Power System Test Bed for Ground Vehicles

Joint Services Power Expo

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LOCKHEED MARTIN

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Introduction

- **DOD products require more power and are limited by alternators**
- **With more and more vehicles adapting parallel and electric hybrid approaches, as well as more electronic loads being added, there is a growing need for power generation and storage that is more than just the traditional alternator and lead acid battery**
- **How can these power needs be obtained?**
- **How will these new power devices integrate with existing equipment?**
- **How can companies be encouraged to strive to use Wide Band Gap electronics to advance State of the Art?**

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Introduction Continued

- **The available option for WBG power electronics is currently very limited and their technology readiness level is currently 3 or lower. To encourage WBG power electronics development and acceptance, we propose a vehicle electronics power test bed which will start with the current state of the art silicon technology as the base, but will be used as a base to integrate, prove out, and increase the TRL to level 6 of the emerging WBG segment**

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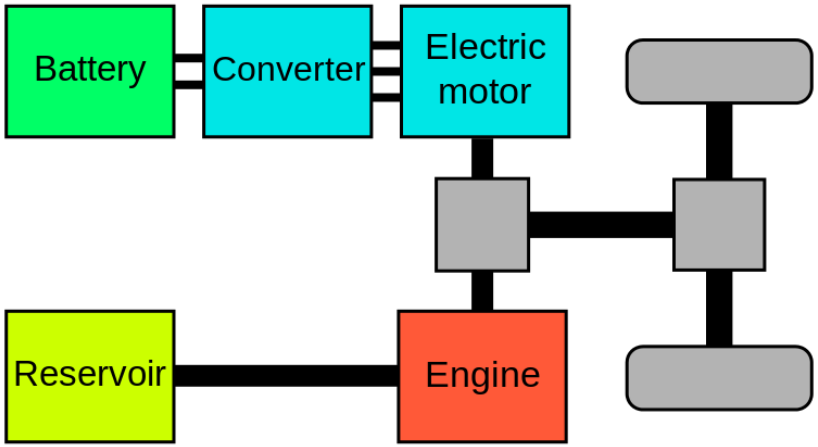
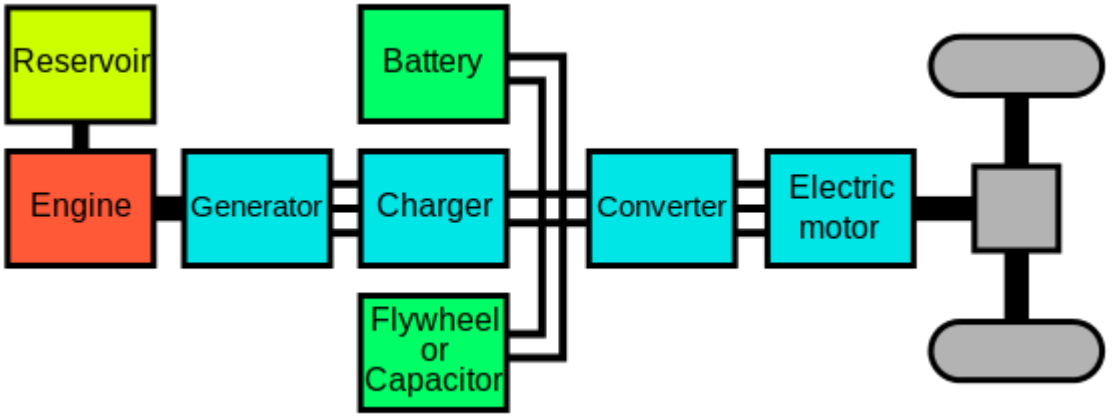
Parallel and Series Hybrid



Example of a Parallel Hybrid Vehicle

Example of a Series Hybrid Vehicle



Vehicle Test Bed Architecture needs to be flexible enough to test for both types of hybrids

