Warning... in order to even begin to understand this article on DoD’s "Other" Combat Power, a major paradigm shift will be required to rethink what is meant by the words "Combat Power". Why? Because we’ve been conditioned to primarily associate combat power with programs like Joint Strike Fighter (JSF), DDX, Future Combat System (FCS), etc... and often ignore other areas equally critical to the success of our warfighting forces. One increasingly critical area that impacts every soldier, sailor, airman and marine and the focus of this paper is the availability of the "other" power in every single system on the battlefield. DoD defines this power as Mobile Electric Power (MEP).

While we tend to take power for granted at home, power on the battlefield is an entirely different matter. Without the right type, quantity and quality of electric power, most, if not all, of our combat systems will experience catastrophic failure. This has become increasingly true over the past two decades where information technology now dominates virtually every deployed system in a network centric environment. The good news from a MEP prospective is that information technologies and network centric environments have resulted in a significant increase in power requirements on the battlefield. The bad news is that the increased requirements are being met by a combination of platforms not designed for such power and 87,000+ current force generators fielded to Army, Navy, Air Force and Marine Corps units worldwide. The worse news is that the vast majority of DoD’s generators were built with 1970-80’s technologies, and in addition to having noise, weight and maintenance issues, are deployed in a vast number of stovepipe architectures. While it’s true that emerging technologies (hybrid electric, fuel cells, etc.) have the potential to power our future combat platforms, it’s also true that their impact on DoD’s overall power requirements will be minimal for several years to come. However, it’s not all gloom and doom. The bottom line up front is that there are several near-term actions that could significantly improve DoD’s "Other" Combat Power and our support to the warfighter. Continued on page 3
Ladies and Gentlemen:

I am excited about continuing the theme of "Transformation" in this WSTIAC Newsletter, with a hard-hitting article on "Combat Power"...and its affect on Army, Navy, Air Force and Marine Corps Tactical Units on the battlefield. As a Department of Defense (DoD) level issue, the technical, business and operational insights into this area are definitely worth understanding as we move forward with an increasingly complex, systems-of-systems, network-centric capability for the warfighter.

The majority of this article was written by Colonel (Retired) Mark W. Jones, as the former DoD Project Manager for Mobile Electric Power (MEP), with technical review by PM MEP's former Deputy Project Manager (Dr. Jim Cross), and the Army's Power & Energy IPT on Fuel Cells and Hybrid Electric Vehicles. By now you may have figured out that the term "Combat Power" refers to something other than Joint Strike Fighter, DDX and Future Combat Systems that are typically discussed in this vein. With that, I will close my opening comments and simply encourage you to read on.

Gary
"Other" Combat Power

In order to understand these near-term actions, I have organized this paper as follows:

- DoDD 4120.11 - Standardization of Mobile Electric Power (MEP) Generating Sources
- Force Structure Changes - How the Army re-powered the Stryker Brigade Combat Team
- Potential for Future Hybrid Electric & Fuel Cell systems - A Reality Check
- Summary

II. DoDD 4120.11 - Standardization of Mobile Electric Power (MEP) Generating Sources

DoDD 4120.11 was established in the late 1960's based on lessons learned during the Vietnam War when an out-of-control procurement system produced over 2000 different power sources on the battlefield creating an unmanageable training, fielding, and logistics support situation. The Directive established centralized management of tactical power sources, fostered Joint Service interoperability, and ensured compatible power standards.

DoDD 4121.11 defines MEP as "all-mobile, engine-driven, electric power generating sources, 750-kilowatt (kW) and smaller, which are skid-mounted, wheel-mounted, or man-portable that are complete equipment assemblages or a part of an assemblage, and that are capable of independently producing electric power when operating on diesel, gasoline, or other fuel from integral or remotely located fuel sources. Included are follow-on power sources; e.g., fuel cells and thermoelectric devices. Power sources less than 0.5-kW rating, to include batteries, are not included in this definition, although they obviously play a role in providing power on the battlefield. MEP, alternatively called "Tactical Electric Power", includes:

- Small stand-alone generators (2-3kW)
- Auxiliary Power Units (APU), 5-10kW such as those found on the High Mobility Multi-Purpose Wheel Vehicle (HWWMV), Standard Integrated Command Post Shelter (SICPS) and the M1068 Track Wheel Vehicle
- Under-the-Hood Power (UHP), to include belt-driven and Hybrid Electric (HE) platforms
- Skid-mounted generators (5-200kW)
- Generators mounted on trailers, which are defined as either power units (one generator on a trailer) or power plants (two generators on a trailer)

Concurrent with establishment of DoDD 4020.11, the Department of Defense established a DOD Project Manager for Mobile Electric Power (PM MEP)(under the US Army as Executive Agent), with the responsibility to develop, field and sustain all power sources from 0.5kW to 750 kW for the Army, Navy, Air Force and Marine Corps. Over the years, PM MEP has made significant reductions in the number of generators employed within DoD. From thousands of generators, today the number is less than 50, a major "good news" transformation story. Conversely, there has been a notable lack of progress in transforming other areas -- which is the focus of the remainder of this paper.

