A Study of Human Behavior & Operational Energy

Analysis and Recommendations for the Marine Corps
to Increase Its Operational Reach

Prepared for

The United States Marine Corps Expeditionary Energy Office

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Abstract

Years of combat have exposed operational vulnerabilities in the U.S. Marine Corps due to energy overuse and dependence. Reducing energy use in the expeditionary forces offers the opportunity to extend reach, save lives, and use money wisely. This research first describes a behavioral framework for how situational and personal factors impact the efficient use of energy. The framework explains how Marines' personal knowledge, attitudes, values, and motivations vary by each scenario of use. It then outlines five areas where organizational interventions can be applied to increase energy efficiency: Revise operational procedures; initiate policies that improve overall efficiency; build individual energy awareness and knowledge; incorporate energy efficient technologies; and nurture a culture of energy awareness. The paper then takes a detailed look at how energy behaviors play out in an operational environment. Using ethnographic methods and Grounded Theory, this research uncovered opportunities to balance energy efficiency with mission effectiveness. These opportunities include revising the structure of the exercises, increasing accountability, strengthening the role of leadership, conducting more efficient operations, improving planning processes, developing information systems, increasing the usability of supporting systems, developing energy reducing technologies, and reducing the overall weight of vehicles, supplies, and armor.

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The USMC Expeditionary Energy Office

By 2009, eight years of combat had revealed a capabilities gap within the United States Marine Corps (USMC). Operational vulnerabilities were exposed due to energy overuse and dependence. In response to this capability gap, the Commandant of the Marine Corps (CMC) created the USMC Expeditionary Energy Office (E2O) on November 19, 2009. The purpose of the E2O is to "analyze, develop, and direct the Marine Corps' energy strategy in order to optimize expeditionary capabilities across all warfighting functions."[1] In March 2011, the Commandant issued the Expeditionary Energy Strategy and Implementation Plan that outlines this change:

> *"The current and future operating environment requires an expeditionary mindset geared toward increased efficiency and reduced consumption, which will make our forces lighter and faster. We will aggressively pursue innovative solutions to reduce energy demand in our platforms and systems, to increase our self-sufficiency in our sustainment, and reduce our expeditionary footprint on the battlefield. Transforming the way we use energy is essential to rebalance our Corps and prepare it for the future.[2]"*

Later that year, the Assistant Commandant of the Marine Corps signed and issued a comprehensive requirements' document, the Expeditionary Energy, Water, and Waste Initial Capabilities Document (E2W2 ICD), which identifies and prioritizes 152 capability gaps across 29 tasks in six E2W2 capability areas. Each of these areas—Planning, Production, Storage, Distribution, Disposal, and Management—affects every warfighting consumer or producer of energy, water, and waste. The report outlines material—not material recommendations—scoped within the E2W2's 2025 Mission[3] and aligned to its Vision:

> *"To be the premier self-sufficient expeditionary force, instilled with a warrior ethos that equates the efficient use of vital resources with increased combat effectiveness.4"*

Concurrent with the creation of the E2O, the Commandant created the USMC Experimental Forward Operating Base (XFOB). XFOB annually brings together stakeholders from across the Marine Corps requirements, acquisition, and technology development communities, as well as representative from the other services to dynamically evaluate, eliminate, and promote technologies aligned to E2W2 requirements.

The behavioral aspect of the Marines' "ethos change" is at the early stages of study and analysis. Previous research with Navy Fleet Forces indicated that stakeholder motivations, attitudes, cognition, and risk perceptions impact a sailor's willingness to conserve energy.[5] Similarly, research on key drivers to the adoption of energy efficient technologies found that Marines decision points,

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[1] Office of the Assistant Commandant of the Marine Corps (November 19, 2009). *Establishment of the Marine Corps Expeditionary Energy Office* [Memorandum]. Washington, DC: Author.
[2] Commandant of the Marine Corps (CMC) (February 23, 2011). *United States Marine Corps Expeditionary Energy Strategy and Implementation Plan* (p. 3). Washington, DC: Author.
[3] By 2025, we will deploy Marine Expeditionary Forces that can maneuver from the sea and sustain C4I and life support systems in place. The only liquid fuel needed will be for mobility systems which will be more efficient than systems are today.
[4] Ibid., 17.
[5] Salem, A., King, C. L., Fox, S., Haley, R., & Klotzbach, M. (2009). *Best practices in the Navy's energy programs: Strategic communication factors operating in the Tactical Forces* (Research Report). Monterey, CA: Naval Postgraduate School.

perceived attributes, and risk perceptions impact the adoption of new technologies or processes.[6] Our research extends this behavioral aspect more broadly to include research into the broad behavioral and attitudinal factors that may impact the overall efficient use of energy.

Ethnographic Methods and Grounded Theory

In order to explore the broad factors impacting energy use in the Marine Corps, we adopted an ethnographic approach. By using in-situ observations and interactions, the ethnographic approach reveals patterns of existing attitudes and practices. Ethnographic data collection methods are designed to "capture the 'social meanings and ordinary activities' of people (informants) in 'naturally occurring settings' that are commonly referred to as 'the field.' The goal is to collect data in such a way that the researcher imposes a minimal amount of personal bias on the data."[7] It is important in ethnographic studies not to disrupt the natural behaviors with the researcher's presence or preconceived ideas and agendas. After our observations, the notes were coded using Grounded Theory to reveal the scenarios and their inter-relations.

Grounded Theory provides a systematic generation of theory from data using both inductive and deductive reasoning. The four stages of Grounded Theory data analyses are:

1. Codes—code is opened where everything is recorded and then analyzed for recurring points and key points
2. Concepts—a collection of codes with similar content are grouped and may lead to further data collection
3. Categories—groupings of similar concepts to reveal integrated or sequential patterns relating recurrent themes
4. Theory—a collection of categories that details the subject of the research

Data Collection Methods

We observed and interviewed 60+ Marines in four environments, capturing field notes on observed behaviors and interviews:

- ITX3-14 (end of exercise)
- ITX5-14 (beginning of exercise)
- April WITI (beginning of exercise)
- Deployed MEU (embarked on an LHD)

After our observations, we reviewed our notes and coded them by concepts and categories. Concepts included Rank, Role, Scenario, Equipment, Area of Influence, and Theme. As we analyzed the data, we identified separate concepts and sub-concepts. For instance, Scenarios were broken down into 12 separate activities (e.g., maintenance, communications, provisioning …) and Themes were broken down into nine topics (e.g., Attitudes, Motivations, Awareness …). Themes were

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[6] Aten, K., Brinkley, D. & Ciarcia, J. C. (2013). *Key drivers of Marines' willingness to adopt energy-efficient technologies* (Master's thesis). Monterey, CA: Naval Postgraduate School.
[7] Brewer, J. D. (2000). *Ethnography* (p. 10). Philadelphia: Open University Press.

further broken down into sub-themes. For instance, "Attitudes" included differentiators such as safety and risk, leadership, and abundance. Based on these concepts and categories, we constructed a theoretical model of the observed behaviors that outlined key concerns, leverage points, areas needing further study, and key decision or policy areas that further the E2O's goals.

A Scenario Model for System Change

Based on our observations of Marines at ITX, WTI, and a deployed MEU, we created a conceptual framework of the behavioral and organizational factors operating within the Marine Corps in regards to energy use. This framework (illustrated in Figure 1) is a result of our Grounded Theory process and is based on the observation of these exercises.

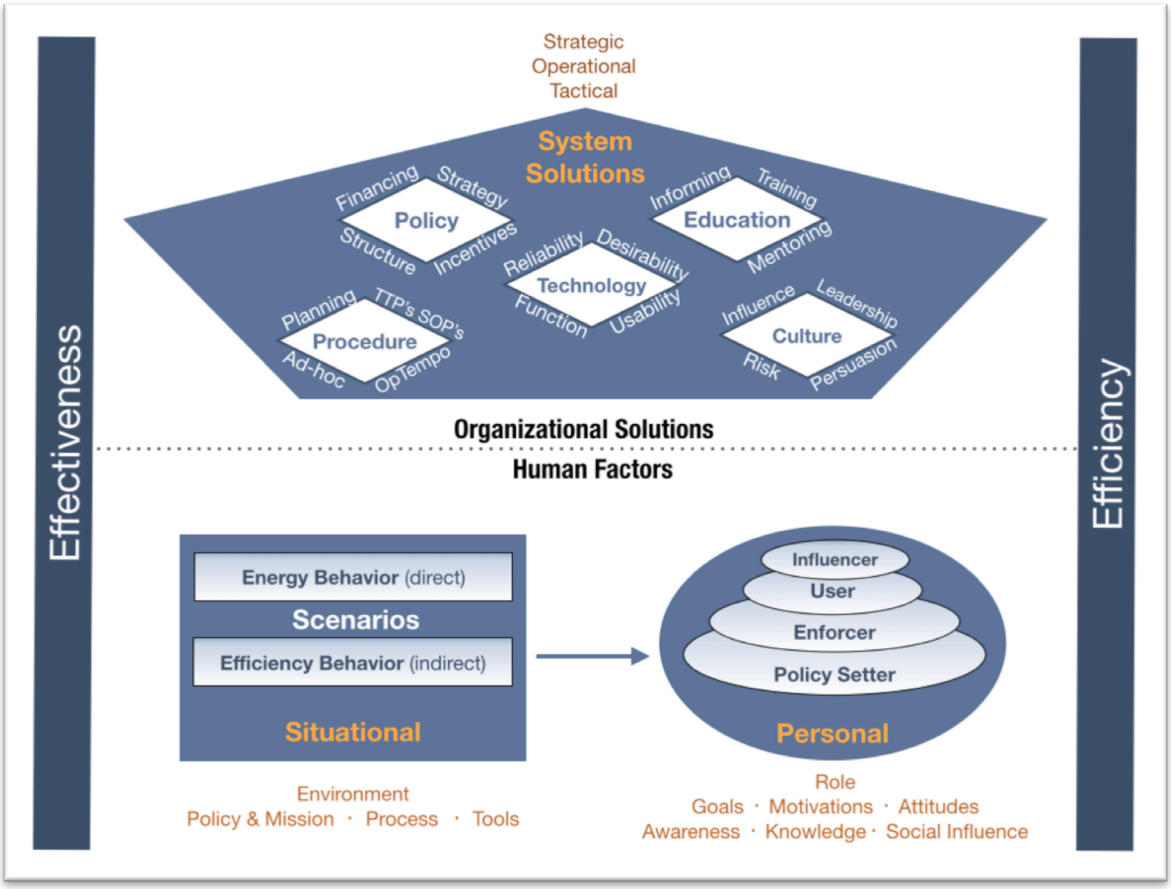


Figure 1. Scenario Model

In this model, we identify the human factors impacting energy use as both situational and personal. Situational factors are contextually situated behaviors—the behaviors occur in a specific circumstance with unique environments, missions, policies, processes, and tools. The behaviors associated with these individual scenarios can directly or indirectly impact energy use. Direct energy behaviors represent actual fuel use (e.g., idling). Indirect energy behaviors are those that impact energy use but not directly (e.g., planning). Personal Factors on the other hand are

individual characteristics that impact a person's willingness and ability to change behavior. These personal characteristics are typically shared by those with similar roles (e.g., convoy commanders) and goals (e.g., safety). As we observed Marines' behaviors, we noted that there are sets of organizational solutions or mitigation strategies that can be applied to reduce energy use. As shown in the upper half of the model, these systemic solutions include policy, procedure, technology, education, and cultural changes. Finally, we noted that all decision-making regarding energy use operates between the tensions of effectiveness and efficiency.

