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Reducing Battlefield Fuel Demand:
Mitigating a Marine Corp Critical Vulnerability

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Table of Contents

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Executive Summary

Title: Reducing Battlefield Fuel Demand - Mitigating a Marine Corp Critical Vulnerability

Author: Major William B. Fenwick, United States Marine Corps

Thesis Statement: Expeditionary Maneuver Warfare, the future of Marine Corps doctrine, demands highly mobile forces operating from bases over the horizon with a minimal logistics footprint ashore. A dichotomy exists between expeditionary maneuver warfare doctrinal theory and the logistical reality of operations. It is time to fix these problems with a cogent energy strategy for the Marine Corps.

Discussion

Reducing battlefield fuel consumption in the Marine Corps is of paramount importance. There exist strategic, operational, and tactical reasons for pursuing immediate and long term proposals to "unleash" the Marine Corps from the tether of fuel from which all Americans perilously cling today.

The Marine Corps' battlefield dependence on fossil fuels carries not only fiscal implications, but far more importantly, it is costing the lives of Marines required to deliver that fuel. While it is conceded that the Marine Corps will require battlefield fuel to conduct combat operations, it is arguable, that we can reduce the amount of fuel required in theater through more efficient fuel consumption. By reducing the amount of fuel required in theaters of operations, the number of fuel convoys can be reduced thereby decreasing Logistics Marines exposure to vulnerable supply line. Recognizing the dangerous confluence of strategic energy dependence and the mammoth effort required to deliver that energy to the battlefield prompted General James Mattis to issue the challenge to DOD planners, "Unleash us from the tether of fuel." Unfortunately, the Marine Corps finds itself in a situation where logistics concepts and initiatives required to sustain the force are not keeping pace with the operational gains of new combat systems.

Conclusion

More specific strategic guidance is required from top Marine Corps leadership on the subject of battlefield energy dependence. Many implementable solutions exist to our battlefield energy dependence to include advances in hybrid vehicle technology, alternative power generation systems, and simple adjustments to operating procedures. Longer-term solutions with significant energy reduction technologies are on the drawing boards as well, but will require a strategic vision for their implementation.

The Fully Burdened Cost of Fuel (FBCF) offers a transparent construct for the DOD to monetize the "real" cost of fuel delivered to the battlefield. It is a method of activity based costing which has helped corporate America provide clarity on the impact of costs on operations and can certainly be a useful tool for the DOD.

Simply waiting for guidance from the Secretary of Defense and the DOD is too passive of a stance to adopt on this important issue. The Marine Corps leadership should proactively seek solutions to better ensure battlefield energy security.

Preface

Marine Corps' battlefield fuel dependence is an emerging topic highlighted by tenuous supply lines in current combat operations. Many businesses are implementing impressive cost cutting measures by adapting green solutions to their processes and gaining competitive advantage while doing so. While cost cutting measures rarely play a part in the Department of Defense culture, our growing dependence on battlefield fuel supply to austere regions of the world highlighted the need for greater attention to this problem. The intent of this report is to illustrate the issues that our fossil fuel dependence in combat has created for us and to stress the need for strategic guidance on the topic from the highest echelons of the Marine Corps.

Rachel S. Kingcaid, MLIS, Chief Reference Librarian at the Library of the Marine Corps provided invaluable research assistance. Michael Boyd, a retired Marine Colonel and current Engineer Advocacy Head and Explosive Ordnance Disposal Head provided credible primary source information. Mr. Boyd currently works for the Assistant Commandant of the Marine Corps for Plans, Policy, and Operations. He is an advocate for energy independence initiative in the Marine Corps. His interview was invaluable in providing the insight and reference materials which shed light on the DOD and the Marine Corps to determine their actions thus far on reducing battlefield energy dependence. Last, but not least, Dr Adam Cobb, provided the necessary guidance to best communicate the intent of this research in a cogent and effective manner.

Reducing Battlefield Fuel Demand - Mitigating a Marine Corp Critical Vulnerability

Thesis: Expeditionary Maneuver Warfare, the future of Marine Corps doctrine, demands highly mobile forces operating from bases over the horizon with a minimal logistics footprint ashore. A dichotomy exists between expeditionary maneuver warfare doctrinal theory and the logistical reality of operations. It is time to fix these problems with a cogent energy strategy for the Marine Corps.

Defining the Need for an Energy Strategy

"In a world where we borrow money from China to purchase oil from unstable Persian Gulf countries to fuel our Air Force planes that protect us against potential threats from these very countries, it's high time to make the choices and investments necessary to protect our country." Rep Steve Israel, D-NY.[1]

Strategic Reasons for Pursuing Energy Independence

There are compelling strategic reasons for pursuing a more comprehensive energy independence strategy. From a political perspective, the United States' negotiating power is diminished due to our debilitating dependence on imported oil. Sixty percent of US oil originates from countries whose political and ideological values are antithetical to our own.[2] Russia is using it's natural gas reserves to influence its political bargaining power while Venezuela and Iran's political prominence in the world is over-accentuated due to their vast energy reserves.[3] Political options available to oil importing allies, as well as the US to respond to issues such as proliferation and counter-terrorism are complicated due to the concerns about availability of oil from uncooperative sources.[4] In essence, the United States' freedom to maneuver in international relations is restricted due to our addiction to foreign energy.

