



**Temasek Defence Systems Institute**

**MDTS 2022  
STUDENT SEMINAR  
17 October 2023**



A Showcase of TDSI's Graduation Cohort of MDTS 2022 Students' Theses and Integration Project Completed at TDSI's Partner Universities

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An opportunity for research and collaborations among the local defence community



Presented by MDTS 2022



Information on the Integration Project, thesis and project posters will be posted on TDSI website <https://tdsi.nus.edu.sg/mdts/>

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# **MDTS2022 Student Thesis Presentations**

**Cranfield University****Astronautics and Space Engineering Track****Exploring the Potential of a Space Sustainability Market: Lessons from the Carbon-Offset Market**

By ME5 Liao Zuliang (DIS)

**Synopsis**

This research aims to investigate the potential for a space sustainability market to inform the development of space sustainability practices to mitigate debris building on lessons learned from the carbon-offset market. Space sustainability is a critical issue as the amount of debris in space continues to grow, posing a threat to space activities and impacting the environment. By drawing on the experiences of the carbon-offset market, this research explores the potential to establish a space sustainability market, which could provide economic incentives for companies to engage in sustainable practices and reduce space debris.

**Cranfield University**

**Information Capability Management Track**

**Federated Learning Approach for Machine Learning: Examining the Influence of Individual Differences on Perceived Utility and Ease of Implementation**

By MAJ Ong Jian Jie (Army)

**Synopsis**

This research has the main aim of understanding federated learning (FL) and its perceived utility and ease of implementation in Defence. AI plays a central role in modern defence systems and one key aspect of operationalising AI is the training of the machine learning models. Federated learning is the training of machine learning models without collecting and storing data centrally. The insights from the decentralised data would be shared through model updates to the global model which will be disseminated back to all the clients.

The benefits of this approach have been recognised by other sectors such as healthcare and transport, but not studied for defence applications. Understanding the perceptions regarding perceived utility and ease of implementation would increase the Singapore defence community's understanding of the potential for applying federated learning to improve AI development. This is important as defence has private and sensitive data that are purposely separated for security purposes, which federated learning may provide the solution to overcome this challenge.



**Naval Postgraduate School****Systems Engineering Track****Analysis Of A Multi-Layer System Of Systems To Counter-UAS**

By MAJ Aaron Seow Chengyi (Army)

**Synopsis**

The intent is to analyze the operational and cost effectiveness of a combination of systems to counter Unmanned Aerial Systems (UAS) such as surveillance or loitering munition. A few dimensions to be analyzed are: (1) kinetic vs non-kinetic; (2) active vs passive defense; and (3) high-cost vs low-cost per shot. At the end, this system would enable decision-maker the right mix of system to be incorporated into his portfolio with a variety of sensors and strikers. The literature review will delve into the different aspects of (1) sensing with the various types of sensors (5G, radars etc.); (2) striking with various systems (kinetic, non-kinetic, directed energy etc.); and (3) cost and technicalities of these systems. The analysis will leverage on ExtendSim to simulate various scenarios using the different technical specifications obtained during the literature review. Conclusion for the optimized mix of systems would be based on the cost-benefit analysis derived from the simulation.

Proposed thesis will explore the possibilities in addressing UAS threats that are emerging and prevalent in the global scene. This academic study would draw lessons learnt from literature review while applying model-based systems engineering to conduct simulations for an optimized cost-benefit analysis of a C-UAS System-of-Systems.

**Naval Postgraduate School****Systems Engineering Track****System Engineering Approach to Optimize Active Protection System Allocation for Armored Combat Vehicles**

By MAJ Loh Jian Hao, Charles (Army)

**Synopsis**

With the proliferation of advanced anti-tank weapon systems and an increasing sophistication of threats on the battlefield, military forces are exploring new ways to enhance the force protection capabilities of Armoured Fighting Vehicles (AFVs). With AFVs seen as critical assets in military forces, Active Protection Systems (APS) have emerged in the last decade as a promising solution against these threats on the battlefield. However, the high cost of developing, equipping, and maintaining these systems may prove as a challenge for some militaries. Through modelling and simulation, this thesis seeks to conduct simulated battlefield experiments to address the allocation of APS-es in an armoured force, exploring trade-offs, effectiveness, and limitations between equipping a smaller sized force versus an entire fleet with APS. By providing a more informed understanding of the allocation considerations of APS in an armoured force, this study will contribute to the development of more effective and cost-efficient military strategies.

With anti-armour threats on the rise, SAF will need to be ready to respond to them effectively by increasing the protection capabilities of our armoured combat vehicles. However, APS-es do not come cheap and require a great deal of resources and maintenance. The thesis would see the optimal allocation of active protection systems (APS) in armoured combat vehicles should the SAF decide to acquire them, maximising force protection with the least cost required.

