Proposal Information Package (PIP)

Predictive Analysis for Naval Deployment Activities (PANDA)

BAA 05-44

28 September 2005

CHANGE (highlighted in green)	PAGE
Section D.2.1, 3rd paragraph, is revised to reflect FAQ A27	24
Section D.2.2, Table 2, has been revised as noted at FAQ A63	25

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B PROPOSAL MANAGEMENT

B.1 GENERAL INFORMATION

B.1.1 Definition of a Broad Agency Announcement

The information provided in this Proposer Information Package (PIP), in addition to that provided in the FedBizOpps Announcement for BAA 05-44, constitutes a Broad Agency Announcement (BAA) as contemplated in the Federal Acquisition Regulation (FAR) 6.102 (d)(2)(i). The FedBizOpps announcement and this document are available online at http://dtsn.darpa.mil/IXO/solicitations/PANDA/index.htm.

B.1.2 Briefing to Industry

A Briefing to Industry (BTI) is scheduled to be held on 16 September 2005 at: MITRE facility, 7515 Colshire Drive, McLean, VA 22102-7508. The BTI will be classified SECRET/SCI and will cover the following topics: general overview of the PANDA program; contractual issues; proposal instructions; information on the PANDA problem domain, data, and technical and system aspects; and Q&A. Due to space limitations, attendance will be limited to one person per organization; but if space permits, the government may elect to allow additional attendees. Additional information on the PANDA BTI may be found via the World Wide Web (WWW) at: http://dtsn.darpa.mil/IXO/solicitations/PANDA/index.htm. Pre-registration for the PANDA BTI is required; the deadline for pre-registration is 9 September 2005 at https://www.tfims.darpa.mil/bti/. Instructions for passing classified visit requests will be provided to PANDA BTI registrants. All pertinent information and materials presented at the UNCLASSIFIED session of the PANDA BTI will be made available at http://dtsn.darpa.mil/IXO/solicitations/PANDA/index.htm. Proposal abstracts ARE NOT requested in advance of full proposals.

B.1.3 Frequently Asked Questions

All questions and answers of relevance to the community will be posted to a “Frequently Asked Questions (FAQ)” accessible at: http://dtsn.darpa.mil/IXO/solicitations/PANDA/index.htm.

B.1.4 BAA Correspondence

DARPA will use electronic mail for all technical and administrative correspondence regarding this BAA. Administrative, technical or contractual questions must be sent via email to BAA05-44@darpa.mil. All requests must include the name, address, and phone number of a point of contact. Technical and contractual questions should include the originator's full name, email, and postal address in the text.

B.1.5 Contract Types

This BAA affords proposers the choice of submitting proposals for the award of a Grant, Cooperative Agreement, Procurement Contract, Technology Investment Agreement, Other Transaction for Prototype Agreement, or other such appropriate award instrument. The Government reserves the right to negotiate the type of award instrument determined appropriate under the circumstances. The Government retains the right to make single, multiple, or no awards under this BAA and to award without discussion.

B.2 SUMMARY OF IMPORTANT DATES

Table 1 provides a schedule of important events and dates associated with BAA 05-44:

DATE	EVENT	URL
31 August 2005	FedBizOpps Anouncement and Proposer Information Package published	http://dtsn.darpa.mil/IXO/solicitations/PANDA/index.htm
9 September 2005	Registration for BTI closes; visit requests for classified session due to DARPA	https://www.tfims.darpa.mil/bti/
16 September 2005	DARPA BTI on proposal process and BAA technical topics	N/A
1 October 2005	Proposal registrations (for electronic submissions of UNCLASSIFIED proposals ONLY) due to DARPA	http://www.tfims.darpa.mil/baa
17 October 2005 1200 Noon EST	Proposals due to DARPA	http://www.tfims.darpa.mil/baa
1 December 2005	Estimated Proposal decision	N/A

Table 1. Schedule for Submission and Review of Initial Proposals

B.3 PERIOD OF SOLICITATION AND INITIAL SUBMISSION SCHEDULE

This BAA shall be open from 31 August 2005 through 31 August 2006. Proposal abstracts ARE NOT requested in advance of full proposals. For planning purposes DARPA has developed a timetable for the receipt and evaluation of the first set of submissions against this BAA. This schedule is listed in ***Table 1***. Funding has been identified for a series of awards against this initial set of proposals, if received in

accordance with this timeline. While the proposals submitted after the initial 17 October 2005 deadline will be evaluated by a Government review panel, proposers should keep in mind that the likelihood of funding such proposals is less than for those proposals submitted in connection with the initial evaluation and award schedule.

B.4 SECURITY AND SUBMISSION GUIDELINES

Awards for the PANDA Program are expected to result in access to classified U.S. SECRET, TOP SECRET, and/or Sensitive Compartmented Information (SCI) information. A DD Form 254 will be issued upon contract award.

Proposers may submit proposals at the UNCLASSIFIED, SECRET, TOP SECRET, and/or SCI levels. Proposers who choose to submit a classified proposal, using information from another government effort, must first receive permission of the Original Classification Authority (OCA) to use their information in replying to this BAA and cite and submit the applicable OCA classification guide(s) to ensure that the proposal is protected appropriately.

A Security Classification Guide (SCG) for the PANDA Program is available from DARPA to eligible contractors in order to properly protect any information submitted into this program solicitation. To obtain a copy of the PANDA Program Security Classification Guide (DARPA CG-364), please email your request to:

Government Security Officer
Predictive Analysis for Naval Deployment Activities (PANDA) Program
BAA05-44@darpa.mil

Include in your email the following information: Company, Facility Security Officer's (FSO's) name; FSO's phone number; secure fax number; and CAGE code. DARPA CG-364 is FOR OFFICIAL USE ONLY (FOUO); as such it will be sent via secure fax.

Proposals must be submitted according to the following guidance:

UNCLASSIFIED Information: DARPA will employ an electronic upload process for all UNCLASSIFIED proposal submissions. Please DO NOT attempt to submit a CLASSIFIED proposal through the electronic upload process for UNCLASSIFED submissions, as this is PROHIBITED. Performers may find guidance for proposal submission at: http://dtsn.darpa.mil/IXO/solicitations/PANDA/index.htm.

Organizations must register at: http://www.tfims.darpa.mil/baa to make an UNCLASSIFIED proposal submission. Only the lead or prime organization should register. One registration per proposal should be submitted. Organizations wishing to submit multiple UNCLASSIFED proposals should complete a single registration for each proposal. The deadline for registration for the electronic submission is 1 October 2005 at the registration Uniform Resource Locator (URL) listed above. By registering, the Proposer has made no commitment to submit. Proposal submissions made through the Technical – Financial Information Management System (T-FIMS) Proposal Submission System must be UNCLASSIFIED.

The T-FIMS Proposal Submission System can support the following files, including: Portable Document Format (pdf), Word Document (doc), Plain Text (txt), Comma-separated Values (csv), PowerPoint Presentation (ppt), Excel Worksheet (xls), and Excel Workspace (xlw).

Proposal submissions made through the T-FIMS Proposal Submission System must be no larger than 50 megabytes per file. This means that the Technical Volume file, as well as the Cost Volume file, must not exceed 50 megabytes, individually, as the T-FIMS program will not allow it.

Collateral Classified Information: Use classification and marking guidance provided by previously issued security classification guides, the Information Security Regulation (DoD 5200.1-R), and the DoD Overprint to the National Industrial Security Program Operating Manual (DoD 5220.22-M) when marking and transmitting information previously classified by another original classification authority.

Those wishing to make a classified submission must provide a hard copy, as well as a soft (electronic) copy, of their proposal. DARPA can accept the following files, including: Portable Document Format (pdf), Word Document (doc), Plain Text (txt), Comma-separated Values (csv), PowerPoint Presentation (ppt), Excel Worksheet (xls), and Excel Workspace (xlw).

Classified information at the CONFIDENTIAL and SECRET level may only be mailed via USPS Registered Mail or USPS Express Mail (USPS only; not DHL, UPS or FedEx) and should include electronic versions of all documents. All classified information will be enclosed in opaque inner and outer covers and double wrapped. The inner envelope shall be sealed and plainly marked with the assigned classification and addresses of both sender and addressee. The inner envelope shall be addressed to:

Defense Advanced Research Projects Agency (DARPA)
ATTN: BAA05-44, Information Exploitation Office
3701 North Fairfax Drive
Arlington, VA 22203-1714

The outer envelope shall be sealed with no identification as to the classification of its contents and addressed to:

Defense Advanced Research Projects Agency (DARPA)
Security & Intelligence Directorate, Attn: CDR
3701 North Fairfax Drive, Suite 832
Arlington, VA 22203-1714

Classified information at the TOP SECRET level must be hand carried via an authorized, two-person courier team to the DARPA Classified Document Registry (CDR). Those wishing to make a TOP SECRET submission must provide a hard copy, as well as a soft (electronic) copy, of their proposal. The submission should also include both a hard copy and a soft copy of the applicable OCA classification guide. DARPA can accept the following files, including: Portable Document Format (pdf), Word

Document (doc), Plain Text (txt), Comma-separated Values (csv), PowerPoint Presentation (ppt), Excel Worksheet (xls), and Excel Workspace (xlw).

Sensitive Compartmented Information (SCI) Information: Contact the DARPA Special Security Contact Office (SSCO) at 703-812-1993/1994 for the correct SCI courier address and instructions. All SCI data must be transmitted through your servicing Special Security Officer (SSO) / Special Security Contact Officer (SSCO) and through SCI channels only (i.e., approved SCI Facility to SCI facility via secure fax).

Those wishing to make a SCI submission must provide a hard copy, as well as a soft (electronic) copy, of their proposal. The submission should also include both a hard copy and a soft copy of the applicable OCA classification guide. DARPA can accept the following files, including: Portable Document Format (pdf), Word Document (doc), Plain Text (txt), Comma-separated Values (csv), PowerPoint Presentation (ppt), Excel Worksheet (xls), and Excel Workspace (xlw).

The PANDA program will involve the use or generation of CLASSIFIED data and results. *At a minimum, the System Engineering and Integration (SE&I) and Performance Evaluation (PE) contractors will need to access, store, and process SECRET/SCI data at their own facilities.* If CLASSIFIED data is required in an offeror's proposal, the offeror must show that personnel needed to perform the work possess the appropriate clearances. They must also show that they have facilities available to store and, if needed, process data at the appropriate level.

Proposers must have existing and in-place prior to execution of an award, approved capabilities (personnel and facilities) to perform research and development at the classification level they propose.

A DD Form 254 will not be provided at this time since DARPA is soliciting ideas only. After reviewing the incoming proposals, and if a selection for award is made, a DD Form 254 will be issued and attached as part of the award.

