Network Centric Warfare Technological Research and Development Proposal

In Response to:
BAA N00421-01-R-0176

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Submitted to:
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Naval Air Warfare Center Aircraft Division
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Period of Performance:

Base Contract: 60 Months

Funding Requirements:

Base Contract: $48,000,000

Subcontractors:

University of Hawaii, Oceanit, ORINCON Hawaii, Inc., SOLIPSYS, Cambridge Research, SAIC, SYS, W R Systems, Ltd.

Special Requirements and Considerations:

Use and Disclosure:

1.0 Introduction

The Research Corporation of the University of Hawaii, 2800 Woodlawn Drive, Suite 200, Honolulu, Hawaii, 96822, a non-profit institution, is pleased to present this unsolicited proposal for the accomplishment of innovative technology products and services to the:

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION (NAWCAD, Code 2.5.1.4.1)
Bldg. 588, Suite 2
47253 Whalen Road
Aircraft Division
Patuxent River, MD. 20670-1463

This contract's period of performance is proposed for;
Fiscal years 2002 through 2006.

This proposal is submitted pursuant to Broad Area Announcement;
N00421-01-R-0176, SENSOR INTEGRATION AND COMMUNICATION TECHNOLOGIES

The estimated total funding for the period of performance is: 48,000,000.

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2.0 Background

The Research Corporation of the University of Hawaii (RCUH), in conjunction with the University of Hawaii, has provided, and continues to provide, major research and development initiatives for the Department of Defense (DoD). The accumulation of these research areas with the operational needs of Naval research can provide the operational forces with effective communications systems to enable meeting the goals of Vision 2010, total information dominance in the battlefield. The research corporation of the University of Hawaii represents a management and scientific team of personnel providing products and services to the MAUI High Performance Computing Center, the Pacific Missile Range Facility, and PACFLT, Hawaii. The collaboration of those current and future efforts, coupled with the research and development projects now in development, provides NAWCAD an opportunity to create effect-based research and development utilizing new technological advances, with direct application to DoD operational forces. The unique environment provided in the Mid-Pacific area provides an established operational test and training environment that includes service, joint, theatre and national missile defense assets for both rapid prototyping and analysis. The accomplishment of the tasks listed within this proposal are intended to utilize the resources of existing military facilities, including the Pacific Missile Range Facility, the Maui High Performance Computer Center, the University of Hawaii research laboratories, and the productive capacities of the companies designated below. The execution of this proposed contract will provide a mechanism and process to channel the University of Hawaii, relevant research and development grants; to support effect-based product lines for the DoD.

3.0 Team Capabilities and Expertise:

3.1 University of Hawaii/Research Corporation of the University of Hawaii

The Hawaii Center for Advanced Communications is currently embarking on a multidisciplinary approach to interdisciplinary research with a theme of high-performance wireless networks. The transmission technology for the networks will use millimeter-wave frequencies (30-300 GHz), which only recently have become practical for high data rate networks. It can provide transmission rates on the order of 5 gigabits per second, which is more than 100 times the T3 (45 Mbps) transmission rate. In fact, this rate is competitive with optical fiber transmission rates, which is currently the technology-of-choice to transmit large amounts of information. Millimeter-wave networks not only provide the necessary bandwidth for high bit rates and wideband modulation schemes, but the associated short wavelengths also imply small antenna and circuit size, resulting in more compact modules for mobile communications.

3.1.1 Research Areas

Millimeter-Wave Devices

High-performance electronic devices are a key enabling technology for today's wireless communication systems. In recent years a revolutionary new device technology---micro electromechanical (MEMS) systems---has emerged. Electronic and MEMS devices will both play a central role in tomorrow's wireless communication systems. Developing these high-performance devices is a major technical thrust of this proposal. Examples of current research include the investigation of surface passivation on the performance of GaAs and InP electronic devices, and the development of MEMS reconfigurable antennas and variable capacitors.

Millimeter-Wave Circuits

Recent advances in solid-state and MEMS technology has enabled compact, lightweight and reliable millimeter-wave circuits. To reduce transmission power losses, which are mainly due to conductor losses, the elegant technique of quasi optics has been proposed and is rapidly being developed. This approach integrates hundreds, possibly thousands, of solid-state devices to boost power, without the losses associated with more conventional combining techniques. We are currently developing quasi-optical amplifiers, oscillators, beam-steerers, switches, multipliers, mixers, and detectors. These are all necessary to realize a wireless network

Radio-Frequency Integrated Circuits

This work includes circuit design for giga-bit per second communications for radio frequency (RF) line-of-sight wireless communication. These channels, including both terrestrial and satellite, have many potential advantages over optical fiber counterparts. They can be deployed over a wide range of geographical areas; are flexible and can easily be expanded; allow rapid deployment in remote environments including military, disaster relief, and emergency medical applications; and finally, can act as a back-up for optical fiber-based networks.