"Oil imports also account for a financial vulnerability of strategic importance. At $200 a barrel, the proven oil reserves of the six Gulf nations alone would rise in value to $95 trillion, about twice the size of public equity markets," according to Morgan Stanley managing director Stephen Jen.[5] That would make the Sovereign Wealth Funds of oil states market kingmakers. When oil was selling for $147 per barrel in 2008, this alarming proposition became quite realistic with stunning implications. Volatility in the world oil market wildly complicates the budgeting of energy costs for the Department of Defense (DOD), which can have strategic implications. "John Young stated that every $10 increase in fuel, is a billion dollars less the DOD can play with."[6]

Recognizing the dangerous confluence of strategic energy dependence and the mammoth effort required to deliver that energy to the battlefield prompted General James Mattis, USMC to issue the challenge to DOD planners in 2003, "Unleash us from the tether of fuel."[7] In order to frame the problem and magnitude of its effects, a transformation is required in terms of how energy costs are determined. No longer can the cost of fuel be viewed simply in terms of the price upon delivery from the refinery. The Fully Burdened Fuel Cost is a construct that addresses this shortfall and will be discussed in detail in the third section of this paper.

Operational and Tactical Reasons for Pursuing Energy Independence

The Global War on Terror has illuminated the tenuous addiction America's operational forces have for energy by stressing and testing our long supply lines into austere, hostile environments with little modern infrastructure. Operation Enduring Freedom in Afghanistan poignantly illustrates this predicament.

Afghanistan is a land-locked country with extremely limited road and rail networks. All supplies brought into country must traverse border nations, none of which are particularly fond of U.S. intentions in the area. Attacks on convoys from Pakistan have increased, Kyrgyzstan has declared its territory closed to U.S. operations in 6 months, and slow movement on opening a northern land route has put increasing pressure on U.S. forces to work out their supply flow problem. [8] According to General Duncan McNabb, commander of the U.S. Transportation Command over 130 contract drivers have been killed trucking American supplies through Pakistan. [9] There is a large flow of sustainment supplies through a very few, predictable chokepoints into Afghanistan and this is a critical vulnerability the U.S. can do little to mitigate with its current dependence on fuel in combat operations.

Not only do supply problems exist in Afghanistan, but also in Iraq, where the country's infrastructure is far more robust. The Defense Science Board stated, "As of November 2007, approximately 80 convoys travel continuously between Kuwait and Iraq destinations, all protected by uniformed forces. This degrades combat capability, resulting in real costs, even if not attributed to the supplies themselves."[10]

- Seventy percent of military convoys in Iraq transport fuel.[11]
- 1.29 million gallons of fuel per day are brought into country by US forces in Iraq, 890,000 gallons from Kuwait alone.[12]
- Insurgents targeted logistics convoys from Turkey, Jordan and Kuwait with attacks as high as 30/day.[13]

The DOD plan insists, "there has always been a strategic motive for reducing energy dependence on fossil fuels, now there is a tactical one."[14] The proliferation of

high-energy consumption weapon systems serve as a critical vulnerability for U.S. forces and will continue to be a greater concern in proportion to the emphasis placed on Expeditionary Maneuver Warfare in the future.[15] For example, the M1A1 Abrams main battle tank gets 0.6 mile per gallon of fuel, has a combat radius of 275 miles and requires 300 gallons of fuel every 8 hours for a standard mission.[16] The adverse implications for expeditionary operations is clear.

The logistics concepts and initiatives required to sustain the force are not keeping pace with the operational gains of new combat systems. For instance, one of the Marine Corps' crown jewels for the future of Expeditionary Maneuver Warfare is the Expeditionary Fighting Vehicle. It requires four hundred percent more fuel to accomplish the same mission as its legacy platform, the Amphibious Assault Vehicle.[17] "The DOD must find a way to integrate sustainment with maneuver and the other functions in the battlespace."[18] As previously mentioned, the need to reduce the fuel consumption by US forces is real and is being targeted by a smart, adaptive enemy. However, there are striking statistics from the DOD that point to ambivalence on the part of operational and tactical planners when it comes to energy consumption and accounting. Here are a few examples:

- The Air Force spends eighty-five percent of its fuel budget moving six percent of its fuel around in airborne tankers.[19]
- According to the 2001 DSB report, of the top 10-battlefield fuel users only 2 were combat systems. The rest were support systems. For example, the water heater for the field kitchen created a larger battlefield fuel demand than the AH-64D attack helicopter.[20]
- During peacetime, fuel consumption by Army aircraft makes up fifty percent of its total. But during wartime, generators become the largest single fuel consumer on the battlefield.[21]

As mentioned above the biggest issue is our Defense spending dwarves our nearest competition to such an extent, our enemies dare not challenge us in the conventional fight. The

enemy exploits our strategic weakness; our prodigious dependence on fossil fuels. By formulating a cogent strategy to reduce our dependence on fossil fuels in combat operations, we can mitigate a critical vulnerability. ***Marine Corps Reasons for Pursuing Energy Independence***

The overarching message for Marine Corps specific fuel consumption policy can be found in the 2025 Commandant's Vision Statement, "we need to become more fuel efficient."[22] However, more guidance is required from Marine Corps leadership.

The Marine Corps' unique expeditionary characteristics provide a complex array of problems in the provisioning of energy requirements. *Operational Maneuver From the Sea* and *Ship to Objective Maneuver,* emphasize maneuver to attack enemy critical vulnerabilities within the maxims of combined arms warfare. Both of these doctrinal constructs describe highly mobile forces operating from a sea base, with reduced logistics buildup ashore. However, current doctrine for logistic support requires a large logistical buildup ashore, as well as secured lines of communications to forward units.

A dichotomy exists between doctrinal theory and logistical reality. The notional fuel requirement for a MEF, with a full Marine Aircraft Wing ashore, is approximately 1.2 million gallons per day.[23] To give a metric to understand this fuel requirement, a typical fuel truck carries 9,000 gallons of fuel. A MEF ashore would require 133 fuel trucks per day to supply its fuel requirements alone.[24] It quickly becomes apparent that current energy demands are not consistent with current and future doctrinal mandates that require a shortened "tooth to tail" ratio. The future of USMC maneuver warfare hinges upon a more agile logistical train. Reducing energy demand will decrease the tooth to tail ratio for the Marine Air Ground Task Force and thus make it a more efficient and lethal instrument of national power.

