

Energy Magazines for Directed Energy Weapons and Back-up Power

IQPC Directed Energy Summit 2018

Don Klick, Leonardo DRS Naval Power Systems, Director Business Development

June 27, 2018

Carlos Aguirre, Leonardo DRS Land Electronics, Senior Manager Business Development



Leonardo: We Are A Global Company

More than 218 Sites Worldwide*

TOTAL WORKFORCE	47,156
ITALY	29,853
UNITED KINGDOM	7,321
USA	5,969
POLAND	3,043
REST OF THE WORLD	970



A Leading Global Partner for Defense, Aerospace & Security Solutions

*Industrial Legal Entities, Partnerships (JVs-Consortia), Branch and Representative Offices Shown.

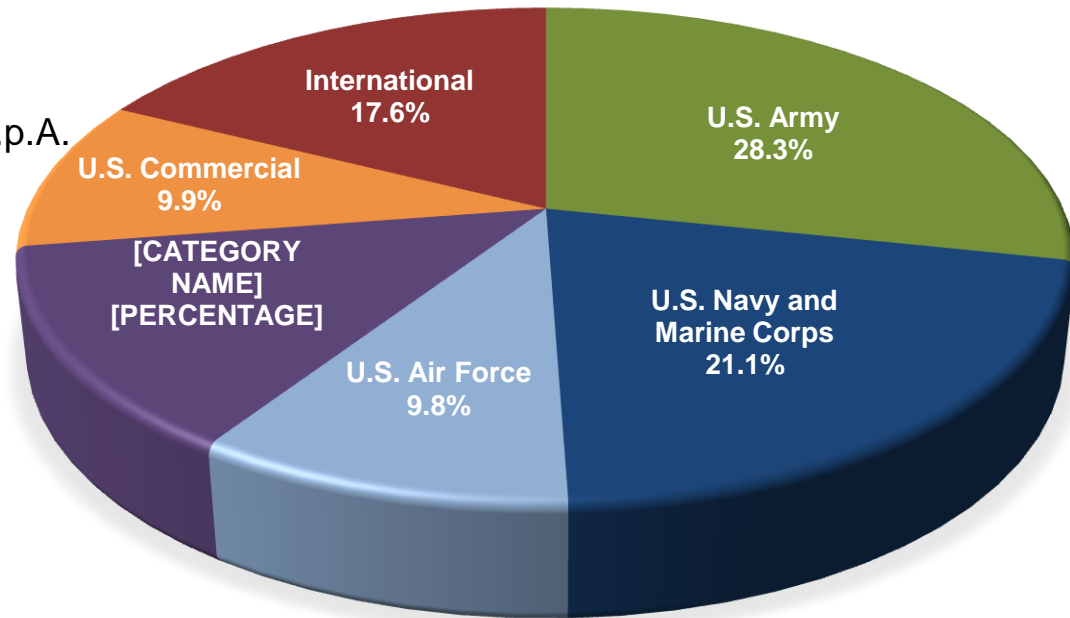


An Overview of Leonardo DRS



A leading technology innovator and supplier of integrated products, services and support to military forces, intelligence agencies and prime contractors worldwide

- A wholly owned subsidiary of Leonardo S.p.A.
- Headquartered in Arlington, Virginia
- \$2B+ Revenue
- We are organized into eight customer-focused lines of business
 - Airborne and Intelligence Systems
 - Daylight Solutions
 - Electro-Optical and Infrared Systems
 - Global Communications and Security
 - Land Electronics
 - Land Systems
 - Naval Electronics
 - Naval Power Systems

