Report of the Defense Science Board Task Force on DoD Energy Strategy

"More Fight – Less Fuel"

February 2008

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
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OFFICE OF THE SECRETARY OF DEFENSE
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WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

4 Feb 2008

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY & LOGISTICS

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on DoD Energy Strategy

I am pleased to forward the final report of the DSB Task Force on DoD Energy Strategy, chaired by Dr. James R. Schlesinger and General Michael P.C. Carns, USAF (Ret). This study examined DoD's strategy to achieve assured energy supplies for DoD missions.

As requested in the Terms of Reference the Task Force was asked to identify opportunities to reduce fuel demand by deployed forces and assess the effects on cost, operations and force structure; identify opportunities to deploy renewable and alternative energy sources for facilities and deployed forces; identify institutional barriers to making the transitions recommended by the Task Force; identify and recommend programs to reduce facility energy use; and identify the potential national benefits from DoD deployment of new energy technologies.

The final report concludes that the DoD faces two primary energy challenges: unnecessarily high, and growing, battlespace fuel demand compromises our operational capability and can jeopardize mission success; and critical missions at military installations are vulnerable to loss from commercial power outage and inadequate backup power supplies. These primary challenges are the basis for the Task Force's findings and recommendations.

I endorse the Task Force's findings and recommendations and encourage you to forward them to the Secretary of Defense.

William Schneider, Jr.

Dr. William Schneider, Jr.
DSB Chairman

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DEFENSE SCIENCE BOARD

January 14, 2008

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on DoD Energy Strategy

The Undersecretary of Defense for Acquisition, Technology & Logistics directed the Defense Science Board to form a Task Force to examine DoD's energy strategy. The Terms of Reference asked the Task Force to investigate a range of issues that map into four broad areas:

1. Identify opportunities to reduce fuel demand by deployed forces and assess the effects on cost, operations and force structure.
2. Identify opportunities to deploy renewable and alternative energy sources for facilities and deployed forces.
3. Identify institutional barriers to making the transitions recommended by the Task Force, and recommend programs reduce energy use.
4. Identify the potential national benefits from DoD deployment of new energy technologies.

The Task Force concluded that DoD faces two primary energy challenges:

- Operations suffer from unnecessarily high, and growing, battlespace fuel demand which degrades capability, increases force balance problems, exposes support operations to greater risk than necessary, and increases life-cycle operations and support costs.
- Military installations are almost completely dependent on a fragile and vulnerable commercial power grid, placing critical military and Homeland defense missions at unacceptable risk of extended outage.

Reducing Operational Fuel Demand

"Unleash us from the tether of fuel" was a quote briefed to the Task Force and attributed to Gen James T. Mattis, USMC during his 2003 tour as Commanding General, 1st Marine Division in Operation Iraqi Freedom. This could have been a guiding vision for the findings and recommendations of this report calling for key Departmental decisions that drive fuel demand to be informed of their consequences before they are made.

- The Department has no consistent methodology to simulate the battlespace conditions created by high fuel re-supply requirements during campaign analyses, war gaming or staff training exercises. This makes fuel supply consequences invisible to operations and force planners.
- DoD has not yet fully implemented two key recommendations from a 2001 DSB Task Force on energy – establish a Key Performance Parameter (KPP) to constrain battlespace fuel demand; and establish the fully burdened cost of fuel (FBCF) to guide acquisition investments for deployed systems.[1] This Task Force recommends the Department accelerate implementation of these, and that the Deputy Secretary exercise oversight.
- Non-developmental items such as air conditioners and field kitchens create high demand for fuel in the battlespace, sometimes exceeding that from combat systems. The Task Force recommends investing to make them efficient to a level commensurate with the value of reducing demand for fuel in the battlespace.
- Competitive prototyping during the '70s and '80s produced rapid improvement in the capability and reliability of key combat systems. Today it could do the same to improve capability through greater endurance and reduced battlespace fuel demand.
- The Task Force identified several disruptive technologies with the potential to significantly increase operational capability and reduce the burden of battlespace fuel demand, and recommends specific actions to accelerate their development and acquisition.

Critical Missions at Installations

- Backup power at military installations is based on assumptions of a more resilient grid than exists and much shorter outages than may occur, and is not sized to accommodate new Homeland defense missions.
- The Task Force recommends DoD launch a comprehensive program to assess and mitigate site-specific risks based on mission criticality, risk and duration of outage; and cost effectiveness of risk mitigation options, such as greater efficiency, islanding, renewable sources, distributed generation, and higher commercial grid reliability where necessary.
- High-performance building designs are generally underutilized and underfunded. DoD should treat Energy Policy Act of 2005 and Executive Order 13423 mandates and Green Building Council standards as minimum levels, not stretch goals.

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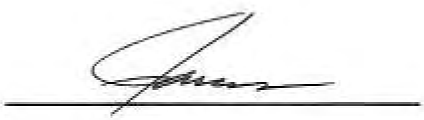
[1] 2001 Defense Science Board Report "More Capable Warfighting Through Reduced Fuel Burden"

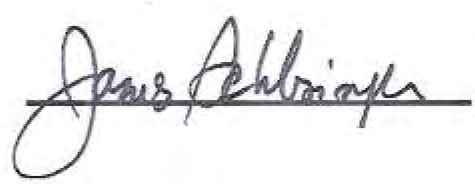
Leadership and Governance

The Task Force concluded that solving DoD's energy problem would take more than producing documents establishing the new policies, procedures and analytical products recommended by this report. It depends on leadership's willingness to provide the oversight to ensure they are effective. Currently, decisions that affect DoD's energy demand are scattered throughout the organization with little accountability or oversight. While there is a senior official with responsibility for energy use at installations, this function oversees only about a quarter of DoD's energy usage. The Task Force recommends senior leadership establish oversight and accountability for implementing the recommendations in this report, and ongoing measurement of their progress across the whole of DoD.

National Benefit from DoD Actions

DoD's energy problems are not unlike those of the nation. Just like the nation, to reduce its energy risks, DoD must significantly improve its energy productivity and use renewable sources where possible. Technologies that extract more capability from the energy we use improve our military capability and make our industries that produce them more competitive in a global market that increasingly values efficiency. As these technologies find their way into commercial products, they will also limit our national dependence on foreign oil.





General Michael P.C Carns, USAF (Ret.)
Co-Chairman

Dr. James Schlesinger
Co-Chairman

ACKNOWLEDGEMENTS

The Chairmen acknowledge the exceptional commitment of several Task Force members who, as volunteers, devoted an enormous amount of time and effort in the development and writing of this report. The four Task Force panels drafted their respective sections but the challenge of rationalizing and integrating the substance rested primarily on the shoulders of Mr. Tom Morehouse who has done a superb job. As part of the substantial integration and editing effort, the skilled contributions of Mike Canes, Gueta Mezzetti and General "Speedy" Martin, USAF, (Ret), in assisting Tom Morehouse merit special mention.

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EXECUTIVE SUMMARY

On May 2, 2006 the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) directed the Defense Science Board to create a Task Force to examine DoD Energy Strategy. Citing significant risks to both our nation and our military forces, he challenged the Task Force to find opportunities to reduce DoD's energy demand, identify institutional obstacles to their implementation, and assess their potential commercial and security benefits to the nation.

Overview

Based on its study and deliberations, the Task Force concluded that DoD faces two primary energy challenges:

- Unnecessarily high and growing battlespace fuel demand that:
  - compromises operational capability and mission success;
  - requires an excessive support force structure at the expense of operational forces;
  - creates more risk for support operations than necessary; and
  - increases life-cycle operations and support costs.
- Almost complete dependence of military installations on a fragile and vulnerable commercial power grid and other critical national infrastructure places critical military and Homeland defense missions at an unacceptably high risk of extended disruption.

These observations lead to the following set of findings and recommendations.

Finding #1: The recommendations from the 2001 Defense Science Board Task Force Report "More Capable Warfighting Through Reduced Fuel Burden" have not been implemented.

The main Task Force recommendation in 2001 was that DoD re-engineer its business processes to make energy a factor in the key Departmental decisions that establish requirements, shape acquisition programs and set funding priorities. This was based on their findings that these decisions were not informed about their energy consequences, yet ultimately drove operational fuel demand, and that high fuel demand compromised operational effectiveness. This Task Force finds these situations have not changed.

Finding #2: Critical national security and Homeland defense missions are at an unacceptably high risk of extended outage from failure of the grid.

In addition to their warfighting responsibilities, installations have taken on significantly expanded Homeland defense missions. Installations now serve as a base of operations to coordinate the full range of national relief and recovery efforts; and a source of skilled personnel to provide rescue, recovery, medical and other emergency services required by survivors. They rely almost entirely on the national power grid and other critical national infrastructure, which is highly vulnerable to prolonged outage from a variety of threats, placing critical missions at unacceptably high risk of extended disruption. Backup power is often based on diesel generator sets with limited on-site fuel storage, undersized for new Homeland defense missions, not prioritized to critical loads, and inadequate in duration and reliability.

Finding #3: The Department lacks the strategy, policies, metrics, information, and governance structure necessary to properly manage its energy risks.

Decisions that create energy demand are dispersed organizationally across the Department and throughout the Services. There is no unifying vision, strategy, metrics or governance structure with enterprise-wide energy in its portfolio. Information collected about energy end-use is inadequate for the purposes of establishing a baseline, establishing metrics or making management decisions. DoD efforts to manage energy are currently limited to complying with executive orders, legislation and regulations which are mostly limited to facilities, non-tactical fleet vehicles, purchase of renewable energy from utilities, and procurement of commercial products. There is a senior political appointee responsible for these activities, which encompass about a quarter of DoD energy consumption. There are currently few efforts to manage energy demand by operational forces, which consume about three quarters of DoD energy, perhaps because no one is in charge. The lowest organizational level where all decisions that drive DoD energy use come together is the Deputy Secretary of Defense, implying the need for a senior energy official, and oversight of the Department's energy strategy and program by the Deputy's Advisory Working Group (DAWG).

Finding #4: There are technologies available now to make DoD systems more energy efficient, but they are undervalued, slowing their implementation and resulting in inadequate future S&T investments.

The Task Force heard over a hundred presentations on technologies that addressed all categories of end use, covering the full range of maturity from basic research to ready-to-implement. Many appear quite promising, but DoD lacks accepted tools to value their operational and economic benefits. As a result, cost effective technologies are not adopted, science and technology programs significantly under-invest in efficiency relative to its potential value, and competitive prototyping to accelerate deployment of efficiency technologies is not done.

Finding #5: There are many opportunities to reduce energy demand by changing wasteful operational practices and procedures.

Operational practices and procedures affect energy consumption by aircraft, land vehicles, ships, installations, forward operating bases (FOBs), and battery powered equipment carried by individual soldiers. The Task Force found no strong, sustained focus by senior leadership to change the culture that assumes readily available energy, or to create a culture that inherently recognizes the clear linkage between energy productivity and combat effectiveness. The Task Force found this to be one of the most significant barriers to changing wasteful practices.

Finding #6: Operational risks from fuel disruption require demand-side remedies; mission risks from electricity disruption to installations require both demand- and supply-side remedies.

Moving fuel to deployed forces has proven to be a high risk operation. Reducing operational fuel demand is the single best means to reduce that risk, but DoD is not currently equipped to make informed decisions on the most effective way to do so. Fixed installations are 99% dependent on the commercial power grid and other critical national infrastructure, which is fragile and vulnerable and poses serious risks to critical missions. Significantly increased end-use efficiency to reduce demand combined with alternative energy generated nearby or on-site offer the best opportunities to reduce that risk to acceptable levels.

Recommendation #1: Accelerate efforts to implement energy efficiency Key Performance Parameters (KPPs) and use the Fully Burdened Cost of Fuel (FBCF), to inform all acquisition trades and analyses about their energy consequences, as recommended by the 2001 Task Force.

The Task Force recognizes two key initiatives recently launched by the Joint Staff (JS) and Office of the Secretary of Defense (OSD) to implement the 2001 Task Force recommendations:

- An August 17, 2006, Vice Chairman of the Joint Chiefs of Staff (VCJCS) memorandum (JROCM 161-06) endorsing a Joint Requirements Oversight Council (JROC) decision to establish an Energy Efficiency Key Performance Parameter (KPP).
- An April 10, 2007 USD(AT&L) memorandum establishing Department policy to use the "fully burdened cost of fuel" (FBCF) for all acquisition trade analyses.

While these are essential reforms, little progress has been made in implementing them and little action has been taken to develop the necessary analytical capabilities to establish meaningful values for either initiative. The Task Force recommends that the Department accelerate the following tasks:

- Build fuel logistics into campaign analyses and other analytical models and simulations to inform the requirements process of the operational, force structure and cost consequences of varying battlespace fuel demand;
- Establish outcome-based energy KPPs; and
- Use FBCF as a factor in all Analyses of Alternatives (AoAs) / Evaluation of Alternatives (EoAs) and throughout all acquisition trades.

The Task Force recommends these apply to all actions that create demand for energy, including "black" programs, and non-developmental systems used at forward operating locations.

Recommendation #2: Reduce the risk to critical missions at fixed installations from loss of commercial power and other critical national infrastructure.

The Task Force recommends DoD launch a comprehensive program to mitigate mission risk using an integrated risk management approach, based on importance of missions, likelihood and duration of outage, and cost effectiveness of risk management options. The Department should take immediate actions to "island" the installations listed in Appendix G and increase the efficiency of critical equipment to reduce the burden for backup systems. Successfully executing this program will require a joint effort by Assistant Secretary of Defense for Homeland Defense and Americas Security Affairs (ASD(HD&ASA)), the Mission Assurance Division at Dahlgren, the Office of the Deputy Under Secretary of Defense (Installations and Environment) (ODUSD(I&E)) and the Services.

Recommendation #3: Establish a Department-wide strategic plan that establishes measurable goals, achieves the business process changes recommended by the 2001 DSB report and establishes clear responsibility and accountability.

Fixed installations use about one quarter of DoD's total energy. There are policies, metrics, reporting requirements and a senior official in charge. Deployed systems use about three quarters of DoD's total energy. There are few policies, procedures or reporting requirements; no metrics and no one in charge. The lowest level at which all decisions affecting energy use by the Department converge is with the Deputy Secretary of Defense. It is very difficult to achieve sustained focus and accountability for performance on energy use at this level. The Task Force concluded that lack of leadership is a root cause of DoD's energy problem.

In addition to oversight, DoD needs a comprehensive energy plan that addresses both fixed installations, to include critical Defense Industrial Base (DIB) plants, and operational forces. It should include both measurable goals for energy demand reduction and reduction in energy risks. Implementing new analytical products to better inform key decisions will be essential to enabling effective energy management. For operational forces, this requires adding energy to force planning analyses, and implementing the energy KPP and FBCF. For fixed installations and industrial base plants, it includes applying integrated risk management principles to reduce the likelihood of prolonged loss of critical missions due to commercial power and other critical national infrastructure outages.

These basic business process changes will enable the Department to more effectively manage the amount of fuel and electricity it requires to accomplish its missions and reduce its risk from supply disruptions.

Recommendation #4: Invest in energy efficient and alternative energy technologies to a level commensurate with their operational and financial value.

The same lack of analytical tools that prevent the requirements and acquisition processes from developing more efficient systems also prevent science and technology investments from identifying the most effective investments in energy efficiency technologies. Investments should be guided by a common understanding of their operational, force structure and cost value, but the tools and business processes needed to establish this understanding do not exist. The Task Force recommends USD(AT&L) accelerate development efforts on the following innovative concepts based on the Task Force's qualitative assessment:

- Blended Wing Body Aircraft
- Variable Speed Tilt Rotor Vertical Lift
- Lightweight Composite 'Blast-Bucket' Tactical Vehicle
- Advanced electro-mechanical actuators
- Semi-rigid, lighter-than-air high altitude lifting bodies
- Advanced micro-generators
- Biomimetic design for platform components
- Very high efficiency electronics for soldier systems (National Research Council recommendation) and other combat systems applications

The Task Force also recommends USD(AT&L) re-establish early competitive prototyping for key Acquisition Category I (ACAT I) programs to accelerate the adoption of high payoff, innovative energy efficient technologies and concepts.

The Task Force recommends the Department invest in basic research to develop new fuels technologies that are too risky for private investments and to partner with private sector fuel users to leverage efforts and share burdens. The Task Force also recommends the Department work with commercial partners to conduct full "well-to-wheel" life cycle assessments of each synthetic fuel technology under consideration. This is to fully assess environmental, cost, material flow and scalability issues. Synfuel production technologies that can be adapted to forward deployed locations using local materials (such as bio-waste) would be valuable because it would directly reduce the amount of fuel that would have to be moved and protected in theater.

Recommendation #5: Identify and exploit near-term opportunities to reduce energy use through policies and incentives that change operational procedures.

Since WWII, energy has been abundant and cheap, with the exceptions of two short periods during the 1970s and 1980s, and very recently. During WWII, tankers moving fuel to U.S. forces were attacked, and the response was to devise ways to avoid using tanker ships, such as building pipelines to mitigate the risk. During Korea and Vietnam, energy security was not a concern. Changing a culture that considers energy cheap and abundant is one of the most difficult challenges facing the Department and the nation. The business changes recommended by the Task Force will take time to show results, but changing operational practices to conserve energy can show immediate results.

Leadership sets the tone. The Task Force recommends the Deputy Secretary of Defense (DEPSECDEF) and the VCJCS direct all Components to review current practices to identify opportunities to reduce energy use, to include expanded use of simulators, emulators and task trainers; and limiting afterburner use; that can be enacted without affecting operations and provide incentives to save energy throughout the Department. Regular reviews of actions taken and their results across Components will help track progress and validate techniques.

CHAPTER I: INTRODUCTION

In May 2006, the Under Secretary of Defense for Acquisition, Logistics and Technology commissioned a Defense Science Board Task Force on DoD Energy Strategy. The Terms of Reference asked the Task Force to investigate four broad areas:

1. Opportunities to reduce fuel demand by deployed forces; assessing the effects on cost, operational and force structure.
2. Opportunities to deploy renewable and alternative energy sources for facilities and deployed forces.
3. Institutional barriers to making the transitions recommended by the Task Force.
4. Potential national benefits of DoD deployment of new energy technologies.

To address these issues, 77 Task Force members and government advisors divided into four panels to examine policy issues, combat platforms, facilities and infrastructure, and research and technology. From May 2006 to March 2007, the Task Force conducted 37 meetings, heard 143 briefings, examined numerous studies, and held many discussions to arrive at its findings and recommendations. This report reflects the integrated assessment of the panels and deliberations of the entire Task Force. It is organized as follows.

Chapter II provides an overview of DoD's energy posture in terms of the fuel used for combat and deployed systems, including forward operating bases, and the electricity needed to power fixed installations and their critical missions. It identifies several key issues regarding DoD fuel demand management, decision processes that drive energy demand patterns, data collection and organization of energy management. The Chapter also examines security threats to missions and installations that come from potential attacks on a national electrical grid characterized by small capacity margins, vulnerable components and infrastructures, limited availability of spares and insufficient resilience.

Chapter III describes risks to DoD operations from fuel disruptions and describes means available for DoD to better manage its use of fuel. It reinforces the findings of the 2001 Defense Science Board report, "More Capable Warfighting Through Reduced Fuel Burden," that DoD's fuel-related problems are in large part the consequence of poor business processes. The chapter identifies the burdens that high battlespace fuel demand places on combat success and identifies concrete steps the Department can take to reduce such burdens. It focuses on making fuel logistics an integral consideration in warfare analysis and system design, resulting in greater force endurance through higher levels of energy productivity.

Chapter IV identifies a wide range of technologies that appear capable of improving the efficiency of deployed systems. Some of these technologies are radical but offer the promise of very substantial gains while others are more conventional but provide solid prospects for nearer-term efficiency improvement. The Chapter also considers technologies to increase fuel supply to DoD, particularly synthetic fuels derived from coal, biomass and other feedstocks.

Chapter V addresses methods to better assess the risk to DoD of long term power outages, to formulate options for managing those risks, and to build business cases for making the necessary investments. Risk mitigation options include much higher efficiency levels for buildings, distributed generation near- or on-base, islanding from the commercial grid, renewable energy sources, and where necessary higher levels of local grid reliability and conventional power sources on-base. Identifying the appropriate mix of options will involve business and decision processes based on risk assessment and mitigation, new operational practices and new relationships with external organizations. The discussion addresses both supply and demand side options.

Chapter VI offers the findings and recommendations of the Task Force.

A list of priority installations for mitigating risk from commercial power outage is contained in Appendix G.

CHAPTER II: DOD'S ENERGY POSTURE

2.1 Introduction

The Department of Defense is the largest single consumer of energy in the United States. In 2006, it spent $13.6 billion to buy 110 million barrels of petroleum fuel (about 300,000 barrels of oil each day), and 3.8 billion kWh of electricity. This represents about 0.8% of total U.S. energy consumption and 78% of energy consumption by the Federal government. Buildings and facilities account for about 25% of the Department's total energy use. DoD occupies over 577,000 buildings and structures worth $712 billion comprising more than 5,300 sites. In 2006, the Department spent over $3.5 billion for energy to power fixed installations, and just over $10 billion on fuel for combat and combat related systems. These figures exclude energy used by some contractors that performed "outsourced" DoD functions, but are as accurate as current accounting systems permit.

At the national level, dependence on foreign sources of energy is mainly a petroleum issue. The U.S. currently imports some 60% of its oil from foreign sources and the percentage is increasing. This is problematic for a number of reasons. Current high prices adversely affect our trade balance. Much of the global petroleum endowment resides in countries that are not friendly to the U.S., or exhibit political values antithetic to our own. While the international petroleum market is relatively open and fungible, approximately 94% of the known global reserves are controlled by governments directly or indirectly, mainly through state-owned companies. As a result, the amount of petroleum that remains to be extracted is imprecisely known. Further, estimates of remaining reserves are considered state secrets by many oil exporting nations. There are two main elements of uncertainty. First, the estimates of currently inaccessible reserves are questionable. Second, the extent to which existing fields can be extended through new or more costly technologies is unknown. Our need to maintain good business relations with oil exporting countries complicates our foreign policy options. Some of them are known to support extremist groups. In effect, through our imports of oil we help to fund both sides of the global war on terror.

The electricity problem is wholly different. The U.S. has adequate domestic resources to meet its electricity needs into the foreseeable future, from coal, nuclear, natural gas, hydropower and other renewable sources such as wind, geothermal and solar. The main problems with electricity are the fragility, and as we shall see vulnerability, of the national grid which transmits and distributes electricity from large central generating stations to individual users across the country and into Canada. It is susceptible to extended outage from natural disaster or sabotage. There is an important distinction between failure from natural disaster or overloading, and the kinds of disruption possible from sabotage. Informed and capable saboteurs can inflict damage that would take down significant portions of the grid and other critical infrastructure for long periods and make restoration, even work-around measures, difficult, costly, time consuming and marginally effective. Consequently, deliberate attacks represent a different kind of threat, requiring different mitigation strategies.

Interconnected, interdependent infrastructure and the potential for cascading grid failures makes the resilience of the grid important to other essential services, such as telecommunications, water supplies and treatment, and operation of the pipeline systems that distribute oil and natural gas around the country. These critical national infrastructures, in turn, are needed for the recovery and operation of the power grid. Grid failure could shut down the systems that deliver petroleum and natural gas to end users, and to generating stations that power military installations. Emergency communications, transportation systems, medical institutions and other essential services would also be disrupted. The Task Force finds that any assessment of the risk to military missions from grid failure must also take into account the ability of the national pipeline system to provide fuel to installations where it critically warrants.

2.2 Petroleum Supply and Demand

The world presently consumes about 86 million barrels per day (mbpd). Of this, the U.S. consumes about 21 mpbd, or, about 24%. While DoD is the single largest user of energy in the nation, its requirement is small relative to the total market. To provide perspective, DoD's recent wartime petroleum consumption has been slightly larger than a major international airline. The Defense Energy Support Center (DESC) maintains a robust global network of supply points and sources for all types of DoD fuels, and has established contracts with strategically placed refineries around the world. In addition, if needed for national security, DoD could exercise eminent domain over commercial energy contracts. Therefore, the Task Force finds it difficult to imagine a scenario where DoD would be unable to obtain the petroleum it needs to perform its mission from commercial sources.

Top World Oil Net Exporters, 2004*

	Country	Net Oil Exports (mbpd)
1)	*Saudi Arabia*	8.73
2)	Russia	6.67
3)	Norway	2.91
4)	*Iran*	2.55
5)	*Venezuela*	2.36
6)	*United Arab Emirates*	2.33
7)	*Kuwait*	2.20
8)	*Nigeria*	2.19
9)	Mexico	1.80
10)	*Algeria*	1.68
11)	*Iraq*	1.48
12)	*Libya*	1.34
13)	Kazakhstan	1.06
14)	Qatar	1.02

*Includes countries *with net exports exceeding 1 million bpd in 2004.*
(OPEC members in italics)

Table 2.1: Petroleum Exporting Countries

DoD uses military specification fuel produced from petroleum in its combat systems and the systems that support them – aircraft, ground systems, and naval vessels. Electricity needed to power forward operating bases, such as those in Iraq and Afghanistan, is generated using the same fuel that powers combat and support systems. Commercial grade petroleum products can be converted in the field to military grade by blending with additives.

Alternatively, DoD systems can operate on commercial grade fuels if military grade are not available, with little compromise in performance. Since operational forces do not

ship fuel from the U.S. into theater but buy it from sources near theater, DoD operations are entirely dependent on the commercial global petroleum market for its supplies.
From a geo-strategic perspective, most of the countries exporting oil are far from free and democratic (e.g., Saudi Arabia and Iran), are hostile to the United States (Iran and Venezuela) or are corrupt and fragile (such as Nigeria). On page 12, Table 2.1 shows the top oil exporting nations. Citizens of some of these nations are suspected of using their oil revenue to sponsor terrorist activities against the U.S. [1] Reduced fuel consumption has long been a national aim, yet demand continues to grow. By addressing its own fuel demand, DoD can serve as a stimulus for new energy efficiency technologies, and help limit national dependence on foreign oil.

2.2.1 Price Volatility in a Tight Global Market

Recently, tight supplies and strong demand have characterized the oil market, putting upwards pressure on prices. Fiscal Year (FY) 07 is the first year the DESC has changed its standard price in mid-year. This price is used by government customers to budget for fuel purchases. In real terms, world oil prices are currently near historic highs, approaching those of the oil crisis of the early 1980s. From 2004 to 2006, DESC fuel sales more than doubled from $5.9 B to $13.6 B., most of the increase being due to rising prices for petroleum products.

Such rapid increases in the commodity cost of fuel get leadership attention because of their effect on budgets. DoD operates on a six year Future Year Defense Plan (FYDP) funding horizon. Increases of this magnitude mean that large sums of money must be re-programmed in order to meet operating costs, wreaking havoc on programs from which the funds are taken.

