

MASTER OF SCIENCE IN SPACE SYSTEMS OPERATIONS

CHANGE DETECTION ANALYSIS WITH SPECTRAL THERMAL IMAGERY

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Spectral imagery offers additional information about a scene that can enhance an analyst's ability to conduct change detection. Change detection is required to automate the process of sifting through countless images to identify scenes that have significant intelligence value. Change detection in spectral thermal imagery enables exploitation at night by taking advantage of the emissive characteristics of the scene. Data collected from the Spatially Enhanced Broadband Array Spectrograph System (SEBASS) were used to investigate the feasibility of spectral thermal change detection in the long wave infrared (LWIR) region. This study used analysis techniques such as differencing, histograms, and principal components analysis to detect spectral changes and investigate the utility of spectral change detection. Many undesirable characteristics exist that influence the sensitivity of change detection methods. Temperature dependence and gross registration errors greatly affect an analyst's ability to make use of spectral thermal data for change detection; however, with effort, spectral changes were still detected with these data and suggest that the techniques would be useful once the undesirable characteristics are minimized.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Remote Sensing, Hyperspectral, Digital Imagery Analysis, Change Detection, SEBASS, CARD SHARP, Camp Pendleton

MARITIME SITUATIONAL AWARENESS: DEDICATION OF THE ON-BOARD PROCESSOR FOR A SPACE-BASED SOLUTION (U)

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Maritime Situational Awareness (MSA) is a vital component of the intelligence picture for any at-sea commander. At present, Maritime Situational Awareness requires the synthesis of various intelligence sources in a laborious, semi-automated process. If realigned, an existing national system may provide improved, automated delivery of near real time situational data to a tactical user. Implementation of experimental components of the national system may optimize intelligence collection of commercial vessels. This thesis summarizes the intelligence sources that contribute to maritime situational awareness today. A detailed description of the national system's experimental capability is presented. An experiment carried out at the Naval Postgraduate School provided data for analysis and conclusions regarding future system applications. Experiment design, methods, and results are included. For the purposes of discussion,

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the thesis presents a new Concept of Operations for a national system. Advantages and disadvantages discussion addresses the re-allocation of the system's assets. Of primary concern is how realignment would impact the tactical and national users of national intelligence products. Final recommendations suggest ways in which the national system might be applied for improved Maritime Situational Awareness.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronic Warfare, Sensors

KEYWORDS: Maritime Situational Awareness, On-Board Processor, Maritime Navigational Radar, Ship Tracking

THE RUSSIAN FEDERATION AND THE INTERNATIONAL SPACE STATION: LEVERAGING RUSSIAN SPACE STRENGTHS TO CONTROL ITS MISSILE TECHNOLOGY PROLIFERATION

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In an effort to stop the old Soviet space program from plunging into a cataclysmic spiral of illicit foreign sales of its ballistic missile technology, and also to prevent the Russian space infrastructure from imploding, the United States entered into a series of bilateral and multi-national agreements to work with, and to support the inheritor of the Soviet space legacy, the Russian Space Agency. This thesis discusses how a partnership with the Russian Federation and Russian Space Agency within the International Space Station can both act as an incentive for the Russians to prevent illicit proliferation of its space and ballistic missile technology and offer unique, viable operational, technical, and scientific advantages for the International Space Station and the United States. Alternative options to, and limits on, a partnership with Russia are also presented and discussed.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Aerospace Propulsion and Power, Other (International Space Station, Ballistic Missile Technology Proliferation)

KEYWORDS: Ballistic Missile Technology Proliferation, Russian Space Agency, Missile Technology Control Regime

CONSIDERATIONS OF THE TACTICAL REAL-TIME TARGETING SYSTEM (TARTS) SUPPORT TO INTELLIGENCE OPERATIONS (U)

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The next generation of Navy Surface Combatant has been deemed the Land Attack Destroyer (DD 21) and its Land Attack mission requires an all-source data fusion and exploitation effort to execute targeting in near real-time. The Navy's answer to this data fusion and exploitation effort is the Tactical Real-time Targeting System (TARTS). TARTS, an integration of advanced antenna and processing technology, delivers data from national and tactical sensors to enable targeting solutions. The intelligence and targeting cycles are the processes which transform this data into a targeting solution. This thesis explores the utility and effectiveness of the Tactical Real-time Targeting System as an intelligence tool to execute targeting.

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The exploration will also explore organizational and operational considerations involved with the introduction of this technical capability.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Space Vehicles, Command, Control and Communications, Human Systems Interface, Manpower, Personnel, and Training, Sensors

KEYWORDS: Intelligence Cycle, Targeting Cycle, Command and Control, Fusion

LASER REFERENCE BEACON CONCEPT OF OPERATIONS (U)

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The Laser Reference Beacon program is a Navy TENCAP (N632) initiative to improve the geolocation precision of the Space-based Warning System (SBWS) through the removal of sensor bias-errors and thereby improve Joint Theater Ballistic Missile Defense (TBMD) operational effectiveness and support to the warfighter.