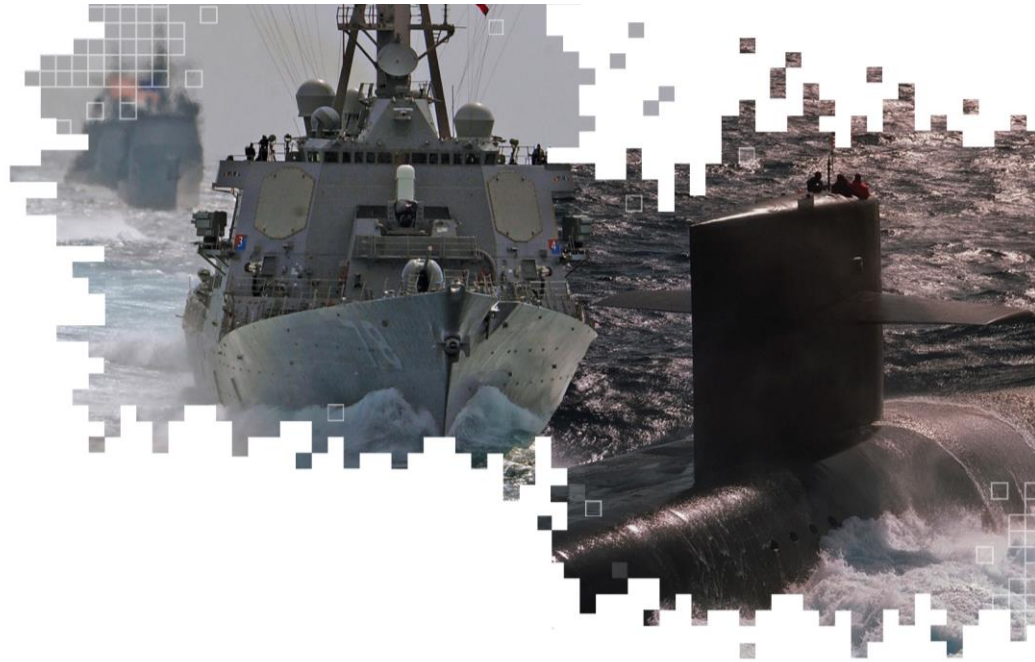


**2015 – 2019
Business Mix By Customer**

Naval Power Systems

As a trusted provider of naval power and control technology we deliver quality, customer-focused products and support solutions for the U.S. Navy and our allies. Our products meet stringent specifications and have been proven to perform in harsh marine environments.

We also provide power & control solutions for other applications including power plants, oil and gas drilling, and electric vehicles.



Milwaukee, WI



Power Conversion, Control & Distribution

Power storage, low & medium voltage power distribution and modular power solutions for ship & submarine platforms

Danbury, CT



Naval Nuclear Instrumented Control Systems

Trusted provider of critical naval instrumentation and controls for nuclear submarines & aircraft carriers

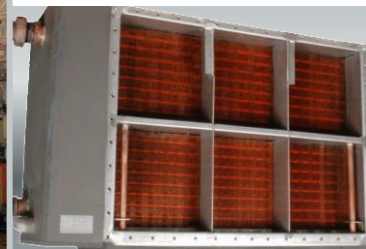
Fitchburg, MA



Machines for Electric & Hybrid Electric Platforms

Motors, generators & drives for demanding applications ranging from small pump motors to 36.5 MW PM ship propulsion motors

High Ridge, MO



HVAC & Refrigeration

One of the U.S. Navy's largest suppliers of shipboard heating / cooling coils, air handling units, product coolers and refrigeration plants



Gas Turbine Packaging

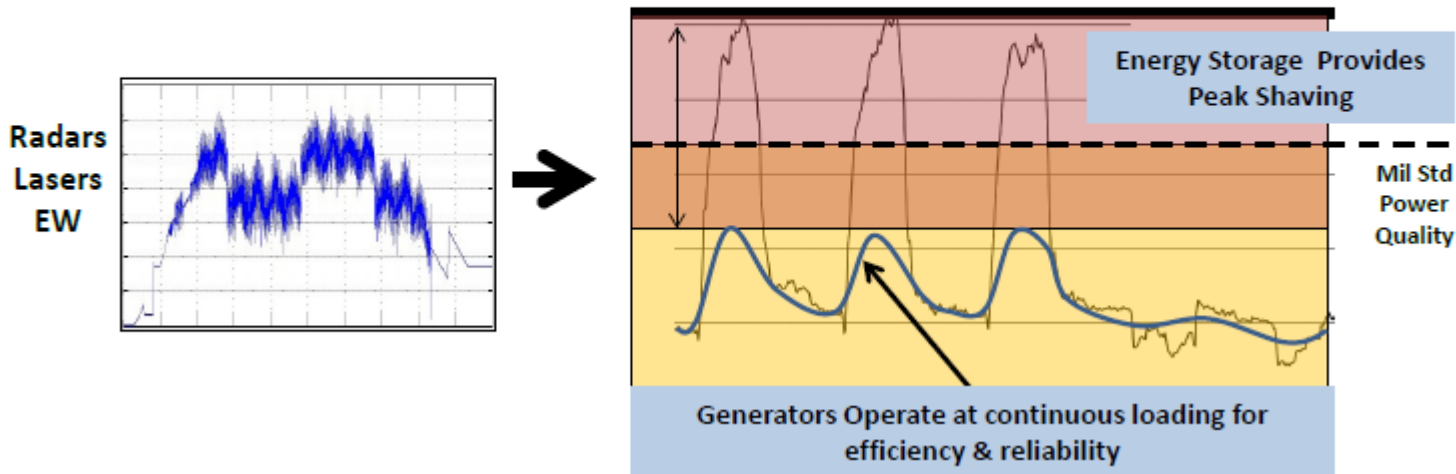
As a full-service equipment packager we have provided packaging for major engine manufacturers for service in naval and ground power applications around the world