2.2.2 Peak Oil

Peak oil is the point in time at which roughly half of the extractable oil on the planet has been used, and future production enters terminal decline. Such a decline would put strong, persistent upwards pressure on prices. The theory was first advanced by Marion King Hubbert, an American geophysicist with Shell Oil, who created a method of modeling the production curve for an oil field. His theory said all oil fields follow the same bell-shaped production curve over their lifetimes. He based this on the observations that the amount of oil is finite and that the rate of discovery initially increases quickly, reaches a maximum, and then declines irreversibly. The factors that indicate the point of maximum production include discovery rates, production rates and cumulative production. However, these are difficult if not impossible to know with certainty. Early in the curve, production increases due to the discovery of new fields and the addition of production capacity. Post-peak production declines due to resource depletion. In 1956, Hubbert predicted U.S. oil production would peak in approximately a decade, and fourteen years later it did. Today, in the lower 48 states the U.S. produces

[1] See Frank H. Denton *Nexus, Oil and Al Qaeda, available at* <http://www.americanenergyindependence.com/nexus.html>; and George P. Shultz and R. James Woolsey, *A Committee on the Present Danger Policy Paper: OIL & SECURITY,* 10 June 2005, available at <http://www.defenddemocracy.org/publications/publications_show.htm?doc_id=282100&attrib_id=10197>.

roughly half the oil it produced in 1970. However, Hubbert's predictions were incorrect with respect to ultimate U.S. production. Improved technology and higher prices have resulted in far greater production since 1970 than predicted by Hubbert's model.

Numerous studies have estimated the timing of global peak oil. In 2005, Robert Hirsch produced a study for the Atlantic Council called "Peaking of World Oil Production: Impacts, Mitigation, and Risk Management." In it, he compared twelve expert projections of when global peak oil would occur. They ranged between 2006 and "2025 or later." In July 2007, the National Petroleum Council (NPC), an industry advisory group, conducted a study for the Secretary of Energy titled "Facing the Hard Truths about Energy: A comprehensive view to 2030 of global oil and natural gas."[2] It concluded that while the world is not running out of energy resources, there are significant challenges to meeting projected total energy demand. Until this report, the NPC had been generally optimistic about future petroleum supplies. It found the U.S. must moderate its growing demand for energy by increasing the efficiency of its transportation, residential, commercial, and industrial sectors; expanding and diversifying production from other energy sources; enhancing long-term research into energy supply and demand; and developing the legal and regulatory framework to enable carbon capture and sequestration.

In February 2007, the Government Accountability Office (GAO) published a study entitled "Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production." It identified 22 separate studies on peak oil conducted since 1996 and noted that most predict peak oil to occur between now and 2040. It noted there is no coordinated federal strategy to reduce uncertainty about the peak's timing or to mitigate its consequences.

Among the implications for DoD are that after peaking, prices for fuel will be even higher than today. The Task Force did not discuss the geopolitical, economic or national security implications of peak oil, but the recommendations in this report regarding reduced fuel demand would help mitigate its effects.

2.2.3 Understanding and Managing Fuel Demand

2.2.3.1 Fuel Demand Data

Figure 2.1 shows who is responsible for specific fuel delivery costs. The costs incurred from Points A to D are included in the "standard" price DESC charges its customers for the commodity. Costs incurred beyond Point D are typically paid by the military services through the support force structure they maintain, operate and sustain. These costs are borne by budgets not attributed to fuel. They are the total ownership costs of assets such as tanker aircraft, fuel trucks and oiler ships; and personnel, parts, training and fuel needed to keep them operational. They also include protection required to assure delivery of the fuel from Point D to the point of use. The costs of protection are

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[2]See National Petroleum Council, *Draft Report: Facing Hard Truths about Energy,* available at <http://downloads.connectlive.com/events/npc071807/pdf-downloads/Facing_Hard_Truths-Report.pdf>.

difficult to measure and are often not monetary costs. They include reduced combat effectiveness, risk to mission, and casualties. In Iraq and Afghanistan, combat forces are dedicated to supply line protection rather than combat operations. 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.

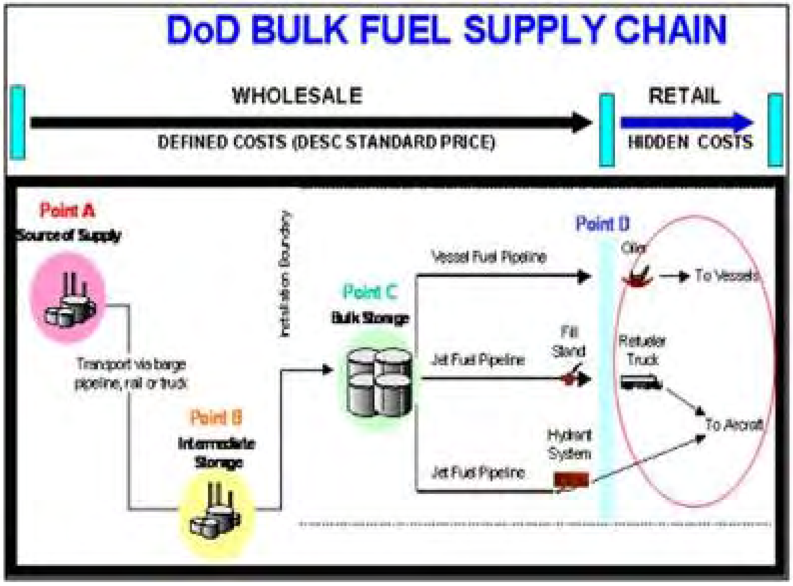

Figure 2.1: DoD Fuel Delivery Cost Responsibility

Effectively managing fuel demand requires an in-depth understanding of the activities that are creating the demand. Unfortunately, data on energy usage are unevenly collected across the Department, making it difficult to form a comprehensive picture. For operational systems, DESC operates an accounting system for the purpose of tracking purchases, but data showing where it is used, for what purpose, and by which end-items are inconsistent. The Air Force keeps excellent records of aircraft fuelings by tail number, quantity, date and location. Data on use by ground systems are not collected. This makes it difficult to establish baselines by system, establish metrics or management demand. It also makes it difficult to establish priorities based on systems creating the greatest demand. For installations, electricity is metered for the purpose of billing by utility companies, but metering within the installation for energy management purposes has been spotty. Policies to meter all buildings are very recent, were directed by Congress, and will be implemented as new buildings are constructed or renovated.

The Task Force was struck by the contrast between the energy demand data collected by DoD and that collected by another very large energy consuming entity – Wal-Mart. If a single freezer cabinet door remains open too long at an individual store, an alarm is triggered at Wal-Mart's headquarters in Bentonville, AR. Wal-Mart uses detailed demand and consumption data to inform corporate wide decisions that affect energy demand including capital investments, maintenance policies and operational procedures.

On the next, page Figure 2.2 shows the proportion of DoD energy consumption by end use in FY06. It gives a broad idea of DoD energy use but is insufficiently detailed to understand the causes of fuel demand. For example, jet fuel is by far the largest use, but is not used just for aviation. It is the main battlefield used to power land combat and support vehicles and generator sets at deployed locations. Aircraft use is well documented by tail number, but airlift is difficult to link back to the source of lift demand. For example, significant airlift resources are used to transport Army and Marine assets. Linking a reduction in the weight or volume of those assets to a reduction in airlift fuel requirements may be difficult. But it is a key input in determining the best choice among competing options for Army or Marine assets that are transported by air, and would significantly increase the benefit of lighter-weight and more fuel-efficient land platforms.

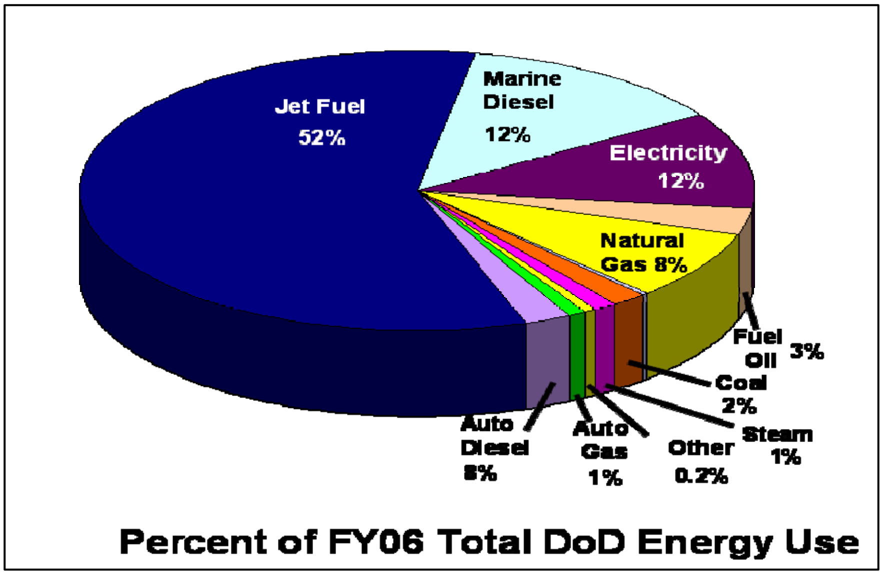

Figure 2.2: DoD Energy Consumption by Type of Fuel

2.2.3.2 Valuing Fuel

The 2001 DSB report "More Capable Warfighting Through Reduced Fuel Burden" found that DoD was systematically underestimating the true cost of supplying fuel to its battlespace forces. It recommended use of a burdened cost for such fuel, the burden capturing the assets (force structure) required for delivery and protection of fuel from the point of commercial supply to the point of use. Fuel delivery costs include the part of Military Sealift Command that delivers fuel, the Air Force airborne tanker fleet, the amount of F-18 flying time spent serving as airborne tankers delivering fuel to other aircraft and the attendant refueling equipment, and the refueling vehicles owned by the Army and Marine Corps. The amount of fuel delivery equipment required to support specific units is included in tables used by the Services to build deployment packages. These are the Tables of Allowances (TOA), Tables of Distribution and Allowance (TDA) and Tables of Organization and Equipment (TOE). Fuel delivery costs also include assets used to protect the fuel as it transits from the point of commercial supply to the battlespace. Improving the efficiency of a deployed system would reduce the amount of fuel needed for battle, and hence the number of the fuel logistics assets the DoD would need to buy, maintain, train on, buy fuel for, and protect. The costs of those assets should be included in calculating the true cost of fuel to DoD, and should be compared with the cost to make deployed systems more efficient.

The Task Force found that while some progress has been made since the 2001 DSB report, the fully burdened cost of fuel is not yet calculated nor well integrated into DoD's business processes. In consequence, potential gains in operational effectiveness from increasing combat system fuel efficiency have not been realized. Integration of the fully burdened cost of fuel into DoD business processes remains a significant challenge.

2.2.3.3 Managing Fuel Demand

The Task Force found that there is no enterprise wide strategy for managing DoD's energy usage. No one office is in charge; there are few objectives or metrics, and no one is accountable. Decisions that affect DoD's demand for energy cut across multiple Undersecretaries, all the Services, the Joint Staff, the Combatant Commands (COCOMs) and Defense Agencies. Facility energy managers, specialty functions (e.g., medical, laboratory, industrial), fleet vehicles, non-developmental deployed systems, procurement policy governing commercial equipment purchase, and combat and support systems all drive DoD energy use, but are disconnected from each other organizationally, functionally and culturally.

There are a number of external mandates driving energy practices, such as executive orders and legislation, but these are limited to non-tactical vehicles and installations. For example, Executive Order (EO) 13423, "Strengthening Federal Environmental, Energy and Transportation Management," requires each Agency to improve the energy efficiency of its facilities and to utilize alternative fuels in its non-tactical alternative fueled vehicles. However, the Executive Order covers only about 25% of DoD's energy use. The remaining 75% used for combat and combat related systems is not subject to its mandates – these functions are exempt. Hence, no one has been assigned responsibility for energy strategy or management for DoD's largest category of energy use. The implications of this management vacuum are significant because once required, developed, acquired and fielded, inefficient platforms lock DoD into decades of large fuel logistics force structure and high fuel costs.

2.2.3.4 Benefits of Better Fuel Management

The Task Force found that combat and combat related systems generally are inefficient in their use of fuel. This represents a major constraint on the operational effectiveness of U.S. forces and translates directly into poor endurance and persistence in the battlespace. Platforms are forced to use time transiting to fuel sources instead of residing on station, and more of them are needed to maintain a continuous presence. Improvements in the efficiency of platforms therefore would enable U.S. forces to increase their in-theater effectiveness by spending more time on station relative to transit, and by allocating fewer of their assets to sustain a given number at that station.

Platform inefficiency affects operational effectiveness in other ways as well. Moving and protecting fuel through a battlespace requires significant resources. It constrains freedom of movement by combat forces, makes them more vulnerable to attack, and compels them to redirect assets from combat operations to protection of supply lines. Thus, the need to move and protect fuel detracts from combat effectiveness in two ways; by adding to sustainment costs and by diverting and endangering in-theater force capability.

The payoff to DoD from reduced fuel demand in terms of mission effectiveness and human lives is probably greater than for any other energy user in the world. More efficient platforms would enhance range, persistence and endurance. They also would reduce the burden of owning, employing, operating and protecting the people and equipment needed to move and protect fuel from the point of commercial purchase to the point of use. An important implication is that increased energy efficiency of deployed equipment and systems will have a large multiplier effect. Not only will there be direct savings in fuel cost, but combat effectiveness will be increased and resources otherwise needed for resupply and protection redirected. Truck drivers and convoy-protectors can become combat soldiers, increasing combat capability while reducing vulnerabilities caused by extensive convoys. In short, more efficient platforms increase warfighting capability.

2.3 Electricity

Unlike petroleum, the U.S. possesses sufficient domestic resources to generate the electricity it needs for the foreseeable future. Coal is used to generate about 52% of the nation's electricity. Estimates of the remaining resource range between 50 and 250 years, depending on assumptions and accounting for uncertainties in methodologies used to estimate reserves. Current estimates show the U.S. is endowed with a larger coal supply than any other nation in the world, although recent National Research Council (NRC) reports cast question over the validity of those estimates and growing concerns over warming suggest that future use will depend in part on the ability to manage carbon dioxide in the combustion process. Nuclear produces about 20% of the nation's electricity from 104 central plants. Natural gas produces about another 20%. The remainder is produced by hydroelectric (~6%), petroleum (~ 3%) and renewables such as wind, geothermal and solar. Wind is currently the fastest growing renewable source, but all renewables taken together still provide only a small percentage of the nation's electricity demand. The U.S. is currently the top producer of electricity in the world with about 25% of the total, followed by China, Japan and Russia.

DoD's key problem with electricity is that critical missions, such as national strategic awareness and national command authorities, are almost entirely dependent on the national transmission grid. About 85% of the energy infrastructure upon which DoD depends is commercially owned, and 99% of the electrical energy DoD installations consume originates outside the fence.[3] As noted below, however, the grid is fragile, vulnerable, near its capacity limit, and outside of DoD control. In most cases, neither the grid nor on-base backup power provides sufficient reliability to ensure continuity of critical national priority functions and oversight of strategic missions in the face of a long term (several months) outage.

2.3.1 State of the Grid

The U.S.-Canadian electric grid is very efficient and cost effective but its design metric is efficiency more than resiliency. As a consequence, it is vulnerable to natural disaster

[3] Department of Defense Naval Surface Warfare Center – Dahlgren, Mission Assurance Division Briefing, 6 September 2006.

or deliberate attack. The Task Force received several briefings from the Mission Assurance Division at Dahlgren (MAD), the Department of Energy and the utility industry. Based on these briefings, the Task Force is concerned about the condition of the grid and the ability to effect timely repairs.

This concern extends not only to the complete dependency of critical national security missions on the grid, but also to its centrality to all facets of the nation's economic life. To appreciate the seriousness of the impacts of an extended disruption, consider the 2003 Northeast blackout. At around 4:15pm EST on August 14, 2003 about 50 million people living in a 9,300 square mile area in the U.S. and Canada lost electrical power. More than 500 generating units at 265 power plants shut down during the outage, 22 of which were nuclear. Those plants took about two weeks to regain full capacity, and lost an average of more than half their capacity for 12 days. The shutdown was in part precautionary in nature. If an imbalance between load and supply occurs, power lines grow longer and sag from overheating and other hardware can fail. These imbalances can damage equipment that is hard-to-repair, requires long lead time to produce and is expensive. So, the grid quickly disconnects itself when a threatening imbalance is detected. Nuclear plants are required for safety reasons to shut down when the grid they're connected to is de-energized.[4]

A U.S.-Canada Task Force found the main cause of the blackout to be the failure of a utility in Ohio to properly trim trees near a power line, causing the first in what became a set of cascading failures.[5] Secretary of Energy Spencer Abraham said there would be no punishment for the utility because current U.S. law does not require electric reliability standards. However, the Energy Policy Act of 2005 (EPAct 2005) gave the Federal Energy Regulatory Commission (FERC) new authority to direct the industry to develop reliability standards. It directs FERC to designate an Electric Reliability Organization (ERO) to develop and propose reliability standards, which only after agreement by the industry become mandatory. The ERO chosen by the FERC is a volunteer, industry run organization. While FERC oversight of industry developed standards is an improvement over the previous situation, the Task Force remains concerned that FERC may be unable to reduce the risk to critical DoD missions to acceptable levels in a reasonable timeframe.

Some have argued that the August 2003 incident shows that the protections built into the grid worked. Within several hours electricity was restored to many areas, though a few areas waited nearly a week. However, the incident highlights how easily the power grid could be taken down. Also, quick restoration was possible because no significant equipment was damaged, something that might not occur in future incidents. Further, during the blackout most systems failed that would detect unauthorized border crossings, port landings, or unauthorized access to vulnerable sites. Future such

[4] Information derived from the US-Canada Power Systems Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, April 2004, available at <https://reports.energy.gov/BlackoutFinal-Web.pdf>.

[5] Ibid.

blackouts could be exploited for terrorist activity, with potentially far more catastrophic results.

These risks exist elsewhere than in the U.S. For example, on September 28, 2003 Italy experienced the largest of a series of blackouts suffered through that year, affecting a total of 56 million people, and spilling into Switzerland.[6] It was also the most serious blackout in Italy in 20 years. DoD installations located outside the continental United States (OCONUS) are dependent on the commercial grids serving their locations. Security of their power supplies and continuation of their missions is as important as within the U.S.

2.3.2 Consequences of Prolonged Outage

Briefings to the Task Force on grid vulnerability generally, and to military installations specifically, were alarming because they highlighted single-point-failures and the difficulty of restoration.

Unfortunately, the current architecture of the grid is vulnerable to even simple attacks. In addition to physical attacks, cyber attacks could take down parts of the grid for extended periods.[7] Grid control systems are continuously probed electronically, and there have been numerous attempted attacks on the Supervisory Control and Data Acquisition (SCADA) systems that operate the grid. None have yet resulted in major problems in the U.S., but the potential exists for major outages. Recently discovered types of cyber attacks illustrate this vulnerability and would impose unique DoD consequences.[8] They are discussed further in the classified annex to this report.

A long term major power outage would have significant consequences for both DoD and the nation. To begin with, there is the threat to critical DoD missions. A number of installations in the U.S. and OCONUS host missions that are critical in strategic and tactical terms and must function 24/7. The resilience of these missions is wholly dependent on continued power to the buildings and equipment involved.[9]

There is also the threat to DoD installations. Historically, DoD has viewed the mission of each installation to be to launch or deploy combat forces when directed. Beyond that, the installation itself has been viewed as less critical. However, this is changing. Concern over domestic terrorist attacks, the establishment of the Department of Homeland Security and a new Homeland defense mission for DoD have created a new

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[6] *Lessons Learned from the Power Outage in North America and Europe*, 15 December 2004, available at <http://www.iea.org/textbase/speech/2004/nvh_tokyo.pdf>.

[7] Information derived from CRS Report for Congress, *Government Activities to Protect the Electric Grid*, 4 Feb 2005, available at <http://italy.usembassy.gov/pdf/other/RS21958.pdf>.

[8] Information derived from Mike Burks *Control Systems Vulnerabilities,* July 2003, available at <www.dtic.mil/ndia/2003triservice/burk.ppt>; and Calvert L. Bowen, Timothy Buennemeyer and Ryan Thomas, *Next Generation SCADA Security: Best Practices and Client Puzzles,* 2005, available at <http://www.itoc.usma.edu/Workshop/2005/Papers/Follow%20ups/WP%20IEEE%20(Jun%202005)%20-%20Next%20Gen%20SCADA%20Security.pdf>.

[9] Information derived from Inspector General U.S. Department of Defense*, The Effects of Hurricane Katrina on the Defense Information Systems Agency Continuity of Operations and Test Facility,* 12 December 2006, available at <http://www.dodig.mil/Audit/reports/FY07/07-031.pdf>.

role for military installations.[10] Not only is there now a critical need for installations to continue functioning 24/7, but the power needed is significantly greater than that needed to support only specific critical missions.

Finally, there are the consequences to the nation. While assessing this is beyond the scope of the Task Force, a review of the consequences of the August 2003 outage is instructive. The outage caused cascading failures of critical infrastructure. Some areas lost drinking water because pumps or treatment systems or both failed. In at least one case, a chlorine leak at a chemical plant caused by the outage went undetected for nearly a week. Sewage systems failed as well, causing raw sewage to spill into waterways, including the ocean and rivers. People became sick from consuming unclean water. Rail service was significantly curtailed or stopped completely along Amtrak's northeast corridor, on Long Island and in Canada. Air travel was affected because passenger screening stopped at most airports, electronic ticketing did not work and air traffic could not function reliably. Gas stations closed because they could not pump fuel, hindering not only commutes, but also transportation of goods. Price gouging took place in some instances, and gas lines were reminiscent of those in the 1970s and early 1980s. Many oil refineries on the East Coast shut down. Cellular communications were disrupted because of inadequate backup power at communications towers and because customers could not recharge their phones. This overwhelmed some land line systems, and those with only cordless phones could not recharge them either. A number of television and radio stations went off the air temporarily though many had backup power. Cable television systems stopped broadcasting, some internet service providers were taken down and desktop computers not on backup power did not work. Large numbers of factories closed. And because of the interconnectedness of supply chains, many not directly affected by the outage had to close or slow because of supply problems. Border check systems did not work and truck traffic became severely backed up. This can be a serious economic problem when a "just-in-time" supply system depends on these trucks. Some industries took over a week to return to full production. Also, looting incidents were reported, though not to the level seen in New York City during the 1977 blackout. Overall, the nation lost output, some 50 million people in the U.S. and Canada were adversely affected, and U.S. national security was compromised.

Because DoD faces substantial risks to its missions via grid and other critical infrastructure vulnerability, it must find means to manage these risks. Chapter V discusses how.

2.4 Global Warming and Our Energy Choices

An important and growing issue affecting energy is global warming. In the U.S., oil, coal and natural gas supply about 85% of total energy, and all produce greenhouse gas emissions (GHGs). Since the U.S. is responsible for more than 20% of annual worldwide emissions, global warming has become a major geopolitical issue, with

[10] Information derived from CRS Report for Congress, *Homeland Security: The Department of Defense's Role,* 14 May 2003, available at <.http://www.fas.org/man/crs/RL31615.pdf>.

international pressure growing for the U.S. to take a more active leadership role to address it. Many of our closest allies consider global warming among their most important issues.

On February 14, 2002, President Bush announced the Administration's Global Warming Initiative, with a key goal of reducing U.S. greenhouse gas intensity by 18% between 2002 and 2012.[11] Since then the U.S. has reduced this intensity by about 11%, though absolute emissions have not declined. In April 2007, the Supreme Court decided that EPA has the legal authority to regulate carbon emissions as a pollutant. In addition, a number of legislative proposals have been introduced to limit U.S. GHG emissions, and several regions of the United States have adopted or are adopting their own carbon cap-and-trade systems. Many senior energy industry executives have suggested the inevitability of future carbon regulation, and a number have publicly advocated federal regulation as preferable to a patchwork of state and local laws.[12]

The global movement toward constraints on future carbon emissions is gaining support. DoD cannot be oblivious to this trend. Thus, the Task Force recommends that if DoD decides to provide financial backing to synthetic fuel production plants, it should avoid investing in processes that exceed the carbon footprint of petroleum. The Task Force recommends DoD continue to invest in low carbon synthetic fuel technologies that address unique, pressing DoD needs. For example, equipment capable of producing fuel at forward deployed locations using locally available renewable or waste feedstock reduces gallon for gallon the amount needed to be moved and protected in theater. DoD should continue to invest in research into alternative, non-petroleum, renewable and low-carbon footprint fuels for the long term.

[11] Greenhouse gas intensity is the ratio of greenhouse gas emissions to economic output. The U.S. goal is to lower emissions from an estimated 183 metric tons per million dollars of Gross Domestic Product (GDP) in 2002, to 151 metric tons per million dollars of GDP in 2012. For more information see < http://www.epa.gov/climatechange/policy/intensitygoal.html>.

[12] "Energy Firms Come to Terms With Warming," *Washington Post*, 25 November 2006: A1.

CHAPTER III: MANAGING FUEL DEMAND – A BUSINESS PROCESS RE-ENGINEERING CHALLENGE

3.1 Unfinished Tasks from the 2001 Defense Science Board Task Force

The 2001 Defense Science Board Task Force report "More Capable Warfighting Through Reduced Fuel Burden" found that:

- Fuel logistics represent a significant portion (~70%) of the tonnage the Army ships into battle.
- Multiple technologies are available for all categories of deployed systems and at all levels of maturity that could reduce fuel demand.

The key finding was that warfighting, logistics and monetary benefits occur when weapons systems are made more fuel-efficient, but those benefits are not valued or emphasized in the requirements and acquisition processes. This is because DoD's business processes do not explicitly, routinely or systematically consider either the energy problem or opportunities to address it. The report found that the requirements process does not require energy efficiency in deployed systems, the acquisition process does not value it, the procurement process does not recognize it, and the Planning, Programming, Budgeting, and Execution System (PPBES) process does not provide it visibility when considering investment decisions.

The 2001 report made 5 recommendations:

- Base investment decisions on the fully burdened cost of fuel and on warfighting and environmental benefits.
- Strengthen the linkage between warfighting capability and fuel logistics requirements through wargaming and other analytical tools.
- Incentivize fuel efficiency throughout DoD.
- Target fuel efficiency improvements through investments in Science and Technology and systems design.
- Include fuel efficiency in requirements and acquisition processes.

It asserted that DoD's warfighting capability could be greatly strengthened through implementation of these recommendations because it would result in more resources available to fight (more tooth), with fewer needed for support (less tail). It asserted too that DoD's budget challenges would be eased through reductions in Operations and Support costs and less exposure to volatile energy prices.

The present Task Force again examined DoD's business processes, investments, policies and practices as they relate to the energy efficiency of combat and combat related systems. It concluded that while some progress has been made, it is limited and late, stimulated mainly by recent high oil prices rather than the fundamental forces that affect DoD energy costs.

