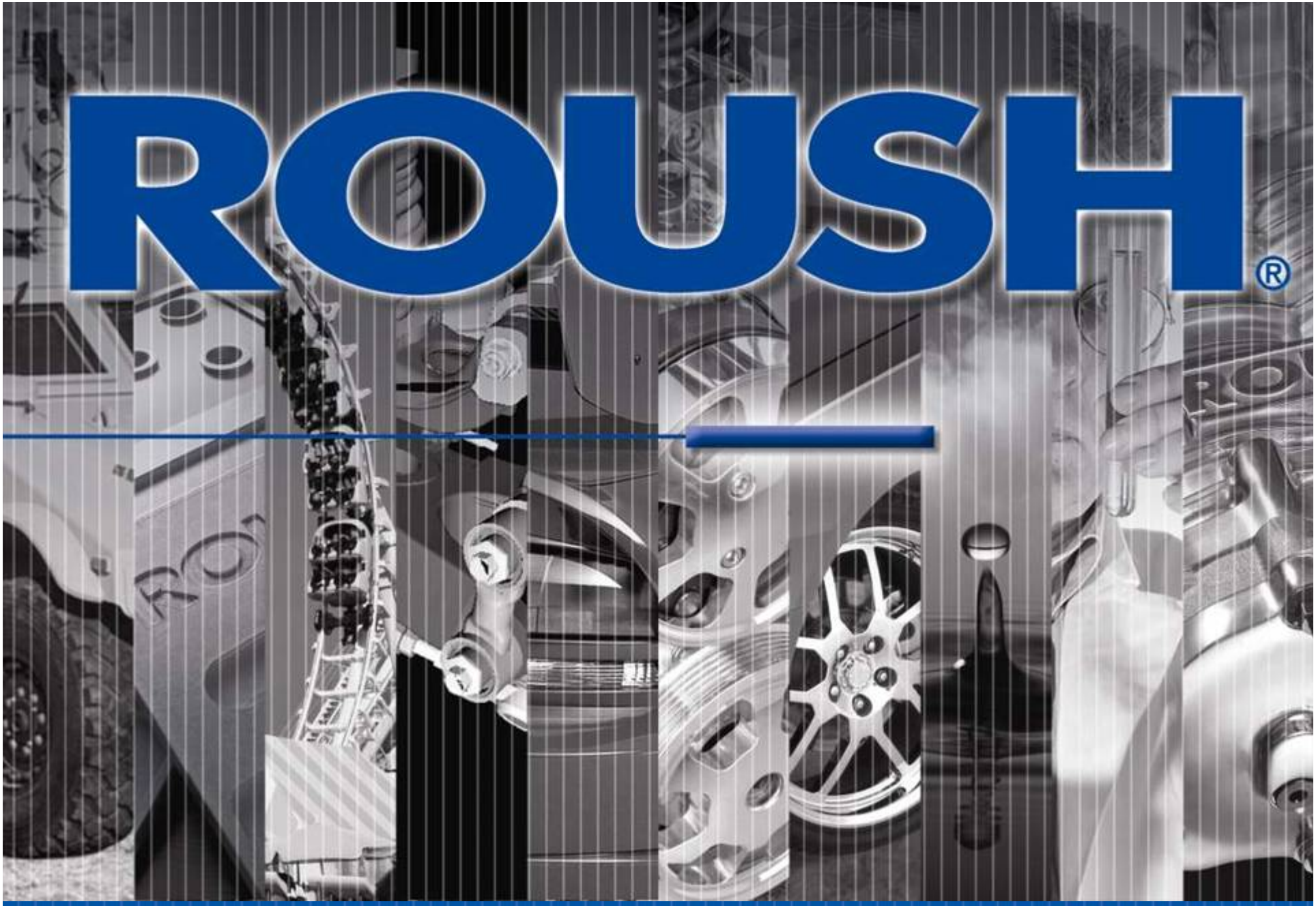
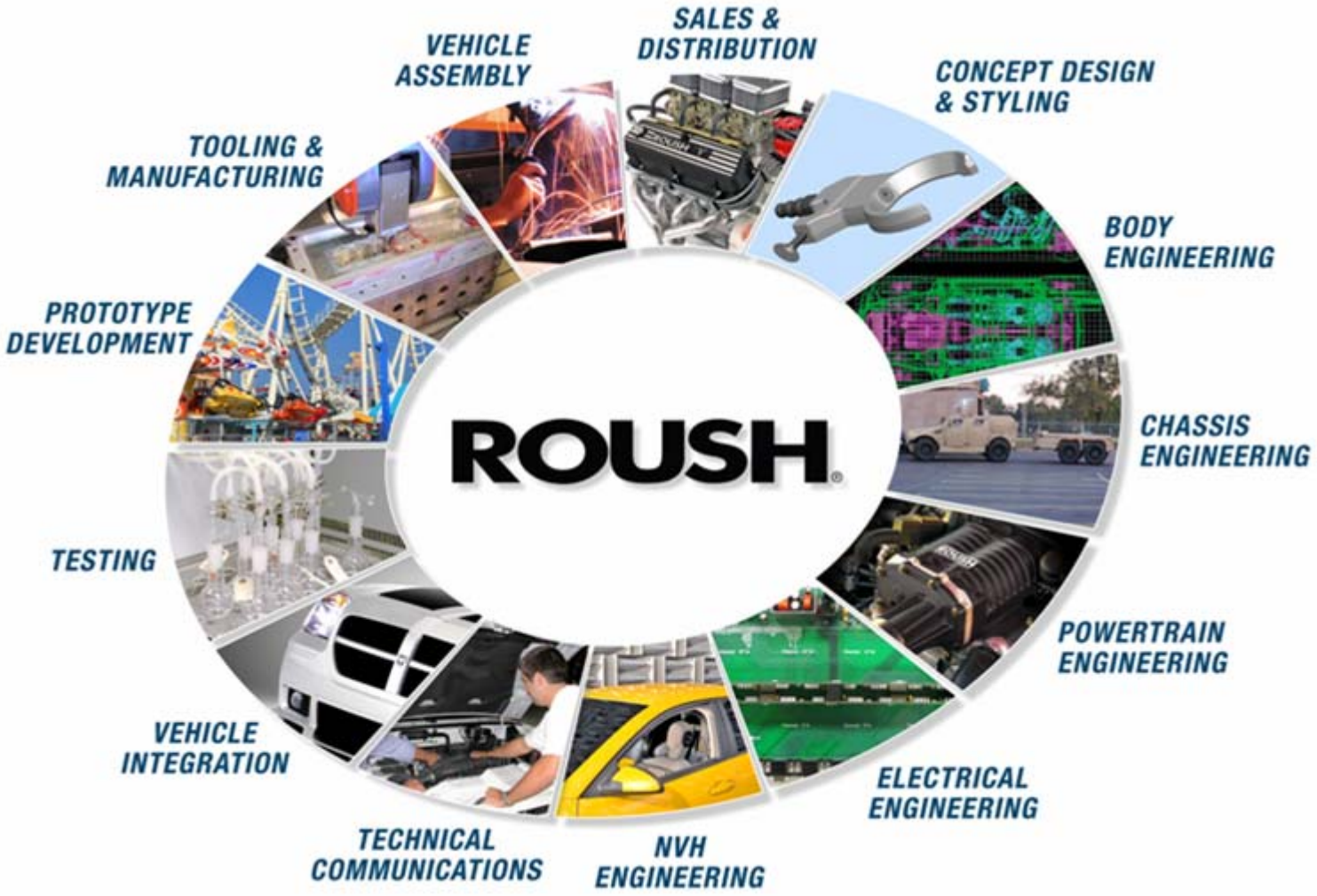