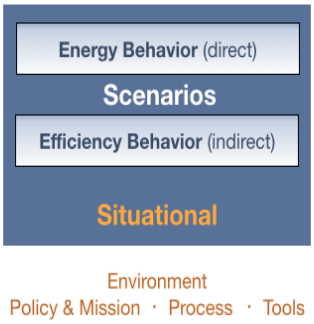
This model demonstrates the complexity of factors impacting energy use and proposes a multi factor framework for changing the "energy ethos" of the Marine Corps that includes behavioral factors and organizational solutions.

Behavioral Factors Impact Energy Use

When it comes to changing Marines' behaviors, it is important to understand the importance of context. In our study, we observed that people adapt their behaviors based on the situation in which they are operating and their own personal influences. For instance, policies regarding the movement of supplies are not the same for Ground Combat Element (GCE) and the Logistics Combat Element (LCE). Because GCE has a primary focus on the immediate combat mission, they prioritize operational effectiveness. Because their mission *is* logistics, the LCE is more focused on supply effectiveness and efficiency. We also observed how the situational context impacts processes. This is somewhat self-evident: The sequence and flow of how things are done necessarily depends upon the conditions under which the activity occurs. For instance, it is not surprising that fuel planning in the field is often inaccurate because it is done by hand using "pencil whip" estimates while logistical planning in Garrison is more thorough and done using log statistics and historical consumption data. Situational differences also impact the use of specific technologies or tools.[8] For instance, the use of solar in the field is more limited because of concerns about reliability and safety.

Energy Use Varies by Scenario

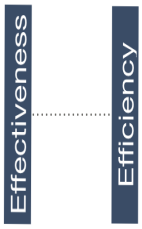
In our observations, we noted two distinct types of scenarios or situational behaviors related to improving energy efficiency in the Marine Corps—behaviors *directly* related to energy use *and* behaviors that impact overall efficiency and, therefore, *indirectly* impact energy use. In our research, we began by looking at energy scenarios that involved direct use of fuel for transportation and power—air support, convoying, fueling, communications, command centers, garrisoning, medical, mess, and billeting. As we observed the core scenarios, we noticed that fuel use was also impacted by things such as load planning, maintenance, and overall mission requirements. For instance, if a truck does not have to



[8]Tools include low fidelity devices such as pen and paper, sophisticated software programs, as well as hardware such as Uninterruptible Power Supplies (UPS).

make a trip to resupply or can carry less cargo, it will use less fuel. Based on these observations, we expanded our model and observations to include these "indirect" behaviors.

There is a Tension between Effectiveness and Efficiency



An overarching situational factor that brackets all decision-making is the tension between mission effectiveness and efficient operations. Many of the decisions about whether or not to use less energy are made in terms of how that decision will impact the ability to accomplish the mission. As budget constraints increase in the Department of Defense, the challenge of balancing operational effectiveness and organizational efficiency will most likely increase.

Energy Behaviors Come Down to the Personal

The impact of context on human behavior extends into the personal arena. There is no single stakeholder (except perhaps the Commandant) who can effect an ethos change regarding energy. If monitoring and strategic communication efforts are targeted at the wrong stakeholder, the organization will waste resources and decrease communication effectiveness. Our research indicates that there are at least four types of stakeholders related to energy use. These stakeholder types vary by scenario and are based on roles. First, we have the *User*. The *User* is the person who is directly responsible for using energy—the truck driver, the cook, the communication tech. A second stakeholder type is the *Enforcer.* The *Enforcer* is the person who has direct control over the user. For instance, in a convoy the person who controls the driver is the convoy commander. A third stakeholder type is the *Influencer.* The I*nfluencer* may not be able to control behavior but has some sway over another stakeholder. For instance, in convoying, the "A Driver" may influence (but not control) the speed of travel, and the communications officer may influence (but not control) the driver's decision to idle. Finally, there is the *Policy Setter*. The *Policy Setter* is the person who sets rules for how things are done. In the convoy example, the convoy commander is currently the *Policy Setter* (as well as the *Enforcer.*) Identifying the key stakeholders for each scenario is an important step to developing effective mitigation strategies that help to target interventions to key stakeholders and leverage the right influencers to affect change.

For each stakeholder type, we observed six factors that impacted ability and willingness to change: personal goals, motivations, attitudes and values, awareness, knowledge, and social influence. Personal goals include desired work outcomes and life objectives. For instance, Radar Techs goals include setting up communications and getting promoted. Motivations on the other hand are the driving force behind behavior—those internal and external factors that stimulate desire and energize people to act. For communications personnel for instance, motivations include the desire for education and the avoidance of punishment. A third personal factor is one's attitudes and values. These include emotions, beliefs, and opinions, which may influence an individual's actions.

An example of a shared value that might support reduced energy use is the belief that the Marine Corps should be "agile." The fourth factor—awareness—relates to how conscious a person is of the existence or impact of his or her energy behaviors. For example, does a commander know what his relative fuel usage is? Another cognitive factor related to awareness is knowledge. This factor refers to whether or not an individual has the information, understanding, or skills to be efficient in one's energy use. Do utility engineers understand the impact of running generators at low loads? Finally, we have the impact of social influence. Social influence is the effect that other people have upon beliefs or behaviors. For example, the family can exert an influence on the energy behavior of a Marine through his or her children's schoolyard awareness and promotion of conservation behaviors.

All of these factors help shape individual actions and decisions on how energy is used. The personal factors, in conjunction with the situational factors, establish a "behavioral factors" model for understanding energy behaviors in the Marine Corps. The question becomes "how can these factors be utilized to create a plan for moving forward in reducing energy use." Based on our observations and interviews during ITX and of WTI exercises we have created a framework for thinking about the organizational solutions to reducing energy use.

Organizational Solutions Require a Systems' Approach

When looking at our observation and interview data it became clear that in order to reduce energy use in the Marine Corps the organization would need to take a multifaceted approach to behavior change that looked across strategic, operational, and tactical practices. Based on our data, we created a five-factor systems' model for making systemic changes to support energy efficiency. The five solution areas are procedure, policy, technology, education, and culture.

Improve Formal and Informal Procedures

System solutions begin with looking at procedural changes that can impact energy use. Procedural changes include changes in the processes for planning (e.g., logistical planning and exercise planning), changes to formal procedures (e.g., TTPs and SOPs,), and changes to ad hoc decision-making processes (e.g., battery charging, hot fueling). In addition, informal and formal procedures are affected by the variations and uncertainties of the operational tempo. For example, we observed that energy requirements are often based on worst-case scenarios and do not account for the ebb and flow of combat operations.

Revise Financial, Structural, Strategic, and Incentive Policies

In our observations, we noted a number of energy policy issues that should be a part of the solution set. First, many of the structures of the Marine Corps are at odds with reducing energy use. For instance, structural elements such as the length and design of exercises, the shortage of pilots, and the role of liaison officers impact energy use. Along with structure, we observed several strategic opportunities. Strategy—a plan to bring about a desired future—operates across tactical, operational, and strategic levels in the Marine Corps. For instance, a tactical strategy might include looking at new ways to transport goods; an operational strategy might revisit the role of the Medical Corps in refrigeration planning; and a strategy that operates at the strategic level might address the structure and expected outcomes of the small-scale exercises during ITX. A third policy area is that of financial accountability. Our study revealed gaps in individual awareness of financial impacts, in mechanisms for tracking and managing finances, and in unit accountability for expenditures. The final policy factor is in the area of incentives. An incentive is a motivational device to encourage desired behaviors or actions and may include monetary and non-monetary benefits.

Deploy Technologies that are Functional, Reliable, Usable, & Desirable

When looking at possible solutions to reducing energy, technology is an obvious factor. Our data indicates, however, that for energy technology to be adopted in the Marine Corps, it must satisfy four requirements. It must provide the functionality that is appropriate for the scenarios of use in the Marine Corps; it must be reliable; it must be easy to use; and to be adopted, it needs to meet a minimum level of desirability. Functionality means that energy technologies are designed for expeditionary use and provide the features and functions that are required for the job. For example, batteries are designed for extreme temperatures. Reliability—the ability of a system to consistently perform its intended function without failure or degradation—is a second necessary requirement for the ready adoption of energy-efficient technologies. The failure of batteries under high heat is an example of a reliability challenge. The third technology factor is usability. Usability—the ease of use of a product—is an important aspect to the adoption of energy technologies. Technologies that are difficult to use or require a lot of

mental effort are less likely to be used. For instance, if a thermal liner for a tent tends to get torn, it is more likely to be left open. The final technology requirement is that the user and buyer perceive the technology as being desirable. The desire to use tools is based on preconceived notions, product packaging, and initial experiences with the technology. For instance, we noted that Marines, who had not used solar in the field, viewed the use of solar as desirable because of its perceived effectiveness, ease of use, and "cool" factor.

Build in Education that Includes Information, Training, & Mentoring

A common approach to behavior change is to introduce additional training. Although not sufficient, educational solutions provide a method of strengthening change-management efforts. Our research indicates that there are three levels of training that should be addressed. First, it is important to provide information about technical requirements and functionality. For instance, convoy drivers need to understand the charging requirements of different equipment. Secondly, we observed the need for formal training initiatives. An example is training needed for power planning. Formal training includes MOS schools and continuing education. The third area that should be included in the educational arena is mentoring. Establishing methods for skilled personnel such as utility engineers to coach junior (and senior leadership) in power planning can be a cost effective and efficient way to educate Marines in energy efficient behaviors.

