Southwest Research: Powertrain Engineering

SOUTHWEST RESEARCH INSTITUTE®

Michael Kocsis, Manager
Engine Certification and Emission Development
October 2020

Southwest Research Institute - Background

Benefiting government, industry and the public through innovative science and technology

- 73 years of operation (1947)
- 501 (c)(3) nonprofit corporation
- 2700+ employees
- 1,200-acre facility in San Antonio, TX
- 2.2 M sq-ft of laboratories & offices
- Over 1180 patents
- 38 R&D 100 awards

Southwest Research Institute

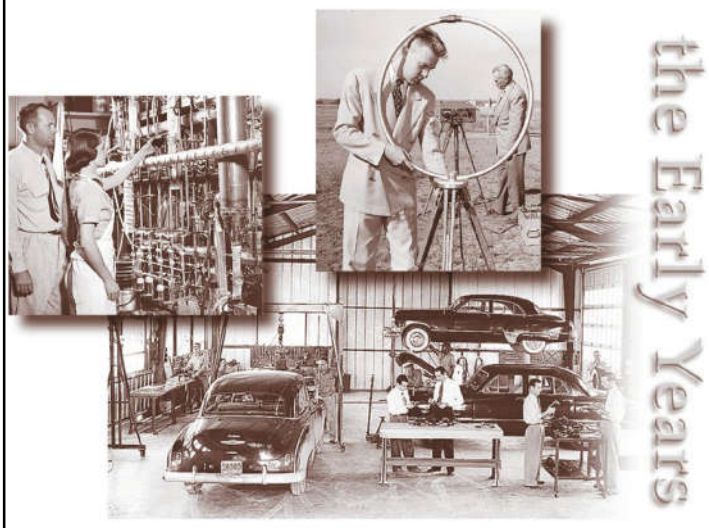
Nine Technical Divisions

Chemistry and Chemical Engineering
Powertrain Engineering
Fuels & Lubricants Research
Intelligent Systems
Applied Power
Applied Physics
Space Science & Engineering
Defense & Intelligence Solutions
Mechanical Engineering

From Deep Sea To Deep Space And Many Applications In Between

SwRI in the Technology Spectrum

Automotive Business Started in 1949

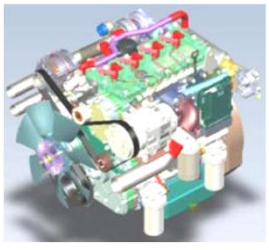


Conducted projects on diesel smoke and odor in late 1960's, before formation of US EPA

Powertrain Engineering Division

Core Strengths:

- Developing innovative technologies to meet future emissions and fuel economy regulations
- Multi-client pre-competitive research programs
- Engine performance & emissions development
- Engine design & production development
- Engine & vehicle emissions certification
- World-class engine & vehicle testing facilities

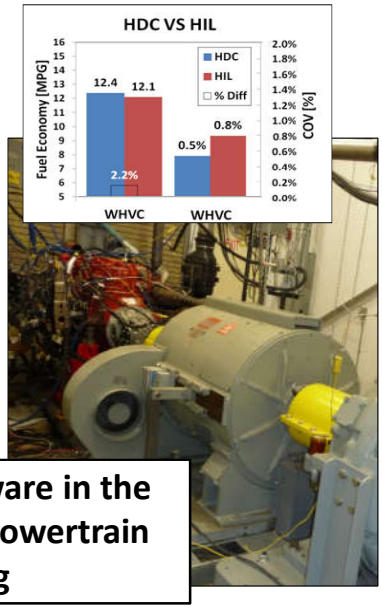


SwRI Partners With Industry, Regulators, and R&D Labs

SwRI, as an independent expert in the field, acts as a partner to the commercial market as well as the regulatory system

SwRI Support to Government Programs Today

- 2013-20
  - EPA HD GHG support program
- 2013-16
  - NHTSA HD technology analysis
- 2014-20
  - CARB low NO_X demonstration program (NO_X = 0.02 g/hp-hr)



