



UNCLASSIFIED: Dist A. Approved for public release.



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Ground Vehicle Power & Mobility Overview for
For Japan TRDI
15 Mar 10

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 15 MAR 2010	2. REPORT TYPE N/A	3. DATES COVERED -	
4. TITLE AND SUBTITLE Ground Vehicle Power & Mobility Overview for For Japan TRDI		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA		8. PERFORMING ORGANIZATION REPORT NUMBER 20611RC	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) TACOM/TARDEC	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) 20611RC	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited			
13. SUPPLEMENTARY NOTES The original document contains color images.			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	
19a. NAME OF RESPONSIBLE PERSON			



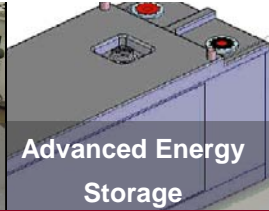
JP-8 Reformer



Engine Testing



Air Cleaner Testing



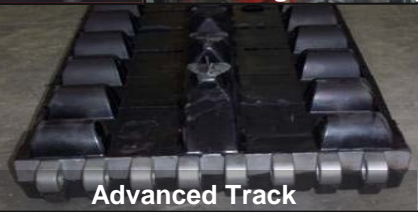
Advanced Energy Storage



Power and Energy SIL



Engine / Generator Test Lab



Advanced Track



Transmission Testing



Air Conditioning Test



Auxiliary Power Units



Engine Research

VISION:

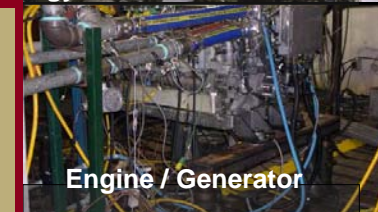
To be the **Best in the World** at determining and delivering the **Best Integrated Power, Energy and Mobility Solutions** for the Joint Warfighters' needs; and to be the Army's recognized **"focal point"** for **Power, Energy and Mobility Technology** expertise and the **GVPM Technology Systems Integrator** for the current and future force ground vehicle systems.

MISSION:

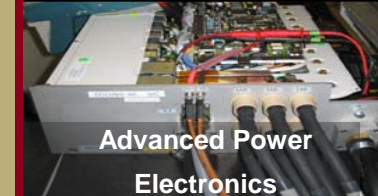
To **research, develop, test, validate and integrate** the right **Power, Energy and Mobility** technology solutions to **provide superior capabilities** for the current and future force ground system forces.