B.5 HUMAN USE

Proposals selected for funding are required to comply with provisions of the Common Rule (32 CFR 219) on the protection of human subjects in research (http://www.dtic.mil/biosys/downloads/32cfr219.pdf) and the Department of Defense Directive 3216.2 (http://www.dtic.mil/whs/directives/corres/html2/d32162x.htm). All proposals that involve the use of human subjects are required to include documentation of their ability to follow Federal guidelines for the protection of human subjects. This includes, but is not limited to, protocol approval mechanisms, approved Institutional Review Boards (IRBs), and Federal Wide Assurances. These requirements are based on expected human use issues sometime during the entire length of the proposed effort.

For proposals involving "greater than minimal risk" to human subjects within the first year of the project, performers must provide evidence of protocol submission to a federally approved IRB *at the time of final proposal submission to DARPA.* For proposals that are forecasted to involve "greater than minimal risk" after the first year, a

discussion on how and when the proposer will comply with submission to a federally approved IRB needs to be provided in the submission. More information on applicable federal regulations can be found at the Department of Health and Human Services – Office of Human Research Protections website - http://www.dhhs.gov/ohrp/.

C PROBLEM STATEMENT

It is critical that the United States develop an enhanced capability to identify threats to the Maritime Domain as early and as distant from our shores as possible by integrating intelligence, surveillance, observation, and navigation systems into a common operating picture…"

Presidential Directive NPSD-41/HSPD-13
Maritime Security Policy
21 December 2004

C.1 DEFINITION OF MOTION-BASED PATTERN ANALYSIS

It has long been a desire to go beyond merely tracking objects to *automatically* perform *motion-based pattern analysis* on those objects' tracks and their correlated activities. The goals of motion-based pattern analysis are to (1) *learn normal patterns of behavior* for objects of interest; (2) leverage those patterns to *perform motion-based anomaly and change detection*; and (3) *provide anticipatory situation awareness* by alerting our military forces to emerging threats and changes in our enemies' operating patterns. To date, we have been limited in our ability to learn motion-based patterns by our incapacity to perform persistent surveillance and develop long-duration tracks on objects of interest. DARPA's Information Exploitation Office (IXO) is currently developing advanced sensing and tracking technologies that have the potential to achieve persistent surveillance and tracking in the near future. Given that we will be able to persistently and automatically detect and track large numbers (possibly tens of thousands) of objects, we must ask what we can and should do with this information. Motion-based pattern analysis will provide the logical revolution in information exploitation and allow us to move beyond tracking (Level 1 fusion) to understanding and predicting the enemy's activities and providing vastly improved situation awareness (Level 2 and Level 3 fusion).[1]

While we have not yet achieved persistent tracking in most domains, recent developments in the maritime domain have the near-term potential for providing us with long-duration tracks on surface vessels. The International Maritime Organization (IMO) has mandated that every ship above 300 gross registered tons (GRT) carry an Automatic Identification System (AIS), which continuously broadcasts information about the vessel. In addition, many port authorities around the world now require that vessels entering their ports and harbors provide advance notification along with detailed information about their cargoes, crews, ownership, and prior ports of call. With the advent of AIS and these additional reporting requirements, it is now feasible, for the first time, to develop and maintain long duration tracks on a large number of commercial

[1] Joint Director of Laboratories.(1991).Data Fusion Subpanel of the Joint Directors of Laboratories, Technical Panel for C3, "Data Fusion Lexicon." Washington, DC: US Department of Defense.

maritime vessels, i.e., we now have the data we need to learn the normal motion-based behavior of these ships.

Existing efforts, including the Naval Research Laboratory's Vessel Tracking Program (NRL's VTP) and the Wargoddess program's SIGINT Fusion for Ship Tracking (SF4ST) programs, have developed or are developing all-source tracking algorithms for maritime surface vessels, are currently working to fuse all-source data in order to generate long-duration tracks on surface maritime vessels. The Predictive Analysis for Naval Deployment Activities (PANDA) program will develop a system that can perform motion-based pattern analysis on these tracks and associated data and provide anticipatory maritime situational awareness, at both the local and global levels. PANDA will go beyond current Maritime Domain Awareness (MDA) activities, which focus predominantly on tracking an ever greater number of ships, to understanding those ships' normal behavior, detecting changes in their behavior, providing notice of changes in ships' behaviors, and providing warning on those ships whose behavior may be indicative of a threat.

The resulting motion-based pattern analysis capabilities developed in an increasingly information-rich environment will have a wide variety of military applications, ranging from monitoring the activities of traditional, state-based foreign military forces to combating insurgents in such settings as the current conflicts in Afghanistan and Iraq to fighting the Global War on Terror (GWOT). In terms of traditional, state-based foreign military forces, the ability to conduct motion-based pattern analysis on a potential adversary's peacetime, exercise, and wartime operations will allow us to automatically predict how that adversary would deploy its forces, detect changes in the adversary's force posture, and recognize changes in the adversary's Concept of Operations (CONOPS). These goals may be achieved by analyzing the motion-based activities of the adversary's command vehicles, Special Forces, or support units. The same capability can be applied to monitor known or suspected insurgent leaders or terrorists and their modes of conveyance to learn their normal patterns of behavior, recognize when they are about to engage in threatening activities (vice going about their normal lives), and support interdiction. As we instrument our own forces, motion-based pattern analysis could be used to monitor activities and automatically detect when a patrol encounters hostile forces so that we can provide rapid support.

C.2 TRANSFORMATION IN GLOBAL MARITIME DOMAIN AWARENESS

In the post-9/11 world, there has been a growing concern about international commercial maritime traffic. Several factors contribute to this concern: an increase in the incidence of piracy and hijacking that poses a threat to the free flow of international commerce; the on-going use of commercial vessels for smuggling and trafficking in people, drugs, and other contraband, including weapons; and a growing concern over the potential use of commercial maritime vessels to support terrorist activities, including

smuggling terrorists and weapons of mass destruction, or hijacking a vessel for use in a terrorist attack against areas or assets of US national interest, including sea lines of communication, US Naval forces, or international ports. Presidential Directive (NPSD-41/HPSD-13) on Maritime Security, released in December 2004, calls for vast improvements to our ability develop and maintain global maritime situation awareness.

Current CONOPS focus our tracking and monitoring efforts on 100-200 “High Interest Vessels” (HIVs) – those ships that are suspected or known to be affiliated with some bad activity, person, or organization, or which carry cargoes that could be dangerous in the hands of the wrong people. In fusion centers around the world, watchstanders and analysts are busy manually tracking and assessing these HIVs. They look for inconsistencies in what those ships say they are doing by manually comparing that information to what they said an hour or a day ago, or by determining if it is feasible for the vessel to arrive at its destination port when it plans to do so. Efforts are underway to automate this manual process, but those efforts are still focused on the 100-200 HIVs, which represent a tiny fraction of the >50,000 vessels over 300 GRT that are engaged in international maritime commerce.

Today, even as the scope and scale of maritime threats to our national security have expanded, we continue to use the same approach we used during the Cold War: we look for those vessels and activities that we have already defined as potential “threats” and put all of our resources against them. Today, we have no way to detect an emerging threat coming from an unexpected vessel, unless that vessel violates some clearly stated rule or regulation. If, however, we can learn the normal behavior of that vessel and automatically detect deviations in its movements or associated activities, we can alert on those anomalies and seek additional information about the vessel, contact the vessel’s owner or leaseholder, or conduct an interdiction (directly or via one of our international partners).

Several issues make achieving anticipatory situation awareness in the maritime domain an interesting and challenging problem:

- **More sensors and data**: The current trend is to collect and process increasingly large amounts of data about commercial maritime vessels. This is true in both the military and commercial domains. Efforts are currently underway to bring together data from a vast array of sensors (tactical to national) and databases (military to commercial) to support developing Maritime Domain Awareness. These data have the potential to help us continuously improve surveillance coverage and tracking quality.
- **Stove-piped data**: At the same time, we can expect to see continued separation of data at different processing centers due to security, bandwidth, and data cost considerations. Hence, different organizations may have access to different data. In some cases, these organizations may be sampling the same nominal data stream, at very different sampling rates.

- **Broad and diffuse threat**: Highly motivated adversaries, be they terrorists or foreign navies, no longer confine themselves to operating with known threat platforms. Just within the commercial maritime shipping industry, there are over 50,000 vessels, any of which could used to deliver an attack on US interests.
- **More diverse targets**: The commercial shipping industry encompasses a wide array of vessel classes, each of which has specific capabilities and operating considerations related to the types of loads they carry, vessel size, loading/unloading requirements, and so forth.
- **Highly variable environment**: The commercial shipping industry has been called one of the purest forms of capitalism currently in existence.[2] It is a highly competitive environment with little regulation and less enforcement and very slim profit margins. As a result, commercial shipping companies and operators are constantly adapting to market conditions, tax laws, and environmental conditions.
- **Fewer analysts**: Continued pressure to reduce staff will continue, even as the number of vessels and the amount of data about each vessel increases, adding to the need for automatic motion pattern analysis technology, including automated ways for processing anomalies and only presenting to the user those anomalies that have a high probability of representing a threat.
- **Decentralized analysis**: Multiple organizations are responsible for monitoring commercial maritime shipping and providing maritime situation awareness. The division of labor is a function of roles, other tasking, sensor ownership, and data access. The organizations range from CONUS-based intelligence centers to Fleet-level fusion centers to ship-board situation awareness cells.

The PANDA program has three objectives: First, automatically learn motion-based activity patterns from long-duration tracks and associated data. Second, automatically perform motion-based change detection. Third, provide anticipatory situation awareness and threat assessment to watchstanders across multiple echelons.

C.3 EMERGING TECHNOLOGY FOR MOTION-BASED CHANGE DETECTION

During the Cold War, the US Navy successfully – and manually – performed motion-based pattern analysis on Soviet Naval vessels. This motion-based pattern analysis effort was extremely expensive (billions of dollars) and labor intensive (millions of person years). In addition to the cost of existing methods, in today's GWOT environment (where a threat may emerge from any platform, and not just from a known set of platforms), these manual methods are not sufficient. Recently, DARPA and other organizations have implemented technologies to automatically detect instances of known bad behaviors and rule violations in maritime vessel activity. Since this approach

[2] http://www.wesjones.com/anarchy.htm.

requires *a priori* knowledge of the bad behaviors and the rules, it is limited by our ability to predict *a priori* all possible threats and their indicators. A bad actor who has taken control of a vessel has merely to follow the posted rules and avoid obviously bad behavior to pass unnoticed. We require technology and systems that can detect emerging and previously unseen threats.