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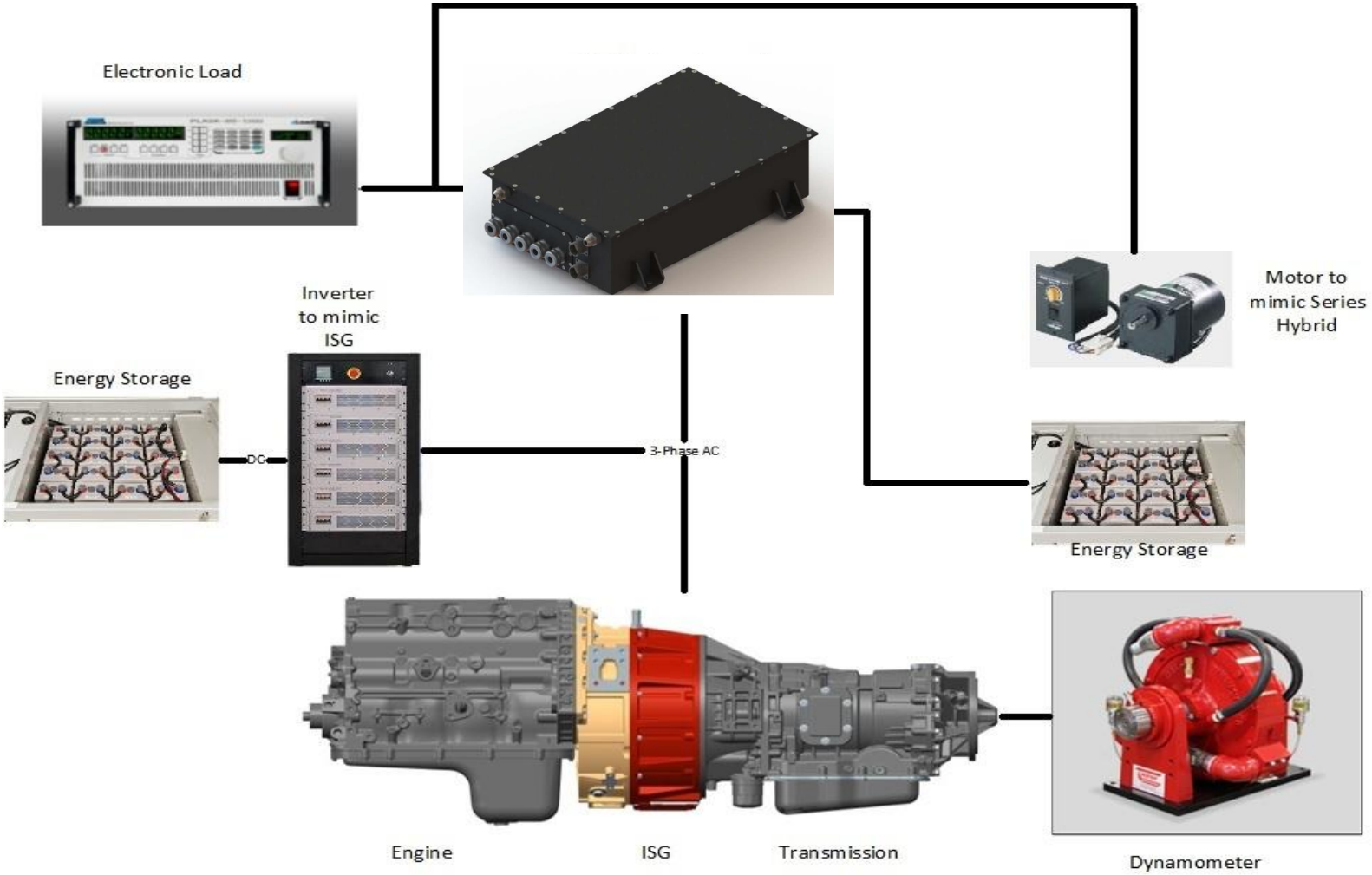
Vehicle Test Bed Architecture