There are two major shortfalls with the Marine Corps' approach to energy planning. The first is that planning and procurement processes fail to account for the risks associated with delivering fuel to deployed forces and only account for the pure commodity costs associated with fuel.[25] Secondly, planning constructs assume that energy and fuel will be available in the quantity required, at the right time and place. Although this assumption has been true in modern warfare, it is not without its costs and should not be assumed for future conflicts.[26]

Technology, philosophies, and ideas abound for reducing energy consumption in military and civilian applications. The next section of this thesis captures some of the most promising solutions to reducing the Marine Corps' energy dependence on fossil fuels by focusing on ideas germane to the operational forces of the Fleet Marine Force. Formulating architecture to guide this strategy will be the focus of the third section of this thesis.

Capturing Possible Solutions

Shaping the Solutions

The search for solutions for reducing the Marine Corps' energy dependence can lead to a variety of answer sets. There is no shortage of ideas when it comes to reducing energy consumption by the military. However, shaping actions are required to frame the problem and focus the exploration for viable solutions. This must be done so efforts are not wasted pouring money into solutions, which may reap short term results, but fail to achieve long term goals of sustained energy consumption.

The Department of the Navy's N4 Energy Task Force has stated that improved fuel efficiency initiatives will not adversely impact operational capability.[27] On the other hand, this same task force has challenged the Department of the Navy to make energy an operational advantage. Michael Boyd, a retired Marine Colonel and Engineer Advocacy Head and Explosive Ordnance Disposal Head, currently works for the Assistant Commandant of the Marine Corps for Plans, Policy, and Operations. He is an advocate for an energy independence initiative in the Marine Corps. In an interview with Mr. Boyd in November of 2008, he stated, "Energy is an operational liability, we want to turn it into an operational advantage in relation to the enemy."[28] Boyd explained that this ideal relates to a conventional enemy force and admitted it is not as applicable when dealing with an unconventional force whereby our energy reliance is a critical vulnerability. Boyd stated in an interview, "Unleashing us from the energy tether is possible, but how much money are we willing to throw at this problem?"[29]

Near term solutions

A study conducted in 2003 showed that ninety percent of the Marine Expeditionary Force's fuel consumption would come from Tactical Wheeled Vehicles (TWV's).[30] Examples of TWV's include HMMWVs, 7-ton trucks, and other logistics vehicles. Although armored vehicles consume far more fuel per unit, their numbers are far fewer. Therefore, the Marine Corps should focus near term energy reduction initiatives on making TWV's more efficient consumers of energy.

Hybrid electric technology offers the possibility of reducing MEF fuel consumption by twenty percent in the near term.[31] According to Mike Boyd, the Marine Corps could have fielded hybrid HMMWVs for $200,000 per unit versus $50,000 per

unit for conventionally powered models.[32] From a force planning perspective, it is not difficult to see why the Marines did not buy the more expensive hybrid model. The cost-reward curve of a twenty percent efficiency gain from a four hundred percent price increase does not make much sense. However, what the preceding statement fails to account for is the associated cost required to transport, protect, and store that 20% extra fuel which the non-hybrid TWV's require. A construct that better accounts for the hidden cost of fuel will be investigated more thoroughly in the third section of this paper.

Like the Army, the Marine Corps' forward operating bases consume a great deal of fuel running generators. While commanding 1st Marine Division in Operation Iraqi Freedom, Major General Richard Zilmer submitted an urgent request for renewable energy generating systems due to the vulnerability of American supply lines to insurgent attack by ambush and roadside bombs. The request stated, "reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys, and "without this solution [renewable energy systems], personnel loss rates are likely to continue at their current rate. Continued casualty accumulation exhibits potential to jeopardize mission success."[33] Again, a Marine General has gone on record emphasizing the severity of the problem facing the deployed forces in terms of our tether to fuel. Zilmer directly links casualties to the large numbers of logistics convoys.

Although difficult to militarize, wind and solar power options for energy production hold promise in the operating environments of current military conflicts. Skybuilt Power of Arlington, VA produces a transportable hybrid electric power system that produces power from a variety of modalities to include wind, solar, battery, and diesel. The device utilizes wind and solar when available, stores any excess power

generation in a battery and only trips to diesel power generation as a last resort.[34] This type of device has the potential to reap significant rewards for deployed forces by reducing the overall fuel demand at forward operating bases. According to SkyBuilt, their hybrid electric power system can achieve fuel savings surpassing ninety five percent compared to a conventionally fielded military tactical field generator.[35] (See Figure 1)

The last near term solution to be discussed is perhaps the most difficult to implement because it requires a paradigm shift in mindset by Marine operational forces and leadership. For decades, Marines have operated without regard to energy efficiency or conservation because there has always been a "blank check" mentality. Simple operating procedure adjustments can have a large impact if enforced across the Corps. Wal-Mart, the largest retail chain in the world, was able to extract a twenty five percent savings in fuel efficiency just through operational planning and cost saving measures and no capital investment.[36]

Strategically sensible conservation holds promise for the Marine Corps, but such a change such a change in operational practices and mindset can only come from the top. An example of efficient operational practices can be applied to the Marine Aircraft Wing. Due to aviation's massive fuel consumption requirements, it is an excellent starting point to apply a conservation mindset by carefully adjusting operating practices without compromising safety or mission effectiveness.