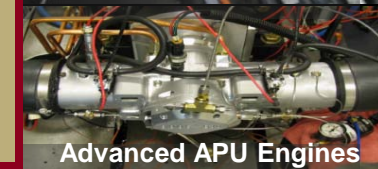
Unclassified



Full Load Cooling Test



Advanced Power Electronics



Advanced APU Engines



Integrated Power and Thermal Systems



APU Testing & Analysis



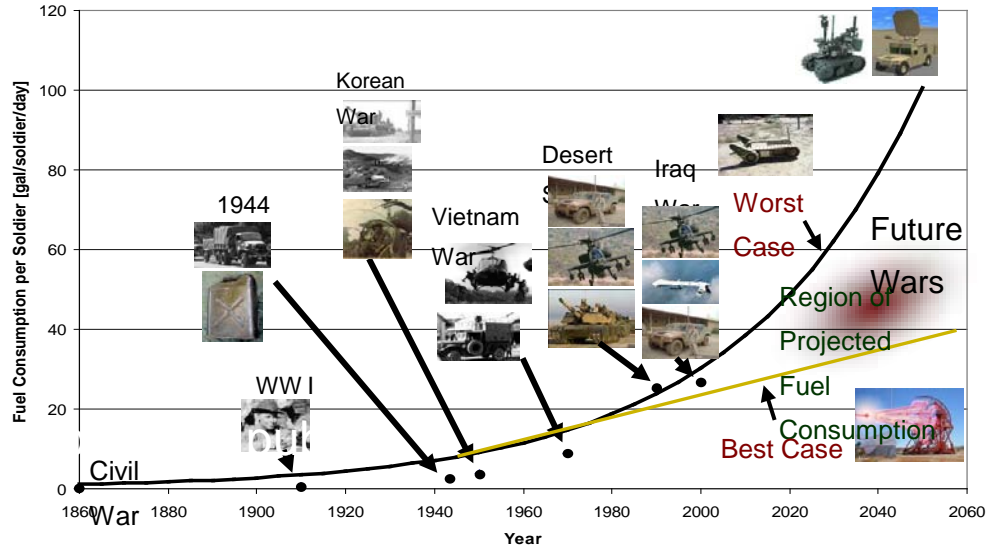
Elastomer Research



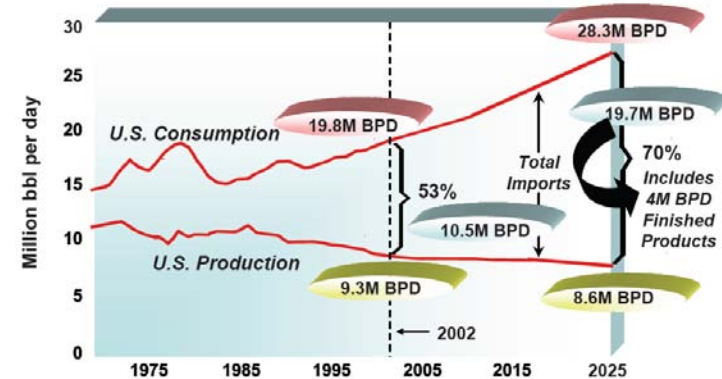
Energy Storage

The Challenges

- Battlefield consumption of energy increasing
 - New C4ISR technologies
 - IED Defeat Systems
 - New weapons
- Energy security problematic
 - Increasing dependence on foreign oil
 - Alternative sources sought -- wind, solar, bio-mass, waste to energy
- Operational issues
 - Battery usage & limitations – energy & power density
 - Demand for auxiliary power on-board vehicles
 - Emphasis on silent (“quiet”) watch
 - Unmanned vehicles (air/ground)
 - Unattended sensors
 - Inefficient management/ distribution of power
 - Demand for soldier-wearable power
- Increased emphasis on system power metrics (KPPs, low consumption components)



The US: Our Increasing Reliance on Fossil Energy Imports



Power Generation	Diesel Engines Rotary Engines Transmissions Traction Motors JP-8 Fuel Cells Integrated Starter Generator Turbine Engines Alternators Drivelines
Energy Storage	Li-Ion / Ultracap Hybrid Energy Storage Capacitors Advanced Batteries Fuels
Thermal Transport & Distribution	Radiators Thermal Interface Materials Heat Recovery Phase Change Cooling Advanced Electronics Cooling Thermal Architectures
Power Control & Distribution	Power Controllers for Power Management Power Converters/Inverters Wide Band Gap Materials (SiC) High Temperature SiC Modules Pulse Power Switching High Temp Inductors High Temperature Capacitors
Track & Suspension	Track Systems Suspension Systems Electronic Stability Control Elastomer Research

- **High power and temperature capable Power Electronics.**
- **Advanced component and system Thermal Management systems.**
- **Advanced component and system Power Management systems.**
- **Military adaptable, high power density, efficient, Diesel Engines.**

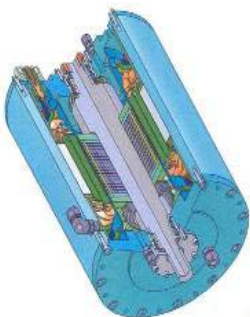


Problem:

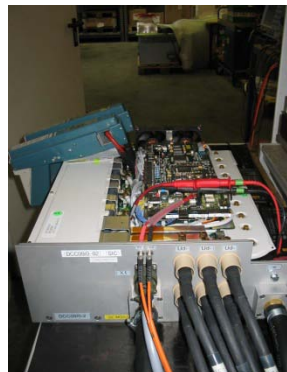
- Hybrid electric systems for combat and tactical vehicles are challenged to meet mobility requirements within the specified space and weight constraints
- The State Of the Art power electronics operate at low temperatures resulting in a large thermal burden, increasing the power needed from the prime mover to cool the system
- These challenges result in over sizing the engine/generator to gain power lost to the cooling system

Research Challenges:

- Research high temperature / high frequency compact power electronics
- Research high power / high torque density motor / generators



Traction Motor



DC-DC Power Converter



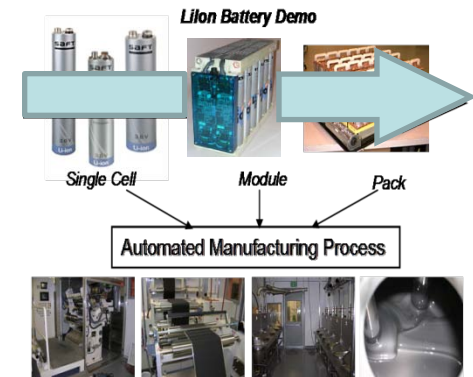
Integrated Starter Generator

Problem:

- High power battery packs sized for combat hybrid electric vehicles are too large or extremely costly.
- High power advanced batteries for combat hybrid vehicle application must be safer and more reliable.

Research Challenges:

- Research thermal runaway process and its control.
- Research power vs. energy trade-off design optimization.
- Research manufacturing process development and cost control.
- Research thermal management.
- Research cell & system, safety & reliability.
- Research system control & cell and battery management systems.
- Research alternative electrochemical improvements, including alternative chemistries and battery materials.

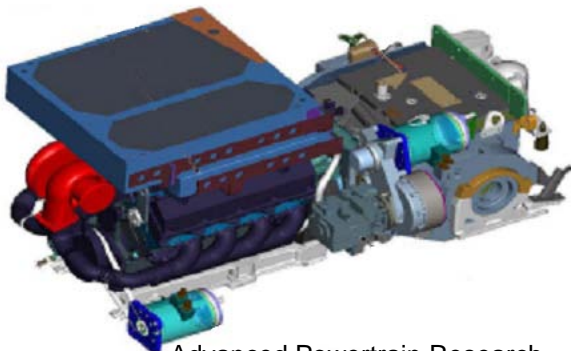


Problem:

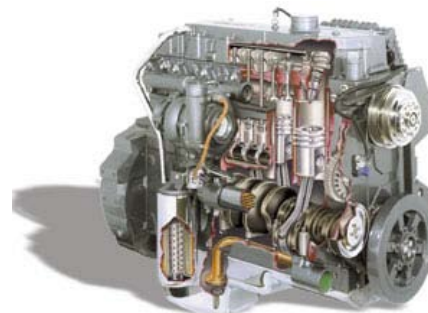
- Current high power commercial engines/powertrains are not compact enough for future manned ground combat platforms.
- Future ground combat vehicles will require lighter and more efficient powertrains that occupy less space, improve vehicle mobility, reduce fuel consumption and thermal load.
- Current state of the art engines require development to operate on one fuel forward (JP-8) and meet future vehicle power and mobility needs.

Research Challenges:

- Diesel combustion research to decrease physical burn time.
- Propulsion system research to increase power density and efficiency.
- Propulsion system thermal management research.
- Research combustion optimization strategy for JP-8 military version of an emission compliant commercial. Engine control strategy for maintaining power with alternative heavy fuels.



