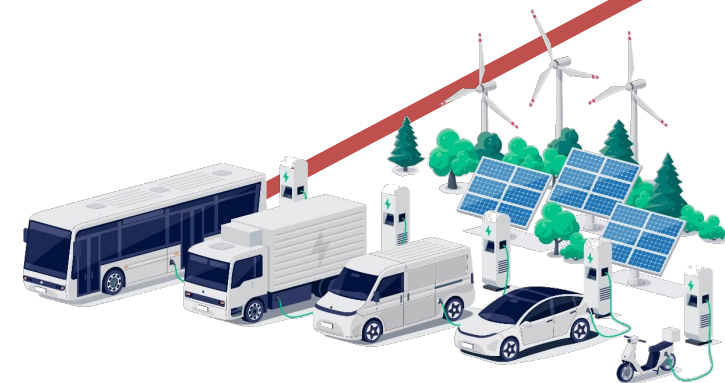




# 2022 Corporate Presentation



# CORPORATE INFORMATION

Hybrid Design Services, Inc. ( HDS™ ) is an ISO 9001:2015 certified company headquartered in Troy, MI, offering a full range of engineering consulting services, including: design, manufacturing, prototyping, and testing services.

HDS focuses on advanced mobility and energy storage.

Phone: +1.248.298.3400  
Fax: +1.248.298.3402  
Web: [www.hybriddesignservices.com](http://www.hybriddesignservices.com)



HDS Headquarters – Troy, MI USA

HDS Manufacturing – Madison Heights, MI USA

# HYBRID DESIGN SERVICES SPECIALITIES

Battery Pack Design & Engineering

Electric / Hybrid Vehicle Design & Engineering

Hardware & Power Electronics Development

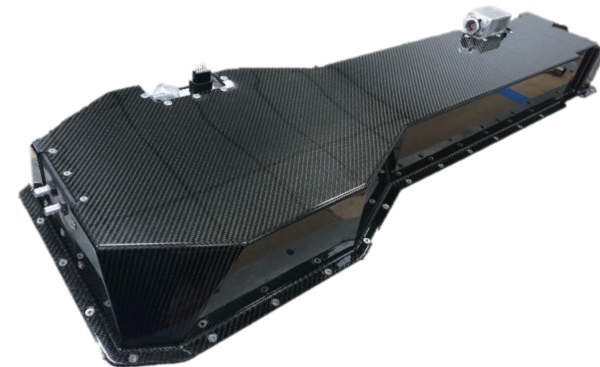
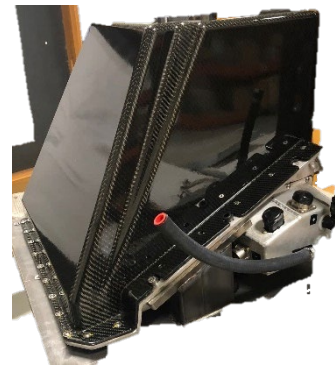
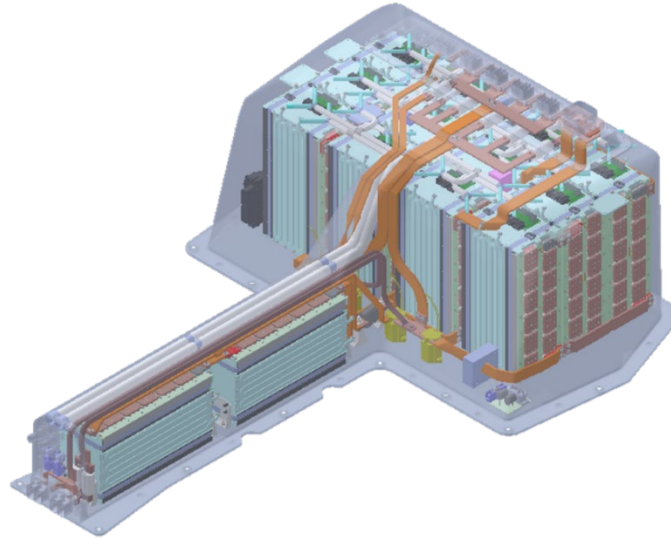
Specialized Services, Products & Technologies