In essence, the Task Force found that many of the same problems that existed in 2001 still exist today. A great deal of work goes into identifying options across the DOTMLPF (Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities) spectrum that produce warfighting "effects." Yet too little attention is paid to the amount of effort necessary to achieve those effects, where effort encompasses the delivery of necessary logistics, particularly fuel logistics.

Following release of the 2001 report, some encouragement was given to implementation of its recommendations. The Principal Deputy Under Secretary of Defense signed a memo (undated), stating "…include fuel efficiency as a Key Performance Parameter (KPP) in all Operational Requirements Documents and Capstone Requirements Documents." However, the Director, Joint Staff, non-concurred with the DSB recommendation to make energy efficiency a requirement, saying "We do not agree that 'fuel efficiency' should be a mandatory performance parameter expressed in operational requirements documents."

In Sep 2001, H.R. 2586 passed the Congress: "It is the sense of Congress that DoD should implement recommendations by the Defense Science Board to incorporate fuel efficiency in terms of procurement requirements, warfighting capability and logistics requirements, and base investment decisions on the true cost of fuel." However, a sense of Congress is not binding on DoD, and the Task Force was unable to identify tangible evidence that the Department took tangible action to implement the recommendations until August 2006.

3.2 Recent Initiatives to Implement the 2001 Task Force Report

In August 2006, the Vice Chairman of the Joint Staff signed a memorandum, "Key Performance Parameter Study Recommendations and Implementation" announcing a Joint Requirements Oversight Council (JROC) decision to endorse "selectively applying an Energy Efficiency KPP…as appropriate" (JROC 161-06). In May 2007, CJCSI 3170.01F "Joint Capabilities Integration and Development System" was released which incorporates the requirement for an energy related KPP and assigns the Joint Staff Director J4 to review and comment on the analysis and recommendations.

On April 10, 2007 the USD(AT&L) signed a memo "Fully Burdened Cost of Fuel Pilot Program" making it "DoD policy to include the fully burdened cost of delivered energy in trade-off analyses conducted for all tactical systems with end items that create a demand for energy and to improve the energy efficiency of those systems, consistent with mission requirements and cost effectiveness." To develop the procedures and guidance needed to implement the policy, the USD(AT&L) identified three pilot programs (the Joint Light Tactical Vehicle, the Maritime Air and Missile Defense of Joint Forces alternative ship propulsion and efficiency options AoA, and the Next-Generation Long-Range Strike concept decision) and is providing support to the programs to help perform the trade analyses. A preliminary analytic effort identified some key elements of the fully burdened cost of fuel delivered to platform in theater in wartime, but at this writing the analysis remains incomplete.

The Task Force views these as positive developments, but believes significant work remains to be done to:

- identify the data and analytic products needed to inform these decisions;
- develop and deploy the necessary analytical tools and data collection systems to produce accurate and relevant analytical products;
- issue an unambiguous policy that use of energy KPP and FBCF extends to "black" programs; and
- develop the policies and procedures necessary to ensure these analytical inputs are integrated into relevant decision processes at the right time.

Without follow-through on these steps, the Task Force is skeptical that energy considerations will be quantified to the degree necessary to be accurately factored into key requirements, acquisition and PPBES decisions.

3.3 Means to Increase the Endurance of Combat and Combat Related Systems

Endurance: ability to sustain operations for an extended time without support or replenishment.

In thinking about how to improve the endurance of operational forces by producing more "effect" for less "effort," the Task Force identified three core approaches that could be applied across the spectrum of DoD activities that generate battlespace fuel demand. They are:

- DoD Business Processes;
- Operational Practices and Procedures; and
- Technology Advancement, to include Research, Development and Demonstration.

3.3.1 DoD Business Processes – Uninformed About Fuel Burden

There are three key business processes operating in DoD that collectively determine the size and character of the force structure. The first establishes military requirements across the Doctrine, Organization, Training, Material, Leadership and Education, Personnel, and Facilities (DOTMLPF) spectrum. This process is called the Joint Capability Integration and Development System (JCIDS). The second is the Acquisition system. It produces equipment in response to requirements for materiel solutions to fill gaps in military capability. The third is the budget adjudication process, currently called the PPBES. It establishes a six year investment program with the ultimate objective of providing operational commanders the best mix of forces, equipment, and support attainable within fiscal constraints. A simplistic, but useful, model to think of these three processes is as an internal DoD market: the requirements process as the customer, the acquisition process as the product developer, the research community as the technology provider, and the PPBES as the source of capital. It is only after these decisions have been made that satisfying their resulting fuel demand becomes a planning factor. Since the Combatant Commanders are suffering operationally from high fuel burden, the Task Force concluded greater COCOM input to the requirements process would improve its ability to value fuel efficiency.

The processes are logical, but they do not function properly with respect to energy. This is not to say that fuel is never considered, but it must reach a high threshold before it becomes an issue. For example, in the 1970s the F-16 was selected over a two-engine competitor due to its lower fuel consumption. Mach number decisions for specific aircraft have been influenced by their fuel demands. But to manage fuel effectively, it must become an integral part of the decision processes, rather than just when it reaches a level where singular decisions can have significant operational and force structure consequences. If the requirements process does not understand energy efficiency in terms it values – operational capability, combat vulnerability, and force structure balance – it will have no reason for making efficiency a requirement. If the acquisition process does not understand the total ownership cost of buying, moving and protecting fuel to systems in combat (fully burdened cost of fuel), then its business case analyses will use only the commodity price for fuel. This distorts the results to make high return investments in efficiency look much worse than they really are. The PPBES process has two barriers to overcome. First, it cannot compare options that have not been developed. The inability of the requirements and acquisition processes to properly value efficiency means they are unable to produce a business case for such efficiency. And second, the PPBES process is current-year focused, making it very difficult for investments with paybacks of more than one year to compete for funds. Paying current year bills is a higher priority than making investments to reduce multi-year operating costs.

Because of these flaws, the JCIDS process is good at knowing the operational capabilities it needs, but not at finding the most efficient way of providing them. Sub-optimal choices are delivered to the acquisition process to develop. The Task Force concluded that giving the COCOMS the analytical capability to better understand the fuel logistics “price” of specific weapons systems “capabilities” and a stronger voice in the JCIDS process would benefit efforts to better capture the value of fuel in JDICS decisions. The acquisition process does not properly value energy efficiency and hence programs are designed that consume too much of it. Program designers do not know how much they should pay for energy efficiency, or how much of it to buy. Options to invest in technologies that would make new systems more efficient and reduce future fuel logistics demand are not identified, and often not even developed; hence are not visible to the PPBES process, nor, often, brought to maturity for adoption.

3.3.1.1 JCIDS and Pre-JCIDS Service Planning

JCIDS is a Four-Step Process. The Functional Area Analysis (FAA) defines operational success in terms of tasks to be accomplished. It does not include the need to move and protect fuel. The Functional Needs Analysis (FNA) assesses the ability of current and programmed capabilities to satisfy the FAA, and identifies gaps. The Functional Solutions Analysis (FSA) identifies possible approaches across the DOTMLPF spectrum to fill the capability gap and determines the optimum approach. Fuel logistics becomes a task for the logisticians to solve after these decisions have been made. However, each of the possible approaches identified in the FSA may impose different fuel demands. Rather than treating battlespace fuel as a problem to be solved after the FSA decision has been made, the fuel consequences of each option should be an input to the FSA decision. As shown in Figure 3.1 below, Percentage of Cost Locked in by Phase, the earlier in the planning cycle these issues are considered, the more control decision makers have over the outcome. The Task Force strongly urges the JROC to require battlespace fuel demand to be a factor in the FAA phase of JCIDS, and that fuel logistics and protection be explicitly modeled by the Service planning functions in the pre-JCIDS process.

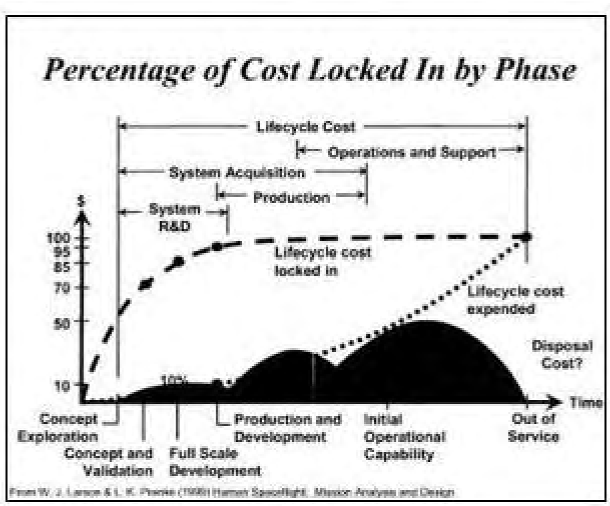

Figure 3.1: Percentage of Cost Locked in by Phase

Modeling and simulation conducted during JCIDS and the Service pre-JCIDS planning functions lack the capability to quantify the contribution of system efficiency to battlespace outcome or force structure requirements. Force-on-force models and simulations used to explore new concepts and test new systems do not explicitly include logistics; this is a serious shortcoming. The Task Force recognizes that the models make simplifying assumptions for the sake of looking at battlefield effects and outcomes under certain constraints and limitations, but it strongly recommends that analysts not turn a blind eye to the need to account for logistics in the capability documents. Lessons learned and military judgment sometimes get applied as sanity checks and programmatic goals, but in the absence of explicit modeling it becomes easy to minimize what is inherently inconvenient. Such explicit modeling of logistics assets would better reflect reality, and would have significant impacts on concepts and the way required capabilities are developed.

3.3.1.2 Acquisition

Acquisition translates capability needs into material solutions. Technology evaluations, engineering studies and trade-off analyses occur at the interface between JCIDS and acquisition, as well as throughout the acquisition process. These analyses identify the best technologies and designs to keep the program on target in terms of cost, schedule and performance and to address the myriad of "ilities" (maintainability, reliability, transportability, etc.) imposed on programs. The rules and methodologies that acquisition programs use to conduct cost-benefit analyses dictate their outcome. Generally, technologies must have achieved a Technology Readiness Level (TRL) 6 to be considered mature enough for an acquisition program. TRL 6 means a prototype has been tested in a high fidelity laboratory environment or in a simulated operational environment. TRLs are used to manage the technical risk to programs. They range from TRL 1 where basic principles have been observed and reported and scientific research begins to be applied; to TRL 9 where technologies are being used under operational mission conditions.

Technologies that could reduce the fuel demand of a deployed system but which do not appear cost effective if the fuel cost is assumed to be $2.50 per gallon might be extremely compelling if the actual cost of moving and protecting the fuel were used instead. According to preliminary estimates by OSD Program Analysis and Evaluation (PA&E) and the Institute for Defense Analyses (IDA) the cost of delivering fuel to battle begins at around $15 per gallon and increases the deeper into the battlespace the fuel moves, assuming no force protection requirements for the supply convoys. Fuel delivered in-flight has been estimated to be on the order of $42 per gallon. The Task Force estimates these values to be low, and not accounting for much of the force structure needed to deliver the fuel demanded by deployed assets. In order to implement FBCF, the Department will need to undertake a rigorous effort to develop a methodology for estimating the values, and establish a policy formalizing them. As of this writing, the Department has yet to establish appropriate values to use for FBCF. Using FBCF drastically changes the calculus of system energy efficiency.

The rules by which these processes function are themselves the primary barriers to reducing fuel burden. Changes in the rules would improve the "tooth to tail ratio," or put another way would achieve maximum operational effect through reduced logistics effort. Change the rules, change the outcome.

Another important observation of the Task Force is that what JCIDS currently calls "capability" is actually the theoretical performance of a platform or system unconstrained by the logistics tail required for its operation. But tail takes money, people, and materiel that detract from tooth. True net capability, constrained by sustainment, is thus the gross capability (performance) of a platform or system times its "effectiveness factor" - its ratio of effect to effort:

$$\text{Effectiveness Factor} = \text{Tooth} / (\text{Tooth} + \text{Tail})$$

Also, in an actual budget, Tooth = (Resources – Tail), so:

Effectiveness Factor = (Resources – Tail) / Resources

Effectiveness factor ranges from zero (with infinite tail) to one (with zero tail). If tail > 0, true net capability is always less than theoretical (tail-less) performance; but DoD consistently confuses these two metrics, and so misallocates resources. Buying more tooth that comes with more (but invisible) tail may achieve little, no, or negative net gain in true capability. While the Department recognizes the need to reduce tail, the analytical tools needed to inform decisions on how to do so are not in place. Focusing on reducing tail can create revolutionary capability gains and free up support personnel, equipment, and budget for realignment. The Task Force recommendations are intended to build the analytical and policy foundation to begin introducing this way of thinking into the requirements, acquisition and budget forecasting processes.

The Task Force was encouraged to see the April 10, 2007 policy memo by USD(AT&L) requiring use of the fully burdened cost of fuel to be used for all acquisition trade analyses. Establishing rules for who determines the costs, how they will be determined and how they will be used by both government and industry Program Managers (PM) will be challenging. This is especially true since the fully burdened cost of fuel is strongly scenario dependent. Nevertheless, recognition that calculation of the fully burdened cost is a necessary component of system evaluation will move system design and program management in the right directions.

3.3.1.3 Non-Developmental Deployed Systems

> Fuel that is transported at great risk, great cost in lives and money, and substantial diversion of combat assets for convoy protection, is burned in generator sets to produce electricity that is, in turn, used to air condition un-insulated and even unoccupied tents.

In addition to combat systems, equipment, systems and infrastructure at forward operating bases also create significant battlefield fuel demand. 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.[13] According to briefings received by the Task Force, the situation today is no better than the campaign plans suggested in 2001.

Based on energy use patterns found by the Rapid Equipping Force (REF), the Task Force finds it difficult to conclude that much, if any, consideration has been given to the

[13] Defense Science Board Task Force on Improving Fuel Efficiency of Weapons Platforms, *More Capable Warfighting Through Reduced Fuel Burden*, January 2001, p. 43, available at < http://www.acq.osd.mil/dsb/reports/fuel.pdf>.

battlefield fuel demand created by equipment designed, developed or purchased for FOBs. One recently analyzed FOB used about 95% of its genset electricity for this purpose, and about one-third of the Army's total wartime fuel use is for running gensets (see Table 4.1 on page 44). The inefficient use of electricity at deployed locations raised grave concerns. However, the Task Force is encouraged by the work of the REF and hopeful that its findings will result in a new emphasis on efficiency for deployed equipment and a new focus on wasteful operational procedures.

3.3.1.4 Energy as a Key Performance Parameter

The Task Force welcomes DoD policy requiring selective application of an energy efficiency KPP, interpreting it to mean applying it to all systems that create significant battlespace fuel demand. It is concerned, however, with implementation of the recommendation. Presentations by the Joint Staff indicate little progress to date toward defining how an energy efficiency KPP will be developed, how it will be applied or how a milestone authority will determine whether it has been satisfied. Further, the intended outcome of an energy related KPP is to drive the development and adoption of technologies that reduce battlespace fuel demand. The Department has not yet developed the analytical tools needed to do so. The objective is to develop tools that enable milestone authorities to understand the battlespace fuel consequences of the options identified in the JCIDS FSA and to use that information as a factor in the Concept Decision. This has not been done, and the Task Force was unable to discover plans to do so.

3.3.1.5 Fully Burdened Cost of Fuel (FBCF)

Previous efforts have been made to quantify the effects of including logistic infrastructure, delivery and protection costs in the full cost of fuel. The results indicate that the FBCF far exceeds its commodity price. For example, estimates by the 2001 DSB, JASON, OSD(PA&E), IDA and Service cost groups have shown delivered costs for fuel to range from a low of $4 per gallon for ships on the open ocean to $42 per gallon for in-flight refueling to several hundred dollars per gallon for combat forces and FOBs deep within a battlespace. By comparison, the DESC standard price for JP-8 was $2.14 per gallon on April 1, 2007. On October 1, 2007 it increased to $2.31 and on December 19, 2007 it increased to $3.04 per gallon.[14]

The use of FBCF is needed to answer the question "how much should DoD invest in efficiency to the demand for fuel into the battlespace?" The FBCF figure is to be used to inform decisions at all levels, from design concepts, to choice of propulsion system to technology choices made at the component level by systems engineers to the types of equipment deployed to field installations. DoD currently has no analytical function dedicated to answering this question. While the OSD(PA&E) Cost Analysis and Improvement Group (CAIG) have been given the task of developing guidance for producing the estimates, it is unclear which office will be assigned the task of actually doing so. The Task Force questions whether program offices have the analytical

[14] See Defense Energy Support Center, <http://www.desc.dla.mil/DCM/DCMPage.asp?LinkID=DESCCutomerService>.

capability to make this determination, and whether leaving it to individual program offices will result in consistency of approach across programs.
The Army has centralized this function in its Sustain the Mission Project (SMP). SMP developed a methodology for estimating the FBCF based on the 2001 DSB "More Capable Warfighting Through Reduced Fuel Burden" report. It estimates the energy-related resources and costs to sustain Army missions in the training base and in theaters of operation, and has been validated by the Office of the Deputy Assistant Secretary of the Army for Cost and Economics. The Army has chosen to establish this capability through contract, rather than as an organic capability. This relieves program offices of the task, provides consistency across programs, and gives it independence and transparency.

However, its use is not mandatory for Army acquisition programs, and it does not explicitly measure or analyze the effects of energy demand on combat effectiveness, mobility, and other mission goals. Steps to implement the use of SMP in acquisition and to fully understand the implications of energy demand on combat effectiveness could help identify a variety of means for improved Army operations.

The Task Force has one concern with how the Department is implementing FBCF. The OSD(PA&E) guidance memo for estimating FBCF cautions "the fully burdened cost of fuel should generally assume peacetime OPTEMPO. Using "worst case" or combat scenarios to evaluate alternatives for the entire life cycle of a platform will skew the burdened rates, making some technologies appear to have a greater return on investment than they are likely to achieve in actual practice during a life cycle exceeding 30 years."

The Task Force does not support this approach. FBCF is a wartime capability planning factor, not a peacetime cost estimate. Because it is scenario dependent, it should be estimated across the range of scenarios and missions envisioned for the system in question. The logistics structure needed to deliver fuel for those scenarios and missions and the operational assets used to protect that fuel during transit are part of the FBCF for that system.

The challenge is to translate reductions in battlespace fuel demand into the savings that would result from retiring or diverting the equipment and systems no longer needed to deliver that fuel. The methodology developed by OSD(PA&E) provides the most comprehensive estimate of the costs of fuel in peacetime at installations and in specific operational situations but has not yet been converted into a full analysis ready to apply. The task of relating reductions in these costs to specific reductions in battlespace fuel demand also remains to be done.

3.3.1.6 Reset Opportunities

While not acquisitions, reset (or recapitalization) programs direct substantial sums of money to rebuilding existing equipment to original specifications. The net effect is to refurbish yesterday's equipment buys to yesterday's vehicle technology baseline. A refurbished 1970s technology High Mobility Multipurpose Wheeled Vehicle (HMMWV) is still a 1970s vintage HMMWV. The Army estimates its current reset requirement at about $85 billion.[15] The Task Force views this investment as an opportunity to move technology forward. While there are limitations imposed by the basic configuration of the equipment, the Task Force strongly recommends explicitly exploring opportunities to improve the energy efficiency of systems scheduled for reset.

3.3.2 Operational Procedures

How systems are operated also significantly affects fuel consumption. Despite a few programs to induce careful operator use of energy, the Task Force found that commanders generally are not incentivized to reduce fuel consumption. More programs are needed like the Navy's Incentivized Energy Conservation program (i-ENCON) that allows ship commanders to keep a portion of the money saved through operational efficiency measures and use it for morale, welfare and recreation or investments in further efficiency measures; or the Air Force Model Base Energy Initiative which includes operational practices in its effort to minimize installation energy footprint. Many further improvements in operational procedures among all the Services and Defense Agencies appear possible. Some examples of steps that could be taken follow:

<u>Aircraft</u>

- 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 afterburners as much as possible.
- Plan and execute efficient flight routing.
- Make more extensive use of simulators.
- Refuel in-flight only when absolutely necessary.
- Move fuel by air as little as possible.
- Plan missions to minimize any need to "dump" fuel.

<u>Ships</u>

- Slow steam ships on only one engine running at peak efficiency instead of multiple engines at lower efficiency.

<u>Ground Forces</u>

- Reduce battery re-supply in the field through use of lightweight portable photovoltaic systems.

[15] CSA & CMC Testimony before House Armed Services Committee, as reported by Army News Service, 26 January 07.

- Reduce air conditioning losses at hot weather FOBs through tent insulation.

Logistics and Planning

- Make maximum use of ocean shipping to avoid the need for air shipping.
- Plan air logistics transport to maximize load factors.

Aircraft and Ground Vehicles

- Use Auxiliary Power Units (APUs), or batteries when power is needed for stationary vehicles instead of running main propulsion engines.

Facilities and Shipboard Hotel Loads

- Use only Energy Star or Federal Energy Management Program (FEMP) designated efficient products where available.
- Maintain heating and cooling systems in top performance through continuous commissioning.
- Manage thermostat settings.
- Use compact fluorescent light bulbs or solid state / light-emitting diode (LED) lighting.
- Use occupancy sensors to turn lights on and off.
- Eliminate requirement for computer systems to be on 24/7 through better scheduling of software updates and other maintenance activities.

Procurement Policy

- Defense Logistics Agency (DLA) and Government Services Administration (GSA) to offer only Energy Star or FEMP designated products as required by the Energy Policy Act of 2005, Section 104.
- Prohibit government credit cards from being used to purchase non-Energy Star or FEMP designated products.

The Task Force found that the key barrier to implementing actions such as these is people taking the availability of energy for granted. Overcoming this will require a campaign linking saved energy to national security and strong leadership attention focused on strategy, metrics and accountability. It will require inculcating energy considerations into business processes, fitness and performance reports, education and training programs and incentive programs. The challenge is now greater than it was in the 70s and 80s and the consequences of failure even greater. Creating both incentives and awareness at all levels will focus people's attention and make implementing many of the recommendations of this report easier by unleashing the creativity of the Department's best assets – its people.

3.3.3 Director of Defense Research and Engineering (DDR&E) Investments in Efficiency

> Cost effective energy efficiency is an unqualified good that DoD should recognize.

As the technology supplier to acquisition programs, DDR&E is in a difficult position regarding technologies that improve efficiency. Big ticket items such as new propulsion systems or new design concepts get attention, but because they apply across a wide range of platforms and systems their constituency is diffuse. Technologies with the potential to make incremental improvements often are not significant enough to attract much funding and are disadvantaged in their competition for deployment into programs. As the warfighting value of efficiency becomes recognized by the requirements process and cost effectiveness becomes recognized by the acquisition process through the use of FBCF for trade analyses, this situation should improve.

3.3.4 Competitive Prototyping

Operators are risk averse, quite understandably so. New technologies, such as lightweight composite armor, new design concepts or new propulsion technologies may look good on paper but operators risk their lives and prefer the comfort of proven systems. Incremental improvements may be acceptable, but disruptive breakthrough technologies are seen as too risky to chance. Yet it is exactly such technologies that can propel the U.S. to superior combat position. They need to be tested under realistic conditions to see whether they will work. To accelerate the process of validating new concepts and making them more acceptable to operators, the Task Force recommends expanded use of competitive prototyping.

The Task Force recognizes that proving new concepts at scale through competitive prototyping requires significant investment. But DoD has used this approach before and by doing so has achieved rapid advancements in shorter periods than required today. Unfortunately, DoD abandoned this practice a few decades ago as unaffordable.

The Task Force concluded that DoD cannot afford not to do competitive prototyping. Such prototyping reduces the risk of deploying advanced technologies more quickly in multi-billion acquisition programs. The Task Force also noted the competitive prototyping program should include several important features to ensure effective execution:

- It must remain uncoupled from Future Year Defense Plan (FYDP) approved programs in order to avoid risk-aversion and “dumbing-down” by program advocates, whether contractor or government.
- The prototypes should be administered by an independent organization with experience in these types of programs in order to: a) streamline the contracting

process, b) minimize program management interference with the contractor, c) avoid Service bias, and d) demonstrate contractor's claims.

- The competitive prototype program should fund at least two competitors per vehicle category in order to: a) broaden the number of technological approaches, b) maintain competitive pressure, and c) ensure industrial design base continuity.
- The funding should be from Budget Activity 4 accounts ("Advanced Component Development and Prototypes"), and not Science and Technology (S&T) (Budget Activity 1-3), to ensure strong ties to acquisition. The Task Force's Platform Panel suggests a dedicated level on the order of $500M per year.

An effective program would provide operators and program manager's confidence in innovative technologies through real world testing. It would also provide the industrial base with experience in using new technologies, help to secure technological leadership and improve the competitive position of the defense industry.

3.4 Strategic Technology Vectors

Technology does not develop in a particular direction for arbitrary reasons. It does so in response to a perceived need. The Task Force noted recent DSB summer studies on the subject of strategic technology vectors to guide research investments and concluded DoD's energy problems sufficiently critical to add two new strategic vectors: endurance and resilience.[16] This Task Force concluded they would compliment the current vectors of speed, stealth, persistence and networking.

Endurance exploits improved energy efficiency and autonomous energy supply to extend range and dwell—recognizing the need for affordable dominance, requiring little or no fuel logistics, in persistent, dispersed, and remote operations, while enhancing overmatch in more traditional operations. Resilience combines efficient energy use with more diverse, dispersed, renewable supply—turning the loss of critical missions from energy supply failures (by accident or malice) from inevitable to near-impossible.

3.5 Opposition to Change

Opposition expressed to the Task Force for the changes being recommended fall into a number of categories. The one most often heard for not valuing or investing in efficiency was based on a presumption that the benefits will never be realized because the Services will not give up the logistics assets made redundant by the improved efficiency. The Task Force did not consider this valid. What DoD decides to do with the extra logistics capacity does not diminish its value. Presuming that leadership will decide to use the extra logistics capacity to deploy the force more quickly rather than reduce logistics force structure is not a reason to not want to know that the option exists. How leadership decides to use the benefit is a separate issue.

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[16] See Defense Science Board, < http://www.acq.osd.mil/dsb/reports.htm>.

A second reason cited is the "split incentives" argument. This is a well known management issue and one DoD recognizes. It says the owner of one corporate account is not incentivized to make investments that only benefit the owners of other accounts, even if the investment is in the best interest of the corporation overall. For DoD, the issue is investing acquisition funds to reduce operating and support costs. If a more efficient combat system requires more acquisition investment, DoD could decide to increase the acquisition budget at the expense of the operating and support budget. The argument goes that the logistics community will not permit their budgets to be reduced, so the acquisition programs will not get the increased funding. But again, this is no reason for choosing not to understand that the option exists. Additionally, there are other reasons for making combat systems more efficient beyond the logistics budget – operational vulnerability and force protection demands may be more important issues. Understanding the full range of costs, benefits and risks of making deployed systems more efficient reveals options to decision makers that would not otherwise be visible. Having more options available is better than having fewer.