Advanced Powertrain Research
And Development



Advanced Engine Research



Advanced Combustion
System Research

Problem:

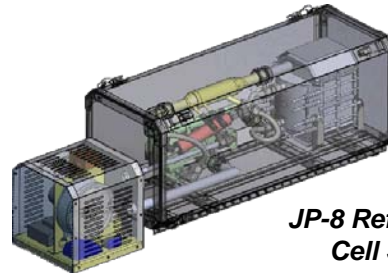
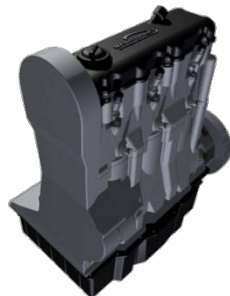
- Current non-primary power approach in field is inadequate for silent watch.
- Lead-acid batteries store insufficient energy to meet War Fighter requirements for vehicle silent watch (main engine off). Silent watch requirements vary from several hours to 24 hours. Current approach requires restarting of main engines during silent watch to recharge batteries, causing excessive fuel use, acoustic and thermal signatures.

Research Challenges:

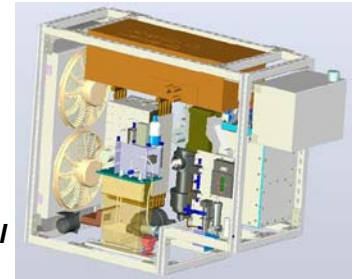
- Research engine-generator technologies with high power densities and low acoustic signatures.
- JP-8 reformation and desulfurization necessary for battlefield fuel cell application.
- Integration of fuel cells with JP-8 reformers to create APU system compatible with combat vehicle requirements
- Research fuel cell system optimization with batteries and ultra-capacitors.



Power Dense APUs



JP-8 Reformed Fuel Cell Systems



Problem:

- Current and future force electrical power demands exceed power generation and energy storage capabilities.
- Advanced power generation systems depend on sophisticated control methodologies for safe operation.
- Limited fuel availability in the field.
- Increasing number and size of electrical loads on a vehicular platform increases the heat generation.
- Presently, no automated way to recover from faults and induced faults (i.e. Sympathetic tripping, chain tripping of loads).
- Current vehicular electrical architectures contain vehicle-unique electrical components which increase the logistics burden.

Research Challenges:

- Research ability to accurately monitor and control the power distribution and react to fluctuating loads and sources in real time through algorithm development.
- Research common architecture approach (plug & play) for future electrical power equipment insertion.
- Research power requirements of military equipment and load management strategy.



