

Background and Motivation

- Modeling Virtual Environments Simulation (MOVES) course MV3500 Networked Graphics and Simulation is first of two-course sequence examining distributed Live Virtual Constructive (LVC) defense applications.
- Theme: LVC is major gap in global C2, badly needed. Distributed Interactive Simulation (DIS) standard links.
- Three pairs of students pursued opportunity to write point-papers for NPS...Next transformation planning, assessing value of MOVES M+S links to NPS and DoD.
- **External connections have major potential benefits.**

Test and Evaluation (T+E) Orientation

- Test and Training Enabling Architecture (TENA) software suite, can emulate (and perhaps connect to) operations on all DoD test ranges. GOTS software, includes DIS.
- Directly relevant to NPS field experimentation (FX) and CRUSER activities at both Camp Roberts and the Sea Land Air Military Robotics (SLAMR) beach facility.
- Recent National Academy of Sciences (NAS) study on Test Range of Future exactly aligns with NPS designs.
- **NPS can pattern after DoD test ranges without fees.**

Network Infrastructure Connectivity

- Joint Mission Environment Test Capability (JMETC) is SIPRNET connectivity for all DoD test ranges. Uses TENA.
- NMETC is a similar NIPR enclave, UNCLAS allowed, supported by individual allied nations. Likely a good pattern for NPS Field Experimentation (FX) to pursue.
- NPS needs to provide connectivity to JMETC so that students and faculty can observe test range activities.
- **NPS requires SDREN connectivity so external partners have visibility into our capabilities and contacts.**

Engaging DoD and Coalition Partners

- C2SIM is emerging work to bridge C2 with M+S led by Simulation Interoperability Standards Organization.
- Part of NATO Federated Mission Networking (FMN) working groups with ongoing NPS participation.
- Students connected using Calytrix Australia software for voice communications using standard IEEE DIS protocol.
- Improved recognition of coalition importance by CTF59 operationalization of warfighter-deployed robotics.
- **Establishing links improves NPS engagement, relevance.**

NPS...Next: MOVES Connectivity for Modeling, Simulation and Testing

The clear emphasis on warfighter innovation provided by the *NPS...Next* transformation initiative has provided excellent vision and motivation for significant improvement in external NPS engagement, influence and impact. Six students in the Modeling Virtual Environments Simulation (MOVES) curriculum wrote excellent point papers on M+S LVC connectivity as contributions for *NPS...Next*. These were final projects for NPS course MV3500 Networked Graphics. Each makes cogent summaries of important opportunities that MOVES might execute.

1. The first point paper by Justin Frank and Joshua Keeven considered how NPS might utilize the Test and Training Enabling Architecture (TENA) software suite and Joint Mission Environment Test Capability (JMETC) connectivity to emulate and connect to operations on all DoD test ranges. This is especially relevant to NPS field experimentation (FX) at Camp Roberts and the Sea Land Air Military Robotics (SLAMR) beach facility.
2. The second point paper by John Morris and Brian Pugh examines how connectivity to C2SIM/NATO Federated Mission Networking (FMN) might help connect M+S analytic capabilities to diverse C2 systems, robotics field experimentation (FX) and NATO partners. Faculty involvement includes Dr. Curt Blais as one of the principal leads on C2SIM, and Chris Fitzpatrick who has enabled NPS student participation in remote NATO experiments. Concurrent with the students' briefing, the Navy announced how the new Combined Task Force (CTF) 59 led by Fifth Fleet will advance unmanned systems operations in partnership with 60 coalition nations.
3. The third point paper by Matthew Robinson and Max Schlessel examined and tested IEEE Distributed Interactive Simulation (DIS) Protocol, specifically Voice Communications using Calytrix Australia software, demonstrating positive results. They took the initiative to write this up as well, since having simulated tactical voice communications (or even distributed verbal narratives during shared simulations) is a powerful capability. Immediately following their brief, the planned partnership USA-Australia-UK regarding nuclear submarines was announced, further encouraging us to think about standards-based collaboration with Australian allies.

Point papers attached. In each case no software costs or licensing fees are necessary. Some labor will be needed to maintain NPS connections securely and effectively with external parties over public and secure networks. Each fits well with broader NPS teaching, research and field experimentation (FX). We stand ready to help assess detailed costs and benefits.

