDA:

- The timely knowledge of position, identity, intent, and history of every element in any area of interest operating in or influencing the Maritime Environment, and
- Actionable information pertaining to any threat requiring a response.

The first part of the definition provides a Common Operating Picture (COP) of the Maritime Environment, while the second part addresses the tactical application of MDA to a particular incident or problem. A system that addresses both parts of this definition is needed.

Several key assessments came out of the workshop:

- The wide diversity of organizational and functional users with a vested interest in MDA presents a number of unique challenges. Identified user groups include: defense, security, law enforcement, public safety, commercial, environments, and other government organizations (DoS, EPA, etc.) Any project which aims to improve MDA needs to address the specific requirements and constraints of all these organizations.

- Essential Elements of Information (EEI) for MDA include the following: location, vessel/element profile and signatures, intent, cargo, crew/passengers, history, and quality measure (confidence level). An improved MDA system must be able to report any and all of the EEIs, with estimates of their accuracy and credibility.

- Potentially exploitable signatures for MDA include at least the following items: stack effluents, acoustics, ship radars (ELINT), ship wakes, optical sensors, radar sensors, self-reporting via AIS, self-reporting via INMARSAT-C, and commercial tracking by shipping and insurance companies. Many organizations collect and exploit some of these signatures. One of the major problems is that organizational "stovepipes" and classification issues related to the sensors and collectors relegate the data collected into separate databases, many of which are not available to the majority of stakeholders.

Development of overarching MDA requirements, with consideration of all organizations and stakeholders' needs, is a necessary first step to achieving comprehensive MDA.

There is no one intelligence source that provides enough data to allow for the definition of the EEIs for MDA. This research project will define a candidate architecture for MDA and to identify tools and technologies that will enable a successful system for multiple consumers at multiple levels of security. Rather than build a new database, this project aims to provide tools and portals to existing databases that can be integrated into the stakeholder's existing workstations.

Dr. Herschel H. Loomis (hloomis@nps.edu) is the primary member of the MDA System Demonstration team.

MARITIME DOMAIN PROTECTION GAMING LABORATORY

This project focuses on designing a national Maritime Domain Protection Modeling and Gaming Laboratory. Working with the Systems Engineering and Design effort, NPS modeling researchers and administrators, and major stake-holders, researchers will design a classified lab that would provide a "test bed" for federal, state, and local governments to test their MDP concept of operations. The desired lab would be capable of multiple security play, be distributed-capable, able to replicate real-world intelligence and operational communications, be interactive, and retain major decision lessons learned.

Essential components in the development of Maritime Domain Protection and Homeland Security include the evolution of new doctrine, capabilities, and policies. Each of these components requires analysis and research in order to understand the second and third order effects, as well as the discovery of best practices to accelerate successful implementation of the same. This laboratory will have multiple stations which will be networked. The lab will be able to assimilate data feeds from multiple sources and will be able to handle all levels of classification.

This laboratory will give leaders and researchers a "test bed" for the evaluation and development of Maritime Domain Protection CONOPS and will be a dual use facility.

LTC Saverio Manago, USA, (smmanago@nps.edu) is the primary member of this research team.

APPLIED AT-SEA TECHNOLOGY

This effort focuses on studying variations on radar and IR surveillance sensor performance caused by lower atmosphere and ocean surface conditions. Emphasis is placed on low radar cross section and low thermal cross section targets. Threat surveillance, detectability of own forces and general maritime domain protection can be vastly improved when lower atmosphere, surface conditions, and time of day are known and considered when responding to threats.

The project is based on transitions of models and procedures developed for U.S. Navy (USN) sensor performance prediction, to apply in port and coastal surveillance and also in response detection estimations. The U.S. Coast Guard, Research and Development Center (USCG/R&DC) is also adapting USN propagation effects tools in initiated programs to account for atmosphere and ocean surface effects in Search and Rescue Operations Planning Software (SAROPS). SAROPS uses a Multi-Sensor Performance Prediction (MSPP) toolset based on USN radar and IR effects models.

NPS experience in supporting field tests on radar/IR sensor performance suggests that, for port and coastal security, surveillance has to take atmosphere and ocean surface effects into account. The recent Northern Arabian Gulf incidents with low radar cross section and low thermal contrast small boats indicate that knowledge of such influences on surveillance sensor performance, and of the threat characteristics, will become essential in the design and selection of different procedures and assignments of resources. The environmental conditions affecting sensors, the targets involved, and the threat procedures important to Maritime Domain Protection are very different from ship self-defense against mach-1 surface-skimming missiles. Hence, special integration of models and testing of approaches are necessary.