Over the past decade, several DARPA programs have produced new technologies that significantly improve behavior/activity modeling, anomaly detection, context modeling and switching, and information presentation and exchange. These technologies offer new potential to achieve the three PANDA objectives listed in section C.2 and include:

- **Transactional Profiling:** Statistical-based machine learning methods have been successfully applied to learn normal spending patterns in support of detecting instances of credit card fraud. Existing techniques assume complete data with low latency and low dimensionality in data types; statistical independence between the entities' spending behavior; and require large training sets.
- **Motion Pattern Learning:** Various machine learning techniques (self-organizing maps, neural computing, Bayesian techniques) have been employed to capture and model normal path-based movements (e.g., heading, speed, GPS location). These techniques have only been utilized for individual entities in a small geographic area (single pier to single harbor) for a single class of vessels, with a large number of exemplars, and focusing solely on kinematics.
- **Activity Monitoring and Pattern Recognition:** Template-based methods have been used to detect known patterns of bad behavior to detect instances of stock, cell phone, and credit card fraud. The known bad behavior may be defined by humans or learned from prior instances of fraudulent behavior. Existing techniques have little or no geographic component, complete data, low dimensionality (i.e., one or few types of events/transactions), and require large training sets.
- **Knowledge Management:** Recent advances in knowledge capture, representation, and management provide a starting place for automatically constructing and adapting context models to support domain understanding and anomaly resolution. Advances are needed in to achieve computational efficiency, and automatic or semi-automatic support for evolving ontologies or knowledge representations.
- **Software Architectures:** The emergence of service oriented architectures (SOAs), web standards and services, and related technologies provide the basis for developing a common framework to support software interoperability in a distributed computing and information environment.
- **Adaptive, Intelligent Agents:** Agent-based computing in military systems have evolved to a state where intelligent software agents are retrieving relevant

information from data bases, closely monitoring specified events, alerting operators to suspicious activities, distributing electronic mail to designated recipients, and preparing information for high level presentations. User-configurable and composable intelligent agents are currently being developed and deployed under DARPA funding. Agent technologies can be extended with learning so that a system can automatically configure and compose new agent suites as the motion-based patterns and context change.

Specific technologies that will enable PANDA include, but are not limited to: Hidden Markov Models (repetitive behavior and continuous learning of parameters); Neural Processing (pattern feature detection and rapid pattern learning); Boundary Detection (learning sequences and detecting pattern changes); Artificial Intelligence Techniques (context and higher level models); Bayesian Methods (multiple hypothesis generation/evaluation); conceptual graphs, conceptual spaces, and/or ontologies (learning structured yet flexible representation and fast search of context); adaptive case-based reasoning (rapidly learn new cases, compare individually processed cases and classify those that are similar); and agent-based computing (extensions of DARPA's CoABS and Fast C2AP technologies), including web services and related technologies. It is the intent of PANDA to leverage all of these advances and more within a single program concept - uniting the technologies within a unified, system design; testing that combination of technologies against real-world data, and providing a framework that is explicitly aligned with Navy efforts to insert advanced technology into the US Navy's FORCENet framework.

C.4 TECHNOLOGY AND SYSTEM CHALLENGES FOR PANDA

Maritime Domain Awareness is the responsibility of multiple organizations, each of which has access to different and sometimes overlapping data streams. Each organization has its own assets with their own capabilities including different sampling rates on the data streams and classification levels. Since it is not feasible to have a single data repository on which to learn and detect anomalies, PANDA will have to operate at multiple levels (local, regional, and global) and at different organizations (afloat, theatre, and national nodes). As a consequence, PANDA will need to be able to exchange models, tracks, alerts, and other information across these nodes and classification levels. In addition, the commercial maritime domain is highly dynamic and subject to a variety of economic and environmental forces. These forces drive the industry to develop patterns that support efficient commerce and rapidly adapt to changing conditions, resulting in both evolutionary and sudden changes in patterns. PANDA will need learn and adapt a wide variety of context models to support anomaly resolution and avoid inundating watchstanders with anomalies that occur for good business reasons.

This particular problem domain gives rise to several interrelated technical- and system-level challenges that need to be addressed in order to achieve PANDA's vision of motion-based pattern analysis and change detection in support of anticipatory situation awareness. These include:

- Multi-resolution data (different sampling rates, different data streams available to different nodes);
- Multi-resolution learning, prediction, and hypothesis management (local, regional, and global);
- Efficient exchange of models, tracks, predictions, and alerts across organizations and classification levels and adjudication of competing / complementary models, tracks, predictions, and alerts;
- Rapid (re)learning on a small number of exemplars (2-6 voyages);
- Individual and class of vessel learning (each vessel may belong to more than one class);
- Flexible and adaptive context modeling to capture economic and environmental effects, including on-line capture of feedback and context model updates;
- Pattern and context model management and maintenance, including efficient search and model switching; and
- Clear and concise presentation / explanation of models and alerts to watchstanders and analysts.

C.5 THE COMING TRANSFORMATION OF MARITIME DOMAIN AWARENESS

The current CONOPS for achieving situation awareness in the maritime domain calls for close monitoring of those entities that we already have reason to be concerned about (i.e., we already suspect are threats or which carry cargos that could be dangerous in the hands of the wrong people). The goal of PANDA is to automatically evaluate the behavior of all larger surface maritime vessels (not just those that we are already concerned about), to determine which ones are deviating from their normal, expected behavior in ways that may be indicative of an emerging threat.

PANDA will advance technologies and develop an architecture that will alert watchstanders to anomalous ship behavior as it occurs, allowing them to detect potentially dangerous behavior before it causes harm. These technologies and systems will be transitioned to various partners and customers throughout the development process, ensuring that the end product meets the needs of the services and watchstanders. Participants will work closely with the transition partners to aid in this process.

D PROGRAM STRUCTURE

D.1 SYSTEM CONCEPT

Figure 1 illustrates the major elements of the PANDA program. The PANDA system concept incorporates four functional areas that operate on vessel track data. Within each functional area there are multiple technical components. These components will be developed in parallel, coordinated efforts with increasing integration as the program proceeds. This Broad Agency Announcement (BAA) solicits proposals to develop these components.

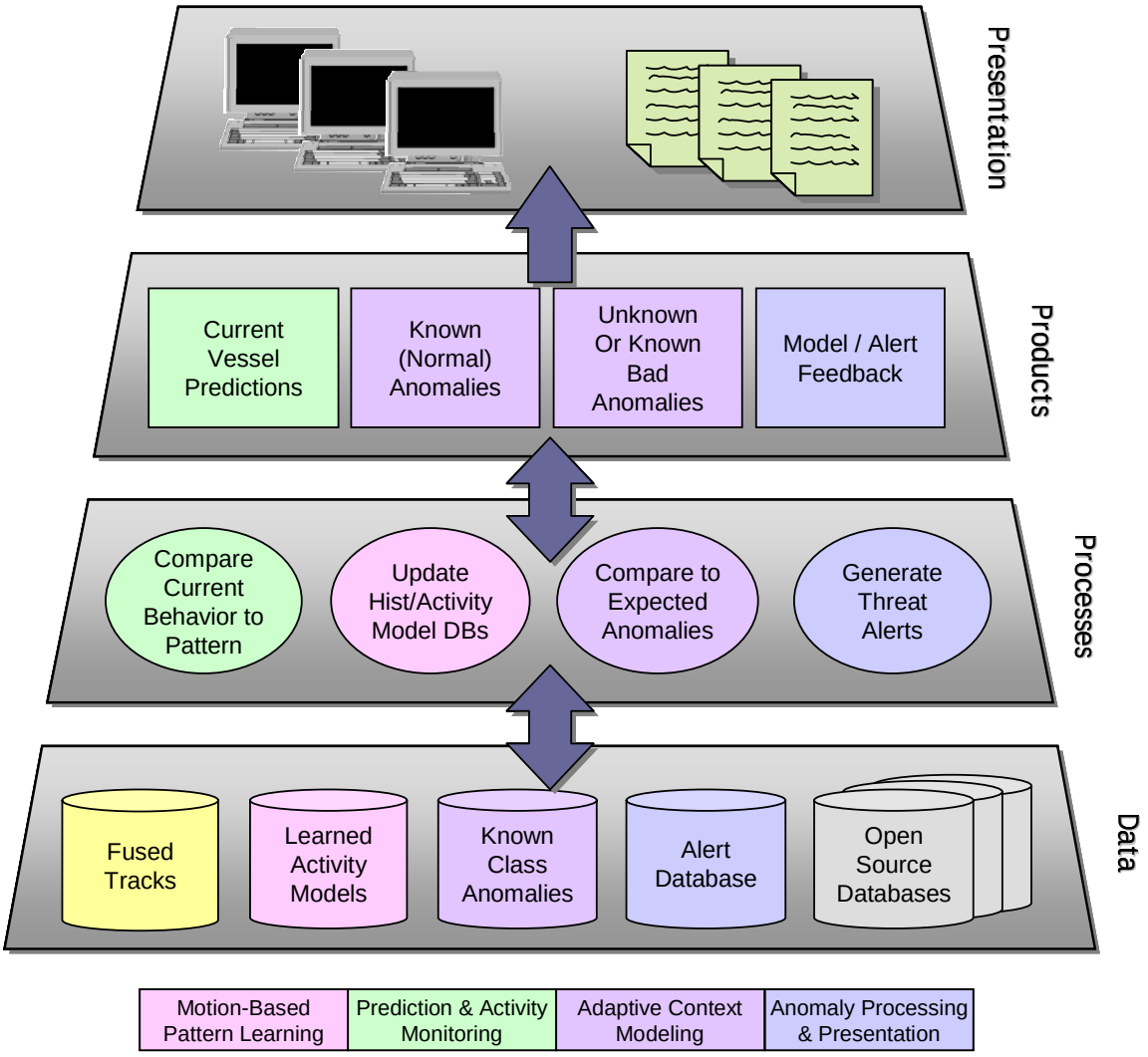

Figure 1. Key Elements of the PANDA System

The PANDA technology components and system will be designed to operate in a distributed, services-oriented architecture (SOA) consistent with the US Navy's current FORCENet acquisition policy. Additionally, PANDA will be exercised against real data in a testbed via a series of carefully designed experiments to assess the accuracy, efficiency, and robustness of both the integrated system and the components. These assessments will involve integrating the PANDA components, both with one another and with the testbed, along with experiment planning, execution, and analysis to objectively measure progress toward program goals. This BAA also solicits proposals to perform this integration, and to design and conduct the evaluations. The testbed itself, along with relevant subject matter experts, will be provided by the government.

D.1.1 Inputs

The PANDA system nominally expects the following inputs: maritime surface vessel tracks and associated data, militarily-relevant context information, and open source context information. This information will enable PANDA to automatically learn normal motion-based behavior patterns from long-duration tracks and associated activity data, and leverage these patterns to predict future vessel behaviors (anticipatory situation awareness), perform anomaly detection (motion-based change detection), process anomalies against context models to distinguish between those motion-based changes that occur for good business reasons and those that may be indicative of an emerging threat. More specifically, PANDA's inputs will include:

- **Model Templates:** Subject matter expert (SME) descriptions of individual or class of vessel behavior patterns, both for normal activities and known bad activities. PANDA's technology components will convert the templates into an internal representation, apply the templates and learn individual and class of vessel patterns and context models, and provide users with access to the templates and the learned pattern and context models.
- **Vessel Tracks:** For each vessel, its track will consist of the calculated track (from external trackers) and the "all source" data that makes up the vessel's track. All-source data may be derived from, but is not limited to, the following:
    - Radar: possible sources include land-based (harbors, littorals), shipborne, airborne systems, and space based (future) systems.
    - Acoustic Intelligence (ACINT): possible sources include the Integrated Undersea Surveillance System (IUSS), Sound Surveillance System (SOSUS), long-range acoustic sensors (hydrophones), Surveillance Towed Array Sensor System (SURTASS), Fixed Surveillance System (FSS), Fixed Distributed System (FDS), and Advanced Deployable System (ADS).
    - Signals Intelligence (SIGINT): various tactical and national systems may be available as sources.

