Marine Forces Pacific
Experimentation Center

"Innovation in the Pacific"

April 2002

Experimentation Center Initiatives

Page 2	**Platform for Innovation - The Marine Forces Pacific Experimentation Center** *(Reprinted and updated from "Innovation in the Pacific," October 2000)*	**BGen J. Castellaw, Shujie Chang**
Page 4	**Language Translation Efforts at Marine Forces Pacific Experimentation Center**	**Katherine P. Lunsford, GySgt Robert Turner**
Page 7	**Information Assurance and the MARFORPAC/DARPA Partnership**	**GySgt William Rybczynski, Major Richard Wolf, Brian Witten**
Page 9	**Marine Corps Project Albert - Leveraging High Performance Computing to Support the Warfighter**	**Dr. Alfred Brandstein, Bruce Duncan, Dr. Gray Horne**
Page 11	**Sensors and Logistics Information Systems**	**LtCol James B. Eusse, Major Franklin McLain, Major David A. Runyon, Daniel J. McCambridge, Jessica Hiraoka**
Page 16	**Pre-First in Command and Control System (Pre-FICCS) Initiative - A Partnership for Progress**	**Gordon Mattis, Cliff Ayer**
Page 18	**Fuel From the Sea**	**CWO4 Dave Ray, CWO4 Mike Giambruno, Mark Miller**
Page 21	**Republic of Korea Marine Corps (ROKMC) JP-8 Fuel Interperability Evaluations**	**Greg L. Philips, CWO4 Dave Ray**

Deputy Commander's Comments

It is my pleasure to update you on our experimentation activities at Marine Forces Pacific (MARFORPAC). Since our last publication, the Force Warfighting Lab (FWL) has been renamed the MARFORPAC Experimentation Center (MEC). This change better reflects our efforts and focus on experimentation. The MEC is responsible for testing and experimenting with advanced technologies that are relevant to MARFORPAC. Experimentation will help validate our requirements and allow us to play a more pro-active role in the science and technology (S&T) and acquisition process.

I am happy to report that we have made significant progress since our last update. We completed our first major logistics experiment during Exercise Foal Eagle 00. Our forces successfully tested an advanced fuel delivery concept by delivering over 35,000 gallons of JP5 fuel from 25 miles offshore to a tactical fuel farm on the beach. Results from this experiment provided valuable lessons learned to the bulk fuel community in regards to our capabilities and shortfalls.

With the help of our key partners throughout the science and technology community, we continue to establish new initiatives in Command and Control, Expeditionary Logistics, Modeling and Simulation, Information Assurance, and Language Translation. We are currently planning to conduct major experiments during several of our exercises this year. During exercises Reception, Staging, Onward Movement & Integration (RSO&I) 02 and Ulchi Focus Lens (UFL) 02, we will experiment with the latest information assurance technologies to ensure that our computing systems are safe from intruders and viruses and at the same time flexible enough to receive the relevant information essential for mission accomplishment. During Cobra Gold 02, we will experiment with radio frequency identification tags to provide web based asset visibility information to commanders throughout the theater. During Cobra Gold 02 and UFL 02, we will experiment with Thai and Korean language translation technologies to improve interoperability with our coalition partners.

As we reflect on our efforts and accomplishments, we must not lose sight of the great challenges that lie ahead. We continue to solicit valuable input from the Marines, Sailors, and civilian Marines of MARFORPAC, and from the technical community. I encourage each and every one of you to bring to our attention additional ideas and ways for us to improve our warfighting capability.

John G. Castellaw
Brigadier General, USMC

Platform for Innovation
The Marine Forces Pacific Experimentation Center

(Reprinted and updated from "Innovation in the Pacific," October 2000)

BGen John G. Castellaw, Marine Forces Pacific
Shujie Chang, Marine Forces Pacific

The United States Marine Corps (USMC) over the years has established itself as among the world's greatest innovators. From the concept of forcible-entry amphibious assault to close air support/vertical envelopment to now Expeditionary Maneuver Warfare, the Marine Corps has continually sought better and more efficient ways of improving its warfighting capability. Keeping up with this culture, Marine Forces Pacific (MARFORPAC), under LtGen Krulak's leadership, developed a concept for innovation in the Pacific Theater. This concept was based on establishing a platform where innovative ideas from Marines, Sailors, and civilians can be rigorously assessed, evaluated, tested, and analyzed. This concept of innovation was later established as the Commandant's Warfighting Lab in Quantico, Virginia to "serve as the focal point of warfighting innovations…" (ALMAR 305/95) The Commandant's Warfighting Lab has since been renamed the Marine Corps Warfighting Lab (MCWL).

In the meantime, MFP established the Force Commander's Warfighting Lab (FCWL) in 1996 "to engage the operating forces in the process of change, providing 'forward presence' to the Commandant's Warfighting Lab." In 1998, the FCWL was renamed the Force Warfighting Lab (FWL) and a charter was developed and signed by LtGen Carlton Fulford. The FWL was renamed the Marine Forces Pacific Experimentation Center (MEC) in 2001 to reflect our emphasis on experimentation.

MEC Operations

The principal mission of the MEC is to serve as the focal point for innovation by Marines, Sailors and civilians throughout the Pacific and Central Theaters. The MEC receives ideas from Marines, Sailors and civilians, especially at the junior levels, and get the right people involved to work on the initiatives. To succeed, we have to involve the requirements, scientific, and acquisition communities at early stages of the initiative.

A fundamental philosophy of MEC operations is that we leverage off of the numerous efforts underway in the Science and Technology (S&T) community. Therefore, it is imperative that we form early partnerships with the S&T community, such as the MCWL, Office of Naval Research (ONR), Defense Advanced Research Projects Agency (DARPA), and Navy laboratories and centers. It is a solid partnership with each focusing on its strength areas - the technical community provides technical expertise and funding while the operational community articulates true warfighter requirements and provides experimentation platforms in the form of exercises.

Though innovation is not prone to processes, the methods of accepting ideas and initiating projects are. Figure 1 shows the process of how requirements are developed, technologies identified, and experiments conducted. The first step is to establish the requirements through the Command Capabilities Issues (CCIs) process. The Science Advisor leads development of the CCIs and the Commander approves the final list. It is a compilation of MARFORPAC's most critical requirements that can be solved by technology. This list is then submitted to OPNAV N091 for consolidation into the Navy's list of CCIs.

Using the CCIs as a baseline, we solicit the technical community for technologies that they are currently working on that may directly or partially meet our needs. If a fit is identified (technology with requirement), then we invite the technical sponsors to participate in MEC activities. If agreed, then a focus team is stood up comprised of operational and technical experts. The focus team has the job of developing technology prototypes and/or models for experimentation, identifying the appropriate test platforms, developing objectives and metrics, and ensuring that all advanced planning requirements are met. Normally the purpose of the experiment is not to test the soundness of the technology, but rather to test the technology's ability to perform in an uncontrolled environment within our concept of operations. During testing, the focus team, with assistance from the Center for Naval Analyses (CNA), will perform rigorous assessments based on our tactics, techniques, procedures, and systems. Results from this experimentation and assessment allow us to better understand and articulate our requirements for handoff to the requirements and acquisition communities.

Progress to Date

In over 4 years since the signing of the charter, we have made much progress. Our first project, the ONR-sponsored D-Day Mobile Fuel Distribution effort, was successfully completed during Foal Eagle 00. This initiative was executed by our Petroleum and Water Logistics focus team, which includes fuel officers from MFP HQ, I MEF, III MEF, and engineers from the Naval Facilities Engineering Services Center (NFESC).

During UFL 00, we were able to perform a preliminary test on the DARPA-sponsored English to Korean PowerPoint Language Translator. Results showed that the translation worked well for the bullets within the presentation; however, there is still much work to be done in translating the notes sections.

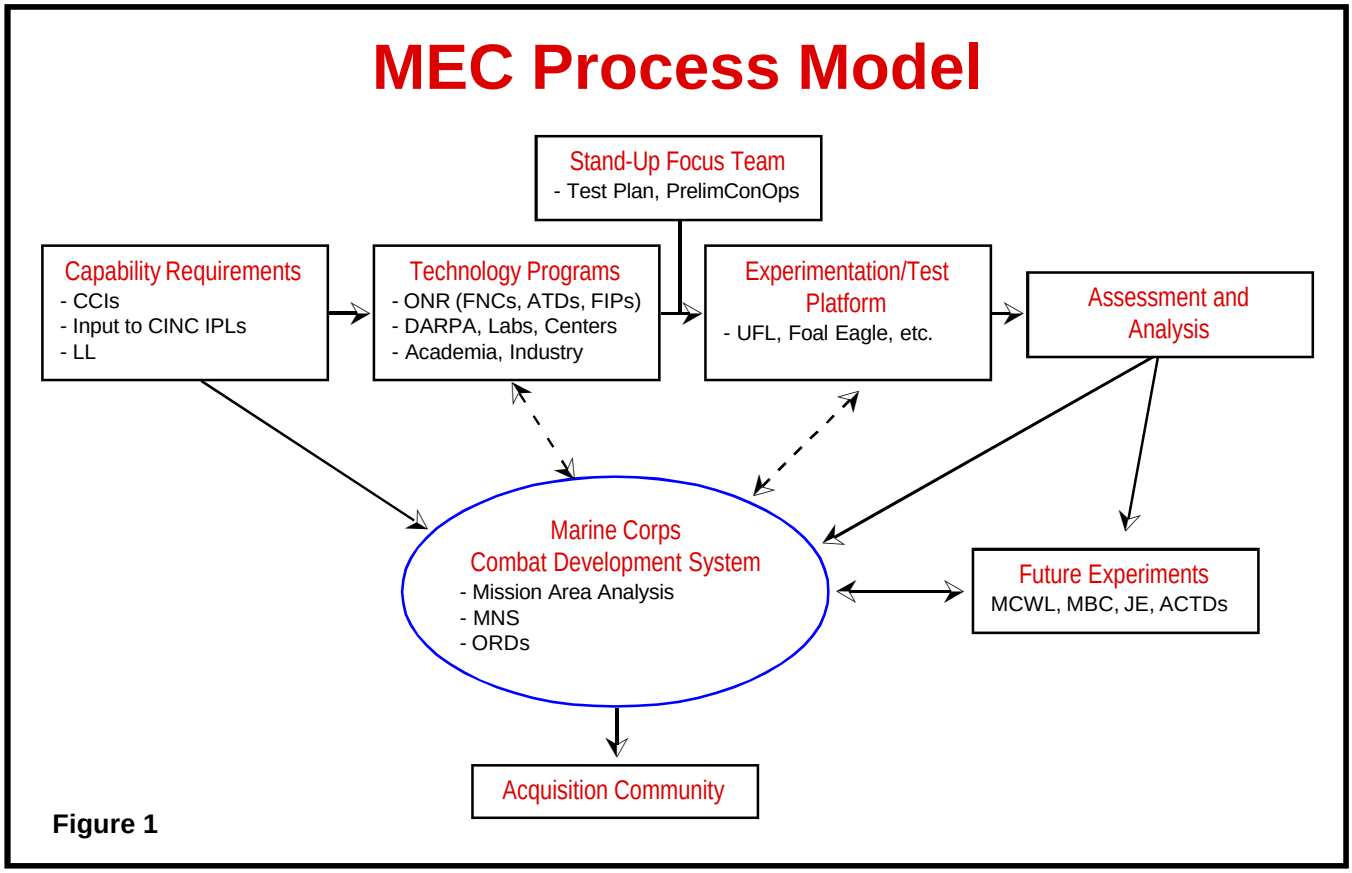


Figure 1

We currently have plans to conduct major experiments during some of our exercises in FY 02. During Exercises Reception, Staging, Onward Movement & Integration (RSO&I) 02 and Ulchi Focus Lens (UFL) 02, we will experiment with the latest information assurance technologies to ensure that our computing systems are safe from intruders and viruses while maintaining the flexibility to receive relevant information to accomplish the mission. During Cobra Gold 02, we will experiment with radio frequency identification tags to provide web-based asset visibility information to commanders throughout the theater. During Cobra Gold 02 and UFL 02, we will experiment with Thai and Korean language translation technologies to improve interoperability with our coalition counterparts.