III. Force Structure - How the Army re-powered the Stryker Brigade Combat Team (SBCT)

Independent of any power solution or emerging technology, DoD has a significant opportunity to transform the "Other" Combat Power, simply by addressing how power assets are allocated across the force structure, which in a nutshell is broke. What that means is that in most units individual generators provide power to one platform or shelter at a time, with little to no backup, typically oversized for the requirement, and located where noise, fumes and maintenance are issues. The analogy to how power is typically allocated within units would be if you designed your house such that each and every room was separately wired, individually powered by a stand-alone generator, and each of a unique size and shape that the members of your household would separately operate, fuel and maintain. If you take that analogy one step farther, consider that while even the smallest town or city is supported by a power grid with power management capabilities that monitor usage, isolate failures, and prioritize critical users, in DoD's tactical force structure, this capability is almost non-existent.

To address such concerns during the design of the Army's new Stryker Brigade Combat Teams (SBCT), a combined team of PM MEP, I CORPS G7, Training & Doctrine Command's (TRADOC) Brigade Combat Cell (BCC) and the Communications Electronic Command (CECOM) Research Development Engineering Command (RDEC), conducted the
first-ever power assessment of the SBCT at Fort Lewis, WA, from April-December 2001, with an overarching goal to improve the way the DoD allocates power to tactical units. This effort was unique in that in addition to technical measurements the SBCT Power Assessment addressed key operational and sustainment areas such as fuel requirements, deployability (weight/size), back-up power, and life-cycle costs. Although this assessment was specifically focused on the SBCT-1’s Tactical Operations Centers (TOCs), lessons learned are already being applied to other Brigade elements.

![SBCT Brigade TOC (Main and Forward Co-located)](image1)

![SBCT BDE Main TOC Power Distribution Alternative B](image2)

![SBCT BDE Forward TOC Power Distribution Alternative B](image3)

**Figure 1**

<table>
<thead>
<tr>
<th>Power Source</th>
<th>Baseline</th>
<th>Alternative B</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>APU (10kW)</td>
<td>7</td>
<td>7</td>
<td>ALT B - Does not require APU’s to operate except as backup</td>
</tr>
<tr>
<td>3kW Skid</td>
<td>1</td>
<td>0</td>
<td>100% Reduction</td>
</tr>
<tr>
<td>5kW (Skid)</td>
<td>1</td>
<td>0</td>
<td>Eliminates Fork Lift Requirement &amp; Cargo Trailer Safety Issues</td>
</tr>
<tr>
<td>10kW (Skid)</td>
<td>2</td>
<td>0</td>
<td>Eliminates Fork Lift Requirement &amp; Cargo Trailer Safety Issues</td>
</tr>
<tr>
<td>5kW PU</td>
<td>2</td>
<td>0</td>
<td>200% Reduction</td>
</tr>
<tr>
<td>10kW PU</td>
<td>9</td>
<td>4</td>
<td>56% Reduction</td>
</tr>
<tr>
<td>15kW PU</td>
<td>-</td>
<td>1</td>
<td>Centralized Power - Replaces BSN #1 5kW PU &amp; 10kW PU</td>
</tr>
<tr>
<td>60kW PU</td>
<td>-</td>
<td>2</td>
<td>Centralized Power - Main (1 - 60kW PU) and FWD (1-60kW PU)</td>
</tr>
<tr>
<td>Total (APU/Gen)</td>
<td>7/15</td>
<td>7/7</td>
<td>Both Baseline and Alt B meet TOC Requirement = 134.4kW</td>
</tr>
<tr>
<td>Capacity (kW)</td>
<td>198</td>
<td>175</td>
<td>Both Baseline and Alt B meet TOC Requirement = 134.4kW</td>
</tr>
<tr>
<td>Back Up Power</td>
<td>35%</td>
<td>57%</td>
<td>Significant Operational Advantage</td>
</tr>
<tr>
<td>Annual Fuel</td>
<td>7,120</td>
<td>5,860</td>
<td>Significant Cost and Transportation Savings</td>
</tr>
<tr>
<td>Weight</td>
<td>33,551</td>
<td>30,268</td>
<td>Reduction</td>
</tr>
<tr>
<td>Life Cycle Cost</td>
<td>$493,976</td>
<td>$377,943</td>
<td>Significant Reduction - Primarily in Unit OMA $$</td>
</tr>
</tbody>
</table>

**Table 1**
The Figure 1 and Table 1 show just one of the alternatives that resulted from the assessment. As a result, in 2003 HQ DA G 3 approved a totally new power force structure for not just SBCT-1, but all of the Army's SBCTs. On the left side of Figure 1 are the SBCT Main and Forward TOCs, with a previous requirement for 15 generators and 7 Auxiliary Power Units (APU) (generators mounted in a vehicle that are operated as a part of the vehicle). There were several issues with the SBCT’s original force structure of generators and APUs:

**Excess capacity:** The SBCT TOCs were on average 100% overpowered (Capacity = 198kW vs. Requirement = 98kW);

**Noise and toxicity:** APUs in Standardized Integrated Command Post Shelter (SICPS) produced over 85dB of noise inside the shelter/crew compartment and their exhaust required a separate adapter kit to port the fumes out of the work area. The noise was at the limit of DoD safety levels requiring hearing protection. As a reference point, normal conversation is around 50-60DB, street traffic is about 60-70DB and a subway in a tunnel registers around 90DB;

**Safety and operational issues:** Several of the SBCT’s generators were skid-mounted and transported in cargo trailers. For anything above 3kW, that meant external lift was required to move many of the generators in the field;

**Back-up power:** The Army’s process of allocating a dedicated generator or APU to each shelter, created single points of failure at multiple nodes throughout the TOC. Overall, this meant that throughout the SBCT-1 TOCs less than a third of the shelters had any type of backup or alternative source of power;

**Support:** Finally, one must consider the impact on the soldiers who that had to move, set up, operate, fuel, and maintain dozens of individual generators in a tactical environment.