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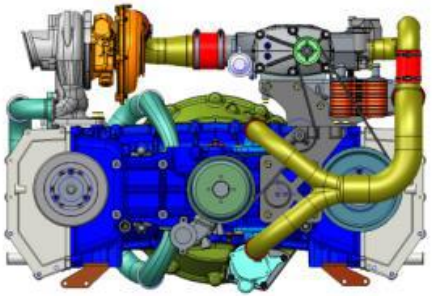
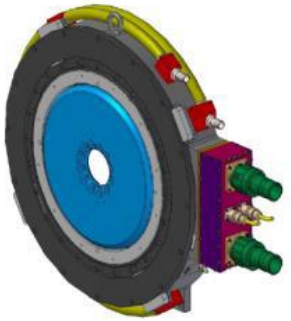
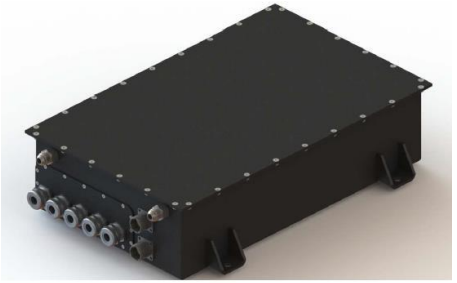
Power Generation

- Engine



- Integrated Starter Generator (ISG)
  - Takes the place of a traditional alternator
    - Higher power available
    - Directly in line with the drive train
- Bidirectional Inverter
  - Takes the power from the ISG and makes it useful for the vehicle
  - Provides ISG cranking pulse for start up





Photos from TARDEC, GVPM Industry Day Presentation, 4/21/16

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Loads and Energy Storage

- **Loads**
  - **Mechanical**
    - **Dynamometer- Allows full testing of engine loading with varying RPM and Torque loads**
  - **Electrical**
    - **Electronics load- Can mimic hotel loads and dynamic loads for the entire spectrum of vehicles**

  - **Electric Motor**
    - **Series Hybrid mimic**
    - **Parallel Hybrid: ability to test multiple motor options for integration with vehicle inverter/PCU**

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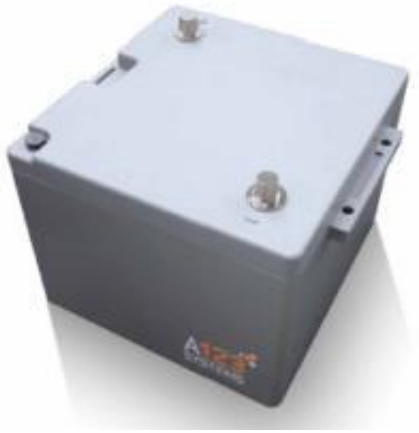
Loads and Energy Storage Cont.

- **Energy Storage**

  - **Various Chemistries can be inserted**
  - **Vehicle inverter/PCU integration**
  - **Easy to instrument for current testing**