- Open Source Vessel Information: includes vessel owners'/operators' published schedules, and messages generated by each vessel's Automatic Identification System (AIS).

A number of on-going programs, including NRL's Vessel Tracking Program (VTP) and the Wargoddess program's SIGINT Fusion for Ship Tracking (SF4ST) program, have developed or are developing all-source tracking algorithms for maritime surface vessels. These and other existing programs will provide the technology for generating tracks for inputs to PANDA.

- **Militarily Relevant Context Information:** Military and intelligence-related information providing specific priorities or describing specific military activities that might influence other surface maritime vessel behaviors. Data sources include, but are not limited to:
  - Vessel Lists: Those vessels that have been determined to be of significant interest, variously referred to as High Interest Vessels (HIVs), Vessels of Interest (VOIs), Contacts of Interest (COIs), and Critical Contact of Interest (CCOIs). These lists may be generated by ONI, NATO, or a Theatre Commander.
  - Own and Foreign Naval Activities: Exercises and operations that may have an impact on maritime surface traffic.
  - Sensor Status and Coverage: When detecting anomalies involving missing behavioral data, it is important to know if the behavior could have been observed.
- **Open Source Data:** Publicly-available information useful for better understanding maritime surface vessel behavior, particularly those things that might lead to changes in a vessel's operating pattern and/or anomalies. Data sources include, but are not limited to, the following:
  - Weather;
  - OceanWatch;
  - International Telecommunications Union;
  - Journal of Commerce;
  - Lloyd's Register;
  - National Data Buoy Center Registry;
  - Port and Customs; and
  - World Port Index.

D.1.2 Outputs

PANDA will produce five major outputs:

- Models of Normal Motion-Based Behavior for Maritime Surface Vessels: User-accessible depiction of normal behavior models via combined report and display, with playback and drill-down capability, including highlighting of key indicators. These will occur at both the individual and class-of-vessel level.
- Context Models: User-accessible presentation of contexts affecting maritime surface vessel behavior and of known good/bad anomalous behaviors via combined report and display, with drill-down capability to support user-centered model tuning and understanding.
- Current and Predicted Vessel Behavior: Reports and/or display of current and predicted vessel behavior as requested at a specific node.
- Notifications, Alerts, and Warnings: Identification of changes in a vessel's motion-based behavior characterized as a notification (non-threat), alert (potential threat), or warning (likely threat), via reports and/or visual cues on a GUI, with drill-down capability to support analysis of current and previous voyages and measure the significance of the anomaly or similarity to known bad behavior.
- Information Requests: Recommendations for additional data collection to support one or more behavior hypotheses.

D.1.3 Key Interfaces within the PANDA System

The PANDA program envisions several additional, internal component interfaces:

- Compact model representation and exchange;
- Track and associated data representation; and
- Data, model, and alert/notification exchange interfaces across PANDA nodes.

D.1.4 PANDA System Components

The objective of PANDA is to develop the highest level of accuracy, robustness, and automation possible for these components, recognizing they will always be supervised by analysts and watchstanders. In addition to the four PANDA Technical Components, this BAA requires efforts in System Engineering and Integration (SEI) and Performance Evaluation (PE).

- **Motion-Based Pattern Learning (MPL):** Design and construct a system that learns motion-based activity models for individual, groups, and/or classes of vessels. This system should integrate local and global learning. Demonstrate increases in robustness, flexibility, and computational efficiency as the program progresses.
- **Prediction and Activity Monitoring (PAM):** Design and construct a vessel prediction and activity monitoring function, which compares the incoming and emerging vessel tracks/behaviors with the existing vessel patterns and can determine if the current behavior is consistent with the learned pattern.

Demonstrate increases in accuracy, robustness, and computational efficiency as the program progresses.

- **Adaptive Context Modeling (ACM):** Design and construct a component that learns, maintains, and efficiently stores "business process" models related to variations in surface maritime ship behavior as well as suspicious behaviors. Models can be entered manually by an analyst/watchstander or learned by the system by observing a watchstander's activities in resolving previously unknown anomalies. Demonstrate increases in robustness, flexibility, and computational efficiency as the program progresses.
- **Anomaly Processing and Presentation (APP):** Design and construct a component that compares anomalies generated by PAM to the anomaly database to determine if the anomaly is an emerging threat or not, and present the results to an analyst/watchstander for them to review or manually resolve. Demonstrate increases in robustness, flexibility, and computational efficiency as the program progresses.

D.1.5 External Components and Interfaces

Certain advanced technical capabilities will be in development through other programs, in acquisition, or otherwise likely to be available by the time that PANDA is adopted for operational use. Specifically, tracking capabilities and associated vessel data as well as external databases, both government-provided (e.g., SeaWatch, SeaLink) and open source (e.g., Lloyds), are components outside of PANDA that will be provided by others.

While the PANDA effort may develop its own displays and human interfaces to support System and Component Performance Analysis and to fully realize PANDA's goals for providing anticipatory situation awareness and motion-based change detection, with the attendant abilities to perform playback and conduct forensic analyses, it will also be necessary for PANDA to interface with those systems that are currently deployed, or in the process of being deployed, into operations and fusion centers. These interfaces include, but are not limited to, the following:

- Operational Command & Control Information Systems
    - Global Command and Control System – Maritime (GCCS-M)
    - Joint Command and Control (JC2) System – net-centric replacement for GCCS
- Intelligence Community Systems
    - Gale-Lite
    - Ocean Surveillance Information System Evolutionary Development (OED)
    - SeaLink
    - WarGoddess

- Tracking Programs
    - Vessel Tracking Program (VTP) – Joint Naval Research Laboratory (NRL) and U.S. Coast Guard program addressing fusion of vessel track data and automated vessel tracking
    - SIGINT Fusion for Ship Tracking (SF4ST)
- Infrastructure Tools
    - Fast Connectivity for Coalitions and Agents Program (Fast C^2AP)
    - Web-Enabled Temporal Analysis System (WebTAS)

D.2 MANAGEMENT CONCEPT

D.2.1 Program Elements

Based on the goals of the PANDA Program, there are three program development areas: Technology Development (TD), Systems Engineering and Integration (SEI), and Performance Evaluation (PE). DARPA intends to award multiple Technology Development contracts, one SEI contract, and one PE contract. Over the course of the first two phases, DARPA expects to downselect the TD contracts according to performance against the Go/No-Go criteria (see Table 2).Throughout the life of the program, all TD contractors will be expected to agree to take direction from the SEI contractor who will be responsible for integrating the different technology solutions into a prototype PANDA system.

The following subsections describe each of the three program development areas in more detail. The technical proposal should indicate which of the three areas to which the offeror is responding.

- **Technology Development:** This project development area has four major technology topics: Motion-Based Pattern Learning, Prediction and Activity Monitoring, Adaptive Context Modeling, and Anomaly Processing and Presentation. These are described in Section D.1.4.
- **System Engineering & Integration:** Formulate a system architecture for all the component technologies and assemble the pieces into a coherent, scalable, maintainable, and robust system with the necessary interfaces between all PANDA internal components, across PANDA nodes, and between PANDA and the external components. Include communications management as necessary. Interface with government test sites to perform experiment coordination, design, verification/validation, and data/metrics definition and gathering.
- **Performance Evaluation:** Plan and execute experimentation/demonstration activities during each phase to quantitatively assess progress toward the program goals as defined in Section D.3. The culminating event for each phase will provide the government with performance measures necessary to justify

additional phases and should also include measures of performance that can be fed back to the individual technology component providers as indicators of the effectiveness of their component designs.

Teaming is permitted and encouraged. Offerors may submit proposals to more than one area. However, no individual technical person should be named in more than one proposal. Any proposals for technology development should be separate from System Engineering & Integration and Performance Evaluation work. Offerors may submit proposals to both TD and SE, but the PE contractor/team will remain independent of the TD and SEI contractors/teams throughout the life of the program.

The effective and efficient management of the resources of both the prime contractor and those of any subcontractors, as well as management of the program fiscal resources, is of critical importance to the government and the PANDA Program. The offeror should propose an efficient, streamlined, and cost effective management structure and plan to perform all of the tasks identified in the proposed Statement of Work (SOW). The offeror should identify how they will effectively and efficiently manage any subcontractors to ensure that the subcontractors' products are developed and delivered in an efficient and timely manner. The offeror should identify any specific tasks related to this development area and include them in both the proposed SOW and Work Breakdown Structure (WBS).

D.2.2 Program Phases

PANDA will be conducted as a four-year program. For planning purposes, assume this effort starts1 February 2006. Work will be performed in four phases.

The objective of this phased approach is to incrementally deliver technical components, integrate those components, and evaluate those components and the overall system. As the program progresses, the focus of each phase will change to ensure the Program Metrics are met and a fully integrated, transitionable system is produced. Each successive phase builds on the work of previous phase(s). The high-level objectives and evaluation criteria for each program phase are shown in ***Table 2***. Proposers should provide more detailed evaluation criteria and a plan for measuring performance against these additional criteria.

- **Phase I – Learning and Detection:** Demonstrate that individual and class-of-vessel motion-based activity patterns can be learned and used to detect anomalies; use patterns to predict movements and classify (groups of) vessels as potentially (non)hostile with a low incidence of false alarms; learn and detect multi-ship correlated activities; incorporate initial context models. Scale: To be specified by the proposer, but no less than 1,000 vessels.

Phase	Challenges	Evaluation Criteria
1	• Demonstrate that motion & emission patterns exist & can be learned • Discover & learn correlated activities (tankers, single-owner liners) • Install three individual nodes	• Discover & learn individual patterns for 1000 vessels • Detect and classify 70% of anomalies • Learn patterns on 20 exemplars • False Alarms: 1%
2	• Rapidly relearn models in response to sudden changes and generate timely alerts • Integrate with two nodes simultaneously • SeaTrial Demonstration	• Discover & learn individual patterns for 10,000 vessels • Detect and classify 80% of anomalies • Learn patterns on 10 exemplars • False Alarms: 1%
3	• Learn patterns on small number of exemplars • Integrate with three nodes simultaneously • SeaTrial Demonstration	• Discover & learn individual patterns for 100,000 vessels • Detect and classify 90% of anomalies • Learn patterns on 6 exemplars • False Alarms: 1%
4	• Incorporate smaller vessels • Harden, scale and transition system • SeaTrial Demonstration	• Scale to global traffic • Detect and classify 95% of anomalies • Learn patterns on 6 exemplars • False Alarms: 1%

Table 2. PANDA Program Phases

- **Phase II – Automation:** Increase number of patterns detected (to be specified by the proposer, but at least an order of magnitude increase expected) and speed of detection (rapid relearning in response to sudden changes); improve accuracy of detection and classification of anomalies; automate integration technology component (MPL, PAM, ACM, APP) outputs.
- **Phase III – Integration:** Increase number of patterns detected (to be specified by the proposer, but at least an order of magnitude increase expected) and speed of detection (learn on several exemplars); improve accuracy of detection and classification of anomalies; integrate across nodes for simultaneously function at multiple locations.
- **Phase IV – Technology Scaling and Transition:** Leverage future detection/tracking capabilities to expand system to smaller (harbor) vessels (scale equal to world traffic); increase number of patterns detected; improve accuracy of detection and classification of anomalies; harden and transition PANDA system.