Navy Directed Energy Weapons: Need for Energy Magazines

- Ship electrical generators source pulse loads < 2 MW/second per MIL-STD-1399
- Directed Energy Weapons and Sensors provided power at 650 VDC
- Multiple high-power DE weapons and sensors create a stochastic composite load profile:

*The Power System Challenge NOW:
Support High Power Mission Systems*



Energy Magazines for Current US Navy Ships

The Challenge NOW: Putting New Systems on Current Ships

Electric Ships Office
320
Directing the Future of Ship Power

SSL
AMDR X
Active Denial
EASR
SEWIP
EMRG
CPES OIPT

Power Magazine
Lasers
EW
EM Railgun

Power System is the Foundation of the Kill Chain

Approved for public release. Distribution is unlimited.

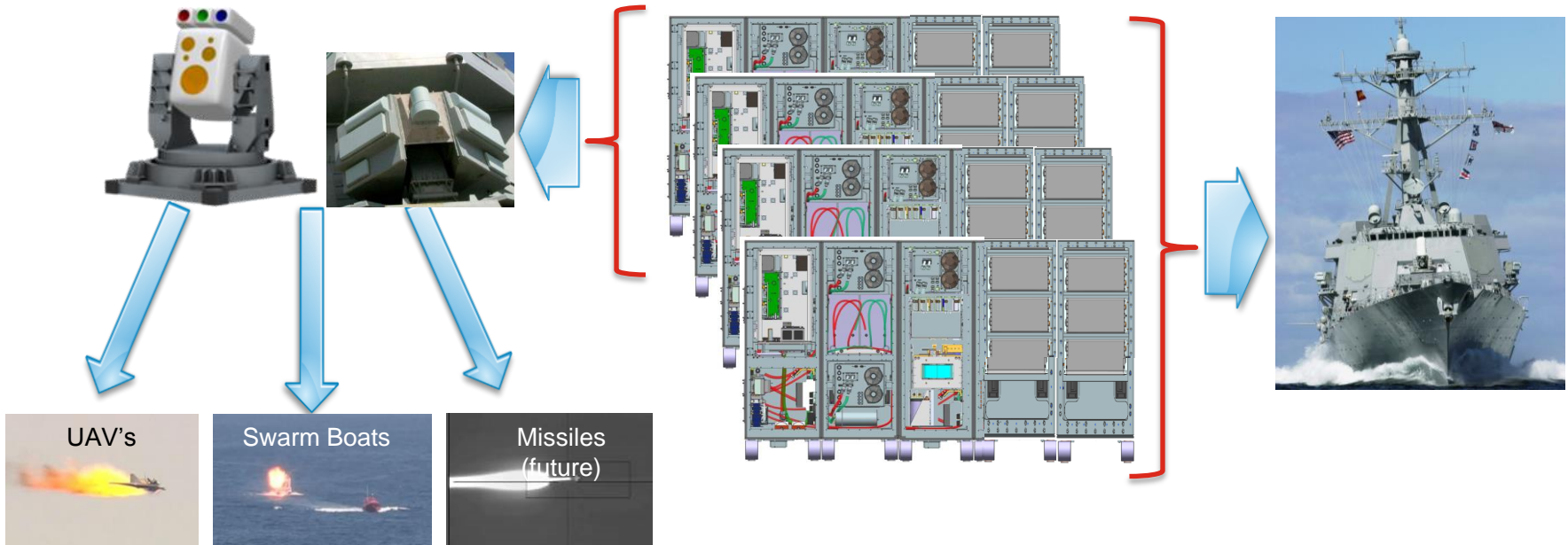
DDG 51 Energy Magazine – Modular, Multi-output, Cabinets

Pulsed Power Weapons/Sensors

- Lasers
- SEWIP
- Radars

Ship Stable Backup Power:

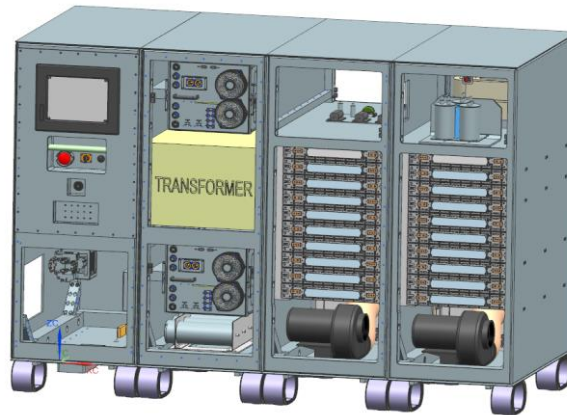
- Single Generator Operations
- Peak Shaving



Energy Magazine-Laser Prototype Demonstrator

Energy Magazine Capability:

- 660kW of 650 VDC, galvanically isolated output; 50% five second duty cycle for 4 minutes
- Air-Cooled LFP batteries
- Recharge to full power in 53 minutes with 450VAC power input



- Successfully validation tested at DRS September 2017
- Shipped to US Navy at FSU CAPS for system testing
 - Successfully completed November 2017
 - Navy demonstration test completed January 2018

Proven capability for ship installation

Energy Magazine Evolution

EM-Laser

LFP Batteries

- 1000 VDC output (dual stacks)
- Air Cooled Design
- 71 kW-hr (256MJ) total



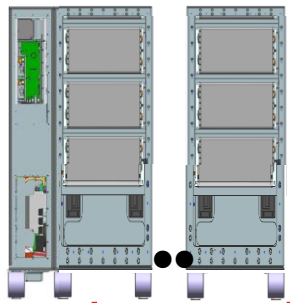
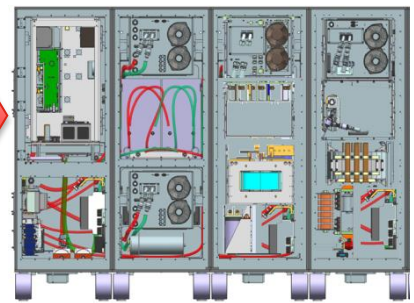
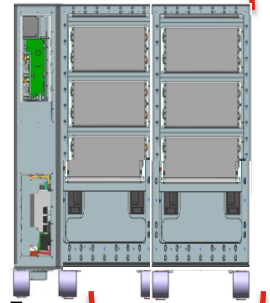
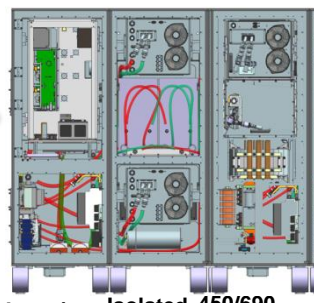
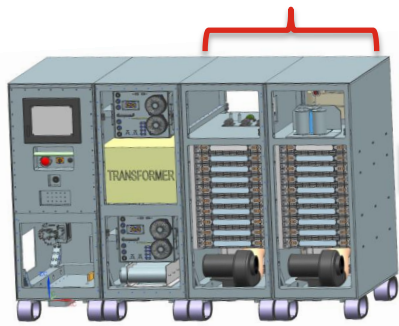
EM-Laser Plus



EM-Mark II

LFP Batteries

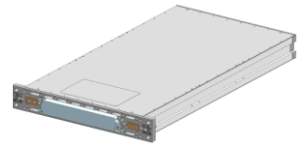
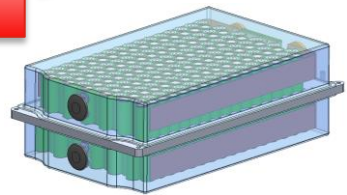
- 1000 VDC output in each stack
- Liquid Cooled Design
- 71 kW-hr (256MJ)



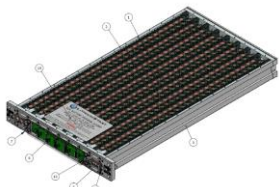
Input/Control Isolated 450/690 VDC VAC AFE Bi-directional Energy Storage Control

Input/Control Isolated 450/690 VDC VAC AFE Non-Iso. 300-650VDC Energy Storage Control

Hybrid Storage Options:
Capacitors, Batteries



Control Drawers: 70 lbs



Battery Drawers: 105 lbs
18 @ 16S30P

Design Compliant to:

- MIL-STD-1399, Section 300B, Input Power Quality
- MIL-STD-167-1, Type I, Vibration
- MIL-STD-741-1 Airborne Noise
- MIL-STD-741-2 Structure-borne Noise, Type III
- MIL-STD-461F, EMI
- DDS-072-1/ -5, Grade A Shock
- DOD-STD-1399-70-1 Magnetic DC Field
- NEMA IEC 60529, IP54 Enclosure
- NAVSEA S9310-AQ-SAF-010/ SG270-BV-SAF-010
- DOD Directive 8500.01/02 Information Assurance Options