The right side of Figure 1 shows the result of months of soldiers working tactics, techniques and procedures in conjunction with the power assessment team to refine and implement a more centralized approach to powering the SBCT TOCs. The “Xs” on the left represent generators and/or APUs that were eliminated by this more centralized approach. In addition to reducing fuel and weight, the alternative provided a significant increase in back-up power. It also all but eliminated the noise and toxicity issues associated with running APUs as a primary power source.

Table 1 summarizes for each generator and key decision criteria (weight, fuel, etc.), the advantages of centralized power versus the baseline configuration (in this case for Alternative B). For example, the centralized approach maintained the same physical layout on the ground between shelters (even though the picture shows two separate sections for the purpose of explaining the power distribution). As an aside, noise and toxicity addressed by this centralized approach will have to be revisited with any plan to field Hybrid Electric (HE) HMMWVs to power external equipment or, in other words, operate them 24x7 as “large generators” inside a unit formation.

The good news is that the SBCT-1’s force structure for power was approved before the unit deployed to Iraq. The bad news is that the vision to take this example and start a process to achieve similar results in other units throughout DoD, appears to have stalled. This is especially unfortunate given the opportunity to address MEP as a part of such efforts as the Army’s Transformation of units as they rotate back from Iraq. The other unfortunate result of not addressing force structure issues now is that we will wait until it’s too late, to figure out how to best integrate new technologies and, at the same time, fail to realize fuel, maintenance and personnel savings in not just the tactical units but the entire logistics pipeline as well.

**IV. Hybrid Electric & Fuel cell systems - A Reality Check**

While there are several individual efforts in DoD to address next-generation power sources, the primary issue that continues to slow any real progress is widespread ignorance of who, what, where and when it makes sense to take a commercial technology (e.g., fuel cells), integrate it into a component (stack), design that component into a subsystem (engine), integrate that subsystem into a platform (fuel cell vehicle), modify or redesign the system for military use (HMMWV) and finally support that military system in a tactical environment with its unique supply, maintenance and readiness requirements (e.g., Iraq). Rather than ask “Why don’t we have a fuel cell vehicle in the field?” the better question would be “Where’s the roadmap that addresses doctrine, training, organization, leadership, material and soldier considerations for DoD’s next generation MEP?” To help address at least the material part of that question, let’s examine two of the more popular technologies that many postulate (or believe) could have a major impact on DoD’s “Other” Combat Power - Hybrid Electric Vehicles (with exportable power) and Fuel Cells.

**Hybrid Electric (HE):** Several hybrid-electric passenger cars are now being sold and advertised as exceptionally fuel-efficient. Popular media credits the hybrid electric propulsion system as responsible for this outstanding fuel economy. However, closer examination reveals that many other significant factors are at work, which have little to do with the fact that a car is a hybrid. These factors should be clearly identified and considered before crediting the hybrid system with fantastic fuel savings. In fact, the answer to any fuel and/or maintenance question depends on several inputs, not the least of which is driving cycle and the baseline comparison vehicle. A closer look at the current commercial Hybrid Electric Vehicles (HEV) reveals the following:

**Lightweight Materials** - Hybrid cars are very small sub-compacts. Much of their structure is made up of lightweight (and costly) structural materials not generally used in other models and definitely not designed for a warfighting environment.
**Engine Controls** - Using control software, a hybrid electric car's engine is designed to be shut down during long periods of idle in order to perform well against the well-known, well-established Environmental Protection Agency driving cycles. Note that an engine shutdown feature has nothing to do with being a hybrid - as several European manufacturers have developed conventional vehicles with the same automatic shutdown/rapid-start type engines.

**Regenerative Braking** - Much is made about regenerative braking. The amount of regenerative braking energy that can be recovered depends on the driving cycle, the size of the energy storage device and the rate that the device can safely absorb and discharge energy (system impedance, charge-rate acceptance and rider comfort). On commercial cars, the battery pack and consequent hybrid boost is quite small in order to meet cost, reliability, system life, weight, and volume constraints. On military vehicles, the boost requirements are yet to be determined, and battery packs on either type vehicle don't store or deliver enough significant energy to make a very dramatic difference in fuel economy.

**Emissions Reduction** - On the plus side, because even a small battery can provide short boosts for acceleration, engine throttling losses and emissions are reduced. Emissions are of primary interest to the commercial sector.

**Summary** - When all factors are taken into account, the hybrid system on today's hybrid cars only accounts for an estimated 5% or less in fuel savings over an equivalent optimized sized/weight conventional vehicle. It is also revealing to note that one of the hybrid car manufacturers also makes a similar weight-class, non-hybrid vehicle equipped with a conventional diesel engine in Europe. Their European diesel actually achieves better fuel economy than their hybrid car sold in the U.S.

So where does that leave us relative to when or where hybrid vehicles will make sense in a military environment? To help answer that question, a combined team of power experts conducted an assessment of the Army's HE HMMWV program during 2002-2003, which at the time was in the early prototype stage. The study addressed technical, operational and cost issues based on data obtained from current known sources.