# BATTERY PACK DESIGN / ENGINEERING / BUILD

## HYBRID VEHICLE DESIGN / ENGINEERING / BUILD

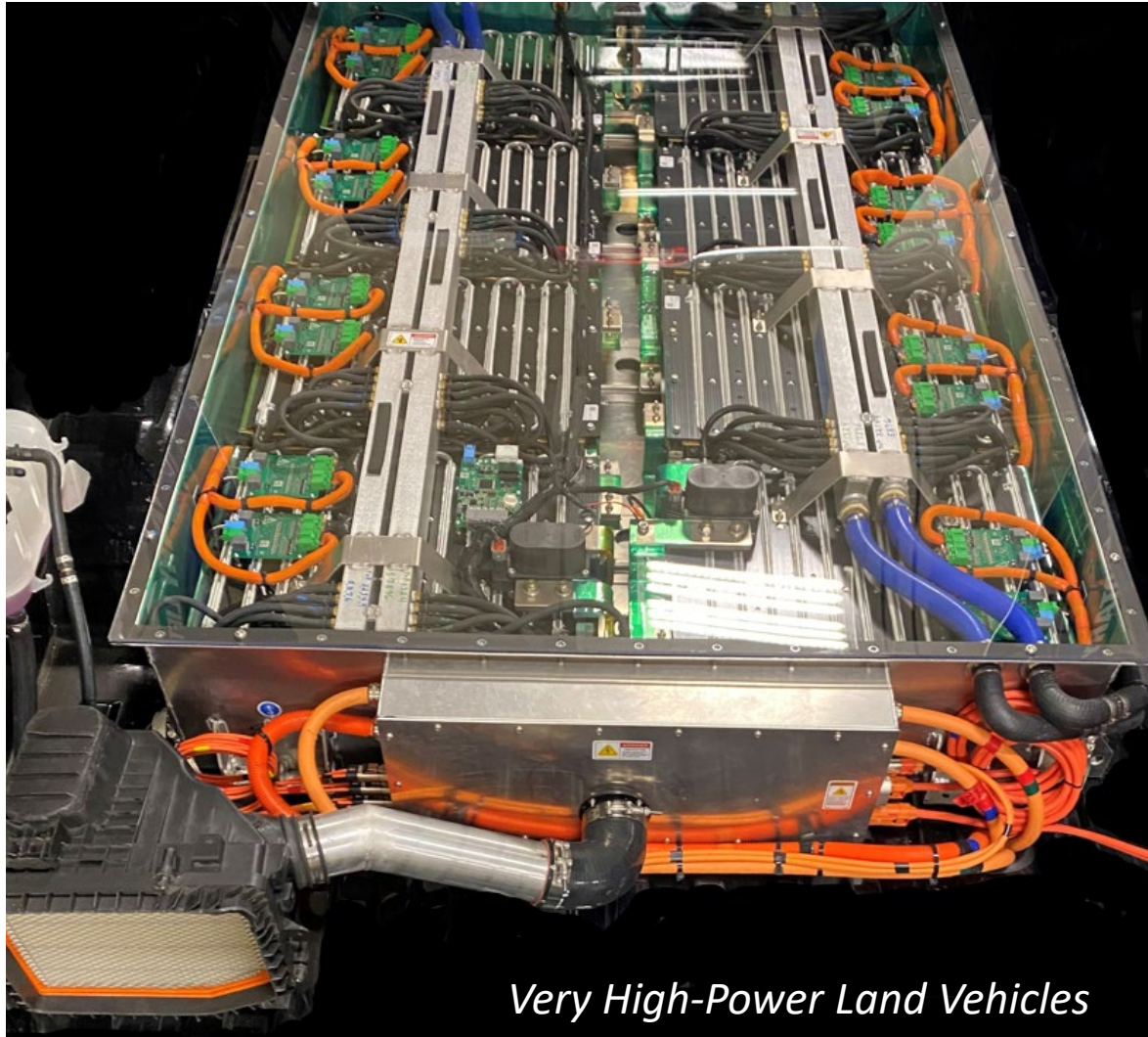
### HIGH PERFORMANCE VEHICLES



# BATTERY PACK DESIGN / ENGINEERING / BUILD

## BATTERY PACK DESIGN / ENGINEERING / BUILD

### HIGH PERFORMANCE VEHICLES



*Very High-Power Land Vehicles*

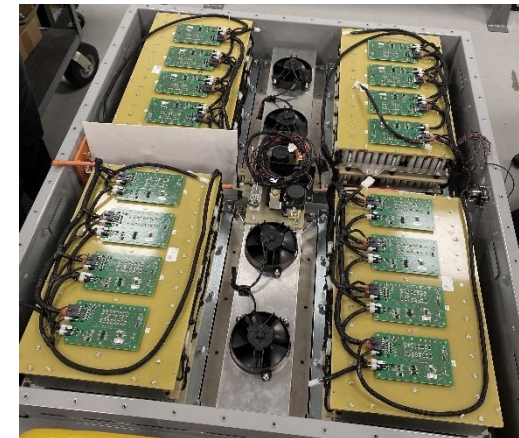
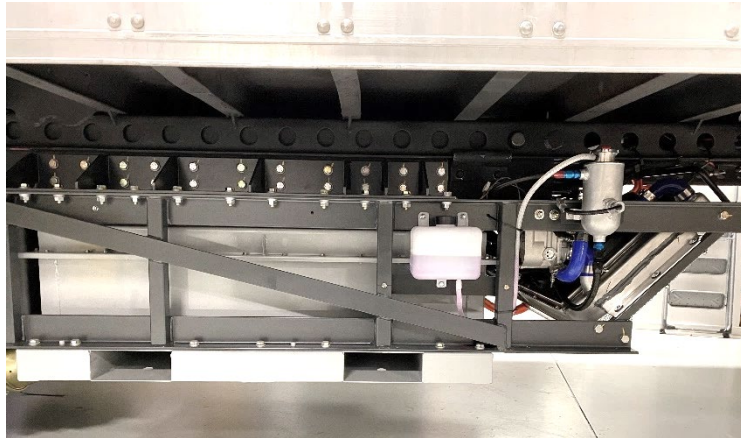
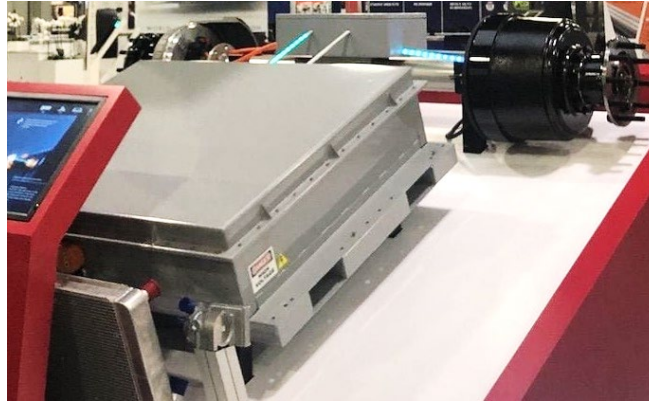
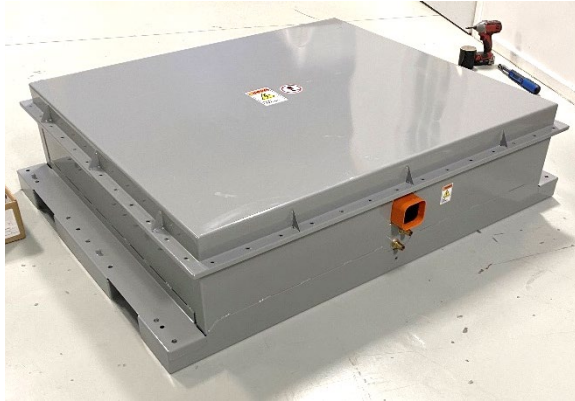