Overview for XP Vehicles

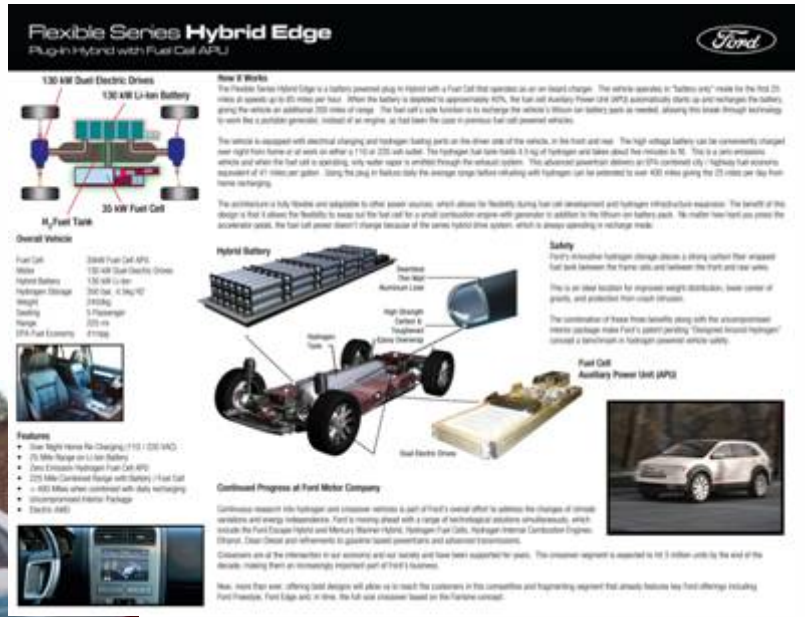
ROUSH

- Privately Held
- Founded in 1976
- Over 2,500 employees worldwide
- Primary Activities:
  Engineering, Testing,
  Prototyping and Manufacturing

Single Source Solution



Hydrogen Fuel Cell Vehicles



ROUSH

Hydrogen Fuel Cell Vehicles

207.297mph

Bonneville 2007

- Vehicle design
- Aerodynamics development
- Vehicle fabrication
- Propulsion system integration
- Race crew support

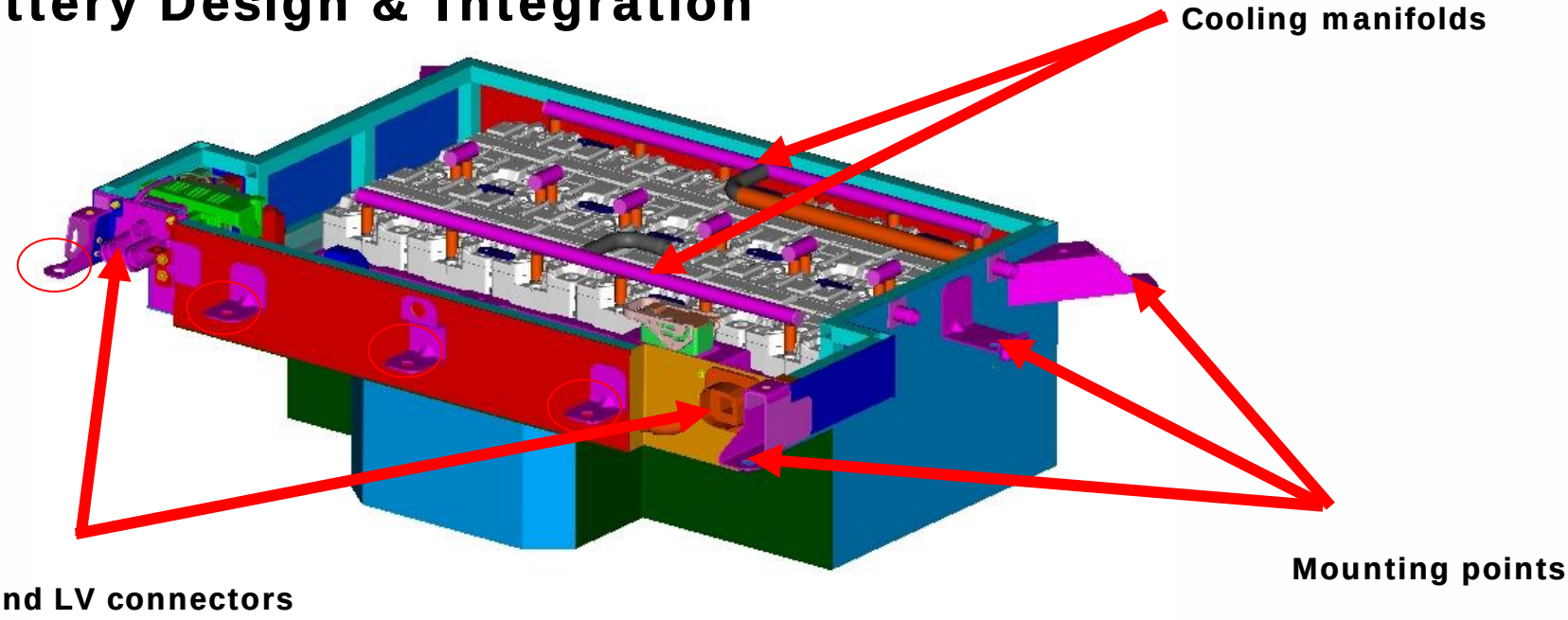
Plug-In Hybrid Electric Vehicles

Ford Escape and Edge

- Roush has performed all vehicle modifications to support integration of PHEV battery systems and charge capabilities.