Communications and Coding

As the demand for data integrity increases, the importance of error control coding in data transmission and data storage systems increases. Nowadays channel coding has become an integral part in almost every digital communication system and very sophisticated error control systems are being used to achieve reliable data transmission. One of the dramatic developments in bandwidth efficient communications over the past decade is the introduction and rapid applications of combined coding and bandwidth efficient modulation, known as coded

modulation, for error control. Recently, a new type of codes, referred to as "turbo codes" have been invented. These codes have received a great deal of attention over the past few years due to their drastic improvements in error performance over previous conventional coding techniques.

Signal Processing and Multi-user Detection

This work studies different signaling schemes for sending and receiving information streams in wireless environments. This involves using coding, modulation, equalization, and detection algorithms to transmit different sources of information. Code Division Multiple Access (CDMA) signaling schemes will be considered because of superior performance, advantages offered by signal processing, and security considerations. Most third generation wireless networks incorporate some form of CDMA. Because many of the transmitters and receivers are mobile and environmental conditions change, many of the algorithms that will be deployed will be adaptive.

Efficient Network Control and Management

The wireless environment provides unique challenges to reliable communication not commonly found in wire line networks. We study networks where nodes are mobile resulting in changing network topologies (ad-hoc networks). The ad-hoc networks must operate effectively in a wide range of different environmental conditions and terrain changes. The networks must also be able to transmit a variety of information sources over the mobile links. We address networking problems; communications systems design problems, and efficient transmission of multimedia traffic

Optical Communications

The Optical Communications Laboratory has research projects in three distinct areas: Dense Wavelength Diving Multiplexing, Optical Networking with Non-linear Optics, and Free-Space Laser Communication. One of the primary initiatives is to advance device applications and technology related to new concepts in laser sources, optical amplifiers, and optical detection systems, with direct applications in the telecommunications industry. Applications of these remote sensing technologies span from Biomedics to the Atmospheric Sciences.

3.2 Oceanit Corporate Summary

Oceanit's space and defense activities produce advanced sensing technologies for military and space applications to address existing and emerging threats. Oceanit provides added value to its customers by providing scientific and engineering services, including light manufacturing and prototyping. Oceanit has strong and growing capabilities in a number of emerging defense technologies of priority to national defense. Our West Kauai office has provided engineering and technical support, expanding technical research, development, test and evaluation (RDT&E), as well as emerging National Missile Defense (NMD) in association with the Navy's Pacific Missile Range Facility (PMRF) for 6 years. Oceanit collaborates with the Office of Naval Research to deliver technology that engages new and emerging sensor, signal processing and communications for Theater Air Missile Defense (TAMD) and other related missile defense requirements through our Advanced Sensor, Signal Processing and Communications Integrative Research, Science and Technology (ASSIST) Program. Past efforts included project Mountain Top (original DARPA Theater Missile Defense Program), as well as Mountain Top legacy programs including UHF Electronically Scanned Array (UESA) Navy Advanced Technology Demonstration (ATD). Oceanit's Advanced Space Systems group in Kihei, Maui is at the

forefront of space surveillance technologies with its continuing R&D and support roles at the Maui Space Surveillance Site and numerous research programs with the Air Force Research Laboratory (AFRL) and the National Aeronautics and Space Administration (NASA).

Oceanit Capabilities

High-bandwidth optical wave front sensor system supports both strategic and tactical airborne high-energy laser (HEL) applications. This specialized instrument is necessary for the correction of high-speed aero-optical aberrations that can compromise the integrity of out-going laser light. An airborne platform can experience compressible free shear layers, separated turbulent boundary layers, detached oblique shock waves, and engine-induced acoustic-optic disturbances, all of which can distort light at extremely high speeds.

Oceanit's advanced sensor technology has the bandwidth to capture and characterize these high-speed aberrations for eventual correction using adaptive optics.

The Physiological Monitor is a battlefield monitoring technology built directly into the litter material, and along with miniaturized electronics and wireless communications that provide instant and accurate vital-signs monitoring data to nurses and other caregivers without the need for attachments, electrodes, or cuffs. The completely passive system can measure a wounded soldier's physiological signal through layers of clothing and gear, including fragmentation armor and mission oriented protective posture (MOPP) suits for chemical and biological operation.

High Accuracy Networked-orbit Determination System (HANDS) is a low-cost solution to provide early detection and warning of missile and space launches. Because of the significance to national security, it is important to help protect these space-based assets. Oceanit/AFRL has shown that accurate (sub-arc second) angular observations, along with range (transponder) observations produce an improvement in orbit determination accuracy.