The planned MDP measurement and data transmission system/network systems/procedures will be designed on the basis of field collection that occurred with NAVSPECWARCOM combatant craft radar signature tests and in SOCOM/3rd Fleet endorsed overland network and surveillance systems demonstrations in several locations:

- Dam Neck, Virginia, August 2002
- San Clemente Island, California, June 2003
- NPS Surveillance, Targeting Acquisition Network (STAN-5) field test, Camp Roberts, California, 02/2004.

Continuous small vessel measurements in the combatant craft target signature tests provided information on non-radar cross-section related variability in target range. Although fielded for target signature verification/validation, the combatant craft test involvement provided an excellent demonstration of application of sensors and propagation models for real-time descriptions for radar. Continuous multi-location measurements of the lower atmosphere and surface in STAN-5 NETWARCOM based demonstration provided a measure of the value of wireless network links between the field sensors to a Tactical Operations Center.

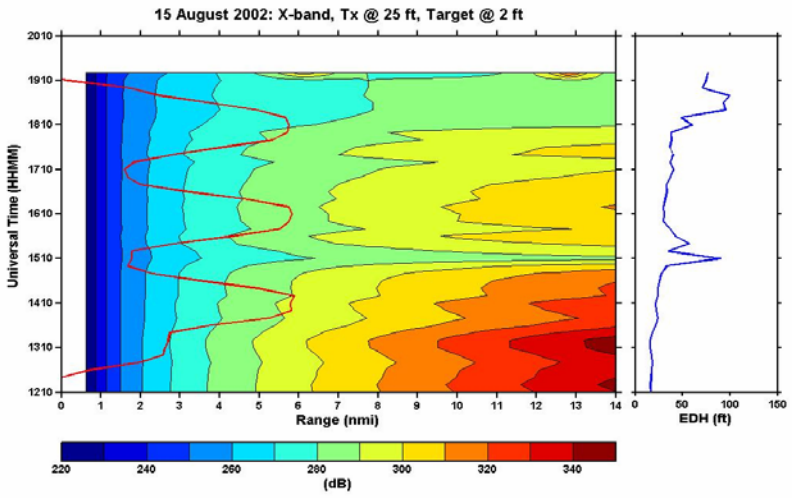

Figure 2: X-band 2-way loss out to 14 nmi as versus time-of-day. Right hand panel is calculated evaporation duct height. Estimated from lower atmosphere and ocean surface measurements and propagation model. Coastal region off Dam Neck, VA, August '02.

In a MDP NETWARCOM operation, the atmosphere data would be derived from deployed sensor nets to provide COP of surveillance capabilities, and response detection that varies with conditions.

Figure 2 illustrates distance versus time-of-day variability of predicted 2-way loss, exclusively caused by measured variability of atmosphere and ocean surface condition, during an August field test off Dam Neck, Virginia. Unclassified effects for a test of radar signatures of low cross section combatant craft are shown.

However, the significant variability shown in these results was confirmed in the actual detection results, for S- as well as X-band radars. Knowing the variations during execution of the described surveillance detection in the Northern Arabian

Gulf or, better, forecasting the variation 24 hours in advance, would be critical to MDP operations. The influencing condition in the Dam Neck tests was associated with warm surface temperature (~26 C) that occurs in the Arabian Gulf and in the vicinity of Singapore, another MDP region of interest. An additional feature of this field test and a similar test off San Clemente Island, California, was to assess the value of mesoscale model 24-hour predictions for estimating the changes and, hence, being a part of mission planning.