*High-Power Aircraft*



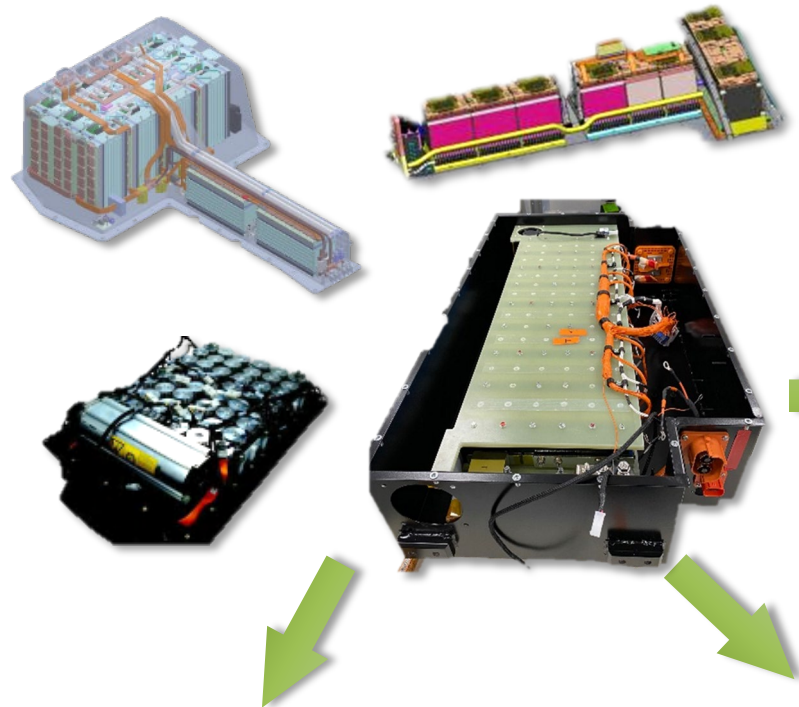
# BATTERY PACK DESIGN / ENGINEERING / BUILD

## COMMERCIAL VEHICLES



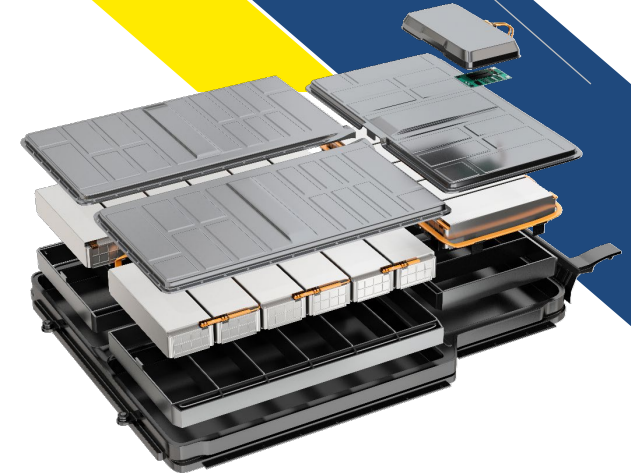
# BATTERY PACK DESIGN AND ENGINEERING

## Development, Design, and Prototyping



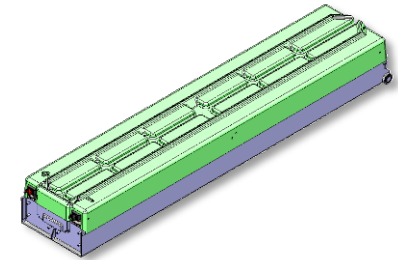
### Pack Design and Optimization

- Module Size and configuration optimization
- Pack Electrical, Mechanical and Thermal Interface
- Vehicle Packaging & Environmental Protection
- BMS Development and Integration
- Structural and Thermal/Fluid CAE Analysis



### Module Design and Optimization

- Cell Selection
- Module Packaging
- Cell carrier and Interconnect strategy
- Module V/T sense
- Thermal System Integration

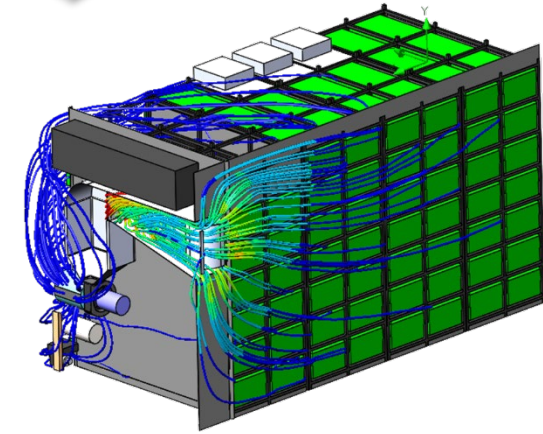
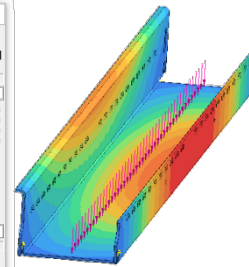
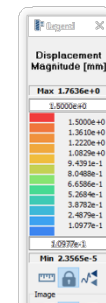


### Prototype Development

- Module Builds
- Pack Builds
- Incoming and End-of-Line testing
- Supply Chain Management