Another reason cited is the large investment in modeling and simulation (M&S) needed to develop accurate logistics modules. While such M&S is not without effort, a few million dollars per year to provide better tools to the warfighters and acquisition community and new insights to senior leaders is negligible relative to the improvements to multi-billion dollar acquisition decisions it can generate.

3.6 National Spinoff Benefits

Finally, there are spin-off benefits addressed in the TOR - the national benefits. OSD (PA&E) estimated it is worth $42 to avoid delivering a gallon of fuel through aerial refueling and at least $15 to avoid delivering a gallon of fuel to the forward edge of a battlefield. If the cost of force protection for fuel convoys in Afghanistan and Iraq were used, the $15 figure likely would be far higher since it is based on minimal force protection. It is unlikely that energy efficiency has a higher value to any other organization in the country, possibly the world. If DoD were to invest in technologies that improved efficiency at a level commensurate with the value of those technologies to its forces and warfighting capability, it would probably become a technology incubator and provide mature technologies to the market place for industry to adopt for commercial purposes. The overall national outcome of changing DoD business processes to accurately value efficiency is difficult to predict but doing so would be consistent with best business practices used by the world's most successful companies and likely would develop multiple technologies for use in the civilian sector as well as by DoD itself.

CHAPTER IV: TECHNOLOGIES FOR ENERGY EFFICIENCY AND ALTERNATIVE SUPPLIES

The Task Force examined the special challenges associated with combat systems and identified technical options for addressing those issues. The Task Force also examined fuel supply technologies and made some recommendations on research investments and the potential of alternative fuels' to mitigate DoD's energy risks.

4.1 Technologies to Improving Combat Endurance

There are huge gaps between the efficiency of current platforms and what is technically and economically achievable in the future. Fortunately, technology exists to enhance the fuel efficiency of air, maritime and ground platforms. Some of this is potential breakthrough technology that can increase force effectiveness many times over while others will produce more modest gains but is lower in risk and in many cases can be done more quickly.

Technical improvement in platform fuel efficiency can be achieved via three pathways:

- fundamental – new vehicle configurations that affect overall aerodynamics and structural efficiency; new propulsion architecture and over the longer term, fuels.[17]
- major subsystem increments – step improvements in engines, pervasive introduction of new structural materials, etc.
- small component evolution – such things as all-electric actuation, winglets, more efficient generators, thrusters, material substitution, etc.

We discuss examples of each of these pathways. All need to be pursued for DoD to maximize the operational effectiveness of its fighting forces. Based on briefings, papers, reports, and other sources made available to the Task Force, the Task Force believes there is enormous technical potential to cost effectively become more fuel efficient and by so doing to significantly enhance operational effectiveness.

4.1.1 Potential Fundamental Breakthrough Technologies

The Task Force reviewed literally hundreds of technologies with potential to improve fuel efficiency. All have merit but most individually offer incremental, often single digit percentage, improvements over current technology. This is not to say they are not worth pursuing—the collective effect of many incremental improvements would have a major cumulative effect. However, there are three technologies with the potential to fundamentally alter DoD capabilities and enable new concepts of operations. These offer the potential of double digit percentage improvements in energy efficiency over

[17] In the long term, fuels that are lighter per unit of energy produced, such as liquid methane and liquid hydrogen, may prove advantageous for long range and high speed aircraft; however, many technical and operational hurdles must be overcome first.

current technologies, and to propel our domestic industrial base to new levels of performance. They have the potential not only to improve DoD's capabilities, but to benefit the nation through commercial adoption. A more detailed description of these technologies is contained in Appendix D. The three technologies are:

- Blended Wing Body for fixed-wing, heavy-lift aircraft;
- Variable Speed Tilt Rotor for vertical lift aircraft; and
- Blast-Bucket design concept for light armor ground vehicles.

The three are shown in Figure 4.1 below with rough estimates of their operational gains and fuel savings.

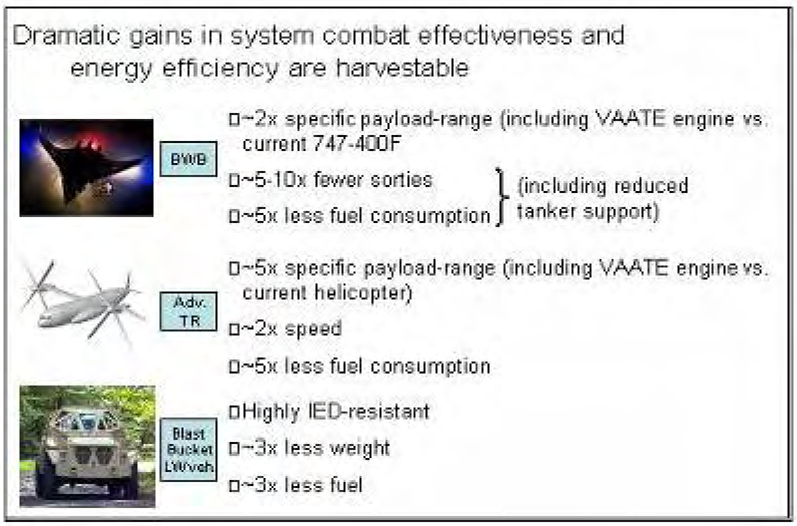

Figure 4.1: Examples of Fundamental Energy Efficiency Disruptive Breakthrough Technologies

In addition, alternate fuels for specific missions and systems (e.g. cryogenic liquid methane and hydrogen fuels for long-range and/or high speed aircraft) could offer the potential for much higher energy densities than current fuels. Such fuels could impart important operational capability benefits in the future, but their availability is beyond the timeframe of the other technologies addressed in the report. The potential for such fuels suggests basic research in this area should continue.

4.1.1.1 Blended Wing Body (BWB)

The BWB design would fundamentally alter the design of heavy aircraft such as tankers, bombers and transports (DoD's single largest fuel use). It offers the possibility of 2x gains in range and payload, and of 5-10x in system level fuel efficiency (see Figure 4.2). If the technology can be successfully applied to both tankers and bombers, the potential exists for far fewer sorties needed to accomplish a given mission. The enhanced range of both bombers and tankers would offer the possibility of far fewer aircraft devoted to a single mission, freeing aircraft to conduct other missions or to focus more firepower on a given target.

The overall efficiency and productivity improvements enabled by BWB designs are striking. For example, the enhanced fuel efficiency of a BWB relative to a B52 bomber and a KC-10 tanker could mean that a mission to deliver 100K lbs of munitions that today requires 1½ B52 bombers and 9 KC-10 tankers might be replaced by 1½ B52s and 3 BWB tankers; or by 1 BWB bomber and only 1 BWB tanker. The combination of efficiency improvements to both the combat and support aircraft creates the possibility of order of magnitude savings to achieve this particular mission, freeing up resources for other purposes. It is a prime example of how enhancement of fuel efficiency can translate into enormous potential for increased operational effectiveness.

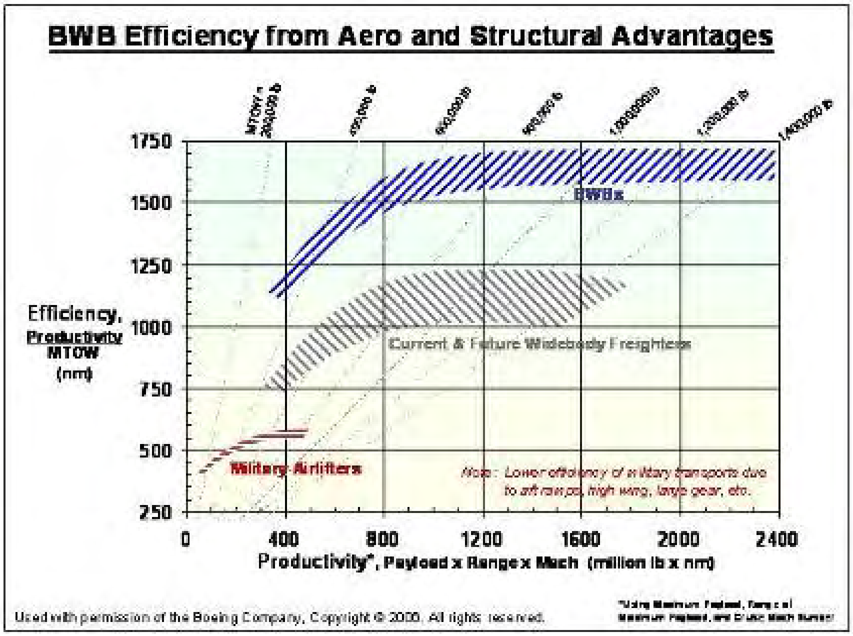

Figure 4.2: BWB Efficiency from Aero and Structural Advantages

4.1.1.2 Variable Speed Tilt Rotor

Current rotorcraft and those in development continue to embody decades-old technology that allows only small incremental gains in fuel efficiency and performance. However, emerging vertical lift technologies and new rotorcraft designs, specifically advanced tilt rotor designs exploiting variable speed rotors, hold promise of far greater range, speed and operational flexibility (e.g., Sea Base operations), with substantially reduced fuel consumption. Figure 4.3 compares the cruise efficiency and speed of various vertical lift aircraft. NASA and DoD analyses show advanced tilt rotors with 100 – 150% greater aerodynamic cruise efficiency than the V-22 and 300 - 400% better efficiency than current or new design helicopters based on improved Lift/Equivalent Drag. Additionally, new technologies available in engines, structures, drives, flight controls and subsystems make significant improvements possible in empty weight, propulsive efficiency, and overall fuel economy. In effect, such aircraft may be able to achieve efficiency capabilities approaching that of the C-30 cargo plane, and do so with a short takeoff and landing capability. They hold promise of rapid, long-range vertical insertion of ground forces for mounted maneuver—a capability currently unobtainable.

Army analysis indicates that the operational benefits of advanced tilt rotor designs with variable or advanced configuration rotors are compelling. As an example, a notional Future Combat System (FCS) Brigade Combat Team (FBCT) requires approximately 2,215 short tons of cargo, including fuel, every three days. Using current platforms, a typical delivery scenario covers a distance of 600 km and requires using an intermediate staging base and a combination of C-130s and CH-47Fs. A tilt rotor aircraft employing a variable speed rotor would eliminate the need to transit the forward operating base and the need to use 2 types of aircraft. It would accomplish the mission in one third the flight time with 70% fewer sorties and less than half the fuel. Operationally, forces in the field could move more quickly, with less exposure time to hostile fire and with fewer aircraft resources, so that a given fleet could perform a broader set of lift or maneuver operations than current aircraft and do so with far greater fuel efficiency. This also creates the possibility of eliminating the FOB altogether, including the ground time, personnel, resources and attack vulnerability associated with offloading the fixed wing assets and reloading the Vertical Take-Off and Landing (VTOL) aircraft.

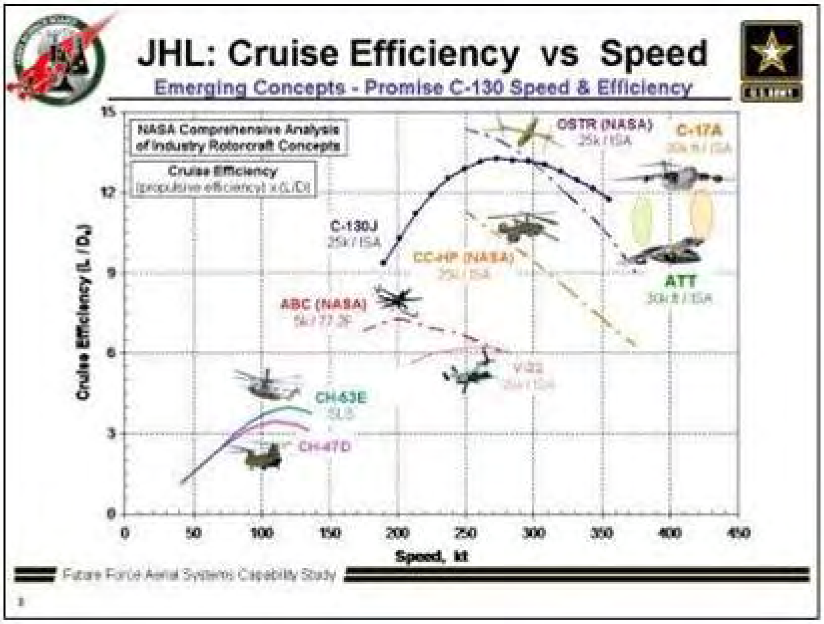

Figure 4.3: Cruise Efficiency, Speed of Vertical Lift Aircraft Compared

In a Joint Multi Role (JMR) configuration, an advanced variable speed tilt rotor or other advanced rotorcraft design has the potential to greatly improve the range, mission loiter time and speed of the Army and Marine rotary wing attack / escort and armed reconnaissance / VTOL Intelligence, Surveillance, and Reconnaissance (ISR) fleet while providing up to a 50% reduction in fuel demand when operating over extended (expeditionary) distances. These advancements in mission performance would be essential to support escort for advanced lift fleets and landing zone security and protection operations for mounted vertical maneuver operations. These designs would also be much more suited for operations for naval vessels and future advanced sea bases.

4.1.1.3 “Blast Bucket” Light Armored Ground Vehicle.

In Iraq, Army ground vehicles have proven highly vulnerable to Improvised Explosive Devices (IEDs). To mitigate this problem, the Army has “up-armored” its vehicles.

However, this has reduced fuel mileage from about 10 mpg for a standard HUMVEE to about 4 mpg. This significantly reduces their range and increases the amount of fuel they require. Further, the additional weight puts the vehicle beyond the design limit for its suspension, brakes and tires. This results in frequent tire blowouts, vehicle rollovers and other accidents with serious or fatal consequences for soldiers.

There are currently two programs intended to replace the HMMWV: the Joint Lightweight Tactical Vehicle (JLTV) and the Mine-Resistant, Ambush Protected (MRAP) Vehicle. Both are significantly heavier than the current up-armored HMMWV, sending battlefield fuel demand in the opposite direction it needs to go. But there may be another way. Research on lightweight structural materials and innovative design concepts have demonstrated the potential to produce survivable, militarily capable ground combat systems that weigh less and use less fuel than current systems. One example, known as the Badenoch vehicle, was developed at the Georgia Tech Research Institute with funding from the Office of Naval Research.

Figure 4.4: Badenoch Vehicle Concept

The Badenoch vehicle weighs less than half as much as an up-armored HMMWV, has much greater fuel efficiency, carries as many soldiers, provides better ability to fight from the vehicle, and vastly improves protection against blast and projectiles. It packages NASCAR tested safety and reliability features into an agile, multi-purpose vehicle to replace the familiar HMMWV, which was not intended to be used in combat situations involving shoulder fired rocket propelled grenades and IEDs. The concept and a number of technical innovations are shown in Figure 4.4. The “blast bucket” vehicle could be fitted with hybrid electric and Opposed Piston Opposed Cylinder engine technology to achieve a 50% increase in fuel efficiency in wartime conditions and a 200% increase in garrison or local use.

The fuel savings alone would result in reduced logistics needs and significant gains in range. Moreover, the blast bucket concept would better protect soldiers utilizing light vehicles and provide them more combat options. If the concept works as designed, it would greatly reduce the ability of enemy combatants to hinder light mobility assets and to inflict casualties on U.S. forces.

The Task Force concluded that this problem of an efficient, survivable, lethal ground combat system is of such high importance to DoD’s ability to fight, that the next generation vehicle should be the subject of intense development, design and competitive prototyping. There are many examples in the areas of commercial vehicles, racing, and aerospace where survivability has not required more mass. Armor constitutes half the total gross vehicle weight of some variants. The Task Force was not satisfied that sufficient creative effort has gone into employing innovative shock deflection, dispersion, absorption and packaging concepts to light vehicles to address the problem of protecting occupants against mines, IEDs, rocket-propelled grenades (RPGs) and small arms.

4.1.2 Other Important Platform Fuel Efficiency Technologies

If technology is to be used to enhance platform fuel efficiency, it makes sense to do so where fuel consumption is greatest. U.S. forces currently consume about 300,000 barrels of petroleum-based fuels per day. Of this, between 70% and 75% are consumed by aircraft. Therefore, the Task Force particularly looked to those technologies that could significantly affect aircraft fuel consumption. Other technologies offer potential to increase the fuel efficiency and operational effectiveness of naval and ground platforms, and some are applicable to a variety. Several of the more promising are described below.

4.1.2.1 Aircraft Fuel Efficiency Technologies

Versatile Affordable Advanced Turbine Engine (VAATE)

The VAATE program has two principal components:

- Highly Efficient Embedded Turbine Engine (HEETE)
- Adaptive Versatile Engine Technology (ADVENT)

The goal of the VAATE program is to improve specific fuel consumption by 25% compared to a FY2000 State of the Art (SOA) engine, such as that for the Joint Strike Fighter. The technologies involved could also be used on current systems such as the F/A-22, the B-1B and the C-17, and future systems such as the Long Range Strike fighter, Advanced Mobility Aircraft and Air Breathing Launch Vehicles.

HEETE expects to reduce engine weight relative to FY2000 SOA design by about 3000 lbs, double its bypass ratio and increase its overall pressure ratio by 75-100%. It also would reduce exhaust temperature by about 40%. Overall, its thrust to weight would increase by 60% compared to a SOA design. The Air Force expects over 25% improvement in fuel efficiency from the HEETE program, and estimates it can achieve a 2x increase in loiter time and 100-400 kW of power extraction needed for onboard multi-sensor suites. Both of these latter features would increase the operational effectiveness of air and ground forces in the field.

ADVENT would allow engines to adjust fan and core airflow and cycle on-the-fly for optimized performance at all flight conditions. The engines would increase fuel efficiency and reduce drag. The Air Force expects up to 35% improvement in subsonic performance and 14% in supersonic performance compared to FY2000 SOA engines.

Structural Design and Configuration

Advances in materials and design processes will enable the design of stronger, lighter aircraft with simpler, unitized structures that are easier to manufacture. Composite materials in particular will allow bonded joints and reinforcement technologies for complex loads. Lighter weight structures based on advanced materials and computer aided design will allow significant fuel savings without compromising performance or structural integrity. Such fuel savings will extend to fighters, lift and tankers, and possibly to helicopters.

Aircraft configurations can be modified to reduce drag, e.g., from skin friction. A blended wing body, for example, reduces wetted area by about one third relative to a tube and wing configuration. According to the Air Force Research Laboratory (AFRL), new configurations can be up to 40% more fuel efficient than conventional designs. Savings of such magnitude would significantly reduce aircraft fuel use, enabling greatly enhanced mission performance.

Lightweight Composite Materials

Lightweight composite materials such as carbon laminate, carbon sandwich and fiberglass and aluminum, are estimated to be the most important single factor in achieving fuel savings of 20% in the new Boeing 787 Dreamliner compared to a conventionally built aircraft of the same shape. Composites such as these also resist fatigue and corrosion, reduce maintenance, and curb emissions. Further advances in the use of composites in aircraft are possible, however. AFRL is examining tailorable materials that can morph and repair themselves as well as dissipate heat, thus increasing force endurance. Nano-tailored complex hybrid materials promise further weight savings, improved durability, and yet more heat resistance. Improved understanding and better modeling of the performance properties of complex materials architectures will allow less expensive manufacture with fewer parts. Also, composites being developed by AFRL for future aircraft appear to have application to ships, boats and ground vehicles. The potential energy savings over all DoD platforms and the resulting performance enhancement from increased use of advanced composites appear very considerable.

Multimegawatt Electric Power System (MEPS)

MEPS would provide a substantial boost in power capability aboard aircraft while cutting generator weight by 1000 lbs and reducing thermal load. It is based on cryogenic cooling and high RPM generator technology, and has application for directed energy weapons and Naval vessel distributed power. It offers 4-8x the kW/lb of existing or developmental aircraft power systems. The weight savings and reduced thermal load of power onboard power generation will allow for more energy efficient flight and enable more accurate, more powerful weaponry.

Powered Wheels

Electric motors placed in the wheels of aircraft can provide sufficient power to move them on the ground without use of the main engines, thereby saving fuel and extending range or loiter time. A more advanced version of electric wheel motors may be able to capture kinetic energy from landings and convert that energy into electric energy for powering the aircraft on the ground. The result would be even further fuel savings.

4.1.2.2 Land Forces and Forward Operating Bases

While the Army consumes less fuel than the Air Force, that fuel is generally difficult to move and protect. As shown in Table 4.1, the Army's peacetime and wartime fuel consumption patterns differ considerably. During peacetime, fuel consumption by Army aircraft makes up almost 50% of its total. But during wartime, generators become the largest single fuel consumers on the battlefield. Gensets in Iraq, overwhelmingly used for space-cooling, seem especially amenable to innovative technical solutions for improved fuel and load efficiency. Solutions such as non-refrigerative cooling systems that can provide more cooling per unit of electricity, coupled with design improvements that keep tents passively cooler. In addition, solar powered refrigeration units have been successfully used by the UN and other international aid agencies in a number of developing countries.

Category	Peacetime OPTEMPO	Wartime OPTEMPO
Combat Vehicles	30	162
Combat Aircraft	140	307
Tactical Vehicles	44	173
Generators	26	357
Non-Tactical	51	51
Total	**291**	**1040**

Table 4.1: Army Fuel consumption in peacetime & wartime (million gallons per year)

Foot soldiers also consume energy via the equipment they carry. U.S. foot soldiers probably are the most electronically equipped in history. While this gives them high capability, it also increases the weight they carry, particularly the batteries they need. Approximately 15-20% of a soldier's 70-90 lb pack consists of batteries. Also, obtaining replacement batteries adds to the fuel consumed by resupply lines while the task of recharging batteries adds to the load on generators at forward bases. But far fewer batteries would be needed if end-use devices were as efficient as is justified by the fully burdened cost of batteries delivered to the warfighter in theater.

4.1.2.2.1 Energy Efficiency and Renewable Energy Reduce Fuel Demand at Forward Operating Bases.

Last summer, in order to "improve the security posture of the al-Anbar province of Iraq," Command officials certified as "priority 1" a Joint Staff Rapid Validation and Resourcing Request on behalf of Marine Corps Maj. Gen. Richard Zilmer, seeking a "renewable and self-sustainable energy solution to support forward operating bases, combat outposts and observation posts throughout MNF-W's battlespace." The Resourcing Request went on to say "[b]y reducing the need for [petroleum-based fuels] at our outlying bases, we can decrease the frequency of logistics convoys on the road, thereby reducing the danger to our Marines, soldiers, and sailors."

This is a two part problem – end use inefficiency drives up electrical demand, and increases the difficulty of meeting power requirements using renewable energy.

Conversely, efficiency is the key enabler – improving end use efficiency reduces demand and makes it possible to satisfy a greater proportion of the load using renewable sources.

The Army's Rapid Equipping Force (REF) at Fort Belvoir has taken on this request for action.[18] It was created in 2003 to quickly address material needs in connection with the global war on terror, especially in cases where existing systems acquisition and procurement processes are incapable of responding to urgent requests. REF's goal is to respond to requests from operating forces by fielding a solution within 90 days when possible. Four off-the-shelf renewable energy supply systems are currently being tested before shipment to the United States Central Command (CENTCOM). Although the purchase price for these systems is higher than for a similar capacity diesel generator, MG Zilmer's request showed that they are expected to pay for themselves by offsetting fuel use in just 3-5 years depending on conditions.[19] It was not clear to the Task Force whether this payback calculation was based on FBCF. The Task Force suspects it was not, and that based on the true cost of delivering fuel to al-Anbar province the payback would be measured in months, not years. After this time, the energy produced by these systems is essentially free of cost when compared to other options. MG Zilmer's request listed a requirement for 183 systems of various power capacities. At least one U.S. manufacturer has estimated that this quantity could be produced in six months to one year.[20]

Another system being utilized by the Army's REF in Afghanistan is enhanced insulation for tents. The insulation dramatically curbs demand for air conditioning, thus reducing power demand and therefore fuel demand. The expected payoff for this system is measured in months rather than years, and fuel resupply costs and risks are significantly reduced.

4.1.2.3 Land Force Energy Efficient Technologies

Energy Starved Electronics for Land Warriors

As stated earlier, a principal problem facing the land warrior is the weight of batteries needed to power the equipment carried into combat. Various supply-side solutions have been proposed, including lightweight high energy density batteries, rechargeable batteries, and fuel cells powered by methanol, JP-8, propane or some other source.

Another approach is to severely reduce the power demands of the end use equipment. A recent NRC study recommended that the Army make energy efficiency a first-order design parameter and provide direct monetary incentives to manufacturers to reduce power demand in all procurements for soldier electronics, and especially for communications gear. That study recommended that the Army aim for a future soldier system that would require no more than 2W average power and 5W peak power, a very

[18] Wall Street Journal 9 January 2007.

[19] Commander MNF-W Renewable Energy System Request 25 July 2006.

[20] SkyBuilt Power, Arlington VA.

substantial reduction from what soldier systems require today. Defense Advanced Research Projects Agency (DARPA) is supporting a program ("Energy Starved Electronics") to reduce the power consumption of conventional signal processor electronics by >10x while maintaining comparable throughput. Such performance would exceed that of already power-efficient portable consumer electronics, but would indeed be feasible using new technologies already nearing commercialization.

Significant soldier equipment efficiency improvements coupled with improved batteries and new lightweight, portable, collapsible solar collectors for recharging batteries in the field could significantly reduce the weight soldiers carry. The improvements would reduce soldier requirement for power and also the number of batteries required to supply it. This could lighten packs and reduce jump injuries, or could permit more food, water, munitions, etc. to be carried, increasing endurance.

Ground Source Geothermal Cooling at Forward Operating Bases

Even in hot desert climates the ground temperature just a few feet below the surface is usually much cooler and more stable than the air temperature. While summer air temperatures can exceed 120F, the subsurface temperature at a depth of only 10 to 20 feet can be 70F. By circulating a working fluid from the surface to this depth and back, cooling can be provided to supplement or, in some cases, eliminate the need for conventional air conditioning. Coupled with insulation for the tents and renewable solar and wind power to circulate the coolant and operate fans, the process can be self sustaining, requiring no fuel powered generators at all. The example illustrates the power of coupling efficiency with renewable energy sources.

Fresh Water at FOBs

In the great majority of cases, water comes from municipal supplies and is purified using reverse osmosis systems, then trucked to FOBs over long distances. This creates an additional demand for transportation fuel and exposes more delivery trucks to attacks. An alternative is to check the subsurface availability of water at each FOB itself, and if the check confirms an accessible water table, then combat engineers or civilian contractors can drill a water well on site. Where an FOB is expected to remain in place for many months or longer, an onsite water supply offers many advantages: less fuel demand to move water and the potential to use evaporative cooling in lieu of air conditioning.