The comprehensive approach followed in the MDP-TF effort encompasses five components:

- **Integration** of operational/near-term in situ and remote METOC measurement and prediction systems, including real-time satellite retrievals (3-D) and meso-scale model predictions (4-D).
- **Data transfer** from surface platforms to a tactical operations center to produce a Common Operating Picture (COP). The building blocks of the proposed mobile network include: Wireless data transmission unit in a forward (field) measurement vessel linked to base METOC receiver unit on the command platform; and Software/hardware interface between the base METOC receiver installed with multi-agent architecture for 2-way information exchange via network to Tactical Operations Center (TOC).
- **Adapt and integrate** physical environmental models (developed and verified) that produce radar refraction profiles and clutter and IR refraction, absorption, and turbulence (scintillation) from available METOC data sources (platform-measured, meso-scale model and satellite-based).
- **Selection and adaptation** of operational propagation models that use atmospheric descriptions (3-D refractivity profiles and 2-D surface roughness) to determine propagation characteristics.
- **Selection** of surveillance/detection Tactical Decision Aids (TDAs), which predict detection range probabilities for various sensors and targets and can be available both on operational platforms themselves and at a C4I center.

Integration of existing technologies for MDP purposes must be based on:

- Present remote and in situ measurement of atmosphere and ocean surface properties
- High resolution model prediction and assimilation of dynamic processes of both the atmosphere and ocean
- Open-ended information systems architecture
- Radar and IR sensor modeling/representation, and
- Full evaluation of threat concepts and capabilities.

This project will integrate existing technology and provide surveillance operations information on the detectability of low cross section and low thermal contrast targets by radar and IR, and eventually by acoustic sensors. The outcome of this effort will be a highly modular set of components that can be "shaped together" in a variety of operational configurations for multiple uses, including port security surveillance and small unit response team C4I support.

The members of the Applied At-Sea Technology team are Drs. Kenneth Davidson and David Tucker, and Professor Rex Buddenberg. Please address questions to Dr. Davidson (kldavids@nps.edu).

Additional information on the Maritime Domain Protection Task Force is available at:
http://www.nps.edu/Academics/MeyerInstitute/MDP/.

ADDITIONAL MDP-TF NEWS

MDP-TF Members Work with NORTHCOM

Maritime Domain Protection Task Force (MDP-TF) members from NPS traveled to Colorado Springs, Colorado in April, for an information gathering meeting with representatives of NORTHCOM. As the DOD's lead agent in executing DOD's responsibilities for Homeland Defense, NORTHCOM is a key stakeholder in MDP-TF efforts.

The meeting was attended by CAPT Jeff Kline, MDP-TF Lead, Dr. Tom Huynh, Principal Investigator for the Systems Engineering Design Integration Research effort, and several other faculty and staff from NPS and NORTHCOM, including officers and analysts from NORTHCOM J2, J3, and J5. All U.S. services, the U.S. Coast Guard, and Canadian allies were represented.

The primary focus of the meeting was to familiarize key NORTHCOM staff members with MDP-TF research efforts, solicit their input on the current system for MDP, and elicit some preliminary views on the general status of MDP.

The meeting provided a valuable opportunity for the discussion of potential problems and successes of the current system and ongoing proposals to modify or restructure C2 in this arena, and to share information on previously completed NORTHCOM efforts, particularly in the area of MD vulnerability and threat analysis.

MDP-TF members interacted once again with NORTHCOM by attending the second NORTHCOM Maritime Threat Identification and Tracking Conference at the Combined Intelligence Fusion Center on Peterson Air Force Base in Colorado from 30 March–1 April 2004.

The purpose of the conference was to discuss and coordinate interagency and bi-national communication links and input into the Common Intelligence Picture (CIP) and its subsequent feed into the Common Operating Picture (COP).

Participants included ONI, MTAC, NMIC, NCIS, HQ USCG, MIFC EAST, MIFC WEST, JFMCC (NAVNORTH), 2nd Fleet, 3rd Fleet, NSA, DIA, as well as Canadian NDHQ, Navy, and both Trinity and Athena Joint Ocean Surveillance and Information Centres (JSOIC). Mark Stevens of the Systems Engineering and Integration group attended on behalf of the MDP-TF and NPS.

The first day of the conference was devoted to a synchronous threat, while the second and third days focused on an asynchronous threat. Participants divided into three major working groups for discussion on CIP/COP requirements, the actual Joint and Bi-national intelligence process and products, and collection of intelligence. All parties sought to find working solutions in an effort to provide their respective organizations and operational commanders with the best maritime intelligence picture available.

The conference provided a great deal of information and insight into the current state of maritime intelligence and MDA within NORTHCOM and the degree to which that information is shared with Canada, and vice versa.

For additional details on this conference, please contact Mark Stevens (mstevens@nps.edu), SEI Group, MDP-TF.