Conclusion

LtGen Rhodes stated in his January 1998 Marine Corps Gazette article "Every Marine an Innovator," "It is essential that we engage the entire Marine Corps; all hands can and should participate in the process." The MEC is one avenue for which MARFORPAC can participate through aggressive experimentation to better articulate our requirements.

Our challenges are many. First, we must formalize the relationship between MARFORPAC and the S&T organizations. The MEC can act as a champion of the warfighters in the S&T community and an educator to staff members of the Research, Development, Test, and Evaluation (RDT&E) process. We seek to improve the interaction and coordination between the researchers and the Pacific Marines. Second, we must promote innovation and innovation within our subordinate commands. Our best ideas are yet to come and they will likely come from the junior ranks. We must get the word out that there is a platform for innovation and that it will support their ideas. Lastly, we must harness S&T dollars for innovation. It is extremely difficult for an operational command to secure new S&T dollars; however, it is much easier to help redirect existing dollars towards our needs. Therefore, it is essential that we partner with the S&T community to articulate our requirements and to ensure that the dollars being spent will truly meet our expectations.

In view of the magnitude and dynamics of the task at hand, the MEC activities are not intended to address all the problems. But rather, they are intended as a platform that will promote innovative thinking, analysis, and understanding of our requirements.

The challenges mentioned above are difficult, but not insurmountable. However, a dedicated, coordinated, and concerted effort on the part of MARFORPAC, its subordinate commands, and the scientific and acquisition communities will be necessary. It is a full commitment of resources, time, money and manpower, which must be undertaken to achieve the objectives that make the Marine Corps a more capable fighting force.

Language Translation Efforts at Marine Forces Pacific Experimentation Center

Katherine P. Lunsford, Marine Forces Pacific
GySgt Robert Turner, Marine Forces Pacific

The U.S. military must operate worldwide in a variety of international environments where different languages are used. There is a critical need for translation, and there is a shortage of translators, particularly translators who can correctly interpret military terminology. To address this need the Marine Forces Pacific Experimentation Center (MEC) is investigating various types of language translation devices.

Background

The simplest kind of language translation device is a card with pictures. Communication occurs by pointing to the pictures and gesturing. The next level is a small computer that can repeat pre-recorded phrases in a desired language, such as Korean or Thai. The free speech type of language translator, where an operator speaks into a computer and the computer says the given phrase in a given language is the least mature type of machine language translation. Development of these types of language translators is being conducted at various universities, laboratories, and industry. In order for a computer to correctly interpret language, artificial intelligence is required.

Matching Expectations with Capabilities

Language translators in general suffer from overly high expectations. The average user expects a translator capable of immediately interpreting any phrase, including slang and acronyms. The reality is that the majority of machine language translators cannot provide much more than a clever artist can get by drawing pictures and using sign language. A language translator is nothing but a tool and, like any tool, works best when used for what it is designed for. The best use of a language translator is as an electronic dictionary; i.e., a trained linguist using a translator to know how to say "semi-conductor." The machine language translators cannot necessarily assist a person who does not speak the language to say, "Afghanistan does not have a semi-conductor capability." However, if the user is willing to accept the inherent limitations of this technology, machine language translators will be of value to the operating forces.

Machine language translators also suffer from the fact that different languages are built on different assumptions. For example, consider the question, "Country X is not attacking?" with a reply of "Yes." That "yes" in English can mean, yes, Country X is attacking. However, that same yes in Korean means, yes, your last statement is correct, Country X is NOT attacking. Another example is the word "compromise." Compromise in English carries a very positive connotation. It means that you are a reasonable human being who is willing to meet the other person halfway. The word in Korean, however, carries a negative connotation. It means that you are not strong enough to meet the challenge and must back down. The statement "I compromised" in Korean leaves the listener with the impression that the speaker was defeated. Another problem with language translators is that effective communication depends on non-verbal signals, but these signals are usually very different in other parts of the world. For example, in English looking somebody in the eye means that you are honest, but looking an older or higher ranking Korean in the eye is extremely rude; it means that you are challenging his authority. Putting one's finger to one's lips in both America and Korea means, "keep quiet," but in America it also means, "keep this a secret." This additional meaning is absent in Korea.

On-Going Efforts

The MEC will be testing three language translators this fiscal year. The translators include two machine language translators, the DARPA One-Way Phraselator and the Integrated Wave Technologies (IWT) Voice Response Translator. The third type is called the Kwikpoint International Translator.

DARPA One–Way Phraselator

The objective of the DARPA One-

DARPA One-Way Phraselator

Way is to develop a robust voice-to-voice phrase translation system (PTS) for use by military operational forces. When an English phrase is spoken into the system's microphone, speech recognition software matches the input phrase with prerecorded translation, which is in turn played back through a speaker. For example, a Marine could ask: "Show me your identification." The system would then produce the proper output phrase in the target language such as Farsi or Arabic. The responding individual could then give a simple yes/no voice response or use head or hand movements to answer or produce the required documentation. DARPA One-Way is primarily for one-way translation from English to another language.

The units to be tested will be ruggedized personal data assistants (PDA). The units will include application software, computer hardware, custom microphone/speaker, and phrase module builder and database management software.

Current modules include a baseline phrase including introduction, date and time, and numbers. There is a module for military police including force protection and area security. The third module is geared for the medic with phrases for medical assessment and exam commands. The medic module is used by corpsmen to treat indigenous, non-English speaking casualties. These modules are currently translated into Korean, Cambodian, Chinese, Tagalog and Russian.

It is possible for most any user - male, female, or accented - to have good recognition accuracy with no system audio voice adaptation. With minimal voice adaptation (i.e., ten phrases) accuracy is further improved.

A new user can be trained in the basic use of the DARPA One-Way in less than an hour as a result of the simplified user interface and system functionality. Power users who would develop and build their own phrase modules can be trained in less than a day.

Approximately 50 units will be received from DARPA, once manufacturing is complete. The units will be deployed to Cobra Gold 02 and Ulchi Focus Lens (UFL) 02. The units are to be used by both Marines and Naval Construction Force (NCF) personnel. The units will be distributed to III Marine Expeditionary Force (III MEF) and the 3rd Force Service Support Group (3rd FSSG). The units distributed to the Marines will be used to support force protection, area security, and medical support. NCF personnel will build modules to support construction and contingency contracting in support of the exercises.

Integrated Wave Technologies Voice Response Translator

The IWT Voice Response Translator is a compact device (4" x 6" x 5/8") capable of repeating pre-programmed phrases in selected languages. The device fits in a shirt pocket and uses a clip-on microphone and built-in speaker. Its battery life is 12 hours of continuous use, and up to 20 hours of standby time. In addition, the unit has an adapter that uses standard military batteries, size "AA" batteries, and a cigarette lighter.

The Voice Response Translator operates by responding to predetermined key words. These key words trigger pre-programmed phrases synthesized in the desired language. The complexity of pre-programmed phrases is based solely on the user's needs. This pre-programmed association gives the appearance of translating words and phrases.

This device effectively translates in one direction only. A series of aids may be developed to assist in non-verbal communication (hand signals, signs with generic colors, other objects, etc.) from the 'foreigner' back to the device operator.

The software for this device would be organized in accordance with the predetermined phrases supplied by the user. These phrases would reflect different scenarios in which the device would be used. For instance, given a multinational peacekeeping scenario, one section could be programmed to support medical questions, while another could support administrative matters.

The languages the device supports (or that the user desires) would then be programmed to relate directly to those predetermined phrases. While the memory chips used by the device are fairly compact, the device has a large capacity for data. For instance, if the desired capability consisted of 10 modules with 50 phrases per section, the device would be capable of supporting as many as 40 languages or dialects.

The software must be trained in the operator's voice. The units can be programmed with up to eight different

IWT Voice Response Translator

user profiles. Any of the user profiles can be reprogrammed. The operator must repeat a series of key words when prompted by the device. Training the software takes approximately 30 minutes, depending on the number of phrases, and is fairly effortless.

Currently the Voice Response Translator contains Dari-Persian and Serbian. The developer is adding additional modules and additional languages. Construction and contingency contracting modules are being developed. Additional languages include Thai, Korean, and Japanese.

The IWT Voice Response Translator and the DARPA One-Way Phraselator will both be tested in Cobra Gold 02 and UFL 02. They will also be tested for Japanese and Arabic translation capabilities.

Kwikpoint International Translator

The Kwikpoint is the simplest technology of all the language translation devices being tested. The Kwikpoint International Translator is a laminated, five-fold card with various pictures. It can be used by two individuals by pointing and gesturing at the pictures. Because it is about the size of a passport, it will fit into any number of pockets on a military uniform.

Kwikpoint is a picture card featuring color illustrations designed to help communicate. It is easy to use – users just point to a picture indicating what they want to communicate. Kwikpoint's visual vocabulary will help you when you eat out, find accommodations, need directions, have car problems, or need medical help. The version being developed for the MEC will include various military symbols including military vehicles, aircraft, and weapons. There is also a section for identification of individuals, with pictures indicating features such as facial hair and skin tone. The military version will also contain the flags of the countries located in the Pacific and Central Command areas of operations.

Language Translation Requirements Definition

Each of the language translators will be tested by Marines and Naval Construction Force (Seabees) during Cobra Gold 02 and UFL 02. The object is to provide a capability to warfighters in the arena of communication with local nationals. By using the translation devices, the requirements for the final version will be further defined and refined. Feedback will be provided to the developers to further refine the technologies to meet the warfighter's needs.

Kwikpoint International Translator

Information Assurance and the MARFORPAC/DARPA Partnership

GySgt William Rybczynski, Marine Forces Pacific
Maj Richard Wolf, Marine Forces Pacific
Brian Witten, Defense Advanced Research Projects Agency

Recently our information infrastructure has come under increasing attack and warfare has moved beyond the physical realm of mud, rain, bullets and bombs, to the less visible domain of "cyber war." Here in the realm of complex computer systems and networks is where we find a new breed of warriors, the "cyber warrior," slugging it out against an often invisible adversary intent on bringing down our critical command and control infrastructure. Today it is the "info warrior," armed primarily with computers, who must carry out a cyber mission against a determined enemy who is shrouded in the shadows of a diverse and extremely complex web of computers and networks. In the future much like today these info warriors will defend our sensitive command and control networks against a flurry of enemies who capitalize on virus attacks, Trojan horses, and a host of other vulnerabilities. And, with the ever increasing interdependence and intertwining of information and physical infrastructures our vulnerability to attack is likely to increase. It is no longer important for an enemy to be in close physical proximity to a target for an attack to be successful. Now our adversary must only possess the requisite tools and the knowledge to mount a network attack against or exploit critical command and control vulnerabilities that can temporarily disrupt telecommunications, power production, transmission, etc. Subsequently, the importance of maintaining an expertly trained and highly equipped team of info warriors becomes increasingly critical to the survival of our nation. It may ultimately be these individuals, the info warriors, who determine the outcome of future conflict.