### Thermal and Structural Analyses

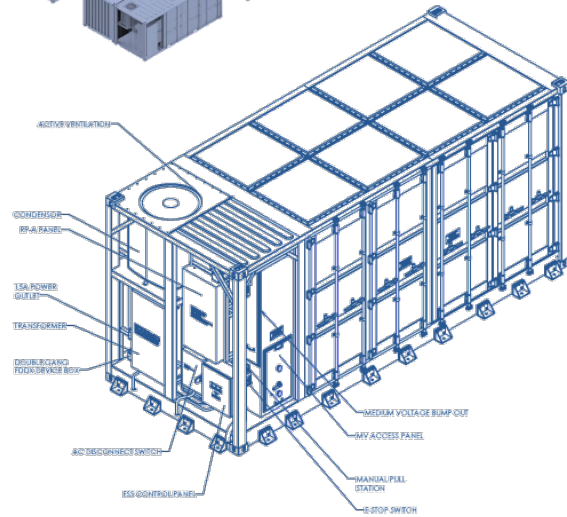
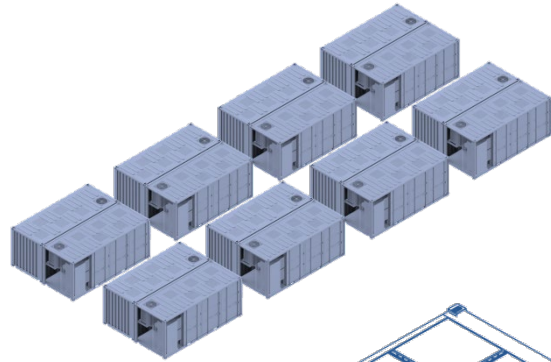
- Cell Thermal Model Correlation
- Module model development and correlation
- Module and Pack Thermal strategy development
- Module and Pack Structural System Design





# STATIONARY PACK DESIGN & ENGINEERING

UTILITY SCALE ESS



## EMERGENCY POWER



- Packaging: battery modules, HV/LV wiring,
- Venting, fire suppression, HVAC
- FMEA, Risk Analysis, DVP – UL, Telcordia
- Installation, assembly and service
- CAE (mechanical and thermal analysis)
- Controls and SCADA integration

## EXPORTABLE POWER - V2G / V2X





# PACK DESIGN AND ENGINEERING

## ULTRACAPACITOR SYSTEMS

### Initial Specifications

Size: 1055mm L x 500mm W x 310mm H

Weight: 49kg (329lb) steel / 102kg (225lb) Al

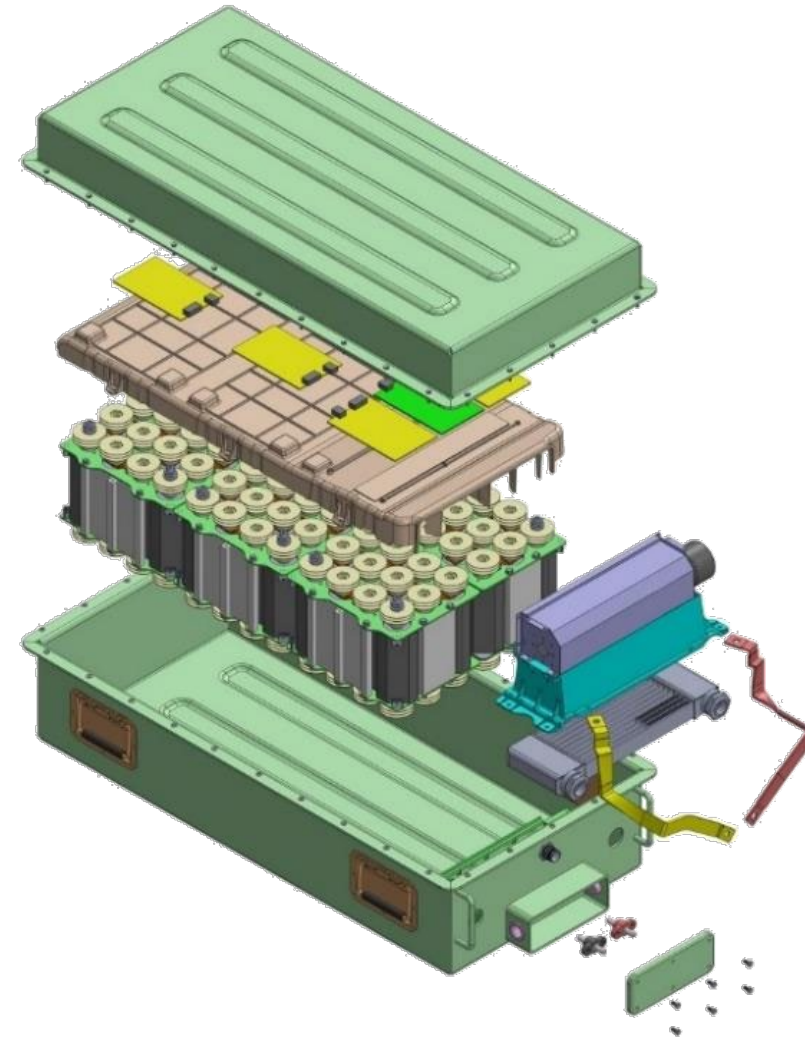
### Configuration A

Voltage & Capacitance: 205 Vdc / 47.2 F  
Peak Power: 410 kW (2000A)

### Configuration B

Voltage & Capacitance: 216 Vdc / 41.7 F  
Peak Power: 410 kW (1900A)