Efficient Generators

According to U.S. Army data shown in Table 4.1 on page 44, generators are the single largest user of fuel for that Service during wartime. In addition to their fuel use, generators impose very significant logistical burdens, particularly a need for transport to the battlefield, trailers and tow capability once there, and ongoing maintenance and repair. A 3 kW tactical quiet generator (TQG) weighs 325 lbs, a 5kW TQG 888 lbs. Further, tactical generators often are over-powered relative to the loads required of them. This both wastes fuel and causes maintenance problems, e.g., wet stacking. A new generation of 5-60 kW generators called Advanced Medium-size Mobile Power

Sources (AMMPS) has been developed and will be fielded shortly. These generators, which utilize variable speed motor technology, are designed to be lighter and more fuel efficient than their predecessors and are expected to impose fewer maintenance requirements, thus directly reducing logistics load in several ways. Attempts also are being made to integrate these generators with renewable energy sources to provide hybrid systems that are more efficient than either system operating alone. When logistic considerations are taken into account, the return on investment to these lighter, more efficient generators appears to be very high.

Another technological alternative is the development of micro generators, capable of producing 0.5 to 1 kW. Such generators appear to have practical application in the field as they would impose much less weight burden per kilowatt of power produced than existing generators, while using about the same amount of fuel. A concept 0.5 kW version, for example, is projected to weigh only 8 lbs, compared with a commercial 1 kW gasoline-powered version weighing less than 30 lbs. Full scale testing and evaluation of this technology could bring lightweight generators into the field within 5-6 years.

4.1.2.4 Naval Vessel Fuel Efficiency Technologies

Though fuel supply generally is less of a problem for naval vessels than for air or ground platforms, ships at sea nevertheless can become more effective fighting platforms through enhanced energy efficiency. The following technologies are particularly promising.

Reduced Hotel Loads

The 2001 DSB study identified a number of retrofit technologies for current Naval ships that would decrease energy use. These include occupancy sensors, centralized light pipe systems, and waste heat-using fresh water production systems. The 2001 Task Force estimated that cost effective savings of 20-50% in hotel load demand were possible. It further noted that reduced hotel energy demand would help enable additional combat system electrical loads and facilitate progress towards the Navy's goal of an all-electric ship. Since most current ships are likely to operate for many more years, hotel load efficiency gains will provide operational benefits for long periods. Further, the return on investment is even more favorable now than in 2001 because fuel prices are significantly higher now than they were then.

Shipboard Contra-rotating Propellers

Contra-rotating propellers offer opportunity for propulsion efficiency improvements in the 5-10% range, achieved mainly through improved hydrodynamics. Test evidence suggests that contra-rotating propellers can achieve significant power consumption reduction at design speeds and some improvement in cavitation at inception speed when compared to a controllable pitch propeller with shaft and strut configuration. It appears likely that energy efficiency gains obtainable through this technology would be augmented by gains in speed and signature reduction.

Advanced Waterjets

High power density water jets offer opportunities to move ships and boats more efficiently than with present water jet technology. The Office of Naval Research estimates that a compact high power density waterjet under development may be as much as 50% more efficient than existing models, with even higher efficiencies obtainable in future and reduced noise signature. The efficiency gain would come about through better cavitation control, jet thrust augmentation and advanced blade forms.

Greater Power Requirements to Support Net-Centric Warfare

The newest generation of Cruisers, and possibly Destroyers in the near future, are fielding ever more powerful radar and electronics combat systems with ever larger electrical demands. The loads are becoming so large that the cost effectiveness of nuclear plants on surface ships other than aircraft carriers is again being debated. The Task Force is concerned that the benefits of amending the radar's electronic and power architecture to improve its energy efficiency are not being examined, with the result that the cost of providing a sufficiently large power plant to power the combat loads in their current configuration is taken as a given. A total systems approach to maximizing efficiency in this context could reveal very worthwhile trades.

4.1.2.5 Other Energy Efficiency Technologies

Several energy efficiency technologies apply to platforms of all kinds and hence are not specific to a given type. Several particularly promising technologies are discussed below.

Unmanned Vehicles (UAVs, UGVs, UUVs)

Unmanned vehicles can significantly reduce energy use in the battlespace while providing increased persistence, intelligence, survivability and lethality. According to AFRL, one possible UAV system has the potential to replace the ISR functions of three separate manned systems: Joint Surveillance and Target Attack Radar System (JSTARS), Airborne Warning and Control System (AWACS) and Rivet Joint. No inflight refueling would be required over a 50 hour period, and on average, given the large increase in system fuel efficiency, 1 UAV sortie could provide the same reconnaissance services as 9 ISR sorties and 9 tanker sorties. The compounding effects of less fuel needed per sortie (of given length) and fewer sorties result in fuel savings estimated at as much as 97%. While such savings estimates are case specific and need to be demonstrated in practice, it seems clear that where UAVs can adequately substitute for manned systems they offer breakthrough potential in terms of persistence and endurance. There is strong reason to invest in this technology to determine and develop its full efficiency potential.

Investment in other types of agile and intelligent unmanned vehicles will allow them to perform a broader range of functions. The Army, for example, is investing in the Multifunction Logistics/Equipment (MULE), an unmanned vehicle that will carry supplies and provide power for soldier battery recharge. The Navy is investing in robotic undersea vehicles both to more effectively gather intelligence and to carry and utilize weapons. In the longer term, use of robotic vehicles for an ever-increasing set of military functions should not only increase fuel efficiency but enhance operational capability and hence overall force effectiveness.

Electro-mechanical Actuators

Actuators drive anything that moves within aircraft as well as ships and ground vehicles. They vary widely in complexity and performance envelope. Recent developments appear to offer the potential to replace aircraft hydraulics with electrical actuators, significantly reducing weight, increasing maintainability and fault tolerance, and producing better controllability. One source estimates that modern electro-mechanical actuator technology aboard military aircraft would reduce weight by up to 50% relative to comparable hydraulic systems, increasing range through greater fuel efficiency and enabling greater weapon capacity.[21] Logistics savings from the use of electro-mechanical actuators also are available on Naval vessels. For example, full application of electro-mechanical actuators to an aircraft carrier (to weapons handling and elevator, aircraft elevator, rudder mechanism, anchor windlass, etc.) is estimated to reduce each carrier's onboard weight by 1.4 million lbs, space requirements by 61,000 sq ft, and personnel by 500 billets, while reducing overall costs by $20-25 million per year.[22]

Biomimetics

Biomimetic design mimics natural design characteristics that minimize energy usage through reduced friction and drag. Biomimetic spiral type designs streamline fluid movement through management of turbulence and allow reduced weight to strength ratios with greater output and efficiency. Such designs are applicable to fans, pumps, propellers, turboexpanders, heat exchangers and compressors, and to surface profiles and vortex generators. For example, a biomimetic propeller is estimated to reduce energy consumption on the order of 25% while reducing system noise. Figure 4.5 shows a biomimetic propeller design. The concept would apply to platform components, not to major subsystems, but if valid in practice and extensively employed, it could provide substantial energy efficiency gains in a wide variety of platform types. Some specific Naval and aeronautic applications could be quickly tested and deployed.

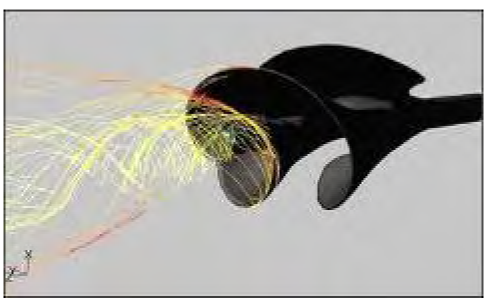

Figure 4.5: Biomimetic Screw

4.1.2.6 Non-Tactical (Fleet) Vehicles

Non-tactical vehicles (NTVs) are not used for combat purposes, but support operations at DoD installations that ultimately are related to combat purposes (e.g., training).

[21] Professor Dale Tesar, University of Texas, Briefing to the Defense Science Board, May 26, 2006.

[22] Ibid.

Further, DoD's non-tactical vehicles are covered under energy legislation pertaining to domestic fleets and by Executive Orders regarding energy efficiency goals. For these reasons, DoD needs to focus attention on its non-tactical fleet and the fuels that it uses.

DoD has approximately 164,000 non-tactical vehicles, primarily located at CONUS bases and facilities. To date, it has purchased about 41,000 light duty flexible fuel vehicles (FFVs) under 8500 pounds gross vehicle weight. While FFVs are no more energy efficient than conventional vehicles, they can reduce petroleum use by using non-petroleum based fuels. However, in many areas of the country there are no alternative fuels available and, on bases where only conventional gasoline is available, FFVs offer no advantage. While some Services have acquired FFVs only in locations with alternative fuels available, others have met their legislative requirement for a specific number of vehicles without regard to their ultimate destination. The result is that many DoD FFVs use conventional gasoline because they were acquired for locations where no flex fuel is available.

Rather than considering legislative and executive order mandates drive policy, DoD could look for opportunities to reduce its overall energy consumption and stimulate market adoption of nascent commercial products. Plug-in hybrid vehicles are expected to become available by 2010, with GM announcing its intent. DoD could work with GSA and GM to begin using these vehicles when they become available to help generate market acceptance. DoD should also investigate expanding the use of the most cost effective hybrids available to meet functional requirements as well. DoD could also use its fleet to test new battery technologies being developed for plug-in hybrid vehicles. This might include conversion kits with retrofitted batteries. On most military bases, speeds above 40 mph are normally not needed and usually prohibited. Conventional light trucks and SUVs are capable of speeds over 100 mph and are highly over-powered for use only on bases. The Air Force has recently announced a plan to purchase low speed vehicles (LSVs) that use all-electric propulsion on its bases. Its goal is that by FY10, 30% of all vehicles on Air Force bases will be LSVs. These vehicles use electricity that is the equivalent of gasoline purchased for less than $1/gallon, and do not rely on any petroleum since almost no electricity is produced from oil. The Task Force encourages the Department to view mandates as a minimum performance level, be creative in finding effective ways of using its extensive NTV fleet to reduce energy consumption, and to look for opportunities to offer broader national benefits as a demonstration for new vehicles.

4.2 Fuel Supply Technologies

> Domestically produced synthetic fuel does not contribute to DoD's most critical fuel problem – delivering fuel to deployed forces.

The U.S. is an expeditionary oriented force. When it fights, it uses fuel closest to the point of engagement. Yet, DoD is currently pursuing a number high profile, high cost demonstrations of domestically produced synthetic fuel. For example, the Air Force recently completed a $35M test program which showed that a jet fuel comprised of 50% Fischer-Tropsch synthetic fuel and 50% commercial fuel performs well in TF-33 engines on B-52 aircraft. This result is not unexpected since South African Airways have been flying a 50/50 mix of synthetic and commercial fuel for about 8 years. The expressed purpose of the initiative is to stimulate a domestic market for synthetic jet fuel. Further, the Air Force has stated a goal of obtaining half its domestic fuel consumption from domestic synthetic sources by 2016. Specifically, the Air Force has stated its intent to secure this fuel from a coal-to-liquid Fischer-Tropsch process.

The Task Force has strong concerns about the viability of this technology for a variety of reasons. Capital costs and production costs are high, putting investments at long term risks. The environmental control technologies needed to allow the plants to operate over the long term have only been demonstrated at limited scale and their costs are highly uncertain. Water demand also is very high using current production technology, and many coal reserves are in arid regions. The process produces large amounts of contaminated wastewater that must be treated. Further, a recent National Academy of Sciences report has raised questions about the estimates of coal reserves.[23] The Task Force concluded these large expenditures could be used for more productive contributions to DoD's most pressing energy challenges, rather than demonstrating synthetic fuel technologies that do not appear to have a viable market future or contribute to reducing battlespace fuel demand.

The Task Force recommends the Department continue investing in basic research to develop new fuels technologies that are too risky for private investments and to partner with other fuel users, such as airlines and engine manufacturers, to leverage efforts. The Task Force also urges the Department to work with partners to conduct comprehensive and objective "well-to-wheel" life cycle assessments of each synthetic fuel technology. It should include issues such as environmental footprint and its mitigation costs and risks, resource availability and scalability, all of which can affect the viability of alternative fuel technologies. The Task Force notes that in order to be viable, any synthetic fuel technology must have a full life cycle carbon footprint less than petroleum.

Mobile, in-theater synfuels processes would address DoD's fuel problem by reducing battlespace fuel demand. The Task Force was briefed on experimental processes that may be able to produce fuel in the field from military or indigenous biological or waste sources. Such a technology could have high value for military operations because it would replace gallon for gallon the amount of fuel needed to be delivered by fuel convoy into the battlespace. The Task Force recommends DoD continue research in this area and invest in full scale development because it addresses a unique military need.

[23] "Coal - Research and Development to Support National Energy Policy," NAS, June 2007.

CHAPTER V: MANAGING RISKS TO INSTALLATIONS

5.1 DoD's Approach to Assured Power at Installations

Historically, the mission of DoD installations has been to train combat forces and deploy them when needed. Critical missions at most installations were limited to those needed to execute the deployment of forces. In the event commercial electric power failed, small diesel generators with short-term fuel supplies were adequate to power those activities. Installations with substantial Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and military strategic deterrence missions have higher mission criticality and greater power requirements. Backup power systems at these installations are larger, but are still based on diesel generators and fuel supplies sized for only short-term commercial outages and seldom properly prioritized to critical loads because those are often not wired separately from non-essential loads. DoD's approach to providing power to installations is based on assumptions that commercial power is highly reliable, subject to infrequent and short term outages, and backup can meet demands. Unfortunately, DoD's assumptions about commercial power and other critical infrastructure reliability are no longer valid and DoD must take a more rigorous risk-based approach to assuring adequate power to its critical missions.[24]

5.2 A Confluence of Events Adds to Already Unacceptable Risks

Critical missions at DoD installations have expanded significantly in recent years. During Hurricane Katrina, military installations became central to recovery efforts in three key ways: by serving as the base of operations for relief and rescue missions using military assets; as the central command and control hubs to coordinate the work of other deployed national resources; and as a source of skilled personnel to provide rescue, recovery, medical and other emergency services required by survivors.[25] Under DoD's new homeland defense mission, military installations would serve a similar function in the event of a terrorist attack on the homeland, becoming operational bases in theater.[26] As a result, a much larger portion of the installation becomes a critical mission requiring highly reliable power. This drives a fundamental rethinking of what it means to provide power to these installations.

Similarly, C4ISR and strategic deterrence missions have taken on new real-time tactical and strategic criticality. They directly support real-time operations, and must be an uninterrupted, dependable, credible and trusted source of command, control and

[24] Information derived from Inspector General U.S. Department of Defense, *The Effects of Hurricane Katrina on the Defense Information Systems Agency Continuity of Operations and Test Facility.* 12 December 2006., available at <http://www.dodig.mil/Audit/reports/FY07/07-031.pdf>.

[25] Information derived from CRS Report for Congress *Hurricane Katrina: DoD Disaster Response,* 19 September 2005, available at <http://www.fas.org/sgp/crs/natsec/RL33095.pdf>.

[26] Information derived from CRS Report for Congress. *Homeland Security: The Department of Defense's Role,* 14 May 2003, available at <http://www.fas.org/man/crs/RL31615.pdf>.

execution capability. As a result, their power requirements and need for resiliency have also increased.[27]

For various reasons, the grid has far less margin today than in earlier years between capacity and demand. The level of spare parts kept in inventory has declined, and spare parts are often co-located with their operational counterparts putting both at risk from a single act. In some cases, industrial capacity to produce critical spares is extremely limited, available only from overseas sources and very slow and difficult to transport due to physical size.[28]

In many cases, installations have not distinguished between critical and non-critical loads when configuring backup power systems, leaving critical missions competing with non-essential loads for power. The Task Force finds that separating critical from non-critical loads is an important first step toward improving the resilience of critical missions using existing backup sources in the event of commercial power outage. The confluence of these trends, namely increased critical load demand, decreased resilience of commercial power, inadequacy of backup generators, and lack of transformer spares in sufficient numbers to enable quick repair, create an unacceptably high risk to our national security from a long-term interruption of commercial power.

5.3 Four Sources of Risk for Grid Outages

The first risk is from overload. As wires become overloaded, they heat up and sag, making them vulnerable to entanglement with trees and other objects. This happened near Cleveland, Ohio on August 14, 2003. According to the U.S.-Canada Power System Outage Task Force, high demand caused a high-voltage line to come in contact with overgrown trees. The resulting cascade of failures plunged many of the 50 million people in the Northeast U.S. and Canada living in an area covering 9,300 square miles into darkness. It shut down more than 500 generating units at 265 power plants, including 22 nuclear plants.[29]

A second risk comes from natural disasters, such as hurricanes, tornadoes, electrical storms or other extreme weather events. The consequences could be very much as described above, but with the added risk of physical damage to the infrastructure. Favorable commentary about the performance of the grid following the August 2003 outage focused on the fact that restoration occurred fairly quickly. Within a few days power was restored virtually everywhere, with much of the area back up within a few hours. This was largely because safety features built into the grid successfully prevented damage to critical equipment such as generators, breakers and transformers.[30] However, the Task Force is concerned that such an extensive outage

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[27] See Footnote 24 on p. 53.

[28] Information derived from CRS Report for Congress *Government Activities to Protect the Electric Grid*, 4 February 05, available at <http://italy.usembassy.gov/pdf/other/RS21958.pdf>.

[29] Information derived from the US-Canada Power Systems Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, April 2004, available at <https://reports.energy.gov/BlackoutFinal-Web.pdf>.

[30] Ibid.

could be caused by such a commonplace event – a single line contacting a tree. This inevitably raises the next issue below: what the result might have been had there been physical damage to infrastructure, such as from a deliberate attack by knowledgeable adversaries?

A third risk comes from sabotage or terrorist activity, whether local, trans-national, or state-sponsored, and including both conventional and nuclear attack. Nuclear attack could take place either directly or through the generation of a high altitude electromagnetic pulse (EMP). The grid is a relatively easy target for a terrorist. It is brittle, increasingly centralized, capacity-strained, and largely unprotected from physical attack, with little stockpiling of critical hardware. Although the system is designed to survive single points of failure, increasing demand on the system and increasing network constraints make multiple points of failure more likely. These are difficult to anticipate and more likely to result in cascading outages and catastrophic outages that cover large areas for long periods of time. Network Single Points of Failure (NSPF) are abundant. High voltage transformers, breakers, and other long-lead time items are particularly critical system elements.[31] They can be easily targeted and destroyed. Grid sections could be taken down for months even if replacement transformers and breakers could be found; or for years if certain components need to be newly manufactured and transported. There are only limited backups located around the country—generally co-located with operating equipment. For some of the largest equipment, there is no domestic supply and only limited overseas production capacity which is fully booked years ahead.[32] For example, 765 kV transformers are manufactured only by one company in Canada. Armed with the right knowledge, a small number of people could shut down electricity over significant areas for an extended period of time, including power to critical DoD missions. The grid is not designed to withstand a coordinated multi-pronged or wide-area attack.[33] The Task Force noted that attacks on the grid are one of the most common and effective tactics of insurgents in Iraq, and are increasingly seen in Afghanistan.[34]

In addition to physical attacks on the grid, there is the potential for cyber attacks. U.S. grid control systems are continuously probed electronically, and there have been numerous attempted attacks on the Supervisory Control and Data Acquisition (SCADA) systems that operate the grid. None have yet resulted in major problems in the U.S., but the potential exists for major outages in the same way successful hackers can disrupt computer networks.[35] Further details regarding the potential for deliberate

[31] See footnote 28 on p. 54.

[32] Information derived from sources "Staged cyber attack reveals vulnerability in power grid," CNN, 26 Sep 07, available at <http://www.cnn.com/2007/US/09/26/power.at.risk/index.html>.

[33] Information derived from Massoud Amin, *Security Challenges for the Electricity Infrastructure, available at* <http://ieeexplore.ieee.org/iel5/2/21810/01012423.pdf?arnumber=1012423>.

[34] "Iraq's national electricity grid nearing collapse: Residents 'fed up' as power, water become increasingly scarce," MSNBC, 4 August 07, available at < http://www.msnbc.msn.com/id/12784358/>.

[35] Information derived from John D. Fernandez and Andres E. Fernandez, *SCADA Systems: Vulnerabilities and Remediation,* Journal of Computing Sciences in Colleges, April. 2005: 160-168, available at <http://delivery.acm.org/10.1145/1050000/1047872/p160-fernandez.pdf?key1=1047872&key2=1178971021&coll=GUIDE&dl=GUIDE&CFID=52726045&CFTOKEN=41522929>.

attacks to the grid and their potential consequences are contained in a classified annex to this report.

A fourth risk comes from interruptions in supplies to generating plants, which can be caused by natural events, infrastructure failures, attack or even market forces. This occurred in California during 2000 and 2001 when supplies of natural gas were interrupted and forced a reduction in electricity generation.[36] Approximately 20% of U.S. electricity is generated by natural gas and market prices have swung wildly over the past several years.[37] Approximately 52% of U.S. electricity is generated by coal and transportation routes that move coal from mines to generating plants are sometimes remote and lacking in alternatives. Critical rail lines or bridges could be taken out by determined saboteurs. For example, in May 2005, 43 rail cars came off the tracks. The disruption to coal deliveries caused prices to spike, and raised electricity prices by 6% nationally, according to the Bureau of Labor Statistics. The 100 mile length of rail line through Wyoming that carries the output of the Western coal belt to power plants is the most heavily traveled in the nation.[38] So in addition to risks from grid outage, there are risks to the supply chain that enables the grid to work—not least from electricity supply failures themselves, which could disable the pipelines and controls used by other forms of energy, notably oil and gas.

5.4 National Security Implications of Reliability Standards

The Task Force noted that in addition to degrading national military and homeland defense capabilities, failure of the grid for any extended period could significantly affect national economic and social stability. Pumps that move natural gas and oil through pipelines rely on electricity, as do refineries, communications systems, water and sewage systems, hospitals, traffic systems, first response systems, border crossing detection systems and major transportation hubs such as airports.

Despite the criticality of the grid to the very functioning of the nation, until the EPAct 2005, we relied on industry to establish reliability standards. EPAct 2005 gave the Federal Energy Regulatory Commission (FERC) authority to direct the industry to develop reliability standards and the authority to designate an Electric Reliability Organization (ERO) to develop and propose mandatory reliability standards for all owners, users and operators of the bulk power system. Once such standards are approved by FERC, the ERO and regional entities may enforce the standards, subject to FERC oversight. FERC selected the North American Electric Reliability Counsel (NERC), a voluntary private industry coordinating body, as the ERO in 2006 and, by rulemaking, approved 83 reliability standards proposed by NERC in March 2007.[39]

[36] See PBS Frontline – The California Crisis, <http://www.pbs.org/wgbh/pages/frontline/shows/blackout/california/>.

[37] See Energy Information Agency Summary of Statistics for the United States, <http://www.eia.doe.gov/cneaf/electricity/epa/epates.html>.

[38] Elliot Blair Smith "A mountain of coal waits for a ride," USA TODAY, 7 December 2006, available at <http://www.cbsnews.com/stories/2006/12/07/ap/business/mainD8LRQAB00.shtml>.

[39] Notice of Proposed Rulemaking, Federal Energy Regulatory Commission 18 CFR Part 39 [Docket No. RM06-22-000] Mandatory Reliability Standards for Critical Infrastructure Protection (July 20, 2007).

While the regulatory structure created by EPAct 2005 is an improvement, it is not the same as government authority to directly establish and enforce reliability standards.

From a commercial utility's perspective, risk mitigation actions such as hardening facilities and systems and stockpiling critical spare parts incur significant costs that it may not be possible to fully pass on to customers. This lack of proper economic incentives is one reason the grid is not as secure as it could or should be.

5.5 Assessing Risk

The Task Force observes that DoD has conducted vulnerability analyses of its installations regarding energy supply disruption but has not developed a risk management strategy to deal with those vulnerabilities. The latter requires understanding of the potential impacts on its operations, identifying options to deal with the vulnerabilities, and selection of those that are most cost effective.

5.5.1 Vulnerability Assessments

DoD and DoE (Department of Energy) have conducted many vulnerability assessments of critical infrastructure. Taking the next step requires understanding the threats to specific locations, their likelihood of occurring, and their consequences.

The vulnerabilities briefed to the Task Force described points and modes of power failure. The Task Force was briefed in depth on points of failure on the grid, at installations in the U.S. and OCONUS, with emphasis on infrastructure that powers some of DoD's most critical missions. Modes of failure relate to how something failed. A transmission line coming into contact with a grounded object is a failure mode. Equipment failure and information compromise are two key vulnerabilities that represent failure modes not usually discovered until after the fact. Understanding these modes before the fact is an element of risk assessment. Specific vulnerabilities identified are discussed in the classified annex (Appendix G) to this report.

5.5.2 Potential Impacts

Assessing risk also requires understanding the consequences of a failure. The events of the August 2003 outage provide insight into the scale of destruction that could be caused by a sophisticated and multi-pronged terrorist attack. It is useful to think of two separate types of consequences.

The first is the threat to critical missions hosted on installations, including some defense industrial base facilities. There are a number of installations and industrial locations in the U.S. and OCONUS which host missions that are critical in strategic and tactical terms and must function 24/7. The resilience of these missions is wholly dependent on continued power to the buildings and equipment involved. The size and scope of the critical missions vary greatly among installations. Concern over domestic terrorist attacks, the establishment of the Department of Homeland Security and a new homeland defense mission for DoD has also expanded the critical loads at some installations.

The second is to the physical and economic security of the nation, as described in Section 2.3.2 on page.21.

5.6 Risk Management

The Task Force found that there is little understanding of the risk or consequences of power failure at DoD installations. To improve awareness and formulate a program to more effectively manage risk involves a number of specific tasks. First, is to assess the relative risk of power outage at each installation. The Navy's Dahlgren Mission Assurance Division's (MAD) vulnerability assessments are an important first step. In the interim, the Task Force identified a number of critical missions with single point failures that would require long lead times to restore. DoD may want to use this list as a starting point while assembling the capacity to conduct a more comprehensive risk assessment. The list is provided in the Appendix G.

Second is to identify and assess the cost and feasibility of options to satisfy power requirements for the possible duration of a serious outage. Both demand and supply side options can help to do so and both should be investigated and applied.

Third is to develop the business case to identify the options or mix of options that brings risk to within acceptable limits for the least cost.

5.6.1 Demand Side Options

Demand side approaches can significantly reduce the amount of energy necessary to sustain operations, making it easier and cheaper for alternative electricity sources to meet the load. Such approaches could include investing in LED and other advanced efficient lighting systems, geothermal and other highly efficient heating and air conditioning, advanced electrical use controls, passive efficient-building designs, data-center efficiency retrofits, energy-starved electronics and other techniques. Efficiency can be a powerful enabler. An efficiency improvement of 50% turns a six month backup source into a 12 month backup source, or reduces the size of needed supply by half, or doubles the amount of functionality that a backup supply can support. In this context, rapid improvements in the electrical efficiency of DoD facilities has a national security value far greater than the economic value of its reduced consumption.