Office of Naval Research sponsors high-bandwidth communication antennas for the CEC/TCN, Tactical Components Network. Oceanit has developed and is manufacturing an advance phased array antenna for use on land, air, and sea vehicles, enabling data and voice transmissions at broadband speeds while being smaller and approximately 20 time lighter and less expensive than current antenna technology.

Other missile defense work includes experimental radar for PMRF, which is connected with the Navy Theater Wide program. One such program is the UESA system where we assisted with design, and development of two UESA subsystems.

3.3 ORINCON Hawaii

ORINCON is a technology leader in the design, development, and integration of Web-centric technology solutions and systems supporting the war fighter. ORINCON specializes in developing innovative rapid prototypes and transitioning prototypes into deliverable systems to support Pacific Fleet activities.

ORINCON has extensive experience in net-centric warfare, information management, data fusion, signal and image processing, network design and implementation, software development, rapid system prototyping, and integration and deployment of COTS-based systems for military customers.

ORINCON has the technical staff and equipment necessary to support technical work in close association with Pacific Fleet activities. Our technical staff has an ideal mix of engineers, hardware and software applications developers, operational specialists, and scientists to support any phase of development. The Kailua office has a Top Secret facility clearance, Secret storage

clearances, and utilizes STU-III telephones for secure communications. ORINCON meets all federal environmental laws and regulations as well as state and local government requirements.

3.4 SOLIPSYS

Solipsys Corporation is a small, high technology business specializing in products for defense application. Founded in 1996, and with primary headquarters in Laurel, Maryland, Solipsys has created products that reflect a unique combination of the best commercial practices and an in-depth understanding of the challenges facing the military services. Our primary corporate focus is the development of products designed to address the multi-faceted problem of Joint and Coalition Forces information networking.

Many of our information synthesis and visualization products are being used to meet the demands of test range operations. Supported by our corporate office in Kauai, Hawaii, the Pacific Missile Range Facility is employing Solipsys products to automate the daunting process of planning and executing complex, many-player range test events.

Engineering Analysis

Engineering analysis encompasses the whole suite of products offered by Solipsys. In 1996, the Tactical Component Network (TCN), an architectural framework for Solipsys' analysis and modeling team's work in information processing and distribution, detection, optimal estimation, non-linear filtering, signal processing, communications, and sensor and system performance, was merely a concept. After years of analysis and modeling, TCN has emerged an effective and desirable tool for military and commercial interests.

Information Synthesis

Solipsys is a leader in information flow and data synthesis concept designs for a number of high profile military efforts including the most advanced joint service information warfare and targeting coordination initiatives. The Tactical Component Network and the Multi Source Correlator Tracker (MSCT) represent two forms of information synthesis or data source integration: Collaborative information integration and Independent source integration. These two forms bring information together from diverse communication networks to create a common operational picture.

Networking and Portability

The development of object-oriented software components that communicate in a platform-independent fashion is a significant capability in today's network-centric world. The ability to reuse software across the most popular operating systems while keeping modifications to a bare minimum is also important when trying to reduce software development costs. The SoliNet toolkit allows the creation of applications that are transportable across platforms by isolating machine-specific functions within the networking structure rather than at the application level.

Solipsys Corporation has extensive capability in the development of sensor data processing systems and has a number of products that perform this function at various levels of integration.

Solipsys has developed a concept for netting sensor data from non-collocated sensors to form a single integrated picture. This concept, the Tactical Component Network, develops the single integrated picture in an efficient manner and takes full advantage of the sensor geographic diversity and accuracy attributes.

The Exercise Scenario Planning and Real-time Integrated Test (ESPRIT) product accepts sensor data from the test range sensors, processes this data, and compares the data to the exercise plan in real time. This provides for the real-time assessment of test event performance and contingency re-planning.

3.5 Cambridge Research Associates

Cambridge Research Associates, Inc. (CRA) was formed in 1987, and is headquartered in McLean, Virginia. CRA has become one of the premier high technology research and development firms focusing primarily on the leading edge of defense related technologies in a variety of disciplines.

The diverse activities of CRA and its affiliates are orchestrated by The Cambridge Technology Group. CRA has developed in-depth expertise and strong performance records in Systems Engineering, Computer Imaging, Visual Simulation, Digital Cartography, Photogrammetry, Parallel Computing, Operational Modeling and Analysis, Process Modeling and System Simulation, and Software Engineering.

CRA has developed a strong following in the Defense Department and is currently under continuing contracts to support the Navy, Air Force, Army, JCS, Office of the Secretary of Defense, NIMA (National Imagery and Mapping Agency) and the JSF (Joint Strike Fighter Program). Recently, CRA's modeling capabilities have produced a three-dimensional Integrated Response Surface Model, which is being used by the JSF to interactively and dynamically consider cost, lethality, survivability and supportability trade-offs in the engineering and design phases of the next generation of fighter aircraft.