A Defense Science Board Task Force on Energy Strategy analyzed operational procedures for all military aircraft units and suggested several initiatives, which could safely and effectively decrease fuel consumption without any capital investment:

- Reduce unnecessary equipment aboard aircraft to reduce weight and accurately manage cargo center of gravity.
- Avoid tank top off when not needed
- Use single engine taxiing
- Avoid use of afterburner as much as possible
- Plan and execute efficient flight routing
- Make more extensive use of simulators
- Refuel in-flight only when absolutely necessary
- Plan missions to minimize any need to "dump" fuel. [37]

Long term solutions

Long term solutions to providing battlefield energy must be shaped by the government in the form of incentives for corporate and academic America to develop the technology required to sustain forces in theater and reduce the threat to their logistical tail. On the drawing boards exist hundreds, if not thousands of possible solutions to reducing Marine Corps dependence on fossil fuels.

A memorandum published in 2008 by the Defense Science Board identified technologies with the potential to fundamentally change military capabilities and offer the potential of double-digit improvements in energy efficiency over current technology.[38] It is important to note, each of these five technologies have civilian sector applications and implications. The transcendence of this technology between civilian and military sectors may be the most important characteristic, by achieving economies of scale, the technology can be more quickly and cheaply developed.

Blended Wing Body - Blended Wing Body (BWB) has the possibility of doubling range and payload for aircraft and increasing fuel efficiency 5-10 times over current aircraft designs. BWB applies to larger aircraft that typically operate in the strategic tanking, lift, and bombing roles.[39] (See Figure 2)

Variable Speed Tilt Rotor - Variable Speed Tilt Rotor is an emerging technology which improves upon existing technology of the V-22 Osprey. Studies by NASA on advanced tilt rotor design indicate significantly improved performance and efficiency parameters of 100-150% over existing technology. The significance of this new technology is a vastly reduced logistics footprint in theaters of battle since supplies can be delivered long distances, at great speeds, to landing zones thus negating the need for intermediate forward operating bases.[40]

Blast Bucket Light Armored Ground Vehicle - Utilizing NASCAR tested safety and reliability features, the Office of Naval Research funded a prototype Badenoch vehicle. This "blast bucket" design weighs half as much as an up-armored HMMWV, carries as many soldiers, while getting better fuel efficiency and affording the occupants vastly better protection against blast and projectiles. The vehicle will require more research into employing better shock, deflection, dispersion and absorption concepts before it is ready for further development, but vast improvements are noted over existing technologies, especially in terms of survivability, weight, and fuel efficiency.[41]

Space Solar Power (SSP) - Solar power panels in geosynchronous orbit in space are not subject to weather, atmospheric scattering, or nighttime. These space-stationed panels can produce over five times the energy as ground based panels because they are not subject to night time shadowing by the earth or atmospheric obscurants that plague terrestrial based panels. The solar powered satellite can then send the collected photons of energy down to earth based collection stations via microwave beams. In May 2008, SSP researchers successfully conducted a microwave beam transmission test between two Hawaiian Islands 148 kilometers apart, the same distance the beam would need to

transmit power from outer space to ground based stations.[42] Studies conducted by the Department of Energy, NASA, the Environmental Protection Agency, and the Department of Commerce concluded that no technical barriers exist to fully implementing SSP. What remains prohibitive is the cost.[43] Coal fired electricity costs ten cents per kilo-watt hour. Under the best case scenario, SSP cost fifty cents per kilo-watt hour.[44] As the technology improves, the cost will undoubtedly drop, but the military may already being paying more than 50 cents per kilo-watt hour to supply fuel to generators in combatant theaters of operations. (See Figure 3)

Portable Nuclear Power - Portable nuclear power is not a new phenomena in the Department of Defense, but its application has been relegated to U.S. Navy submarines and aircraft carriers thus far. Promising trends point towards the installation of portable nuclear reactors for combat operations at major bases such as Al Asad in Iraq and Bahgram Air Base in Afghanistan. Portable nuclear devices could provide the electrical needs for these bases and free them from the power tether of generators and the inconsistent local electrical grids. The U.S. Army successfully provided electrical power to the Panama Canal from 1968 to 1976 with a nuclear reactor on a floating barge.[45] For military applications, portable nuclear reactors could be transported inland via truck or rail or setup offshore on barges as in Panama. The Department of Energy is funding an innovative and secure nuclear reactor for this type of application. The reactor's straight burn core would provide power for 8 years and may be available as early as 2010.[46]

As this section has illustrated, adequate technological solutions exist or can be developed currently to reduce energy consumption without compromising operational readiness or capabilities. With further research and development, longer-term

technologies offer promise of considerable improvement in capability while simultaneously reducing energy requirements.

The goal of an energy reduction strategy should be to apply emerging technologies to achieve a less energy dependent force structure for the future prosecution of Expeditionary Maneuver Warfare (EMW) across the spectrum of conflict. Although the Marine Corps does not budget for robust research and development, it must work closely with its sister services to develop appropriate technologies germane to EMW.

Formulating Energy Management Strategy

What Strategy Exists now?

Executive Order (EO) 13423 requires all Department of Defense military installations to reduce energy consumption by thirty percent by 2015 from 2003 baseline figures. This mandate has created a flurry of activity aboard DOD bases and spurred innovative alternative energy solutions. The EO 13423 also gives very specific guidance on reducing non-tactical vehicle consumption by twenty percent no later than 2015, and electricity from renewable resources to be at twenty five percent by 2025 on military installations.[47] However, this Executive Order does nothing to address the greatest source of DOD energy consumption: that culprit is the operating force.