Battery Modules: 120 lbs
24 @ 24S16P

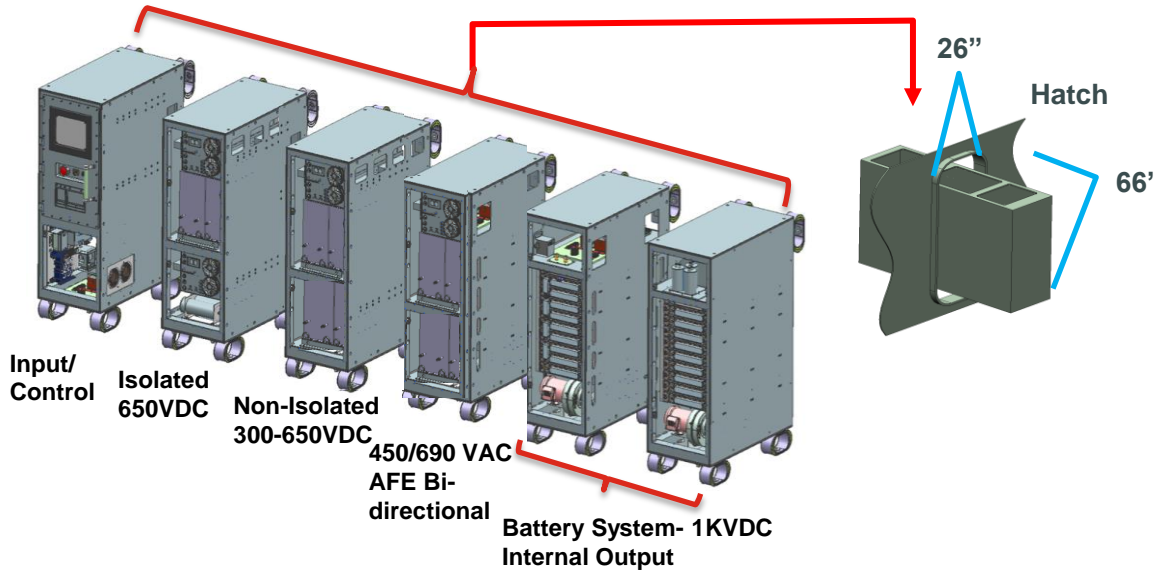
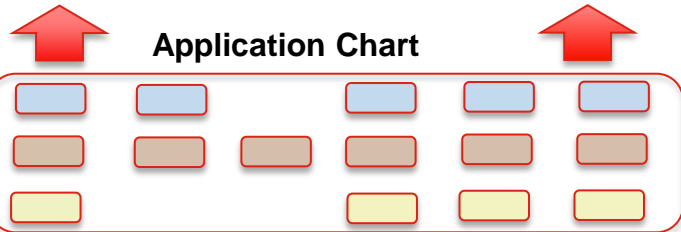
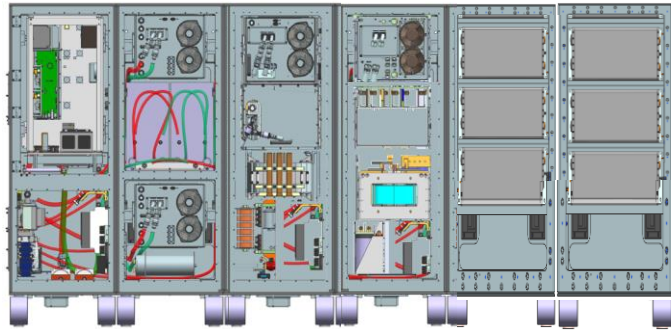
**EaglePicher™
Technologies, LLC**

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Technologies, LLC**

Statement A: Approved for Release. Distribution is unlimited. Per NAVSEA 00D #2016-0690