Bidders should propose tasks for all four phases but funding for later phases is entirely contingent upon meeting system-level technical and operational performance goals established for earlier phases.

D.2.3 Program Spirals

The first three phases will contain Technology Development and Integration (TDI) spirals and Performance Evaluation (PE). Phase IV will be focused on scaling the system, and hardening and transitioning the technology.

All contractors (i.e., those performing Technology Development, System Engineering & Integration, and Performance Evaluation) are expected to actively participate in the full cycle of each phase. Each phase will consist of the following activities:

- Definition of system-level functionality upgrades;
- Updates to Interface Control Documents (ICDs);
- Definition of test execution activities and schedule at the experimentation/ evaluation facility;
- Development and delivery of intermediate technical components to support testing and experimentation; and
- Integration of technical components, delivery of an enhanced version of the system, and participation in evaluation exercises.

Following the first program Go/No-Go milestone, each phase will contain quarterly spiral experimentations and annual evaluations. These events will be conducted at one or more of the following locations:

- Maritime Analysis Support Team (MAST) and Defense Security Operations Center (DSOC), Denver, Colorado;
- Office of Naval Intelligence (ONI), Suitland, MD; and.
- Theater Maritime Fusion Center (TFMC) CNE-C6F, Capodachino Naval Support Activity, Naples, Italy.

Additional partners may include the National Geospatial Intelligence Agency (NGA), the U.S. Navy Space and Naval Warfare Systems Center (SPAWAR SYSCEN or SSC SD), and others.

D.2.4 Component Technologies

Each technical component should deliver software, in accordance with the SEI contractor's architecture and procedures, for integration into the classified exercise facility approximately one month prior to each PANDA assessment. Prior to those points, however, incremental deliveries of technical components are encouraged in order to better support integration and evaluation.

Each technical component must be prepared to support the SEI and PE activities. Because there will be no formal contractor/subcontractor arrangements between the SEI contractor and the technical component developers, each technical component developer must include in its final proposal a signed one-page commitment that will become legally binding upon contract award agreeing to conform to the design decisions made by the SEI contractor. Any component proposal lacking such a commitment will not be selected.

Technical component development may involve the skills of advanced algorithm designers, a blend of junior and senior software engineers, and data analysis for diagnosis and performance assessment. Development teams consisting of dedicated individuals, including a designated, *full-time Principle Investigator*, are preferred.

D.2.5 System Engineering and Integration

The purpose of the SEI effort is to design and implement a system architecture that integrates all the component technologies into a distributed PANDA system in a manner that demonstrates increasing scalability, utility, and computational efficiency as the program progresses. This effort will also establish common data representations for the PANDA system architecture and supporting inter-component software substrate and will interface with external systems at government test sites to perform system evaluation coordination, on-going spiral experimentation, verification/validation, and data/metrics definition and gathering. The Contractor shall build and operate both an UNCLASSIFIED and a SECRET/SCI software integration facility and deliver, test, and verify functional behavior at one or more government facilities.

The SEI effort should:

- Provide a software framework into which components can be installed, consistent with those used by PANDA transition partners;
- Collaboratively define representations of models and information products shared by technical components;
- Establish and refine a system design as components mature;
- Integrate components into that framework during development spirals;
- Coordinate setup and design of the integration facility with that of the classified testbed;
- Provide continuous, unimpeded access by the component developers to the UNCLASSIFIED integration facility and to appropriately cleared component developers to the CLASSIFIED integration facility; and
- Lead PANDA transition activities.

These activities should be planned and executed in a manner that supports an open design and integration approach, a Services Oriented Architecture, and the U.S. Navy's FORCEnet architecture for network-centric operations. These activities should

include representation from, and review by, personnel from each component technology developer, PE contractor, and government managers. Additionally, proposers should provide up to two (2) personnel who shall support this effort as full-time, on-site resources at the Maritime Analysis Support Team (MAST) in Denver, CO, and up to (1) person who shall support this effort at the Office of Naval Intelligence (ONI) in Suitland, MD. One of the positions at the MAST may be shared with the Performance Evaluation contractor.

SEI efforts may involve technologists and systems engineers familiar with technologies that are embedded in the components, senior software designers, real-time secure communication protocols, facility management, and fielded systems. SEI teams consisting of dedicated individuals, including a designated, *full-time Principle Investigator*, are preferred.

D.2.6 Performance Evaluation

The purpose of the Performance Evaluation effort is to define system- and component-level metrics, design tools to obtain data from field instrumentation and components to compute those metrics, maintain and operate a classified PANDA exercise facility, and establish and maintain secure, low-latency connectivity between the exercise facility and exercise partners.

The Performance Evaluation effort should:

- Refine system-level program metrics and work with component developers to translate them into component-level metrics;
- Use rigorous experimental design techniques to methodically explore tradeoffs between metrics;
- Develop tools to reduce and analyze experiment data obtained from that instrumentation for all major functions in the PANDA system architecture; and
- Feed experiment data back and suggested failure causes to the SEI and component development teams throughout the spiral design process.

These activities should include representation from, and review by, personnel from each component developer, the SEI contractor, support contractors, and government managers. Additionally, proposers should provide up to one (1) person who shall support this effort as full-time, on-site resources at the Maritime Analysis Support Team (MAST) in Denver, CO. This position may be shared with the SEI contractor.

Performance Evaluation efforts may involve expertise in experiment design, statistical performance modeling, and fielded systems. Experiment efforts consisting of dedicated individuals, including a designated, *full-time Principle Investigator*, are preferred.

D.2.7 Technology Transition

PANDA technologies are targeted to transition into a Naval land-based operational site, CONUS-based intelligence analysis centers, and on board a Naval vessel. The PANDA program office has formally briefed various government organizations and is planning on engaging the following groups as PANDA technology transition partners:

- Theater Maritime Fusion Center (TFMC) CNE-C6F;
- Maritime Analysis Support Team (MAST) and Defense Security Operations Group (DSOC);
- Office of Naval Intelligence (ONI);
- PEO C4I&SPACE PMW 180 (ISR/IO).

Additionally, in order to formally validate the program's technical components the PANDA program office plans to team with the Commander, Fleet Forces Command (CFFC) in order to participate in future Sea Trial events and the Naval Warfare Development Command (NWDC) and the Naval Network Warfare Command (NNWC) to participate in future Trident Warrior exercises, beginning with Trident Warrior '06.

D.3 PROGRAM METRICS

Progress on the PANDA program will be assessed near the end of each phase. In addition to component-level assessment metrics to be proposed by each Technology Development contractor and the Systems Engineering and Integration contractor, these metrics gauge progress of the program for DARPA management and provide the basis for continuation of funding for the program.

The PANDA program will measure its progress by new capabilities introduced in each phase as shown in the table in section D.2.2 as well as by quantitative effectiveness measures against real operational data.

E TECHNICAL OBJECTIVES

E.1 MOTION-BASED PATTERN LEARNING

E.1.1 Scope

The purpose of the motion-based pattern learning (MPL) component is to learn motion-based activity patterns for maritime surface vessels from long-duration tracks and associated activity data. The MPL component will learn, update, and maintain the motion-based pattern models. The resulting models will be used to predict the behavior (future path and activities) of those vessels.

MPL assumes the availability of long-duration tracks and additional data (provided by external systems) to each PANDA node along with the ability to exchange models and data across nodes (provided by the PANDA architecture). The MPL component at different nodes will have access to different data streams and will sample those data streams at different rates. Local nodes will typically have high sampling rates over small coverage areas, while global nodes will have low sampling rates over broad coverage areas. As a result, there may be gaps in tracks for some local nodes (while the vessel in question is operating outside the local node's coverage area. At the same time, the precision of the locally learned models is likely to be higher than for the globally learned models. MPL will learn both individual and class of vessel motion-based patterns and will have the ability to exchange model information via efficient model representation schemes.

E.1.2 Technical Challenges

The technical bases for MPL include (1) transactional profiling, and (2) fixed scene motion pattern learning. Transactional profiling is commonly performed by credit card companies to determine each customer's normal spending patterns. Transactional profiling systems have the advantage of complete data sets for each person, large volumes of training data, statistical independence between people, and low dimensionality of data (all transactions). Current fixed scene motion pattern learning systems typically employ a vision-based system to "stare" at a particular scene (small geographic area) and focus on learning the regular behavior within that scene (e.g., traffic flows in/out/through an area, repetitive movements for loading/unloading) for a large number of entities.

Learning motion-based patterns in the maritime domain presents several challenges that provide opportunity to go beyond the current state of the art. These include:

- Multi-dimensional data including tracks, kinematic behavior (speed, maneuver), interactions with shore-based and afloat entities (e.g., reporting to weather buoys), and self-reported information.

- Local, regional, and global geographic behavior: vessel behavior and variability in behavior is a function of specific location (port, choke point, open ocean) and its general operating areas (vessels may operate in a relatively small area only on up to global operations).
- Rapid learning on few exemplars (as few as two-six voyages) and rapid relearning in response to sudden changes (e.g., weather, outbreak of hostilities, sale of a vessel).
- Individual vessel and class-of-vessel level learning, where each vessel may be in more than one class (e.g., a specific tanker may belong to the following classes: Tanker class, vessels owned by a particular company, vessels operating as part of a particular convoy, etc.).
- Local and global learning reflecting different nodes' coverage areas, sampling rates, and available data sets to sample from. Due to bandwidth limitations and security restrictions, there will not be a central repository containing all of the data from all of the nodes. Each node will operate on its own data and exchange models, alerts, and notifications with other nodes.

Potential technical approaches include, but are not limited to: hidden Markov models for learning repetitive behavior and continuous learning of parameters; neural processing for conducting pattern feature detection and rapid pattern learning; and machine learning and other statistical modeling techniques. DARPA is interested in other novel approaches for performing MPL.

E.1.3 Metrics

Proposers should describe a self-evaluation plan coordinated with, but extending beyond, the system evaluation described in Section D. MPL metrics may include, but should not be limited to:

- Model accuracy as a function of training set size;
- Coverage of modeling approach (range of vessels and types of patterns that can be learned with a specific approach); and
- Speed of learning.