Use Cultural Levers—Persuasion, Influence, Leadership, & Risk Awareness

The final organizational intervention is one directed at changing the culture of the Marine Corps to support reduced energy use. This organizational solution is one that is often owned by strategic communication groups. In our observations, we noted a need to focus on persuasion, leadership development, social influence, and direct appeals to managing risk. Persuasion is a managed process that is aimed at changing attitudes by using written or spoken words. Persuasive communications are successful when they address the underlying goals, motivations, and values of the audience. For instance, communicating the personal benefits of solar as increased comfort resulting from carrying lighter weight batteries. Related to persuasion is the need to address perceived risk. In our research, risk was shown to be an area where much of the cultural resistance was focused. Both real and perceived risks were seen to drive individual decisions to be energy efficient. The third mitigation strategy for culture change, especially in this era of social networking, is a strategy that leverages social influence. Research in the role of social influence shows that it is important to utilize the appropriate social levers to influence and change attitudes.[9] Finally, in a command and control environment such as the Marine Corps, it is critical to develop the support of leadership. Leadership—Field grade officers, Company Officers and Staff NCOs—is an important stakeholder group and as such needs to be engaged in setting energy policies, enforcing energy policies, and influencing others in efficient resource usage.

[9] Reed, M. B., McIntyre, D. M., & Gatchalian, N. I. (2014). *The use of social media to maximize energy performance in the United States Marine Corps* (Master's thesis). Monterey, CA: Naval Postgraduate School.

At higher levels of command, leadership is the key to initiating formal procedures and the touchstone for financial accountability and operational strategy. At the lower to mid levels of command, leadership skills are essential in establishing energy efficient procedures and mentoring and informing others in energy planning.

Depending upon the desired behavior changes and the situational and personal factors at play, the Marine Corps should select interventions that cross over multiple solutions. The following section outlines our observations, highlights key findings, and includes some proposed organizational solutions. The organizational solutions that we propose in the following sections are straw men; they are presented as hypothetical areas for mitigation. Ultimately the decisions regarding organizational change efforts should be conducted in consultation with industry, academia, and Marine Corps stakeholders.

Ethos Change

The overall goal of E2O is to change the beliefs and attitudes of Marines regarding energy use. At the same time, the Marine Corps is refocusing on its expeditionary roots, stressing "fast, austere, and lethal." Marine Corps command sees reduced energy use as an enabler of this renewed focus on agility and extended reach. In order to accomplish this, we believe that E2O needs to have a clear understanding of Marines' awareness and knowledge regarding energy, Marines' attitudes and values towards efficient energy use, and the factors that can help motivate Marines to be more energy efficient. Based on our observations, we have identified some of the factors that should be taken into account when implementing strategic communication and change efforts. Because we took a broad look at energy use, we do not have sufficient data on individual roles to make MOS-specific recommendations.

"It's a strategic advantage: If I have two chess moves for every one of your single chess moves, I have the advantage."

Marines Need More Awareness & Knowledge

Our observations of Expeditionary Marines uncovered gaps in awareness and knowledge. Marines are generally not aware of the impact of energy on mission accomplishment and are often lacking skills in efficient energy planning and use.

Marines are not Aware of Fuel Usage or its Impact

The first step in any change is awareness of the need for change. During our observations, we noted two areas where energy awareness comes into play. First, the majority of infantry Marines we spoke to were not aware of their usage patterns. Fuel tracking is "not on their radar" and "no conscious thought is given to energy use." Second, many in the GCE are not aware of the impact of idling on vehicle and battery maintenance. When asked about proper idling behaviors, Marines we spoke to had inconsistent responses. For instance, estimates of *how long* to idle a Humvee to charge

batteries ranged from 5 to 30 minutes and estimates of *how often* to charge batteries ranged from hourly to once a day. This lack of awareness also extends to generator use. For example, infantry Marines were generally not aware or concerned with the under loading of generators and the resultant "wet-stacking."

"I doubt that Marines waste much energy."

Two groups appear to have a higher awareness of the impact of energy use: logistics personnel and the ACE. This finding is not surprising given that energy use is directly related to the success of these group operations. Logistics, both LCE and GCE, is aware of the impact of energy use. We heard logistics personnel talk about the need to look at energy consumption and the role of idling, battery drains, and wet-stacking on maintenance. The ACE, being highly dependent on accurate fuel projections, also appears to be more aware of the importance of fuel monitoring. In our discussions with WTI aviation personnel, senior leadership indicated higher levels of awareness regarding fuel consumption and expressed some frustration communicating the importance to junior officers and enlisted.

There were some signs however, that there is a potential for increasing awareness of fuel use. Both on-base and in their personal lives, some Marines are aware of the push for energy efficiency. A few Marines we spoke to referenced the fact that on base they have automatic light switches, timed air conditioners, limitations on hot water, recycle bins, and artificial grass. At home, Marines also have the social influence of community and family. They are aware of the high cost of fuel for Americans and themselves. Their children also impact them: Many are learning about recycling and energy conservation in schools.

There is a Lack of Knowledge in Energy Planning and Management

"We need to teach all MOS the efficient use of all energy resources."

Finally, there are knowledge gaps in the Marine Corps regarding energy planning, energy management, and maintenance. Lieutenants often do not have experience in energy planning and senior leadership is often not aware of the intricacies of the impact of their power planning decisions: "I (the utilities engineer) develop a plan and then am overridden—they have an idea of what they want and insist." Junior engineers also lack the knowledge they need to do energy planning. Energy planning is only taught at the highest levels of utilities engineering education and is currently learned on the job as "unspoken rules." Although technical manuals are available, they are cumbersome, difficult to use, and are impractical for quick decision-making. Skilled energy planners—utility engineers—are also in short supply and, in the upcoming years, their numbers will likely be reduced.

Attitudes and Values Limit Willingness to Change

When looking at changing the ethos of the Marine Corps, it is important to understand existing attitudes and values that might impact a Marine's willingness to use less energy. One's attitude (the way you think and feel about someone or something) and ones values (what you think is important) both affect a person's behavior. During our study, we identified four value areas that impact individual Marines willingness to be energy-efficient.

There is a Sense of Abundance

"Fuel's not a concern: We always have what we need."

One of the dominant attitudes that we observed was that there is "always a source of fuel and that the job will get done no matter what." The attitude is that fuel is always available and difficulties only happen because of bureaucracy or contractor delays. Budget considerations are sometimes an issue and it always works out.

There is Little Financial Accountability

"Reducing the budget is the best incentive for saving fuel."

The sense of abundance is based on a disconnect between using energy and paying the energy bills. The attitude is that it is "government money" and "not your wallet." In personal life, one Marine noted that having to pay the utility bill (and, thus, knowing what it costs), consciously makes one use less. In LCE for instance, the person that pays the most attention to budget considerations is the operations chief who is aware of the budget numbers. If you have to pay for your own fuel, you have an incentive to use less. As one aviation person put it, "MAWTS is more conscious of energy use because of the large amounts of money they spend on fuel."

Change is Associated with More Bureaucracy

"It's another pebble in the pack."

Interviews with Marines indicated that there is a certain level of resistance to change in the Marine Corps. Adding new energy policies is seen as just "one more thing" to do. The burden of paperwork and the tendency of the Department of Defense to overreact to problems were observed and cited as causes of resistance. The "reawakening," if acknowledged, was viewed with distrust: "It's just another way to wash out the old they don't want." Other initiatives, such as a program at WTI that personally identifies errant car rental drivers based on tracking equipment and cameras is viewed with disdain as a "nanny state" system and another example of broken trust. In addition, systems that are difficult to use or maintain are seen as a burden. Some suggested that changes should be large rather than many small and include enforcement mechanisms such as policies, procedures, and orders.

Effectiveness Trumps Efficiency

"Energy efficiency is a nuisance."

There is a tension within the Marine Corps between effectiveness and efficiency. The bottom line is that nothing should adversely affect operations or training and anything that makes Marines lighter and more mobile is valued. This is especially true in combat situations. At the same time, amongst some officers and senior leadership, there is a connection made between the refocusing on expeditionary and efficiency: "Our job is to be efficient" and "Expeditionary means efficient." Several interviewees recognized the role of efficiency in making fuel last as long as possible, in simplifying energy planning, and in enabling Marines to "go farther on less"—"Anything that makes Marines lighter and more mobile is good." Young enlisted Marines, however, had no connection with the concept of the Marine Corps expeditionary roots. In addition, the concept of "extending reach" was not seen as a realistic rationale since the Marine experience is that needs are always met: "There's always fuel." One attitude that aligns with energy efficiency is the attitude that the Marine way is to "adapt and overcome—to make it work."

Motivations for Change are Weak

Motivations, or what energizes people to act, are an important factor in creating an ethos change. We identified five factors that impact individual motivations. These factors can be used as levers to incentivize change.

Comfort Trumps Efficiency

"Marines won't change unless it's more convenient to do it that way."

Quality-of-life factors—hot showers, light loads, shade, air conditioners, keeping warm, and keeping their personal electronics charged—are important motivators for Marines. Having experienced 120° temperatures, the researchers do not take this need for comfort lightly. These basic needs will always dominate as core motivators and efforts to increase energy efficiency should always include a Marine's basic needs.

Safety and Risk are Key Considerations

"I plan for the worst case scenario."

Based on our observations, safety and risk are key decision points for every Marine action and they impact a Marine's willingness to modify behavior to be more efficient. One example is in power planning, in which the size and number of generators is based on worst-case scenarios in order to avoid power failures. Other examples on the ground side include refueling at half a tank to avoid running out of gas, idling to avoid difficulties in restarting, idling to enable quick response in emergency situations, and charging batteries unnecessarily to prevent failures. For the ACE, a fuel shortage negatively impacts safety in the obvious way of an increased probability of a plane crash

as well as in reducing training time. Perhaps the most important safety and risk issue is balancing the safety benefits of heavy armor with the comfort benefits of reduced weight.

Rewards and Incentives can Change Behavior

"Being a Marine means we're resilient, resourceful, are willing to put up with shit."

Rewards are important motivators for behavior. Rewards can be either intrinsic or extrinsic. An extrinsic reward is an award that is tangible or physical and given for accomplishing something. Intrinsic rewards are intangible rewards that give an individual personal satisfaction. Enlisted Marines have a number of intrinsic motivations for being a Marine—"bettering my life," "getting an education," "patriotism," "pride," "challenge," "cool uniforms," "travel," and "the thrill of shooting a gun." Appealing to internal motivational elements may be a way to reinforce the desired behavior of reduced energy use. Some examples of internalized values that we collected that might align with the desired cultural change include professionalism, respect, perseverance, resilience, resourcefulness, adaptability, and pride. Another way to incentivize Marines to be energy efficient is to use traditional extrinsic rewards. Some extrinsic rewards that were mentioned include rewarding and recognizing units, avoiding physical punishment, receiving educational benefits, and getting more liberty and pay.

Leadership is a Key Force

"That's for other people to think about—those above me."