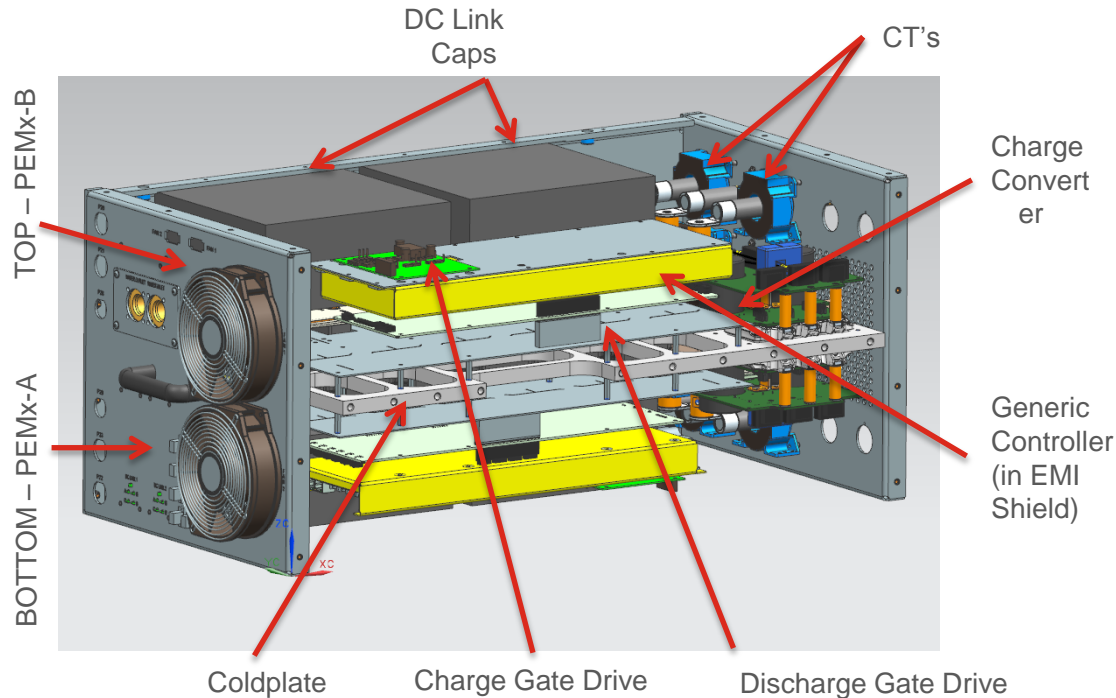
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Energy Magazine: Modular, Hatch-able, Adaptable



	Power / Duration	Duty Cycle	Recharge Time	Output Voltage	Discharge Cycles	Galvanic Isolation	Cabinet Size
EM-Pulse Power-Limited	660kW / 4 Minutes	Notional 50% 	< 15 min (10 Min.)	650VDC Galvanic Isolation	>1000	AC-DC; DC-AC	48" D x 66" H x 125" W
EM-Pulse Power-Continuous	900kW / Continuous	Stochastic 	Continuous	650VDC; Isolated & Non-isolated	N/A	AC-DC; DC-AC	48" D x 66" H x 150" W
EM-Stable Backup Power	750kW / 3 Min.	100% Continuous	< 15 min. (10 Min.)	450/690 VAC, 60 Hz	> 250	AC-DC; DC-AC	48" D x 66" H x 125" W

Power Electronic Module (PEM) Model: Dual Power Module



Redundant Power Modules @ 450kW each: 900 kW total @ 440Vac

Redundant power module: building block for critical mission weapons

Land Electronics

Leonardo DRS provides world class cyber hardened network & tactical computing for C4I and integrated situational awareness. Provides state of the art embedded diagnostics, vehicle power management and combat vehicle integration products and services.

- Cyber Secure Network & Tactical Computing Solutions
- Battlefield Management & Situational Awareness
- Vehicle integrated Test & Diagnostics
- Depot Level Test & Diagnostics
- Power Generation, Distribution & Management
- Avionics/EW Test Equipment