Operationally Flexible and Operationally Reliable Systems – The Keys to Success

Future conflict will likely continue to reach beyond the physical regions of air, land, and sea. We may find that here within "cyber space" is where we experience the greatest threat to national security/survival. Unfortunately, our joint vision of information driven warfare is asymmetrically vulnerable. Cyber-war is an attractive option for many adversaries, ranging from terrorist groups to well resourced nations/nation-states. In response to this challenge the Defense Advanced Research Projects Agency (DARPA) began a long-term research program many years ago. Much of the effort expended by DARPA and its subsequent research and development is now coming to fruition. However, lab-based research alone has never constituted progress. Getting these products in the hands of the warrior has been and continues to be the ultimate goal. It is here that these concepts and products are proven and it is where the confidence in them is established so that they can be used where and when they are needed. This is why DARPA and Marine Forces Pacific (MARFORPAC) have partnered together to explore the operational effectiveness of various advanced technologies.

DARPA Information Assurance Program

In 1997, DARPA embarked on an ambitious program of research and development to prepare for America's future cyber war. Known as *Information Assurance (IA)*, this program was designed to reduce the risk to DOD systems and more importantly to reduce the risk to future information technologies currently on the DARPA drawing board.

The driving strategy behind the IA program has been and continues to be how to create trustworthy systems from what may be less than trustworthy components. Information driven warfare currently requires the kind of functionality and performance only offered by somewhat imperfect commercial off the shelf (COTS) technology. Due to the size and complexity of our information systems it is certain that we will continue to have vulnerabilities throughout the DOD. This is true even with those systems that are strictly military. Moreover it is the constant and rapid change of information systems, ever-changing mission requirements, and the continued likelihood of "come as you are" conflict that serves to underscore the need to rapidly compose a flexible but trustworthy system from this mixed bag of less trustworthy components.

The key to the IA program has been the process of scientific experimentation to rapidly explore the many "dark spaces" of IA which have traditionally received scant attention from either commercial and/or government researchers due to complexity, cost, and other reasons. This broad search has helped focus efforts on high leverage technologies and appropriate strategies for composition.

Several of these technologies are now beginning to show promise. Many were presented or demonstrated at the recent "DISCEX II" conference (http://www.iaands.org/discex_II/) in Anaheim, CA during June 2001. With lab successes under their

belt, DARPA began to interact with operational activities in hopes of both accelerating transition of these technologies as well as getting timely and valuable operational feedback in order to improve research and development. The operational organizations include several PACOM commands. With strong relationships emerging for field evaluation of this research, DARPA officially restructured the IA program into an Operational Partners in Experimentation (OPX) program for studying performance of these technologies in the field and accelerating transition.

The MARFORPAC / DARPA Partnership

Two years ago MARFORPAC began a dialogue with DARPA regarding IA for Marine Corps units within the Pacific area of operations (AOR). In July 2000, BGen Castellaw met with DARPA's Dr. William Mularie and discussed a list of MARFORPAC IA concerns. BGen Castellaw and Dr. Mularie agreed that their staffs would continue discussions to examine ways in which DARPA IA technologies could be applied to MARFORPAC concerns. Follow-up discussions took place in December 2000 and the two sides agreed to establish an Information Assurance Focus Team (IAFT). The first IAFT meeting was held in March 2001 and is now developing plans to transition specific technologies to the operational forces. Two initiatives are on the drawing board.

Hardened Client Laptops.

The initial hardened client laptop effort will address MARFORPAC concerns about protecting laptop computers and the information contained on laptop storage media while users are on travel status. Concerns included providing:

- Protection from attack and identification of an intrusion or attack.
- Protection of information stored on laptop hard drives.
- Protection from malicious email.

As we go to press for this issue, MARFORPAC and DARPA are engaged in technical interchange discussions to finalize details of the hardened client laptop plan. Many milestones for the plan have already been agreed to. For example, an initial version of the plan was presented by DARPA to MARFORPAC during the first week of May 2001. MARFORPAC has also received an initial prototype laptop for familiarization and a Limited Objective Experiment (LOE) will be conducted during exercises Reception, Staging, Onward Movement & Integration (RSO&I) 02 and Ulchi Focus Lens (UFL) 02 with less than a dozen of the hardened client laptops. DARPA will provide the laptops for the LOE so that the originals may be kept as back ups and so that integration and testing phases do not interfere with other operational requirements. The LOE is envisioned to be an initial operational experiment before using the hardened client laptops in a major exercise next year.

Information Design Assurance Red Team (IDART) Training.

IDART assessments evaluate projects and programs for system vulnerabilities in the areas of information warfare, information assurance, and information surety. Established by Sandia National Laboratories, assessments are intended to provide feedback for improvement of systems, to provide awareness of residual vulnerabilities, and to allow for procedural mitigation of remaining vulnerabilities. As part of the MARFORPAC/DARPA cooperation, DARPA arranged for three MARFORPAC technicians to receive training on the IDART methodology in October 2001. These technicians are now in a better position to perform self-evaluation of MARFORPAC systems and train others as necessary.

MARFORPAC Information Assurance Team

For further information regarding MARFORPAC IA please contact any of the following:

Ms. Susan T. Elliott
Information System Security Manager
elliottst@mfp.usmc.mil
DSN 315-477-8884

Mr. Jan T. Hiranaka
Defense Information Operations/IA
hiranakajt@mfp.usmc.mil
DSN 315-477-8492

GySgt William H. Rybczynski
MFP Network Security Chief
rybyczynskiwh@mfp.usmc.mil
DSN 315-477-8304

Marine Corps Project Albert
Leveraging High Performance Computing to Support the Warfighter

Dr. Alfred Brandstein, Marine Corps Combat Development Command
Bruce Duncan, Maui High Performance Computing Center
Dr. Gary Horne, MITRE Corporation

United States Marine Corps Project Albert, named after Albert Einstein, seeks to advance the state-of-the-art in modeling, simulation, and analysis of questions important to the Marine Corps and collaborators around the world. It was initiated because of deficiencies of existing tools and techniques to assist warfighters in answering many of the questions important to them. The inadequacy stems from two different root causes. The first is the failure to take into account three phenomena inherent to warfare: non-linearity (e.g., small changes in capability can lead to large changes in combat effectiveness), intangibles (e.g., leadership, bravery, morale), and co-evolution (e.g., changing plans based on what the commander thinks the enemy thinks). The second cause is the inadequacy of the available tools themselves. For example, for simulations there is difficulty knowing when a sample is representative; for analytic models there is a lack of confidence in the underlying algorithms and instabilities in their executions; and for wargames there is difficulty in making them reproducible and in dynamically extracting the thoughts in order to support decision makers.

Project Albert has undertaken to ameliorate the inadequate support to warfighter questions described above. The questions are longstanding and difficult, so innovative officers and scientists have been tapped from around the world to begin to develop the meta-structure to provide this support. The particular approaches chosen will generally depend on specifics of the particular question at hand. The questions range from tactical to operational to strategic and an example of a generic question that cuts across the full range is: when should command and control be centralized? As an example of a specific effort, Project Albert is working with Marine Forces Europe to examine questions involving force protection by means of merging high performance computing with information dissemination and collection assets. Other question areas were examined at two recent Project Albert working sessions, one a joint working session on Military Operations on Urbanized Terrain (MOUT) and the other an international session on counterterrorism. And Project Albert has begun to explore other areas where the maturing infrastructure of tools and techniques may be of help to warfighters in Marine Forces Pacific.

Our intent is to employ these tools and techniques where they may apply, but not to force them on questions that are not amenable to them. Where there is a match, three major thrusts are common to our attacks on questions.

(1) The use of a special class of agent based models we call "distillations." These distillations are designed to capture the essence of a situation seen from the point of view of the decision maker as well as represent the phenomena of interest. As of now, we are using four different distillations: ISAAC, MANA, SOCRATES, and PYTHAGORAS. The richness of our models enables the exploration of a wider variety of questions.

(2) The use of super-computers and massively parallel machines. In order to capture non-linearities and emergence as well as to explore multi-variable parameter space, the use of supercomputers is essential. Data farming is used to both create and mine data of interest and to extract information for our synthesis methods. (More information on data farming can be found in reference *Maneuver Warfare Science 1998* published by MCCDC.)

(3) Operational Synthesis is our process for merging all the tools and data so as to better address providing the decision maker with the support he needs. (More information on Operational Synthesis can be found in *Maneuver Warfare Science 2001* published by MCCDC.)

The Maui High Performance Computing Center (MHPCC) is providing computing and applications support services to Project Albert. MHPCC is supporting the development of the infrastructure to leverage the high performance computing power organic to MHPCC. Data farming and advanced visualization methods are also being researched. Today's military operational environment has added new complexities to the understanding, doctrine, and execution of combat operations. This is particularly true with the many new emerging missions such as homeland defense, humanitarian assistance, peacekeeping, and urban warfare. Due to its high degree of participation in such missions, the Marine Corps is interested in exploring new technologies and methods to increase its understanding and effectiveness in these areas. The Marine Corps Combat Development Command (MCCDC) located in Quantico, Virginia has been exploring innovative methodologies in reaching this understanding, including:

- Wargaming. The injection of the human decision process under a controlled set of circumstances in the understanding of a question.
- Deterministic Models. Closed formed models of a situation providing most likely outcomes for force-on-force engagements, usually based on a set of mathematical equations.
- Distillations. Abstractions of a situation, concentrated on

Figure 1. Depiction of Project Albert tools

intangible influences of the system, such as unit cohesion, aggressiveness, and other human factors. Success in combat depends largely on the capability of military leaders to make and execute effective decisions under physical and emotional stress.

MCCDC believes that no single methodology will ultimately provide the answers needed to completely address the complexities of this environment. Accordingly, MCCDC has been researching ways of combining the methodologies and extracting relative information from one system to help drive another. Figure 1 is one vision of how Project Albert tools may support warfighting decision-making as the tools and techniques mature. The two men depicted are computer avatars that are the vehicle to communicate information and identify relationships from the data produced by the models. One avatar, "Chesty" (the Marine), explores the data from a friendly perspective and ensures that the decision maker is aware of potential outcomes and consequences of applying various Courses of Action (COA's). The other avatar is an amalgamation of potential enemies and provides inputs to the decision maker regarding recourses an enemy might make given a particular action.

Project Albert has begun the exploration of warfighting questions using simulations in new and innovative ways to study the possible application of these relatively new technologies and to understand evolving data relationships produced by them. The distillation models used in the research are based on cellular automata models and are applied to military operations. Simple rules within the model are used to express relationships that define the propensity of agents to react with other agents of friendly or enemy forces. These relationships can help define human factors and their influence within the simulation. The factors that make up these relationships are stochastic, to account for the variability of such relationships. Therefore, it is required that the simulation be run multiple times to portray the full range of possibilities within the distillations. Project Albertis varying the rules of human behavior by modeling what could occur on the battlefield. Intangibles, such as unit cohesion, aggression, courage, and leadership are variables in this modeling and simulation project, as are tangibles such as the number of combatants, their firepower, the communication range, and the amount of ammunition. To fully understand operations in a military environment, it is important to understand the effects and relationships resulting from simultaneously changing inputs. Accordingly, MCCDC has employed the new concept of Data Farming, which employs the generation of information by starting with a broad sweep of the parameter space, identifying areas of interest, and then re-running the current simulation, or a more detailed simulation, over a different parameter range.

In summary, MHPCC has been instrumental in helping Project Albert begin to move toward the goal of supporting the warfighter by providing the high performance computing resources necessary to meet the computational demands of the project. The focus is on the overall goal of Project Albert—to create and use innovative tools to help make better maneuver warriors, which includes making real time meaningful support available to the warfighter at all levels.

Sensors
and
Logistics Information Systems

LtCol James B. Eusse, Marine Forces Pacific
Maj Franklin Mclain, Marine Forces Pacific
Maj David A. Runyon, Combat Service Support Group 3
Daniel J. McCambridge, Naval Facilities Engineering Service Center
Jessica Hiraoka, Naval Facilities Engineering Service Center

Introduction

What is the latest buzzword in the world of Marine Corps logistics? Answer: sensors. What's a sensor? Merriam-Webster's Collegiate Dictionary defines a sensor as a device that responds to a physical stimulus (such as heat, light, sound, pressure, magnetism, or a particular motion) and transmits a resulting impulse (for measurement or operating a control).