Hardware in the loop Powertrain Testing

High accuracy HD Chassis Dyno testing

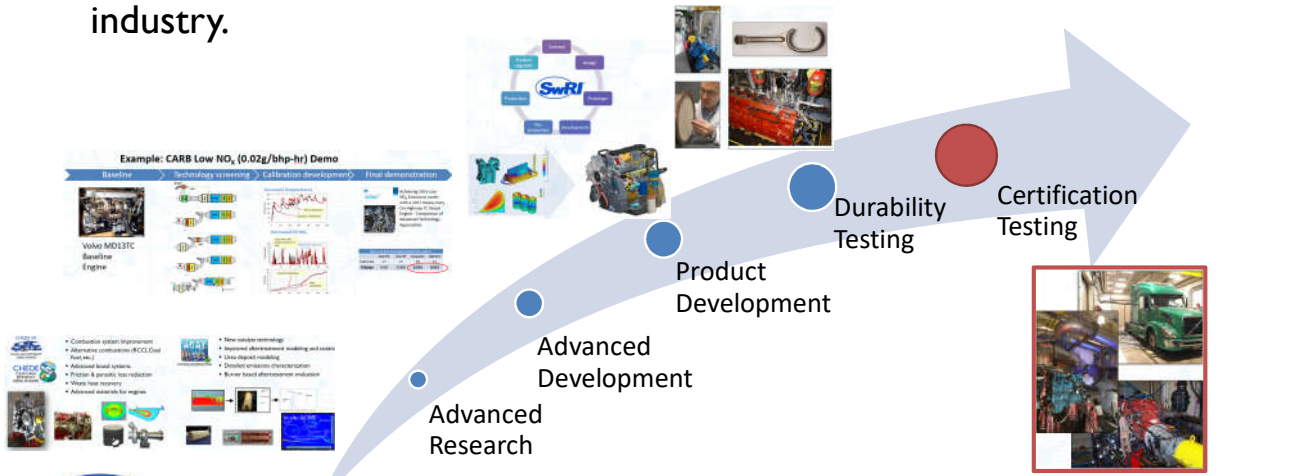
Powertrain Engineering Division

- SwRI has a team of over 250 development engineers, mechanics and operators who are experienced in powertrain performance development and calibration. We have extensive laboratory facilities, including on-site access to complete chemistry and metallurgy laboratories and non-destructive analysis facilities

- **65 test cells** for development and certification work
  - 36 → 5000 kW
  - Low and high-speed data acquisition (DAQ)
  - Gaseous, PM, and PN emissions
  - Many cells are Part 1065 compliant
  - Several cells automated for 24/7 operation
  - Altitude and cold start capabilities
  - NVH test cells
- Chemistry lab
  - Used / new oil analysis
  - GC / MS
  - FTIR
  - Non-regulated emissions and exhaust toxins
- Extensive mechanical development facilities
- Energy storage and electrification facilities

Powertrain Engineering Division

- Powertrain Engineering activities address advanced research needs as well as production development for OEM's, suppliers, and the oil industry.



Advanced Research

- SwRI leads several industry consortium focused on advanced research to support future powertrain solutions

CHEDE-VII
CLEAN HIGH EFFICIENCY DIESEL ENGINES

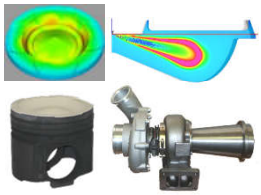
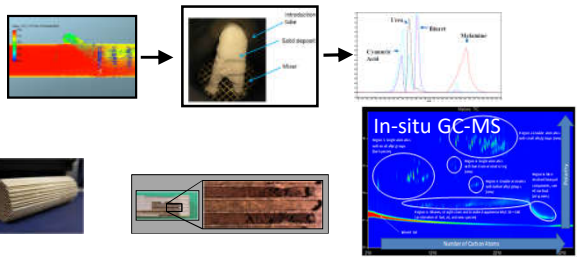
CHEDE
CLEAN HIGH EFFICIENCY DIESEL ENGINES

- Combustion system improvement
- Alternative combustions (RCCI, Dual Fuel, etc.)
- Advanced boost systems
- Friction & parasitic loss reduction
- Waste heat recovery
- Advanced materials for engines

ACAT
Advanced Combustion Catalyst & Aftertreatment Technologies

- New catalyst technology
- Improved aftertreatment modeling and controls
- Urea deposit modeling
- Detailed emissions characterization
- Burner based aftertreatment evaluation



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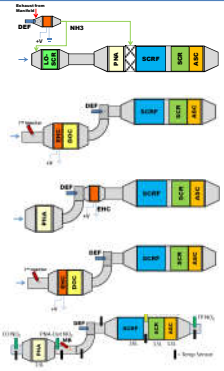
Advanced Development