Huntsville, AL



Platform Computing

Integrated computer & display systems for enhanced SA on the battlefield



Platform Electronics

Integrated Mission Systems for enhanced situational awareness on the battlefield



Test & Diagnostics

Diagnostic & data acquisition systems for domestic and foreign combat vehicles



Operational Energy

Providing tactical battlefield power, when and where it is needed

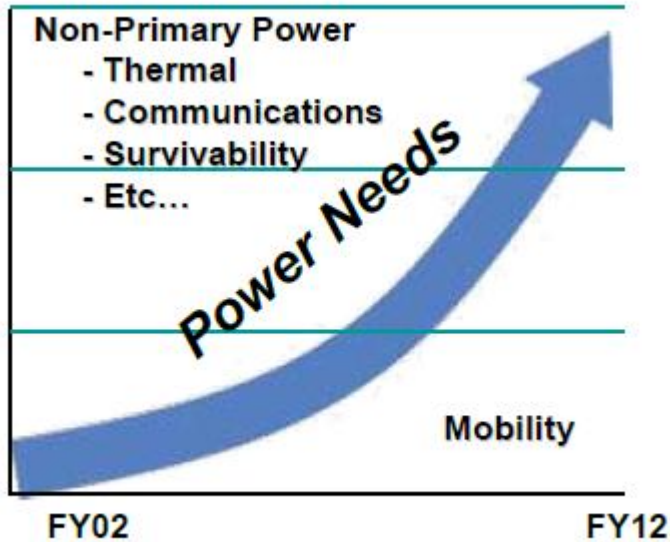


Flight Line Equipment

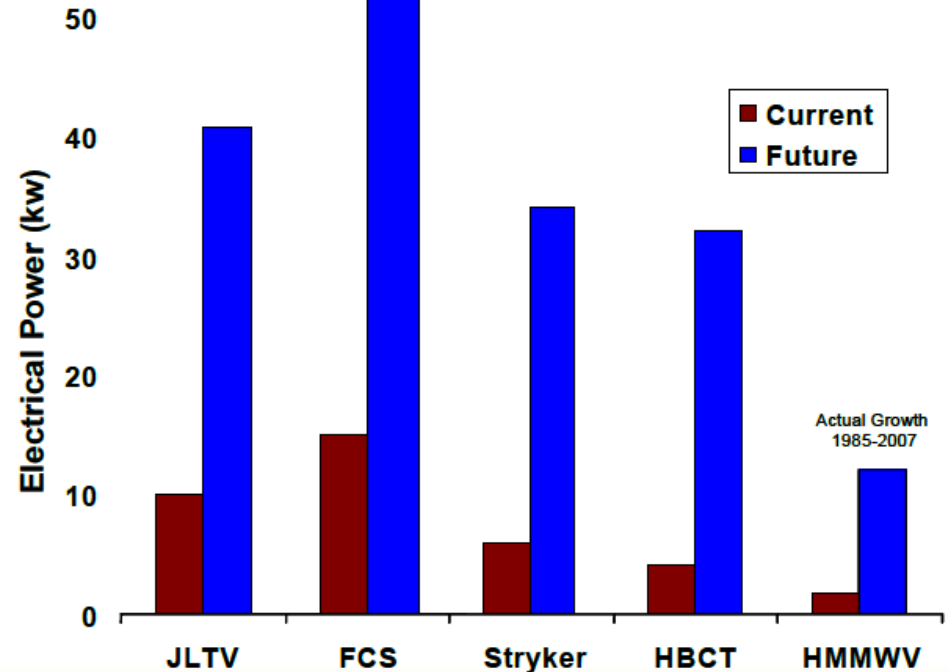
Providing verification of installed Electronic Warfare equipment at factory and prior to mission

Joint Light Tactical Vehicle Power Requirements Study

24 April 2007



**Non-Primary Power
Estimated Electrical Power Growth**



THEN

Ms. Jennifer Hitchcock
Associate Director of Ground Vehicle Power and
Mobility TARDEC

NOW

Dr. Jennifer Hitchcock, SES
Executive Director, Research, Technology &
Integration
TARDEC

Shortage of a System of System Requirement(s)(1 of 2) PEO C3T - 2013

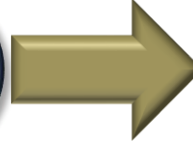
Consumer of Tactical Vehicles and Tactical Power



Too many trailers to tow!
Too many generators to set up!



GAP



Requirements for Tactical Vehicles

- Requirement only for Tactical Vehicles
- Truck mounted tactical power not a requirement
- Power is not my problem

Requirements for Tactical Power on a Tactically Mobile Vehicle (OBVP)

Requirements for Tactical Power

- Requirement only for trailer mounted tactical power
- Truck mounted tactical power not a requirement
- Vehicles are not my problem

Army needs to develop requirements for OBVP

Combat Vehicle Power Gap

19 January 2017

POSITION PAPER

SUBJECT: Maneuver Center (MCoE) position on combat vehicle power and energy

1. MCoE position: Current levels of combat vehicle power and energy do not support the Brigade Combat Team (BCT) required capability to perform semi-independent operations nor to integrate combat vehicle technologies requiring additional power. To meet these capabilities requires a mid-term objective of a 50% increase in available power and a 100% increase in energy on each combat vehicle. The long term objective is an order of magnitude increase in power and orders of magnitude increase in energy.