The DOD has attempted to spur its own energy management initiatives with studies and task forces, the most pertinent being the November 2008 DOD Energy Security Plan (ESSP). The ESSP is designed to serve as a framework for energy considerations across the entire DOD much the way EO 13423 directs installation energy usage.[48] The ESSP recognizes that "energy risks have increased over time, while the

analytical tools, policies, and procedures necessary to understand and make informed decisions to better manage energy risks have not kept pace in all cases."[49]

The ESSP will aim for reducing total operational fuel demand by 15% by 2015, reduce total force fuel consumption by 2% per year for training, and perhaps most importantly, implement the fully burdened cost of energy in acquisitions and planning of future systems.[50] These metrics are the first concrete numbers produced by the DOD which address goals for managing operational energy consumption. Unfortunately, these metrics are nothing but writing at this point and do not have the weight of an Executive Order behind them.

What gaps exist in strategic guidance governing energy security?

EO 13423 governs military installation energy use, but this addresses only twenty five percent of total DOD energy consumption. The remaining seventy five percent of DOD energy consumption goes towards operational systems, which remain unchecked in terms of energy governance.[51] The ESSP is currently only advisory in nature and thus carries little weight. This dichotomy in governance is one reason for the slow pace of reform in the operational forces versus the noteworthy rate of change on the garrison side. Operational forces must receive the same type of guidance and oversight that is now governing the garrison side of the DOD. Without real teeth behind the mandate to reduce energy consumption, operating forces will be poorly postured to cope with the threats associated with our energy dependence.

The overriding principal that flows through the ESSP is that energy efficiency will not come at the expense of operational capability.[52] A reasonable compromise must be made to field the most reliable *and* energy efficient weapon systems. This balance must

be achieved with the operational capability of our armed forces, but also taking into consideration the cost and risk imposed by the logisticians who supply the energy to power these weapon systems. The Marine Corps fights as a Marine Air Ground Task Force (MAGTF) made up of the Ground Combat Element (GCE), Air Combat Element (ACE), and Logistic Combat Element (LCE). When we consider that energy efficiency will not come at the expense of operational capability, we must think in holistic terms. While we increase the energy requirements and combat capability of the GCE and ACE, we decrease the combat effectiveness of the LCE. In doing so, a force is created that is skewed to a long logistics tail and thus increased vulnerability to the men and women that must sustain that very tail. The MAGTF needs to be structured towards a heavier tooth and a shorter tail.

Another major gap in strategy for energy management deals with the manner in which energy requirements are evaluated, analyzed, and incorporated into campaign planning and future combat systems. Current decision processes in the DOD irrationally assume that energy requirements will be met and the operational value of a reduced energy requirement is overlooked.[53] Force planners must include energy considerations in their analysis. In campaign planning, this means making energy logistics and the force protection requirements for that energy "visible" to the red cell.[54] It also means giving the logisticians greater input into the campaign design. Typically the size of maneuver units is decided upon in a logistical vacuum and logistician brought in only once the size of the necessary force has been determined. Energy logistics must be incorporated into the planning earlier because it can have a drastic impact on how the plan unfolds.[55] Fuel supply consequences must be made visible to campaign planners.[56] The Fully Burdened

Cost of Fuel could be the answer for elevating the importance of energy logistics in the eyes of the Pentagon leadership.

The last major gap to be explored deals with a Government Accountability Office Report released in March 2008 faulted the DOD for not having an overarching framework to guide their energy management efforts. In January 2008, the Defense Science Board noted, "decisions that create energy demand are dispersed organizationally across the Department and throughout the Services. DOD efforts to manage energy are currently limited to complying with executive orders, legislation and regulations which are mostly limited to facilities, non-tactical vehicles, purchase of renewable energy from utilities, and procurement of commercial products."[57] These two comprehensive reports both point to a Defense Department that is ill equipped to handle an energy security problem that has strategic, operational, and tactical consequences of the most profound importance. Energy security's importance in the DOD has been highlighted by sustained combat operations against an irregular enemy that has targeted our critical vulnerability; energy logistics.

Fully Burdened Cost of Fuel (FBCF)

A key performance parameter, which will elevate the importance of fuel cost in campaign design and determine the true cost of battlefield fuel, is the fully burdened fuel cost. The ESSP states, "FBCF is an analytical construct that monetizes the burdens associated with moving and protecting energy from the point of purchase to the point of use."[58] FBCF is the market price of energy plus the total ownership costs of the personnel, systems, and other assets required to supply, store, transport and guard the source of energy from the point of purchase to delivery to the end user.[59]

The current method of DOD pricing for fuel energy is the contract price and all costs associated from the source of the fuel to the storage destination.[60] The most expensive portion of the FBCF is the cost incurred in delivery to the end user in a combat theater of operations. The costs associated with this delivery include the entire force structure required to deliver the fuel, aircraft, personnel, training costs, storage costs, maintenance costs, and armed escort costs.[61] One can easily determine that FBCF is not an exact science and must be implemented with guidelines to make the measurement uniform across varying mission profiles.

The implications of the FBCF, however, are revealing. As of January 2009, the average retail cost of a gallon of gasoline in the United States was $1.78.[62] According to an interview with Boyd, Admiral Stephen Luce N4, states the FBCF for a gallon of fuel supplied in the DOD is a $44.00.[63] If the end user is an M1A1 main battle tank conducting operations in downtown Fallujah the FBCF could be as high as $100 per gallon.[64] If the end user is a mechanized maneuver unit conducting operations out of reach of their logistics lines, the FBCF could be an astronomical $600 per gallon according to the Rocky Mountain Institute.[65]

Two issues surround the implementation and application of the FBCF. The first issue deals with providing guidance on how to calculate FBCF in consistent terms that can be used for a basis of comparison in making military decisions. It is easy to understand that costs associated with movement of fuel into combat zones should include the trucks, the infrastructure and personnel to support those trucks. It's not as easy to determine if casualties associated with movement of the fuel, medical bills from the casualties associated with movement of the fuel and a litany of other applicable, but

perhaps unnecessarily burdensome costs should be included in FBCF. Clear guidance from the Pentagon is required to resolve specifically how FBCF should be determined.