Plug-In Hybrid Electric Vehicles

HV Battery Design & Integration



- **Unique HV battery design and fabrication**
- **Maintained: production mounting points, HV connector and LV connector and locations.**
- **Unique Cooling manifold design**

Plug-In Hybrid Electric Vehicles

HV Battery Design & Integration

Final PHEV HV Battery Integrated Into vehicles

Electrical System Integration

- Clean-Sheet Prototype Military Vehicles – Electrical Integration of two unique vehicles
  - Entire Electrical Architecture design and integration
  - Distributed control strategy and software algorithm design
  - Wire Harness logical and physical design
  - Multiplex communication protocol design
  - EMI, RFI analysis and testing
  - LV and HV Power Distribution
  - Diagnostics and Prognostics
  - Component Design and Sourcing
  - Instrument Cluster
  - Lighting
  - Power Generation
  - Hybrid Controls
  - Active Suspension Control

- HEV to PHEV Conversion
  - Integration of Battery module
  - Communications gateway
  - Wiring

Roush REV – Electric Vehicles

Vehicle Integration and Build

- AC Motor
- Controller
- Lead Acid Gel Battery Pack
- 72-volt System
- Off road vehicle with top speed limited to 25mph
- Range 45 miles
- 1,100 lb payload capacity

Roush – Propane Vehicles

Vehicle Integration and Build

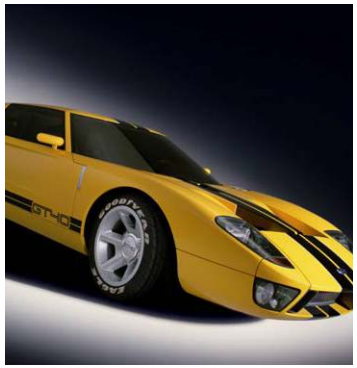
- Liquid Propane Injection
- Fuel Rail
- Fuel line
- ECM modification
- Under bed/in bed fuel tank

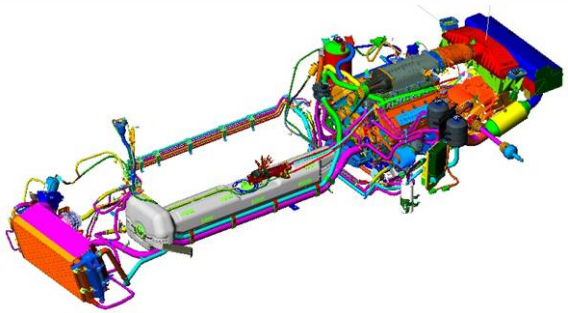
Ford GT Vehicle Integrator

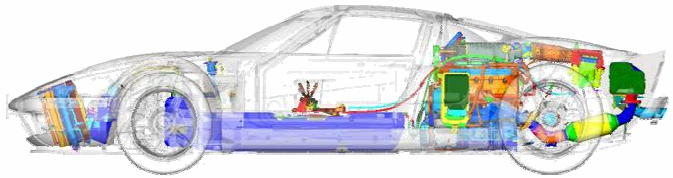
Powertrain Integration Engineering Role:

Engineering, Design, Development and Integration of the following:

- Base Engine
- Drivetrain
- Air Induction
- Exhaust
- Fuel System
- Engine Cooling
- HVAC System
- P/T Calibration







Body Integration Engineering Role:

Design & Release/Supplier Management of the following:

- Instrument Panel/Door Trim/Centre Console/Headliner/NVH
- Handles, Latches & Hinges (Decklid, Hood, Doors)
- Window Regulators
- Locksets

Vehicle Properties Produced by Roush:

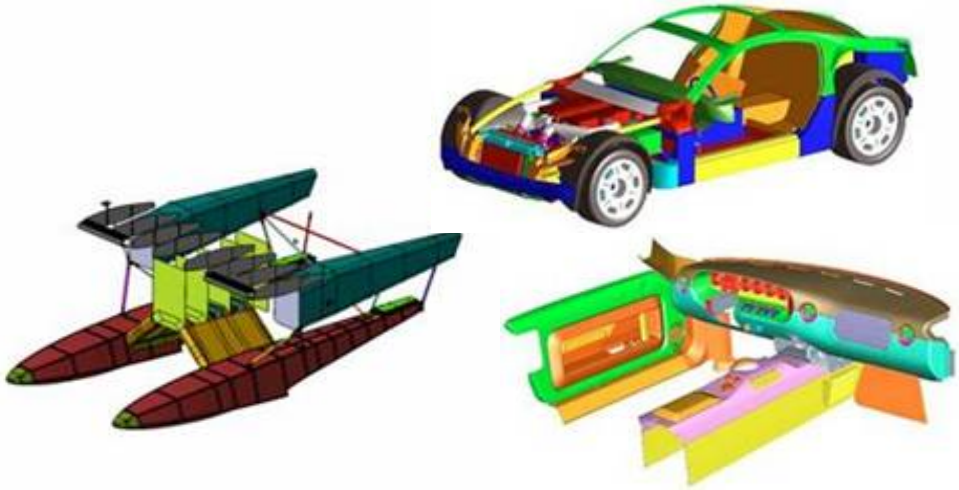
- Design Aid Buck Build,
- 13 Workhorse Vehicle Carbon Bodies
- 15 Prototype Build Carbon Hood and Decklid Inner Panels