Survivability Loads											
Device Name	Voltage	Current	Power	Device Name	Voltage	Current	Power	Device Name	Voltage	Current	Power
1.1.1.1	0.00	0.00	0.00	1.1.1.2	0.00	0.00	0.00	1.1.1.3	0.00	0.00	0.00
1.1.1.4	0.00	0.00	0.00	1.1.1.5	0.00	0.00	0.00	1.1.1.6	0.00	0.00	0.00
1.1.1.7	0.00	0.00	0.00	1.1.1.8	0.00	0.00	0.00	1.1.1.9	0.00	0.00	0.00
1.1.1.10	0.00	0.00	0.00	1.1.1.11	0.00	0.00	0.00	1.1.1.12	0.00	0.00	0.00
1.1.1.13	0.00	0.00	0.00	1.1.1.14	0.00	0.00	0.00	1.1.1.15	0.00	0.00	0.00
1.1.1.16	0.00	0.00	0.00	1.1.1.17	0.00	0.00	0.00	1.1.1.18	0.00	0.00	0.00
1.1.1.19	0.00	0.00	0.00	1.1.1.20	0.00	0.00	0.00	1.1.1.21	0.00	0.00	0.00
1.1.1.22	0.00	0.00	0.00	1.1.1.23	0.00	0.00	0.00	1.1.1.24	0.00	0.00	0.00
1.1.1.25	0.00	0.00	0.00	1.1.1.26	0.00	0.00	0.00	1.1.1.27	0.00	0.00	0.00
1.1.1.28	0.00	0.00	0.00	1.1.1.29	0.00	0.00	0.00	1.1.1.30	0.00	0.00	0.00
1.1.1.31	0.00	0.00	0.00	1.1.1.32	0.00	0.00	0.00	1.1.1.33	0.00	0.00	0.00
1.1.1.34	0.00	0.00	0.00	1.1.1.35	0.00	0.00	0.00	1.1.1.36	0.00	0.00	0.00
1.1.1.37	0.00	0.00	0.00	1.1.1.38	0.00	0.00	0.00	1.1.1.39	0.00	0.00	0.00
1.1.1.40	0.00	0.00	0.00	1.1.1.41	0.00	0.00	0.00	1.1.1.42	0.00	0.00	0.00
1.1.1.43	0.00	0.00	0.00	1.1.1.44	0.00	0.00	0.00	1.1.1.45	0.00	0.00	0.00
1.1.1.46	0.00	0.00	0.00	1.1.1.47	0.00	0.00	0.00	1.1.1.48	0.00	0.00	0.00
1.1.1.49	0.00	0.00	0.00	1.1.1.50	0.00	0.00	0.00	1.1.1.51	0.00	0.00	0.00
1.1.1.52	0.00	0.00	0.00	1.1.1.53	0.00	0.00	0.00	1.1.1.54	0.00	0.00	0.00
1.1.1.55	0.00	0.00	0.00	1.1.1.56	0.00	0.00	0.00	1.1.1.57	0.00	0.00	0.00
1.1.1.58	0.00	0.00	0.00	1.1.1.59	0.00	0.00	0.00	1.1.1.60	0.00	0.00	0.00
1.1.1.61	0.00	0.00	0.00	1.1.1.62	0.00	0.00	0.00	1.1.1.63	0.00	0.00	0.00
1.1.1.64	0.00	0.00	0.00	1.1.1.65	0.00	0.00	0.00	1.1.1.66	0.00	0.00	0.00
1.1.1.67	0.00	0.00	0.00	1.1.1.68	0.00	0.00	0.00	1.1.1.69	0.00	0.00	0.00
1.1.1.70	0.00	0.00	0.00	1.1.1.71	0.00	0.00	0.00	1.1.1.72	0.00	0.00	0.00
1.1.1.73	0.00	0.00	0.00	1.1.1.74	0.00	0.00	0.00	1.1.1.75	0.00	0.00	0.00
1.1.1.76	0.00	0.00	0.00	1.1.1.77	0.00	0.00	0.00	1.1.1.78	0.00	0.00	0.00
1.1.1.79	0.00	0.00	0.00	1.1.1.80	0.00	0.00	0.00	1.1.1.81	0.00	0.00	0.00
1.1.1.82	0.00	0.00	0.00	1.1.1.83	0.00	0.00	0.00	1.1.1.84	0.00	0.00	0.00
1.1.1.85	0.00	0.00	0.00	1.1.1.86	0.00	0.00	0.00	1.1.1.87	0.00	0.00	0.00
1.1.1.88	0.00	0.00	0.00	1.1.1.89	0.00	0.00	0.00	1.1.1.90	0.00	0.00	0.00
1.1.1.91	0.00	0.00	0.00	1.1.1.92	0.00	0.00	0.00	1.1.1.93	0.00	0.00	0.00