The Task Force found DoD's efforts in this area to be modest compared to what can be technically and economically justified. The risks and consequences of grid outage should be the basis for a business case to pursue higher levels of efficiency at installations. Unfortunately, these risks are not currently considered during installation planning or PPBES investment decisions. Further, when budget constraints create a need to find cost reductions, efficiency investments are among the first to be eliminated.

The Task Force concluded that DoD's current approach to building energy efficient buildings and installations is conservative. Uniform Facility Guide Specifications (UFGS) and Uniform Facilities Criteria (UFC) are generally based on Energy Star and FEMP standards and use Leadership in Energy and Environmental Design (LEED) as a rating system. LEED is a nationally accepted benchmark for the design, construction, and operation of high performance green buildings. But the Task Force believes there are two problems with LEED and DoD's use of it. First, energy is only one portion of the rating and can be "traded" against other features to achieve a higher rating. Thus, for example, implementation of the LEED Silver rating level for DoD buildings may improve their environmental performance, but does not guarantee a specific improvement in energy efficiency. DoD will need to set a minimum acceptable level of energy performance within the LEED system. Second, application of these sustainable design/development and high-performance building concepts has varied among the Components and is generally underutilized and under-funded. If DoD were to establish a minimum energy efficiency level for all of its buildings, budget reductions would have less impact on investments in such efficiency. It is important to DoD's energy future to aggressively increase the efficiency levels of buildings and infrastructure, not compromise them.

5.6.2 Supply Side Options

A supply side approach includes consideration of expanded backup power supply capability (e.g., more or larger protected generators and more fuel storage to supply them). This strategy would extend an installation's capability to support critical missions, but is unlikely to fully satisfy an installation's power needs over an extended grid outage and would do little to relieve stress on surrounding communities.

A supply side approach also would involve building resilient local power sources, sized according to the mission load and the duration of an outage the installation is at risk of experiencing. The Task Force recommends DoD pursue the concept of "islanding," which would isolate critical loads, and selectively entire installations, from the grid and make them self-sufficient. A combination of much higher end-use efficiency coupled with alternative power supply sources would move the Department in this direction. The Task Force recommends that DoD collaborate closely in these endeavors with other agencies, especially the DoE and its national laboratories, whose mission is energy research and technology deployment. DoE national laboratories have historical energy advisory relationships with the Services that can accelerate results. Completely isolating installations from the grid is not practical, and islanding with distributed generation of local electricity sources can mitigate the risks.

DoDI 1470.11 §5.2.3 states it is DoD policy to use onsite, self-contained power for critical functions, DoD-facilities-based microgrids, and netted area microgrids for extended strategic islanding, coupled with end-use energy efficiency measures. The Renewable Electricity Purchasing and On-Base Development Plan developed in 2004 by the Renewables Assessment Working Group was designed to quickly improve energy reliability and security at installations by working in deregulated states where no utility cooperation is required to make them less vulnerable through islanding, as recommended by the National Research Council. Thus, policy and plans are in place to move towards islanding for critical mission purposes.

However, the Task Force could find no evidence that DoD has taken tangible steps to implement this policy or plans beyond a very small number of high profile projects. This is so even though renewable energy sources such as solar, wind and geothermal are often economically advantageous and resilient, reducing the risk of mission interruption. Buying renewable energy credits, while an admirable step toward reducing carbon footprint, accomplishes nothing toward mitigating risks from power loss to critical missions.

At specific locations where remedies within DoD's ability to implement are not technically or economically feasible, it may be necessary to engage local utility companies, regulatory agencies, and possibly State governments or the Congress to improve the reliability of the grid. In principal this might be done through regulatory or legislative action. However, it would require building redundancy at key nodes, redundant substations or buying spare equipment. Where DoD is the sole requesting party, it will probably have to fund these improvements.

"Decoupling" is a recent regulatory trend enacted in a number of states that has the potential to reduce stress on the grid.[40] Historically, utility regulators have set electric and gas rates based on projected sales volume. Since this also sets a utility's revenues, it is a disincentive for them to promote efficiency or to make it easy for customers to install on-site generation. "Decoupling" breaks the linkage between the amount of electricity or gas a utility sells and its ability to generate profits. This approach has the potential to enable utilities to remain profitable while investing in improved efficiency and reliability. Some states let utilities keep a small part of what they save for their customers as extra profit. This fully aligns utilities with customers' incentives and can strongly motivate utilities to help customers use electricity more efficiently. DoD may wish to include supporting such legislation as a possible approach to reducing risk at high-risk locations.

The Task Force concluded that as the world's energy sources transition from fossil fuels (petroleum, natural gas, and coal) to renewable energy sources (wind, solar and biomass), the energy infrastructure will become more distributed and will consist of smaller, more numerous plants. Some of these will produce multiple products such as liquid fuels, electricity, and industrial chemicals. The electric power distribution grid, pipelines, and rail beds will change to accommodate this distributed production trend. DoD's move toward islanding and local generation can help move this trend along. In general, such distributed energy systems, properly designed, should gradually reduce the brittleness and increase the resilience of the nation's energy system, and enhance our national security.

[40] Decoupling refers to disassociation of a utility's profits from its energy sales. Instead, a rate of return is aligned with meeting revenue targets, and rates are adjusted up or down to meet the target at the end of the each period. This makes the utility indifferent to selling more vs. less energy, and improves the ability of energy efficiency and distributed generation to operate within the utility environment. By early October 2007, decoupling had been adopted (docketed) in 5 (6) states for electricity and in 13 (11) for natural gas.

5.6.3 Net Zero Installations

The Task Force considered whether it was possible to build net-zero energy capability at critical installations, and found a range of emerging enabling technologies. The concept is based on combining significantly greater end-use efficiency with onsite power generation from renewable sources and distributed generation. The Energy Policy Act of 2005 and Executive Order 13423 already move DoD in this direction by requiring DoD to: reduce energy use by 30% by 2015; build buildings that are 30% more efficient than ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) standards; supply 7.5% of its energy from renewable sources by 2013; reduce fleet vehicle petroleum use by 20% by 2015; increase use of non-petroleum fuel by 10% annually; and switch to plug-in hybrid vehicles when they become life cycle cost effective. Other concepts such as passive design features to minimize heating and cooling loads, higher insulating levels and other design and technology approaches will be needed, but the Task Force recommends DoD carefully select candidate demonstration installations and establish this as a goal.

5.6.4 Overseas Considerations

What is true for CONUS installations is even more relevant outside the U.S. where commercial systems are often less reliable and less well protected than domestically. Reliability standards vary significantly from country to country and often are not enforced. In some locations, poor maintenance and political or social instability create further risks. Yet DoD conducts little or no planning to cope with long-term blackouts at its OCONUS installations. As in CONUS, military installations frequently rely on a single commercial power feed, providing a single point of failure that is weaker than the overall grid. Few OCONUS installations can generate enough power on their own to meet their missions. The typical backup plan is the same as in CONUS; a series of (diesel) generators designed for limited run-time, with short-term on-site fuel storage and not networked to ensure continuity of supply in the event one of the generators fails. The solutions—end-use efficiency and properly deployed islandable on- or near-site supplies that are inherently resilient and preferably renewable—are the same as in CONUS but will often provide even greater value for mission continuity and often for operating budgets.

CHAPTER VI: FINDINGS AND RECOMMENDATIONS

The Task Force arrived at six findings and five recommendations, with numerous supporting tasks needed to fully implement the recommendations.

6.1 Task Force Findings

Finding #1: The recommendations from the 2001 Defense Science Board Task Force Report "More Capable Warfighting Through Reduced Fuel Burden" have not been implemented.

The principal finding of the 2001 DSB report was that DoD systematically underestimates the cost of fuel to its tactical forces by failing to recognize the costs of the support structure and the protection necessary to bring that fuel to the systems that use it. As a consequence, significant warfighting, logistics and monetary benefits are available from making weapons systems more fuel-efficient, but those benefits are not valued or emphasized in DoD's requirements and acquisition processes. The report found that the requirements process does not require energy efficiency in deployed systems, the acquisition process does not value it, so the PPBES process cannot not provide it visibility when considering investment decisions.

These findings remain valid today. Few of the recommendations of that study have been implemented to date. Those that have begun; making energy efficiency a selective Key Performance Parameter in system design, and using the fully burdened cost of fuel in life cycle costing of alternative systems; are in their early stages of implementation. Focused leadership will be required to complete the recommendations of the 2001 study and similar recommendations made herein.

Finding #2: Critical national security and Homeland defense missions are at an unacceptably high risk of extended outage from failure of the grid and other critical national infrastructure.

In addition to their warfighting-related responsibilities, installations have taken on significantly expanded Homeland defense missions. DoD is now responsible for serving as a base of operations to coordinate the full range of national relief and recovery efforts, and as a source of skilled personnel to provide rescue, recovery, medical and other emergency serviced required by survivors. In addition, certain industrial facilities are critical because of their role in supplying operational forces.

These installations rely almost entirely on the national power grid. According to estimates by the Navy's Dahlgren Mission Assurance Division, 99% of the electricity DoD installations consume is from the commercial grid. Yet, the grid is highly vulnerable to prolonged outage from a variety of threats. This places critical mission assets at unacceptably high risk of extended disruption.

Backup power at installations is based on diesel generator sets with limited on-site fuel storage and not prioritized to critical tasks. As the reliability of the national grid has declined, the adequacy of backup power has become an issue. For both warfighting-related activity and the new Homeland defense mission, backup power is inadequate in terms of size, duration and reliability.

Finding #3: The Department lacks the strategy, policies, metrics, information or governance structure necessary to properly manage its energy risks.

Decisions that create energy demand are dispersed organizationally across the Department and throughout the Services, OSD, the Joint Staff and Defense Agencies; and functionally throughout JCIDS, pre-JCIDS planning, acquisition, procurement, policy, installations management, privatization, logistics, and so on. There is currently no unifying vision, strategy, metrics or governance structure with enterprise-wide energy in its portfolio. DoD efforts to manage energy are limited to complying with executive orders, legislation and regulations which are mostly limited to facilities, non-tactical fleet vehicles, purchase of renewable energy from utilities, and procurement of commercial products. These activities consume approximately a quarter of the Department's total energy. Efforts to manage energy to combat forces are generally limited to building logistics capacity to meet warfighter needs. These activities drive approximately three quarters of the Department's and have no single point of leadership, no policies, no metrics and no accountability.

The lowest level at which all activities that create energy demand come together is the Deputy Secretary of Defense. This implies that in order to effectively manage energy, a governance body operating at this level, such as the Deputy's Advisory Working Group (DAWG) will need to exercise active and ongoing oversight.

Finding #4: There are technologies available now to make DoD systems more energy efficient, but they are undervalued, slowing their implementation and resulting in inadequate S&T investments.

The Task Force heard over a hundred presentations on technologies that addressed all categories of end use, covering the full range of maturity from basic research to ready-to-implement. Many of these appear quite promising. But because the operational and economic value of energy efficiency is not visible to decision making processes, cost effective technologies are not adopted, and science and technology programs under-invest in efficiency relative to the potential value of this attribute.

The Task Force found the defense acquisition process to be inherently risk-adverse, not incentivized to be energy efficient, and generally preferring to support incremental improvements over new system designs. From an operator's perspective this is understandable, but it also forecloses disruptive technology that could greatly enhance operational effectiveness through order of magnitude changes in energy efficiency. Competitive prototyping provides a means to test whether such ideas are worthwhile and to select the best of them.

Finding #5: There are many opportunities to reduce energy demand by changing wasteful operational practices and procedures.

Operational practices and procedures involve choices made by personnel regarding how they use the equipment under their charge. These choices occur at the scale of an aircraft, land vehicle, or ship; an installation; a forward operating base; or battery powered equipment carried by individual soldiers.

DoD must change its energy culture to value efficiency. Here, there is no substitute for strong, sustained attention by senior leadership. The ingrained belief that energy will always be cheap and plentiful must be replaced with the clear linkage between energy efficiency and operational success. The Task Force found the lack of understanding of this linkage to be the most significant barrier to addressing unnecessary and wasteful practices.

Finding #6: Operational risks from fuel disruption require demand-side remedies; mission risks from electricity disruption to installations require both demand- and supply-side remedies.

The most significant energy-related risk to DoD's combat capability is the burden of moving fuel from the point of commercial purchase to the combat systems that need it. Greater efficiency in the use of fuel within the battlespace is the single best means to reduce that risk, with potential to provide multiple benefits in terms of operational effectiveness, reduced logistics and budgetary costs.

The most significant risk to critical mission at fixed installations is the fragility and vulnerability of the commercial power grid. Significantly increased end-use efficiency to reduce demand combined with alternative energy generated close- or on-site and enhanced backup capability offer and the best opportunities to reduce that risk to acceptable levels.

6.2 Task Force Recommendations

Recommendation #1: Accelerate efforts to implement energy efficiency Key Performance Parameters (KPPs) and use of the Fully Burdened Cost of Fuel to inform all acquisition trades and analyses about their energy consequences, as recommended by the 2001 DSB Task Force.

Task 1.1: By July 2008, the DEPSECDEF require the Defense Acquisition Board to apply milestone exit criteria to all programs to determine whether an energy related KPP has been appropriately applied, and whether FBCF has been appropriately used as a factor for acquisition trade studies and systems engineering activities. "Black" programs should not be exempt from this requirement.

Task 1.2: By May 2008, establish a policy requiring all force-on-force campaign analyses and other models and simulations used to support AoA or EoAs to incorporate energy, energy related logistics, and energy protection requirements.

Task 1.3: By May 2008, VCJCS establish a policy requiring:

- All wargames, major unit field training, and joint exercises include fuel and fuel logistics.
- Establish a fuel battle-lab to experimentally find ways to achieve successful battlespace outcomes with reduced ener inputs.

Task 1.4: By June 2008, USD(AT&L) establish a policy requiring application of FBCF and efficiency related capability improvements to engineering decisions affecting modifications made to legacy systems during reset programs. The Task Force recommends these also apply to non-developmental systems used at forward operating locations, since these create large demand for fuel in theater.

Task 1.5: By April 2008, USD(AT&L) publish initial official values for FBCF to be used in all acquisition trade analyses, and establish a schedule and process for their periodic updating.

Recommendation #2: Reduce the risk to critical missions at fixed installations from loss of commercial power and other critical national infrastructure.

Task 2.1: By June 2008, Assistant Secretary of Defense for Homeland Defense and Americas' Security Affairs (ASD(HD&ASA)), in coordination with the JS and Office of the Deputy Under Secretary of Defense for Installations and Environment (ODUSD(I&E)), develop a program plan to assess the risks to mission from power failure, identify mitigation options, assess their efficacy and develop a phased investment plan to bring the risks to within acceptable limits at CONUS and OCONUS installations.

Task 2.2: By June 2008, ASD(HD&ASA), in coordination with the JS and ODUSD(I&E), establish metrics for acceptable risks to installation missions from failure of energy supplies, with priority given to critical C4, ISR, strategic deterrence and Homeland defense missions.

Task 2.3: By August 2009, ASD(HD&ASA), in coordination with the JS and ODUSD(I&E), complete risk assessments for critical C4, ISR, and strategic deterrence missions and identify the most cost effective risk mitigation options to assure mission resilience, to include efficiency to reduce the demand for on-site power, enhanced backup capability via greater on-site generator capacity, and provision of on-site alternative sources of power.

Task 2.4: By June 2008, ODUSD(I&E) develop a plan to "island" critical missions from the grid by December 2009. A preliminary list of Joint Staff identified assets is contained in Appendix G.

Task 2.5: By June 2008, the Under Secretary of Defense for Policy (USD(P)) develop a legislative proposal to make grid reliability a factor in future Base Realignment and Closure (BRAC) decisions.

Task 2.6: By June 2008, ODUSD(I&E) update its 2004 Renewable Energy Assessment by adding biomass, waste-to-power, geothermal power generation systems, and bio-based ground transportation fuels; and by October 2009 develop a comprehensive efficiency and renewables investment roadmap to exploit the resources identified in the assessment. The results should be incorporated into the net-zero-energy installations plan.

Task 2.7: By October 2008, ODUSD(I&E) require all new Military Construction (MILCON), Operation and Maintenance (O&M) and privatized construction and all facility renovations that exceed 50% of replacement cost to meet energy efficiency standards that are at least 50% better than ASHRAE 90.1.2004.

Task 2.8: By April 2008, ODUSD(I&E) issue a policy requiring all installation maintenance, whether by contract or in-house, to install only Energy Star and FEMP designated products, and maintain equipment to at least that standard of efficiency.

Task 2.9: By April 2008, USD(AT&L) issue a policy requiring the DLA to carry only Energy Star and FEMP designated products, as established by the Energy Policy Act of 2005, Section 104; requiring GSA to offer only those products to DoD customers, and prohibiting DoD personnel or contractors from using Government credit cards to circumvent this policy.

Task 2.10: By October 2009, ODUSD(I&E) require that electricity and fuel/gas meters be installed on all DoD buildings and facilities in order to more effectively manage energy consumption.

Task 2.11: By October 2008, ODUSD(I&E) require that all new MILCON, O&M and privatized construction started in FY 2020 and later meet a "net zero" energy consumption specification.

Task 2.12: By October 2008, ODUSD(I&E) require that all DoD installations meet a "net zero energy standard by 2025.

Recommendation #3: Establish a Department-wide strategic plan that establishes measurable goals, achieves the business process changes recommended by the 2001 DSB report and establishes clear responsibility and accountability.

Fixed installations use about one quarter of DoD's total energy. There are policies, metrics, reporting requirements and a senior official in charge. Deployed systems use about three quarters of DoD's total energy. There are few policies, procedures or reporting requirements; no metrics and no one in charge. The lowest level at which all decisions affecting energy use by the Department converge is with the Deputy Secretary of Defense. It is very difficult to achieve sustained focus and accountability for performance on energy use at this level. The Task Force concluded that lack of leadership is a root cause of DoD's energy problem.

In addition to oversight, DoD needs a comprehensive energy plan that addresses both fixed installations, to include critical Defense Industrial Base (DIB) plants, and operational forces. It should include both measurable goals for energy demand reduction and reduction in energy risks. Implementing new analytical products to better inform key decisions will be key to enabling effective energy management. For operational forces, this requires adding energy to force planning analyses, and implementing the energy KPP and FBCF. For fixed installations and industrial base plants, it includes applying integrated risk management principles to reduce the likelihood of prolonged loss of critical missions due to commercial power outages.

Currently, energy demand is an unplanned consequence of poorly informed decisions. Analytical tools are needed to develop meaningful and achievable energy goals, and business process changes are needed to enable new information to be considered when making key decisions that affect energy use. Success will require a plan that is horizontally and vertically integrated throughout the Department, with participation by all functional areas that make decisions affecting energy use with sustained oversight at the Deputy Secretary of Defense level.

Task 3.1: By June 2008, establish a senior energy official responsible for development of policies and procedures and oversight of their implementation. This official should have a voice at the key decision bodies throughout the requirements, acquisition, and funding processes to ensure energy considerations have been accurately factored into key decisions that affect DoD's energy demand patterns and risks from disruptions in commercial energy supplies.

Task 3.2: By June 2008, USD(P) incorporate the concepts of resilience of critical missions at installations and endurance of combat forces as tactically and strategically important metrics to be included in future strategy and planning documents. While the names of these documents change frequently (e.g., Quadrennial Defense Review, National Military Strategy, Strategic Planning Guidance (being renamed Guidance for Development of the Force / Guidance for Employment of the Force)) these concepts should guide the formulation of Department goals and strategy for managing energy.

Task 3.3: By July 2008, USD (AT&L) direct the establishment of partnerships with:

- ODUSD(I&E) and the Department of Energy office of Energy Efficiency and Renewable Energy (DoE/EERE) to identify technologies related to renewable and distributed energy supplies for installations that have the potential to contribute to resilience metrics for installations.
- DDR&E and DoE/EERE to identify technologies with the potential to contribute to endurance metrics by reducing battlespace fuel demand by deployed forces and at forward operating bases.

Task 3.4: By July 2008, DEPSECDEF establish an interagency oversight group in cooperation with the National Security Council, the Homeland Security Council, the Department of Energy and the Federal Energy Regulatory Commission to:

- ascertain the risks to DoD missions from commercial grid outages;
- determine the adequacy of actions being taken under current legislative authority to establish and enforce grid reliability standards; and
- propose case specific remedies, as needed, to achieve grid reliability standards needed to support the level of mission resilience considered necessary by DoD and DHS.

Task 3.5: By October 2008, develop and implement a Department-wide plan to integrate energy into appropriate education and training programs, to include professional military education, to include Senior Service Schools, Capstone and Apex; and specialty-specific education, such as acquisition corps and engineering. Curricula should include risk to mission, cost and force structure aspects of energy as addressed in this report and appropriate to the course.

Recommendation #4: Invest in energy efficient and alternative energy technologies to a level commensurate with their operational and financial value.

Combat and Combat Related Systems:

Task 4.1: USD(AT&L) accelerate development efforts on innovative concepts and their enabling technologies applicable to prime mover platforms with the potential to change ConOps to significantly improve operational capability and reduce demand for battlespace fuel and fuel logistics assets:

- Blended Wing Body Aircraft
- Optimum Speed Tilt Rotor Vertical Lift
- Lightweight Composite Blast-Bucket Tactical Vehicle
- Electrical actuators
- Semi-rigid, lighter-than-air high altitude lifting bodies
- Micro-generators

- Biomimetic design for platform components

Task 4.2: By July 2008, USD(AT&L) issue a policy re-establishing early competitive prototyping for major ACAT I programs. These programs have been all but abandoned by the Department due to cost, but their ability to accelerate technology maturation to a readiness level appropriate for program adoption, overcome reluctance by operators to consider and adopt new technologies, and to guide multi-billion dollar development and acquisition investments, suggests to the Task Force that their value far exceeds their cost. The Task Force recommends dedicating on the order of $500M a year in order to better leverage the billions dedicated to major acquisition programs.

Task 4.3: By July 2008, DDR&E initiate a research program to identify the characteristics of synthetic fuels likely to be producible at deployed locations, and identify, or develop as needed, materials for use in propulsion systems compatible with that range of fuel types. Technologies to produce synthetic fuels on a small scale using indigenous feedstocks are under development, and the ability of deployed systems to use those fuels would be operationally advantageous. Locally available feedstocks could include kitchen and human waste, other biological materials or used motor oil.

Task 4.4: April 2008, USD(AT&L) direct all acquisition programs for soldier electronics systems, especially communications equipment, to implement the National Research Council (NRC) study recommendation that energy efficiency be a first-order design parameter, and provide direct monetary incentives to manufacturers to reduce power demand. The study recommended future soldier systems should require no more than 2W average power, 5W peak power, substantially less than current systems.

Task 4.5: The Task Force recommends the Department continue to invest in basic research to develop new alternative fuels technologies that are too risky for private investments, and to partner with private sector fuel users to leverage efforts and share burdens. The Task Force also recommends the Department work with commercial partners to conduct full "well-to-wheel" life cycle assessments of each synthetic fuel technology to assess environmental, cost, material flow and scalability issues. The life cycle carbon footprint of alternative fuels should be less than petroleum. The Task Force recommends DoD give priority to synfuel production adaptable to forward deployed locations using local materials. Such technologies could reduce the amount of fuel needed to be moved and protected in theater gallon for gallon.

Installations and Infrastructure:

Task 4.6: By June 2008, DUSD (Logistics and Material Readiness (L&MR)) issue a policy to convert fleet vehicles used at installations to all electric or plug-in-hybrid as rapidly as vehicle availability and suitability for end-use permit in order to accelerate commercialization of the technologies and reduce DoD petroleum use.

Task 4.7: By July 2008, ODUSD(I&E) establish a policy requiring all buildings to incorporate renewable energy (e.g., solar, wind and ground geothermal) into their design, as appropriate to the location and function of the building in order to reduce the requirement for power from the commercial grid.

Task 4.8: By April 2009, ODUSD(I&E) identify five installations for strategic islanding demonstration projects, with a roadmap for implementation within 18 months.

Cross-Cutting Technologies:

Task 4.9: By budget year FY10, DDR&E increase investments in energy storage technologies to improve the performance of electrically powered vehicles, and enable storage of electricity generated by renewable sources at forward operating bases.

Recommendation #5: Identify and exploit near-term opportunities to reduce energy use through policies and incentives that change operational procedures.

Task 5.1: By April 2008, DEPSECDEF and VCJCS direct the Services to initiate a comprehensive review of how the Services currently employ simulators, emulators and task trainers, the extent to which their use could be increased while maintaining mission qualification, and to identify technical improvements that could permit increased use. The review should include authoritative experts in the field of cognitive responses to ensure the results and recommendations will lead to a better trained and more capable force

Task 5.2: By July 2008, VCJCS commission a study of military and DoD-funded civilian airlift practices to ensure the DoD is using the most effective and efficient means of lift, optimum equipage of DoD aircraft to take advantage of commercial air traffic management systems that permit optimum routing and separation, and to ensure that force sizing for airlift and sealift systems are commensurate with the validated weight, cube, volume and timing requirements of the deployed and forward based forces.

Task 5.3: By July 2008, DEPSECDEF and VCJCS issue a joint directive prohibiting unnecessary operational practices that increase fuel usage and costs, such as use of afterburner on takeoff when conditions allow safe operations with military power, multi-engine taxi operations, sprint and drift steaming operations; and requiring annual reviews to determine the completeness of the list, effectiveness of the policy, and recommended changes to further reduce unnecessary fuel use.

APPENDIX A: TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION, TECHNOLOGY AND LOGISTICS

MAY 0 2 2006

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Task Force on DoD Energy Strategy

You are requested to form a Defense Science Board Task Force on DoD Energy Strategy.

Optimizing tactical performance often results in operational and strategic constraints. For example, the employment of external fuel tanks on fighter aircraft and at sea refueling enable platforms to expend energy as required for tactical performance. Although tactically beneficial, the tyranny of the tanker imposes operational and strategic constraints and incurs operational and strategic vulnerabilities which are open to exploitation. Additionally, the infrastructure required to transport and distribute energy to the battlefield is extremely costly and diverts resources away from combat capabilities. A previous Defense Science Board report calculated the actual cost of fuel delivered to be at least one to two orders of magnitude greater than the price charged to the Military Departments. Approximately 70% of the tonnage required to position today's U.S. Army into battle is attributed to fuel itself. Millions of gallons a day are critical for Naval operations. As the largest consumer, the Air Force spends over $4.7B/yr on aviation fuels. The artificialities of low price and easily developed work-arounds have blinded DoD to alternative energy design patterns and trades.

At a national level, DoD is the largest single user of energy in the United States. With an energy usage amount of a little over 1% of the nation's total, DoD short-term needs can readily be met by diverting energy resources from the civilian economy. However, even moderate disruptions to U.S. energy supplies severely impact the U.S. economy and potentially the DoD. Despite this known vulnerability, alternative energy supplies have not been economically viable.