What's shown in Figure 2 is: 1) A simple picture of the prototype HE HMMWV; 2) A slide which graphically shows the systems compared in the HE HMMV Analysis, and: 3) A graph of the Life-Cycle Cost Comparison. The systems compared in this analysis were: 1) A HMMWV + SICPS shelter + 15kW generator versus a HE HMMWV capable of producing 15kW of power, and, 2) Two HMMWVs + Two 15kW generators versus one HE HMMWV capable of producing 30kW of power + one standard HMMWV. The mission profile (Figure 3) for this comparison was based on the HMMWV Operational Requirements Document (ORD) which specified, during a 96-hour mission (Figure 4), how long the HMMWV was driven, riked and maintained, and parked (i.e., operating as essentially a large generator).

The bottom line from a life-cycle cost standpoint was that no time is a HE HMMWV, which only produces 15kW of power, a cost-effective solution. However, the analysis does show that over time, a HE HMMWV that could produce 30kW of power (i.e., enough to power more than just one shelter or system) could be a cost effective solution.

![Figure 2](image-url)
However, even if DoD could develop a cost effective >30kW HE HMMWV, there are several technical issues recently documented by the Army’s Power & Energy Integrated Process Team (IPT) that need to be addressed relative to HEVs in a military environment:

- **Performance and Economy Baselines** - To justify a hybrid acquisition on the basis of fuel economy, decision makers and planners must know approximately how much fuel will be saved. The simple fact is that the fuel economy of a vehicle is directly related to how it is used. Without having a representative driving cycle, one cannot make that determination. Consequently, there is a fundamental need to develop and use realistic, standard, accepted military vehicle driving cycles. This is also true of "Silent Watch", which to date is a rather poorly defined requirement.

- **Army Fuel Economy Measurement** - Existing Army test protocols are only suitable to support RAM testing, engineering tests and cruising range estimates. Two fuel economy test courses currently exist at Aberdeen Proving Ground (APG): the Standard Fuel Course and the Harford Loop Fuel Course. Neither course can be used to predict fielded fuel economy in a mission context. APG fuel economy test courses are not traceable to how vehicles are actually driven in the real world - nor were they designed to be. Without using a representative driving cycle, there is no controlled, scientific baseline for vehicle comparison.

- **Reliability and Battery Life** - Putting performance and economy aside for the moment, the driving cycle affects HEV component/system life and reliability. HEV battery life can vary significantly depending upon how the vehicle is used, or abused. Without a representative driving cycle and adequate testing, DoD has no way to assess or predict HEV battery pack life. This single unknown easily has the potential to drive HEV operations and sustainment costs beyond the point of acquisition program affordability, and create major readiness issues in the field.

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**Figure 3**

**HE versus Baseline System**

<table>
<thead>
<tr>
<th></th>
<th>15 kW</th>
<th>30 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acq Cost</td>
<td>$144,000.00</td>
<td>$140,000.00</td>
</tr>
<tr>
<td>Fuel Cost</td>
<td>$890.2</td>
<td>$1,590.47</td>
</tr>
<tr>
<td>Maint Cost</td>
<td>$207.7</td>
<td>$207.7</td>
</tr>
<tr>
<td>PMCS Total O&amp;S</td>
<td>$33.49</td>
<td>$459.1</td>
</tr>
<tr>
<td>Event</td>
<td>$1,590.47</td>
<td>$2,715.63</td>
</tr>
</tbody>
</table>

**Figure 4**

**15kW: No Business Case**

**30kW: ROI ~ 17 yrs**

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**BASELINE 30kW**

**HE HMMWV**

**HE HMMWV 15kW**

**BASELINE 15kW**

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Fuel Cells - Even more popular than FCS, DDX JSF and HE, are the emerging fuel cell technologies. From a military standpoint, fuel cells appear to be attractive due to the potential electrical efficiencies and the fact that the fuel stack is virtually silent (although the cooling and other system components are not). However, industry's efforts with fuel cells are based on using non-logistic fuels such as hydrogen and methanol, with only an insignificant amount of funding programmed to examine JP-8/diesel reformers for fuel cells. Why? There are several reasons: 1) JP-8 has a much more complex chemical structure making the reforming process for JP-8 fuel significantly more difficult than other fuels; 2) JP-8 has a byproduct of sulfur, which acts as to "poison" a fuel cell stack; 3) Hydrogen-based fuel cells hold much more promise to "fit" within President Bush's challenge for a totally hydrogen-based infrastructure by 2020; 4) Industry isn't necessarily motivated nor constrained by the same warfighting requirements that support DoD's Single Fuel Policy (i.e., safety, transportability, low flash point, etc.). DoD's recent Fuel Cell Report best summarizes this point by stating that "several fundamental technologies will have to be developed before successful fuel cell propulsion... or APU... system can be developed".

In addition, there are several other technical issues relative to fuel cells, which include:

- **Energy Storage** - HEV battery packs are not just bigger cell phone batteries. These are large, very complex electro-chemical energy storage systems that must incorporate battery pack housing design, thermal management and charge equalization. Battery life is affected by the depth of discharge, the number of discharge cycles, and overcharging. The larger the capacity of the battery the better, but that increases system weight and size. Despite the marketing claims of enthusiastic energy storage manufacturers, there is currently no large-scale industrial base for military HEV batteries and energy storage systems. Commercialization of advanced energy storage is several years and millions of dollars away.