Simple sensors do simple things. A barcode label may be the most familiar example. That sensor responds to light by providing a data field. Complex sensors can do much more. They can measure equipment operating parameters and perform onboard diagnostics. Complex sensors can contain large amounts of inventory data and enable the enhancement of the management of that inventory. Simple or complex, there is at least one common attribute among sensors. They are absolutely useless unless the data contained in them is transmitted and used by an information system. The proper marriage of sensors, information systems and Marine Corps processes will provide an incredible enhancement to the logistics systems that enable the 21st century warfighter.

This article discusses how sensors and information systems can play in the arena of Marine Corps logistics. The macroscopic vision of the role of sensors and information systems will be described. The programmatic issue of requirements is also addressed. Some specific work that has been performed recently will be reviewed. Finally, a discussion on where the efforts should be directed for future development will be provided.

Vision of ISLIS

The ultimate vision of an integrated sensor/logistics information system (ISLIS) is to track and manage commodities down to the eaches level. There was a description provided at an Automated Information Technology conference not too long ago that discussed how this vision exists in the mind of an executive of a pizza manufacturer. Not the pizza parlor kind, but the frozen kind you buy at the grocery store. It goes like this: Joe grabs a pizza off the frozen rack at the store. That pizza box has a sensor on it. The sensor says "Hey, manufacturer, I was just taken off the shelf at store xyz." Joe goes to the register and pays for it. The sensor, of course, knows that it has been bought and not left to thaw in some non-frozen-pizza-friendly environment in the store. If it were left in such an environment, it would be sending out SOS calls to the store personnel. The pizza goes home with Joe. Let's say Joe is hungry and throws the pizza in the oven instead of the freezer. The pizza sensor knows he's in the oven because he has talked to the oven sensor. The oven sensor is going to cook Joe's dinner so first she (now, it could also be a he) looks in her database to see if she knows this pizza. If she does, she cooks it up for him. If she doesn't, she contacts the pizza manufacturer for updated cooking instructions and off she goes. Joe's eating pizza and drinking beer before he knows it.

There is another thing happening in the background that started when Joe put his pizza in the oven. This is the thing that is driving the manufacturer to invest in this technology. When that pizza sensor knew that it went into the oven instead of the freezer, it told the pizza manufacturer. That bit of data is worth its weight in gold. The manufacturer now can dynamically configure its production process to ensure that it is at its optimum. Make sure there is always a pizza on the shelf for purchase by the consumer and keep your inventory at the lowest point possible. That is the name of the game.

This story is not 100% analogous to the Marine Corps supply chain as a whole. The uncertainties of battle prohibit it. There are, however, parts of the process that do apply, exactly. Can the logistician benefit from having real time data on the identification, location and status of the equipment and supplies all the way from the supply point in CONUS to the foxhole in the battlefield? Certainly. And that benefit to the logistician is directly related to the unit commander's ability to accomplish their mission.

Needs and Requirements

Talk of technology is wonderful but is of little value unless there are needs and requirements against which to develop. The needs have been captured in two Mission Needs Statements (MNS). These are titled Automatic Identification Technology Devices (AIT) (LOG 1.94) and Autonomic Logistics (AL) (draft).

The AIT MNS focuses on improving the "accuracy, timeliness, and handling of combat service support and base support data." Data is currently inaccurate, untimely, and handled poorly. The use of AIT can obviously improve these deficiencies. As stated in the MNS, "AIT encompasses a variety of read and

write data storage technology that can be used to improve the accuracy, timeliness, and handling of combat service support and base support data. These technologies include barcodes, magnetic strips, integrated circuit cards, optical memory cards and radio frequency identification tags." Past research in this area has clearly demonstrated that AIT can better capture, handle, and push data.

Data collected by AIT is useless unless acted upon to provide information for unit commanders. The draft AL MNS states that "In order to reduce the logistical footprint and implement future warfighting concepts, [combat service support (CSS)] elements will require access to accurate, real-time, mission critical information relating to the various elements and equipment of the MAGTF … AL … devices will collect and transmit mission critical data to a central point within in the MAGTF … then be parceled to the MAGTF's command and control and CSS applications."

Developing requirements is a critical component in technology development. The Naval Facilities Engineering Service Center (NFESC), through funding from the Office of Naval Research (ONR), has been working with the fleet Marine Forces to develop requirements. This process has included work in the laboratory and the field. The discussion following involves some of the projects that are pushing the development of this technology towards meeting the requirements.

Pushing the Envelope

There are two areas in which sensor technology and information systems have recently been developed and investigated by NFESC for the purposes of bringing these capabilities to the fleet. Discussed in order are an MPF radio frequency identification demonstration and a shipboard asset location test.

CSSG 3 MPF RFID Demonstration

In January 1999, NFESC was funded by ONR and the Naval Science Assistance Program to bring radio frequency identification (RFID) technology to the field under an operational environment. This work is described briefly in an issue of the Force Warfighting Laboratory newsletter[1] and in more detail in an after action report[2]. During the effort, RFID technology was overlaid on an MPF exercise that CSSG 3 was conducting. The objective was not to interfere with the operations but to show the users how the technology can enhance the MPF process. This effort was termed a limited technology assessment. Lessons were learned and documented in the after action report. These lessons were used to provide enhancements to the RFID system that was used and bring it out again with the goal of leaving it as a residual for CSSG 3 in future operations. This second deployment occurred in August 2001 and was termed a technology demonstration.

During the August demonstration, CSSG 3 conducted a unit exercise. As an augmentation to that exercise, an MPF offload operation was simulated. NFESC took this opportunity to demonstrate the RFID system with CSSG 3 and train the Marines on the system.

The RFID system was set up to provide identification data about the Principle End Items that were used during the simulation. RFID tags were applied to the vehicles (Figure 1).

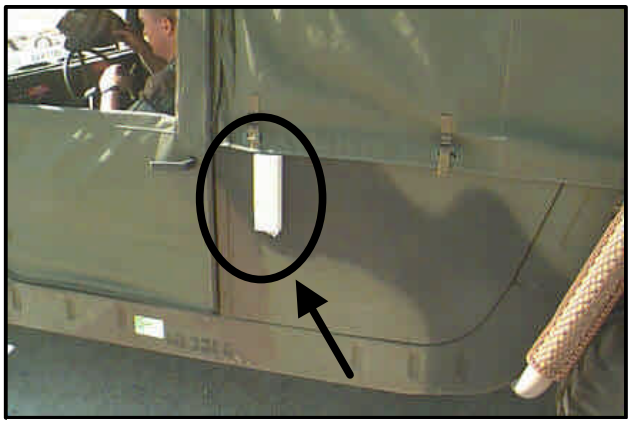


Figure 1. RFID Tag on HMMWV

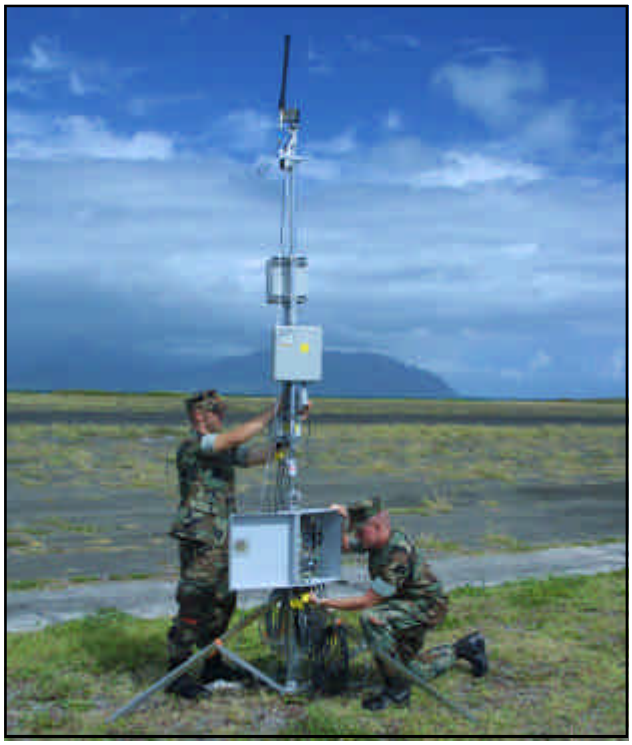


Figure 2. Hands-On Training

[1] Where Are We Going In Asset Management, R. Flores & N. Olah, Force Warfighting Laboratory Newsletter, October 2000.

[2] R. Paguio & D. McCambridge, May 1999, TECHNICAL MEMORANDUM TM-2315-AMP, Naval Asset Visibility (NAV) Limited Test Assessment (LTA) During Pacific Impact Exercises in Support of Combat Service Support Group 3, by R. Paguio and D. McCambridge, May 1999.

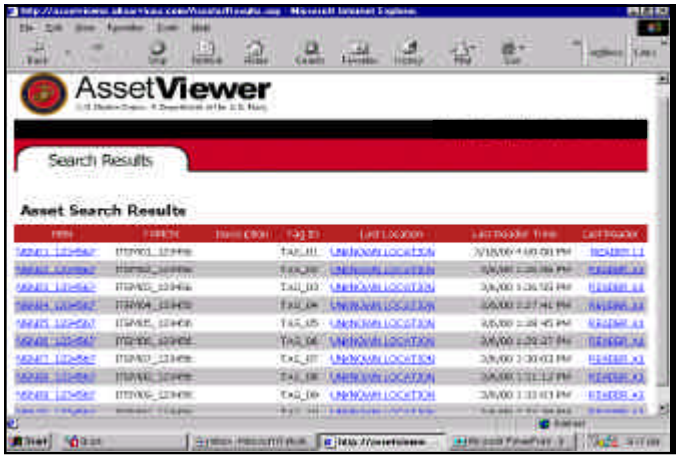


Figure 3. Asset Viewer Manager

Figure 4. Marine Using AVM at AAOE

RFID readers were staged at the ship, Port Operations Group (POG), Movement Control Center (MCC) and the Arrival Assembly Operations Element (AAOE). The system consisted of the RFID component (the sensors) and an information system component.

The Marines were provided training on the system. The training consisted of hands-on and classroom training (Figure 2).

There were three significant differences in this RFID system when compared to how this technology has been used in the past. First, the data transfer between the RFID sensors and the data collection points occurred using an organic Marine Corps communications asset, the MCR-142 system. The second feature was the capability of transmitting the RFID data to a web-enabled viewer. The Asset Viewer Manager (AVM) (Figure 3) posted the data streaming from the RFID system to a web page. The data was sortable according to user requirements. This capability allowed users at the AAOE (approximately 30 miles away from the POG), shown in Figure 4, to view in near real time the location of the equipment as it moved from the ship into the POG and then exited the MCC. The third feature closed the loop on the effort and allowed a true ISLIS. The AVM had the capability to interface with the MAGTF Deployment Support System II (MDSS II). The AVM accepted the Equipment Density List that was generated by the Marines before the deployment. This data was used to populate the AVM database. As equipment moved through the RFID nodes, data could be exported in a file format compatible with MDSS II. This data export to MDSS II was performed after the operation. This feature will allow users to reconcile inventory lists at any point in the MPF operation with a minimum of effort.

Figure 5. RFID Reader at POG

The system used in this demonstration is a commercially available system. The system does not meet the Marine Corps requirements of a system that would be deployed to support MPF operations. There is no currently available commercially system that does meet these requirements. The two most significant features lacking in current systems are ruggedness and compatibility with Marine Corps organic assets.