NPS...Next offers students and faculty major opportunities for influence and impact. All scrutiny of these three specific alternatives are welcome. We offer these paths as ways for MOVES to help NPS broaden, deepen and extend our command's influence and impact, to the benefit of Navy USMC USA defense and coalition partners.

Very respectfully submitted.

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References

- [MV3500 Networked Graphics Course](#)
- [MV3500 Student Point Papers for NPS...Next](#)



Problem statement: How can NPS utilize TENA and JMETC?

CPT Justin Frank and Capt. Joshua Keeven

08 September 2021

Naval Postgraduate School Mission: The Naval Postgraduate School provides defense-focused graduate education, including classified studies and interdisciplinary research, to advance the operational effectiveness, technological leadership, and warfighting advantage of the Naval service.

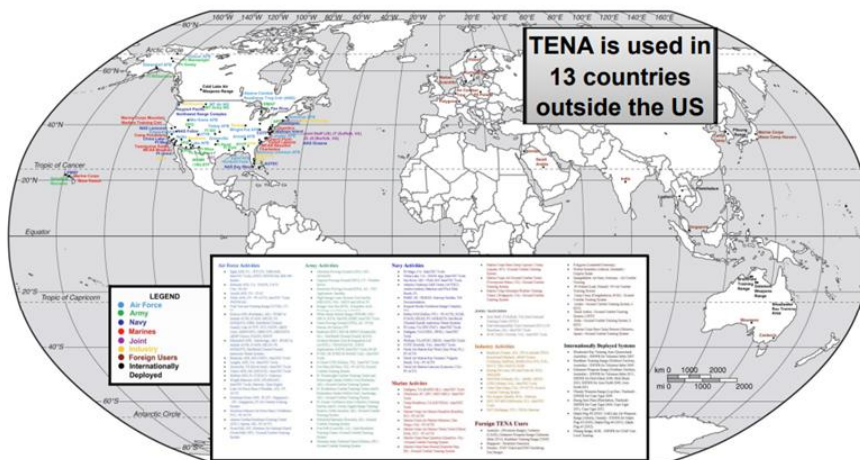
MOVES Mission: Enhance the operational effectiveness of joint and coalition forces by providing superior education and research in the field of modeling and simulation

What is Test and Training Enabling Architecture (TENA)? The purpose of TENA is to provide the necessary enterprise-wide architecture and the common software infrastructure to: Enable interoperability among range, C4ISR, and simulation systems used across ranges, HWIL facilities, and development laboratories. Leverage range infrastructure investments across the DoD worldwide to keep pace with test and training range requirements supporting the warfighter. Foster reuse of range assets and reduce the cost of future developments.



Distribution Statement A: Approved for public release. Distribution is unlimited.

Worldwide Use of TENA



One of the best qualities of TENA is that all its software and support is free to users and is the most capable and sophisticated interoperability solution. TENA claims high reliability and frequent testing to ensure a quality product. TENA uses Auto-Code

Generation in its middleware to provide straightforward application and automation of making various kinds of software interoperable. TENA comes with the TIDE Tool that manages installation and configuration, upgrading, and maintenance. TENA can catch errors at compile time rather than at run time, ensuring that issues are caught early in the development process.



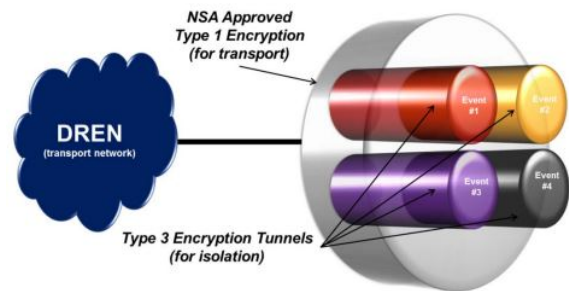
Auto-coded interface software can be standard TENA Object Models that the community has designed and agreed upon or designed for unique user requirements. TENA Object Models are auto-code generated software interfaces that include data formats, data definitions, and standard algorithms. This is how TENA can connect multiple software packages with different protocols. TENA already has a library of developed traditional Object Models: 1 Time, TSPI, Coordinate Systems (including conversions), GPS, Radar, Telemetry, Event Control, Video Distribution, Weather. This means that developers already have working examples to reference when creating their standard Object Models specific to the interoperability function they are trying to facilitate.