The second issue deals with determining the environment in which to apply FBCF. Do we utilize peacetime FBCF calculations or combat FBCF calculations when applying the figures to costing analysis and budgetary allocations? One-argument states by utilizing a peacetime operational tempo factor, it enables the true return on investment over a 30 year lifespan for most equipment to be accurately assessed. If the combat FBCF is used for planning it skews the return on investment sharply in favor of a less energy dependent, but probably more expensive piece of gear.[66] This assumes that the piece of equipment will not be in a combat environment for the majority of its lifespan, a big assumption for the Long War. The other side of this argument leans towards utilizing the wartime FBCF, which is a much higher planning figure because of the armed escort costs in combat. The Defense Science Board Task Force makes the stronger point of utilizing wartime FBCF, but planning across the spectrum of combat scenarios the fuel could be delivered in.[67] One possible solution is to average the commodity price and the sustained combat FBCF cost to achieve a reasonable compromise.

Need for USMC specific strategy

The Marine Corps requires its own separate and distinct energy strategy. Because of its combined arms constitution, naval character, and organic aviation component, it has interests that transcend each of its sister services and interest, which are unique to its expeditionary ethos. The Marine Corps mission stresses flexibility, mobility, agility and firepower. That mission has little room for error and demands an efficient logistics combat element to support the full spectrum of combat in which Marines thrive. The

Marine Corps must devote the necessary resources and leadership attention to reducing our energy dependence and realize the benefits of reducing our logistics tail. The principles of an energy efficient force are in consonance with our maneuver warfare doctrine, which calls for a lethal force skewed towards a large tooth and a small tail structure. The nature of irregular warfare has only served to exacerbate our over-reliance on fossil fuels and the associated vulnerabilities in supplying them in mass quantities to dangerous areas of operations.

When Major General Richard Zilmer made his urgent request for renewable energy source power generation in the Marine Corps' area of operations in Western Iraq, he identified the frequency of logistics convoys on the road and the danger incurred by Marines, Sailors, Airmen, and Soldiers in delivering that fuel. The Marine Corps did not field this request. The Army's Rapid Equipping Force at Fort Belvoir took it over. [68] Though the Marine Corps should be applauded for working closely with the Army in solving this issue, it can also be criticized for not having the necessary strategies or working groups in place to handle an urgent, life threatening request from the field by its own commanders. The fact that the Army is fielding this urgent request on behalf of the Marine Corps points to a glaring omission in the Corps' ability to cope with battlefield fuel and energy management.

The ESSP has called on the use of individual component energy security plans. This requirement is still being codified, but begins by tasking the Services to develop timelines and tasks for implementing their energy security policies.[69] The Marine Corps should be leaning forward in this endeavor and not waiting for the Secretary of Defense or the President to force the issue.

The Marine Corps' energy security plan is unique in that it must account for energy reduction measures while at the same time growing by 22,000 Marines. This is a problem shared by the Army, not by the Air Force or Navy. Certainly, the Marine Corps does not have the discretionary budget excesses to embark on energy security initiatives on its own. The Corps needs to work in concert with its sister services on many issues, but should not rely on them for Marine Corps Energy Strategy.

Leadership

The Final Report of the Defense Science Board Task Force on DOD Energy Strategy in January 2008 concluded that solving the DOD's energy problems would take more than conducting studies, setting guidelines, and providing guidance on paper to effect real change.[70] The stakes are too high for the Marine Corps and the DOD to let our energy dependence critical vulnerability be subject to mere policy. The change necessary to affect the cultural underpinnings of energy dependence can only be brought about by an unwavering commitment by leadership at all levels in the chain of command. Currently, the leadership in energy security and energy dependence does not exist and is the most significant barrier to resolving the energy addiction of the DOD and the Marine Corps.[71]

Conclusion

Battlefield fuel consumption is a critical vulnerability for the Marine Corps. The trend of ever-increasing consumption on the part of new combat weapons systems is on an unsustainable trajectory. General's James Mattis and Richard Zilmer, both Marine combatant commanders in Operation Iraqi Freedom, have recognized the perilous tether that Marines cling to in the theater of operations. Viable short term and long term

solutions exist and require careful consideration and a sense of urgency on the part of DOD leadership in their implementation.

The DOD has provided no clear guidance to address the energy consumption by its operating forces nor does it have the systems in place to understand the impact of energy requirements on future weapons systems. By implementing the Fully Burdened Fuel Cost concept, the DOD can achieve greater clarity on the impact of energy on the budget. For its part, the Marine Corps can begin to understand that by reducing energy consumption in the theater of operations, it can make a leaner expeditionary fighting force and better protect the lives of those Marines who are tasked with energy logistics. The Marine Corps requires clear guidance from its commanders on how to go forward with energy management in the operating forces. Marines must manage the tether of fuel more efficiently.