The thesis explores many of the key operational issues relating to the employment of the system (Beacon Effectiveness, Standoff Distance, Operational Availability, "Cost" to Warfighter) and discusses the range of employment options. A more complete concept of operations (CONOPS) is proposed that details the process and sequence of actions necessary to operate the system and the organizational support that must be created. A general Operational Test Plan (OTP) outline is included to illustrate the operational effectiveness and suitability issues that must be considered during follow-on development phases.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors

KEYWORDS: Laser Reference Beacon, Concept of Operations (CONOPS), Bias-Error Correction, Theater Ballistic Missile Defense (TBMD), Space-based Warning System (SBWS), Operational Test Plan (OTP)

MODELING AND SIMULATION OF A GLOBAL BROADCAST SERVICE REACH BACK ARCHITECTURE FOR INFORMATION DISSEMINATION MANAGEMENT

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The Global Broadcast Service utilizes commercial direct broadcast satellite technology tailored specifically for military application. With this service, the military directly addresses oversubscribed communication paths and introduces a quantum leap in information dissemination. However, the potential for information overload comes with the ability of this service to readily deliver multi-megabit per second data. Therefore, to make the Global Broadcast Service a value-added addition to command and control, an information management process must be developed concurrently.

This project builds a Global Broadcast Service model (using Extend™) to provide a tool to analyze information dissemination management. Recent technologies such as asymmetric networking and automated radio frequency management are integrated into the model. In this thesis, asymmetric networking is equated to Global Broadcast Service "reach back," and automated radio frequency

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management is equated to the functionality of the “Automated Digital Network System.” Using a simulation, an initial analysis of various reach back channels is provided. The resulting model and analysis serve as a foundation for future process development for Global Broadcast Service Information Dissemination Management.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Space Systems Operations, Information Systems)

KEYWORDS: Asymmetric Networking, Automated Digital Network System, ADNS, Extend™, Global Broadcast Service, GBS, Information Dissemination Management, IDM, Integrated Broadcast Service, IBS, Modeling, M&S, MILSATCOM, Reach Back, Satellite Communications, SATCOM, Simulation, Smart Push, User Pull

MULTISENSOR FUSION AND THE MARITIME SITUATIONAL AWARENESS PICTURE (U)

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Achieving maritime situational awareness means providing the battlespace commander a true fused real-time representation of his area of operations to include friendly and enemy force disposition - something commanding officers have been long tasked with comprehending, yet lacked complete information to do so. Multisensor data fusion deals with the issue of combining data from multiple sensors in order to make inferences about a physical entity or situation where those inferences may not be possible or accurate with a single sensor alone. This thesis looks at the creation and experimentation of an architecture composed of several different sensor inputs which will heighten the at-sea commander’s maritime situational awareness in terms of the merchant shipping tactical picture. A major focus is the development of a “center of excellence” or central fusion facility that will act as the blueprint for all future fusion efforts. This central fusion facility will take the lead in the creation of a system that upon completion will be responsive enough to support worldwide merchant ship tracking requirements. Additionally, this technology will be exportable to other fusion efforts.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Battlespace Environments, Command, Control and Communications, Sensors

KEYWORDS: Maritime Situational Awareness, Multisensor Data Fusion, Merchant Ship Tracking

AN OPERATIONAL UTILITY ANALYSIS OF THE TACTICAL REAL TIME TARGETING SYSTEM (U)

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Military victories are often decided based on the quality and amount of information available and utilized by force commanders. Tomorrow’s battles will require ever-increasing amounts of information acquired from ever-increasing numbers of sources. Consequently, military decisionmakers are being flooded with data that must be converted into useful information before meaningful and successful decisions can be made. The Tactical Real Time Targeting System (TARTS), which consists of a low-observable phased

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array antenna and a powerful fusion processor, promises to provide all units on the battlefield with the ability to receive, process, display, and manipulate multiple intelligence inputs. This capability may reduce the number of analysts involved in the handling and interpretation of the incoming data, ultimately reducing the amount of time that elapses before a decisionmaker receives the information necessary to make an informed decision. This thesis explores the usefulness of TARTS in a tactical environment, including its utility as an enabler of network-centric warfare by specifically developing requirements for the phased array antenna and processors.