What is the Defense Research Engineering Network (DREN) and (SDREN)?

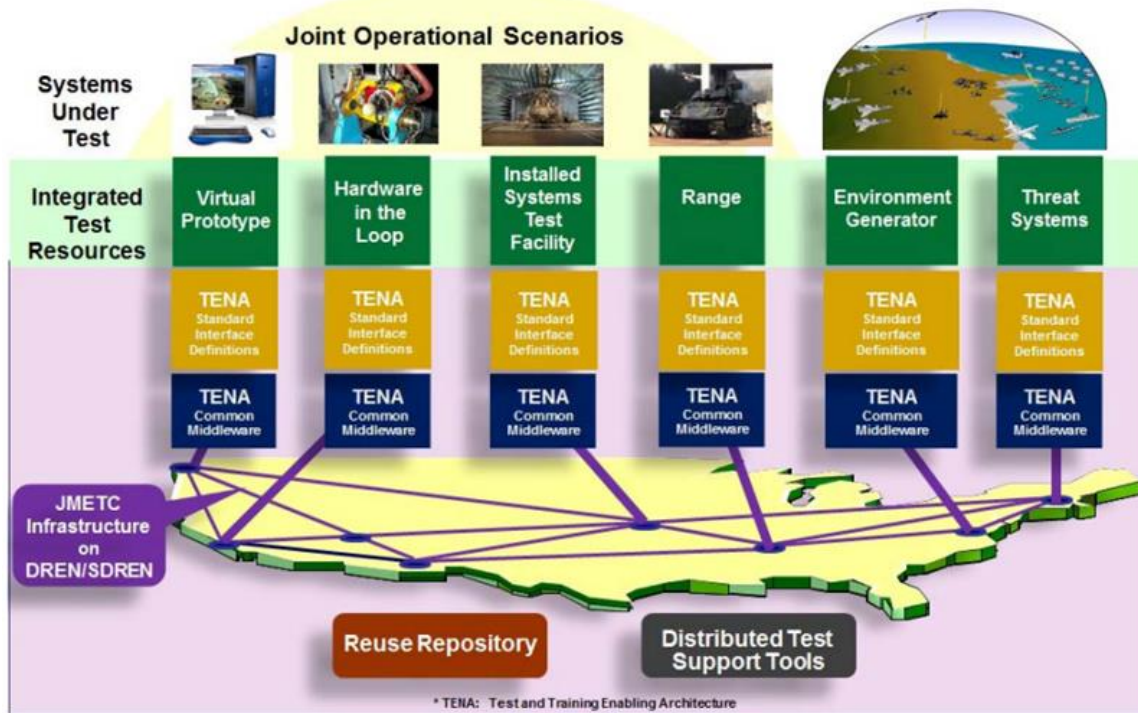
DRENIII is currently underway of implementation. DREN's mission: to provide robust, high-capacity, low-latency connectivity between the HPCMP DoD Supercomputing Resource Centers (DSRCs) and user sites. DREN III also supports DOD scientific research and development. In addition, it supports test and evaluation missions. DREN III provides secure data transfer with NIPRNET, and academic research networks within the continental United States and Hawaii. SDREN is a virtual private network overlay of the DREN using service Delivery Routers and NSA Type 1 encrypted with a common key. SDREN is not synonymous with classified communications across the DREN backbone using keys other than the common SDREN key.

What is Joint Mission Environment Test Capability JMETC? The JMETC mission is to provide a persistent capability for linking distributed facilities, enabling DoD customers to develop and test warfighting capabilities in a Joint Context. JMETC provides a test infrastructure consisting of the components necessary to conduct Joint distributed test events by cost-effectively integrating live, virtual, and constructive (LVC) test resources that are configured to support the users' needs. Additionally, the JMETC program provides its warfighters with a support team to assist with JMETC products and distributes testing. The JMETC MILS Network (JMN) provides secure distributed testbeds to support unconstrained cyber activities and user access to enterprise resources across multiple classifications.

JMN employs Multiple Independent Levels of Security (MILS) using the Defense Research Engineering network (DREN) backbone, which allows for data segregation by stream by protocol, system, event CIO. It can also support multiple events at multiple classifications concurrently and can create isolated Sandboxes.