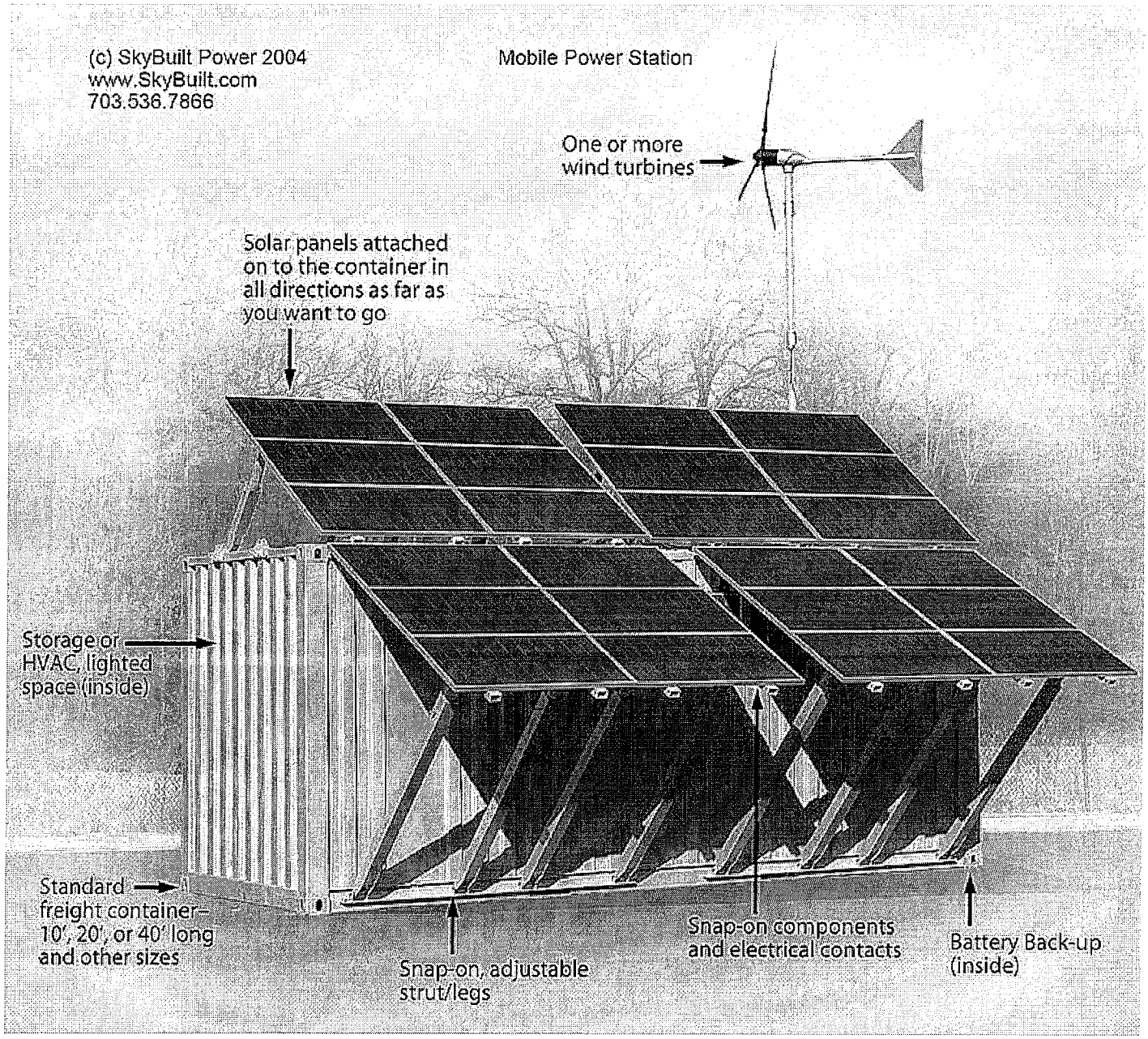

Figure 1. SkyBuilt Power Renewable Resource Generator

http://www.defenseindustrydaily.com/images/PWR_SkyBuilt_THEPS_Labeled_lg.jpg

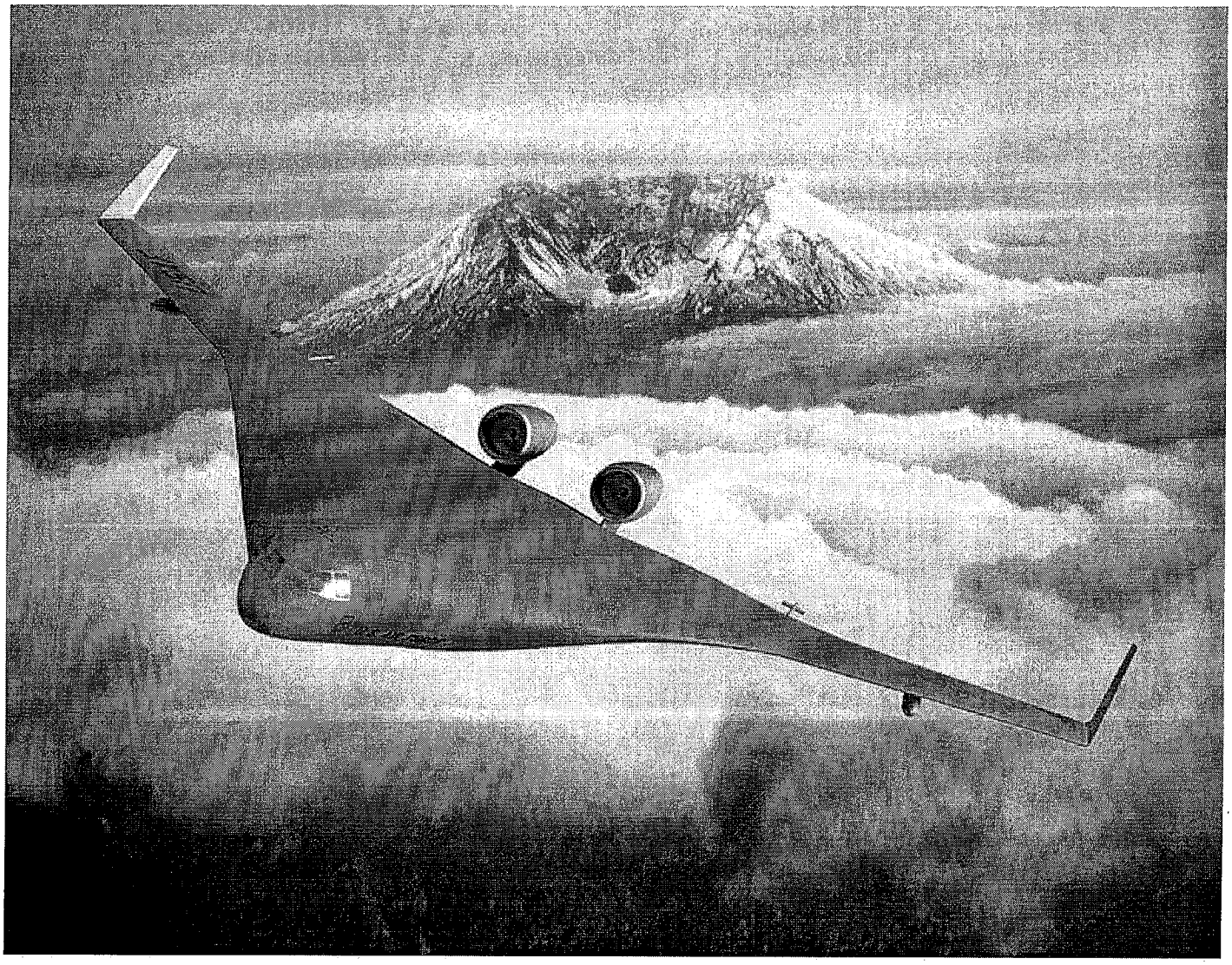

Figure 2. Blended Wing Body Concept