- **Energy Storage System Size** - With energy storage devices, there are known-knowns, known-unknowns and unknown-unknowns. As HEV system size goes up, energy storage system design (and heat management/dissipation) becomes more complex. This helps to explain the technologically misleading, but commercial "success" of lightly-boosted, sub-weight-class hybrid cars. It also helps to explain the lack of progress for heavier military HEVs.

Fuel Cells - Even more popular than FCS, DDX JSF and HE, are the emerging fuel cell technologies. From a military standpoint, fuel cells appear to be attractive due to the potential electrical efficiencies and the fact that the fuel stack is virtually silent (although the cooling and other system components are not). However, industry's efforts with fuel cells are based on using non-logistic fuels such as hydrogen and methanol, with only an insignificant amount of funding programmed to examine JP-8/diesel reformers for fuel cells. Why? There are several reasons: 1) JP-8 has a much more complex chemical structure making the reforming process for JP-8 fuel significantly more difficult than other fuels; 2) JP-8 has a byproduct of sulfur, which acts as to "poison" a fuel cell stack; 3) Hydrogen-based fuel cells hold much more promise to "fit" within President Bush's challenge for a totally hydrogen-based infrastructure by 2020; 4) Industry isn't necessarily motivated nor constrained by the same warfighting requirements that support DoD's Single Fuel Policy (i.e., safety, transportability, low flash point, etc.). DoD's recent Fuel Cell Report best summarizes this point by stating that "several fundamental technologies will have to be developed before successful fuel cell propulsion... or APU... system can be developed".

In addition, there are several other technical issues relative to fuel cells, which include:

- **Efficiency** - Although functional advantages exist at the "cell" level (low thermal and audio signatures), when you consider the system's fuel efficiency and use a starting point of liquid hydrocarbon fuel (which must be reformed into hydrogen), fuel cell systems today do NOT confer greater energy efficiencies than conventional fossil fuel engines (despite media statements to the contrary).

- **Energy Density** - Developments focused on mobile power applications to date, point to the reality that practical hydrogen-based fuel cell systems do NOT offer sufficient energy density to power most military requirements. Longer-term (>3 days) missions or specialty niche applications reveal that fuel cell systems hold weight/power advantages; but the life-cycle analysis and logistical impacts of such systems in the field, have yet to be determined.

- **Environment** - Packaged fuels, such as methanol, are advantageous for soldier-borne fuel cells. But a Direct Methanol Fuel Cell (DFMC) system is not expected to reach Technology Readiness Level (TRL) 6 for two to three years... unless an aggressive program is established. In addition, in a field environment, fuel cells will be subject to battlefield contaminants, which will require engineering of components that add weight, bulk and complexity, all of which have significant impacts to the overall system. Another environmental issue that has yet to be addressed in a military environment is that fuel cells do not perform well at low temperatures.

- **Systems Engineering** - While fuel cells have been around for a long time, cost-effective fuel cell systems that produce reliable power are still TBD. The reason that is true is because from a systems engineering standpoint, there are several years of design, weight, cube, heating, cooling, environmental, and control issues that have yet to be addressed -- even for commercial systems. The Figure 5 helps to illustrate the point that the "cell or stack" is only one small part of the system - and the real challenge may be in integrating the balance of plant equipment within the size/weight limitations imposed on military equipment. In addition, if the fuel cell system has to operate at extreme temperatures and in a contaminated battlefield (dust, smoke, different ambient chemicals), degradation due to poisoning of cathode air supply must be
V. Summary
In closing, this paper was intended to provide you with a baseline understanding of the current status, recent successes and future possibilities relative to DoD’s “Other” Combat Power, which, I submit, is absolutely critical to the continued success of our warfighting forces. Although there are several Integrated Process Teams (IPTs) addressing numerous aspects of power, technical discussions of a “collaborative” nature don’t always come to closure on the key areas that largely determine when we get a capability to the field (cost, schedule, performance, force structure, training, etc.). With that in mind, I have limited my recommendations to the following two priorities:

Recommendation #1 - Initiate an effort to baseline the current force structure of generators, APUs, etc. in DoD. This could be done on a relatively small scale using a representative sample size of tactical units in each Service. The baseline would need to account for quantities of power systems, how they are allocated to meet unit requirements, any power management capabilities and supportability. The baseline would serve as the necessary input to the next logical step, which would be an Analysis of Alternatives (AoA) similar to that done for the SBCT. As an aside, it’s key to note that what I’ve just described is a different task than trying to determine the optimum power solutions for future platforms/systems.

Recommendation #2 - DDR&E should sponsor a joint technical study of Industry and DoD’s Science & Technology (S&T) and Research & Development (R&D) efforts related to Mobile Electric Power. However, to be truly value-added, such an effort would need to include developing a discrete set of operational and business case metrics, which when combined with Technology Readiness Levels (TRL), would provide a much better means to prioritize the efforts required to mature power technologies into warfighter capabilities…which at the end of the day, is what it’s all about.