Leadership plays a key role in any effort to improve energy efficiency in the Marine Corps. Being a hierarchical organization, direction and support from the top is critical. In our conversations with both enlisted and field grade officers in the GCE, there appears to be a lack of awareness and support for energy efficiency on the part of senior leadership. Lower ranks are looking to leadership to set the policy and expect that the change will happen when it is pushed down from above. One of the challenges that we observed was that senior leadership was not always trusted in this area. This distrust is based on lack of skill ("senior leadership doesn't admit they don't know"), unequal access to services ("front of the line privileges"), and commanders gaming the system ("reducing training to meet goals for their Fit Reps"). One field grade officer from the ACE did exhibit the kind of leadership attitude that we feel is necessary: "I'm a steward. It's my job to pay attention to money and efficiency and effectiveness."

Environmentalism is a Weak Force

"I like the idea of using solar to conserve."

At present, conservation does not appear to be a valued principle in the Marine Corps. Attitudes towards energy, however, are part of the larger American culture. High gas prices have increased awareness of energy use on a personal level for Marines and solar energy has an appeal. In addition, we saw some evidence that conservation and environmentalism had threads of support with some younger enlisted Marines.

A Detailed Look at Energy Scenarios and Stakeholders

As we noted in our model discussion, it is important to examine specific scenarios where energy is used. Our focus for this research has been on expeditionary energy and the majority of our observations occurred during training exercises. In looking at specific energy scenarios, we can see that ITX and WTI exercises are a good—but not perfect—way to look at energy behavior in an expeditionary environment. We believe, however, that ITX and WTI are sufficiently representative of an expeditionary environment to provide insights into how to improve E2O processes. It is also important to note that there are some key differences. First of all, the physical environment for both exercises is that of a desert and we do not recommend extrapolating to other physical environments. Second, these exercises are not truly expeditionary and are not as unpredictable or chaotic as a deployment would be. Finally, these exercises are serving dual purposes. They are both training exercises and evaluation tools. Because we could not interrupt training, our observational methodology was limited. Our live observations and field interviews, however, did allow us to gain a situationally grounded view of energy behaviors resulting in a holistic view of the ebb and flow of Marine expeditionary life.

One of the primary requests from the Marine Corps was for the researchers to take an independent view of operations in order to provide an alternative lens on the problem. To support this request, we are providing a detailed ethnographic look at Marine Corps energy use. In this section we will first describe the structure of the Marine air-ground task force (MAGTF) and then describe the flow of events that we observed in a training environment and the impact this flow has on energy efficiency. Finally, we provide scenario-level suggestions for increasing energy efficiency.

Expeditionary Scenarios in the Marine Corps

During our field research, we observed MAGTFs operating in a training and evaluation environment (ITX and WTI). The MAGTF is an air–ground combined arms task organization of the Marine Corps that operates under a single commander and is structured to accomplish a specific mission. MAGTFs are flexible and vary in size and capability according to the assigned mission (see Figure 2). As you can see, there are four sizes of MAGTF structures with corresponding elements (and acronyms.)

MAGTF SIZE (Largest to Smallest)	ELEMENT		
	GCE	ACE	LCE
Marine Expeditionary Force (MEF)	Marine Division (MARDIV)	Marine Aircraft Wing (MAW)	Marine Logistics Group (MLG)
Marine Expeditionary Brigade (MEB)	Marine Regiment (MARREG)	Marine Aircraft Group (MAG)	Combat Logistics Regiment (CLR)
Marine Expeditionary Unit (MEU)	Battalion Landing Team (BLT)	Reinforced Helicopter/Fixed Wing Squadron	Combat Logistics Battalion (CLB)
Special Purpose MAGTF (SPMAGTF)	Elements of a MARDIV	Elements of a MAW	Elements of a MLG

Figure 2. MAGTF Structure

MAGTFs are equipped to conduct amphibious operations as part of Naval expeditionary forces. They are also capable of sustained combat operations ashore. Every MAGTF consists of four elements: command, aviation, ground, and logistics combat element. The command element (CE) contains headquarters and other units that provide intelligence, communication, and administrative support. The ground combat element (GCE) conducts ground operations to support the mission. This element includes infantry, artillery, reconnaissance, armor, light armor, assault amphibian, engineer and other forces as needed. The aviation combat element (ACE) runs offensive and defensive air operations to support the MAGTF mission. Finally, the logistics combat element (LCE) provides service support to maintain readiness and sustainability of the MAGTF. The LCE performs a "just-in-time" coordination and liaison function. As you can see there is a wide variety of applications of the MAGTF.

Our research looked at some of the observed realities of the MAGTF during ITX and WTI and provided a "slice of life" look at energy use in the Marine Corps. This "slice of life" is presented below as a coordinated flow of events supporting the MAGTF. Our observations began with preparing for an exercise and deployment, continued to setting up a forward presence, and ended with looking at field deployment and Air.

Scenario: Preparing for an Exercise or Deployment

Any organizational effort to reduce energy use in the expeditionary forces of the Marine Corps needs to begin with a close look at the support structures that indirectly impact energy use: exercise planning and exercise support. In looking at these areas, we were presented with a picture of the planning process that indicates that there are a number of mission and process opportunities for improving the overall efficiency (and therefore energy efficiency) of the exercises.

Exercise Planning

ITX is an outgrowth of earlier training and evaluation exercises and is focused on preparing troops to deal with the "combined arms dilemma." The exercise is designed to simulate a battle in which geometry of fire is set up between artillery, infantry, and air. In addition, it is also designed as a way to evaluate troops and certify them ready for deployment. Currently shrinking resources impacts ITX planning: facilitators are looking for more cost-effective processes and ways to use fewer resources.

Training

One of the main goals of ITX is to train in "fire and maneuver" tactics at a battalion level. The ultimate goal is unit readiness and unit readiness is defined by mission essential task lists (METLs). These tasks include standards for both units and individuals. For example, a mission task for combat support might include unit-training requirements for setting up communications and individual training requirements for knowing how to operate a radio. These METLs are customized by the units and are not standardized.

ITX occurs five times a year and typically includes two battalions per ITX. Each ITX lasts approximately 30 days, for 150 total days of training a year. For individual units however, the exercise lengths are unpredictable. For example, for one unit the time at the forward operating base was unexpectedly extended from three days to 30 days, resulting in 10 times the fuel burn rate. Other training venues (e.g., Simulations, TTECG, MAWTS-1, MGTOG) compliment ITX training.

A main purpose of the exercises is to have the units mature and grow into a coordinated MAGTF. Training progresses from small-scale exercises to the larger integrated exercises where two battalions converge. Individual trainings move through a "crawl, walk, run" pace that takes individuals from demonstration of tactics all the way to full speed combat operations. As battalions improve over time, exercises get harder in hopes that the battalions will improve. Finally, complications referred to as friction are introduced into the exercises. These artificial frictions are known as "injects" (note: fuel and other resource constraints are not used as "injects").

ITX training is primarily what is called "block 4 training," which is combined maneuver training. Preparatory training, "block 3 training," is usually done before the ITX but may be picked up during what is called "white space" training. White space training is typically funded by ITX. Engineering is often viewed as "white space" training.

"The ITX teaches a Marine how to be a Marine."

In addition to the above, the ITX serves a number of other, softer functions. First, it is a form of enculturation into the Marine Corps. As one Marine stated: "the ITX teaches us what to do and how to be flexible. It is a place where soldiers can learn how to make decisions." The Marine Corps stresses operational flexibility. Doctrine is not as strong as the other services and commanders are able to set the appropriate operational tempo. This is intended to empower leaders at all levels to make decisions. ITX is also a place where Marines learn what it is to be an expeditionary force. Common terms used to describe the expeditionary function were "agile," "mobile," and "efficient." The second function of ITX is to retrain Marines in their expeditionary roots. Training becomes a way to learn how to be more independent, "how to go into underdeveloped nations without logistics already being there." For example, one participant noted the importance of this independence during beach landings: "Fuel should not be the first thing unloaded. We should make a gallon of gas work and operate independently for the first 24 to 36 hours." Finally, ITX is likely to become a more dominant function for the Marine Corps. As the wars in Afghanistan and Iraq wind down, the exercises will become the primary activity of the Marine Corps—continual training in readiness rather than training for deployment.

Reevaluating the appropriateness and efficiency of the overall training mission may offer opportunities for improving efficiency and for reducing energy consumption.

Evaluations

The second goal of ITX is to evaluate the combat readiness of Marines. Marines are evaluated during the exercise by a team of evaluators called "Coyotes." These evaluators rotate in and out and there are some challenges with having an adequate number of trained Coyotes. The Coyotes are judging the performance of individual Marines and units based on a set of METLs. The teams are assessed

using a color code system—green, yellow, and red. Green indicates that units are trained in 80 to 100 percent of the training tasks; yellow equals 50 to 79 percent of training tasks; and red indicates less than 50 percent. These assessments are subjective and very few teams fail. The structure and deliverables of the After Action Reports are also loosely structured, decreasing the effectiveness of exercise evaluations. Finally, the engineering mission is not directly evaluated.

Exercise Planning: Challenges

As we observed Marines behaviors, we identified the following areas for improvement. In Exercise Planning, the goals and structure of ITX are what determine the usage of resources and therefor energy. The following areas may offer opportunities for efficiency improvements:

Goals

- Evaluation of training requirements
- Lack of integration of the engineering mission
- Changing nature of ITX—expeditionary focus, increased training, and reduced combat
- The ineffectiveness of exercise evaluations
- Lack of energy considerations in METLs
- Non standard METLs

Structures

- Integration of other training venues
- Length of the exercise
- Other options for individual trainings in the "crawl, walk" areas
- Use of UAVs and simulations
- Poor integration of white space training
- Lack of energy and resource "injects"

Exercise Planning: Stakeholders

The primary decision-makers in ITX planning are at the higher echelons of the ITX command and in DC. The policy changes necessary to better integrate the engineering mission, improve exercise evaluations, and change the structure of ITX is done at a level that was not accessible to this study but should be included in the organizational change plan.

Exercise Support

The majority of resources—vehicles, fuel, supply, ammunition, and equipment—are supplied and maintained by the Exercise Support Division (ESD).

ITX Support Service

ESD operates at maximum capacity to provide support for the exercises. Support activities are planned nearly two years out. The two budgets associated with the exercises are the ammunition budget, approximately $12 million, and the exercise budget at approximately $5.8 million, both of which are paid by ESD. The operating force pays only for travel and the cost of transporting any vehicles they bring. Occasionally, operating forces must supplement other equipment

"Logistics is just not evaluated in the ITX."

requirements and pay for the cost of convoy. ITX has its own vehicle fleet (white vehicles), which has just recently been reduced through the use of rental vehicles. It is estimated that approximately 720,000 gallons of fuel are used per exercise (excluding air and base use).