1.1.1.94	0.00	0.00	0.00	1.1.1.95	0.00	0.00	0.00	1.1.1.96	0.00	0.00	0.00
1.1.1.97	0.00	0.00	0.00	1.1.1.98	0.00	0.00	0.00	1.1.1.99	0.00	0.00	0.00
1.1.1.100	0.00	0.00	0.00	1.1.1.101	0.00	0.00	0.00	1.1.1.102	0.00	0.00	0.00
1.1.1.103	0.00	0.00	0.00	1.1.1.104	0.00	0.00	0.00	1.1.1.105	0.00	0.00	0.00
1.1.1.106	0.00	0.00	0.00	1.1.1.107	0.00	0.00	0.00	1.1.1.108	0.00	0.00	0.00
1.1.1.109	0.00	0.00	0.00	1.1.1.110	0.00	0.00	0.00	1.1.1.111	0.00	0.00	0.00
1.1.1.112	0.00	0.00	0.00	1.1.1.113	0.00	0.00	0.00	1.1.1.114	0.00	0.00	0.00
1.1.1.115	0.00	0.00	0.00	1.1.1.116	0.00	0.00	0.00	1.1.1.117	0.00	0.00	0.00
1.1.1.118	0.00	0.00	0.00	1.1.1.119	0.00	0.00	0.00	1.1.1.120	0.00	0.00	0.00
1.1.1.121	0.00	0.00	0.00	1.1.1.122	0.00	0.00	0.00	1.1.1.123	0.00	0.00	0.00
1.1.1.124	0.00	0.00	0.00	1.1.1.125	0.00	0.00	0.00	1.1.1.126	0.00	0.00	0.00
1.1.1.127	0.00	0.00	0.00	1.1.1.128	0.00	0.00	0.00	1.1.1.129	0.00	0.00	0.00
1.1.1.130	0.00	0.00	0.00	1.1.1.131	0.00	0.00	0.00	1.1.1.132	0.00	0.00	0.00
1.1.1.133	0.00	0.00	0.00	1.1.1.134	0.00	0.00	0.00	1.1.1.135	0.00	0.00	0.00
1.1.1.136	0.00	0.00	0.00	1.1.1.137	0.00	0.00	0.00	1.1.1.138	0.00	0.00	0.00
1.1.1.139	0.00	0.00	0.00	1.1.1.140	0.00	0.00	0.00	1.1.1.141	0.00	0.00	0.00
1.1.1.142	0.00	0.00	0.00	1.1.1.143	0.00	0.00	0.00	1.1.1.144	0.00	0.00	0.00
1.1.1.145	0.00	0.00	0.00	1.1.1.146	0.00	0.00	0.00	1.1.1.147	0.00	0.00	0.00
1.1.1.148	0.00	0.00	0.00	1.1.1.149	0.00	0.00	0.00	1.1.1.150	0.00	0.00	0.00
1.1.1.151	0.00	0.00	0.00	1.1.1.152	0.00	0.00	0.00	1.1.1.153	0.00	0.00	0.00
1.1.1.154	0.00	0.00	0.00	1.1.1.155	0.00	0.00	0.00	1.1.1.156	0.00	0.00	0.00
1.1.1.157	0.00	0.00	0.00	1.1.1.158	0.00	0.00	0.00	1.1.1.159	0.00	0.00	0.00
1.1.1.160	0.00	0.00	0.00	1.1.1.161	0.00	0.00	0.00	1.1.1.162	0.00	0.00	0.00
1.1.1.163	0.00	0.00	0.00	1.1.1.164	0.00	0.00	0.00	1.1.1.165	0.00	0.00	0.00
1.1.1.166	0.00	0.00	0.00	1.1.1.167	0.00	0.00	0.00	1.1.1.168	0.00	0.00	0.00
1.1.1.169	0.00	0.00	0.00	1.1.1.170	0.00	0.00	0.00	1.1.1.171	0.00	0.00	0.00
1.1.1.172	0.00	0.00	0.00	1.1.1.173	0.00	0.00	0.00	1.1.1.174	0.00	0.00	0.00
1.1.1.175	0.00	0.00	0.00	1.1.1.176	0.00	0.00	0.00	1.1.1.177	0.00	0.00	0.00
1.1.1.178	0.00	0.00	0.00	1.1.1.179	0.00	0.00	0.00	1.1.1.180	0.00	0.00	0.00
1.1.1.181	0.00	0.00	0.00	1.1.1.182	0.00	0.00	0.00	1.1.1.183	0.00	0.00	0.00
1.1.1.184	0.00	0.00	0.00	1.1.1.185	0.00	0.00	0.00	1.1.1.186	0.00	0.00	0.00