While transportation/mobility fuels account for about 75 percent of the Department's total energy demand, review of the portfolio may yield significant rewards.

DoD Transformation initiatives provide a new opportunity to re-examine DoD energy usage practices. The Task Force should examine second and third order effects to determine if any strategic or operational imperatives exist to revising DoD's Energy Strategies. For example, the primary savings from the DSB study on re-enginning the B-52H resulted from the reduced maintenance requirements and subsequent maintenance infrastructure associated with the more reliable engines. In addition to reduced maintenance, the increased range resulted in greater operational utility for the existing platform.

The Task Force should specifically identify strategic transition-opportunities inherently offered by technologies that have implications for energy and their systemic second- and third-order effects. It should also assess the extent to which these enable optimizing across strategic, operational, tactical, and lifecycle cost performance vectors; their commercialization potential; the implications for DoD's Energy Strategy; and impact on force structure and global posture. Institutional obstacles to implementation should be identified.

The Task Force will:

1. Identify DoD operational and strategic constraints and vulnerabilities created by optimizing tactical platforms and capabilities without regard to energy usage.

2. Identify programs and means for the DoD to reduce its energy demand, particularly on petroleum-based fuels. Identify supporting infrastructure requirements.

3. Identify and assess opportunities for the DoD to produce energy for its own use, (e.g. conversion of natural gas to liquids, and supporting infrastructure requirements).

4. Identify synergistic opportunities for renewable and alternative energy sources common to meeting both facility/infrastructure and transportation/mobility energy requirements.

5. Assess second and third order effects that may create opportunities for the DoD to transition to a new energy strategy. Identify metrics which may be used to trade short and long term benefits and true costs. Identify processes for determining true costs across the entire life cycle.

6. Identify potential technologies to assist in the DoD transition. Assess the ability of the DoD to transition these technologies into commercially viable enterprises for possible incorporation into a national energy plan designed to achieve some level of energy independence.

7. Assess the impact of the proposed strategy on force structure and the Department's global defense posture realignment effort.

a. Examine implications of alternative energy approaches for forward stationing and rotational presence of warfighting and support units.

b. Assess tradeoffs and possible synergies between these alternatives and other mobility/logistics approaches (e.g. sea-basing, high speed connectors, enhanced en route infrastructure) and ISR projection capabilities that may enable key operating patterns of our joint forces.

8. Identify institutional/organizational barriers to this transition.

The Task Force will report any interim findings and recommendations as the opportunity permits to the 2006 Summer Study on 21st Century Strategic Technology Vectors.

The study will be sponsored by me as the Under Secretary of Defense (Acquisition, Technology and Logistics), Director, Defense Research and Engineering and the Acting Director, Defense Systems. Dr. James R. Schlesinger and General Michael P.C. Carns, USAF (Ret), will serve as the Task Force co-Chairmen. Mr. Chris DiPetto, Defense Systems, and Mr. Jack Taylor, Defense Research and Engineering will serve as the Executive Secretaries. Major Charles Lominac, USAF will serve as the Defense Science Board Secretariat representative.

The Task Force will operate in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DOD Directive 5105.4, the "DoD Federal Advisory Committee Management Program," It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Kenneth J. Krieg

APPENDIX B: TASK FORCE MEMBERSHIP

CO-CHAIRMEN

Dr. James Schlesinger	*The MITRE Corporation*
Gen. Michael P.C. Carns, USAF (Ret)	*Private Consultant*

FACILITIES PANEL

VADM Albert Konetzni, USN (Ret), Panel Chair	*Private Consultant*
Mr. Bill Browning	*Browning & Bannon, LLC*
Ms. Bobi Garrett	*Strategic Development and Analysis NREL*
Mr. Dan Harrison	*Private Consultant*
Mr. Duncan Holaday	*Private Consultant*
Dr. Thomas Hughes	*Penn State University*
Mr. William Kosik	*EYP Mission Critical Facilities, Inc.*
Mr. James Little	*Washington Safety Management Solutions*
Mr. Scott McCain	*Booz Allen Hamilton*
Mr. Gary Merrow	*Turner Facilities Management Solutions*
Mr. Tom Neelands	*GM*
Mr. Stephen Piccolo	*Private Consultant*
RADM Chris Weaver, USN (Ret)	*Private Consultant*
Mr. Mike Whearty	*Private Consultant*
Mr. Tom Zidow	*Washington Group International*

GOVERNMENT ADVISORS

Mr. Alex Beehler	*ADUSD(Environment, Safety & Occupational Health)*
Mr. Paul Bouley	*HQ Marine Corps*
Dr. Craig College	*DASA(Infrastructure Analysis)*
CAPT Tony Ermovick, USN	*USN (LFF) Facilities Branch*
Ms. Kathleen Ferguson	*Deputy Air Force Civil Engineer, HQAF*
CDR Brad Hancock, USN	*ODUSD (Installations and Environment)*

Mr. Don Juhasz	*Office of Assistant Army Chief of Staff for Installation Management*
Dr. Get Moy	*ODUSD (Installations and Environment)*
Mr. Michael Ostrom	*U.S. Army*
Mr. Robert Sperberg	*U.S. Army*
Mr. Bill Tayler	*U.S. Navy*
Mr. Chris Tindal	*Naval Facilities Engineering Command Headquarters*
Ms. Andrea Valentine	*U.S. Army*

PLATFORM PANEL

ADM Gregory Johnson, USN (Ret), Panel Co-Chair	*Private Consultant*
Gen. Gregory Martin, USAF (Ret), Panel Co-Chair	*Private Consultant*
Dr. Michael Canes	*LMI*
Brig. Gen. John Douglass, USAF (Ret)	*Aerospace Industries Association*
Dr. Paris Genalis	*Massachusetts Institute of Technology*
Mr. David Hawkins	*Natural Resources Defense Council*
LTG Larry Jordan, USA (Ret)	*Burdeshaw Associates*
Dr. Dan Kammen	*UC Berkeley*
Mr. Ira Kuhn	*Directed Technologies, Inc*
Mr. Amory Lovins	*Rocky Mountain Institute*
Mr. Tom Morehouse	*Institute for Defense Analyses*
CAPT Scott Pugh, USN (Ret)	*U.S. Department of Homeland Security*
VADM Richard Truly, USN (Ret)	*Private Consultant*

GOVERNMENT ADVISORS

Mr. Michael Aimone	*USAF Logistics, Installations & Mission Support*
Mr. Bill Budden	*U.S. Air Force*
CoL Donald Jurewicz, USAF	*U.S. Air Force*
Mr. Erik Kallio	*U.S. Army*
Col Gregory Lengyel, USAF	*U.S. Air Force; The Brookings Institution*

Dr. Lourdes Maurice	*Federal Aviation Administration*
CAPT William Porter, USN	*OSD(AT&L)*
Dr. Jonathan Protz	*Duke University*
Dr. Alan Roberts	*U.S. Navy, Office of Naval Research*

POLICY PANEL

Mr. R. James Woolsey, Panel Co-Chair	*Booz Allen Hamilton*
Ms. Gueta Mezzetti, Panel Co-Chair	*Private Consultant*
Dr. Lee Buchanan	*Private Consultant*
Mr. Frank Gaffney	*Center for Security Policy*
Mr. Hugh Montgomery	*Institute for Defense and Homeland Security*
Mr. Robert Taylor	*Private Consultant*
Dr. Mike Telson	*Private Consultant*

GOVERNMENT ADVISORS

Ms. Kay Bushman	*Defense Energy Support Center (DESC)*
Mr. Mike Burks	*Mission Assurance Division J60 NSWCDD, Dahlgren*
Mr. Jeff Fulmer	*Mission Assurance Division J60 NSWCDD, Dahlgren*
Mr. Dan Mathis	*Mission Assurance Division J60 NSWCDD, Dahlgren*
Mr. Andy Pittman	*Defense Energy Support Center (DESC)*
Mr. Gary Seifert	*Idaho National Laboratory (INL)*
Ms. Pam Serino	*Defense Energy Support Center (DESC)*
Mr. Mike Warwick	*Pacific Northwest National Laboratory (PNNL)*
Mr. Jon Wellinghoff	*Federal Energy Regulatory Commission (FERC)*
Ms. Mitzi Wertheim	*CNA*

RESEARCH &TECHNOLOGY (R&T) PANEL

Dr. Ed Reedy, Panel Co-Chair	*Georgia Tech Research Institute (GTRI)*
Dr. Jeff Tester, Panel Co-Chair	*Massachusetts Institute of Technology*
Dr. Feng An	*Energy and Transportation Technologies, LLC*

Dr. Stan Bull	*National Renewable Energy Laboratory (NREL)*
Dr. Sam Fleming	*Private Consultant*
Gen Richard Lawson, USAF (Ret)	*Energy, Environment & Security Group, Ltd*
Dr. Terry Michalske	*Sandia National Laboratory (SNL)*
Mr. Hugh Montgomery	*Institute for Defense and Homeland Security*
Dr. David Parekh	*Georgia Tech Research Institute (GTRI)*

GOVERNMENT ADVISORS

Col. Jocelyn Seng, USAF	*U.S. Air Force*

EXECUTIVE SECRETARIES

Mr. Christopher DiPetto	*OUSD(AT&L)*
Mr. Jack Taylor	*DDR&E*

DSB SECRETARIAT

Maj. Charles Lominac, USAF	*Defense Science Board*

SUPPORT

Ms. Michelle Ashley	*SAIC*
Ms. Diana Conty	*SAIC*
Mr. Jonathan Hamblin	*SAIC*
Ms. Amely Moore	*SAIC*
Ms. Lauren York	*SAIC*

APPENDIX C: BRIEFINGS RECEIVED

PLENARY BRIEFINGS

10 May 2006

DSB Legal Considerations	Ms. Judy Kim	DoD Office of the General Council

30 May 2006

R&D Overview	Jack Taylor	DDR&E
DoD Energy/Fuel	Mr. Dick Connelly	Defense Energy Support Center (DESC)
Authorities/Legislation	Ms. Kay Bushman	Defense Energy Support Center (DESC)
Facilities	Dr. Get Moy	ODUSD (&E))
Services Overview: Air Force	Mr. Mike Aimone	Asst DCS/Logistics, Installations, and Mission Support
Services Overview: Army	Dr. Marilyn Freeman	Army Tank Automotive Research & Engineering Center (TARDEC)
Services Overview: Navy	Mr. Bill Tayler	Navy

28 June 2006

Army Energy Initiatives	Dr. Marilyn Freeman	OASA DAS(R&T)
The activities of the DOE relative to substitutes for oil in the form of fuel liquids	David Garman	Undersecretary of Energy
NRAC Study on Fuels	John C. Sommerer	Director of Science & Technology, and Chief Technology Officer JHU/APL
DARPA Energy Programs	Dr. Valerie Browning	DARAPA
2001 Fuel Burden DSB Report	Mr. Tom Morehouse	IDA

18 July 2006

IDA Fuel Efficiency Study	Dr. Lisa Veitch	IDA

Air Force Science Advisory Board (AFSAB) Quick Look Study on Technology Options for Improved Air Vehicle Fuel Efficiency	Prof Ann Karagozian	UCLA
DoD's Joint Capability Integration & Development System (JCIDS)	MG Mike Vane, USA	JCS J-8

6 September 2006

DOD Electricity and Fuel Infrastructure Vulnerabilities CONUS: Locations, Recommendations, Visions and Policy Challenges	E. Daniel Mathis	Mission Assurance Division (J605), Naval Surface Warfare Center (NSWC), Dahlgren
JASONS	Paul Dimotakis	California Institute of Technology
Carbon Capture and Storage	Professor Robert Socolow	Princeton University
Distributed Generation into combat in Iraq and Afghanistan	Hugh Jones	Energy Consultant
Biotechnology for DoD Renewable Energy Systems - Example: The Tactical Biorefinery	Jerry Warner	Defense Life Sciences, LLC
Overview of Wal-Mart's initiatives related to transportation and facilities energy savings	Mr. Charles Zimmerman	Prototype and New Format Dev., Wal-Mart Stores, Inc.

10 October 2006

Environment Energy Connections - Policy Issues, Energy Efficiency, Energy Usage and the Environmental Impact	Dr. Jeff Marqusee	ODUSD(Installations and Environment)
Economics of the Nuclear Industry (Power Sources)	ADM Skip Bowman, (Ret.) and Dr. Merle Prater	Nuclear Energy Institute
PSU Energy Future Study	Dr. Thomas Hughes	Penn State University

Energy Security IPT Outbrief	Mr. Al Shaffer	DDR&E

29 November 2006

Maritime Industry Briefing	Mr. Steve Carmel and Mr. Bob Bowers	MAERSK
Advanced Energy Technologies: Challenges and Opportunities	Floyd Kvamme	President's Council of Advisors on Science and Technology (PCAST)
PA&E Fully Burdened Cost of Fuel Study	Mr. Matt Kastantin	PA&E

PANEL BRIEFINGS

Facilities Panel

25 August 2006

The Air Force Infrastructure Energy Strategy	Lt Col Brian Weidmann	U.S. Air Force
Army Energy and Utilities	Mr. Don Juhasz	Chief Utilities and Energy, U.S. Army
Department of Defense Facilities and Vehicles Energy Use, Strategies and Goals	Dr. Get Moy	DoD
Department of the Navy Shore Energy Program	Ms. Mary Lingua	U.S. Navy
Brief to DSB Energy Strategy Task Force	Mr. Mark Warner	Johnson Controls

11 October 2006

Role of Energy Manager in General Motors	Mr. Tom Neelands	General Motors
Department of Defense Energy Strategy Task Force Presentation	Mr. Mitch Jackson	FedEx
Emerging Market in Tradable Energy Efficiency Certificates (White Tags™)	Mr. Mel Jones	Sterling Planet

14 November 2006 – NREL

Renewable Energy Applications in Department of Defense Facilities	Dr. Andy Walker	NREL
Influencing Future Vehicles Using Systems Analysis	Mr. Aaron Booker	NREL
Status and Outlook for Renewable Electricity & Buildings Technologies	Dr. Stan Bull	NREL
Renewable Energy Communities: Base Development Perspectives	Ms. Nancy Carlisle	NREL
Alternative Fuels Data Center Tools and Resources	Ms. Wendy DaFoe	NREL

Practical Applications of Renewable Energy	Mr. Jeff Dominick	NREL
Status and Outlook for Renewable Fuels & Vehicle Technologies	Mr. Dale Gardner	NREL
Sustainable Communities	Ms. Bobi Garrett	NREL
National Renewable Energy Laboratory	Mr. Bill Glover	NREL
Building Efficiency Tools/Sustainable Design	Ms. Sheila Hayter	NREL
Alternative Fuel Vehicles and Fuels: Requirements and Status	Ms. Kathleen Nawaz	NREL
Practical Applications of Efficiency and Sustainable Design	Mr. Bob Westby	NREL

13 December 2006

Energy Efficiency in Buildings	Ms. Kelly Speakes	United Technologies
LEED	Mr. Tom Hicks	U.S. Green Building Council
Energy Star Opportunities	Dr. Kathleen Hogan	EPA

Platform Panel

17 July 2006

Joint Staff/J8: Force Structure and CONOPS	COL Camile Nichols, USA	Joint Staff/J8
Overview of Warfighting Analysis on the Joint Staff	COL Walter S. Barge, USA	Joint Staff/J8
U.S. Air Force: Force Structure and COBOPS	Lt. Col. Randy Brawley, USAF	HAF/A3OC

15 August 2006

Shell Mahogany Oil Shale Research Project Site Tour	N/A	Shell Piceance Basin Rifle, Colorado

24 August 2006

The Army: At War and Transforming	COL Ben Rivera	Army G-37, Force Management
U.S. Navy: Force Structure and CONOPS	CAPT Douglass E. Otte	Integration & Force Structure Branch Head Assessment Division (N81)
U.S. Marine Corps: Force Structure and CONOPS	Mr. Mike Boyd	Engineer Advocacy Center

25 August 2006

ULTRA Armored Platform Vehicle	Mr. Scott Badenoch	Badenoch, LLC
Boeing Energy Strategy	Dr. W. James Renton Mr. Ronald Mutzelburg	Boeing
Blended Wing Body: Fuel-Efficient, Multi-Role Platform	Mr. Robert Liebech	Boeing
GE Aviation: More Efficient Turbine Engines and Alternate Fuels Discussion	Mr. Brad Buswell Mr. Bill Dwyer Mr. Steve Newbold	General Electric
GE Energy Strategy	Dr. Sanjay Correa & Dr. Vlatko Vlatkovic	General Electric
Naval Reactors, Propulsion Trends, and Future Propulsion	Mr. Howard Fireman & RDML Kevin McCoy Mr. John Pazik	NAVSEA and Office of Naval Research
ULTRA Armored Platform Vehicle	Mr. Scott Badenoch	Badenoch, LLC

7 September 2006

Electro-magnetic Actuator Devices	Dr. Delbert Tesar	University of Texas at Austin, Department of Mechanical Engineering
AFRL S&T Overview	Dr. Jimmy Kenyon	AFRL/PRT
Aero Configurations	Mr. Dieter Multhopp	AFRL/VAAA
Lightweight Aero Structures	Mr. Dick Holzwarth	AFRL/VASA
Lightweight Composite Materials	Dr. Tia Benson-Tolle	AFRL/MLBC
Versatile Affordable Advanced Turbine Engine (VAATE)	Mr. Jeff Stricker	AFRL/PRT

High Temperature Materials	Ms. Dallis Hardwick	AFRL/MLLMD
Alternative Fuels	Mr. Bill Harrison	AFRL/PRTG
Multi-Megawall Electric Power System (MEPS)	Mr. Scott Rubertus	ODUSD(S&T)/WS
Air Transportation Association (ATA) Brief	Mr. John Heimlich	ATA

11 October 2006

Ultra-light Airframes/Near Space Vehicles	MG John Hawley, USAF (Ret)	Teledyne Technologies
FedEx Fuel/Energy Initiatives	Mr. Mitch Jackson	FedEx
Meeting the Energy Needs of Future Warriors	Mr. Bruce Braun Dr. Millard Rose	The National Academy of Sciences

30 November 2006

Force Protection in Theater (Fuel Convoys)	Lt. Col. Eric Buer	USMC, DAU
Biomimetic Rotor Applications	Mr. Jay Harman Mr. Peter Fiske Dr. Mark Young	PAX Scientific, Inc.
Cost of Fuel: An IDA Business Case	Dr. Lisa Veitch	IDA

13December 2006

New Tilt Rotor Configurations	LTG Jack Woodmansee, USA (Ret)	Army Science Board
Assessment of Foreign Platforms	Mr. John Pazik	Office of Naval Research

17January 2007

Assessment of Foreign Army and U.S. Army Platforms	BG Genaro Dellarocco Dr. Jim Cross Dr. Ed Shaffer Mr. Tom Nguyen	RDECOM PM-MRP/CERDEC ARL SOSI
Concept Development Path Planning	Lt. Col. Emily Andrew, USMC CDR Joan Oldmixon Ms. Amy Grom Mr. Darrel Morben	JFCOM

Foreign Review of Energy Efficiencies	Dr. Daniel Atkins	NASIC

Policy Panel

27 June 2006

Policy, Planning, and Cooperation Challenges to Mission Assurance (Conventional and evolving homeland defense missions) Associated with Energy and Interconnected Infrastructures	Paula Scalingi	The Scalingi Group, LLC
Dahlgren Mission Assurance Overview	Mike Strain	Mission Assurance Division (J60) NSWCDD, Dahlgren
Electricity - Mission Assurance Division Brief	Mike Burks	Mission Assurance Division (J60) NSWCDD, Dahlgren
Fuel - Mission Assurance Division Brief	Jeff Fulmer	Mission Assurance Division (J60) NSWCDD, Dahlgren

5 September 2006

DOD Electricity and Fuel Infrastructure Vulnerabilities CONUS: Locations, Recommendations, Visions and Policy Challenges	E. Daniel Mathis	Mission Assurance Division (J60) NSWCDD, Dahlgren
DOD's Renewable Energy Plan – Plan Synopsis, Policy Issues and Implementation Challenges	Mike Warwick	DOE Pacific Northwest Laboratories
Decentralizing Fuel Production and Delivery with Clean Oil from Organic Recycling (Thermal Depolymerization)	Brian Appel	Changing World Technologies, Inc.
DESC Clean Fuels and Challenges in Logistics Deliveries and Purchasing	Pam Serino	Defense Energy Support Center (DESC)
Environmental Issues with Coal to Liquids	Alex Farrell	Energy and Resources Group, UC Berkeley

7 September 2006

Coal Waste to Fuel and Bio-Gasification to Fischer-Tropsch Fuel	John Rich	Ultra Clean Fuels
Prospects for Algae to Jet Fuel	Michael A. Pacheco	National Renewable Energy Lab (NREL)

23 October 2006

Saving Energy	Paul MacCready	AeroViroment
N/A	Abe Karem	Karem Aircraft, Inc.
Vulnerability of New York City Energy Infrastructure	Adam Victor	TransGas Energy Systems, LLC
Review of Legal and Regulatory Authorities	Kay Bushman	Defense Energy Support Center (DESC)

13 November 2006

How DESC Buys and Moves Various Fuels	Robert Short John Nelson Bruce Blank Patricia Wilkins	Defense Energy Support Center (DESC)
Bio Conversion of Coal to Methane	Dr. Damon Walia	ArchTech
Huge Fuel Efficiency Gains are Available from Practicable Air Vehicle Improvements	Ira Kuhn	Directed Technologies, Inc.
Plug-in Hybrids	Andy Frank	UC Davis

28 November 2006

Power Surety	Dan Nolan	Army Rapid Equipping Force
Energy Planning for the Military	Amory Lovins	Rocky Mountain Institute (RMI)
Commonwealth of Pennsylvania Initiatives to Secure Alternative Energy Resources & Infrastructure	Katie McGinty	Secretary of the Pennsylvania Department of Environmental Protection
Elements of Micro-Grid Power Structures for the Military	Mike Warwick	DOE Pacific Northwest Laboratories

30 November 2006

Transformers	Joe McClelland	Federal Energy Regulatory Commission (FERC)
Micro-Grid Capabilities in the Southwestern United States	Richard Sweetser	*Exergy Partners, Inc.*
Small Nuclear	Dr. James Powell and Dr. Paul Farrell	Brookhaven Technology Associates
The Global Nuclear Energy Partnership	Victor Reis	

11 December 2006

Industry Response to Vulnerabilities	Ms. Laura Hussey	Edison Electric Institute
An EERE and DOD Relationship for Current Times	Andy Karsner	Assistant Secretary for Energy Efficiency and Renewable Energy, DOE

17 January 2007

Space Solar Power - An Opportunity for Strategic Leadership	Lt. Col. Mike Hornitschek	U.S. Air Force
State of PV Technology and Applicability to Zero Energy Bases	Gary Wayne	PowerLight
Army Energy Program	Don Juhasz	Chief Utilities and Energy, US Army
Air Force Energy Strategy	Bill Budden	Logistics, Installations and Mission Support, HQ USAF
Alternative Financing	Mike Telson	
Advanced Vehicle Program	John Waters	Rocky Mountain Institute (RMI)
Energy Related Critical Infrastructure Protection	Bill Bryan	Director of Critical Infrastructure Protection OSD(HD)
Power Grid	Michael Assante Barry Kuehnle	Idaho National Laboratory
Naval Reactors	Mr. Steve Trautman	Deputy Director, Naval Reactors

5 March 2007

Tax Proposals Currently Under Consideration to Stimulate Growth in the Alternative Distributed Energy Sector	Dave Briedenbach	Energy Tax Solutions

What the Solar Industry Needs in Terms of Technology Assistance, Model Contracting and Procurement Methodologies, and other DoD Investments	Scott Sklar	National Defense University

R&T Panel

5 – 6 October 2006 - NREL

Analysis at NREl	Dr. Doug Arent	NREL
RE/EE Portfolio	Dr. Stan Bull	NREL
NREL Distributed Energy Research	Mr. Dick DeBlasio	NREL
Technology and Site Selection Tools	Mr. Jeffrey Dominick	NREL
Solar – Photovoltaics	Dr. Larry Kazmerski	NREL
Concentrating Solar Power	Dr. Chuck Kutscher	NREL
Influencing Future Vehicles Using Systems Analysis	Mr. Tony Markel	NREL
Geothermal Energy	Dr. Gerry Nix	NREL
The Potential of Biofuels to Meet the Military's Jet Fuel Needs	Dr. Mike Pacheco	NREL
Advanced Vehicles	Ms. Terry Penny	NREL
Modeling Uncertainty in Major Drivers in U.S. Electricity Markets: Stochastic Energy Deployment Systems Model (SEDS)	Mr. Walter Short	NREL
The Renewable Resource	Mr. Tom Stoffel	NREL
Hydrogen Technologies for the U.S. Energy Economy	Dr. George Sverdrup	NREL
Wind Energy Status and Future	Dr. Robert Thresher	NREL

Creating Zero-Energy Buildings	Dr. Paul Torcellini	NREL
The Renewable Resource	Mr. Steve Wilcox	NREL
Technology and Site Selection Tools	Mr. Jeffrey Dominick	NREL
Solar – Photovoltaics	Dr. Larry Kazmerski	NREL
Concentrating Solar Power	Dr. Chuck Kutscher	NREL
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Creating Zero-Energy Buildings	Dr. Paul Torcellini	NREL
The Renewable Resource	Mr. Steve Wilcox	NREL

11 October 2006

Trash to Ethanol Technology	Mr. Ray Crabbs	BRI Energy, LLC
FedEx – Energy/Fuel Initiatives	Mr. Mitch Jackson	FedEx
Soldier Survivability and Sustainable Energy – Progress and Innovation through	Dr. William Peters	MIT

Nanotechnology		
Future Soldier Energy – Batteries and Fuel Cells	Dr. Frank Rose	NAS
Bio Conversion of Coal to Methane	Dr. Damon Walia	ArchTech

APPENDIX D: NEW TECHNOLOGIES

RECOMMENDED PLATFORM TECHNOLOGIES - PROPULSION				
TECHNOLOGY	EXPECTED ENHANCEMENT TO MILITARY EFFECTIVENESS	MAGNITUDE OF EXPECTED ENERGY SAVINGS	RISK ASSOCIATED WITH THIS TECHNOLOGY	WHEN THE TECHNOLOGY LIKELY WILL BE READY FOR FIELD USE[41]
PROPULSION - SHORT TERM				
1. Advanced Hybrid Electric Vehicle powertrain technology.	Med	Low (Conventional Vehicles) Med (Mil Specific Vehicles)	Med	Short/Med
PROPULSION - MEDIUM TERM				
1. Highly Efficient Embedded Turbine Engine (HEETE).	Low/Med	High	Med	Med
2. Adaptive Versatile Engine Technologies (ADVENT).	Low/Med	Med	Med	Med
3. Electric power wheel technologies for aircraft & land vehicles.	Low	Low	Med	Med
4. Fuel cell technology for supplemental power onboard ships.	Med	Med	Med	Med/Long
PROPULSION - LONG TERM				
1. Advanced aircraft engine materials.	Low	Med	High	Long
2. Advanced water jet propulsion systems.	Low	Low	Low/Med	Long
3. Contra-rotating propellers.	Low	Low	Med	Long
4. Variable Speed Tilt Rotor aircraft.	High	High	High	Long

[41] In the context of time, short = 0-5 yrs; med = 5-15 yrs; long = >15 yrs.