While logistics is not directly evaluated during the exercise, logistics personnel are evaluated on their level of combat training. Logistical planning is based on equipment density lists, which are supplied by the commands.

ITX Maintenance Service

ESD does the dispatching and maintenance on ITX vehicles, batteries, and generators. Maintenance issues related to reducing fuel use include vehicle upkeep, vehicle tracking, and tire maintenance. Vehicles are maintained during and after each exercise. Maintenance also records and tracks vehicle miles for most vehicles. On large diesels, ESD also tracks engine hours, using a "Hobbs meter." There are reportedly discrepancies between what is tracked—miles do not align with hours. This suggests problems with data collection. Maintenance also establishes policies for tire pressure, which affects the miles per gallon of the vehicles. There is an interactive customer evaluation system (ICE) where users can list problems with the vehicles.

"We have to charge the batteries because we can't trust that they'll keep a charge."

Inefficient use of generators is a huge problem for maintenance. When generators are run at low loads, they become "wet-stacked." Wet-stacking occurs in diesel engines when the units are run at low loads and the unburned fuel passes into the exhaust system. The maintenance crews do not see data on loads, but they do see data on hours of use. Maintenance, however, can determine low loads indirectly by the condition of the units. By one account, up to 95 percent of generators returned after an ITX shows signs of wet-stacking. It requires one-two hours of labor to repair a generator that has been wet-stacked. If the front seal is blown, it can take much longer. E2O efforts have identified that the average generator load at ITX is only 7-15 percent.

Marines in the exercises also complained about the reliability of vehicles and batteries. This resulted in increased idling because the fear was that the vehicles might not restart.

Exercise Support: Challenges

As we observed Marines behaviors, we identified accountability for resource costs, commander-generated equipment density lists, and maintenance practices as gap areas:

Accountability

- ESD supplies the majority of the resources—units have no financial accountability
- Operating forces may convoy their own equipment
- Logistics is not evaluated during the exercise
- Idling time (run time + mileage) is not tracked
- Not all vehicles are tracked (Humvees and heavy equipment are excluded)
- Vehicle mileage and fueling numbers are inaccurate

Equipment Requests

- Equipment density lists are used for logistical planning
- Commands develop their own equipment density lists
- Request systems are not being used efficiently

Maintenance Practices

- ESD tries to extend battery life and does not replace batteries as often as they should
- Tire pressure impacts mpg
- The belief that a vehicle is unreliable results in longer idling times
- The belief that batteries are not reliable results in vehicles being used to charge batteries
- Wet-stacking increases generator maintenance
- Field maintenance people are not adequately trained—e.g., mechanics fixing inverters

Exercise Support: Stakeholders

Stakeholders from Exercise Support include high-level planners who are responding to unit requirements and leadership requests. These are the "Enforcers" and "Policy Setters." Unit requirements are based on equipment density lists, which are supplied by the commands. The battalion commander as "User" and key "Influencer"' decides what supplies are needed in cooperation with his staff. Ultimately, the logistics plan stems from the MEF campaign plan, which is tied to overall national security strategy and international agreements. For instance, in Iraq and Afghanistan, water provisioning was often contracted with local providers to support USA national security objectives regarding cooperation.

By one account, the resource challenges of ITX planning are partially due to undue influences from leadership. The ITX command is a two-star command and does not have the influence to make changes. In addition, the two-star command is under the orders of three-star force providers. The three stars in turn are supplying personnel to the Combatant Commands who are four stars. This chain of influence leads to weak training requirements because of the need to meet COCOM manning requests for quantity. In this study, we were not able to investigate the specifics of how the chain of leadership influences overall exercise efficiency. We recommend, however, that future studies examine the key influencers for establishing equipment density lists and rules for provisioning.

Ideas for Improvements in Exercise Planning

Organizational improvements may include procedural, policy, technology, education, and culture changes:

Procedures

- Evaluate METs and METLs for appropriateness and effectiveness
- Evaluate training requirements for appropriateness and effectiveness
- Add energy "injects" into the exercises
- Use Coyotes to evaluate energy efficiency
- Include the engineering mission in training evaluations
- Formalize outputs of the AARs and include energy accountability

Policies

- Make individual units financially accountable for fuel use
- Evaluate ITX training requirements for efficiency improvements
- Evaluate ITX assessment criteria for mission alignment
- Evaluate provisioning requirements for efficiency improvements
- Evaluate other exercises for lower cost ways to conduct "crawl, walk" training (and still meet mission)
- Conduct individual trainings at other, more cost effective venue
- Evaluate the use of "white space" training for efficiency improvements
- Minimize the convoying of "home" vehicles
- Include reliability factors when establishing battery replacement policies

Technology

- Utilize UAVs and simulations
- Track idling time (engine hours and mpg)
- Utilize the ICE system to minimize maintenance problems (and increase trust)
- Evaluate the fuel costs of ITX's "white vehicle" fleet versus rental vehicles

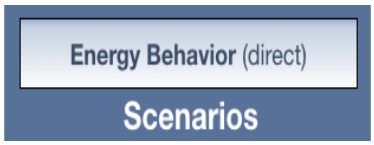
Education

- Educate commanders about poor reliability due to running low generator loads
- Communicate the importance of energy use and its impact on mobility

Culture

- Use ITX and other training venues to acculturate Marines in energy efficiency
- Include energy evaluations (total lifecycle management) in policy considerations

Scenario: Establishing and Maintaining Forward Operating Bases



The Marine Corps Forward Operating Base (FOB) is designed to support tactical operations. An FOB may or may not contain an airfield, hospital, or other facilities. The base also may be used for an extended period of time. FOBs are traditionally supported by Main Operating Bases that are required to provide backup support. In recent years, the USMC FOB has become a primary energy consumer with 24-hour connectivity and semi-permanent residents.

FOBs have become integral to U.S. contingency operations creating distinct advantages in extending expeditionary range and combat agility while simultaneously increasing the operational risk and vulnerability by significantly extending the logistics tail. The easiest way to expose the energy use and requirements in the FOB is to "follow the fuel" and identify the equipment and functions that consume the most energy.

Camp Wilson is the FOB at the heart of the ITX. It is semi-permanent and its facilities include an airfield, laundry, gymnasium, and an all-ranks dining hall with cable television. It is serviced by contractors from the surrounding community. These amenities are similar to the semi-permanent contingency bases established in Iraq and Afghanistan. Camp Wilson's reliance on constantly functioning electricity further blurs the line between forward operating bases and garrisons.

Marines have a name for the residents of the FOB, "FWLFOBs—folks who live at the FOB." Others view the permanence of the FOB as part of a culture change:

> *"Since about 2002, the Marines have had ever increasing use of technology —computers, everything [is] more sophisticated. This is tied to more permanent bases and less expeditionary… Marines don't know how to transition between expeditionary and contingency bases."*

The goals of the FOB are to create a base of operations close to combat zones. This base includes facilities for sleeping, feeding, medical care, hygiene, logistics, and Command, Control and Situational Awareness (C2SA). During ITX, command and logistics skills are honed throughout the exercises within an environment of increasing battle tempo and unpredictability. The establishment and maintenance of the FOB creates logistic complexity; energy plays an integral role throughout the FOB lifecycle. The identifiable phases of the FOB lifecycle are planning and setup, operation and maintenance, and demolition. Though demolition of an FOB has been part of ITX exercises, we did not directly observe this activity.

Establishing an FOB

Establishing an FOB includes initial planning and setup, the operation of generators, and maintaining battalion aid stations.

FOB Planning and Setup

FOB planning is decentralized and requires coordination across multiple parties who often act as both providers and consumers of energy-dependent equipment. FOB setup begins with a list of gear from the commands. Commands will identify the equipment they need and the equipment they will bring. This practice introduces maintenance and reliability variables into the FOB before it is established. Lists of what is needed from the command are based on past experiences and ballpark calculations to meet the upcoming training. Environmental controls are set up based on the following priorities from MAGTF: communication equipment, medical, cooling for night crews, cooling of workspaces, and then physical comfort.

"FOB-ITS of recent years have resulted in a loss of light and agile."

The principal energy source for both generators and transportation is J8 diesel fuel. Fuel farms are located on the main FOB and the airfield. Diesel is supplied through a contractor and delivered daily to the camp fuel farms.

The FOB is responsible for command, strategy, coordination, situational awareness, and response functions. The Command Operating Centers (COC) and the Tactical Air Command Center (TACC) are the central command functions. In our observations, the TACC was a much larger version of the COC and as the air traffic control center, included much more technology. Both the COCs and TACCs work relies on networked, real-time communication and computing power. These are inherently energy-intensive tasks.

Operating Generators at the FOB

Generators are provided by ITX and the participating commands. Because there is no single source of generators, the age and condition of them varies. This variance may diminish in the future since California is restricting the use of certain generators and those out of compliance will either need to be modified or replaced. Power needs for generators are calculated based on the equipment list and manuals. Generator sites are then selected to meet those power requirements. On site the generators were configured and set up with one active backup and another third backup. Utility planning discriminates between mission essential and nonessential uses. Mission essential tasks require an active backup. Nonessential functions can have an off-line backup. Currently live switching to a backup is not possible so the backup generator at the TACC was running in parallel.

"We have to watch the load on the generators for too low or too high of a draw."

Currently, generator configuration is designed for the maximum draw. There is variability in generator use throughout the exercises, with use generally increasing as the exercises ramp up. During low-use periods the generators can be damaged due to wet-stacking and must be carefully monitored. Power planning also needs to account for supporting equipment. For instance, misalignment of equipment was evident at the Camp Wilson ACE, where there were enough small generators to meet the needs but not enough electrical panels to bring them online.

Both trained utilities engineers and junior enlisted often do power planning. In one observation, we noted that sergeants who were trained in proper load balancing were passing on their knowledge through informal training sessions with their corporals.

Managing Communications and Computers at the FOB

The Command Operations Center (COC), Tactical Air Command Center (TACC), and their related communication needs require separate generator farms to be established. Some technologies (antennas and their supporting equipment) are set up early and are constantly operating. Computer requirements also vary over time. Excess equipment is set up and run (without use) to accommodate anticipated needs. One unoccupied TACC had its air conditioners running at full blast with the windows wide open in order to keep the generators running at higher loads and thereby prevent wet-stacking. By planning for maximum operational tempo, operators hope to reduce planning errors and make their energy requirements more predictable. Combat Operations Centers are getting bigger over time, with more people and electronic devices. There are not, however, enough skilled engineers on site to handle the complexity.

