Seminar

Modeling and Simulation of Dynamical Systems

Presented by the
IEEE Control Systems Society
Santa Clara Valley

Sunnyvale, 5 February 2011

Program

Welcome	08:45 – 09:10am	Coffee and bagels, Seminar kickoff at 9:00am
Session 1	09:10 – 10:00am	Mathematical models of dynamical systems Dr. P.K. Menon, Optimal Synthesis
Session 2	10:10 – 11:00am	System Identification - Theory and Practice Dr. Mark B. Tischler, Ames Research Center
Session 3	11:10 – 12:00am	Visualization and Virtual Environments Dr. Hadi Aggoune, Cogswell Polytech. College
Lunch	12:00 – 12:40pm	Sandwiches, sodas, discussions and product demos
Session 4	12:40 – 01:30pm	Applications of Hardware-in-the-Loop Simulators Christoph Wimmer, National Instruments
Session 5	01:40 – 2:30pm	Simulation with Software Tools Elliot English, Dr. Martin Aalund, Dr. Karl Mathia

Session 4

Applications of Hardware-in-the-Loop Simulators

Christoph Wimmer, National Instruments

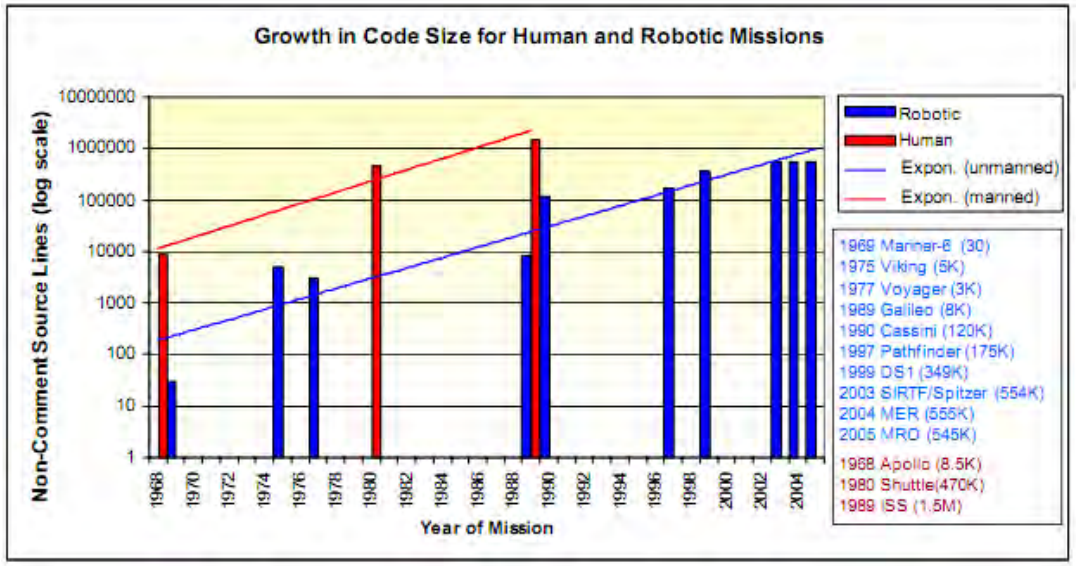
Agenda

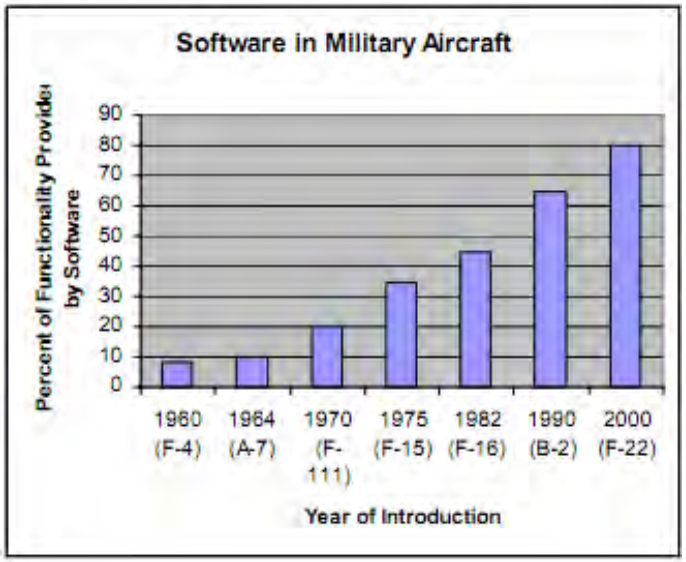
- Reason for HIL
- Components of a HIL System
  - Hardware
  - Software
- Summary