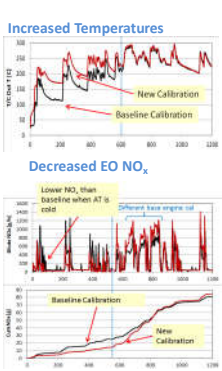
- Experience performing advanced technology demonstration programs for industry and government

Example: CARB Low NO_X (0.02g/bhp-hr) Demo

Baseline > Technology screening > Calibration development > Final demonstration

Volvo MD13TC
Baseline
Engine





Achieving Ultra Low NO_X Emissions Levels with a 2017 Heavy-Duty On-Highway TC Diesel Engine - Comparison of Advanced Technology Approaches

NO_x Levels with Development Aged Parts, g/hp-hr

	Cold-FTP	Hot-FTP	Composite	RMC-SET
Engine-Out	2.8	3.0	3.0	2.1
Tailpipe	0.06	0.008	0.016	0.015

POWERTRAIN ENGINEERING
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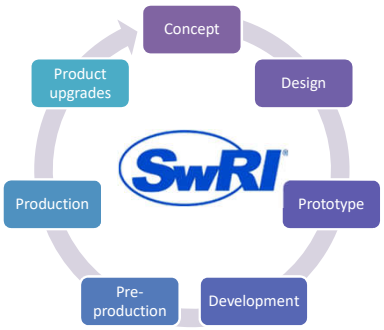
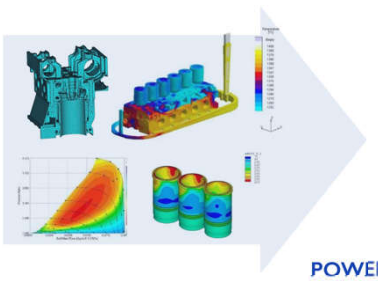
Product Development

- Experience supporting all aspects of product life cycle
  - Concept development
  - Clean sheet engine design
  - Prototype generation
  - Performance development
    - Cycle simulation
    - Hardware selection
    - Steady-state & transient calibration
  - Mechanical development
    - Engine testing
    - Rig testing
  - Current production support
  - New ratings development programs

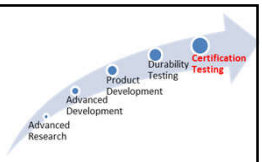




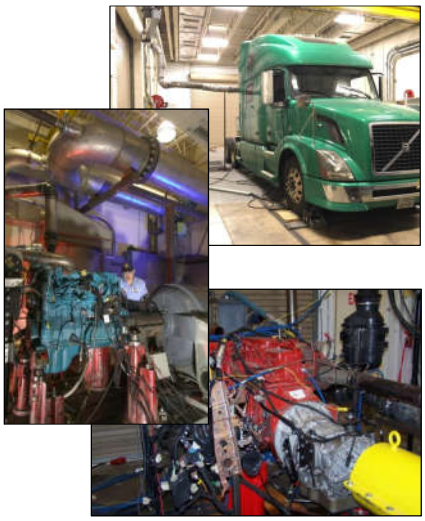
Durability Testing

- Performance evaluation with specialization in engine and aftertreatment survivability and durability
  - Test cells capable of 24/7 operation
- Experienced in developing accelerated engine durability test plans
- Developed precise test methods for accelerated DPF ash loading and evaluation
- Supports engine certification with deterioration factor (DF) testing
- Experience with component level durability evaluations and test cycle development

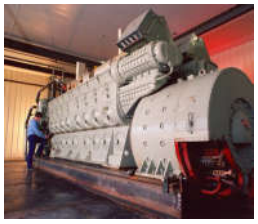
SwRI Certification Capabilities

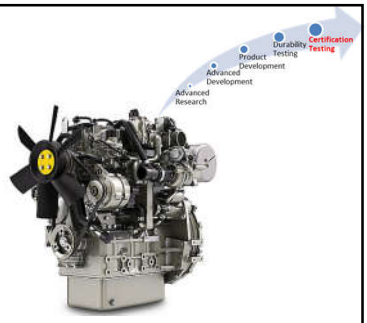


- Recognized expertise in certification testing of engines for worldwide markets
- Thirteen Part 1065 transient certification cells
  - **Part 1065 required for US Certification**
    https://ecfr.io/Title-40/cfr1065_main
- Part 1065 high altitude simulation test cell for not-to-exceed testing
  - Up to 4800 meters above sea level
- Powertrain test cells (engine and transmission) with Hardware-In-the-Loop capability are available (up to 19,000 Nm from zero RPM)
- Twin roll HD chassis dynamometer with high precision CO_2 and emissions measurements
- End of line audit and compliance testing and support
- Long working relationship with regulators in US and other regional markets
  - Have assisted US EPA in data collection and interpretation in support of cycle development



