MASTER OF SCIENCE
IN
SPACE SYSTEMS OPERATIONS

A REQUIREMENTS ANALYSIS OF THE 2008 MILSATCOM ARCHITECTURE
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The U.S. Navy is different from the other armed forces in its communications requirements. Due to the lack of terrestrial connectivity possessed by other services, the Navy has become highly reliant on SATCOM for all forms of communication. This thesis presents a requirements analysis of a proposed MILSATCOM architecture. The architecture, when fielded, will form the backbone for all U.S. military satellite communications. It is expected to be operational in the year 2008. The purpose of the study is to determine if the proposed architecture meets Naval communications requirements as defined in the Emerging Requirements Data Base (ERDB). In keeping with the stated purpose, only Naval requirements were loaded for the analysis. Requirements from other services and government agencies were not considered for this study.

As we enter the Information Age, communications connectivity and capacity will equate to operational effectiveness for Naval forces. This thesis identifies requirement shortfalls in the proposed architecture. It specifies the frequency bands where deficiencies are evident. It also proposes alternatives to fulfill or augment noted requirement shortfalls.

A FUTURE SPACE INTELLIGENCE ARCHITECTURE (U)
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The existing satellite intelligence architecture is an aggregation of individual systems developed during the Cold War era by separate organizations and for different purposes. Their current operation reflects the singularity of their origins, designs, functions, support infrastructures, organizational affiliations, management philosophies, and requirements baselines. Planned systems represent a major initiative to achieve a more coherent functionality and to redress capability shortfalls. However, numerous factors present themselves that, in the future, may require multiple intelligence (Multi-NT) and multiple function (Multi-function) capable architectures to satisfy the needs of national users and operational commanders.

Developing the rationale, system attributes, and requirements for a Future Space Intelligence Architecture (FSIA) and determining the correct mix of reconnaissance, surveillance, and intelligence systems that satisfy national and military requirements is the objective of this thesis.

NAVAL INFRARED IMAGERY EXPLOITATION (U)

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Infrared Remote sensors often detect thermal excess energy emanating from naval ships through the discharge of seawater used to cool the equipment in the engineering spaces. Once the thermal energy has been detected, the properties associated with the production of that thermal energy could be simulated using a three-dimensional hydrodynamic model. The parameters of the engineering plant are estimated when the simulated thermal plume provides a good representation to the observed energy discharged into the harbor. The synergy of data obtained remotely combined with hydrodynamic modeling can provide insight to the intentions of the vessels.

SATISFYING NAVAL LOW DATA RATE MOBILE COMMUNICATION REQUIREMENTS

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In today's electronic age, the Department of Defense is relying more heavily on the transfer of information to maintain battlespace awareness and command and control efficiency. Current military satellite communication systems are unable to keep pace with the growing requirements for electronic transfer of voice, data, and video information. Additionally, these systems are expected to begin failing in the 2003 to 2007 timeframe with no identified replacement. Naval Forces consist of highly mobile units that often operate in harsh environments. New communication systems must be designed that can satisfy the needs of these mobile forces that cannot rely on secure landlines for the timely transfer of information.

This thesis first examines the process for developing requirements and how they relate to the military acquisition and system engineering processes. Established methods for documenting satellite communications requirements are also reviewed. Next, potential technological drivers for a system to satisfy the low data rate needs of tomorrow's Naval Forces are presented. Current systems and plans are examined to provide information on current capabilities. Following that, a set of future architecture options and tradeoffs are presented to satisfy these mobile communications needs. Finally, conclusions and recommendations about the organizations and groups tasked with guiding the military and its use of space are provided.

A SIMULATION OF THE LUNAR PROSPECTOR'S GAMMA RAY SPECTROMETER

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The expected response of the Lunar Prospector's Gamma Ray Spectrometer instrument was predicted using a Monte Carlo simulation. The full lunar spectrum was generated using 90 lines and a continuum gamma ray background taken from Apollo 15 and 16 data. The Monte Carlo program uses the exact dimensions and composition of the Gamma Ray Spectrometer in order to most accurately predict spectral performance, assuming an operating temperature on orbit of-30 0C. The Gamma Ray Spectrometer will be launched aboard the Lunar Prospector spacecraft on October 24, 1997. The Lunar Prospector will assume a 100 km altitude orbit around the moon, allowing the Gamma Ray Spectrometer to map the elemental

composition of the surface. The simulated Gamma Ray Spectrometer response can be used as a comparison for the actual data in order to determine how well the spectrometer is working.

AN OPERATIONAL OVERVIEW OF NATIONAL SIGINT COLLECTION (U)

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National SIGINT collection remains both a national and fleet level priority. As such, a basic understanding of these collection systems is given emphasis at the Naval Postgraduate School for curriculums such as Space Systems Operations, Space Systems Engineering, and Information Warfare. Yet no one document or reference contains all relevant material for instruction of the subject, as taught at NPS. Also, most references do not present the material in a format readily assimilated by students with little or no experience in related fields.

This thesis is intended to produce a document which will provide an operational overview of all relevant national SIGINT collection systems. The primary product of this thesis is a hard copy paper which could be used both as a source for professors and as a reference for students studying national SIGINT collection. Operational usefulness, communications paths, and system differences are the primary topics of the paper. All topics will be researched with an operational, vice technical, consideration.