The focus of this demonstration was on the capability that RFID technology can provide. The ISLIS capability was discussed earlier. One of the other significant capabilities is the hands-free operation (Figure 5). This technology will allow Marines to perform functions other than time-consuming ones such as equipment tracking and data reconciliation. By deploying this system in a Marine Corps operation, data could be collected that can be used to develop the documentation necessary to eventually acquire a proper system.

Shipboard Asset Location

Current and future Naval operational concepts and doctrine are

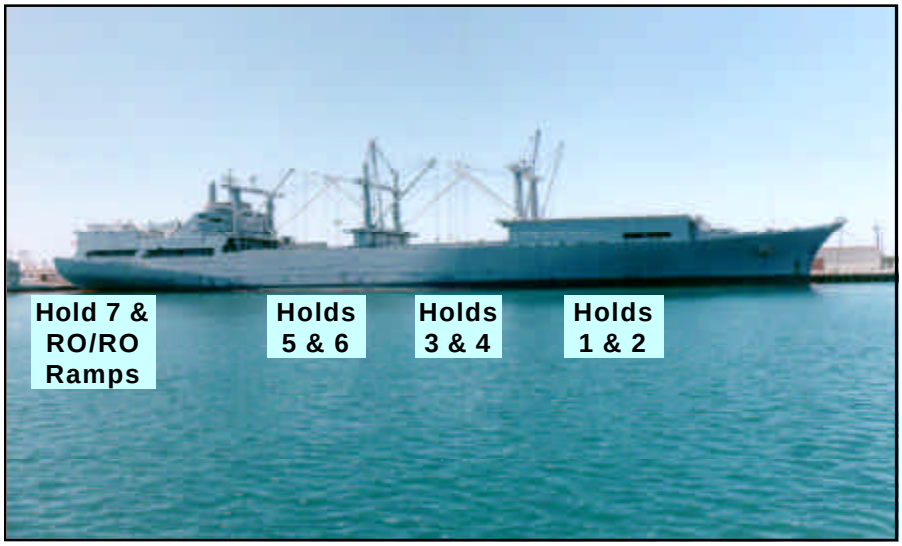


Figure 6. SS Curtiss

focusing more on expeditionary operations. Seabase operations such as Operational Maneuver From the Sea (OMFTS), Ship to Objective Maneuver (STOM), and Sustained Operations Ashore (SOA) will stress the logistics supply chain.

NFESC has been working on two areas of technology that will contribute to enabling seabased operations that will be conducted to supply these expeditionary forces. These efforts are focused on locating assets. One involves locating assets within a box such as an ISO container. The other, which is discussed here, involves locating assets onboard a ship. The requirement to pursue new technology for providing shipboard asset location came from both emerging doctrine and previous work on radio frequency technologies. It was determined that the radio frequency transmission technology that was used to identify assets could not be used to locate assets to the resolution that would be required to conduct efficient shipboard warehousing operations. Reports on a technology called ultrawide band (UWB) provided justification for further investigation.

Figure 7. Test Area in Holds 5 & 6

Two systems were down-selected to award contracts for performing performance tests. One technology was a traditional RFID system that used continuous sine wave (CSW) radio transmissions. The other was a UWB system. UWB transmission is fundamentally different from CSW transmission. UWB is a pulse that is dispersed among the frequency spectrum at a very wide range. One of the inherent characteristics of UWB transmission is the ability of locating the transmission to a fine resolution. The goal of this effort was to test and evaluate each system to determine performance capability inside a ship.

These two systems were installed on a Marine Corps Aviation Logistics ship called the SS Curtiss (Figure 6). The SS Curtiss is part of the ready reserve fleet and was stationed at Port Hueneme, California at the time of the test.

The systems were installed in Holds 5 and 6. The deck was configured into a test grid measuring 70 feet by 90 feet (Figure 7). A laser sighting system was used to establish the benchmark against which the performance of each system would be measured.

Two tests were conducted. The first test was performed with no equipment installed in the holds. The second test was conducted with 22 ISO containers and 4 HMMWVs placed in the holds (Figure 8). During each test, the systems were operated. Position location data was gathered in files. The laser system was used to provide the actual position of the two systems' tags.

Following the tests, data reduction and analysis was performed. The results have indicated that the UWB system can provide finer resolution for equipment location in the hull of the ship. This resolution is to within approximately 2.5 feet.

These test results provide important information to the developers of enabling technologies for Naval forces. With the knowledge that it is possible to determine location, concepts on how to deploy and operate may be expanded. If this

Figure 8. Marine Corps Equipment in Holds 5 & 6 with Tags Installed

location resolution can be reduced, how might that capability affect the future doctrine for logistics operations onboard a seabasing vessel?

Future

The ISLIS used in the CSSG-3 technology demonstrations will be tested again at Exercise Cobra Gold 02 in Thailand. Participation in this coalition exercise will expose interoperability issues between Thai and U.S. systems, fleshing out requirements for AIT and AL. The DOD-exclusive Iridium satellite network will be used to transfer data from a secure Marine Corps network in Thailand to a secure network located in CONUS. This addition will help to further evaluate the capability provided by total asset visibility.

The rapid pace at which ISLIS technologies are maturing will help to overcome the obstacle of declining S&T budgets by allowing quicker and cheaper technology transitions to military forces. However, two issues are always present in transitioning commercial equipment and systems into the military: ruggedization and interoperability. Equipment must be physically hardened for military environments, while system security must be enhanced. With the increasing number of new AIT systems, standardized tag communications and open-architecture systems will be needed to provide interoperability between new commercial technology, U.S. military legacy information systems, and ISLIS systems used by allied forces. Technology insertion into training exercises helps to address these issues so that a successful ISLIS can be implemented, providing total asset visibility for our fighting forces.

Pre-First in Command and Control System (Pre-FICCS) Initiative
A Partnership for Progress

Gordon Mattis, Marine Forces Pacific
Cliff Ayer, Office of Naval Research

Background

Operational and exercise experience with the AN/MSQ-126A has proven the worth of a small footprint, highly mobile command post hub for expeditionary operations. This need was identified in a coordinated Pacific/ Atlantic Fleet Operational Needs Statement (FONS) issued in 1997. Up to now, the desired capability has come at the expense of system agility and flexibility. Marine Expeditionary Unit (MEU) commanders have been faced with a conundrum: load the well deck for maneuverability and lethality, or embark the necessary components to deploy an effective forward command post. The very size of the C4ISR[1] suite precluded serving both warfighting and command and control needs with embarked equipment. "Cargo left on the pier" routinely included highly desirable elements of the erstwhile command post. In this "guns or butter" environment, no commander could afford to strip the MEU of its lethality in order to support the robust information system(s) so often dictated by the nature of Amphibious Ready Group (ARG)/MEU operations. The target footprint for this command post effort was set at 20 tons/two C-130s airlift requirement in order to optimize the expeditionary properties of the system.

Early attempts to mitigate this situation produced the "JTF[2] Enabler" sets of equipment. These packages performed admirably within the limits of their capabilities. A lack of uniformity and the age of the technology involved served to minimize the impact these systems had on fleet operations. However, the "Enablers" further solidified the need for a systematic solution to the problem.

In order to address this need as quickly as possible, Commanding General, Marine Forces Pacific (MARFORPAC), LtGen Libutti, offered the Office of Naval Research (ONR) a partnership for technology insertion and joint experimentation to address the unmet footprint metric. In this same time period, Marine Corps Combat Development Command (MCCDC) was starting its own effort along these lines, an initiative that has become the First In Command and Control System (FICCS). FICCS will use the Lightweight Multi-band Satellite Terminal (LMST), the JTF Enhanced Core Communications System (JECCS), and elements from the Unit Operations Center (UOC) to address this need, starting with the Program Objective Memorandum (POM) 04 cycle. Final FICCS architecture has not yet been solidified. The Pre-FICCS Initiative has provided valuable insight into the packaging, employment, and technology enhancements to the FICCS program and demonstrated mature technologies that will be incorporated in FICCS.

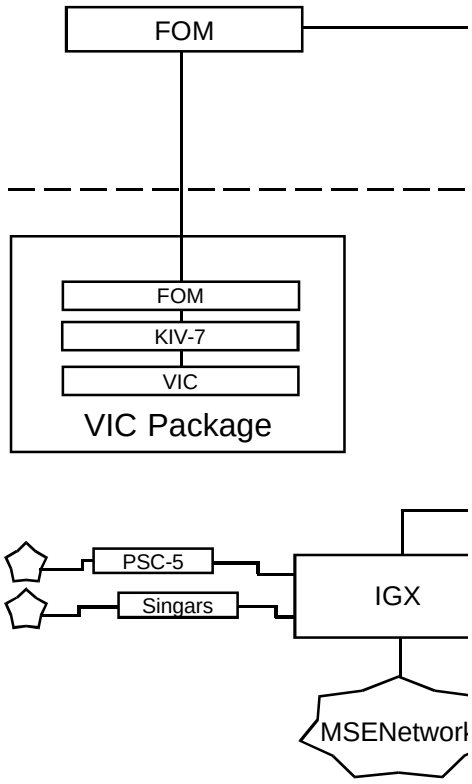
Pre-FICCS Architecture

Pre-FICCS is designed to incorporate the wide-band SHF[3] transmission path in a progressive manner; Ku band only in Phase I, tri-band (dish-based) as soon as possible, and a flat-panel, phased array multi-band SHF antenna as soon as practical. This satellite communication (SATCOM) system will form the core of a command post contained in a shelterized HMMWV-H[4], supported by a DRASH[5] GENSET/ HVAC[6] trailer. Reachback via DISN[7] STEP[8]/ TELEPORT sites will ensure robust connectivity to facilitate joint and coalition operations.

Circuit aggregation uses an open standards ATM[9] switch in place of proprietary time division multiplexers; thus keeping pace with Army and Navy developments as well as the objective DISA[10] Teleport architecture. ATM maximizes use of allocated bandwidth since it does not establish constant bit rate circuits that cannot share unused bandwidth. Inclusion of the REDCOM IGX[11] switch provides support for STU III[12], STE[13], and POTS[14] devices, and connectivity to the MSE[15] via T-1 interface to JECCS[16] or TTC-39E switches. An integrated cell phone base station extends the reach of the voice services up to 5 miles from the command post and will, in the future, offer secure cellular phone service.

Information systems will include GCCS[17], SIPRNET[18], NIPRNET[19], and a wireless enclave-to-enclave LAN[20] secured via Cryptek devices. An ultra-thin client architecture minimizes the system administration burdens for Marines in the field.

Maintenance of situational awareness throughout the SHOOT-MOVE-COMMUNICATE cycle has been achieved by Pre-FICCS. Integration of a UHF[21] SATCOM transceiver,



vehicle mounted SATCOM antenna and a laptop computer running C2PC[22] mounted in the HMMWV cab allow real time updates to the Common Tactical Picture (CTP) on the move.

A power innovation is the use of a 400-amp alternator in place of the standard 200-amp unit. The alternator, via an onboard DC-AC inverter, provides enough power to run all the C4 systems in the event of a generator casualty, negating the need for a backup generator.

Demonstrations

Pre-FICCS has successfully established secure voice, data and video connectivity with the Army Battle Command Battle Lab at Ft. Gordon and conducted interoperability testing at the Joint Interoperability Test Center (JITC) at Ft. Huachuca. Roadability, environmental and transportability certification tests were completed in March 2002 at the Nevada Automotive Test Center.

The Pre-FICCS is slated for demonstration in Millennium Challenge 02 (MC 02). Upon completion of MC 02, it will be turned over to the operating forces for extended user evaluation.

Impact

By partnering with the acquisition community (MCCDC/ Marine Corps Systems Command (MCSC)), the Pre-FICCS initiative fulfills three basic needs.