Prepared by: COL Willie Nuckols

Approved by: MG Eric Wesley

Operational Energy (OBVP Product Timeline)



DRS has over 30 years in hybrid drive and vehicle power systems

OBVP Supported Platforms



Stryker



HMMWV

OBVP Medium Truck

- ✓ Allison 3000 series Transmission
- ✓ 50 - 60 kW @ Engine Idle
- ✓ 120kW @ ~ 2000 RPM



MRAP

OBVP HMMWV, 1100 series

- ✓ 4L80E Transmission / OBVP
- ✓ 10 kW @ Engine Idle
- ✓ 30kW @ ~ 2000 RPM

FTMV



OBVP Heavy Truck (Future)

- ✓ Allison 4500/4700/4800 Transmission
- ✓ 50 - 60 kW @ Engine Idle
- ✓ 120kW @ ~ 2000 RPM

SMDC HEL MD



THAAD Launcher

OBVP Enables Modernization Options



DRS OBVP Provides

- ✓ 50 - 60 kW @ Engine Idle or On The Move
- ✓ 120kW @ ~ 2000 RPM
- ✓ On-Board & Export Power, AC/DC
- ✓ Shore power capability during engine-off operations

Enabling Power for Every Mission

- ✓ Network, C4ISR, Radars, Sensor, Shooter, Counter IED, Survivability
- ✓ C-UAS / C-RAM / HE Laser / HP Microwave
- ✓ Exportable Power (TACs, TOCs, COPs, Launchers, Fire Control Stations, Ground Control Stations, Aviation Support Equipment, Field Hospitals...)

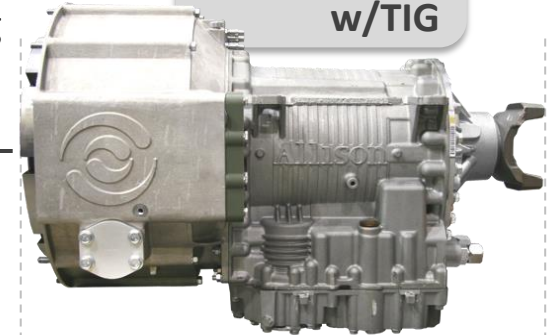
Enabling multiple Vehicle Modernization platforms

- ✓ Maintains existing vehicle's drive line configuration
- ✓ One for One vehicle transmission swap

Reducing Logistics Footprint

- ✓ Increased Power Output with Reduced Convoy Footprint
- ✓ Opens pintles for towing Water, Food, Ammo, Fuel – option to drop trailers from load plan for expeditionary operations
- ✓ Supplying Power In austere environments without burden of towed generators
- ✓ TARDEC V2G Study = 23% fuel savings over TQGs (Jul 2016)

**3200MSG
Transmission
w/TIG**



**3200SP
Standard
Transmission**

← 32.36 in (822.0 mm) →

OBVP Technology Employed at US Army NIEs

MiCP w/ OBVP		MCOTM w/ OBVP	
Description	Qty	Description	Qty
Miles:	135139	Miles:	352
OBVP run hours:	3422.1	OBVP run hours:	1256.8
as of 30 July 2014			
Total OBVP Hours:	4678.9	(constant run intervals)	
Weeks of operation:	116.97	(divide by 40 hrs)	
Days of operation:	194.95	(divide by 24 hrs)	
Major OBVP issues:	0	(zero failures)	
Major Engine issue:	0	(zero failures)	
Engine oil change	1		
Oil lubricity change	0.50%	(Per AOAP)	

The TIG system has been operated at multiple US Army NIE events and wet stacking was a question on the mind of the reviewers.

As evident above, TIG equipped vehicles have operated over several thousand hours and exhibited no wet stacking issues.

OBVP controls are CAN enabled and communicate with the vehicle engine to control engine speed based on load demand; mitigating any wet stacking issues.





Questions ?

INTERESTED IN ATTENDING?

Future weapons, including directed energy weapons have been in the Research & Development phase for the past several years. As the US armed forces, continue to develop and innovate in order to achieve battlefield overmatch and superiority, the Directed Energy weapon systems are making their way from the R&D phase to DoD and Military programs as the next step before acquisition and force integration.

Over the three-day summit we will examine the latest DE advancements, initiatives and plans regarding technology, acquisition and service roadmaps. This event will bring together thought leaders, acquisition executives, industry solution providers, and academia in order to tackle some of the challenges that face this community in the near, mid, and far term fight. We will look to gain insight and lessons learned from warfighter perspectives on the operational challenges and requirements of DES that will influence the capabilities of this game-changing technology.

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