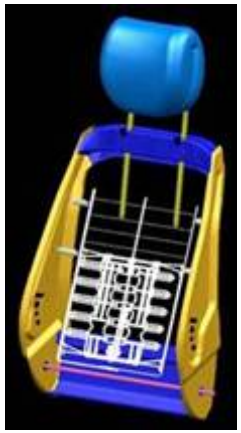
Concept Design & Styling

- Sketches, Renderings & Concept Modeling
- 3,500 square foot studio
- Electronic security system
- 3-D ATOS Optical Scanner
- Norton Surface Plate
- 5-Axis Tarus Mill

Body Engineering

- Body Systems
  - Body Structures
  - Closures / Hardware
  - Exterior Ornamentation
- Interior Systems
  - Instrument Panels
  - Hard & Soft Trim
  - Consoles
  - Noise, Vibration, Harshness

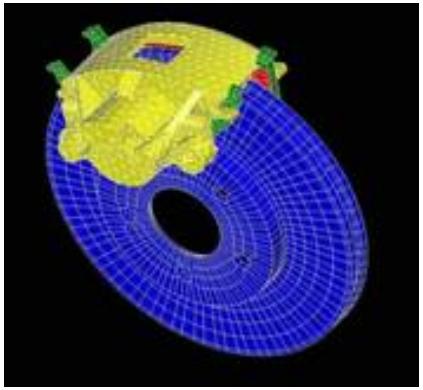


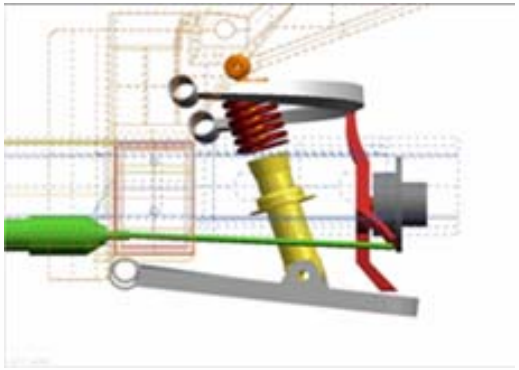


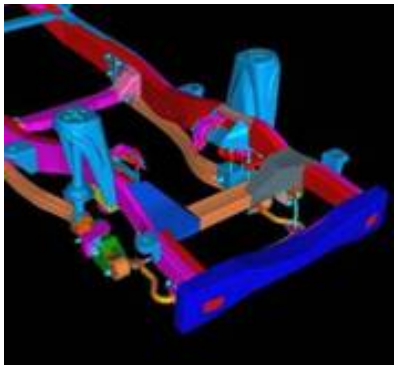
Chassis Engineering

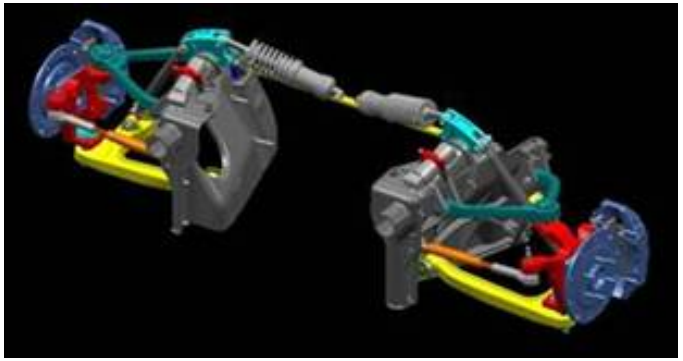
Chassis Systems Design & Development

- Frame
- Braking
- Steering
- Suspension
- Ride & Handling
- Vehicle Dynamics
- Road Load Data Acquisition



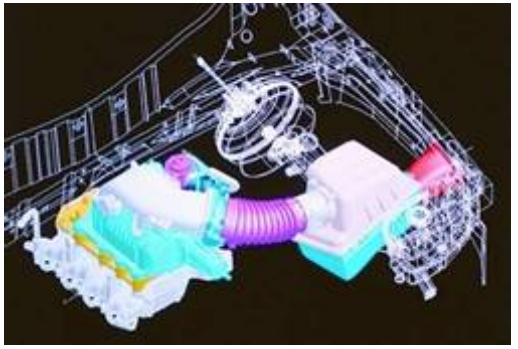


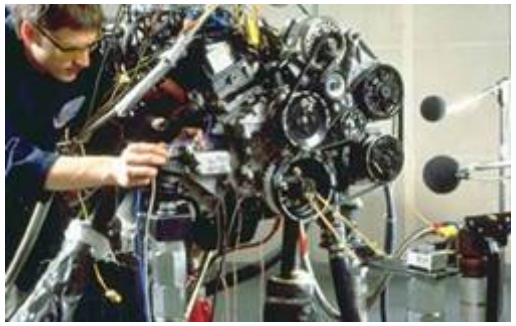


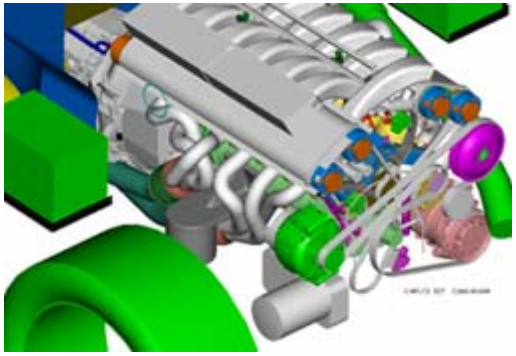


Powertrain Engineering

- Design
  - Base Engine & Components
  - Powertrain Systems & Components
- Development
  - Engine Management Calibration
  - Vehicle Cooling, Heat Management, Climate Control
- Computer Aided Engineering (CAE)
  - Virtual Engine Performance Simulation
  - Valvetrain / Cranktrain Dynamic Analysis
  - Induction Flow, Pressure & Velocity Distributions, Engine Cooling
  - Noise, Vibration, Harshness (NVH)
    - Stress
    - Durability