Acknowledgements:
I would like to acknowledge two recognized experts in the area of Power Generation for their outstanding reviews/advice in writing this article:

Dr. James B. Cross, former Deputy Project Manager, Mobile Electric Power

Mr. Robert Crow III, Associate Director for Power & Energy and Lethality, U.S. Army Research, Development & Engineering Command

Mark W. Jones
PEO for Missiles and Space

Two of the Army's program executive offices were merged to form a new office. Both the PEO for Air, Space and Missile Defense and the PEO for Tactical Missiles were deactivated and a new office, the PEO for Missiles and Space, was activated. The new office will manage all programs formerly assigned to the deactivated PEOs. Brig. Gen. Mike Cannon was designated as the Program Executive Officer. Cannon formerly served as PEO for Tactical Missiles.

Maj. Gen. John Urias, who served as the PEO for Air, Space and Missile Defense since 1999, has been named commander of the Joint Contracting Command-Iraq and head of the Contracting Authority for Iraq. He will be leaving for his tour of duty in Iraq later in the month.

Both PEO's had been in existence in one form or another since 1992. The PEO for ASMD began as the PEO for Global Protection Against Limited Strikes. It was renamed the PEO for Missile Defense in 1993, and the name was changed to PEO for Air and Missile Defense in 1996. The latest change came in 2003 with the addition of the Army's space programs and the name was changed to PEO for Air, Space and Missile Defense.

The PEO ASMD managed the Lower Tier Air and Missile Defense Project Office, responsible for the Patriot system (including Patriot PAC-3) and the Medium Extended Air Defense System; the newly-created Cruise Missile Defense Systems Project Office, the result of a name change of the Short Range Air Defense (SHORAD) Project Office and realignment of the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS) Project Office; the Joint Tactical Ground Station (JTAGS) Project Office; the Army Space Program Office and the Army Core Space Control System Office.

In addition to managing these project offices, the PEO ASMD established two initiatives: the Single Integrated Air Picture (SIAP) and System of Systems. When combined, they will provide a more effective defense than is possible with traditional stove-piped systems.

The PEO for Tactical Missiles was formed from the PEOs for Fire Support and Close Combat Missiles and is comprised of four project offices: Aviation Rockets and Missiles, Close Combat Weapon Systems, Precision Fires Rocket and Missile Systems and Joint Common Missle; and the Non-Line of Sight Launch System Task Force.

The PEO's recent focus has been to improve current systems to maintain technological and combat superiority over potential adversaries. Tactical Missiles has also developed significant warfighting capabilities for the Future Combat System.

195 TEAMS SIGN UP TO COMPETE IN THE DARPA GRAND CHALLENGE

The Defense Advanced Research Projects Agency (DARPA) announced today that 195 teams filed applications to compete in DARPA Grand Challenge 2005. DARPA will award a $2 million cash prize to the Grand Challenge team that builds a completely autonomous ground vehicle that traveIs the fastest time in under 10 hours across approximately 175 miles of treacherous desert roads and trails. DARPA created the Grand Challenge to accelerate the development of autonomous vehicle technology to replace manned vehicles in dangerous missions and save lives on the battlefield. The Grand Challenge will be held in the southwestern United States on October 8, 2005. For additional information please visit the DARPA Grand Challenge website at www.darpa.mil/grandchallenge.

Bridging the Gap: Providing an overview of DARPA and its programs, this document also serves as DARPA's strategic plan.

MDA UPDATE NEWSLETTER WINTER 2004-5
Quarterly publication from the MDA Technology Applications Program features the most recent information on MDA technology research initiatives

Munitions Executive Summit Proceedings
February 9-11, 2005, Washington, DC

16th Annual NDIA SO/LIC Symposium & Exhibition Proceedings

Publications of interest
Directed Energy Weapons Course

Instructor: Dr. Edward Scannell, WSTIAC

Location: Huntsville, Alabama
24 February, 18 May, 10 August, 16 November 2005

Course Description:
This one-day classified short course provides an introduction to the basic principles and techniques of Directed Energy Weapons (DEWs). The technologies behind each type of DEW will be examined, and the critical path components will be identified and explored with respect to their effect on future DEW development. In addition, advantages that can be achieved by employing DEWs will be discussed, as well as the status of U.S. and foreign DE developments and deployments. The key DEW programs in High Energy Lasers and RF-DEWs or High Power Microwaves will be fully described.

This short course will be of great benefit to people who need to understand the basic concepts, technologies, design requirements and practical applications of DEWs, including program and business managers, political decision makers, engineers, scientific researchers and military personnel. An undergraduate technical degree is recommended. Mathematics is kept to a minimum, but important formulas are introduced.

Questions to be examined include:

• What is Directed Energy and what are the different types of Directed Energy Weapons?

• What are the advantages and disadvantages of each type of DEW and what are their target effects and tactical and strategic capabilities?

• How do DEWs work and what are the critical technologies that must be developed for their eventual use in practical systems?

• How may threat DEW effects be countered and how can we protect our own systems?

• What are the major U.S. and international DEW programs that are being pursued?

• What is the prognosis for future DEW development?

About the Instructor:
Dr. Edward Scannell is the Senior Program Manager of the Engineering & Technical Division, Chief Scientist for WSTIAC, and formerly Chief of the Directed Energy and Power Generation Division of the U.S. Army Research Laboratory. He has 30 years of experience in technical areas related to DEWs, including: plasma physics; conventional and alternative energy sources, electromagnetic (EM) guns, particle beam, laser, high power microwave (HPM), and pulse power physics.

Security Classification:
The information presented is kept at the unclassified level, but is designated export controlled and limited to U.S. citizens only. The security classification of this course is UNCLASSIFIED.