Cooling: Air-to-Liquid Cooling



# ELECTRIC/HYBRID VEHICLE DESIGN & ENGINEERING



## Powertrain / Vehicle Simulation

- Performance
- Fuel Economy
- Emissions
- Hybrid / EV Range
- Hybridization Strategies
- Model Correlation

## Controls Development

- Hybrid / EV System Controls
- ESS / BMS
- Simulation → Embedded Controls
- Power Distribution

## Prototype Development

- ESS / Controls
- Powertrain/ E-Drives
- Bench-Top Demonstrators
- Full Vehicle Prototypes
- Supplier Management
- Weight Reduction
- Cost Reduction
- Benchmarking / Teardown

## Advanced Powertrain Design

- ICE Optimization
- E-Motor Sizing & Selection
- Inverter Selection & Design
- ESS Design, Development and Packaging
- Smart Power Distribution / BDU



# ELECTRIC/HYBRID VEHICLE DESIGN & ENGINEERING

## CROSS INDUSTRY SUPPORT

### Automotive / LEV

- EV/HEV/PHEV System Concept Generation and Engineering
- HV & LV Architecture, Schematics, Prototypes
- ESS Concept, Detailed Design, Prototyping, Testing
- Full System Engineering (DFMEA / FTA / HSIS / Specifications, etc.)
- Fuel Economy Simulations
- Full-vehicle Prototype Development, Integration, and Testing
- Control System Development
- Full DV Testing
- Business Case and Technology Analysis



### Utility/Off-Highway/Urban/Commercial

- Fuel Economy Studies and Duty Cycle Simulation
- EV & Hybrid System Development
- Energy Storage System Design & Build
- Power Electronics & Drive System Design & Build



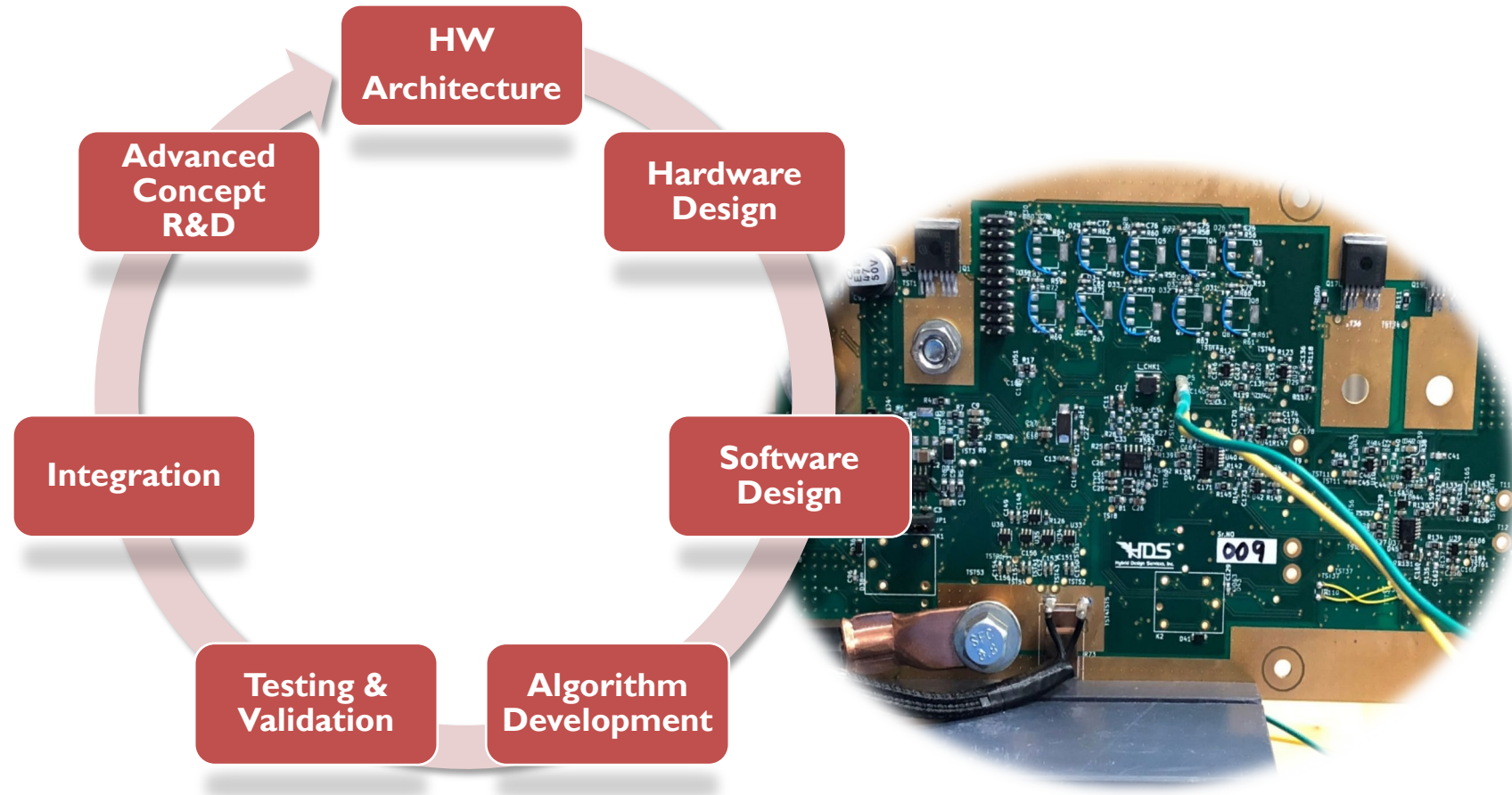
### Heavy-Duty & Military

- Class-8 Hybrids Class-8 'EV'
- Architecture Engineering
- Driveline Design
- Battery Pack Development