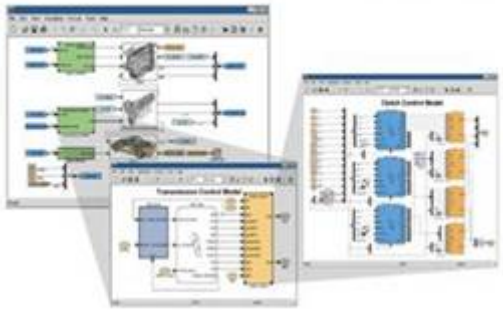


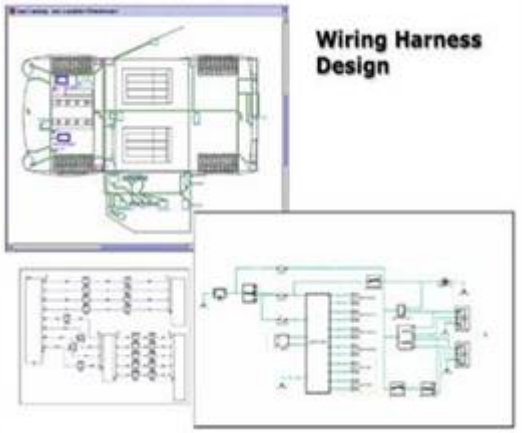


Electrical Systems Engineering

- Control System Development
  - Embedded Control System Software and Integration
  - Algorithm Development
  - On-board Diagnostic Development
  - Vehicle Network Communications
- Electrical Hardware Design and Development
  - Circuit Board Layout and Design
  - Prototype and Small Volume Manufacturing
- Wire Harness Design
  - Prototyping
  - Small volume production
  - Electrical system bucks
- Custom Data Acquisition and Control
  - Engineering test devices built to order

Model-Based Embedded Controls Development

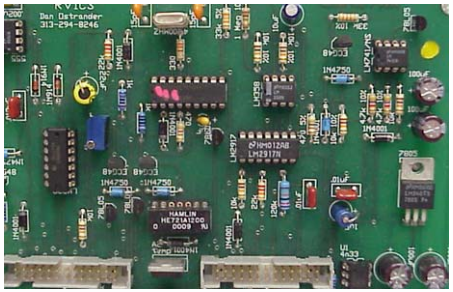


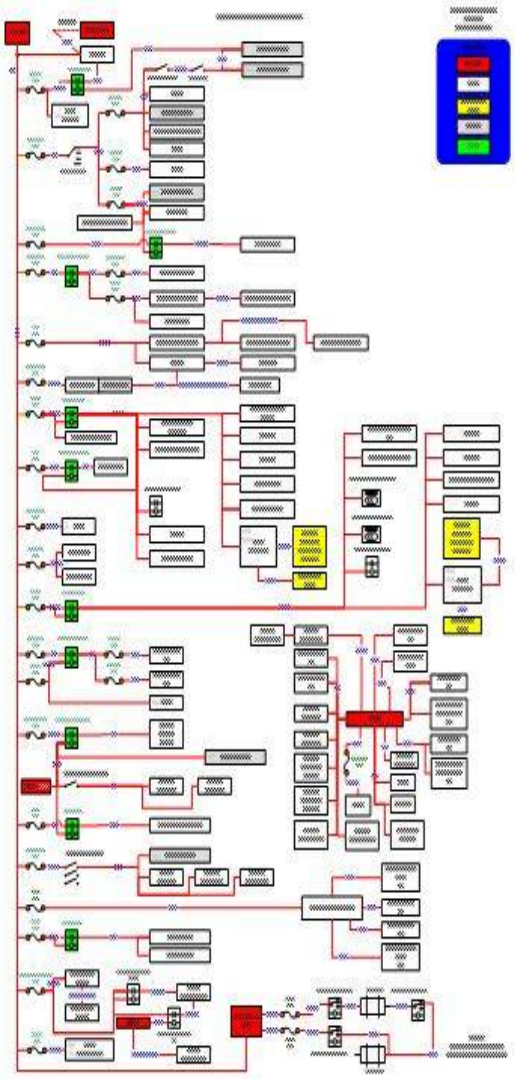


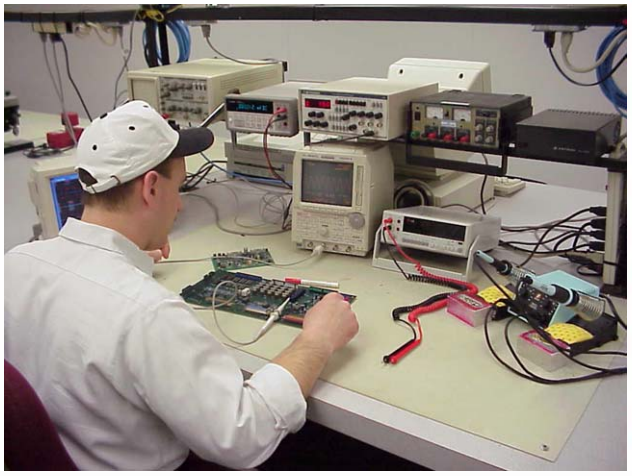
Wiring Harness Design

Automotive Wiring

- Wiring Services
  - Wire Harness Design
  - Prototype Harness Fabrication
  - Circuit Board Development
  - Load Analysis
  - Wire Gauging
  - Transmittals

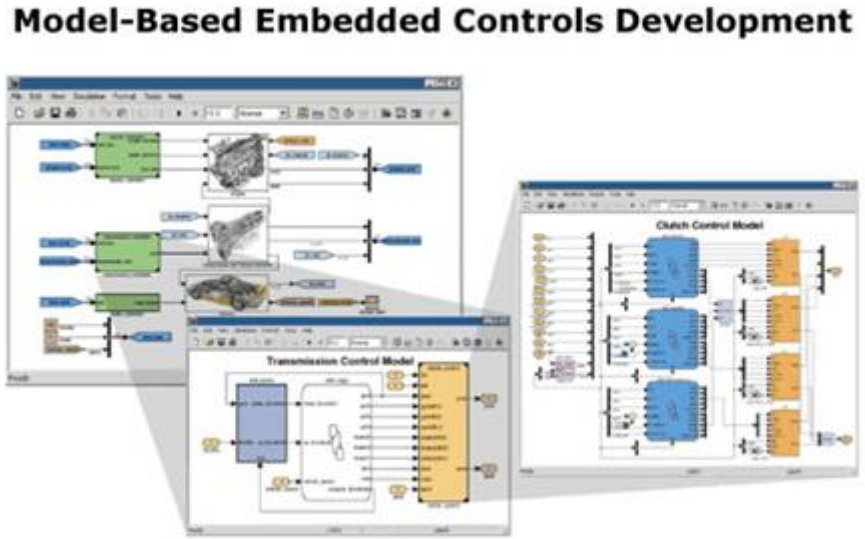






Software Development

- Embedded Software Design
  - System Definition
  - Requirements Capture
  - Algorithm Design and Test
  - C-programming and Code Generation
  - Legacy Code Integration
  - Validation and Verification
  - Calibration
- Test and Measurement
  - Custom Data Acquisition applications
  - Instrumentation Control
  - Data Analysis and Presentation
  - NI/LabVIEW, Visual Studio