Communication equipment is kept in server tents and Quonset huts. Server tents and server stacks are designed to be durable—"Marine-proof"—but they are not designed for efficient expeditionary use. First, the equipment is located in tents that are often—but not always—insulated. For example, one TACC communication tent had no lighting so the top windows were opened to provide light (and let out cool air). This resulted in unnecessary over-cooling of the tents. Second, the servers are not always set up efficiently. For instance, we observed servers stacked tightly within hard carrying cases but with little ventilation. The servers came with instructions to leave them in the shipping

containers to protect them from sand, but the containers did not offer enough ventilation or airflow. In addition, the UPS unit (backup power) was located at the bottom of each stack, causing even more heat to be generated and dispersed. To make matters even worse, the UPS was not even providing an adequate level of backup; it reportedly would only last a few minutes.

We observed servers that were removed from the packing boxes, which were used as risers to provide bottom air flow and keep the servers out of the sand. The operator came upon this solution based on information he had gathered from web-searches and *not* from training. This operator was quite frustrated at the lack of available technical training in his MOS.

"Marines don't have enough technical expertise for networks, networks are too complex, and it's too costly to train."

We also observed one TACC where approximately 50 idle laptops were sitting under continual charge, using electricity and reducing battery life. The default settings for computers in the TACC and the COC do not appear to be standardized and are set up (imaged) for each specific exercise. We were not able to access standby or battery configurations to evaluate power optimization settings. Also, the operators were not aware of any TTPs for laptop setup and maintenance.

Maintaining Battalion Aid Stations

Battalion Aid Stations (BAS) are the forward medical treatment locations. The Medical Corps is responsible for its own environmental controls and refrigeration planning for blood. The Medical Corps feels that they have good prediction models and do not waste much energy. For supplies, they use checklists and monitor supplies carefully. Energy needs for the BAS typically increase over time. The perishability of medical supplies will cause them to transport expiring blood and plasma from an outpost to an operating theater before the blood expires. In medical evacuations they are ruled by coordinating "the golden hour" of stabilizing a patient for transport.

Establishing the FOB: Challenges

The establishment of an FOB has challenges with conducting energy planning, managing resources, providing adequate training, and adapting to the operational tempo.

Planning

- Planning occurs three months prior to the exercise and no adjustment is made
- Power-grid coordination between units is non-existent
- Power is not always consolidated
- Command leadership has disputes about needed equipment
- Power planning discriminates between mission essential and nonessential uses
- Heating and cooling are the biggest draw on generators
- Additional costs are starting to be pushed back to the commands

Resource Management

- The use of small generators results in a shortage of electrical panels
- It is difficult to control air flow and cooling of the servers
- Generators are not versatile—you cannot adjust capacity

- Mission essential functions require an active backup

Training

- Junior, untrained officers often do power setup and they do not have adequate training
- Utility engineers have more complete knowledge of mechanical and electrical functions
- There is a shortage of utility engineers and the MOS may be reduced further

Operational Tempo

- COC and communications are set up for maximum capacity and often run at minimum load
- TACC computers are often idle and are continuously charging

Establishing the FOB: Stakeholders

The primary stakeholders for FOB planning (outside of the ITX structure) are the engineering commands. The key stakeholder in this scenario is the utility engineer who is responsible for establishing policy and enforcing power plant design and operation. Stakeholders also play a key role in mentoring junior and senior personnel in proper power system design. Additionally, Information Technology personnel are responsible for determining the default settings and configuration of computing systems. The command staff, another important influencer, has the ability to establish mission requirements and override engineering decisions. The actual users of the FOB equipment have minimal impact in how the FOB equipment is operated.

Provisioning

As exercises and deployments spin up, the work of the FOB rapidly shifts from setup to full operations. As this occurs, supplies for FOB residents and warfighters need to be resupplied. Supply requires aircraft and trucks for delivery of supplies, weapons, and personnel with a resulting increased vulnerability to attack. The LCE is the connective tissue in provisioning forward operations. They are tasked with supply, sustainment, and evacuation; they are constantly balancing the needs of multiple stakeholders.

TTPs exist for many supplies and services to help determine the minimum needed, but combat experience and knowledge play a key part in the decision process. An FOB logistics person must be aware of the multitude of factors that impact supply. For example, for one LCE officer in the FOB, wasted food is an indicator of overall troop health. It shows that personnel are not adequately hydrating and thus are less hungry. Understanding how environmental factors impact provisioning is key: "…when it's hot, they eat less than planned, use more ice, and engine combustion changes."

"To save energy and be effective, make everything lighter, easier to move— slim down the number and size and weight."

The LCE is trained to anticipate problems before they arise. In the larger FOBs, the tools and methods of assessing needs are more sophisticated than in the field. The LCE uses a variety of communication and data flows to understand the needs of the troops and the supply chain constraints at any given time. Because of this knowledge, logistics officers often fill liaison roles to the troops, helping logistics personnel in the field.

In addition to direct provisioning, the LCE also manages vendor agreements and loyalties and deals with elevated risks to the supply lines in all directions. The costs of outside vendor supplies such as water and waste are often not viewed as a part of overall logistics budget and, therefore, not on the radar for improving efficiency.[10]

Provisioning: Challenges

For provisioning, uncertainty and inadequate procedures were seen to impact energy use:

- Uncertainty increases fuel usage
- Poor adjustment to operational tempo
- Gaps in coordination with infantry logistics
- Ability to store supplies reduces consumption but risks spoilage
- SOPs are broad and not very useful
- Equipment density lists are not always useful and usable
- Cost of moving water is significant

Provisioning: Stakeholders

The primary stakeholders in the supply chain are the LCE commanders and the infantry commanders. When it comes to establishing supply requirements, the researchers could not determine who holds the role of "Enforcer" and "Policy Setter." We did observe that the LCE commanders need to better communicate with the infantry commanders to improve the efficiency of supply planning (and therefore energy use). Forward-deployed users of supplies are secondary stakeholders.

Fueling

The fuel supply and fuel farms are under the control of logistics. The LCE is faced with obtaining, storing, allocating, and transporting fuel. For drivers, having enough fuel for the mission is the primary goal and anything that limits their choices in a chaotic environment is looked down upon. When the focus is on more urgent needs, tacking fuel is viewed as time consuming and interfering. Currently, logistics issues fuel keys (cards) to get fuel. When there are difficulties in gaining access to fuel cards, some operators limit their fuel use.

We noted that recent efforts to track fuel use are prone to error. The accuracy of tally sheet data relies on individuals manually entering correct information, but we noted that inconsistencies are appearing. Some operators recommended modeling fuel tracking after ammo tracking, but our investigation into ammo tracking showed that it too was plagued with usability and efficiency problems.

"Fueling is difficult and messy."

[10] In some cases, contracts for water and waste are used as incentives to host countries.

Fueling: Challenges

For vehicle fueling, inadequate tracking processes impact energy use:

- Fuel tracking processes are manual and are prone to error
- Vehicles are not all tracked
- Idling is not tracked

Fueling: Stakeholders

The primary stakeholders in fueling are fuel farm personnel, drivers, and unit commanders. Fuel farm personnel are the "Policy Setters" for fueling vehicles, and they are responsible for establishing processes for tracking usage, communicating usage data, and requiring accountability for fuel use. Drivers are the "Users "of the system and require simple and easy to use systems. Unit commanders are the "Enforcers" and need to have unit fuel consumption data in order to enforce efficient fuel use within their commands.

Convoying

A tactical convoy is part of planned combat operations to move personnel and cargo via ground transportation. This is done in a secure manner under the control of a single convoy commander. Modern convoys are doing more warfighting and are subject to considerable risk from attack. Convoy commanders must be certain that people do not get lost or injured and that the gear and equipment arrive safely. At the same time, they need to accomplish the mission, assure that the COC is happy, and make the Marines relatively comfortable. Humvees accompany and protect the convoys and often leave first. Their operators are primarily gunners—not drivers. Trucks often strap on external 5-gallon tanks of fuel to provide them with additional flexibility on the road.

The timing of convoys and configurations of vehicles require coordination across the FOB. Convoy runs are coordinated across commands and the types and number of trucks will change depending on how many people and how much equipment and supplies are being transported. Depending on mission objectives, planners will consolidate trips or reduce the number of trucks. Departure times and vehicle configurations are based on the needs of the outpost. There is a convoy checklist that contains standard TTPs for convoys. The TTPs are modified to fit the mission and the type of event. An ad hoc group consisting of S1, S2, and other staff informs the unit commander. The unit commander then establishes mission goals. Convoy commanders must adapt to shifting requirements from the results of this process.

"Idling is just the cost of doing business"

There is variance on how each convoy commander (even a single unit commander) establishes his or her convoy processes. The convoy commanders are responsible for maintenance checks before, during, and after each convoy. They use pre-combat checks (PCCs) to check loads, to maintain equipment, to strap down, inspect tires, etc. These PCCs are currently lengthy and not well organized. There are no TTPs for idling.

While observing vehicles queuing for departure, we observed a number of behaviors related to fuel use. First, drivers must line up trucks in the order in which the trucks need to be when arriving at their destination. When mission objectives change, the trucks need to reposition. This uncertainty often results in unnecessary truck idling. Second, trucks must maintain an electrical charge on communication and artillery equipment. Currently, batteries are charged using vehicles' batteries while idling. The exact length of time for battery charging varies and often the operators do not know the recommended charge times. Charge times vary by the type of equipment, the amount of discharge, the age of the battery, and the environmental conditions. Third, idling occurs when other unforeseen activities arise: unexpected weather, medevac in progress, forgotten equipment, personnel clearance, and unreliable vehicles. Finally, vehicle idling (against policy) may occur in order to keep personnel warm or cool. All drivers try to leave with full tanks in their convoy trucks, and they will never leave with less than half a tank.

Convoying: Challenges

Technology and ineffective policies and procedures have the biggest impact on efficient fuel use in convoying:

Procedures

- Gear lists impact what gets loaded on vehicles
- PCCs and SOPs are overly complex and poorly designed
- PCCs do not include idling
- Units are not accountable for fuel use

Technology

- The amount of fuel used is directly related to the weight of the vehicle
- Howitzer batteries do not last to specifications, are not durable or reliable, and are large and heavy
- Scan gauges and black boxes are not integrated
- Scan gauges are not positioned at the "A" driver (person responsible for fuel monitoring)

Convoying Stakeholders

Currently, the convoy commanders serve a pivotal role in establishing fuel policies. Larger convoys are usually lead by lieutenants and small convoys are lead by NCOs. Convoy commanders are both the "Enforcers" and "Policy Setters" for procedures related to battery charging and idling. Increasing their awareness and accountability around fuel use is therefore important. The unit commanders do not currently play significant roles in establishing vehicle fuel policies. Increased participation on their part (as "Policy Setters") would likely reduce idling time and increase energy efficiency. For this group, operational reach is an important concept and financial accountability is key. In addition, maintenance personnel play important influencing roles as they can impact the reliability of batteries and create standardized procedures for battery charging. Drivers, the fuel "Users," appear to have little discretion in how they operate their vehicles. These drivers are best influenced by increased awareness of what impact driving and idling behavior has on fuel consumption.