Among CRA's accomplishments is the development and deployment of PowerScene and PowerScene equipped systems. PowerScene is a portable software architecture, which accepts raw digital image data from a variety of sources (e.g. satellites, aerial photography, radar, etc.) and presents that imagery in a manner that greatly enhances mission planning, aircrew training, and intelligence analysis and battle space visualization. PowerScene takes a vertical "bird's-eye" view of the earth's surface and translates that view into a horizontal perspective, enabling a flight experience, which is astoundingly true to life.

3.6 SAIC

Founded by a small group of scientists in 1969, SAIC, a Fortune 500 company, now ranks as the largest employee-owned research and engineering firm in the nation. SAIC and its subsidiaries have more than 41,000 employees with offices in over 150 cities worldwide.

Our information systems and technology solutions are helping speed and improve service delivery and giving decision makers better information to make decisions. Our next generation networks are helping clients create new markets in converged voice, video, and data services. Our e-business solutions are creating unprecedented collaboration and efficiency throughout complex value chains. Our wireless solutions are opening up new communications with remote areas faster and better than ever before. SAIC is also a portal to advanced technologies. We provide access to the latest technologies developed by a host of organizations worldwide, including our own world-class research organizations. We bring more than three decades of experience making new technologies succeed in real-world, real-time business. For most of our clients, the right solution provides quick, secure access to the right information from anywhere within the organization to anywhere in the world — and that calls for systems integration.

Hyper spectral Image Processing

Aerial views of the earth's surface have intrigued people since the first experiments in aerial photography occurred from US Civil War surveillance balloons. Since then, "remote sensing" has evolved to include a vast array of sophisticated instruments collecting information from both aircraft and satellites. One relatively recent advance in remote sensing is spectral imaging, which involves acquiring images at multiple electromagnetic wavelengths simultaneously. The

wavelength information can be interpreted as spectral "signatures" of materials on the ground, allowing analysts to identify them remotely.

Simulated Environments

SAIC's success in the field of simulation technology is not only helping to maintain superior U.S. troop readiness, but also helping to keep costs in line with budgets. As a result, other non-military organizations are turning to SAIC to utilize similar technology to train personnel as well.

As an example, SAIC is providing simulated environments to train both first responders and Civil Support Teams (CST) throughout the U.S. Using the Virtual Emergency Response Training System (VERTS), emergency response personnel can experience the entire process that traditional training offers, but without the expense of in-the-field exercises. In the VERTS simulated environment, first responders and CST teams learn how to properly handle a variety of threats or simulated events including: weapons of mass destruction, nuclear, biological or chemical, and hazard or toxic material spills. VERT is designed to focus on training individuals or teams and a variety of specialty professions that will ensure that all domestic preparedness issues are addressed. The system supports METLs (Mission Essential Task Lists) and Battle Tasks in Medical Risk Management.

Supercomputing

Complex systems – power grid operations, sophisticated engineering design, 3-D visualizations of comprehensive strata graphical data, the dynamics of urban infrastructures – all call for highly complex modeling and simulation programs. These types of programs require the advanced computational capabilities of supercomputing. To provide our clients with the latest high-level modeling, simulation and advanced systems integration programs, SAIC accepted the challenge of creating the kind of software research platform primarily developed in universities and government labs – a unique effort for a commercial company.

SAIC's answer to this need, the Cluster Computer, exemplifies the type of technological innovations we apply across a broad spectrum of areas to help clients reduce costs and add value

Extremely rapid computation is crucial to complex simulations. SAIC has run tests that show the Cluster Computer is capable of reaching speeds of 6-12 billion floating point operations a second. These high speeds can be realized because the Cluster Computer's configuration synchronizes computation, communication, and the speed at which data flows on the network connecting the cluster.

3.7 SYS

SYS provides a strong technical engineering staff in support of Department of the Navy programs, ensuring they'll meet the needs of tomorrow's war fighters. In today's world of rapidly emerging technological advances, SYS engineers are supporting the Office of Naval Research (ONR), the Naval Sea Systems Command (NAVSEA), the Naval Air Systems Command (NAVAIR), and the Space and Naval Warfare Command (SPAWAR) in their efforts to bring new technology and capabilities to the Fleet. Among its many accomplishments is the development of Top-Sight, a Theater Assessment Profiling System recently used in the Naval War College's Global War Game 2001, and at the Joint Warfighting Experimentation Battle Lab for Millennium Challenge 02. Top-Sight also provides project management applications that support the Advanced Distributed Learning Network, Regional Engagement Network, and the PACOM Support Center.