Control System Development

- **Roush Embedded Control System Examples (Mototron):**
  - Roush Hydrogen Internal Combustion Engine (HICE) conversion of a Chevrolet Silverado (low volume production). Key roles included:
    - Powertrain design and development
    - Creation of the entire engine and transmission control system.
    - Unique algorithm creation, testing and calibration for driveability, emissions, fuel economy, diagnostics and communications.
  - Revolve HICE conversion of a European Ford Transit.
    - Similar integration as the Roush HICE Silverado

Control System Development

- **Additional automotive embedded control systems include (Mototron):**
  - Roush Crate Engines.
  - Supercharged Gasoline engine strategy for engine dynamometer use.
  - Direct injection diesel engine control system for engine dynamometer use.
  - Production control system for an off-highway ground support vehicle, including an OBDII scan tool interface.

Computer Aided Design

Software

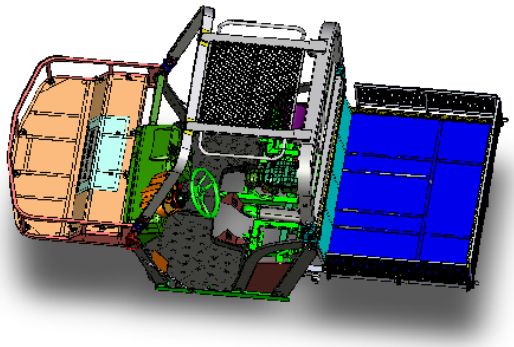
- CATIA V4 and V5
- Unigraphics NX
- PRO Engineer
- ICEM
- VIS VSA
- AutoCAD
- Product View
- VIS Mockup (digital buck)

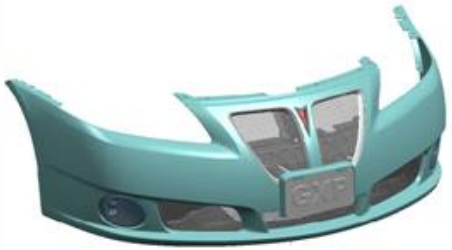
Data Transfer

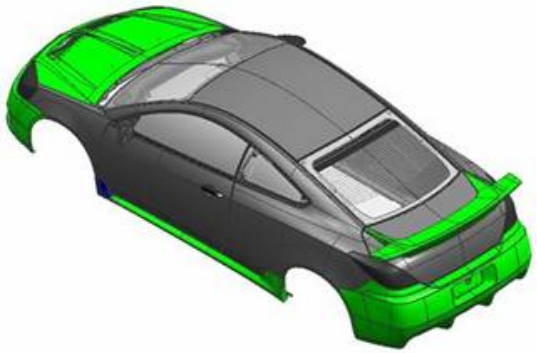
- Multiple high speed connections
- ANX/Supplier FTP
- IMI Bridge (IDEAS Metaphase)
- AUTOWEB
- Secured FTP site
- VPM
- iMAN BRIDGE
- Data Translations

Services

- Class A Surfacing
- Packaging/Feasibility
- 3D Solid Modeling
- 2D & 3D Tolerance Analysis
- Detailing
- Digital Buck
- Data Management

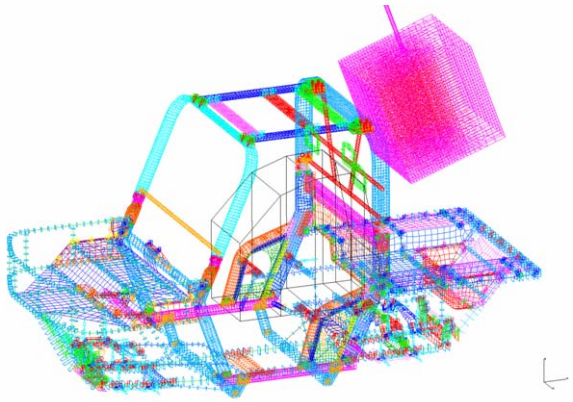


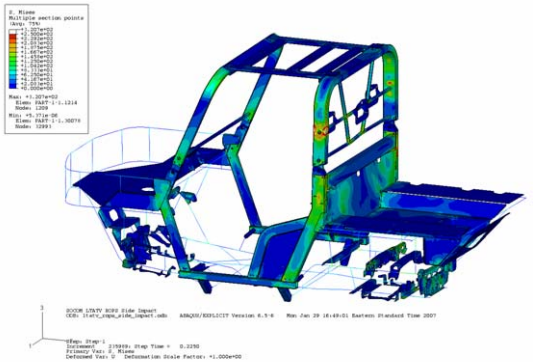


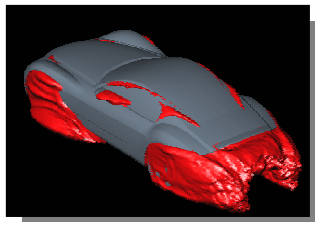


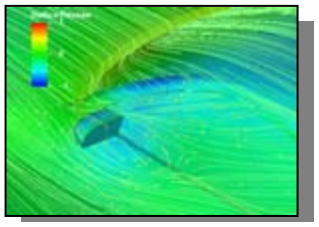
Computer Aided Engineering

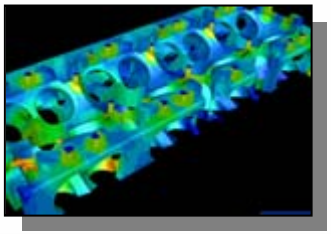
- Finite Element Analysis
  - Predictive Failure / Modal Analysis
  - Crash and Impact Analysis
- Computational Fluid Dynamics
  - Aerodynamics / HVAC / NVH
- Kinematic and Dynamic Analysis
  - Closures / Mechanisms