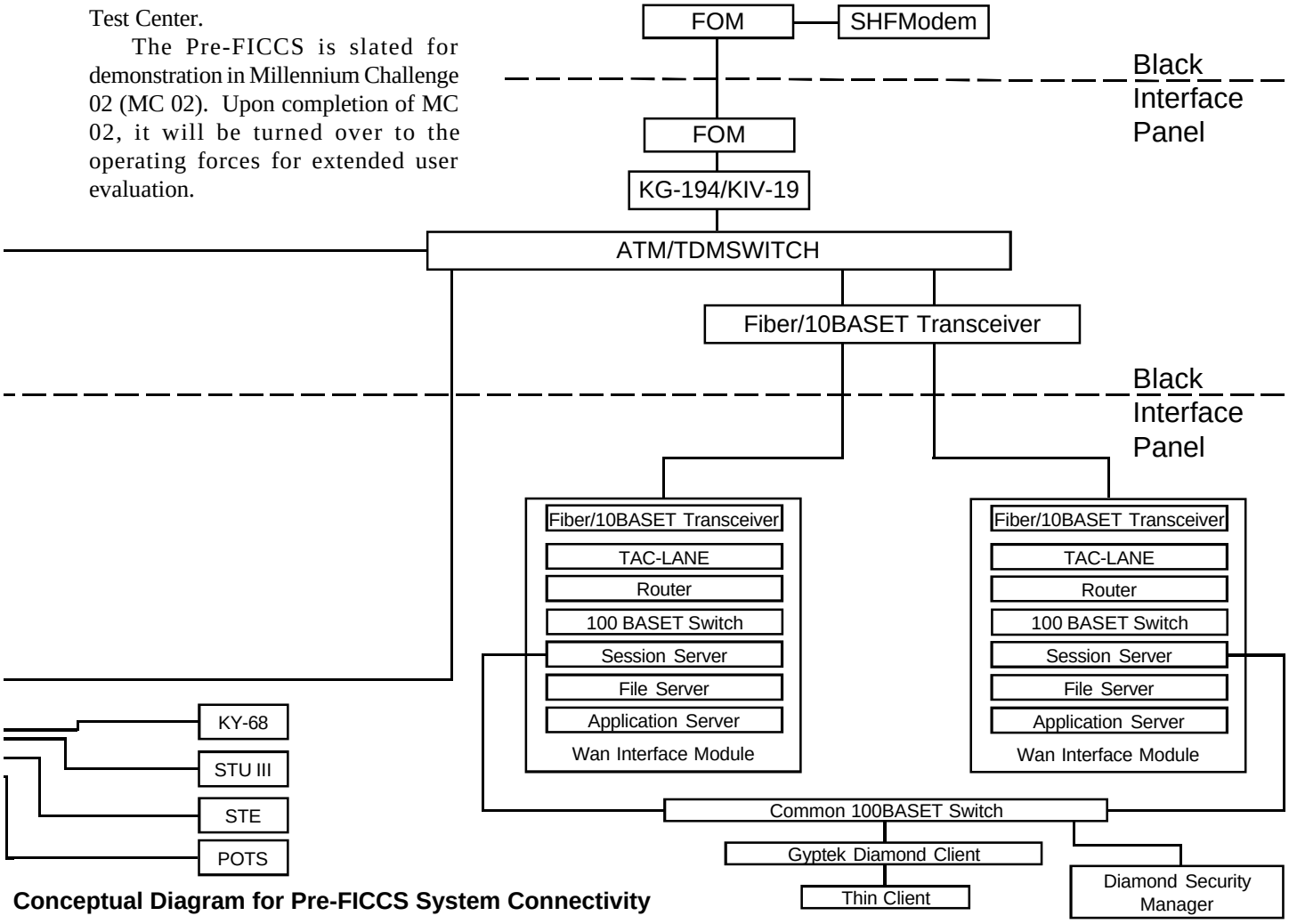
(1) MARFORPAC gets the opportunity to directly shape future C4ISR architectural decisions and strategies.

(2) ONR gets a test bed and a venue to demonstrate advanced technologies.

(3) MCCDC/ MCSC gets to leverage the agility of the S&T community without hazarding programs of record.

This powerful combination establishes a more responsive business model for accelerating the movement of information technology to the warfighter. In conjunction with established modernization efforts, the "new team on the block" will strive to raise the performance bar to better meet the warfighting needs of the fleet Marines.

[1] Command, control, communications, computers (C4) intelligence, surveillance, and reconnaissance
[2] Joint Task Force
[3] Super high frequency
[4] High Mobility Multipurpose Wheeled Vehicle - Heavy
[5] Deployable Rapid Assembly Shelter
[6] Engine-generator set/ heating, ventilation, and air conditioning
[7] Defense Information System Network
[8] Standardized Tactical Entry Program
[9] Asynchronous transfer mode
[10] Defense Information Systems Agency
[11] Readiness Command ISDN Gateway Exchange
[12] Secure telephone unit III
[13] Secure telephone equipment
[14] Plain old telephone service
[15] Mobile subscriber equipment
[16] Joint Enhanced Core Communications System
[17] Global Command and Control System
[18] SECRET Internet Protocol Router Network
[19] Non-Secure Internet Protocol Router Network
[20] Local area network
[21] Ultra high frequency
[22] Command and Control Personal Computer



Conceptual Diagram for Pre-FICCS System Connectivity

Fuel From the Sea

CWO4 Dave Ray, Marine Forces Pacific
CWO4 Mike Giambruno, I Marine Expeditionary Force
Mark Miller, Naval Facilities Engineering Service Center

Abstract

As the Marine Corps enters the 21st century, new technology is emerging to increase the mobility and maneuverability of the Marine Air Ground Task Forces (MAGTF) of the future. With the planned fielding of the MV-22, Advance Amphibious Assault Vehicle (AAAV), and fixed wing tactical aircraft coupled with major power plant upgrades for the attack helicopter fleet, the Marine Corps will greatly increase its capabilities and unfortunately its daily fuel requirements! All of the above new systems will consume larger quantities of fuel per hour than their predecessors. Yet current Combat Service Support and Amphibious support methods of distributing bulk petroleum over the shore and inland are based on 1960's technology and methods.

A new concept to distribute fuel from over the shore and inland was demonstrated off the East Coast of South Korea during Exercise Foal Eagle 00. The demonstration was a Marine Forces Pacific (MFP) Force Warfighting Lab (FWL) initiative and supported by the 31st Marine Expeditionary Unit (31st MEU), Task Force 76, 3rd Force Service Support Group (3rd FSSG) and Combined Forces Command (CFC) Korea. The concept demonstration was titled D-Day Mobile Fuel Distribution (DMFD) and showcased three fuel delivery systems with different sized capacities: 15,000 gallons, 3,000 gallons and 400 gallons.

During the demonstration, over 35,000 gallons of JP5 fuel was distributed from 25 miles offshore to a tactical bulk fuel farm on the beach in an 8-hour period. This was done by using the landing craft air cushion (LCAC) as the delivery platform, simulating an Operational Maneuver From the Sea (OMFTS) bulk petroleum distribution operation. This marked the first time that fuel had been transported by LCAC and distributed to a fuel farm on the beach from over-the-horizon.

With the evolving expeditionary maneuver warfare operational concepts coupled with current capability limitations for traditional doctrinal amphibious assault support, new methods for distributing fuel to forces ashore and further inland must be developed. It is through experiments like this that the Navy and Marine Corps can assess and analyze its capabilities and limitations.

Introduction

The capabilities of three expeditionary fuel distribution systems were demonstrated during Foal Eagle 00. The demonstration showcased three systems: a 15,000-gallon system that is distributed at the beach support area; a 3,000-gallon system that can be transported forward using the logistics vehicle system (LVS); and a 400-gallon modular system, titled expeditionary fuel system 400 (EFS 400), that can be transported by LVS or helicopter. All three systems were transported to the beach from 25 nautical miles offshore using the LCAC.

With the Navy and Marine Corps' dependence on fossil fuels (estimated 1.4 million gallons per day for future Marine Expeditionary Force (MEF)-sized MAGTF) (MCCDC TFS Study, Feb 1998), the ability to provide and distribute bulk fuel to amphibious landing forces during the assault echelon is critical. Previously, the Landing Ship Tanks (LST) class of amphibious ships were used to provide initial bulk petroleum sustainment to the landing force until Logistics Over the Shore (LOTS) operations were initiated and matured. However, the Navy has retired all LSTs from the active fleet. Also, the evolving expeditionary maneuver warfare operational concepts present new Naval bulk petroleum distribution challenges.

15,000-gallon DMFS

To meet this emerging challenge the Marine Forces Pacific Force Warfighting Lab established a Bulk Liquids Focus Team in Jan 2000 (Since rename Petroleum and Water Logistics Focus Team). The focus team consists of bulk petroleum and water experts from MARFORPAC, I MEF, and III MEF teaming with the Office of Naval Research (ONR) and Naval Facilities Engineering Service Center (NFESC) engineers and scientists. The team's charter is to explore emerging science and technology for concepts and hardware to meet the Naval bulk petroleum distribution challenges for current and emerging amphibious and expeditionary doctrinal operations.

The focus team's first major task was to plan and execute a concept demonstration to simulate fuel distribution concepts to support expeditionary operations. About 35,000 gallons of JP-5 fuel was transported and distributed to a tank farm on the beach 25 nautical miles offshore. Support from the 31st MEU and 3rd FSSG along with the USS Fort McHenry and USS Essex were instrumental in making the concept demonstration a great success.

Background

Historically, over 60% of the overall tonnage that U.S. Forces have brought into a contingency theater of operations consists of Class III, bulk petroleum products. For the Navy-Marine Corps focus team, amphibious bulk petroleum sustainment has transitioned from the World War II model of 55- gallon drums and 5-gallon fuel cans to amphibious ships with bulk petroleum discharge systems, floating assault fuel lines, tactical fuel systems and refueling tankers and modules. The modern workhorse for ship-to-shore petroleum support for the Navy was the LST class of amphibious ship. The LST provided the first LOTS sustainment for the landing force via the Navy's Amphibious Assault Bulk Fuel System (AABFS), which consist of 10,000 feet of 6-inch diameter floating assault hose line. The AABFS interfaces at the high water mark with the Marine Corps Amphibious Assault Fuel System (AAFS), which consist of 20,000-gallon capacity fabric fuel tanks, assault fuel hoses, and trailer-mounted fuel transfer pumps. This Naval LOTS bulk petroleum distribution system of the LST, AABFS and AAFS has served the Navy and Marine Corps well during the later half of the last century, but things are changing. Due to the emerging doctrine of (OMFTS) and Ship to Objective Maneuver (STOM) combined with the retirement of the LSTs from the active fleet, the Naval bulk petroleum logistic community must find new hardware, doctrine and procedures to sustain the warfighter.

D-Day Mobile Fuel Distribution (DMFD) Project

In FY96, ONR began the D-Day Mobile Fuel Distribution project with the primary objective of developing advanced bladder technologies to distribute fuel from ships offshore to the beach. As a result of this research, three fuel distribution systems were developed for testing. These three systems are:

The ***15,000-gallon D-Day Mobile Fuel Distribution System*** (15k DMFD) is designed to maximize the LCAC platform to carry fuel ashore during the initial days of an amphibious operation. The 15k DMFD consists of four 3,750-gallon fabric tanks, resulting in a load of approximately 105,000 pounds for the LCAC. It is envisioned that the 15k DMFD would be deployed during the assault echelon after facilities are in place for transferring bulk fuel at the beach, and at which time one or more LCACs can be designated for fuel transport.