**Naval Postgraduate School****Systems Engineering Track****A Model-based System Engineering Approach to Requirements Management**

By Mr Koh Chun Ngee Alvin (ST Engineering)

**Synopsis**

Requirements management is essential to the success of any project or product. Currently, requirements derived from users' needs are often document-centric and expressed in textual statements. Conventional requirements management techniques, although widely used, are known to have various shortcomings. A model-based systems engineering (MBSE) approach to requirements management, using models to capture and represent system requirements, has emerged with promise. This thesis explored the application of MBSE to requirements management with the goal of achieving improved communications, increased reusability, and better traceability. A model was created to transform a sample set of text-based requirements into a model-based representation. From this model, an evaluation of its effectiveness was conducted based on the performance metrics defined. Results showed that an MBSE approach had fulfilled the measures of effectiveness and met the goal of improving requirements management. However, for the successful implementation of MBSE on requirements management, there are hurdles to overcome and future work to be explored.

**Naval Postgraduate School****Systems Engineering Track****Incorporation of Model-Based Systems Engineering into the Vee Model to Aid in Reducing the Time Required for the Design Cycle of a Military Tank**

By Mr Thng Lianquan (ST Engineering)

**Synopsis**

This thesis incorporates an MBSE tool, Dassault Systems CAMEO Magic System of Systems Architect (MSOSA), with a military tank as an application to analyze the benefits and disadvantages of model-based systems engineering (MBSE). This thesis analyzes the degree to which the Verification & Validation (V&V) process is expedited using the MSOSA model to automatically point out any discrepancies, which serves as assessment of the degree to which the overall design cycle is more efficient. This thesis also assesses the ability of MSOSA to adhere to the Vee model and improve the following: top-down visualization, traceability, identification of discrepancies and design continuity. The results of the model illustrate the benefits that MBSE may provide when implemented in the context of the Vee model. One of the primary advantages of MBSE lies in its ability to provide a comprehensive top-down view of the system architecture, capturing interactions between subsystems and offering stakeholders a holistic understanding. MBSE also improves traceability, which is essential for managing a complex system. Furthermore, MBSE effectively identifies discrepancies between design and requirements, providing real-time feedback to engineers. Lastly, MBSE supports project continuity through the life cycle of the system and helps to eliminate redundant elements within the system due to changing requirements.

There may be significant advantages of adopting an MBSE approach in the design and development of complex systems like military tanks. MBSE offers a clear top-down perspective, enhances traceability, identifies discrepancies in real-time, facilitates continuity, and reduces redundancies within the system.

**Naval Postgraduate School****Mechanical Engineering Track****SIM-1 UAS: A Framework for Rapid Prototyping of MATLAB Developed Flight Test Code**

By ME5 Su Juncun (RSAF)

**Synopsis**

Unmanned aerial systems (UAS) like the ScanEagle have been employed in both military and research applications. Despite the ScanEagle's low cost and operational flexibility, its utility for autonomy research is limited due to its proprietary hardware and software. With this in mind, a new UAS, named SIM-1, was procured. It employs open-source hardware and software, making it suitable for research and development.

In this thesis, the SIM-1 UAS was assembled and successfully flown in simulated and actual test flights. Simulations were conducted using Gazebo software which employs a physics-based virtual environment, while flight tests were carried out at local flying fields. A basic MATLAB control algorithm was developed for SIM-1, and flight paths were planned through the ground control station (GCS). Notably, two methods of flight path planning were explored in this thesis. The first method uses open-source GCS software, QGroundControl, while the second method uses algorithms developed, tested, and ported to C++ code using MATLAB/Simulink. This second method provided an avenue for guidance, navigation and control (GNC) prototype algorithms to be flight tested rapidly. Finally, SIM-1 was also configured with a machine learning algorithm for object detection using its onboard camera payload, which opens up opportunities for more advanced research with this UAS platform.

**Naval Postgraduate School****Cyber Security & Defense Track****Applicability Analysis of the Zero Trust Paradigm for Operational Technology**

By Mr Song Meng Wee (ST Engineering)

**Synopsis**

This thesis will explore the feasibility and benefit of implementing Zero Trust (ZT) architecture in an operational technology (OT) environment. Specifically, this study will examine current ZT security models in enterprise (IT) networks and investigate ways to integrate ZT protection mechanisms into existing OT systems. OT-related reference models such as The Purdue Reference Model for industrial control systems (ICS), ZT-related guidelines such as NIST Special Publication 800-207 Zero Trust Architecture, and general cybersecurity guidelines such as NIST Special Publication 800-82 Rev3 or Singapore's Cybersecurity Code of Practice (CCOP) will be referenced for this research.

The thesis will also look into enabling remote connection and BYOD into OT network which will allow critical infrastructures to tap into this technologies safely to better enhance their operational and maintenance processes.

This research will provide insight and detailed analysis on the feasibility of integrating Zero Trust mechanisms into an OT network. The U.S. Government has recently pushed for ZTA to be deployed in US federal network which is a positive affirmation to ZTA. This study aims to provide research an in-depth analysis into the possibility of using ZTA within OT networks.