Training at Your Location:
WSTIAC can conduct this course at your location to reduce your travel time and cost. Please call Mrs. Kelly Hopkins to discuss.

Fee:
$700.00 for government personnel; $800.00 for government contractors.

Handout Material:
Each student will receive a comprehensive set of course notes covering the material presented.

For additional information, contact:
Mrs. Kelly Hopkins, Seminar Administrator, at (256) 382-4747, or by e-mail khopkins@alionscience.com

Notice: WSTIAC reserves the right to cancel and/or change the course schedule and/or instructor for any reason. In the event of a schedule change or cancellation, registered participants will be individually informed.
Introduction to Sensors and Seekers for Smart Munitions and Weapons Course
Instructor: Mr Paul Kisatsky, WSTIAC
Location: Huntsville, Alabama
19-21 April, 7-9 June, 18-20 October, 6-8 December 2005

Course Description:
This 3-day short course provides an introduction to the most commonly used sensors and seekers employed in smart munitions and weapons (projectiles, missiles and wide area mines). It is oriented to managers, engineers, and scientists who are engaged in smart weapons program development and who desire to obtain a deeper understanding of the sensors they must deal with, but who do not need to personally design or analyze them in depth. An undergraduate technical degree is recommended. Mathematics is kept to a minimum, but important formulas are introduced. This course also provides an excellent foundation for those scientists and engineers who desire to pursue this discipline to intermediate and advanced levels.

The course covers:
- Classification of seekers and sensors
- Fundamentals of waves and propagation
- Fundamentals of noise and clutter
- Fundamentals of search footprints
- Introduction to infrared
- Introduction to radar
- Introduction to ladar
- Introduction to visionics
- Introduction to acoustics
- Future projections and interactive brainstorming

Noise and clutter, the predominant obstacles to success in autonomous seekers, are given emphasis. The major sensor types are classified and each is discussed. In particular, infrared, radar, optical laser radar (ladar), imaging and non-imaging, and acoustic sensors are individually covered. Of special interest is the discussion on human visionics versus machine recognition, since this concept is of central importance to understanding autonomous versus man-in-the-loop sensing systems. The implications of "artificial intelligence", "data fusion", and "multi-mode" sensors are also briefly discussed. System constraints, which force tradeoffs in sensor design and in ultimate performance, are also covered. Time permitting, a projection of future trends in the role of sensors for smart munitions will be presented, followed by a "brain-storming" session to solicit student views.

About the Instructor:
Mr. Paul Kisatsky is a Senior Physical Scientist. He is a nationally recognized expert on sensors and seekers for smart munitions and weapons and has more than 30 years of hands-on experience developing sensors and seekers fielded in modern smart munitions and weapons.

Security Classification:
This course is unclassified.

Training at Your Location:
WSTIAC can conduct this course at your location to reduce your travel time and cost. Please call Mrs. Kelly Hopkins to discuss.

Fee:
The registration fee for this 3-day course is $950 for U.S. government personnel and $1150 for government contractors. Contractor teams of 3 or more, registered at the same time, are charged $950 per person.

Handout Material:
Each student will receive a comprehensive set of course notes covering the material presented.

For additional information, contact:
Mrs. Kelly Hopkins, Seminar Administrator, at (256) 382-4747, or by e-mail khopkins@alionscience.com

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Weaponeering Course

Instructor: Professor Morris Driels, US Naval Postgraduate School

Location: Huntsville, Alabama
29-31 March, 21-22 June, 4-6 October, 29 November - 1 December 2005

Course Description:
This 2½-day short course is based on a very successful graduate-level weaponeering course developed by Professor Driels and taught at the Naval Postgraduate School (NPS), Monterey, CA. The course will provide an overview of the fundamentals of the weaponeering process and its application to air-to-surface and surface-to-surface engagements. The course explains the analytical basis of current weaponeering tools known as the Joint Munitions Effectiveness Manuals (JMEMs) produced by the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME). The JMEMs are used by all Services to plan offensive missions and allow the planners to predict the effectiveness of selected weapon systems against a variety of targets.

The short course is divided into three parts.

Part I covers the basic tools and methods used in weaponeering:
- The weaponeering process
- Elementary statistical methods
- Weapon trajectory
- Delivery accuracy of guided and unguided munitions
- Target vulnerability assessment

Part II covers the weaponeering process for air-launched weapons against ground targets:
- Single weapons directed against point and area targets
- Stick deliveries (point and area targets)
- Projectiles (guns and rockets)
- Cluster munitions
- Weaponeering for specific targets: bridges, buildings, etc.
- Collateral damage modeling

Part III covers the weaponeering process for ground engagements:
- Indirect fire systems - artillery and mortars.
- Direct fire systems - infantry and armored vehicles.

About the Instructor:
Professor Driels is a Professor of Mechanical Engineering at the U.S. Naval Postgraduate School in Monterey, California. He has worked with the JTCG/ME on a variety of topics in support of the JMEMs for a number of years. He has taught a quarter-long weaponeering course at NPS for three years and he has published a textbook on the subject.

Security Classification:
The security classification of this course is UNCLASSIFIED.

Training at Your Location:
WSTIAC can conduct this course at your location to reduce your travel time and cost. Please call Mrs. Kelly Hopkins to discuss.