Proposers should identify specific metrics and evaluation methods applicable to their proposed technologies, and provide a detailed evaluation plan.

E.2 PREDICTION AND ACTIVITY MONITORING

E.2.1 Scope

The purpose of the prediction and activity monitoring (PAM) component is to apply models of normal behavior to current motion-based activities and use those models to predict future behavior and detect instances of anomalous behavior. The PAM

component will take as input each vessel's current track and collection of individual and class-of-vessel models and use those to predict the vessel's future motion-based activities projecting out at least 6-72 hours, continuously update the prediction as the track evolves, and detect anomalous behavior as a function of the track kinematics and/or associated behaviors.

PAM assumes the availability of tracks and associated data (provided by external systems), models (provided by the MPL component), and prior predictions from other nodes (provided via the PANDA architecture).

E.2.2 Technical Challenges

The technical bases for PAM include (1) activity monitoring in stock and cell phone fraud, and (2) pattern recognition. Activity monitoring is used in stock and cell phone fraud to detect known patterns of bad behavior and is generally applied to a single type of behavior (transaction-based) in a temporal context. Relevant pattern recognition technologies include those developed under DARPA's Evidence Extraction and Link Discovery (EELD) program; these technologies typically look for known good/bad event/transaction sequences without any geographic context.

Performing prediction and activity monitoring for predictive situation awareness and motion-based change detection in the maritime domain presents several challenges that provide opportunity to go beyond the current state of the art. These include:

- Multi-dimensional prediction: predict both where the vessel will be and what its associated behavior will be (i.e., predict where to look and what to look for).
- Multi-resolution prediction: perform local and global prediction to support allocating local and global assets and situation awareness.
- Context-specific anomaly detection: the "size" of what constitutes an anomaly will be a function of the specific location (port, strait, open ocean), the presence of other vessels, the stated intentions of the vessel, related vessel information and the vessel's model.

Potential technical approaches include, but are not limited to: boundary detection (e.g., maximum entropy analysis) for detecting pattern changes; Bayesian methods for performing multiple hypothesis generation and evaluation; and conceptual spaces for geometric encoding of learned models with distance metrics for classifying instances. DARPA is interested in other novel approaches for performing PAM.

E.2.3 Metrics

Proposers should describe a self-evaluation plan coordinated with, but extending beyond, the system evaluation described in Section D. PAM metrics may include, but should not be limited to:

- Prediction accuracy;
- Anomaly detection accuracy; and

- False alarm rates.

Proposers should identify specific metrics and evaluation methods applicable to their proposed technologies, and provide a detailed evaluation plan.

E.3 ADAPTIVE CONTEXT MODELING

E.3.1 Scope

The purpose of the adaptive context modeling (ACM) component is to capture the evolving background knowledge and contexts in which surface maritime vessels operate. The context and domain models will be used by the anomaly processing and presentation component to resolve legitimate anomalies and by the MPL component to bootstrap (re)learning evolving or changed patterns for individual vessels. ACM will provide an efficient and flexible representation of the data and operating (environmental and business rules) for a wide variety of vessels.

ACM assumes the availability of vessel and class of vessel models (provided by the MPL component), historical data on vessel behavior, and basic domain knowledge as an input. The ACM will provide an interface for entering and reviewing domain models and will learn new contexts and business rules by observing analyst/watchstander activities in resolving new anomalies.

E.3.2 Technical Challenges

The technical bases for state-of-the-art in ACM include (1) prior work in developing ontologies and knowledge bases, and (2) case-based reasoning (CBR) technologies. DARPA has supported several programs in ontology and knowledge base development; these efforts may be leveraged and extended to provide more computationally efficient and flexible context modeling, knowledge capture, and knowledge maintenance. CBR methods have proven to be an efficient way to compare new cases (complex set of information) with prior cases to determine their similarity to a prior case (and hence the applicability of the resolution of that case to the current case). Existing CBR systems are typically narrowly focused and have well-structured data and scenarios (e.g., legal systems).

Performing adaptive context modeling to support anomaly resolution in the maritime domain presents several challenges that provide opportunity to go beyond the current state of the art. These include:

- Multiple context/multiple dimensions: there are a wide range of vessels engaged in a wide range of behaviors that need to be represented in an efficient, flexible, and understandable manner;
- Constantly evolving business rules (tax laws, spot markets, regulations): the maritime domain, and especially the commercial maritime domain, is subject to constant change that affect how business is conducted; and

- Need to update existing cases to maintain a manageable set of cases, including the ability to efficiently search the case base.

Potential technical approaches include, but are not limited to: conceptual spaces/graphs to perform geometric encoding of learned models and learn new contexts; and adaptive CBR to rapidly learn new cases and compare individually processed cases to existing cases. DARPA is interested in novel approaches for performing ACM.

E.3.3 Metrics

Proposers should describe a self-evaluation plan coordinated with, but extending beyond, the system evaluation described in Section D. ACM metrics may include, but should not be limited to:

- Accuracy of learning new cases as a function of the number of new anomalies and their resolution;
- Ease of incorporating new models;
- Speed of searching existing case base as a function of the size of the cases; and
- Accuracy in matching new cases to existing cases or identifying a new case as truly anomalous.

Proposers should identify specific metrics and evaluation methods applicable to their proposed technologies, and provide a detailed evaluation plan.

E.4 ANOMALY PROCESSING AND PRESENTATION

E.4.1 Scope

The purpose of the anomaly processing and presentation (APP) component is to utilize the ACM's models and search agents to process and resolve anomalies as model change events or possible threats and to provide watchstanders and analysts with low priority notifications of resolved anomalies and higher priority alerts (warnings) regarding unresolved anomalies that may indicative of an emerging threat. The APP component will incorporate existing intelligence information, including watchlists, HUMINT, etc., to properly prioritize the notifications and alerts. The APP component will also provide drill down/reachback capabilities to allow the watchstander to review individual vessels' track history, prior behavior models, current anomalous behavior, and related information, and allow the watchstander/analyst to provide feedback, including manually resolving an anomaly, or changing the priority of a notification or anomaly.

APP assumes that it will receive the outputs of the other three technical components and have the ability to query data from and push results to other PANDA nodes. The APP also assumes that it will have up-to-date and militarily relevant context

data, provided via the ACM or external interfaces, regarding current threat conditions and suspected threats.

E.4.2 Technical Challenges

The technical bases for APP includes high-level reasoning methods applied against ontologies, case bases, and knowledge bases; advanced display technologies; and agent-based technologies, and services-oriented computing architectures. The APP will need to interface with existing systems as described in Section D.1.5. In addition, the APP will include its own, advanced interface that will operate in a services oriented architecture to provide advanced display, playback, and analysis capabilities, beyond those provided by legacy systems.

Performing anomaly processing and presentation presents several challenges that provide opportunity to go beyond the current state of the art. These include:

- Efficient matching to alternative cases and selection of resolution plan;
- Efficient use of agent-based resources for conducting searches within, across, and external to PANDA nodes;
- Clear and concise presentation / explanation of alerts, including replay of activity histories; and
- On-line capture of feedback to the ACM component.

Potential technical approaches include, but are not limited to: agent-based computing methods to support efficient execution of anomaly resolution plans, including database searches and organizing results; high-level reasoning methods to provide supporting information and priorities on alerts; Bayesian nets for evaluating alternative hypotheses; and advanced GIS and other presentation capabilities. DARPA is interested in other novel approaches for performing APP.

E.4.3 Metrics

Proposers should describe a self-evaluation plan coordinated with, but extending beyond, the system evaluation described in Section D. APP metrics may include, but should not be limited to:

- Ease and speed of use within and across PANDA nodes.

Proposers should identify specific metrics and evaluation methods applicable to their proposed technologies, and provide a detailed evaluation plan.

E.5 SYSTEM ENGINEERING AND INTEGRATION

E.5.1 Scope

The purpose of the PANDA System Engineering and Integration (SEI) effort is to provide a framework by which interactions between technical components can be

managed and supported, to tie those components together into a single system that operates in real time, and to support operations that involve disciplined collaboration among installations of technical components at geographically separated sites. The SEI contractor will have lead responsibility in developing prototype implementations of the PANDA system and installing them and maintaining them in multiple government facilities. The SEI contractor will be responsible for conducting on-going spiral experimentation in at least one government facility, including providing briefings and demonstrations to visitors to that facility as requested by DARPA and DARPA's partners.

E.5.2 Technical Challenges

While much of this effort will involve conventional management of cooperative software development efforts (technical component development), there are several technical and transition challenges:

- PANDA will be installed at multiple sites, with different data streams, security requirements, and foci for situation awareness;
- Achieving efficient and secure exchange of data and models across PANDA nodes;
- Flexible interfaces to both data sources (and the ability to rapidly add and remove data sources), and presentation systems (legacy and new systems).

E.5.3 Metrics

Proposers should describe a self-evaluation plan coordinated with, but extending beyond, the system evaluation described in Section D. System Engineering & Integration metrics shall include, but should not be limited to:

- **Processing Latency:** Given a user request, the time to process that request and deliver an answer to the user. Faster is better.
- **Usability:** Ease of use is essential and necessary for the analysts who will be dealing with multiple data streams. This can be measured in terms of user training time. Faster is better.
- **Maintainability and Extensibility:** The system design comprises developmental component technologies that are subject to change and upgrade. Time to revise, debug, and upgrade major components should be minimal.
- **Installation:** Time to install the PANDA system in a new operational location. Shorter is better.

Proposers should identify specific metrics and evaluation methods for system-level evaluation, and provide a detailed evaluation plan.

E.6 PERFORMANCE EVALUATION

E.6.1 Scope

The purpose of the PANDA Performance Evaluation (PE) effort is to provide objective evaluation of progress towards PANDA system goals and to generate insight for component developers regarding their respective impacts on performance, especially weaknesses that offer opportunities for improvement.

E.6.2 Technical Challenges

It is expected that PANDA performance evaluations will be held at a government-furnished facility. The offeror shall be required to provide one or more individuals to both interface with the facility personnel and assist in the execution of tests and evaluations. Additionally, the offeror shall be required to develop a performance evaluation plan for the execution of these tests. This plan is to be delivered to the government for review not later than three (3) months after contract award and shall include appropriate metrics for the testing goals described below. The development of this plan shall be shown as a task in the overall SOW and WBS in the technical proposal. The subject and purpose of these tests is dependant on the specific phase of the PANDA program as defined below.

The PE contractor shall also support the SEI contractor and technology developers in developing their test plans for evaluating their technologies. The PE contractor shall review and make recommendations on each technology developer's and the SEI's proposed metrics and evaluation plans, review each contractor's self evaluation results, and provide feedback to the government and the contractor. The PE contractor is not responsible for the actual conduct of individual technology component evaluations, but may incorporate those evaluation approaches into the system level performance evaluation as appropriate.