Ideas for Improvements in FOB Lifecycle

Organizational improvements may include procedural, policy, technological, educational, and cultural changes:

Procedures

- Adapt utility planning processes to account for changing operational tempo
- Evaluate areas for utility consolidation
- Create setup procedures for generators, computers, servers, batteries, etc.
- Use Coyotes to evaluate logistics practices
- Include the engineering mission in evaluations of combat readiness
- Simplify or automate fuel tracking to reduce inaccuracies
- Simplify PCCs and include battery, tire inflation, and idling standards
- Communicate usage to convoy commanders and unit commanders

Policies

- Make individual units financially accountable for fuel use
- Evaluate efficiency improvements in semi-permanent FOBs
- Redesign more efficient, austere COC and TACC
- Evaluate FOB communication and computer use for effectiveness versus risk
- Evaluate FOB provisioning requirements for efficiency improvements
- Minimize the patchwork configuration of generators and computers
- Include reliability factors when establishing battery replacement policies
- Increase the number of utility engineers

Technology

Generators

- Investigate the cost effectiveness of automatically balancing generators
- Evaluate better ways to “live switch” backup generators
- Install load meters on all generators
- Monitor fuel efficiency of generators
- Investigate the cost effectiveness of "Load Bank” technologies used by other services

Vehicles

- Decrease the weight of all tactical vehicles and equipment
- Increase fuel monitor activities to include more vehicle types and “A” driver participation
- Include tire pressure monitoring to optimize tire pressure and increase mpg

Batteries

- Develop batteries that are more reliable in extreme conditions, have fast charge times, and are lightweight
- Provide battery covers for howitzer batteries

Alternative Energy

- Evaluate ITX capabilities to do follow-up testing from XFOB
- Investigate alternatives to using long convoy chains (e.g., UAV drops)
- Evaluate alternative energy technologies for predictable environments (e.g., FOBs)
- Implement solar as backup power for howitzers
- Supply small generators for charging communication equipment

Communications

- Work with industry to create "expeditionary" server equipment and modular stacks that address ventilation/dust issues

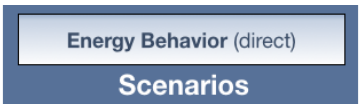
Education

- Provide more in-depth utility training, load planning, and maintenance
- Train junior field engineers in efficient energy planning
- Educate commanders about poor reliability due to running low generator loads
- Train TACC, COC, and communication personnel in efficient configuration of servers
- Conduct command-level utility trainings at more cost effective venues

Culture

- Reinvigorate the USMC "expeditionary" culture: "We are not the Army"
- Use ITX exercises to strengthen the idea of using energy savings to further the mission and save lives
- Instill a "lighten our load" credo that encourages making personal choices that save energy and allows the individual to carry less (a compass and a map versus GPS and batteries)
- Communicate the importance of energy use and its impact on mobility

Scenario: Field Deployment



Fire support is the primary goal of ITX and also for much of the Marine Corps' expeditionary activities. Fire support is the assistance provided to elements of the ground forces engaged with the enemy and the support is coordinated across air and land forces. In ITX and WTI, the main exercises are simulations of this battle space and are structured to provide increases in complexity and coordination. The battle rhythm begins with the deployment of infantry and artillery battalions towards a target and the use of artillery and air strikes for bombing the target. This is usually followed by Marines being helicoptered in to join the fight. Finally, convoys are sent out again to extract the Marines.

Infantry and Artillery

During our observations, we were able to observe and talk to infantry and artillery Marines. The infantry is the main component of Marine ground forces. Infantrymen are trained to locate, close with and destroy the enemy by fire and maneuver, or repel the enemy's assault by fire and close combat. During the ITX, infantry and artillery units practiced a working Battalion assault, where the regiment works through an attack, surrounding the enemy on the left and the right. The artillery or "fire's piece" is responsible for moving, loading, firing, protecting and maintaining the cannon weapon systems.

"Energy is not a big concern for us, I just need to support the mission."

The pace of the exercise is to work through a "crawl, walk, run" combat sequence so that the unit can incrementally build skills. In the crawl phase, activities are explained and demonstrated. In the walk phase, the tasks are performed slowly step-by-step. Finally, the unit performs the task at full

speed as if in combat under realistic battlefield conditions. The goal of combat units and individuals is to be trained in their combat specialty and to be qualified for deployment. After Action Reviews offered suggestions on improving the effectiveness of training by including more fixed wings, adding in Forward Arming and Refueling Points (FARPs), including additional tactical air control, adding in an urban element, increasing long-range activities at night, lengthening the exercise, and adding in maintenance days.

Infantry and Artillery: Challenges

For Marine infantry and artillery, reliability, planning, personal comfort, and usability factors impact energy efficiency in combat operations:

Reliability

- Vehicle batteries are sometimes drained by Marines charging personal electronics
- Older howitzer batteries cannot take a full charge easily, resulting in longer idling times
- Batteries are often old (or impacted by heat and sun) and are not reliable for charging howitzers
- Solar is quieter than generators; it also makes communication in the field easier
- Solar will not fully recharge a howitzer battery
- Direct sunlight reduces the (perceived) efficiency of batteries

Planning

- Equipment needs are not always well known
- Equipment needs are dependent upon the operational tempo
- The utilities chief is not well utilized (utilities chiefs are few in number and they lack organizational power)
- Midterm Planning Conference (MPC) can be better utilized to support combat logistics
- Supplies are tracked poorly

Comfort

- Weight is a primary concern
- Solar on backpacks is viewed as extra weight; it is seen as redundant since they still need to carry batteries
- Marines use vehicle and COC air-conditioning to cool down
- Marines use vehicles to charge personal electronics

Usability

- Large-scale solar acts like a mirror and creates a target
- Personal combat check lists (PCCs) are not standardized
- Personal combat checklists (PCCs) are not easy to use
- Supplies are tracked inadequately (should be the same as ammunition)
- Noisy generators cannot be used to charge howitzers because they block communication
- Solar Packs (Greens) do not provide enough power

Infantry and Artillery: Stakeholders

Infantry and artillery Marines are focused on the mission and comfort—not on fuel use. This is especially true of direct users: howitzer operators, MTVR drivers, and communications personnel. Energy conservation is seen as just "another layer to worry about" and it burdens them with more paperwork.

For foot soldiers, comfort is the primary concern. From their perspective, using generators to cool personal spaces enabled them to "train harder." Weight is another important factor. Carrying solar for instance, was seen as just "extra weight" because soldiers still had to carry ammo, batteries, and water. For these stakeholders, we recommend focusing change efforts on technologies that lighten loads, increase reliability, and increase comfort. For instance, accomplishing this by reducing overall power needs and providing smaller batteries. It is the infantry and artillery commanders who, we believe, have the most influence on energy use during active fire events. They are also the most resistant to efforts aimed at improving efficiency.

"Often, I don't set up a tent, or cots, or anything if it will help me lighten my load."

The few combat commanders we spoke to indicated that it was not important or reasonable to reduce their access to fuel and power. We saw little evidence that the commanders connected energy efficiency to operational reach. And most importantly, there was no financial accountability. The attitude was that energy efforts result in money being shifted around—not saved. A few officers did note that if upper levels of command made it a priority, energy efficiency would filter down through the ranks of leadership. There were indications, however, that there was some distrust of headquarters. One participant noted that MARFOR personnel were not efficient; the participant suggested that it would be more effective to educate headquarters, focus on the ACE, and target motor pool: "energy efficiency is irrelevant for the infantry."

Ideas for Improvements in Infantry and Artillery

Organizational improvements may include procedural, policy, technological, educational, and cultural changes:

Procedures

- Establish energy planning procedures that adjust to fluctuating battle rhythms
- Establish/review standards for equipment density lists
- Utilize more night operations to reduce cooling costs
- Utilize the Midterm Planning Conference to evaluate energy efficiency
- Develop more usable Personal Combat Checklists
- Look at options for moving communication generators (e.g., move generators using helicopters)

Policies

- Include maintenance days as part of the exercise
- Improve tracking of supplies

Technology

- Increase the reliability of batteries and solar
- Evaluate factors impacting the reliability of howitzer batteries (sun, dust, recharging)
- Develop more robust solar batteries for howitzers
- Develop generators that can be sized dynamically
- Install generator "dummy" loads to prevent wet-stacking
- Develop/install hot-switching technology for generators
- Create lighter vehicles and supplies (while preserving survivability)
- Develop/install higher capacity batteries
- Solar backups for howitzers would reduce maintenance and weight

Education

- Train field personnel (in addition to engineers) in power planning
- Increase the number of trained utilities chiefs
- Increase awareness of the impact of solar on reducing weight carried

Culture

- Adapt energy messaging to emphasize combat effectiveness: increased reach, improved reliability, decreased weight, and decreased noise
- Evaluate the cost/benefit of reducing energy use by combat troops

Combat Logistics and Maintenance

The field logistics component of the GCE, much like the artillery and infantry, is focused primarily upon mission. GCE field logistics personnel report directly to the commander and are often overridden by the commander. For example, one utility engineer was aware of the maintenance problems of wet-stacking but was overridden on his power plan by the commander who "felt" that he needed more power. One of the complaints we also heard was that the GCE does not integrate well with the LCE.

Maintenance personnel in the field varied in their perceptions regarding the merits of idling. Several of them believed that vehicles needed to be idled to reduce maintenance and improve performance. Others seemed to be aware of the fact that modern vehicles no longer need to be warmed up.

During the ITX exercises, the GCE Logistics AAR noted that the light utility and supply mission was not included as part of the ITX evaluation. In addition, they noted that there are not enough engineer evaluators. Most importantly, there was resistance to introducing fuel constraints as an "insert;" multiple participants expressed concern that introducing fuel as a logistics challenge would impact the combat training mission negatively.

"Vehicles, especially diesel, have less maintenance when they are run more."

GCE Logistics: Challenges

For combat logistics, planning processes, lack of knowledge, and resources are important factors impacting energy use.