SwRI Certification Capabilities





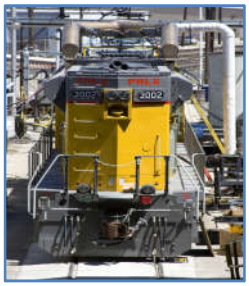
- Performs certification testing for various applications
  - On-road
  - Non-Road
  - Marine
  - Gen-set
  - Locomotive
- Provides other certification related testing
  - Manufacturer Self Test (MST)
  - On-board Diagnostic (OBD)
  - Conformity of production
  - Emissions audit

SwRI Certification Experience

- SwRI performed certification testing with a host of regulatory agencies
  - **CANMET / Canadian Standards Association (CSA)**
  - **U.S. Mine and Health Administration (MSHA)**
  - U.S. Environmental Protection Agency (EPA)
  - California Air Resources Board (CARB)
  - United National Economic Commission for Europe (UNECE-EU)
  - Automotive Research Association of India (ARAI)
  - International Maritime Association (IMO-MARPOL)
  - China Ministry of Environmental Protection (MEP)
  - China Certification Society (CCS – Marine)

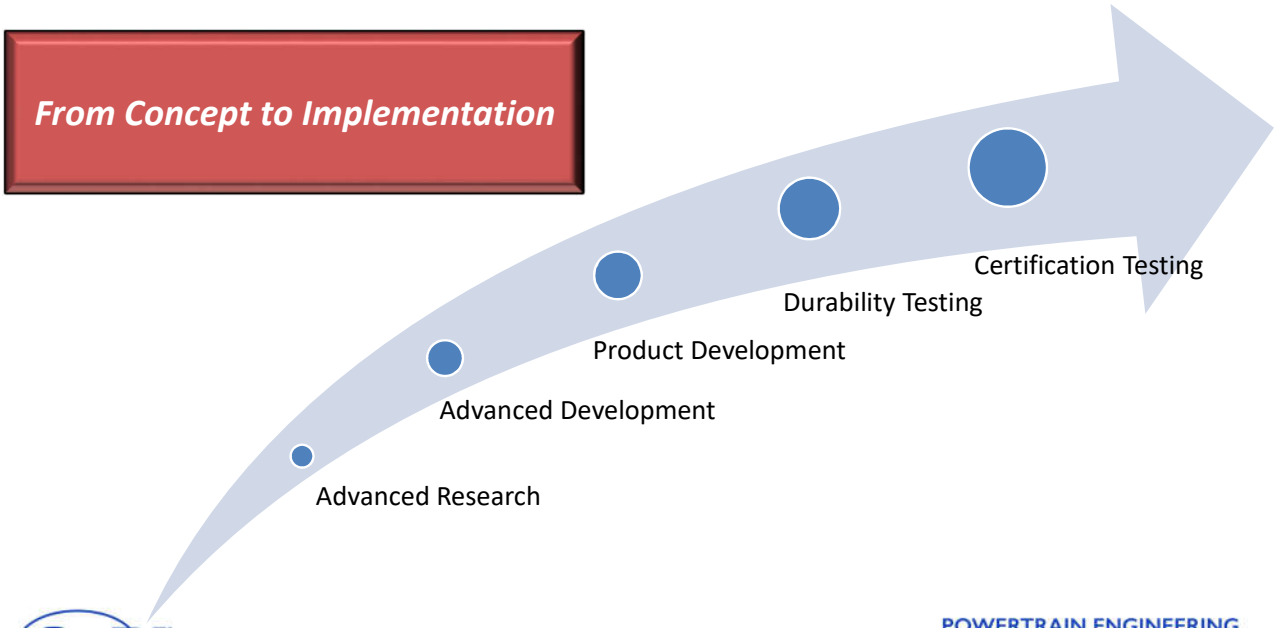
SwRI Certification Experience

- **SwRI typically performs ~50+ HD engine certification tests per year *(36-5000 kW)***
  - Excellent reputation with regulators
  - Successfully conducted numerous certification witness tests
- Multiple projects with US/European/Asian OEMs
- Able to provide a wide range of support, including:
  - Engine certification testing
  - Interaction with government regulators
  - Negotiation with regulation bodies
  - Guidance in certification application process
  - Deterioration factor (DF) testing



Powertrain Engineering Division

From Concept to Implementation



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