(http://img.photobucket.com/albums/v426/wjj102/Blended_Wing_Concept_Phant.jpg)

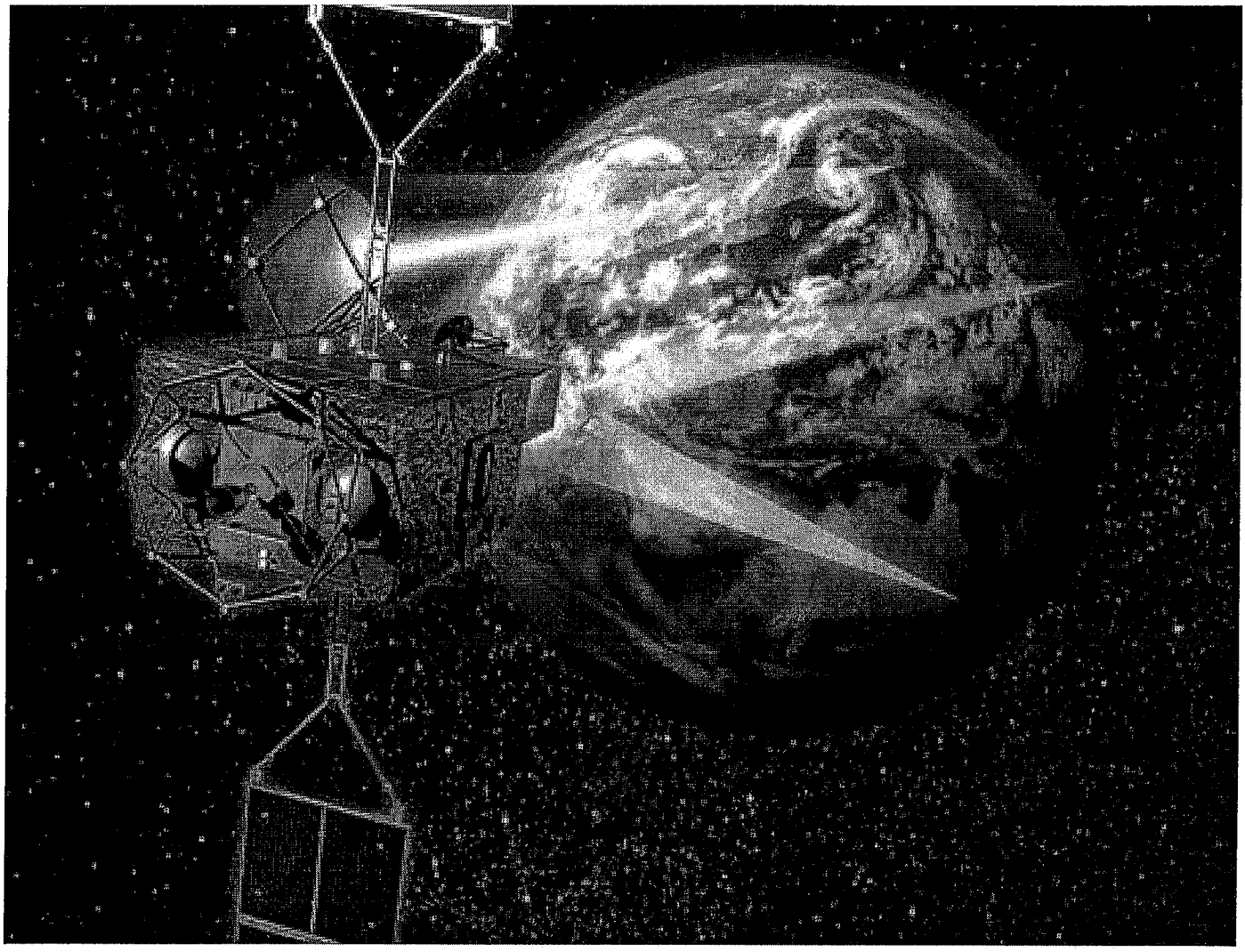

Figure 3. Space Solar Power Concept

(http://www.inhabitat.com/wp-content/uploads/ssps5.jpg)

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