Fee:
The registration fee for this 2½-day course is $950 for U.S. government personnel and $1150 for government contractors. Contractor teams of 3 or more, registered at the same time, are charged $950 per person.

Handout Material:
Each student will receive a comprehensive set of course notes covering the material presented.

For additional information, contact:
Mrs. Kelly Hopkins, Seminar Administrator, at (256) 382-4747, or by e-mail khopkins@alionscience.com

Notice: WSTIAC reserves the right to cancel and/or change the course schedule for any reason. In the event of a schedule change or cancellation, registered participants will be individually informed.
Smart/ Precision Weapons Course

Instructors: Mr. Hunter Chockley and Mr. Mark Scott, WSTIAC

Location: Huntsville, Alabama

1-3 March, 24-26 May, 26-28 July, 13-15 September, 1-3 November 2005

Course Description:
This 2½-day short course provides a comprehensive understanding of smart weapons and related technologies. This course is aimed at providing general knowledge about smart weapons technology and a source of current information on selected U.S. and foreign smart weapons, to include system description, concept of employment, performance characteristics, effectiveness and program status.

A variety of ground, sea and air smart/precision weapon systems are discussed, to include fielded and/or developmental U.S. systems such as Joint Direct Attack Munition (JDAM), Joint Air-to-Surface Standoff Missile (JASSM), Small Diameter Bomb, Javelin, Line-of-Sight Anti-Tank (LOSAT), XM982 Excaliber, Extended Range Guided Munition (ERGM), Common Missile, Tomahawk, Standoff Land Attack Missile - Expanded Response (SLAM-ER), Cluster Bomb Munitions and Airborne Laser, among others, as well as representative foreign smart/precision weapons.

The objective of this course is to inform materiel and combat developers, systems analysts, scientists, engineers, managers and business developers about smart/precision weapons, to include:

- State-of-the-art of representative U.S. and foreign smart weapons systems;
- Employment concepts
- Smart weapons related systems, subsystems, and technologies; and
- Technology trends.

About the Instructors:
Mr. Mark Scott and Mr. Hunter Chockley are Science Advisors. Each instructor has more than 25 years of experience with weapons technology and/or smart/precision weapons.

Security Classification:
The information presented is kept at the unclassified level, but is designated FOR OFFICIAL USE ONLY (FOUO), export controlled, and attendance is limited to U.S. citizens. The security classification of this course is UNCLASSIFIED.

Training at Your Location:
WSTIAC can conduct this course at your location to reduce your travel time and cost. Please call Mrs. Kelly Hopkins to discuss.

Fee:
The registration fee for this 2½-day course is $950 for U.S. government personnel and $1150 for government contractors. Contractor teams of 3 or more, registered at the same time, are charged $950 per person.

Handout Material:
Each student will receive a comprehensive set of course notes covering the material presented.

For additional information, contact:
Mrs. Kelly Hopkins, Seminar Administrator, at (256) 382-4747, or by e-mail khopkins@alionscience.com

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Upcoming Conferences and Courses

March 2005
21-22 March 2005
Defense 2005
Washington, DC
For additional information:
http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=1154

21-24 March 2005
Net Centric Operations, Interoperability & Systems Integration Conference
Norfolk, VA
For additional information:
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10TDO CO &MID=5120

22-23 March 2005
UAV Summit: Combat and Micro
Washington, DC
For additional information:
http://www.iqpc.com/cgi-bin/templates/singlecell.html?topic=221&event=6318

28-31 March 2005
Joint Undersea Warfare Technology Conference
San Diego, CA
THIS CONFERENCE IS CLASSIFIED SECRET U.S. ONLY
For additional information:
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10X40W5&MID=5260

28 March-1 April 2005
Defense and Security Symposium 2005
O rlando FL
For additional information:
http://spie.org/conferences/programs/05/dss/

April 2005
5-7 April 2005
49th Annual Fuze Conference
Seattle, WA
For additional information:
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10TDO CO &MID=5560

7 April 2005
Strike, Land Attack & Air Defense Division Annual Symposium
Laurel, MD
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10TDO CO &MID=5100

11-15 April 2005
3rd Missile Defense Conference & Exhibit
Washington, DC
For additional information:
http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=1133

19-20 April 2005
Military Robotics
Washington, DC
For additional information:
http://www.iqpc.com/cgi-bin/templates/singlecell.html?topic=221&event=6414

19-21 April 2005
6th Annual Science and Engineering Technology Conference
North Charleston, SC
For additional information:
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10TDO CO &MID=5720

25-28 April 2005
40th Annual Armament Systems: Gun - Ammunition - Rockets - Missiles (G ARM ) Conference & Exhibition
New Orleans, LA
For additional information:
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10TDO CO &MID=5590

2-5 May 2005
2005 Joint Service Power Expo
Tampa, Florida
For additional information:
http://register.ndia.org/interview/register.ndia?PID=Brochure &SID=_1G10TDO CO &MID=5670

3-5 May 2005
Joint Electronic Warfare Conference (JEWC)
Monterey, CA
For additional information:
https://jewc.mugu.navy.mil/purpose.asp

9-12 May 2005
IEEE International Radar Conference
For additional information:
http://www.radar05.org/

18-20 October 2005
Weapon System Effectiveness
Austin, TX
Classified - U.S. Only
http://www.aiaa.org/content.cfm?pageid=230&lumeetingid=1242&viewcon=submit
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