The results of the analysis produced an initial G/T for the antenna and data handling minima for the processors. Both of these parameters provide critical design points that will enable system designers to ensure that TARTS meets the requirements necessary for it to be a viable asset to the Fleet.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Computing and Software, Other (Space Systems)

KEYWORDS: Intelligence Dissemination, Real Time Targeting, C4I, Fusion

REQUIRED PERFORMANCE PARAMETERS FOR NAVAL USE OF COMMERCIAL WIDEBAND SATCOM

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Joint and naval vision documents place significant emphasis on information systems and anticipate that the 21st century warfighter will leverage these systems to dramatically increase combat effectiveness while facing a diverse and more unpredictable enemy. Failure to provide the information transfer capabilities that these vision documents rely on will negate the positive impacts that advancements in weapon system technologies will provide. Given the dispersed nature of the future battlefield it is plainly evident that an integrated and robust communication architecture that meets the goals set forth in 21st century vision documents will rely on space based communications (SATCOM). Furthermore, commercial wideband SATCOM assets will be critical contributors to any DoD SATCOM architecture. The high cost of these space systems requires a rigorous evaluation of proposed concepts before acquisition is begun. The cost vs. capability decision should be a negotiated trade between warfighter needs and SATCOM systems costs. Therefore, accurately defining and articulating user needs and performance measures that reflect these needs are critical components of this decision process. The focus of this research is the development of source selection parameters that should be used to evaluate commercial wideband SATCOM systems intended for naval use.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Naval Communications, Commercial, Wideband SATCOM, MILSATCOM, Performance Measures C4I

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JOINT TACTICAL GROUND STATION (JTAGS) MISSILE WARNING DISSEMINATION USING THE GLOBAL BROADCAST SERVICE (GBS) (U)

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The Joint Tactical Ground Station (JTAGS) is an in-theater missile-warning asset. The Global Broadcast Service (GBS) provides high bandwidth, one way communications to U.S. military units. This thesis addresses the suitability of GBS for use in support of JTAGS warning dissemination. It does so by describing Theater Ballistic Missile Defense (TBMD) and the Theater Event System (TES), developing an objective set of criteria for potential JTAGS communications paths, and applying them to GBS. It then reports the results and analysis of data obtained through experimentation with JTAGS remote transmission over GBS and consideration of GBS support to the active and passive defense and attack operations pillars of TBMD. Application of objective criteria, experimentation, and consideration of three of the four pillars of TBMD combine to provide a thorough consideration of GBS as a means of JTAGS warning and report dissemination.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Missile Warning, Theater Ballistic Missile Defense, TBMD, Communications, DSP Ground Processing

ANALYSIS OF OPERATIONAL SCENARIOS FOR THE EXPRESS PALLET ADAPTER

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A Space Shuttle sidewall carrier is needed to carry small payloads and supplies to the International Space Station (ISS). An Express Pallet Carrier and an Express Pallet Adapter fulfill this need as they facilitate robotic transfer operations for small payloads from the Space Shuttle to the ISS. This unique system not only accelerates the process of getting a small payload to the ISS but it also minimizes the use of Extra Vehicular Activity (EVA). EVA is very time consuming, costly and potentially dangerous for the astronauts. This thesis focuses on the robotic transfer operations of the Express Pallet Carrier and the Express Pallet Adapter from the Space Shuttle sidewall to the Express Pallet located on ISS truss. Four scenarios involving the robotic transfer of the Express Pallet Adapter to the Express Pallet are analyzed. The Express Pallet Carrier and Adapter designs are analyzed for compatibility and compliance with the Space Shuttle and the ISS safety requirements. In addition to the design analysis, the feasibility of the scenarios is evaluated to ensure that all the robotic transfer operations are within the ISS requirements.

DoD KEY TECHNOLOGY AREA: Other (Advanced Technology)

KEYWORDS: Express Pallet

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TELEDESIC'S CAPABILITIES TO MEET FUTURE DEPARTMENT OF DEFENSE WIDEBAND COMMUNICATIONS REQUIREMENTS

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Success in modern military operations now depends upon the connectivity provided by communication systems. Space-based communication assets, due to their accessibility, coverage, flexibility, and global reach, are in many cases the only practical means to support transportable and mobile warfighter requirements. Joint Vision 2010's view of future warfighting and its higher, complex operational tempos will demand unprecedented distribution of information, for rapid warfighter interaction, battlefield coordination and joint interoperability. The increasing lethality, mobility and range of weapons, coupled with a smaller and more dispersed force structure, result in significantly increased amounts of three-dimensional battlespace over which an individual force element must maintain awareness and control. The end result is a lethal, deployable military, which is dependent on high-volume information transfers, most of which are graphical, pictorial, or data-intensive in nature. Information, and speed of delivery, are driving the warfighter's demand for higher capacity, wideband satellite communications systems. It is the focus of this research to assist DoD in ascertaining the correct, affordable mix of DoD owned SATCOM and commercial SATCOM that can best meet the warfighter's growing information requirements. The Teledesic Wideband Satellite Communication System is examined for future integration into the DoD MILSATCOM architecture and its military applications. Failure to provide the requisite amounts of communications to the right users when and where required will prevent a full return on the investment in advanced weapons, sensor platforms and combat support systems. Recognizing this, DoD needs to make an investment in Teledesic and other information age throughput technologies.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Battlespace Environments, Other (Commercial Wideband Satellite Communications)

KEYWORDS: Teledesic, LEO, GEO, Naval Communications, Commercial Wideband SATCOM, MILSATCOM