### Marine, Recreational Vehicles, and Alternative Energy

# HARDWARE AND SOFTWARE CAPABILITIES





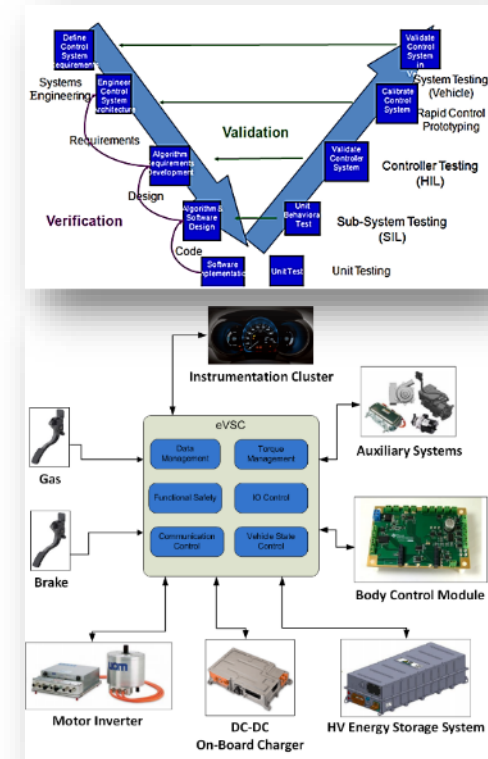
# HARDWARE AND SOFTWARE

## HDS xEV CONTROLS OVERVIEW

HDS' Electric Vehicle Controller Software includes basic and advanced functionality. Customers may choose to leverage existing HDS EV Controller Software, or to develop all-new software to meet their individual needs.

An example of main functionality which can be incorporated into the software is shown below:

- Vehicle Safety & Monitoring
  - HV Safety
  - Thermal Safety
  - Operational Safety
  - Service, Maintenance, Diagnostics
- Flexible User Interfaces
  - Programmable displays
  - Tunable Driver controls
    - Throttle Management
    - Shift Management
    - User Interface
- Efficient Traction Drive Interface
  - Torque Control
  - Power Management
  - Regenerative Braking
  - Gearbox Control
- Battery Management
  - Thermal Management
  - Power Management
  - Protection & Safety
- Energy Management
  - DC/DC & 12V/24V Management
  - Smart Power Distribution & Control
    - Main Traction Bus
    - Accessory Bus(es)
    - Charging Bus(es)
- Thermal System Control
  - Fan Control
  - Cooling Pump Control
- Air Compressor Control
- Hydraulic Pump Control
- Heating & a/c Control
- Auxiliary Systems
- ....



# HARDWARE AND CONTROLS

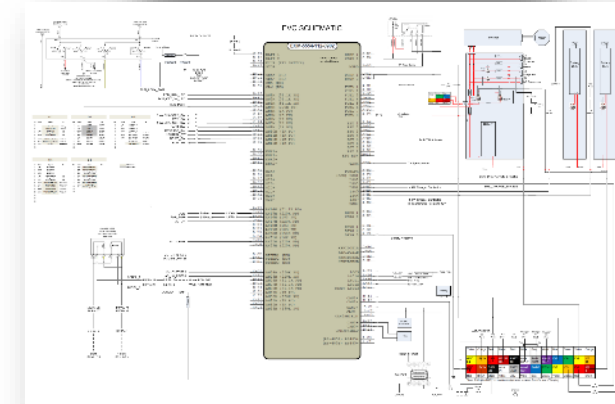
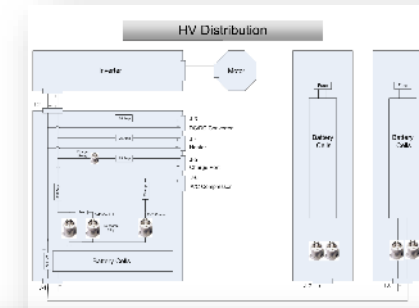
HYBRIDDESIGN.COM/HDS

## HDS CONTROL SYSTEM IN PRODUCTION EV CONVERSION

EV Control Systems in Production – Europe & Asia

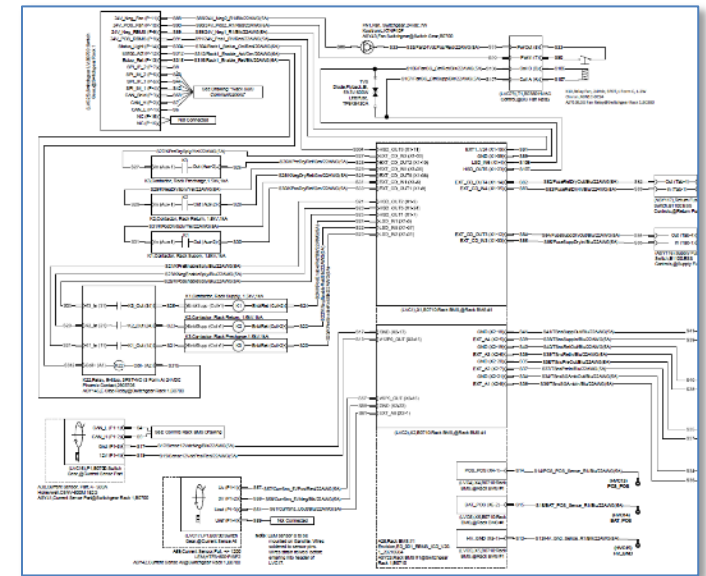
More than 1,000 vehicles on the road, with over 3 years of service

More than 1,200 vehicles/year production in Europe alone





## Full AC and DC DESIGN

[illegible]