Additionally, a version of this operational overview has been placed on the INTELINK secure network. In the form of a web page (not unlike web pages found on the World Wide Web/Internet), the thesis then becomes a user-interactive learning tool. Users can visit the site, download relevant information, then follow hypertext links to related sites such as mission offices or reporting sites.

SUPPLEMENTING NATIONAL SYSTEM SUPPORT TO THE WARFIGHTER: SIGINT CAPABLE UNMANNED AERIAL VEHICLES (UAVS) (U)

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Unmanned Aerial Vehicles (UAVs) represent a platform that could supplement future national system Signals Intelligence (SIGINT) support to the warfighter with the development of proper payloads and procedures, as explored in this thesis. Payload designs must ensure collection capability against the complex, dynamic communications and non-communications threats emerging worldwide. Multi-platform Time and Frequency Difference of Arrival (TDOA/FDOA) geolocation methodologies must complement payload single-platform direction finding capabilities to allow cooperative, precision target geolocation while maintaining independent platform operations capability. Standardized, all-source, automated processing tool kits must allow interoperability between collection platform processing facilities and automated processing whenever possible. To effect the interoperable collection, geolocation and processing capabilities and ensure rapid dissemination of valuable SIGINT information, a robust network of high data rate links must be established. The data links provide the connectivity necessary to accommodate specific cooperative UAV/national system activities envisioned by the author. These key activities include cooperative geolocation, cross-cueing, and data relay operations. In developing the UAV and cooperative UAV/national system SIGINT concepts discussed in this thesis, SIGINT planners provide the warfighter with sustained, improved SIGINT collection in areas and situations too dangerous for collection via other means.

ARGENTINE SPACE ASSETS
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This thesis is an attempt to define how some of the commercial space assets already in use or under development could be useful to the Argentine Navy as tools for better accomplishment of their basic missions. Research efforts involved investigating part of what is available on the international market and some space-related international laws and policies that may represent limits for military use of civilian assets. Basically divided in two main areas, communications and remote sensing, this thesis covers the GEO and LEO communication satellites and provides an overview of what could be expected from commercial remote sensing systems. Through basic examples, the feasibility of using civilian space assets in the military is demonstrated. Finally, an objective analysis is made to define the best approach to improve Argentine Navy space capabilities.

REAL TIME INFORMATION IN THE COCKPIT MISSION UTILITY
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Navy TACAIR mission effectiveness requires timely responses to emerging conditions in the operational environment. Mission effectiveness is improved by increasing pilot situational awareness with Real Time Information in the Cockpit (RTIC). Exploiting updated and new information from offboard sources provides accurate targeting, increases aircraft survivability, and expands mission flexibility. The evolution of RTIC, sensor to shooter, and offboard targeting concepts are summarized through a discussion of past RTIC exercises and Advanced Concept Technology Demonstrations. Existing operations utilizing the Rapid Targeting System in EUCOM illustrates emerging concepts of operation. In order to assess RTIC mission utility, several TACAIR missions are analyzed for specific information requirements that RTIC can support. Measures of Effectiveness and Performance are identified and applied to a heuristic model to determine RTIC mission utility. An example is provided to illustrate the method's application. Finally, conclusions and observations are given regarding the RTIC utility methodology, on-going research initiatives, RTIC mission planning cycle impact, and areas for future studies.

INTEGRATION OF COMMERCIAL MOBILE SATELLITE SERVICES INTO NAVAL COMMUNICATIONS
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Mobile Satellite Services (MSS) need to be integrated into Naval Communications. DoD SATCOM military-owned systems fall well short of meeting DoD SATCOM requirements in general and mobile SATCOM specifically. This thesis examines DoD SATCOM requirements, especially those affecting communications on the move. From these requirements, three systems—Inmarsat, Iridium and Globaistar—are identified and evaluated for potential use in Naval Communications. An overview of space communications and each of the three systems is provided to identify general operational capabilities, system strengths, and system weaknesses. The Naval narrowband functional requirements process is explored and DoD SATCOM and Commercial MSS ability to satisfy those requirements is assessed. Potential Naval MSS communica-

tions missions are examined and possible DoD enhancements are considered for each system as well as the impact these enhancements will have on each system. Recommendations are provided as to which Naval communications missions are best suited for these enhanced MSS.

A METHODOLOGY FOR AN IMAGERY VULNERABILITY ANALYSIS

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The proliferation of high resolution commercial remote sensing satellites over the next ten years will allow potential adversary countries to possess high quality imagery which can be used for intelligence purposes against U.S. forces. This thesis first provides a functional description of each segment of an imagery system, discusses relevant concepts of Command and Control Warfare, and examines three existing vulnerability analysis taxonomies. The author then combines those elements of each taxonomy applicable to an imagery system with the principles of Command and Control Warfare and develops an imagery system vulnerability analysis methodology. This three-phased methodology describes how to determine the vulnerable nodes of an imagery system, provides a framework for developing ways to attack such a system, and presents a method to measure the effects of an attack on the system. Illustrations are provided to “walk “ the reader through the methodology.