RECOMMENDED PLATFORM TECHNOLOGIES - WEIGHT				
TECHNOLOGY	EXPECTED ENHANCEMENT TO MILITARY EFFECTIVENESS	MAGNITUDE OF EXPECTED ENERGY SAVINGS	RISK ASSOCIATED WITH THIS TECHNOLOGY	WHEN THE TECHNOLOGY LIKELY WILL BE READY FOR FIELD USE
WEIGHT - SHORT TERM				
1. Advanced UAVs, UUVs & UGVs.	Med	Low/Med	Med	Short/Med
2. Micro-generators.	Med	Med	Med	Short/Med
3. Lightweight, high strength steels for use in tactical vehicles.	Low	Low	Low	Short
WEIGHT- MEDIUM TERM				
1. Electrically powered actuators.	Med	Low	Low	Med
2. Mega-watt Electrical Power System (MEPS).	Med	Low	Med	Med
3. Advanced composite materials for use in platform bodies (e.g., advanced resins, ceramic-matrix composites, nano-technology materials).	Med/High	Med/High	High	Med
4. Unitized construction of air & land platforms.	Med	Low	Med	Med
5. Blast absorption design & materials for land vehicles.	Low	Med	Med	Med
WEIGHT - LONG TERM				
1. Semi-rigid, lighter than air, solar powered, high altitude (near-space) UAV.	Med	Med	Med	Long

RECOMMENDED PLATFORM TECHNOLOGIES - DRAG				
TECHNOLOGY	EXPECTED ENHANCEMENT TO MILITARY EFFECTIVENESS	MAGNITUDE OF EXPECTED ENERGY SAVINGS	RISK ASSOCIATED WITH THIS TECHNOLOGY	WHEN THE TECHNOLOGY LIKELY WILL BE READY FOR FIELD USE
DRAG - SHORT TERM				
1. Adaptive Wing Technologies.	Low	Low	Low	Short
2. Advanced hull and propeller coatings.	Low	Low/Med	Low	Short
DRAG - MEDIUM TERM				
1. Biomimetic concepts for platform, propeller, fan, pump & weapon design.	Med	Med	Low/Med	Med
2. Blended Wing Body aircraft design.	High	High	High	Med

RECOMMENDED PLATFORM TECHNOLOGIES – SYSTEM DEMAND				
TECHNOLOGY	EXPECTED ENHANCEMENT TO MILITARY EFFECTIVENESS	MAGNITUDE OF EXPECTED ENERGY SAVINGS	RISK ASSOCIATED WITH THIS TECHNOLOGY	WHEN THE TECHNOLOGY LIKELY WILL BE READY FOR FIELD USE
SYSTEM DEMAND - SHORT TERM				
1. Tactical solar power generation.	Low	Low/Med	Low	Short
2. Tactical wind power generation.	Low	Low	Low	Short
SYSTEM DEMAND - MEDIUM TERM				
1. "Energy-starved" electronics for Land Warrior components.	Med	Low (context of DoD total energy usage) High (context of soldier usage)	Med	Med
SYSTEM DEMAND - LONG TERM				
1. Fuel cells for ground use including battery recharge.	Med	Med	High	Long
2. Space-Based Solar Power beamed to FOBs to circumvent conventional base power fuel-dependence.	High	Med	High	Very Long

APPENDIX E: ENERGY KPP AND FULLY BURDENED COST OF FUEL POLICY MEMOS

THE JOINT STAFF
WASHINGTON, D.C. 20318-8000

JROCM 161-06
17 August 2006

JOINT REQUIREMENTS OVERSIGHT COUNCIL

MEMORANDUM FOR: Under Secretary of Defense for Acquisition, Technology, and Logistics
Commander, US Joint Forces Command
Vice Chief of Staff, US Army
Vice Chief of Naval Operations
Vice Chief of Staff, US Air Force
Assistant Commandant of the Marine Corps

Subject: Key Performance Parameter Study Recommendations and Implementation

1. The Joint Requirements Oversight Council (JROC) approved the Key Performance Parameter (KPP) Study recommendations. The JROC endorses the implementation of a mandated Materiel Availability KPP with supporting key system attributes of materiel reliability and ownership cost for all Major Defense Acquisition Programs (MDAPs) and select ACAT II and III programs. The JROC also endorsed selectively applying an Energy Efficiency KPP and a System Training KPP, as appropriate.

2. To better ensure the correct KPPs are selected, the JROC endorsed the use of KPP reference sheets produced as part of this study. The KPP reference sheets will be used as an aid in the process of identifying and validating potential KPPs for any acquisition program.

3. Implementation of the study recommendations will be concurrent with the publishing of the next revision of CJCS 3170-series documents. The revision will incorporate the details of the execution and will be coordinated for final release by 31 October 2006. Specific JROC implementation due backs and approved recommendations are enclosed.

E. P. GIAMBASTIANI
Admiral, US Navy
Vice Chairman
of the Joint Chiefs of Staff

Enclosure

Copy to:
Assistant Secretary of Defense for Networks and Information Integration
Commander, US Transportation Command
Commander, US Central Command
Commander, US European Command
Commander, US Northern Command
Commander, US Pacific Command
Commander, US Southern Command
Commander, US Special Operation Command
Commander, US Strategic Command
Director for Program Analysis and Evaluation

2

Key Performance Parameter Study
Recommendations and Implementation Summary

Key Performance Parameter (KPP) Study Implementation Due Backs to the JROC Within 60 Days of Signed JROC Memorandum (*Task Lead*):

1. Refined KPP Reference sheets to be included as an appendix to the next CJCSI, 3170.01F *(J8 lead)*
2. Definition of Unit Cost *(J8 lead)*
3. Definition of a Key System Attribute (KSA) *(J8 lead)*
4. Matrix of what programs the specific study recommendations apply to *(J8 lead)*
5. Definition of "Fully Burdened" cost of fuel *(OSD lead)*
6. Definition and guidance for Materiel Availability KPP, and the two supporting KSAs: Materiel Reliability and Ownership Cost *(OSD, J4 co-lead)*
7. Proposed enhanced KPP question set for next revision of the CJCS 3170 series documents *(J8 lead)*
8. Recommendations for applying study findings to ongoing acquisition programs if possible - and appropriate *(OSD/ J8 co-lead)*
9. Recommendation for addressing Combat Identification across all acquisition programs *(USJFCOM lead)*
10. Recommended implementation timeline for approved KPP Study recommendations *(J8 lead)*

KPP Study Approved Recommendations Summary:

1. Approval for use of KPP Reference sheets (Capstone Concept for Joint Operations Joint Force Key Characteristics and associated KPP mappings)

2. Cost as a KPP - JROC reserves the right to selectively apply a cost KPP if necessary, but agreed with the study recommendation to not apply a cost KPP as a general rule, but instead:
    a. Utilize a cost trigger specified in JROC Memoranda;
    b. Utilize Earned Value Management System (EVMS) data/Acquisition Program Baseline (APB)/Defense Acquisition Executive Summary (DAES) analysis received from OSD for tracking program performance;
    c. Leverage and participate in program reviews resulting from existing Title 10, Subtitle A, Part IV, Chapter 131 USC trigger; and
    d. More closely and proactively work with OSD with improved data sharing and data transparency.

3. Time/Schedule as a KPP - JROC reserves the right to selectively apply a Time/Schedule KPP if necessary, but agreed with the study recommendation to not apply a Time/Schedule KPP as a general rule, but instead:
    a. Better define when a capability is needed in all capability document submissions;

Enclosure

3

Key Performance Parameter Study
Recommendations and Implementation Summary

b. Utilize the time-defined acquisition approach identified in Quadrennial Defense report;
c. Utilize EVMS data/APB/DAES analysis received from OSD for tracking program performance;
d. Increase visibility and attention of technical maturity at all acquisition phases; and
e. Continue to pilot concept decision point with set schedule and funding boundaries.

4. Sustainment as a KPP – JROC agreed to mandate a Materiel Availability KPP for all MDAPs and select ACAT II and III programs with two supporting KSAs (Materiel Reliability and Ownership Cost).

5. Energy Efficiency as a KPP – JROC agreed to selectively apply an Energy Efficiency KPP as necessary, to include:
a. Defining "fully burdened" cost of delivered fuel to fully price the logistics fuel delivery chain (including force protection requirements);
b. Establish overarching policy mandating fuel efficiency considerations to fleet purchases and operational plans, consistent with mission accomplishment (new department wide guidance is currently pending); and
c. Mandate life cycle cost analysis for new capabilities include "fully burdened" cost of fuel during analysis of alternative/evaluation of alternatives (AoA/EoA) and acquisition program design trades.

6. System Training as a KPP - JROC agreed to selectively apply a System Training KPP as necessary, to include:
a. Ensure system training is addressed in AOA/EOA analysis and subsequent phases; and
b. Ensure projected training requirements and associated costs are appropriately addressed across the program life cycle.

7. Coalition Interoperability as a KPP – JROC agreed to not apply a Coalition KPP at this time, but instead:
a. Partially address through open systems architecture;
b. Leverage Net Ready KPP effort and associated efforts;
c. Communicate frequently with Coalition partners, granting access to applicable products (i.e. Net-Centric Operations and Warfare Reference Model (NCOW-RM), enhancing and improving existing governance and policy, and continue participating on standards/architectural boards;
d. Increase dedicated funding for experiments and demonstrations and improve efficiencies in dollars spent via coordinated efforts; and
e. Continue and place more emphasis on ongoing efforts.

4

Key Performance Parameter Study
Recommendations and Implementation Summary

8. Force Protection and Survivability KPP – JROC agreed no additional guidance is required at this time.

9. Improving the KPP Selection Process – JROC agreed with the study recommendation to use a more deliberate approach to establish KPPs through the following:
   a. Sponsors/FCBs utilize the KPP reference sheets when selecting or validating KPPs;
   b. Institute all study recommendations;
   c. Enhance CJCS 3170 KPP development and implementation guidance by adding an additional question set for KPP selection, which provides the basis for a KPP selection and improves the likelihood of establishing the "correct" KPPs;
   d. Leverage the new EOA experiment for early KPP look and assessment. Look at cost, time needed, and tech maturity first, before setting KPPs; and
   e. Routinely monitor implementation of mandated KPPs and other select KPPs for early signs of problems or possible improvements.

Note: See "KPP Study for JROC Way Ahead Discussions" briefing dated 6 July 2006 for more details of study findings and recommendations.

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

APR 1 0 2007

MEMORANDUM FOR DEPUTY UNDER SECRETARY OF DEFENSE, ACQUISITION & TECHNOLOGY
DEPUTY UNDER SECRETARY OF DEFENSE, LOGISTICS & MATERIEL READINESS
DIRECTOR, DEFENSE RESEARCH & ENGINEERING
SERVICE ACQUISITION EXECUTIVES
DIRECTOR, PROGRAM ANALYSIS & EVALUATION
DIRECTOR, FORCE STRUCTURE, RESOURCES, AND ASSESSMENT, JOINT STAFF

SUBJECT: Fully Burdened Cost of Fuel Pilot Program

Energy has emerged as a dominant factor in the 21st century battle space. Studies by the Institute for Defense Analyses, the Defense Science Board Task Force, the Energy Security Task Force, and JASONS suggest that energy inefficiency is a significant liability, a constraint on operations, and a significant force protection challenge. After reviewing these studies, two conclusions become apparent.

The first is that by reducing energy demand we provide operational forces more flexibility and make them less dependent on the logistics infrastructure. The second conclusion is that the DoD acquisition process undervalues technologies that can improve energy efficiency. One of the recommendations consistent with these studies is that applying the fully burdened cost of delivered energy in acquisition decisions over the life cycle of a system will address these problems. I agree with this recommendation.

Effectively immediately, it is DoD policy to include the fully burdened cost of delivered energy in trade-off analyses conducted for all tactical systems with end items that create a demand for energy and to improve the energy efficiency of those systems, consistent with mission requirements and cost effectiveness.

To implement this policy, I am initiating a pilot program to develop the most effective business practices to incorporate the fully burdened cost of energy into acquisition decisions. The Energy Security Task Force Senior Steering Group has nominated the following programs to participate in the pilot:

- Joint Light Tactical Vehicle

- Maritime Air and Missile Defense of Joint Forces alternative ship propulsion and efficiency options AoA
- Next-Generation Long-Range Strike concept decision

The results of the pilots will be used as the basis for implementing this policy across all relevant acquisition programs and DoD business processes. The implementation specifics of the pilot program will be sent under separate cover.

My point of contact is Mr. Chris DiPetto at 703-695-4421.

Kenneth J. Krieg

2

APPENDIX F: ACRONYMS AND GLOSSARY OF TERMS

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A

ACAT	Acquisition Category
ACSIM	Assistant Chief of Staff of Installation Management
ADVENT	Adaptable Versatile Engine Technology
AFCESA	Air Force Civil Engineer Support Agency
AFRL	Air Force Research Lab
AFVs	Alternative Fuel Vehicles
AMMPS	Advanced Medium-size Mobile Power Sources
AOA	Analyses of Alternatives
AOR	Area of Responsibility
APU	Auxiliary Power Unit
A/S	Assistant Secretary
ASD	Assistant Secretary of Defense
ASD(HD&ASA)	Assistant Secretary of Defense for Homeland Defense and Americas Security Affairs. ASD(HD&ASA) is under the USD(P).
ASD(SO/LIC)	Office of the Assistant Secretary of Defense, Special Operations/Low Intensity Conflict. ASD(SO/LIC) is under the USD(P).
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATD	Advanced Technology Demonstration
AWACS	Airborne Warning and Control System

B

BBL	Billion Barrels
BRAC	Base Realignment and Closure
Btu	British thermal unit
BWB	Blended Wing Body

C

C4	Command, Control, Communications & Computers
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CBRNE	Chemical Biological Radiological Nuclear Explosive
CAIG	Cost Analysis Improvement Group
CDD	Capabilities Development Document
CENTCOM	United States Central Command
CHUs	Containerized Housing Units
CIA	Central Intelligence Agency
CIP	Critical Infrastructure Program
CJCS	Chairman of the Joint Chiefs of Staff
CMU	Central Monitoring Unit
COCOM	Combatant Command
CONOPS	Concept of Operations
CONUS	Continental United States
CPD	Capabilities Production Document
CTL	Coal-to-Liquid

D

DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Projects Agency
DAWG	Deputy's Advisory Working Group
DCIP	Defense Critical Infrastructure Program
DCS	Distributed Control System
DDR&E	Director of Defense Research and Engineering
DEPSECDEF	Deputy Secretary of Defense
DESC	Defense Energy Support Center
DFSP	Defense Fuel Support Points
DHS	Department of Homeland Security
DIA	Defense Intelligence Agency
DIB	Defense Industrial Base
DLA	Defense Logistics Agency
D-MAD	Dahlgren Mission Assurance Division
DOC	Department of Commerce
DoD	Department of Defense
DoDI	Department of Defense Instruction
DOE	Department of Energy
DOE (EERE)	Department of Energy (Office of Energy Efficiency and Renewable Energy)
DOE (OE)	Department of Energy (Office of Electricity Delivery & Energy Reliability)
DOI	Department of Interior
DOTMLPF	Doctrine, Organization, Training, Material, Leadership and Education, Personnel & Facilities

DPS	Defense Planning Scenarios
DSB	Defense Science Board
DSB Study "More Capable Warfighting Through Reduced Fuel Burden"	The 2001 DSB Report "More Capable Warfighting Through Reduced Fuel Burden" also referred to in the report as the 2001 DSB study can be located at: http://www.acq.osd.mil/dsb/reports/fuel.pdf
DSS	Defense Security Service
DTRA	Defense Threat Reduction Agency
DUSD	Deputy Under Secretary of Defense
DUSD(I&E)	Deputy Under Secretary of Defense for Installations and Environment
DUSD(L&MR)	Deputy Under Secretary of Defense for Logistics and Material Readiness

E

EMP	Electromagnetic Pulse
EMS	Emergency Management System
Endurance	The ability of a system to sustain operations for an extended period of time without requiring additional support or replenishment activities.
Energy Policy Act 2005 (EPAct 2005)	Includes provisions for renewed and expanded tax credits for landfill gas; provides bond financing, tax incentives, grants, and loan guarantees; extends renewable energy production incentives to landfill gas. It sets forth an energy research and development program covering: (1) energy efficiency; (2) renewable energy; (3) oil and gas; (4) coal; (5) Indian energy; (6) nuclear matters and security; (7) vehicles and motor fuels, including ethanol; (8) hydrogen; (9) electricity; (10) energy tax incentives; (11) hydropower and geothermal energy; and (12) climate change technology. For text of the full bill, visit: Energy Policy Act 2005.
EO	Executive Order
EOA	Evaluation of Alternatives

EOP	Executive Office of the President
ERO	Electric Reliability Organization
ESPC	Energy Savings Performance Contracts

F

FAA	Functional Area Analysis
FBCF	Fully Burdened Cost of Fuel
FBCT	Future Brigade Combat Team
FCBs	Functional Capabilities Boards
FCS	Future Combat System
FERC	Federal Energy Regulatory Commission
FFV	Flexed Fueled Vehicles
FNA	Functional Needs Analysis
FOB	Forward Operating Base
FEMP	Federal Energy Management Program. FEMP is a DOE program that works to reduce the cost and environmental impact of the Federal government by advancing energy efficiency and water conservation, promoting the use of distributed and renewable energy, and improving utility management decisions at Federal sites.
FERC	Federal Energy Regulatory Commission
FFV	Flexible Fuel Vehicle
Fischer Tropsch	Is a catalyzed chemical reaction in which carbon monoxide and hydrogen are converted into liquid hydrocarbons of various forms. Typical catalysts used are based on iron and cobalt. The principal purpose of this process is to produce a synthetic petroleum substitute, typically from coal or natural gas, for use as synthetic lubrication oil or as synthetic fuel.
FOIA	Freedom of Information Act

FSA	Functional Solutions Analysis
FY	Fiscal Year
FYDP	Future Year Defense Plan

G

GAO	Government Accountability Office
GCC	Government Coordinating Council
GHGs	Greenhouse Gas Emissions
GOCO	Government Owned, Contractor Operated
GSA	General Services Administration
GWOT	Global War on Terrorism

H

HD	Homeland Defense
HD/CIP	Homeland Defense/Critical Infrastructure Protection
HEETE	Highly Efficient Embedded Turbine Engine
HMMWV	High Mobility Multipurpose Wheeled Vehicle (Hummvee)
HS	Homeland Security
HVAC	Heating, Ventilation and Air Conditioning

I

ICD	Initial Capabilities Document
IDA	Institute for Defense Analyses
i-ENCON	Incentivized Energy Conservation
IED	Improvised Explosive Device
IHPTET	Integrated High Performance Turbine Engine Technology program

INL	Idaho National Laboratory
IO	Information Operations
Islanding	Electrical islands are created when parts of an interconnected power grid become separated from the main grid. This typically occurs during grid failures when portions of the area served are able to isolate themselves from the main grid and provide loads within that area sufficient power from generation within the area, the “island.” Islands can be created intentionally by establishing electrical boundaries using relays and controls that are able to isolate loads and sufficient generation to meet them, by ensuring loads and resources can be in balance.
ISOs	Independent System Operators
ISR	Intelligence, Surveillance & Reconnaissance
J	
JASON	An independent scientific advisory group that provides consulting services to the U.S. government on matters of defense science and technology. It was established in 1960. JASON typically performs most of its work during an annual summer study, and has conducted studies under contract to the Department of Defense (frequently DARPA and the U.S. Navy), the Department of Energy, the U.S. Intelligence Community, and the FBI. Approximately half of the resulting JASON reports are unclassified.
JCIDS	Joint Capability Integration and Development System
JCTD	Joint Combat Technologies Demonstration
JFCOM	Joint Forces Command
JLTV	Joint Lightweight Tactical Vehicle
JMR	Joint Multi Role
JPD	Joint Potential Designator

JROC	Joint Requirements Oversight Council
JROCM	Joint Requirements Oversight Council Memorandum
JS	Joint Staff
JSTARS	Joint Surveillance and Target Attack Radar System
JWCA	Joint Warfighting Capabilities Assessment

K

KPP	Key Performance Parameters
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour

L

L/D	Lift to drag
LED	Light-emitting diod
LEED	Leadership in Energy and Environmental Design
LSV	Low Speed Vehicle

M

MAD	Navy's Dahlgren Mission Assurance Division
MBPD	Million Barrels Per Day
MDA	Milestone Decision Authority
MEPS	Mega-watt Electrical Power System
MILCON	Military Construction
MISER	DARPA's Mobile Integrated Sustainable Energy Recovery
MNF-W	Multi-National Force-West

MRAP	Mine-Resistant, Ambush Protected vehicle
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSFD	Multi-Service Force Deployment
MULE	Multifunction Logistics/Equipment
MW	Megawatt
M&S	Modeling and Simulation

N

NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NERC	North American Electric Reliability Corporation
Net Zero Plus	The plus in net zero plus refers to the capability of a base to provide power to its nearby surrounding area in the event of a grid outage.
Network Single Point of Failure (NSPF)	A single network component that, if it fails, results in a nonfunctional service or network.
NIST	National Institute of Standards and Technology
NORTHCOM	US Northern Command
NPC	National Petroleum Council
NRAC	Naval Research Advisory Committee
NRC	National Research Council
NREL	National Renewable Energy Laboratory
NSA	National Security Agency
NSC	National Security Council
NSPF	Network Single Points of Failure
NSSO	National Security Space Office

NTV	Non-Tactical Vehicle
NZP	Net Zero Plus

O

OCONUS	Outside Continental United States
ODASD(HD)	Office of the Assistant Secretary of Defense for Homeland Defense
ODP	Office for Domestic Preparedness
OD/PA&E	Office of the Director, Program Analysis & Evaluation
ODUSD(I&E)	Office of the Deputy Under Secretary of Defense (Installations & Environment)
OPTEMPO	Operating Tempo
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OMB	Office of Management and Budget
ONR	Office of Naval Research
OPOC	Opposed Piston Opposed Cylinder engines
OPTEMPO	Operating tempo
OSD	Office of the Secretary of Defense
OSD(PA&E)	Office of the Secretary of Defense (Program Analysis & Evaluation)
OSTR	Optimum Speed Tilt Rotor
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology and Logistics

P

PA&E	Program Analysis and Evaluation
PCII	Protection of Critical Infrastructure Information

PLC	Programmable Logic Controller
PM	Program Manager
PNNL	Pacific Northwest National Laboratory
POM	Program Objective Memorandum
POR	Program of Record
PPBES	Planning, Programming, Budgeting, and Execution System
PUC	Public Utility Commission

Q

R

RAMCAP	Risk Analysis and Management for Critical Asset Protection
R&D	Research and Development
R&T	Research and Technology
RD&D	Research, Development and Demonstration
RDT&E	Research, Development, Test and Evaluation
RECs	Renewable Energy Credits
REDCOM	Army Research Development & Engineering Command
REF	Rapid Equipping Force
Resilience	The ability of a system to resist failure and provide rapid recovery from breakdowns, should they occur.
Rivet Joint	Air Force primary reconnaissance platform.
RPG	Rocket Propelled Grenades
RTO	Regional Transmission Operator
RTU	Remote Terminal Unit

S

S&T — Science & Technology

SBSP — Space-Based Solar Power

SCC — Sector Coordinating Council

SCADA — Supervisory Control And Data Acquisition system

SCADA systems are used in utility infrastructures as a computer-based monitoring and control system that centrally collects, displays, and stores information from remotely-located data collection transducers and sensors to support the control of equipment, devices, and automated functions.

SDD — System Development & Demonstration Group

SECDEF — Secretary of Defense

SME — Subject Matter Expert

SMP — Sustain the Mission Project

SOA — State of the Art

SPF — Single Point of Failure

STRACNET — Strategic Rail Corridor Network

STRAHNET — Strategic Highway Network

Synfuels — Any liquid fuel obtained from coal, natural gas, or biomass. It can sometimes refer to fuels derived from other solids such as oil shale, tar sand, waste plastics, or from the fermentation of biomatter.

T

TARDEC — Army Tank Automotive, Research and Engineering Center

TDA — Table of Distribution and Allowance

A table, which prescribes the organizational structure, personnel, and equipment authorizations, and requirements of a military unit to perform a specific mission for which there, is no

	appropriate table of organization and equipment. (AR 310-25, Dictionary of United States Army Terms, 15 October 1983).
TOA	Table of Allowance (DoD). An equipment allowance document that prescribes basic allowances of organizational equipment, and provides the control to develop, revise, or change equipment authorization inventory data. (Joint Pub1-02, Dept of Defense Dictionary of Military and Associated Terms, 23 March 1994).
TOE	Table of Organization and Equipment 1. See JCS Pub 1 for definition. (A) 2. A table that prescribes the normal mission, organizational structure, and personnel and equipment requirements for a military unit, and is the basis for an authorizations document. See also modification table of organization.
TPFDL	Time Phased Force & Deployment List
TRAC	TRADOC Analysis Center
TRAC-LEE	TRADOC Analysis Center – Fort Lee
TRAC-Leavenworth	TRADOC Analysis Center – Fort Leavenworth
TRAC-WSMR	TRADOC Analysis Center – White Sands Missile Range
TRADOC	U.S. Army Training and Doctrine Command
TRANSCOM	United States Transportation Command
TRL	Technology Readiness Level
TSA	Transportation Security Administration
TSWG	Technical Support Working Group
TQG	Tactical Quiet Generator

U

UAVs	Unmanned Aerial Vehicles

UESC	Utility Energy Services
UFC	Uniform Facilities Criteria
UFGS	Uniform Facility Guide Specifications
UGVs	Unmanned Ground Vehicles
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
USD(C)	Under Secretary of Defense (Comptroller)
USD(I)	Under Secretary of Defense for Intelligence
USD (P)	Under Secretary of Defense for Policy
US	United States
USA	United States Army
USAF	United States Air Force
USC	United States Code
USMC	United State Marine Corps
USN	United States Navy
UUVs	Unmanned Underwater Vehicles

V

VAATE	Versatile Affordable Advanced Turbine Engines
VCJCS	Vice Chairman of the Joint Chiefs of Staff
VTOL	Vertical Take-Off and Landing

W

W	Watt
WMD	Weapon of Mass Destruction

X Y Z

APPENDIX G: CLASSIFIED

A copy of the classified annex is located in the Defense Science Board office. Please contact Major Chad Lominac for more information.

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