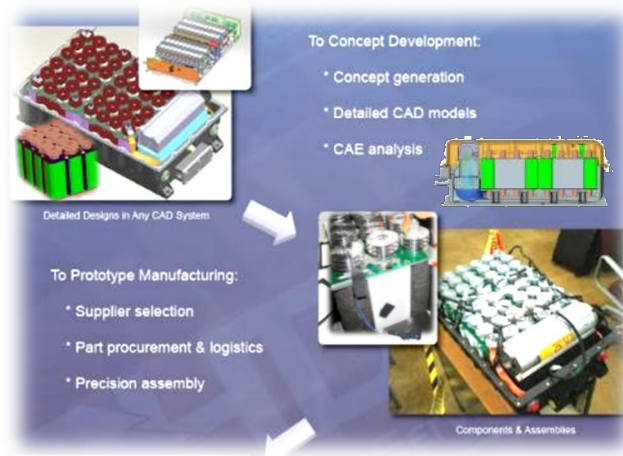
# SPECIALIZED SERVICES

25E01M02 25E01M02

CONCEPT → PROTOTYPE → PRODUCTION

## HDS Develops Products From Idea to Prototype in Record Time

### *Transit Bus Ultra capacitor ESS*



From cell to 90-unit DV-tested delivery in 4 months

### *Heavy-Duty Power System*



From concept to working prototype

### *Tri-mode ICE/HEV/EV Demonstrator*



From idea to running multi-mode xEV vehicle

# MANUFACTURING & TESTING SERVICES



## MANUFACTURING

- Tier-I to OEM Truck/Bus
- Complete Fabrication & Machining
- Supplier Selection & Supply Chain Management
- Component Tooling & Procurement
- Detailed Electronic Inventory Tracking
- Accurate Prototype Construction
- Torque/Angle Testing & Assembly
- UN Regulation Shipping

## TESTING

- Instrumentation
- Data Collection
- Environmental Testing
- IP (Ingress Protection)
- Vibration (SAE, OEM specifications)
- Torque-Angle
- EMC Compatibility (RE, RI, Comp.)
- Thermal Cycling
- ESR/DCR
- EOL Performance/Functionality
- Off-site testing support





# SPECIALIZED PRODUCTS

Specialized Products

## HV SPDM and WATCHDOG

### Smart Power Distribution Modules (SPDM):

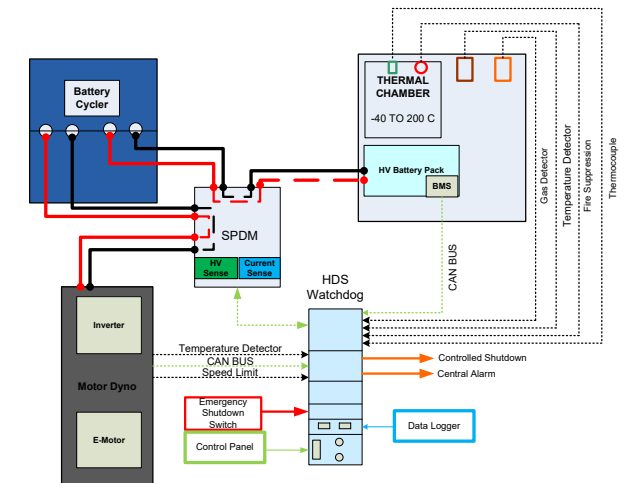
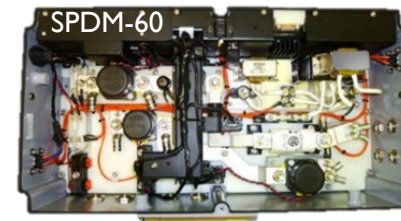
- Connect single or distributed energy storage systems safely to the rest of a vehicle or test system
- Offer a single integrated solution to DC bus management.
- SPDM can be used to safely control power on production vehicles, test vehicles, bench test systems, stationary power systems, battery test, and many other applications.
- Integrated controller with bus voltage and current monitors for contactor control.
- HVIL and available Isolation Monitoring allow safe operation up to >900V DC.
- Very low 12V or 24VVDC continuous power consumption.
- Customizable CAN 2.0 speed, frequency and messages.
- EMI/EMC Compatible
- Remote Monitoring & Reporting

### Watchdog Systems

- Used as redundant monitoring and emergency shutdown system during HV safety critical testing or vehicle system. Highly customizable and configurable system
- Monitors user defines test bench variables from gas detector and thermocouples to CAN and control signals
- Features an optional on-board flash storage for data logging.