The ***3,000-gallon D-Day Mobile Fuel Distribution System*** (3k DMFD) is a mobile system. The 3k DMFD consists of two collapsible bladders secured to a 1077 flatrack. The assembled and filled system (12 tons) is easily moved by the LVS MK18A1. Three complete systems and an LVS MK 48/18A1 can be transported by LCAC simultaneously to deliver 9,000 gallons of fuel. The resulting cargo load seen by the LCAC is approximately 60 tons.

3000-gallon System

The ***EFS 400*** is a modular system capable of deployment aboard a multitude of ground vehicles and aircraft. The EFS 400 is individual modules mounted to a unique transport pallet. The individual tank modules break down for reduced storage cube for transport aboard amphibious shipping, yet assemble to provide a Department of Transportation (DOT) certifiable 400-gallon fuel tank. Ten tanks can be mounted on the transport pallet and provide 4,000 gallons of bulk fuel for transport aboard the LVS. All 10 tanks can be filled or drained simultaneously through the 4-inch camlock fittings located on the transport pallet making the EFS 400 operate just like any other 4,000-gallon bulk transport container. The modular configuration eliminates fluid slosh to improve transportation stability much like extensive baffling in larger single tanks. The EFS 400 is readily configured into a tactical refueler by replacing two tanks with a pumping unit capable of delivering a combined flow of 300 gpm through 4 live reels. The EFS 400 can be further modified by replacing a third tank with a filter/separator unit to provide aircraft quality fuel. Individual tanks can be handled by 4K forklift, and are transportable by 5-ton or Heavy HMMWV, or as either internal or external cargo aboard the CH-53 and MV-22. Individual tanks can be operated independent of the transport pallet, and can be configured into a stand alone fuel station by using an auxiliary pump assembly (24V DC), which is part of pump unit.

Previous Testing

All three DMFD systems were successfully tested with water in lieu of fuel in previous exercises. During RIMPAC East 2000 all three systems were tested at Camp Pendleton, CA, while loaded with water.

The EFS 400 was demonstrated with diesel fuel during a Combined Arms Exercise (CAX) at Twentynine Palms, CA, in July 2000 and also during Millenium Dragon 00 in August 2000.

Exercise Foal Eagle Concept Demonstration

Various schedules of events (SOE) were developed in the months leading up to the demonstration. Originally, 2 days were scheduled for the test with one complete ship-to-shore-to-ship cycle each day. At a meeting between Marine Corps reps and the PHIBRON commander, it was decided to embark the systems late on day one and run two complete ship-to-shore cycles the following day, disembarking the systems on shore following the second run.

The 15k DMFD was embarked aboard the USS *Essex* by LCAC, and the 3k DMFD and EFS 400 systems boarded USS *Ft. McHenry* via LCU (landing craft unit). The EFS 400 systems were embarked completely assembled. The 15k and 3k DMFD systems were assembled that night from staging positions in their respective well decks. All systems were fueled the same night or early the next morning. Fuel was to be delivered by each system to a fuel farm established just beyond the high water mark ashore.

EFS 400

Conclusions

The concept demonstrations showed, for the first time, that large quantities of fuel could be distributed from over-the-horizon to inland objective areas. It was an overall success for several reasons.

(1) The demonstration showed that this technology can and will support the Navy's and Marine Corps' emerging expeditionary warfare operations. Though there were difficult challenges throughout the demonstration, the systems provided enough flexibility to allow the technical and operational support teams to successfully address the challenges. Our major objectives were met without encountering any significant operational or environmental problems.

(2) The strong partnership between the technical and operational community showed that the two communities can work together to accomplish great things. By leveraging each other's strength, major tasks were completed efficiently and effectively with limited resources available.

(3) The demonstration showed our capabilities and limitations. Based on what was learned in this experiment, MFP can better articulate operational requirements and provide meaningful recommendations for the technologies that were experimented with as well as provide recommendations for other related programs.

Republic of Korea Marine Corps (ROKMC) JP-8 Fuel Interoperability Evaluations

Greg L. Philips, Southwest Research Institute
CW04 Dave Ray, Marine Forces Pacific

Introduction

The combined Joint Republic of Korea Marine Corps (ROKMC) JP-8 Fuel Interoperability Exercise is the first Pacific Theatre initiative to demonstrate the Department of Defense's (DOD) Single Fuel in the Battlefield advantages during combined logistics operations with an ally. The ROKMC JP-8 fuel interoperability exercise is the first combined contingency effort to validate the use of JP-8 in ROK vehicles. The exercise was a United States Forces Korea (USFK) effort to work with the ROK Marine Corps concerning contingency logistics issues. The USFK position is that only JP-8 fuel will be provided from tactical fuel systems. It is highly probable that during a contingency operation, the ROK forces will be fueled from USFK tactical fuel systems. Therefore, it is prudent and necessary for USFK to assist the ROK military to understand the process for JP-8 conversion if they are going to rely on USFK for logistical support. In support of this effort, limited DL-2 and JP-8 performance, hot-start, and acceleration evaluations were conducted in M511 and M711 Korean manufactured 2.5- and 5-ton tactical trucks. These model vehicles are the highest density cargo transporters in the ROKMC inventory.

Objectives

The objectives of this program were to: (1) assist Marine Forces Pacific (MARFORPAC) staff in the execution of JP-8 Turbine Fuel Interoperability Exercise Plan of converting selected ROKMC M511 and M711 vehicles from DL-2 diesel to JP-8 fuel and (2) evaluate and quantify differences, if any, in vehicle performance when operating with JP-8 instead of diesel fuel.

Test Vehicles

The test vehicles were selected by local ROK organizations tasked to support the evaluations. Several maintenance procedures were performed prior to evaluations. Fuel filters were changed on the vehicles selected for acceleration evaluations. All vehicles were thoroughly checked for fuel leaks and normal engine operation; lubricant and coolant levels were ascertained to be at manufacturers' specifications.

Figure 1. On-board Fuel Tank Fiber-Optic Evaluation

On-Board Fuel Tank Evaluations

On-board fuel tank evaluations were conducted using an Olympus Model 1F11D4-30 fiber optic scope with a helioid high-intensity light source. The tanks were inspected starting in the left bottom corner moving the scope diagonally across the entire bottom surface of the tank. Figure 1 shows SwRI personnel performing on-board fiber optic inspection of a fuel tank on a ROKMC truck. Results of fuel tank evaluations revealed that tank bottoms contained differing degrees of sediment, suspended water, and microbiological growth. Figure 2 presents the typical pre-conversion condition of the tank bottoms while Figure 3 shows the typical post conversion condition of the tanks after draining and filling with JP-8 fuel.

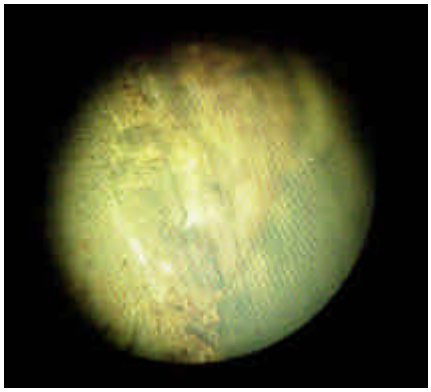


Figure 2. Fiber Optic View of Pre JP-8 Conversion Showing Microbiological Growth and Water

Figure 3. Fiber Optic View of Post JP-8 Conversion Fuel Tank Condition

Fuel Consumption Evaluation

It was not possible within the time frame of the evaluations to instrument each series of vehicles and measure fuel consumption with a flow meter and fuel totalizer. Therefore, the MARFORPAC fuel officer, who coordinated and conducted the convoy phase of the exercise, ensured that accurate records were maintained of kilometers traveled and liters of fuel used. Figure 4 shows the ROKMC trucks in convoy.

Fuel consumption for the 2.5-ton truck was 1.48 L/km and fuel consumption for the 5-ton truck was 1.07 L/km. Figure 5 shows the ROKMC trucks being fueled with JP-8 fuel. The fuel consumption calculated for the Korean manufactured M511 and M711 trucks parallel consumption rates for equivalent U. S. manufactured tactical trucks.

Vehicle Acceleration Evaluations

Full throttle acceleration tests measure the time required to reach a given speed. The acceleration times of a given vehicle is a function of the work produced by the engine. The developed work and subsequent rate of work (power) are a function of the volume and energy content of the injected fuel. Injected fuel volume is a function of fuel density and viscosity. These factors can affect the metering and leakage in diesel injection systems.

Full throttle accelerations from a standing start were performed on the M511 2.5-ton and M711 5-ton vehicles at speeds of 30, 50, and 70 kph. Theaveraged acceleration times-to-speed for the M511, 2.5 ton truck was more than would be expected from fuel property variations. However, as shown in Figure 6, the largest increases in time to speed accelerations were from 30 to 50 and 50 to 70 kph. These acceleration time increases manifested at the higher end of the run support the fact that in worn injection components, internal pump leakage will occur at full rack operation when fuel delivery is at maximum requirement.

The averaged acceleration times-to-speed for the M711, 5 ton truck are presented in Figure 7. The acceleration time increase for this vehicle was in consonance with the difference that would be expected from fuel property variations. The results are similar to equivalent U.S. model vehicles previously evaluated. As seen in Figure 7, acceleration time with JP-8 was faster from 0-30 kph; however, similar to the 2 ½ ton truck, acceleration times with JP-8 increased at the higher speeds.

Hot Starts

Typical kinematic viscosity of JP-8 and DL-2 fuels at 40° C is 1.29 and 2.8 centistokes respectively. This difference in viscosity can affect the starting time of the engine if the injection pump barrel and plunger assembly is excessively worn and fuel is leaking internally during hot-soak periods. Hot-start evaluations were conducted in conjunction with the acceleration runs on both the 2.5- and 5-ton trucks. At the end of each set of acceleration runs, the engine was turned off and allowed to soak for 5 minutes. The engine was then restarted and the time to start was recorded in seconds. There were no discernable differences in starting times with diesel or JP-8 in either vehicle, thus indicating that the lower viscosity JP-8 fuel had no affect in the vehicles' injection pump system during the soak period. The averaged start times results were slightly faster with JP-8 fuel.

Conclusions

The evaluations and demonstration proved highly successful in that there were no operational problems or discernible differences reported when operating with JP-8 instead of diesel fuel. A longer duration JP-8 evaluation program is recommended for tactical vehicles in order to access the long-term use of JP-8 and validate benefits of continued JP-8 use.