Defense Intelligence Agency (DIA) has accreted the JMETC to operate from Unclassified to Top Secret with Special Compartmental Information (TS//SCI). It also includes National Security Agency (NSA) Red Team assessment.



What does NPS currently use? Distributed Interactive Simulation (DIS). DIS is designed to be used peer to peer without the need for a server. It sends a series of formats for packets oriented for military simulation use based on the precision of the PDUs that are commonly used to communicate precise positional data. DIS uses the IEEE standard that individuals developed to create a common language for sending PDUs

What should NPS change to utilize TENA best? First, TENA's ease of use and automated development tools make it more favorable compared to DIS. DIS relies on



users to follow the IEEE standard, which could change periodically without enforcing the changes across all systems using DIS. TENA's automatic updates ensure that all users use the same standard and maintain interoperability as new versions and updates come out. Second, NPS research countless topics that are not necessarily military simulations. DIS has a strong focus on military simulations, where TENA allows developers to create standard object models that may be more appropriate for other academic research applications. Finally, DIS is designed for peer-to-peer, while TENA is designed for interoperability anywhere in the world. Although web-based server reliance can create its own list of issues, TENA provides a much more flexible and user-friendly solution to facilitate interoperability.

What are the benefits that NPS could achieve from using TENA? First, NPS research and thesis projects could be used with the rest of the DOD that also uses TENA by using a common architecture. A student and the organization they are supporting with thesis research could work together simultaneously over the TENA network. TENA has many tools that allow resources located far from each other to be integrated promptly, which would be especially important for military LVC simulations. TENA can filter out classified information and segregate it.

Specific example: NPS does frequent robotic tests at Camp Roberts, which is 2 hours away from the campus, and at NPS SLAMR located on Del Monte beach. NPS should be conducting a simulated test before physical tests. If NPS used the TENA software on an unclassified JMETC network, then NPS could become a JMETC test range that would support NPS NEXT's intent. Also, if NPS could get access to the secret JMETC network, NPS would conduct meaningful research on all data collected from DOD robotic experiments. With TENA being free and open source, the implementation of this scenario has a very high payoff to effort ratio. To support the mission of NPS NEXT, strengthen our joint military aspirations, increase our impact, and enhance our competitiveness, we recommend that NPS. Connect the NPS SIPRNET to SDREN and JMETC and align the virtual networks for field experimentation with JMETC requirements for CUI/UNCLAS and seek certification. Additionally, mainstream long-term NPS capability by exposing students and faculty to LVC robotic experiments and test ranges.

There are countless opportunities across the military services to create interoperability between networked simulations for both academic and military purposes. By implementing TENA and JMETC capabilities at NPS, we become a more integrated part of DoD research and expose service members to its capabilities when they move on to their follow-on billets.

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Exploring Live-Virtual-Constructive (LVC) and NATO Network Standards to Enable C2

White Paper

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Modeling Virtual Environments and Simulations

Naval Postgraduate School (NPS) Monterey California USA

1. **BLUF:**

- a. The Naval Postgraduate School (NPS) becomes a contributing member of the Command-and-Control System-Simulation System Interoperation (C2 SIM) architecture team at NATO.
- b. NPS acquires the appropriate permanent infrastructure to observe NATO and U.S. exercises on CENTRIX and SIPR networks.
- c. NPS School builds a physical white cell CoC to observe and study NATO and U.S. constructive exercises.
- d. NPS should build classes and courses around current Joint and Service Level Exercises.

2. **Background:**

- a. Service Oriented Architecture allows commanders to modify the network to enable greater understanding amongst federates of the current operational pictures. The NATO network, or standards, is a method to implement greater mission understanding and interoperability among the 72 nations and organizations associated with NATO. This is enabled by a common set of network and classification standards being developed by NATO. These standards are called the Command-and-Control System-Simulation System Interoperation (C2 SIM) which allows simulation and C2 systems, and robots to share data.
- b. Frameworks exist for DIS and HLA sharing data. The only international standard to federate C2 systems is C2 SIM (data model), based on Web Ontology Language (W3.org). This language enables automated reasoning on computers. The systems have similarities such as naming units, type of units in battlespaces, reports, etc. An example would be a move order, or simulation report. This enables the exchange of reports, orders, plans, and the incorporation of real world C2 with simulation systems. If done correctly, someday some C2 and robotic system will natively utilize C2 SIM. NATO is working with SISO to implement the C2 SIM standard across the force.
- c. Command and Control: NATO and the DoD struggle to employ LVC interoperability standards, despite regulations encouraging these standards (STANAG). NATO is currently working on one for C2 SIM. This is due to the rapidly evolving network and positional tools available. Further complicating the process are varying privacy, health, and general network communication policies within the NATO nations.
- d. LVC Training: The Army conducts NATO LVC training at the Joint Multi-National Training Center (JMRC) in Germany. Many international interoperability issues are tackled within this training led by the Global Simulation Center at Fort Leavenworth and JMRC.