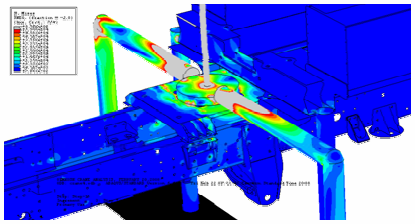


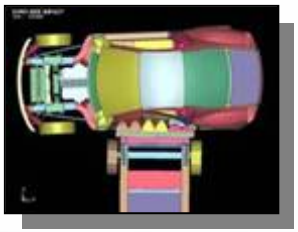








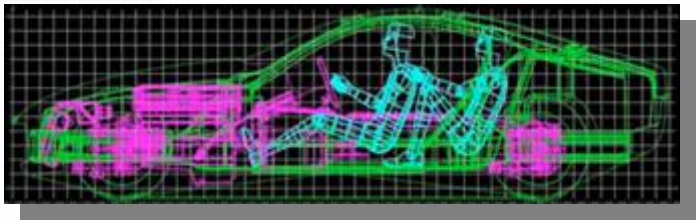


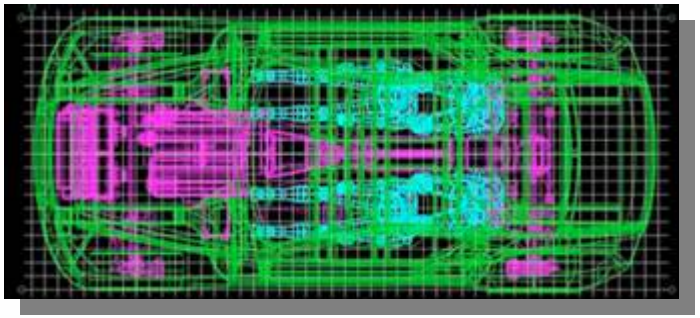


ROUSH

Packaging

- Occupant Package
  - Ingress
  - Egress
  - Safety
  - Visibility
  - Ergonomics
  - Seating Module & Restraints
- Mechanical Package
  - Chassis
  - Driveline
  - Suspension
  - Powertrain
  - Interior, Exterior & Under Hood



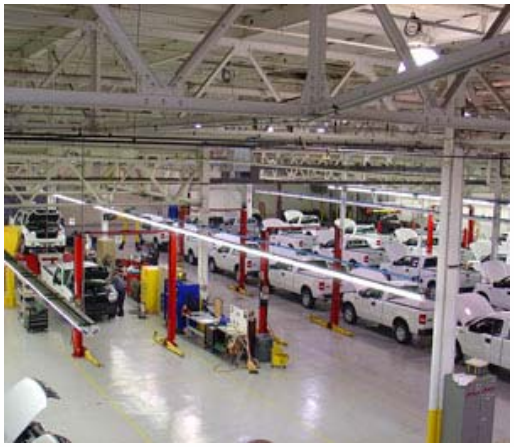


Prototype Services

- Rapid Prototyping
  - Stereolithography (SLA)
  - Selective Laser Sintering (SLS)
- Molded Components
  - Silicone Tooled Components
  - Vacuum Formed Components
- Machining Services
  - 2 Axis Laser Cutting
  - 3 & 5 Axis CNC Milling Machines
- Metal Fabrication
- Composite Lamination
  - Carbon/Kevlar
  - Reinforced Epoxy Panels

Vehicle Build / Mechanical Services

- Vehicle Build Programs
  - Prototype and Low Volume Production
- Mechanical Services
  - Launch Retrofit Support/Vehicle Development
  - High Volume Vehicle Assembly
- Instrumentation
  - Aerothermal Development/Road Load Data Generation

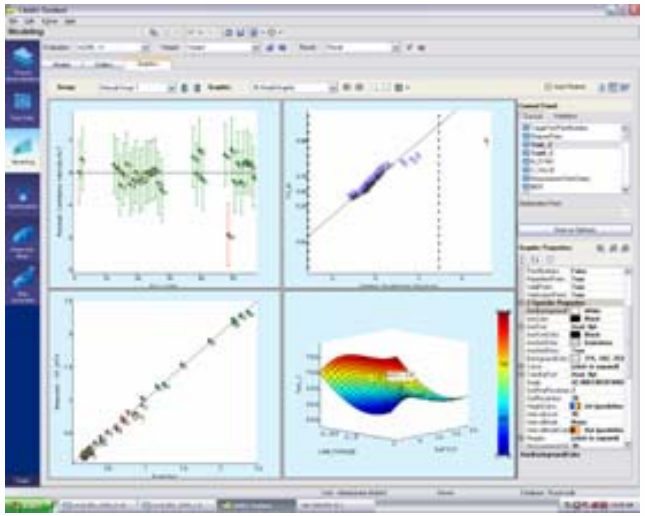


Testing

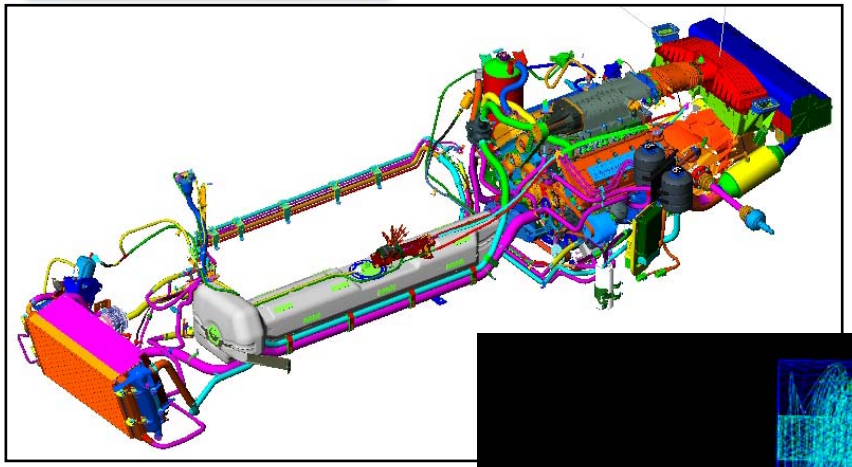
- Vehicle Emissions
  - Tailpipe and Evaporative Testing (LEVII)
  - Electric Range Testing
  - Net Energy Usage Determination
- Powertrain Test Cells
  - 25 Durability & 24 Development
  - Gasoline / LPG / CNG / Diesel Fuels
  - Emissions & In Cylinder Combustion Analysis
  - Deep Thermal Shock
- Brake Testing & Analysis
  - On Road
  - Environmental Dynamometer
- Mileage Accumulation
  - California, Colorado, Florida, Minnesota