Figure 4. ROCKMC Truck Convoy

Figure 5. JP-8 Refueling of ROCKMC Trucks

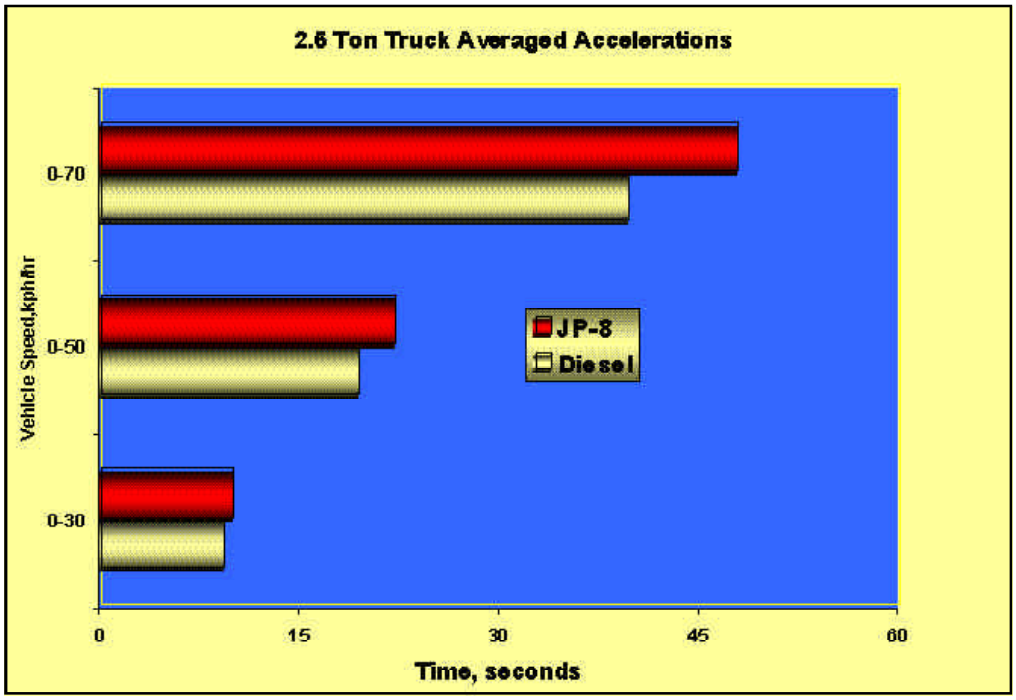


Figure 6

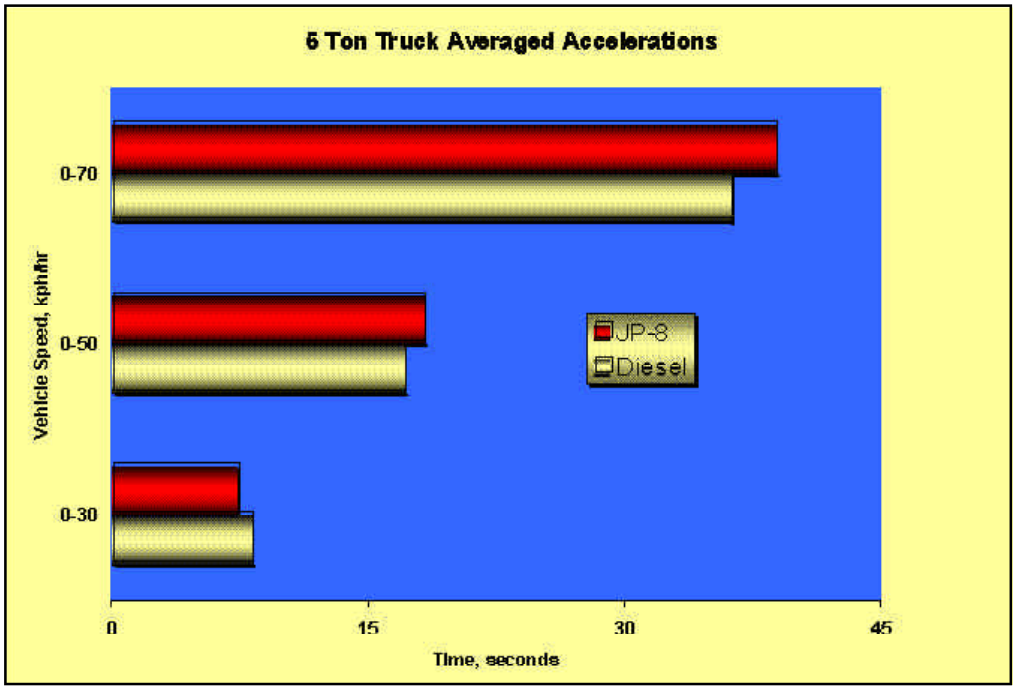
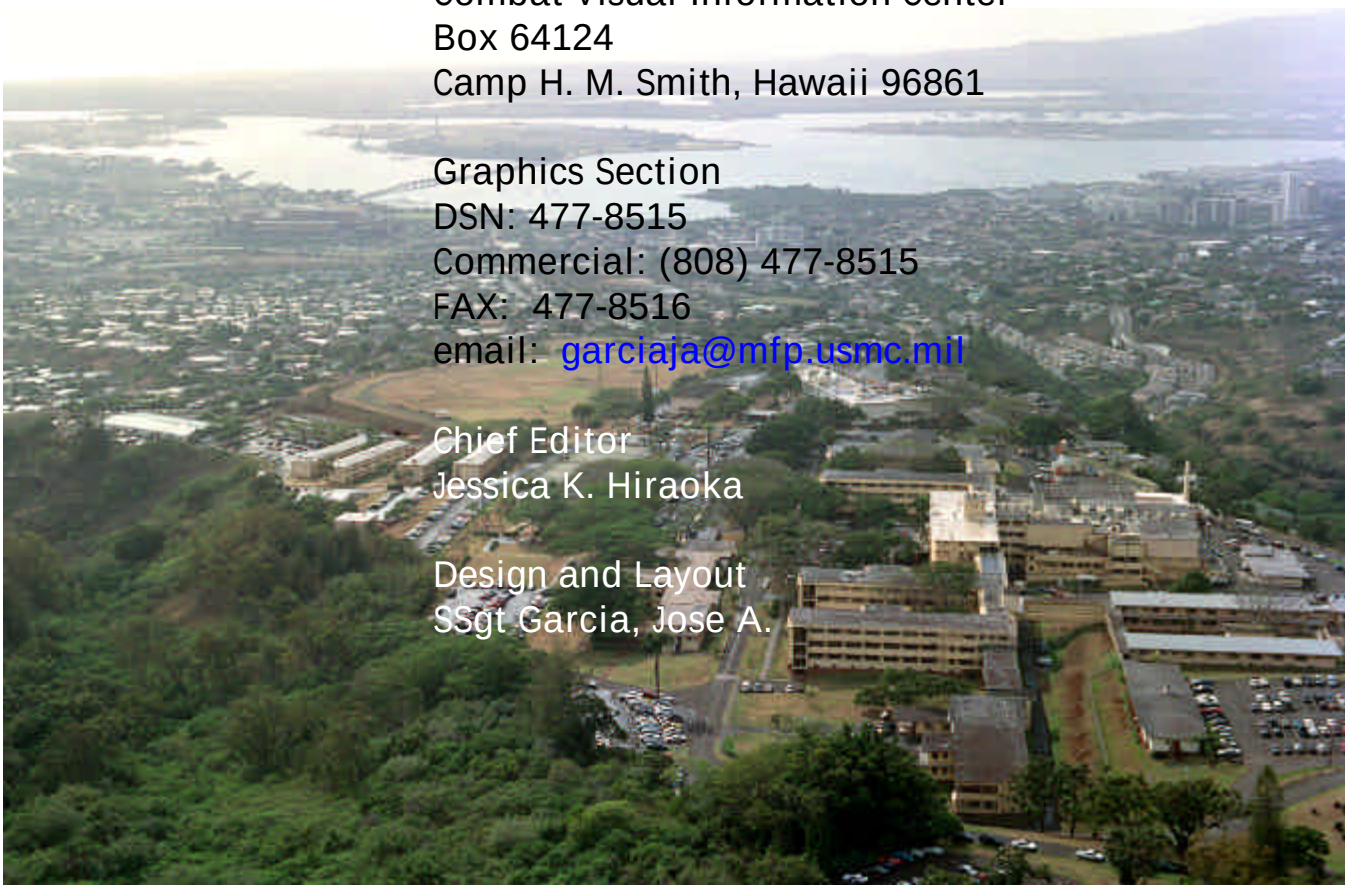


Figure 7

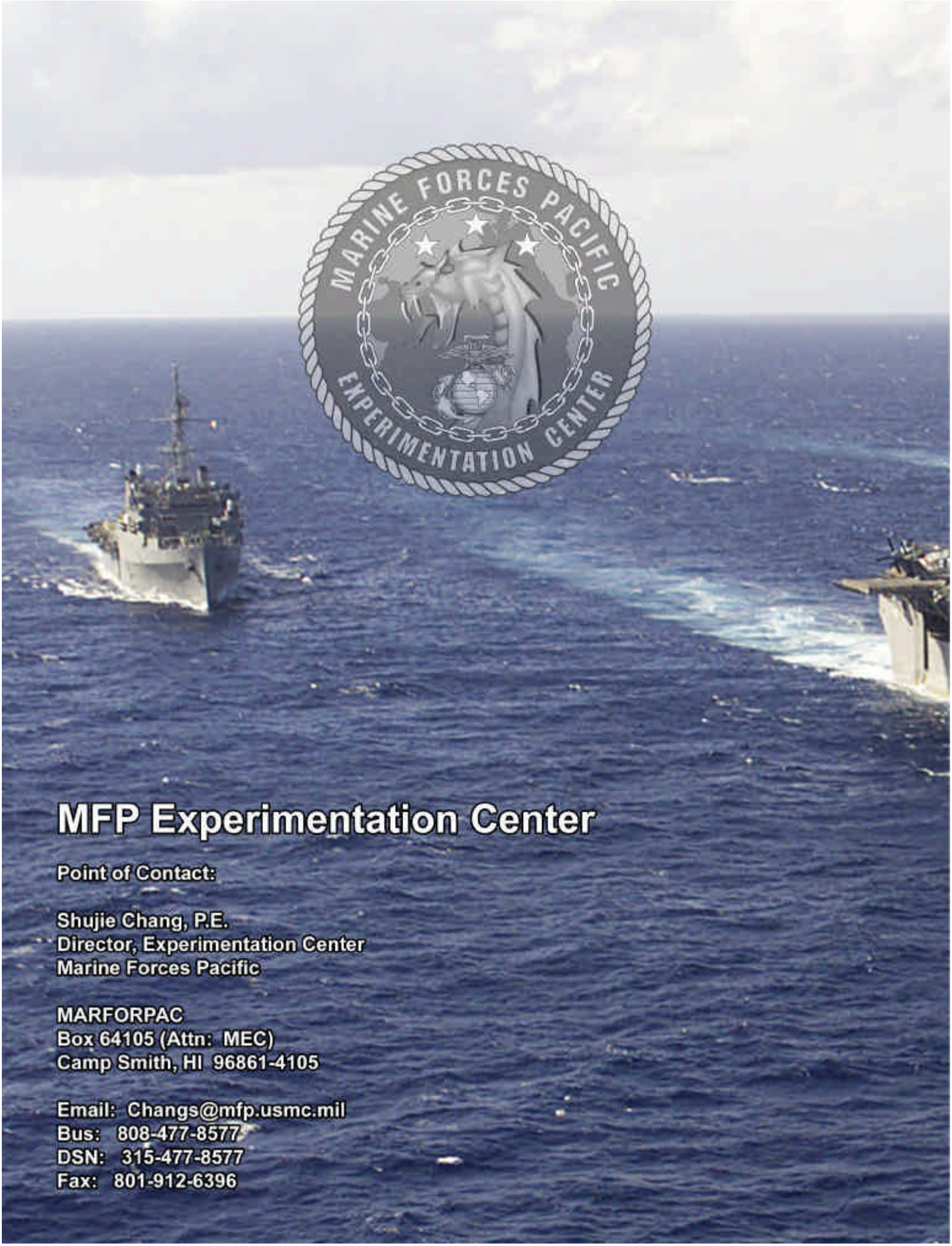


U.S. Marine Forces Pacific
Combat Visual Information Center
Box 64124
Camp H. M. Smith, Hawaii 96861

Graphics Section
DSN: 477-8515
Commercial: (808) 477-8515
FAX: 477-8516
email: garciaja@mfp.usmc.mil

Chief Editor
Jessica K. Hiraoka

Design and Layout
SSgt Garcia, Jose A.



MFP Experimentation Center

Point of Contact:

Shujie Chang, P.E.
Director, Experimentation Center
Marine Forces Pacific

MARFORPAC
Box 64105 (Attn: MEC)
Camp Smith, HI 96861-4105

Email: Changs@mfp.usmc.mil
Bus: 808-477-8577
DSN: 315-477-8577
Fax: 801-912-6396