Planning

- Poor coordination with LCE
- Inconsistent integration of logistics into the GCE
- Lack of clear rationale for requested number of generators
- Energy requirements are based on worse case scenarios
- Units tend to want spare power
- Field conditions, such as temperature, impact battery efficiency

Knowledge

- Inadequate training in the operation and maintenance of generators
- Lack of awareness of specifications for vehicle warm-up
- Lack of awareness of battery charging requirements for communication equipment
- Officers are not trained in energy planning
- Untrained operators are not aware of low loads leading to wet-stacking

Resources

- Utilities engineers numbers are decreasing
- Units are not held responsible for managing generator load

GCE Logistics: Stakeholders

GCE logistics and maintenance personnel are the primary "Policy Setters" for energy efficiency at the infantry level. At this level however, these personnel do not appear to have much power in enforcing these policies. Their policies establishing generator requirements and maintenance practices can be supported or overridden by unit commanders. Logistic and maintenance people in combat share a common goal that is focused on mission effectiveness. Logistics and maintenance personnel at this level, however, do not always have the knowledge, skills, or power to make decisions about efficient energy use. In this scenario, unit commanders are "Enforcers," with power to override policies established by the Engineers. We recommend E2O reach out to unit commanders, educate them about energy planning, establish financial accountability, and provide incentives for energy efficiency.

Ideas for Improvements in the GCE

Procedures

- Integrate energy concerns into GCE planning
- Develop guidelines for generator load planning

Policies

- Increase coordination between the GCE and the LCE
- Create flexible planning mechanisms to avoid "worst case" planning
- Hold unit accountable for generator misuse

Technology

- Include battery charging instructions with equipment

Education

- Use utility engineers as mentors to unit commanders for energy planning
- Educate personnel on recommended vehicle warm up time
- Educate personnel on battery charging requirements

Culture

- Use MOS schools to educate towards long-term cultural change regarding the impact of energy efficiency and reach

The ACE

The ACE is the air combat element of the exercise and is mostly seen as a support function during the ITX. The ACE comes into play as part of a battalion level simulation. Military tactics require asset up of the "geometry of fire" where infantry moves into a target, artillery fire goes over the heads of the infantry, and helicopters and other aircraft provide air support (bombing and extraction). The ITX is a way to practice these "fire and maneuver" activities. Often there is only one cycle of air integration within the ITX exercises. For the ACE, this makes the ITX a different venue than a combat situation. In addition, only a few air commanders are evaluated at the end of ITX, and that is primarily done through simulations. At the same time, air support is the largest single cost area for expeditionary Marines.

The ACE is permanent at ITX and is supported by Marine Wing Support Squadron (MWSS). The MWSS tends to have more assets than other ITX functions and has access to some land power. They have their own equipment and can restock. In fact, they are currently operating a "just-in-time" maintenance cycle and running trucks two times a day and flying once a week to Miramar for airplane parts.

For the ACE MWSS, one of the challenges in energy planning is that there is no clear policy or standard operating procedures to guide personnel in fuel planning—prior planning varies with "different personalities." There is a greater awareness, however, of the cost of fuel. The ACE gets fuel from the Defense Logistics Agency (DLA); DLA bills MWSS; the squadrons are billed by MWSS. Interviews with ACE personnel indicate that they have a much greater awareness of fuel use and understand that the more fuel they have the farther they can go. They also have processes for accurate fuel monitoring. Pilots also are keenly aware of how different factors impact fuel consumption. For instance, air temperature, load, fuel contamination, flight formation, and flight path. As one pilot stated, to lower fuel cost just "fly less, turn less." This awareness, however, does not translate into observed energy efficiencies: "If I carry too much gas and dump it, nobody says anything. If I carry two little gas and I can't go where I need to go, then I hear about it."

"Fuel use is not a major concern—I worry about the aircraft coming in to land."

ACE Challenges

For air operations, safety, fuel planning, and flight time are key fuel considerations:

Safety

- Need to maintain 20 minutes of airtime ("bingo" fuel)
- C-130s and helicopters are not trusted to start when needed, resulting in idling
- Inability to do air refueling when carrying ordnance, making them divert to pick up fuel
- Generators are sized to prevent power loss, not for fuel efficiency

Fuel planning

- Dumped fuel is not tracked
- Burn rate meters only show instantaneous burn rate, not average burn rate
- Need to balance how much fuel to carry with how much load to carry
- Planning software for pilots does not include fuel planning
- More direct routing could reduce costs
- Plane scheduling is complex, inefficient, and done by hand

Flight time

- Slow de-fueling solutions, resulting in fuel dumping
- Limitations on flight paths due to FAA regulations
- Need for more command flexibility in allocating and budgeting flight time
- Flight hours are a budget item and must be used by end of year
- Acquisition funds for new technologies are going to the Joint Strike Fighter
- Need to experience realistic flying (G forces and up-to-date controls)
- Simulations allow practicing of emergency procedures and joint training

ACE Stakeholders

In the air support scenario, we observed and interviewed enlisted personnel, staff NCOs, and company grade and field grade officers in four areas: Marine Wing Support Squadron (MWSS), Forward Arming and Refueling Point (FARP), Aviation Command, and Pilots.

The users of fuel, the pilots, are primarily concerned with safety. Fuel saving is not on their radar: "we always get fuel when we need it." Fuel concerns are focused on getting a certain distance within a certain amount of time. For example, when you are about to go home, leaving your helicopter running while being fueled (hot fueling) is preferable because it saves time. Secondary efficiencies, however, may be achieved by focusing on the pilots in the areas of fuel planning, efficient flying, and energy education.

The primary stakeholders for fuel use in the ACE, we believe, are the company grade commanders who are the energy policy makers and enforcers. Aviation Wing Commanders are already concerned with the impacts of upcoming budget cuts on their training time and readiness. Many of the ones we talked to recognized the need to "do more with less." Currently, wings coordinate with other wings to manage their flight hours and budgets and this should be encouraged. Commanders should be engaged in revising and enforcing policies related to energy efficiency in the air domain: financial accountability, flight planning, and flight hour allocations.

Ideas for Improvements in the ACE

Procedures

- Consider using ground power
- Optimize flight paths
- Do more direct routing of flights
- Evaluate the cost effectiveness of transporting "just-in-time" maintenance supplies
- Evaluate ACE fuel monitoring processes for "lessons learned"

Policies

- Evaluate policies on allowable cargo weights (e.g., V-22)
- Evaluate the appropriate use of UAVs
- Track the amount of dumped fuel
- Evaluate the fuel budgeting process

Technology

- Install *average* burn rate meters on aircraft
- Develop more robust fuel planning software
- Develop more robust flight scheduling software
- Use federated simulations where wing groups coordinate their training
- Evaluate options for air refueling (to reduce dumping)
- Evaluate options for de-fueling

Education

- Include fuel planning curricula in flight schools
- Communicate the impact of saved fuel on distance/time flown
- Evaluate the argument that C130s are not reliable and require idling

Culture

- Address risk perceptions
- Address fuel dumping
- Allow more command flexibility in reallocating fuel savings to training

Summary and Next Steps

Organizational culture is defined as the values and behaviors that contribute to the unique social and psychological environment of an organization. It is based on shared attitudes, beliefs, customs, and written and unwritten rules that have been developed over time and are considered valid by members of the organization.

The desired ethos change within the Marine Corps is focused on reducing energy use and increasing reach. This change is broader than new technologies and integrated networks. In its reclaiming of its expeditionary roots, the Marine Corps has an opportunity to re-evaluate what it is to be a Marine and to re-examine how Marines can operate more effectively in the changing battle space. The first opportunity for this ethos change is in training exercises, specifically in the integrated training spaces. The proof of its success is in the battlefield.

Many of our participants noted the importance of ITX: "ITX is where Marines learn to be Marines." ITX can also serve as the place where Marines can learn to adopt the behaviors and attitudes that support more efficient uses of energy. Beyond introducing and field testing new technologies identified and nurtured through the XFOB, ITX should serve as the context for the desired ethos change. It should be a place to re-evaluate the design of FOBs, to assess the lifecycle impacts of Marine Corps' policies and procedures, to analyze the ROI of energy hungry technologies and polices that are ill suited for expeditionary conditions, and to reduce the excessive and increasing weight the Marines and the vehicles are bearing. Energy is only one aspect of re-evaluating attitudes and practices to make the Marines more lethal, agile, and relevant to the changing battlegrounds. We believe that increased efficiency across the organization will realize energy savings. The ITX by its very name is the place to integrate the policy, procedural, technological, educational, and cultural changes that are necessary to take the Marine Corps back to its expeditionary roots.

Next steps for a behavioral approach to energy would be to:

- Examine industry best practices in monitoring and reducing energy use
- Evaluate how technologies from the XFOB are matured and integrated into ITX
- Utilize *design thinking* to design and socialize new energy behaviors and technologies
- Create an evaluation process for assessing improvements in energy practices
- Develop stakeholder profiles to aid in the design of strategic communication efforts

List of Acronyms

AAR	After Action Review
ACE	Aviation Combat Element
Arty Btry	Artillery battery
ASO	Aviation Supply Officer
BAS	Battalion Aid Station
BTN	Battalion
CERP	Commanders' Energy Readiness Program
CE	Command Element
CMC	Commandant Marine Corps
COC	Command Operations Center
DLA	Defense Logistics Agency
E2O	Expeditionary Energy Office
E2W2	Expeditionary Energy, Water, and Waste
ECM	Elite Combat Marines
ESD	Exercise Support Division
XFOB	Marine Corps' Experimental Forward Operating Base
FARP	Forward Arming and Refueling Point
FOB	Forward Operating Base
FTF	Fleet Marine Forces (FMF) engaged in amphibious or expeditionary
GCE	Ground Combat Element
ICE	Interactive Customer Evaluation
I MEF	Marine Expeditionary Force
ITC	Individual Training Course
ITX	Integrated Training Exercises
LCE	Logistics Combat Element
LHD	Landing Helicopter Deck amphibious assault ship
MAGTF	Marine Air-Ground Taskforce
MALS	Marine Aviation Logistics Squadron
MARFOR	Marine Force
MAWTS-1	Marine Aviation Wing Training Squadron 1
MCO	Marine Corps Order
MEF	Marine Expeditionary Force (largest)
MEP	Mobile Electric Power
METL	Mission Essential Task List
MEU	Marine Expeditionary Unit (command, ground, aviation, and logistics)
MGTOG	Marine Corps Tactics and Operations Group
MOS	Military Occupational Specialty
MSE	Marine Systems Engineering
MPG	Miles per Gallon
MTACS	Marine Tactical Air Command Squadron
MTVR	Medium Tactical Vehicle Replacement

MWSS	Marine Wing Support Unit
NCO	Non-Commissioned Officer
PCC	Pre-Combat Check
ROI	Return on Investment
SAD	Supply Accounting Department (SAD)
SOP	Standard Operating Procedure
SQN	Squadron
TACC	Tactical Air Command Center
TTECG	Tactical Training Exercise Control Group
TTPs	Tactics, Techniques and Procedures
UAV	Unmanned Aerial Vehicle
VIL	Vehicle Identification Link (financial billing data)
WTI	Weapons and Tactic Instructor