SYS is currently assisting the Office of Naval Research and the Program Executive Office-Theater Surface Combatants (PEO-TSC) to assess new technologies in support of the Network-Centric Warfare capabilities that will be required by tomorrow's soldiers, sailors, and marines. In support of these systems, as well as several others, SYS provides a wealth of shipboard combat system, modeling and simulation (M&S), training system, and system integration expertise to support the development, testing, and training associated with the technological advances of these new technologies.

In concert with its strong technical team, is a cadre of financial and program management support professionals providing NAVSEA with unprecedented levels of support for the acquisition and fielding of the hardware and software so vital to the needs of the Fleet. These efforts range from resource and program management, budget formulation input, procurement, financial monitoring and tracking, spreadsheet development and analysis, and preparation, monitoring and maintenance of budgets, spend plans, and expenditures of appropriated funds (SCN, O&MN, OPN, RDT&E and FMS). SYS personnel are expert in the monitoring and execution of budgets for major programs, as well as handling the Foreign Military Sales for AEGIS.

3.8 W R Systems, Ltd.

Incorporated in the State of New York in 1983, W R Systems, Ltd. (WRS) provides state-of the-art Engineering Design and Maintenance Services. Our combined expertise in real-time software and embedded systems plus our hardware design, maintenance, testing and integration capabilities enables us to offer a unique range of services. In addition to our current headquarters in Fairfax, VA, our Small, Minority-Owned business maintains offices in Arlington, Norfolk, and Richmond, VA. A recent graduate of the Small Business Administration's 8(a) program, WRS has doubled in size in the last three years. WRS enjoys a number of technology partnerships and professional affiliations with a variety of organizations Old Dominion University, and the Institute of Navigation. It is also a board and charter member of the Virginia Modeling, Analysis, and Simulation Center (VMASC).

WRS' Technical Service Group offers expert solutions for Navigation Systems, Fire Control Systems, Radar Data Distribution Signals, and Information Technology Support for the US Navy and other government agencies.

WRS' Information Technology Division (ITD) specializes in providing innovative technology solutions in software and Internet database applications development. Its software development methodologies and processes are assessed at SEI CMM Level 3.

WRS' Engineering Services Division (ESD) provides system engineering, technical, and professional program management support services for navigation, guidance, and sensor data systems. Our navigation subject matter experts are widely recognized for their pre-eminence in this field. Our staff offers expertise in the areas of modeling and simulation, digital nautical charting, prototype development, and wireless/RF design. This division currently maintains five in-house laboratories used to conduct numerous aspects of electrical and mechanical engineering, including electronic circuit design, equipment simulation, microminiature testing and repair, and system/equipment testing and integration.

4.0 Overview of Proposed Work

4.1 New Operational Concepts.

Development efforts will be primarily in the areas of concept development (theory to demo), exploratory and prototype development, technology demonstrations, data assimilation and exploitation, and software development data assimilation and exploitation.

Intelligence, Surveillance, Reconnaissance (ISR), and Space Exploitation

ISR and Space Exploitation involve the collection, processing, integration, analysis, categorization, evaluation, and interpretation of available information for intelligence, surveillance and reconnaissance means. Implicit are the development of sensors and processing capability for real time, high resolution imagery/data leading to the capability for target identification and recognition, BDA, sensor-to-shooter transfer of data, and remote sensing of battle space environments, all of which lead to real-time situational awareness of the battle space. More specifically, this Focus Area further involves the following areas:

Remote/Space Sensing; Advancements in; Electromagnetic Scatter, emission, propagation; data assimilation; active/passive phenomenology; Microwave properties affected by environment; Geophysical forcing of ocean/ice/terrestrial; Space sensing effects of atmosphere; Ionosphere specification provide the basis for future Hyper spectral remote sensing..

Space/Airborne Sensor Development Hyper spectral remote sensing and space sensor developments combined with ionosphere bounce imaging and radar systems are technologies requiring inclusion in the identification of targets. Image processing techniques are fundamental to the missile defense challenge of discriminating the reentry target.

Sensor Exploitation and Demonstration [Measurements and Signatures Intelligence (MASINT)] products. This effort includes the integration of; assimilating models; Precision Time/Time Interval/Astrometry; Global Positioning System networks for remote sensing; Situational awareness; Clandestine reconnaissance; Signal processing and data fusion with objectives to provide clandestine intelligence preparation of the battle space beyond imagery products. This field of technological advancement will provide the military the needed intelligence information to engage an enemy in special operation warfare, that is the initial invasion of hostile areas dependent on singular intelligence information of small unit movements.

Technological advancement in signal and acoustic Processing and image analysis utilizing advanced parallel computational processes. The advancement in aperture transmission rates and signal to noise performance measures also requires the computational processes to provide signal processing of the information received relative to the data thru put of the apertures. Advancements in this area are now a part of the RCUH team and will be a part of technological advancements with benefit to the war fighter in achieving total information dominance. Joint operations require increased nodes operating autonomously dependent on command and control data collaboration, this can be achieved through signal and acoustic processing technological advances.