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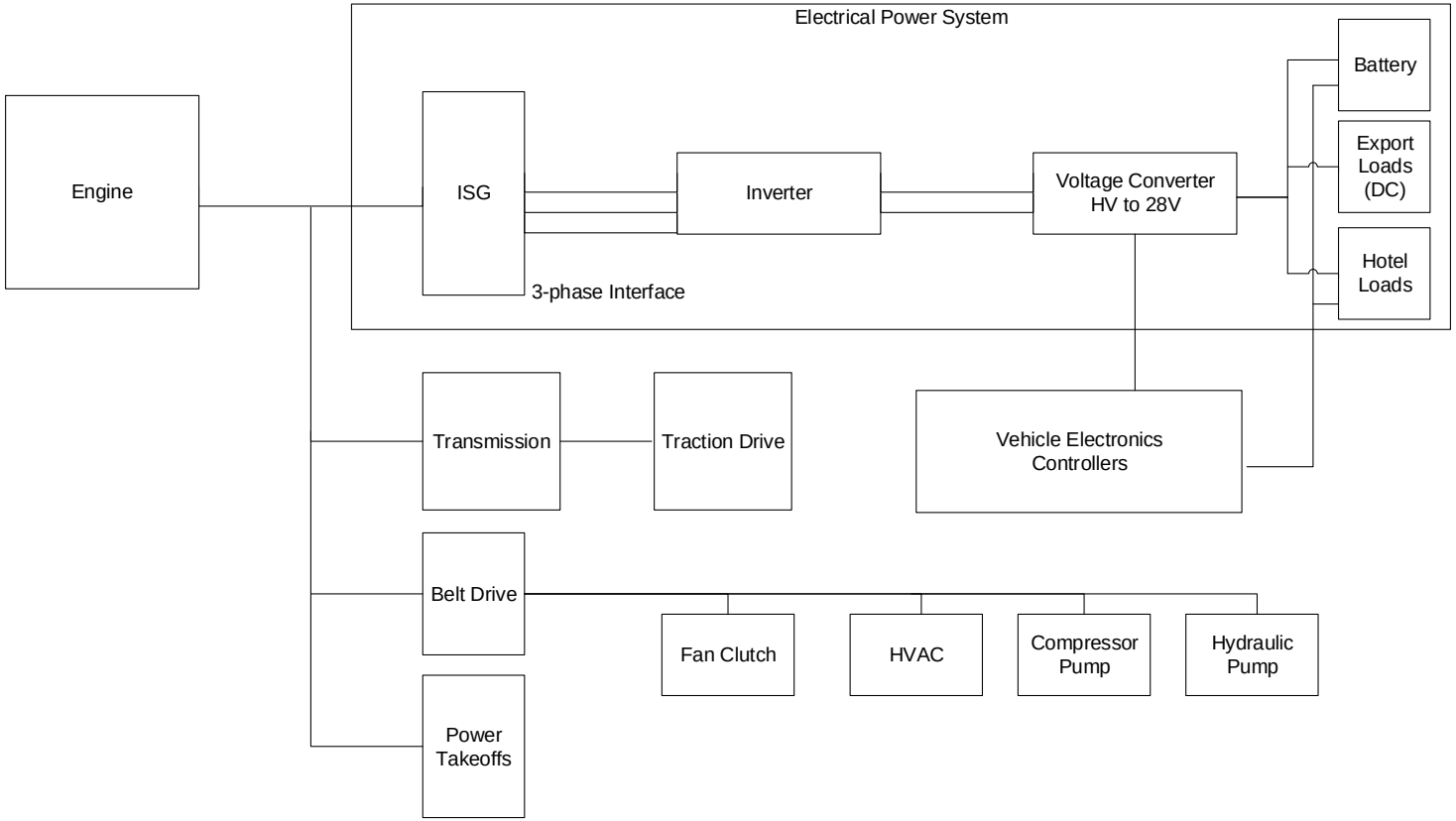
Real World use for the Test Bed

Ground Vehicle Power System Diagram



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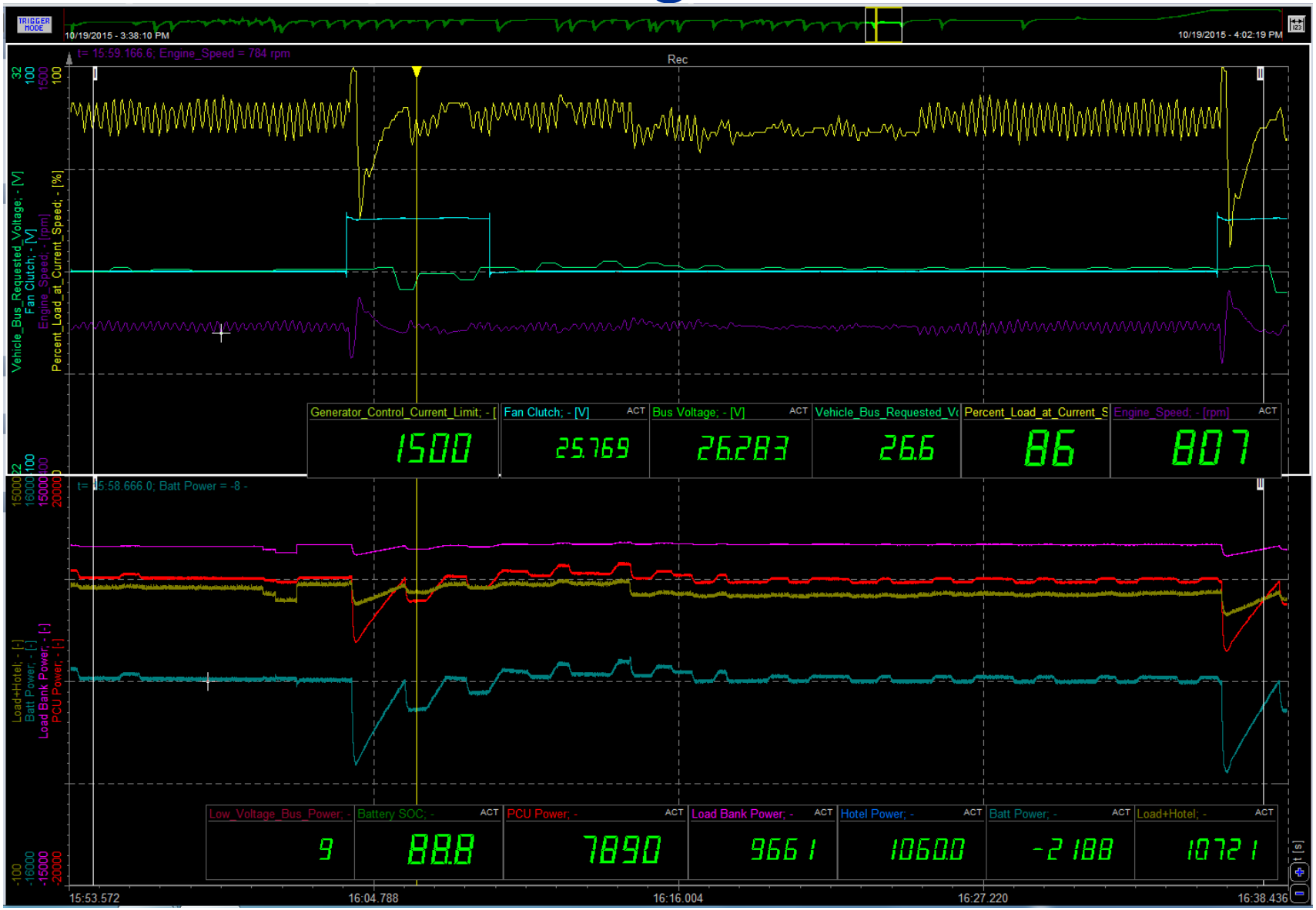
Fan Clutch Loading