E.6.3 Metrics

Performance Evaluation metrics assess both component technologies as well as an overall, integrated PANDA system. These metrics gauge progress of the program for DARPA management and provide the basis for continued support of individual component technologies and overall funding for the program. Offerers are expected to support planning and execution of performance evaluation activities that address the following technical component and system capabilities, in addition to the criteria listed in Section D.2.2:

- **Scale:** The ability to process incrementally increasing numbers of vessels and information about those vessels.
- **Detection:** The ability to detect incrementally increasing numbers of data anomalies and increasingly complex anomalies.

- **False Alarms:** The ability to reduce the number and percent of false alarm events generated even as the overall number of vessels and detections increase.
- **Classification:** The ability to incrementally increase the accurately with which anomalies are correctly classified.
- **Other:** The ability to discover and learn correlated activities, learn new models, provide timely alerts, leverage future detection/tracking capabilities to expand system to smaller vessels, and harden system for full-scale transition to military customers.

Proposers should identify specific metrics and evaluation methods for the system- and component-level performance evaluation, provide a rationale for relating system- and component-level metrics, and provide a detailed evaluation plan.

F PROPOSAL EVALUATION

F.1 GENERAL CONSIDERATIONS

DARPA is interested in awarding multiple Technology Development contracts, one SEI contract, and one PE contract. Proposers are encouraged to submit concise, but descriptive, proposals. The Government reserves the right to select for award all, some, or none of each of the proposals received in response to this solicitation and to award without discussions. All responsible sources capable of satisfying the Government's needs may submit a proposal. Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) are encouraged to submit proposals and join others in submitting proposals; however, no portion of this BAA will be set aside for HBCU and MI participation due to the impracticality of reserving discrete or severable areas of technology for exclusive competition among these entities.

It is the policy of DARPA to treat all proposals as competitive information and to disclose the contents only for the purposes of evaluation. The Government may use selected support contractor personnel to assist in administrative functions only. For this solicitation, non-Government advisors from Bradson Corporation, CACI International, McNeil Technologies, MITRE Corporation, Schafer Corporation, and Strategic Analysis, Inc., who have signed appropriate non-disclosure and conflict of interest statements, and who possess the necessary levels of classified access, may assist in the proposal administration when their assistance is required. These organizations will not participate in the final source selection process.

Proposers are advised that only contracting officers are legally authorized to contractually bind or otherwise commit the Government. The contracting officer for this IXO BAA is: Mr. Michael Blackstone, DARPA/CMO, 3701 North Fairfax Drive, Arlington, VA 22203-1714, Email - Michael.Blackstone@darpa.mil. See B.1.4.

F.2 CRITERIA FOR AWARDS

The selection of one or more sources for awards will be based on an evaluation of a Proposer's response (technical and cost aspects) to determine the overall merit of the proposal in response to the announcement. Proposals shall be evaluated against the following criteria, in descending order of importance. Subtopics within the following criteria are in no particular order.

- Overall technical and scientific merit, innovation, and depth
    - Understanding of the current state of the art in the technologies proposed
    - Soundness of technology approach at the component level and systems level
    - Degree of innovation and potential for revolutionary advance

  - Justification of design choices as compared to alternative techniques
- Relevance to PANDA mission objectives and program concepts
  - Understanding of the depth and breadth of PANDA missions and propose an innovative solution according to PANDA objectives
  - Understanding of PANDA program goals and metrics
  - Familiarity with current and previous work on related systems
  - Awareness of current and projected support requirements to analysts and operational commanders
  - TDs: commitment to comply with decisions of the SE&I contractor, including collaboration with other TDs
  - SE&I: plan for coordinating the activities of the TDs and for working with the PE
  - Precision and coverage of the proposed effort's metrics and evaluation plan
- Personnel and corporate capabilities and experience
  - Qualifications of proposed technical personnel
  - Availability of personnel for the duration of the contract
  - Proposer's experience related to the proposed technology area
  - Ability to collaborate in off-site integration and experimentation
  - Adequacy of proposed facilities
  - Adequacy of security plan
- Proposed schedule and metrics per Phase
  - Consistency of detailed schedule with overall PANDA program plan and goals
  - Consistency of specific proposed metrics with overall PANDA evaluation criteria
  - Likelihood that proposed detailed schedule and specific metrics contribute to achieving increasingly aggressive program performance goals while reducing risk
- Project and technology transfer plans and potential transformative impact on military operations
- Cost realism and value of proposed work to the Government
  - The total cost relative to benefit
  - The realism of cost levels for facilities and staff

- The cost-effective use of existing equipment and software
- Competitive costs on procurements

G PROPOSAL CONTENT

G.1 GENERAL INFORMATION

Proposal abstracts ARE NOT requested in advance of full proposals.

Technical and cost proposals must be submitted as separate volumes (Technical as Volume I, Cost as Volume II), and must be valid for 180 days after submission.

Proposals with fewer than the maximum number of pages will not be penalized. Proposals exceeding the page limit will not be reviewed beyond the maximum page limit. Non-cost information incorporated into the Volume II cost proposal will not be considered. Proposers are encouraged to submit concise, but descriptive, proposals.

DARPA can accept the following files, including: Portable Document Format (pdf), Word Document (doc), Plain Text (txt), Comma-separated Values (csv), PowerPoint Presentation (ppt), Excel Worksheet (xls), and Excel Workspace (xlw).

Proposal questions will be handled according to the process described in Section B.1.4. Proposers are advised that only contracting officers are legally authorized to contractually bind or otherwise commit the Government.

Proposers should appropriately apply the restrictive notice prescribed in the provision at FAR 52.215-12, Restriction on Disclosure and Use of Data, to trade secrets or privileged commercial and financial information contained in their proposals.

G.1.1 Procurement Integrity, Standards of Conduct, Ethical Considerations

Certain post-employment restrictions on former federal officers and employees may exist, including special Government employees (Section 207 of Title 18, United States Code). If a prospective proposer believes that a conflict of interest exists, the situation should be raised to the DARPA Contracting Officer using the contact information specified in Section B.1 before time and effort are expended in preparing a proposal. All proposers and proposed subcontractors must therefore affirm whether they are providing scientific, engineering, and technical assistance (SETA) or similar support to any DARPA technical office(s) through an active contract or subcontract. All affirmations must state which office(s) the proposer supports and identify the prime contract numbers. Affirmations shall be furnished at the time of proposal submission. All facts relevant to the existence or potential existence of organizational conflicts of interest (FAR 9.5.) must be disclosed. The disclosure shall include a description of the action the proposer has taken or proposes to take to avoid, neutralize, or mitigate such conflict.

The Government intends to comply with procurement integrity statutes and regulation and DFARS 252.227-7016 in its treatment of information submitted in response to this BAA solicitation and marked with the individual or company's legend. The proposer is cautioned, however, that portions of the proposal may be subject to

release under terms of the Freedom of Information Act (FOIA), 5 U.S.C.552, as amended. In accordance with FOIA regulations, the proposer will be afforded the opportunity to comment on, or object to, the release of proposal information.

G.1.2 Subcontracting

Pursuant to Section 8(d) of the Small Business Act (15 U.S.C.637(d)), it is the policy of the Government to enable small business and small disadvantaged business concerns to be considered fairly as subcontractors to contractors performing work or rendering services as prime contractors or subcontractors under Government contracts, and to assure that prime contractors and subcontractors carry out this policy. Each proposer who submits a contract proposal and includes subcontractors is required to submit a subcontracting plan in accordance with the FAR 19.702(a) (1) and (2) with their proposal. The plan format is outlined in FAR 19.704.

G.2 VOLUME I - TECHNICAL PROPOSAL

Each technical proposal shall be limited to a total of 45 or fewer pages (including charts, figures and tables) as specified in ***Table 3*** below. Note that specific examples of problems, approaches, or goals are preferred to qualitative generalities in the technical proposal presentation.

Proposal format specifications include: 12 point or larger type, single-spaced, single-sided, and on 8.5 by 11 inch paper with 1 inch margins all around the page. All pages shall be numbered. The page limitation includes all attachments, etc. Pages in excess of the limitation will not be considered by the Government. (Foldout pages not greater than 11” x 17” may be used for the WBS, or to show detailed schedules and milestones. In these instances such foldouts will count as a single page only.)

Each proposal shall include the sections and items listed in ***Table 3*** and described below.

G.2.1 Cover Page

This should uniquely identify the offeror, including at least the following information:

- BAA number;
- Proposal title;
- Technical point of contact including: name, telephone number, electronic mail address, fax (if available) and mailing address;
- Administrative point of contact including: name, telephone number, electronic mail address, fax (if available) and mailing address; and
- Summary of the costs of the proposed research, including total base cost, estimates of base cost in each year of the effort, estimates of itemized options in each year of the effort, and cost sharing if relevant.

SECTION	PAGE LIMIT	TOPICS
Technical Proposal Cover Page	1	• Offeror identification, etc. See below.
Table of contents	2	• Proposal outline and page counts
Proposal roadmap	1	• Summary of key elements of the offer
Technical Approach	25	• Understanding of current state of the art and PANDA mission objectives • Soundness of technology approach and development plan for achieving PANDA goals • Understanding of metrics and approach to evaluating proposed technology • Potential for revolutionary advances in technology • Project and technology transfer plans and potential transformative impact on military operations
Program Management Plan	10	• SOW and WBS, and associated program schedules and milestones • Plan for ensuring continuing collaboration with technology developers, SEI, and PE during the course of program developments
Personnel and Corporate Experience	6	• Key Personnel • Related experience • Facilities • Security plan • Submission Handling/Rights in Technical Data and Computer Software/Patent Rights
Total	45	

Table 3. Summary of Required Technical Proposal Contents

G.2.2 Table of Contents

- The Table of Contents should, at a minimum, provide an index to all primary and secondary headings in the technical proposal.

G.2.3 Proposal Roadmap

This should summarize, preferably in bullet format, the major points and themes of the proposal, in terms of a) technical approach, b) program structure, and c) management plan.

If necessary, offerors should include any material contained in the PIP only by reference (e.g., [PIP E.2.3]), not by verbatim quotes nor by simple paraphrasing.