Production Test Unit



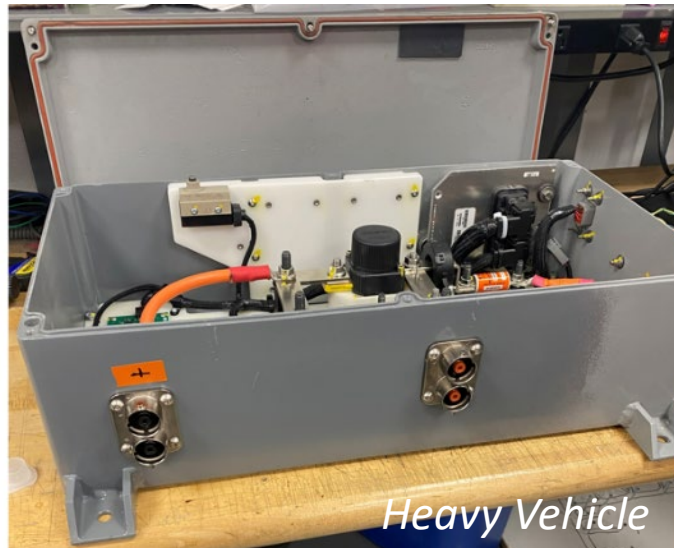
# SPECIALIZED PRODUCTS

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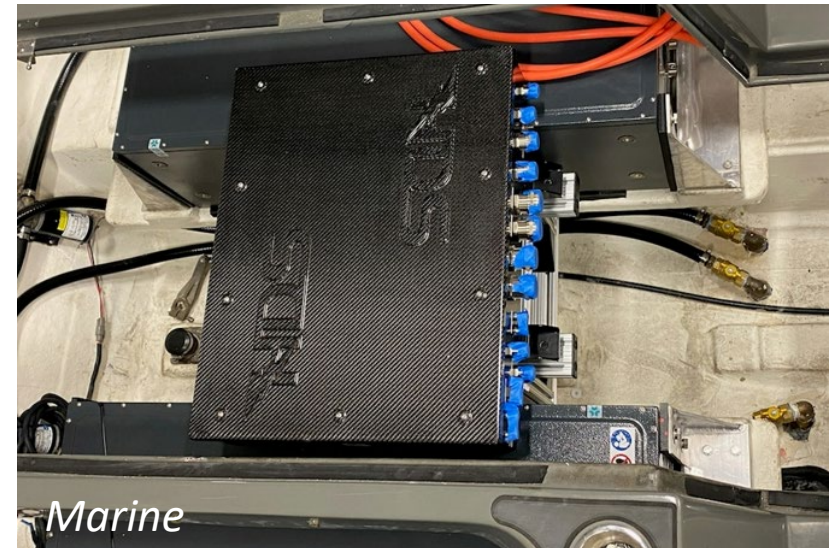
*HV Junction Box / PDU*



*Commercial Truck*



*Heavy Vehicle*



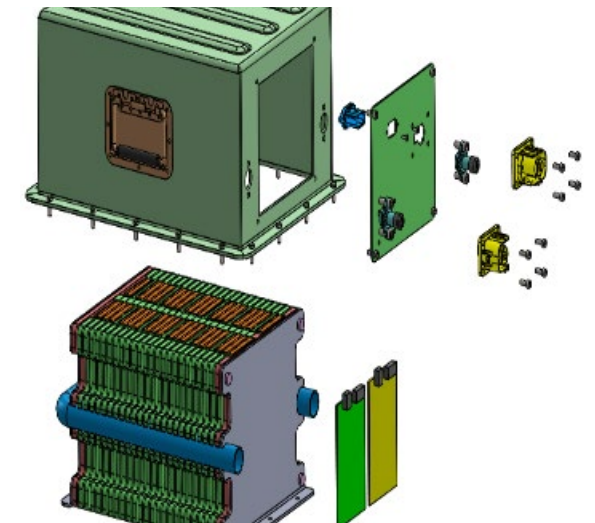
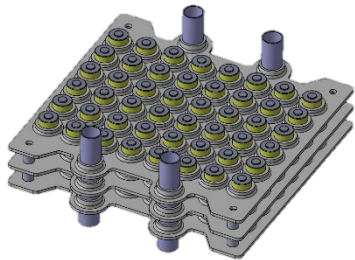
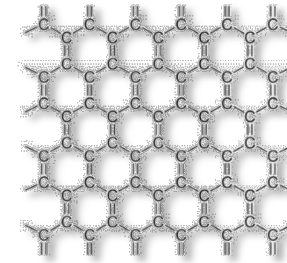
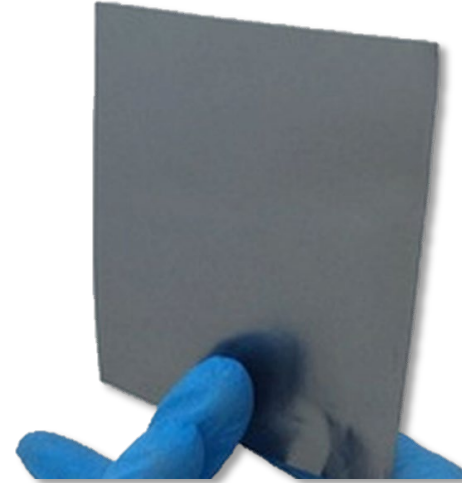
*Marine*

# SPECIALIZED TECHNOLOGY

## GRAPHENE GCF

### Advanced Graphene Cooling Systems

- Battery Cooling System
- Graphene Composite Fin (GCF)
- For Cylindrical, Prismatic, and Pouch cells & Electronics





Online

[www.HybridDesignServices.com](http://www.HybridDesignServices.com)

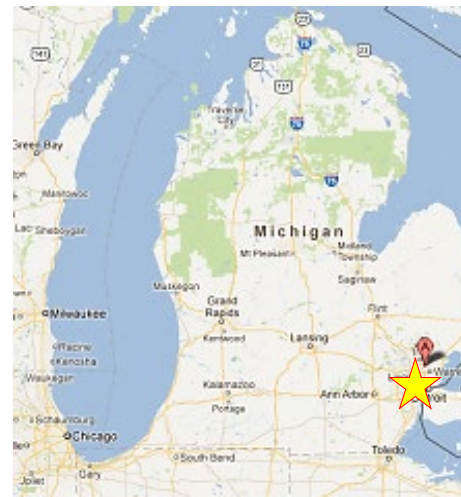


## Headquarters

2479 Elliott Drive  
Troy  
Michigan 48083 – USA

## Manufacturing

32335 Howard Ave.  
Madison Heights  
Michigan 48071 – USA



## Contact Us Directly

+1.866.492.3417  
+1.248.298.3400  
Fax: +1.248.298.3402

## James Pinon

President / CEO  
+1.313.673.6917  
[jpinon@hybriddesignservices.com](mailto:jpinon@hybriddesignservices.com)

## Firdevs Arikan

Operations Manager  
+1.313.205.2017  
[farikan@hybriddesignservices.com](mailto:farikan@hybriddesignservices.com)