Technology insertion to meet evolving Expeditionary warfare, and Missile defense requirements in the 21st century including total information dominance utilization through command and control systems, knowledge walls and their multi utilization for tactical and humanitarian relief needs.

Battle Space Environments (BSE)

Battle Space Environments involves observing, modeling, and predicting both small and large-scale processes in the air, ocean, and shore environments. The war fighter needs an

affordable, reliable operational capability in all environments and the ability to foresee environmental changes that may affect his capabilities. Knowledge of the battle space environment and its impact on the various sensors available to the war fighter is critical to the choice of sensor(s), ability to gain knowledge of the tactical battle space, and effective delivery of weapons.

The focus of Battle Space Environments S&T developments are on improving the Navy and Marine Corp's understanding of environmental evolution, the assimilation of data, and the limits of predictability. It contains the traditional oceanographic and meteorological disciplines and encompasses the following areas:

Environmental Processes, to include environmental processes and phenomena Sensors/Data efforts to develop new or enhance existing shipboard, in-situ, airborne, and space borne sensors and appropriate inversion techniques and data handling techniques to obtain/store/manage environmental data for use in the tactical decision making of employing military resources.

Model Development, including empirical and numerical model development techniques and associated efforts designed to diagnose problems and increase the efficiency and accuracy of those models and model systems in a variety of computational environments; Data Assimilation and Information Exploitation, encompassing developing new/improving existing techniques to utilize (e.g. data fusion, data assimilation, model initialization, signal processing) or exploit (e.g. decision aid products, expert systems) environmental data and create environmental information; and Validation Studies, including field efforts or use of field-collected data designed to ground-truth or check reality and validity of previously developed and exercised analytical, numerical, and empirical models or sensors.

4.2 Technologies that advance the state-of-the art in performance and suitability of theatre-wide tactical sensor integration and communications.

The following telecommunications research and development projects include networking techniques and wireless communication alternatives to be utilized in the Joint Composite Tracking Network environment.

Sensor Networking. Real Time Sensor Networking examines adaptive linear and nonlinear receivers. Nonlinear decision feedback receivers have received much attention as they have superior performance compared to linear receivers such as the decorrelator receiver and the linear minimum mean squared (MMSE) receiver. We will examine a different class of receiver based on using kernel functions. Examples of kernel function receivers include the Support Vector Machine. Another class of receiver that will be studied is based on blind source separation algorithms where adaptive algorithms can be run without training sequences. A variety of algorithms will be examined including minimum output energy algorithms, signal subspace algorithms, algorithms based on independent component analysis, and nonlinear blind algorithms based on kernel functions. These algorithms will also be tested in conjunction with networking algorithms for overall performance increases for sensor networks.

Millimeter Wave Devices This effort focuses on networks based on the millimeter-wave technology, but at transmission rates exceeding one gigabit per second. Using frequency division multiplexing (FDM) and asynchronous transfer mode (ATM), a large number of users will each be provided with a mobile, high-speed, large-bandwidth link. The network will support a large number of applications including personal communications, wireless Internet, local high-definition images and global satellite communications. Other issues that will be addressed include examining future broadband networking applications, networking

management, interoperability, transparency, security, survivability, and reconfigurability. This effort also includes examination of efficient coding and modulation schemes, effective source coding algorithms for different applications, novel signal processing methods to reduce the effects of interference, high-speed integrated circuit design and implementation, and software integration and simulation. This effort has major capability advancements for the war fighter in permitting long range over the horizon network communications for information dominance.

Integrated Circuits. This area involves the investigation of signal processing partitioning and the development of integrated circuits utilizing various IC technologies including InP, GaAs, and silicon to implement highly-integrated portable modems for giga-bit per second throughput over wireless RF terrestrial and satellite channels. A focus of this research is the development of circuit approaches to implement the IF-to-base band processing in the analog domain. An analog solution can potentially result in much lower power consumption than a digital implementation. BPSK and QPSK receiver structures will be examined and methods to maximize integration and minimize power consumption will be studied. A goal of the work is to develop a prototype link including RF, IF, base band, and error control functions with a throughput on the order of a giga-bit per second and a bit-error rate (BER) on the order of 10-12.

Communications and Coding Techniques. New promising methods are being developed for introducing turbo codes in state-of-the-art high-speed communication systems in general, and in particular wireless communication systems. Moreover, the combination of the turbo code principle with bandwidth efficient coding should allow for the design of very high-speed modems. These small modems allow the individual soldier the ability to be an effective node in any expeditionary warfare scenario.