G.2.4 Technical Approach

This is the critical section of the proposal. Specific attention must be given to addressing both risk and payoff of the proposed work that make it desirable to DARPA. It must address the specific technical approach, technical rationale, and strategy for accomplishment of technical goals. Include comparisons with other ongoing research indicating both advantages and disadvantages of the proposed effort/approach. Include a discussion of design decisions made. Explain, with specific examples relevant to the PANDA program, the key technical ideas on which the program concept is based. Include at least:

- A **summary of available technologies** on which the proposed effort builds. The Offeror should describe the state of the art in the proposed technologies, their relationship to PANDA, and proposed advances needed to address the scope of the PANDA problem.
- **Key ideas** that will form the basis for progression to each program phase. Include specific examples illustrating how the ideas address crucial factors encountered in maintaining dynamic maritime situation awareness. Emphasize any experimental evidence, formal theories, performance analyses, or quantitative tradeoffs that lend weight to claims of predicted performance.
- The **approach** to accomplish the program technical objectives for each phase. For component technology developers, emphasize techniques such as repetitive behavior and continuous learning of parameters, pattern feature detection and rapid pattern learning, learning sequences and detecting pattern changes, context and higher level models, multiple hypothesis generation/evaluation, learning structured yet flexible representation and fast search of context, rapidly learning new cases, comparing individually processed cases and classifying those that are similar, and agent-based computing. For the SEI proposers, include a discussion of how you will work with the Technology Developers to achieve the overall technical objectives. For PE proposers, emphasize evaluation methodologies consistent with the likely technical approaches and addressing the unique features of the problem domain, including partial and overlapping data sets, multi-resolution data and learning, interdependency among entities, etc. Offerors should note that the goal of PANDA is not to develop new tracking capabilities; rather, the goal of PANDA is to leverage long-duration tracking and associated data to develop novel motion-based pattern learning and change detection capabilities.
- A discussion of the **system engineering and integration process**: systems analyses, functional analysis, requirements definition and management, interface definition, architecture definition and design analysis and trade studies, design and modeling efforts, interoperability, supportability and total ownership cost of

the end items delivered, integration, testing, verification and validation. For Technology Developers, include a discussion of how you will work with the SEI to support transition to a prototype operational system and with the PE to support assessing the progress of the project.

- **Experimentation and test plan**, both laboratory and fielded, to assess the rate of progress of technical capability over time. Describe the specific evaluations, metrics, methodology for deriving the metrics, and relevance to the technical and program goals. This discussion should go beyond the phases and evaluation criteria described in Section D.2.2 and provide detailed evaluation criteria and intermediate evaluation points to ensure success in achieving program goals. For Technology Developers and SEI proposers, include a discussion of how you will work with the PE to develop a coordinated experimentation and test plan. For PE proposers, provide a discussion of how you will work with the Technology Developers and SEI to develop and execute a successful and comprehensive evaluation plan.
- A discussion of tasks necessary to develop and integrate system components.
- Modeling and simulation approach, if proposed.

Note: The government is currently in ongoing discussions with one or more federal agencies to possibly provide experimentation support in the form of facilities, equipment, subject matter experts, experiment and simulation operations, experiment design and control, experiment data collection and analysis, and simulation modification. Please indicate options with and without government support. For example, providing a facility for experimentation at a contractor facility versus a government facility; provide computer workstations (hardware, software, and support) for experimentation at a contractor facility versus a government facility; etc. Please indicate as many options as possible. These options are to be priced in the Cost Proposal.

Proposals should include detailed descriptions of capability goals, performance goals, informal evaluations and formal evaluations for their individual modules and systems. These plans should include estimates of the amount and kind of data needed to conduct evaluation. These goals and evaluation plans will be reviewed and coordinated in program-wide meetings after program initiation.

G.2.5 Program Management Approach

This section should describe the tasks and resources offered to carry out the technical approach described, to include:

Statement of Work - In plain English, clearly define the technical tasks/subtasks to be performed, their durations, and dependencies among them. For each task/subtask, provide:

A short description of the objective of task;

A short description of the approach to be taken to the task;

Identification of which organization is responsible for task execution;

The resources allocated to each task (person-months and duration);

The exit criterion for each task - a product or event that defines its completion

- **Work Breakdown Schedule.**

Program Schedule - Provide a Gantt chart of the major activities and milestones for the proposed effort, aligned with the phases of the PANDA program. Indicate delivery of technologies in relationship to the integration and experimentation process.

Deliverables - Define deliverables associated with the proposed research, including necessary reports.

Cost Summary - Summarize the cost of the proposed effort as indicated by ***Table 4***. Funding levels have not been predetermined for this program. Therefore, cost proposals must reflect accurate estimates of staffing and other costs. For costing, assume a program start of 1 February 2006 with Phase I (Base) being 18 months, Phases II and III (Options) being 12 months each and Phase IV (Option) being 6 months. Note, the PANDA program will commence as quickly as contracts can be signed. PANDA plans to end four years after contract start.

	GFY 05													GFY 06												
BASE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Direct Labor - Dollars																										
Direct Labor - Hours																										
Travel																										
Equipment																										
Subcontractors																										
Other ODCs																										
Overhead																										
G&A																										
Fee/Profit																										
Total																										

Table 4. Summary of Funding

G.2.6 Personnel and Corporate Capabilities

Personnel - Provide cameos of the qualifications for each key person proposed for this effort. Describe their education, clearance level, work history, specific achievements relevant to the PANDA Program, and areas of expertise. Clearly state the portion of each person's time that will be dedicated to PANDA during Phase I. Do not include summaries for people who will spend less than 50% of their time on PANDA. Smaller teams of dedicated full-time developers are preferable to larger teams of part-time participants. If the expertise is resident in only 1-2 key personnel, the proposer should identify risk reduction measures in case of the loss of said personnel.

Related Experience - Provide short summaries of related work accomplished or in progress by any member of the proposer's team that offers technology or transition

potential for PANDA. Emphasize related projects on which proposed staff have worked, and indicate this fact when applicable.

Facilities - Describe corporate facilities that will be available to support this effort.

Security Plan - Describe the plan to place people into the secure experimentation facility during classified experiments and evaluations, and to process data collected and derived from those evaluations, when required.

Submission Handling/Rights in Technical Data and Computer Software/Patent Rights - General.

Noncommercial Items: (Technical Data and Computer Software) - Proposers responding to this BAA shall identify all noncommercial technical data, and noncommercial computer software that it plans to generate, develop, and/or deliver under any proposed award instrument in which the Government will acquire less than unlimited rights, and to assert specific restrictions on those deliverables. Proposers shall follow the format under DFARS 252.227-7017 for this stated purpose. In the event that proposers do not submit the list, the Government will assume that it automatically has "unlimited rights" to all software the proposer has produced under this contract. The Government may use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE."

Table 5 shows a sample format for complying with this request.

NONCOMMERCIAL			
Technical Data Computer Software To be Furnished With Restrictions	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(LIST)	(LIST)	(LIST)

Table 5. Noncommercial Items

Commercial Items: (Technical Data and Computer Software) - Proposers responding to this BAA shall identify all commercial technical data, and commercial computer software that may be embedded in any noncommercial deliverables contemplated under the research effort, along with any applicable restrictions on the Government's use of such commercial technical data and/or commercial computer software. In the event that proposers do not submit the list, the Government will assume that there are no restrictions on the Government's use of such commercial items. The Government may use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE."

Table 6 shows a sample list for complying with this request.

COMMERCIAL			
Technical Data Computer Software To be Furnished With Restrictions	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(LIST)	(LIST)	(LIST)

Table 6. Commercial List

Where the rights to any technical data/computer software are more restrictive than "Government Purpose Limited Rights" as defined by the FAR, provide a plan for mitigating the impediments such restrictions pose to transition to field users.

G.3 VOLUME II - COST PROPOSAL

The government is currently in ongoing discussions with one or more federal agencies to possibly provide experimentation support in the form of facilities, equipment, subject matter experts, experiment and simulation operations, experiment design and control, experiment data collection and analysis, and simulation modification. For Experimentation and Integration tasks, please provide cost options with and without government support. For example, provide facility costs for experimentation at a contractor facility versus a government facility; provide computer workstations costs (hardware, software, and sys admin support) for experimentation at a contractor facility versus a government facility; etc. Please cost out as many options as possible and do the cost analysis for each year, since government support may vary by year.

G.3.1 Cover Page

- Must include the words "Cost Proposal";
- Name and address of Proposer (include zip code);
- Name, title, and telephone number of Proposer's point of contact;
- Award instrument requested: cost-plus-fixed-fee (CPFF), cost-contract – no fee, cost sharing contract – no fee, or other type of procurement contract (specify), grant, agreement, or other award instrument;
- Place(s) and period(s) of performance;
- Funds requested from DARPA for the Base Effort, each option and the total proposed cost; and the amount of cost share (if any);
- Name, mailing address, telephone number and Point of Contact of the Proposers cognizant government administration office [i.e., Office of Naval Research (ONR)

- if requesting a grant, or Defense Contract Management Agency (DCMA) - if requesting other than a grant] (if known);

- Name, mailing address, telephone number, and Point of Contact of the Proposer's cognizant government audit agency [i.e.Department of Health and Human Services (DHHS) - if requesting a grant, or Defense Contract Audit Agency (DCAA) - if requesting other than a grant] (if known);
- Any Forward Pricing Rate Agreement, other such Approved Rate Information, or such other documentation that may assist in expediting negotiations (if available);
- Contractor and Government Entity (CAGE) Code;
- Dun and Bradstreet (DUN) Number;
- North American Industrial Classification System (NAICS) Number [NOTE: This was formerly the Standard Industrial Classification (SIC) Number];
- Taxpayer Identification Number (TIN); and
- All subcontractor proposal backup documentation to include above items, as is applicable and available.

G.3.2 Detailed Cost Breakdown

The detailed cost breakdown is to include:

- Total program cost broken down by months within a government fiscal year (GFY) [Note: Government Fiscal Year runs from October 1st to September 30th] and Base and Options; further broken down by major cost items (direct labor by category, subcontracts, materials, travel, other direct costs, overhead charges, etc.) (see ***Table 7*** below for an example format);
- For estimating purposes, proposers should assume a 1 February 2006 start date;
- Costs of major program tasks by year and month.(see ***Table 8*** below for an example format - also see FAR Part 15, Table 15-2 for suggested formats/content);
- An itemization of major options (labor by category, travel, materials and other direct costs) and equipment purchases by year and month;
- An itemization of major subcontracts (labor by category, travel, materials and other direct costs) and equipment purchases;
- A summary of projected funding requirements by month (see ***Table 8***); and
- The source, nature, and amount of any industry cost sharing, if applicable (Where the effort consists of multiple phases that could reasonably be partitioned for purposes of funding, these should be identified as options with separate cost estimates for each).

G.3.3 Supporting cost and pricing information

Provide supporting information in sufficient detail to substantiate the cost estimates above. Include a description of the method used to estimate costs and supporting documentation. Provide the basis of estimate for all proposed labor rates, indirect costs, overhead costs, other direct costs and materials, as applicable.

	GFY 05													GFY 06												
BASE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Direct Labor - Dollars																										
Direct Labor - Hours																										
Travel																										
Equipment																										
Subcontractor(s)																										
Sub 1*																										
Sub 2																										
Other ODCs																										
Overhead																										
G&A																										
Fee/Profit																										
Total																										

*Note: Futher breakout of cost elements (i.e., labor hours, labor dollars, travel, equipment, etc.) for each subcontractor is required.

Table 7. Example Detailed Cost Format

	GFY 05													GFY 06												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
BASE																										
OPTION 1																										
OPTION 2																										
Total																										

Table 8. Example Cost Summary Format

G.3.4 Conflict of Interest

This section should contain all affirmations relative to DARPA's Organizational Conflict of Interest requirements.