3. **Discussion:**

- a. Bridging the gap between training and operations: The ability to hastily capture terrain and reconstruct digitally in a realistic simulation enables forces to train on the battlefields which they will fight. High-fidelity terrain and battlefield entities gives NATO forces the ability to generate multiple AI opposing forces (OPFOR). This provides a hyper-realistic environment to train US and NATO allies on current and futures battles.

b.Training on Future Battlefields: The battlefield of the future can only be understood through a diverse input of allies who possess greater cultural similarities with potential adversaries. The ability to work with, and incorporate their input allows for increased model fidelity. Furthermore, it enables greater ability to access data and understand nuances often overlooked in warfare planning.

c. Apply Lessons on Different Battlefields: These lessons learned, combined with data attained from a network which enables NPS to work with NATO partners, places the university in a prime position to develop enhanced understanding of future battlefields. NATO allies not only possess knowledge of Europe, but they enable greater understanding of Southeast Asia and Africa based on historical ties. Enhanced data sets also provide improved data sets opposing AI and potentially Blue AI can be trained.

d.Simulation Agnostic: Enabled by a standards-based environment allowing multiple simulations to interact and efficiently communicate. If NATO CS SIM employs VPN capabilities, combined with the efficiency enabled by a common set of standards, users will be able to employ simulation and data models in a diverse set of machines.

e. There is a growing gap in the ability to develop enhanced models from data gained in training. Experts in military networking and AI are not available to refine the capability and employ this information to sharpen US and NATO warfighters capabilities. NPS long history with military simulations and expertise in behavioral AI modeling can be employed by NATO if a networking link is established. NPS is uniquely positioned as it sits within orbit of academic and industry experts in Silicon Valley; the crossroads of what can be an intersection of immense innovation in LVC simulations.

4. Security:

a.VPN, OpenVPN.net: NPS firewall can inhibit NPS participation. MOVES has been able to do this within a VPN enclave. NPS must work with other DoD organizations to ensure compliance with US and European laws which may inhibit communication.

b.Classification Concerns: NPS must embrace NATO Centrix classification system and standard to enable communication with NATO allies and secure data against threats.

5. Recommendations For NPS:

a.NPS adopt C2 SIM NATO standards to improve simulations interoperability. The future requires enhanced cooperation with allies in Europe and East Asia. Establishing a strong network connection with our NATO allies enables NPS to understand network interoperability standards while enabling greater data sets which incorporates nuanced details.

b.NPS establish formal relationship with JMRC and GSC: Gaining access to the NATO network and allows us adhere to standards, enabling highly effective training, and consequently effective operations. It opens the possibility of NPS students working with NATO aligned universities.

c. Work with Joint US counterparts to ensure compliance. This enables common standards amongst the DoD and other elements of the national security apparatus.

d.NPS must strengthen partnerships with Silicon Valley. Bring their experts to campus and discuss simulations.

e.Allows NPS to serve at forefront of modeling and simulation interoperability standards, and positions university to inform larger technology community in Silicon Valley

f. NPS must adopt a Centrix connection: This enables true sharing of data, and enhanced security.

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NATO short course, MSG-194 Technical Course (Virtual)- Employing the C2-Simulation Interoperation (C2SIM) Standard for Coalition Military Operations and Exercises, 24-25 FEB 2021.