Network Control and Management. Network control will be distributed resulting in peer-to-peer architectures that are self-organizing and have adaptive capabilities. The ad-hoc networks require new forms of network protocols and management. The mobile and changing environments require accurate channel propagation models. Satellite navigation systems such as the Global Positioning System (GPS) can be used to locate the devices. The ad-hoc networks have several characteristics that must be dealt with including: dynamic network topologies, variable capacity links, battery constraints, and security. Network routing algorithms must be simple, have the ability to adapt to the rapidly changing network topologies, and seamlessly interconnect to other communication networks. Algorithms must be simple and robust. Examination of a variety of algorithms from traditional packet radio network algorithms to algorithms formulated by the Mobile Ad hoc Networking (MANET) working group will provide advancements for the increased demands of expanding networks. Additionally Quality of Service (QoS) guarantees including end-to-end data throughput and delay, routing acquisition time, and network efficiency are analyzed to provide complexity versus performance tradeoffs for implementation in military systems.

Spectral imaging: A spectral image applies to any location on the ground; the measurements of all the simultaneously acquired images are combined to form a "spectrum," whose bumps and wiggles are indicative of different materials. Hyper spectral imaging (HSI) contains far more spectral information than previous MSI systems, making it much more information-rich but also much more difficult to process and analyze. HSI has the potential to transform military operations and support. However, man-hours involved in processing and analyzing HSI data can be excessive, often requiring custom software and in many cases cost-prohibitive expert labor. Information from HSI is readily available, and can expedite critical decision-making processes. Automatic processes determine the sub pixel proportions of materials in an HSI dataset and

transform the data into readily interpretable information layers that can be imported into a geographical information system (GIS) database. On a typical HSI data set the time and effort required from two to four days of an experienced analyst's time down to approximately 30 minutes of automated processing. Applications of hyper spectral imaging data can support a diverse range of scientific and military operations.

Multi sensor correlator tracker techniques: Leading to the age of total Joint military operations a continuing challenge is to provide one single integrated tactical picture derived from various autonomous sensors both active and passive. The recent advancements made with the introduction of the Tactical Component Network are an area for increased developmental work to accomplish integration of future and legacy sensors. The development and the development techniques for sensor integration through servers provide an opportunity to produce the military industrial complex tools and techniques for server development and consistency in the level of data provided to the network. The integration techniques for space and airborne sensors and their inherent time latencies will be investigated, prototyped and tested utilizing both test and operational platforms.

4.3 Systems Integration and Demonstration Testing.

Mid-Pacific Integrated sensor network. Establishment of an integrated sensor network in the Mid-pacific region to accomplish technological advances in space object tracking, target discrimination and identification are realizable through the integration of the product line in this proposal. The Ballistic Missile Defense Office initiatives to conduct major test and training events in the mid-pacific range requires and information and sensor communications network spanning from the Aleutian chain to the islands of the south pacific. The installation of the required communications infrastructure will require advancements not only in the component level but also at the systems integration and collaboration level. Application of the technologies to be explored, as defined above and that which is the basis for the synthetic range below are applicable also to the establishment of this new department of defense resource. The RCUH consortium proposes to provide its systems integration knowledge base to the solutions and implementation of this new Pacific range resource.

PMRF Radar Test bed Development. The Cooperative Engagement Capability test bed established at the PMRF revealed the obvious multi-purpose advantage of the mountaintop test environment. Use of this facility to provide an uninhibited test range capability for an unrestricted airspace provides the Navy with unlimited application of active RF sensor testing capability. The major challenge of providing new phased array radars, new UHF radars, or new spectral sensors is the integration and test of the new sensor in a live environment providing the proper fade zones, clutter and interference from other RF sources. Additionally the challenge requires integrating the sensor into a network of sensors thus providing one consolidated track representation or image. The PMRF sensor and Radar test bed provides the Navy a resource to exploit for future advancements in RF technology. Advancements in the PMRF communications infrastructure combined with the integration of the MHPCC will only increase the capability already existent at the current PMRF radar test bed.

Synthetic Range. The synthetic range program is a proof of concept to augment the US Navy's Pacific Missile Range Facility Barking Sands (PMRF) with Department of Defense simulation and super computer technologies. The goal is to provide tools for PMRF to provide more effective training and test environment for both the operational and test and development agencies, which use the range. The use of modeling and simulation has been proven cost effective and deterministic in the Navy's use of the Battle Force Tactical Trainer in operational

platforms. Based on the technology of injecting simulated tracks at the RF level of active sensors the BFTT has achieved a total battle group training capability. The application of this technology to forces operating in the PMRF area, coupled with high fidelity models generated at the MHPCC will provide an excellent environment in which to conduct developmental and operational tests while recording the exchange of information for further analysis. The use of high fidelity models of threats, either air, sea, undersea, land or space can be accomplished using the library of models developed under the Defense Modeling and Simulation Office for the Synthetic Theatre of War demonstrations. The PMRF synthetic range is then a development of the communications infrastructure among the Hawaiian islands, the computational processes and data mining necessary to operate and stimulate the environment and a network of sensors and test facility resources. The application of the Test and Evaluation Network Architecture (TENA) for Range resource networking combined with the sensor networking of TCN, combined with the new telecommunications techniques provided above will provide NAWCAD a undisputed national resource for test and training for application to programs from missile defense to individual soldiers in the expeditionary or special operations theatre of war.