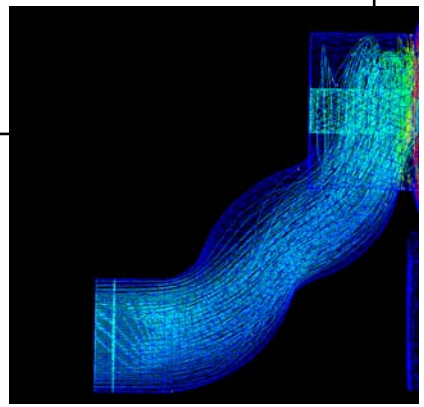
Transient & Climatic Dynamometer Testing

- Complete Drive Cycle Simulation
- Configurations
  - Engine only
  - Engine with Transmission
  - Hybrid Powertrain configuration
- Climatic Testing from -40°C to 90°C with Rapid Engine Cooling
- 16 Channel Combustion Analysis
- Combustion Air and Fuel Conditioning
- Emissions, Drivability & Cold Start Performance
- Calibration Optimization



Thermal Systems Engineering





Noise, Vibration, Harshness (NVH)

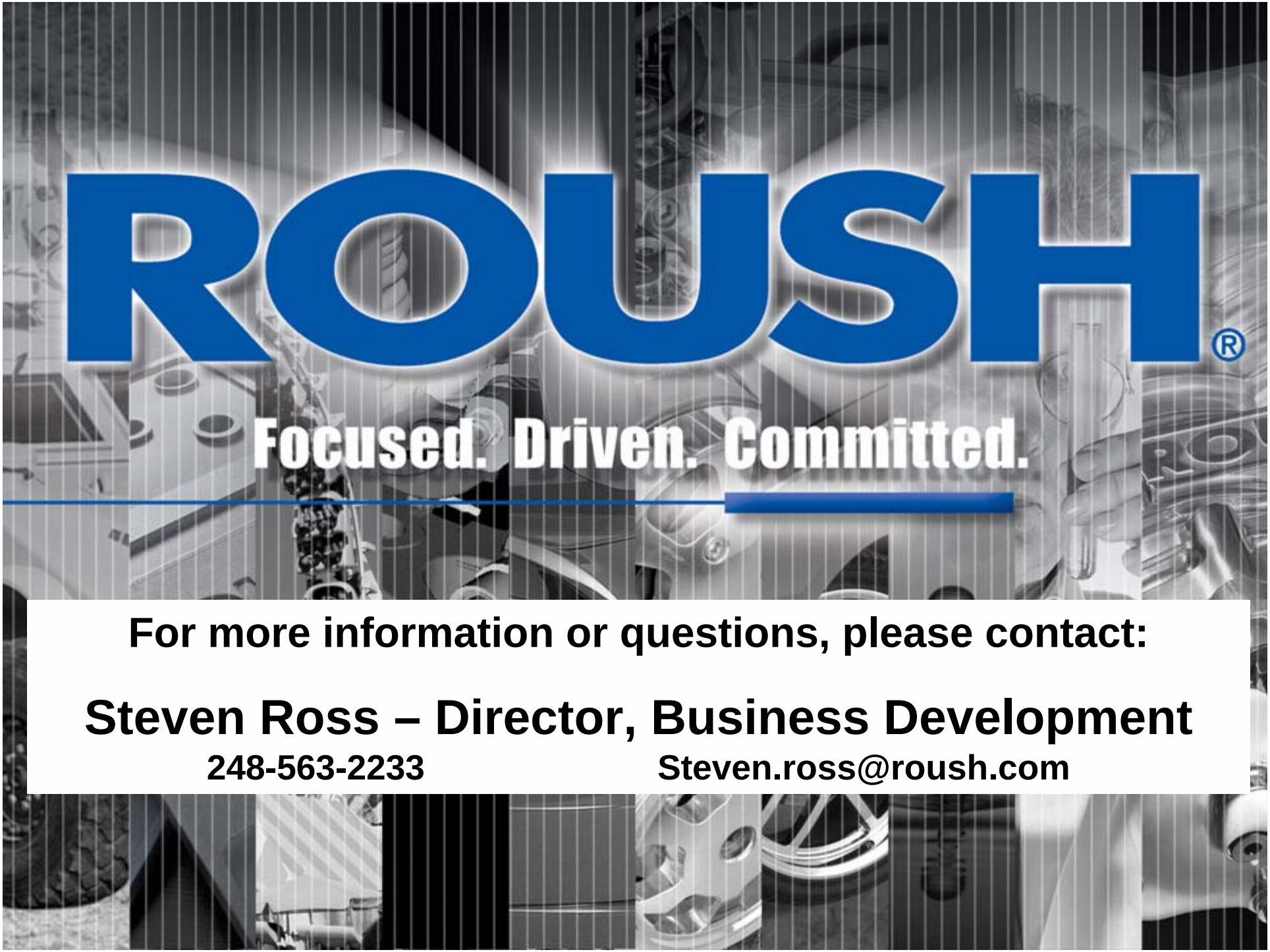
- CAE Noise Analysis
  - Statistical Energy Analysis
  - Finite Element Analysis (FEA)
- Vehicle Sound Package Optimization
- Materials Testing
- Testing Resources
  - 9 Hemi-Anechoic test cells for:
    - Powertrain
    - Vehicle
    - Brakes
    - Accessories
  - Reverberant Chamber (sound absorption)
  - Sound Quality Listening Room
  - Vibration / Durability Shakers

In Summary

- Powertrain Development & Testing is a Core Competency
- Vehicle Integration is Roush's Specialty
- Extensive Range of Local Services to Provide Support for Specific Needs
- Personnel, facilities and support are available in one organization
- Passion to deliver to our customers on time and within budget

- Over 32 years of experience

"Putting Product in the Market Place"



For more information or questions, please contact:

Steven Ross – Director, Business Development

248-563-2233 **Steven.ross@roush.com**