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- <https://c4i.gmu.edu/c4ifiles/MSG145/MSG145-short-web.mp4>
- https://www.youtube.com/watch?v=3L_Hhxuh6Zc

Naval Postgraduate School



Calytrix CNR-Sim and DIS Voice Interoperability Improvements
Summer Quarter AY-2021

Captain Matthew Robinson & Captain Max Schlessel
MV3500: Internetwork Communications and Simulation
Professor Brutzman
09 September 2021

Calytrix CNR-Sim and DIS Voice Interoperability Improvements

Purpose: To explain the importance of reliable communications for training simulations and achieve a better understanding of the capabilities of distributed interactive simulation (DIS) voice found in Calytrix Comm Net Radio (CNR).

Background: The reliability of communications is paramount in training simulations, whether they are aircraft, infantry, or combat convoy simulators. Radio communication simulators perform two crucial tasks for military trainees. The primary task is that the simulators bolster the overall fidelity of the training simulation and make it more realistic to reality. An example would be using headsets for internal and external radio communications within a vehicle simulator such as an aircraft, tank, or amphibious assault vehicle (AAV) simulator. A secondary but equally important task of radio simulators is that they can provide an interface for infantry simulators that do not have the mechanical interfaces of the vehicle simulators. An infantryman interfaces directly with the real world except for his rifle scope or radio, which is difficult to replicate in a simulator such as an interactive synthetic environment (ISE). A radio simulator provides an interface to increase the realism and higher confidence in a scenario as the infantryman uses the radio to conduct tasks within the ISE.

There are many competitors in the area of radio communication simulators. Virtual Battlespace (VBS) by Bohemia Interactive, Advanced Simulation Technology Inc. (ASTi), and the Joint Network Emulator (JNE) in addition to Calytrix CNR are all contracted by the DoD to provide radio simulators and interoperability across various training simulators. There are also several commercial-off-the-shelf (COTS) applications available which largely serve the gaming community. Such COTS software includes Discord, TeamSpeak, Mumble, and Razer Comms, all of which are primarily dedicated to the gaming community and offer some extent of interoperability with games. Lastly, legacy programs like Skype and Zoom support radio communications for industry.

Many of the government contracted radio simulators use DIS-voice or high-level architecture (HLA) to achieve interoperability across platforms or even just between different users. The COTS software largely uses voice over IP (VoIP) to achieve radio communications. VoIP largely fails to provide the level of interoperability that can be achieved with DIS or HLA.

Discussion: The advantage of CNR is described as: “Real radios are expensive, difficult to obtain, need to be secured and require ongoing maintenance. CNR-Sim provides the alternative

solution to using real radios for communications training.” CNR offers a software development toolkit (SDK), a skin simulator for radio training, a log application to record radio transmissions, a monitor for training cadre, and several other tools to accommodate radio training as well as other simulation training. It can be used in conjunction with VBS, SWORD, VR-Forces and Calytrix’s proprietary ISE named Titan Vanguard, and is not limited to certain programs but can successfully run in the background and be used in any simulation with quick and simple setup. It greatly improved interoperability with VBS and proved more reliable and of higher radio quality than the internal VBS radio simulator. CNR’s flexibility across so many platforms makes it uniquely capable among all other radio simulators.

CNR is also exceptional in that it uses both DIS and HLA to achieve interoperability across platforms and within its own software. Prior to version 6.0.0, CNR only offered DIS interoperability, but with the release of 6.0.0, it offered in all of its applications native support for HLA and the Real-time Platform Reference Federation Object Model (RPR-FOM). Users were able to configure CNR to transmit/receive on either HLA or DIS. Such a system not only offers redundancy for increased reliability and quality but the ability to interoperate with many different simulations.

Recommendation/Actions: The Naval Postgraduate School (NPS) Next program can have tremendous outreach across the DoD with our findings:

1. Use NPS Modeling Virtual Environments and Simulation (MOVES) to explore redundancy on any simulation. Since the MOVES institute has access to many of the DoD’s simulations, try to recreate what CNR does with offering HLA and DIS in the same simulation. For radio simulations, explore redundancy with HLA, DIS, and VoIP.
2. There is an Orlando office for Calytrix and the potential for a partnership between Calytrix and NPS. The Marine Corps contracts Calytrix to provide CNR for its simulators, and a partnership can help to bolster not only Marine Corps simulations, but further research in the field.
3. One area of future research as possible thesis topics could be how radio communications affect the fidelity of simulations. A method to achieve this would be to operate an ISE with radio communications and without (simply talking to other participants in the room) to explore the possibility of a positive training effect when using interoperable communications such as CNR.