1.1.1.187	0.00	0.00	0.00	1.1.1.188	0.00	0.00	0.00	1.1.1.189	0.00	0.00	0.00
1.1.1.190	0.00	0.00	0.00	1.1.1.191	0.00	0.00	0.00	1.1.1.192	0.00	0.00	0.00
1.1.1.193	0.00	0.00	0.00	1.1.1.194	0.00	0.00	0.00	1.1.1.195	0.00	0.00	0.00
1.1.1.196	0.00	0.00	0.00	1.1.1.197	0.00	0.00	0.00	1.1.1.198	0.00	0.00	0.00
1.1.1.199	0.00	0.00	0.00	1.1.1.200	0.00	0.00	0.00	1.1.1.201	0.00	0.00	0.00
1.1.1.202	0.00	0.00	0.00	1.1.1.203	0.00	0.00	0.00	1.1.1.204	0.00	0.00	0.00
1.1.1.205	0.00	0.00	0.00	1.1.1.206	0.00	0.00	0.00	1.1.1.207	0.00	0.00	0.00
1.1.1.208	0.00	0.00	0.00	1.1.1.209	0.00	0.00	0.00	1.1.1.210	0.00	0.00	0.00
1.1.1.211	0.00	0.00	0.00	1.1.1.212	0.00	0.00	0.00	1.1.1.213	0.00	0.00	0.00
1.1.1.214	0.00	0.00	0.00	1.1.1.215	0.00	0.00	0.00	1.1.1.216	0.00	0.00	0.00
1.1.1.217	0.00	0.00	0.00	1.1.1.218	0.00	0.00	0.00	1.1.1.219	0.00	0.00	0.00
1.1.1.220	0.00	0.00	0.00	1.1.1.221	0.00	0.00	0.00	1.1.1.222	0.00	0.00	0.00
1.1.1.223	0.00	0.00	0.00	1.1.1.224	0.00	0.00	0.00	1.1.1.225	0.00	0.00	0.00
1.1.1.226	0.00	0.00	0.00	1.1.1.227	0.00	0.00	0.00	1.1.1.228	0.00	0.00	0.00
1.1.1.229	0.00	0.00	0.00	1.1.1.230	0.00	0.00	0.00	1.1.1.231	0.00	0.00	0.00
1.1.1.232	0.00	0.00	0.00	1.1.1.233	0.00	0.00	0.00	1.1.1.234	0.00	0.00	0.00
1.1.1.235	0.00	0.00	0.00	1.1.1.236	0.00	0.00	0.00	1.1.1.237	0.00	0.00	0.00
1.1.1.238	0.00	0.00	0.00	1.1.1.239	0.00	0.00	0.00	1.1.1.240	0.00	0.00	0.00
1.1.1.241	0.00	0.00	0.00	1.1.1.242	0.00	0.00	0.00	1.1.1.243	0.00	0.00	0.00
1.1.1.244	0.00	0.00	0.00	1.1.1.245	0.00	0.00	0.00	1.1.1.246	0.00	0.00	0.00
1.1.1.247	0										

Problem:

- Cooling systems are insufficient to meet mobility requirements of future combat vehicles.
- Vehicular space claims limit additional heat rejection ability
- Increased demands for electrical power significantly impacts vehicle's cooling system sizes and weights
- Thermal degradation has direct impact on component life and reliability.
- Lack of intelligent control strategies for power system adds to thermal burden.
- Insufficient data exists on the efficiency benefits of emerging technologies applied to vehicle power electronics
-

Research Challenges:

- Intelligent thermal (heating/cooling) management system have not yet been explored
- Develop technology that requires less volume and greater heat rejecting capacity than current technology

