Abstract – The Accelerated Masters Program (AMP) in Systems Engineering at the University of Virginia concludes with a capstone systems integration course designed to enable students in the Program to demonstrate mastery of systems engineering skills and methods and to apply them to a large scale problem of national significance. This paper summarizes the work statement provided to the 2005-06 AMP cohort. Four teams of 10-11 students each will address the problem of developing a preliminary system design for a national hazardous material (HAZMAT) truck tracking system and present their recommendations to the Transportation Security Administration.

I. THE ACCELERATED MASTERS PROGRAM IN SYSTEMS ENGINEERING CAPSTONE PROJECT

Designed expressly for technical professionals and managers, the Accelerated Master's Degree Program in Systems and Information Engineering is a hands-on, practical program of study designed to give engineers and technical managers the problem-solving and analytical skills needed to maximize existing resources and uncover breakthrough opportunities for their organizations. The Program's dual emphasis on engineering and business skills places graduates in a unique position to further their company's strategic goals. This unique program of study is completed in just one year by attending classes every other weekend on Friday and Saturday. Most graduates find that they are able to take much of what they learn and apply it at work immediately.

This unique, accelerated, one-year program was created by senior faculty at the University of Virginia's School of Engineering and Applied Science in collaboration with the Darden Graduate School of Business Administration -- coupling courses in business strategy and functionality along with mathematics and modeling.

Each year, the Accelerated Master’s Program in Systems Engineering concludes with a comprehensive team-based design effort involving a large scale system of national significance. This project provides a culminating experience through which students bring together the systems analysis and design skills they have learned over the course of the year and apply them to a real-world problem using real data and presenting their results to an evaluation panel comprised of seasoned practitioners, academics, and client representatives. The 2005-06 AMP cohort is addressing a problem related to the nation’s ability to provide safe and secure transport of hazardous materials over our nation’s highways. The project, sponsored by the Transportation Security Administration, is described below. The project will be completed by four teams of 10-11 students each during the week of April 24-28 with presentations to the sponsor on Friday, April 28 during the annual Systems and Information Engineering Design Symposium held at the University of Virginia.

II. HAZMAT TRUCK TRACKING BACKGROUND

The mission of the Transportation Security Administration (TSA) is to protect the Nation’s transportation systems to ensure freedom of movement for people and commerce. The TSA plans to accomplish this mission by increasing domain awareness, focusing on the prevention of terrorist incidents in transportation and enhancing response capabilities by promoting methods that ensure coordinated agile incident responses to terrorist threats and incidents.

Trucks transport and exchange cargo with all modes of transportation and regularly access and carry shipments into and out of airport operations, rail facilities, military installations, retail establishments, government buildings, maritime ports, and residential neighborhoods. The pervasive and ubiquitous nature of the trucking industry underscores the need to ensure that highway cargo transportation system’s security vulnerabilities are effectively assessed and mitigated to prevent terrorists from exploiting this vital component in our Nation’s supply chain.

1 Much of the material in this section is drawn from TSA’s Request for Proposal “Truck Security Pilot” RFP number HST02-05-R-STZ500
A critical part of securing the Nation’s supply chain involves the rapid engagement of first responders at state and local levels to facilitate agile and effective responses to emergency incidents that may pose an immediate security threat to human life and/or the flow of commerce. As such, methods to ensure first responders have the ability to track and intercept cargo conveyances deemed to be a significant risk to national security must be developed and evaluated. Efforts to coordinate state and local responses with the proper federal authorities and intelligence data will enhance and expedite National response plans to actual live terrorist threats.

The United States Congress is currently deliberating legislation to encourage motor carrier operators to equip vehicles with tracking capability. Section 402 of S. 1052, The Transportation Security Improvement Act of 2005 (as reported) would require the DHS Secretary, through TSA, and in consultation with the DOT Secretary, to develop a program to encourage the equipping of motor carriers transporting high-hazard materials in specified quantities with wireless communications technology that provides continuous communications, vehicle position and location and tracking capabilities, and an emergency broadcast capability.

The Committee's review of the Federal Motor Carrier Safety Administration's Field Operation Test of hazardous material truck tracking technology and current wide deployment of tracking and monitoring equipment for trucks carrying hazardous materials leads the Committee to seek to encourage further deployment and development of this technology for both security and safety reasons.

Completion of the work described in this Scope of Work (SOW) will assist TSA’s Office of Transportation Sector Network Management staff in working with modal administrators, including the Federal Motor Carrier Safety Administration (FMCSA) and the Pipeline and Hazardous Material Safety Administration (PHMSA), governmental, and industry stakeholders to establish best practices and identify security enhancements in the trucking industry.

The Transportation Security Administration recently awarded two contracts relating to HAZMAT truck tracking. Together, these two contracts will accomplish the following:

1. Identify, test and evaluate at least three technically different, but commercially available solutions to track trucks in all 50 states
2. Develop and demonstrate a prototype for a centralized truck tracking center
3. Develop and demonstrate a non-proprietary universal interface system or set of protocols that will allow alerts and tracking information to be transmitted from all commercially available tracking systems to a prototype truck tracking center;
4. Evaluate the feasibility of utilizing the developed universal set of protocols or interface system to pass truck tracking information between a truck tracking center and a 24 hour government intelligence operations center
5. Provide an independent analysis of the recommendations and validate the results of (2), (3), and (4).

The two separate contracts awarded by TSA are as follows: one contract seeks to accomplish (1) and (5) above, and another seeks to accomplish (2), (3) and (4). The requirements of the proposed contracts are to be accomplished using existing off the shelf, or slightly modified technology. Neither is a research and development contract.