A successful result may enable OT network to be better defended and enable new technology to aid in day to day operation and maintenance.

**Naval Postgraduate School**  
**Operations Research Track**  
**Optimizing Ammunition Management in Singapore**  
By ME5 Chea Wei Tien (Army)

**Synopsis**

Ammunition is crucial to Singapore's defense readiness and national security, especially considering global events like the Russia-Ukraine conflict. Challenges faced by Singapore include low peacetime usage, restricted storage capacities, and significant disposal costs of obsolete ammunition, highlighting a need for efficient ammunition stockpile management. Our thesis introduces an optimization model to guide procurement strategies, determine optimal resource allocation between local production and overseas purchases, and recommend appropriate stockpile quantities to optimize the overall lifecycle cost of ammunition. Our model further analyzes the implications of modulating production rates, available component quantities for local production, base production units for an operational production department, and transition expenses of production from dormant to operational states. Leveraging linear programming, our study analyzes 30 specific ammunition items, gauging them against local production proficiencies. By incorporating modular storage management, our model ensures a balance between maintaining a robust ammunition stockpile and cost efficiency. Our model therefore presents our ammunition stockpile manager with an invaluable tool tailored for enhanced ammunition management.

**Naval Postgraduate School****Operations Research Track****Identifying Probable Maritime Piracy Events Using Maritime Incident Data**

By Mr Yeo Jun Yi (DSTA)

**Synopsis**

Maritime security and piracy incidents continue to pose significant risks to commercial navigation in spite of the fact that these incidents have decreased. In 2021, the strategically important Gulf of Guinea and Singapore Straits remained as the most prominent piracy hotspots. Using data from 2014, Desai and Shambaugh estimated the economic cost to the shipping industry from maritime piracy at more than U.S. \$16 billion per year, which impacts international shipping industries and is often associated with violence in which hostages with injuries or deaths are involved. In addition, shipping companies have also privately succumbed to pirates' demands through failing to report incidents of attack, and these suppressions worsen maritime security.

As part of International Maritime Organization's (IMO) agenda to enhance maritime security, the organization publishes acts of piracy and armed robbery incidents as part of the Global Integrated Shipping Information System (GISIS). Our study aims to exploit the available dataset with geospatial and vessels' static details to provide descriptive statistical information about maritime piracy events, such as piracy hotspots. Time series analysis and clustering analysis is applied in the study to predict incident trends and identify piracy hotspots within the given time and space.



**Naval Postgraduate School**

**Sensor Systems Engineering Track (Electronic Warfare)**

**Performance Evaluation of Raised-Cosine Shaped Interference in Communication Systems**

By CPT Peh Sheng Shen Wesley (Army)

**Synopsis**

In this thesis, we explore the effects of a transmit waveform-shaped interference in communications systems. Regardless of its nature, either accidental or intentional such as jamming, the focus of this work is a specific noise interference that takes on the spectral shape of raised-cosine pulse. Monte Carlo simulation experiments are performed to evaluate the effects of the interference to the performance of transmitted communications signals. In evaluating the bit error rate (BER) performance of the affected communications systems, various modulations are utilized in the simulations.

## **MDTS2022 Integration Project Presentation**

## **Cranfield University Integration Project**

### **Space Asset to Monitor Climate Change in Singapore**

By MAJ Ong Jian Jie (Army) and ME5 Liao Zuliang (DIS)

#### **Synopsis**

Climate change has accelerated in the recent years due to human activities. The effects of climate change, such as rising sea levels, is a threat that Singapore is vulnerable to. Information is essential in deciding the measures that Singapore should adopt to tackle the effects of climate change.

The integrated project will study the requirements for the space-based system to monitor and process data that provide insights on climate change and propose a system design of the space-based climate monitoring system. This will allow policymakers understand the effects of climate change timely so that they can make informed decisions.

**Naval Postgraduate School Integration Project**  
**Multi-Domain, Manned-Unmanned Littoral Denial System**

Class of MDTS 2022

Presented by

MAJ Justin Kwan Jing Ming (RSN) and MAJ Loh Jian Hao, Charles (Army)

This interdisciplinary design project details a systems engineering approach to design a manned-unmanned, multi-domain, littoral denial system of systems, projected over the next decade. Mission context scenarios were created to provide diverse system operating environments, enabling a flexible system architecture to address a variety of threats in near-peer competition. With efforts to employ cost-effective and attritable unmanned components, open-source platform reviews were conducted to determine performance parameters, cost, and technical readiness levels, ultimately influencing the eligibility and appropriateness of these platforms for system integration. This evaluation led to a value system design for each candidate platform, providing quantitative analysis for its potential contribution to our system functions as they pertain to each mission scenario. An optimization program under cost constraints was then utilized to yield ideal platform combinations while meeting all functional requirements. Each architecture that resulted from the optimization program was then subjected to a combat model to verify its effectiveness, and then compared to conventional littoral denial constructs.