1.5kW to 10kW load stepping

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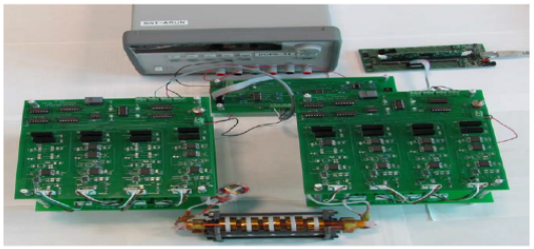
Bi-Directional Power Conversion

Project Objectives:

- 30kW – 5 ea. 6kW Modules
- Power Density (Goal: 5kW/L)
- Input Voltage: 800V
- Output Voltage 28V
- Switching Frequency: 100kHz
- Cooling: Forced Air or Liquid
- Efficiency: 95%
- SiC MOSFET on Primary
  - Wolfspeed
- GaN MOSFET on Secondary
  - GaN Systems or Transphorm

LMCO + JDES + NC State University

Project title: High Power Density WBG Devices (SiC and GaN) Based Bidirectional, Isolated DC-DC Converter for Auxiliary Power in Heavy Vehicle Applications
Objectives: To demonstrate high power density SiC and GaN based bidirectional DC-Dc converter for automotive applications
Major Milestones: 4-5kW high power density DC-DC converter
Major Equipment Acquisition: 1200/1700C SiC MOSFET, 100V GaN MOSFETS, HF magnetics
Deliverables: Grid connection and dynamic performance of MV SiC MOSFET converter, report



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WBG Technology Impact

- SiC/ GAN MOSFET based high power density converter
- Automotive applications
- Hybrid and fully electric vehicles
- Market segments impacted: automotive
- Time frame for commercialization: 2 years

More WBG Impact and Additional impacts

- Impact on the cost of WBG compared to Silicon, energy efficiency, green energy solutions
- Potential for Job Creation, Economic impact
- Workforce Development and Education if applicable

PowerAmerica | Call for Projects | August 2015

Vehicle Test Bed would allow verification of ideas and designs without having it in full mechanically finished format

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Conclusion

- **Growing need for vehicle power generation and storage that is more than just the traditional alternator and lead acid battery**
- **Vehicle Test Bed eases integration of new technology**
- **It is possible to make a test bed architecture that model the various types of hybrids**
- **Fully controllable test conditions and instrumentation**

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