Key requirements of the proposed pilot contract include the ability to: continually track truck locations and load types in all 50 states; and develop a set of protocols capable of interfacing with existing truck tracking systems, a truck tracking center, a Government intelligence operations center, state, local and Federal law enforcement agencies, and first responders. Both of these contracts are currently underway.

III. OBJECTIVE AND SCOPE OF WORK FOR THIS EFFORT

Objective
This effort is in support of the larger effort TSA has undertaken to establish a national HAZMAT truck tracking capability. More specifically, the objective of this effort is to develop a recommended concept of operation and preliminary system design for a national HAZMAT truck tracking system consistent with the legislative intent and with TSA’s goals of improving
the safety and security of surface transportation in the nation.

Scope of Work

The scope of this effort is defined by the following tasks, to be completed during the week of April 24-28 in fulfillment of the requirements for SYS 602, Systems Integration.

Task 1: HAZMAT Truck Tracking Concept of Operations. Develop a concept of operations for a national truck tracking system. The concept of operations is a high level description expressed in user-oriented language that describes how the system will work to achieve the system level objectives. The concept of operations leads to functional requirements and specifications that permit preliminary design and development. The concept of operations should reflect the perspectives of major stakeholders and demonstrate a understanding of stakeholder roles and responsibilities and system priorities and constraints.

Task 2: HAZMAT Tracking System Requirements. Based on the concept of operations, develop the system requirements that must be achieved to field an effective national HAZMAT truck tracking system. The requirements should include measures of performance and evaluation criteria to be used in determining how well the system requirements are met so that alternative designs can be evaluated and the fielded system can be assessed with respect to system requirements. The requirements should address both technical requirements (e.g., technical performance) and procedures (e.g., institutional arrangements).

Task 3: Tracking Technology Assessment and Preliminary Design. Develop feasible alternatives for meeting the system requirements and evaluate these alternatives using the evaluation criteria and performance measures identified in Task 2. Recommend a preliminary design for tracking HAZMAT such that the legislative intent and TSA’s objectives for HAZMAT truck tracking are achieved.

Task 4: Institutional/ Legal/ Regulatory Considerations. Identify the institutional, legal, and regulatory issues and considerations that are likely to affect design, deployment, and operation of a national HAZMAT truck tracking system and identify ways to mitigate such issues. These may include economic incentives/disincentives, jurisdictional authority, response resources, legislative or legal restrictions, proprietary concerns, or other factors that might affect implementation or effectiveness of the tracking system.

Task 5: Findings and Recommendations: Document findings and recommendations in a professional report suitable for submission to TSA that includes the following elements (individual reports will likely include additional material and subsections within these major headings):

- Title page
- Disclaimer (similar to that offered in this document noting that the report contains no proprietary information or security sensitive information)
- Acknowledgement (recognizing agencies or individuals who provided information or advice)
- Executive Summary
- Background
- Study Objective
- Technical Approach
- Analysis (this will be the major part of the report where each task is addressed and systems engineering tools and methods are applied)
- Findings and Recommendations
- References
- Appendices as necessary

Summarize study approach and findings and recommendations in a briefing to be given to TSA and other evaluators in a session not to exceed 30 minutes including a 10 minute discussion and question and answer period following the presentation. Presentations will occur between 2:00pm and 4:00pm on Friday, April 28th during the Systems and Information Engineering Design Symposium held at Newcomb Hall at the University of Virginia.

IV. DELIVERABLES

The project deliverables consist of the following documents and briefings:

1. Work plan with analysis plan and team roles and responsibilities
2. Final report outline
3. Primary data sources and literature review
4. Preliminary analysis and findings
5. Final report
6. Final briefing
V. SCHEDULE

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<td>• Review project documentation</td>
<td>• Identify and locate data and information</td>
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<td>• Subject matter expert interview(s)</td>
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<td>• Complete design</td>
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<td>Fri</td>
<td>• Submit Final Report NLT 10:00am</td>
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VI. EVALUATION CRITERIA

The criteria used to evaluate the final briefing and report are as follows, listed in decreasing order of importance:

1. Demonstrated effective application of systems engineering principles and approaches in defining the problem; formulating appropriate performance indices and metrics; identifying and characterizing key stakeholders’ perspectives; developing functional requirements and design specifications; identifying and evaluating feasible alternatives; assessing and mitigating technical, operational, and economic risks; establishing the basis for and selection of the preferred alternatives (including staged or evolutionary development or deployment); and formulating a plan for implementing the preferred alternative.

2. The thoroughness of the analysis used in completing the project as evidenced by the data obtained and information sources explored; the type and rigor of the analyses conducted; the extent to which assumptions are identified, documented, assessed, and properly applied; and the validity of conclusions drawn from the analysis.

3. The overall practicality of the recommended system design and concept of operations in light of institutional, operational, technical, and economic considerations.

4. The professional quality of the report and final briefing in capturing and communicating the nature of the problem, the analysis, the system design and operational concept, and the recommended course of action.

VII. ACKNOWLEDGEMENT AND DISCLOSURE

The study described herein is primarily for the purpose of enabling students in the University of Virginia Accelerated Masters Program in Systems Engineering to demonstrate mastery of systems engineering skills and methods and the application of these skills and methods to a large scale problem of national significance. The Program is indebted to the Transportation Security Administration for its support in allowing students in the program to study this problem using open source documents and data related to tracking hazardous material. The Program is further indebted to TSA for providing access to key staff that provided background and context for the study.

All information provided in this document was prepared by the Accelerated Masters Program in Systems Engineering as guidance to students, drawing on TSA and other agencies’ open source documents and data. No proprietary data are used in this study and none of the findings or results that proceed from this study will be proprietary to any of the students or the companies that employ them or to the Program. The results of this study are available to the Transportation Security Administration at no cost to the government.