The Synthetic Theater of War with Joint Semi-Automated Forces

In September of 1997 the Synthetic Theater of War (STOW) simulated the first 48 hours of the United Endeavor 98-1 Exercise for U.S. Atlantic Command (USACOM). In doing so STOW fielded the largest High Level Architecture (HLA) federation and demonstrated a long list of technological firsts. A major milestone in the Defense Advanced Research Projects Agency's (DARPA) quest to create a common joint synthetic battle space that could address Department of Defense (DoD) simulation needs in training, research, analysis, and evaluation. As DoD's first Advanced Concepts Technology Demonstration (ACTD), STOW created a complete joint synthetic battle space for USACOM. It was a simulated battlefield with far more scope and detail than had ever before been demonstrated.

Training with JointSAF

Standards like Distributed Interactive Simulation (DIS) specify how different simulators can express a common view of the simulated world. If different simulations have different syntaxes it is usually fairly easy to write a translator or gateway that can convert one syntax into another. This is the initial approach that will be taken to provide a realistic training environment to the war fighter. Initially, distributed simulation control stations, operating via a gateway and running JointSAF, will be utilized to provide the synthetic battle space to Modular Command Center (MCC) and Battle Force Tactical Training equipped ships connected via a local area network (LAN), as well as to the Pacific Missile Range Facility (PMRF). The Maui High Performance Computing Center (MHPCC) will be utilized to provide the atmospheric and oceanographic conditions to the battle space.

The Naval Training MetaFOM Working Group is in the process of defining a common standard for various Navy and Marine Corps trainers to simultaneously interface among the multiple disparate systems to provide a common battle space in which to conduct training. This standard will be implemented in follow-on efforts to remove the requirement for a DIS/JSAF gateway to be utilized. In addition, it will provide the mechanism to integrate additional new virtual training systems (small arms trainers, aircraft trainers, etc.) and equipment with the synthetic environment provided by JointSAF. Alternative forms of connectivity will also be investigated to free the training systems from the requirement to be connected via land-based networks.

5.0 Program Management

The Research Corporation of the University of Hawaii, in collaboration with its partners, shall undertake and accomplish all efforts required to effectively plan, organize, direct, monitor, and report on the tasks described in Section 4.0 of this SOW. The Contractor shall appoint a Program Manager who shall have overall program management responsibility and authority. The Program Manager shall report directly to the Contractor's Director. The Program Manager shall maintain a close working relationship with NAWCAD and with on-site and off-site personnel as appropriate. Face-to-face, telephone, e-mail, and other communications modes shall be used as required. The Program Manager shall support and encourage direct discussion and interfaces between the Contractor and Customer personnel as required. The Program Manager, along with the Project Leader, shall support close liaison with program related organizations. The Contractor shall host and or support regular meetings, and encourage regular dialogue, with program related organizations. The Contractor shall accomplish financial management of program funds. Monthly status reports covering the financial, as well as technical, progress and plans of the program shall be delivered to the customer by the last working day of each month. Program technical progress and plans shall be included in the monthly status reports.

RCUH Advanced Technology Development Program Plan

	FY02	FY03	FY04	FY05	FY06	TOTAL
1. New Operational Concepts						**8.1**
a) ISR & Space Exploitation			200K		200K	
b.) Remote & Space Sensing			300K		300K	
c.) Sensor Exploitation	1M	1.5M				
d.) Signal & Acoustic Processing	1.5M	2M				
e.) Battle Space Environments	300K	300K	200K	300K		
2. Sensor Integration & Communications						**9.3**
a.) Sensor Networking/MSCT	500K					
b.) Millimeter Wave Devices	300K					
c.) Integrated Circuits& Spectral Imaging			1.5M	2M		
d.) Network Control&Collaboration Tools		1M	2.5M	1.5M		
3. Systems Integration & Demo. Testing	500K					**30.2**
a.) Mid-Pacific Integrated sensor network	1M	1.5M	2.5M	2M	3M	
b.) PMRF Radar Test Bed Development	300K	300K	300K			
c.) Synthetic Range	1M	3M	3.5 M	3.5M	3M	
d.) STOW with Joint Semi-Automated Forces			300K	2M	3M	
TOTAL	**5.9M**	**9.6M**	**11.3M**	**11.3M**	**9.5M**	**47.6M**