Increasing Software Content…

Reality

- Software Growth
- SW enables Functionality



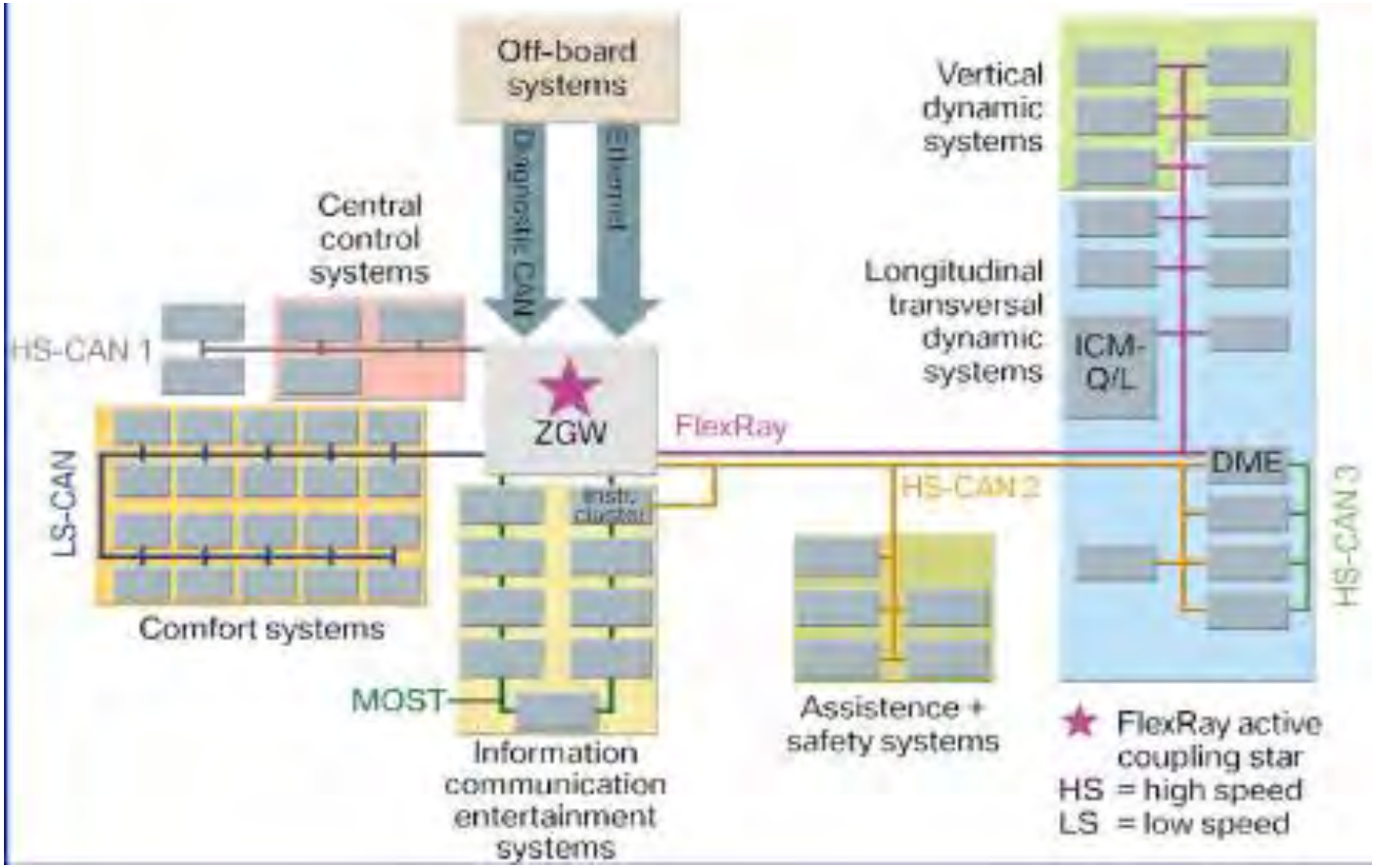


•http://www.nasa.gov/pdf/418878main_FSWC_Final_Report.pdf

Impact

- Complexity
- Risk, Damage
- Time to Market

Complexity



BMW 7 Series: 70 ECUs

Lexus 460: 100 ECUs

Embedded Software Development Process

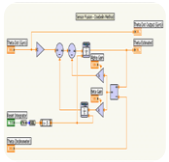
Manage complexity by…

Tying modeling, RCP, and HIL results to requirements

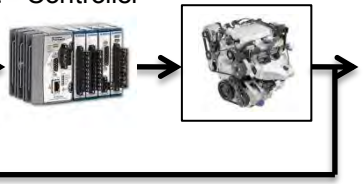
Maximizing system simulation early

Reusing models and tests between stages

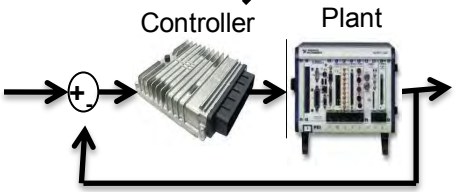
Requirements gathering



Simulation and rapid prototyping



Code generation and ECU flashing



Hardware-in-the-loop testing (HIL)

Physical testing

Test cells

Field test

Calibration

HIL Definition – Dynamic Test

HIL didn't exist 20-25 years ago

Roots in aviation

Host PC

Processor

I/O

Controller

HIL System

Components of a HIL System

- A real-time target computer(s) with I/O.
- A host PC with communications link to target computer and diagnostic link to ECU.
- A Graphical User Interface (GUI) application to download and control the real-time process.
- A test automation application to automate all aspects of the test.
- A math model of the plant (i.e. engine or vehicle model).
- Sensor models
- Real or simulated loads
- Fault insertion relay matrix

Aircraft Arrestor System

ZODIAC AEROSPACE

Hydraulic Control System Testing

"The out-of-the-box capabilities of NI VeriStand **made it practical** for us to develop an HIL test system, reducing our total testing cost by more than $500,000."

– Greg Sussman, CLA, Process Automation

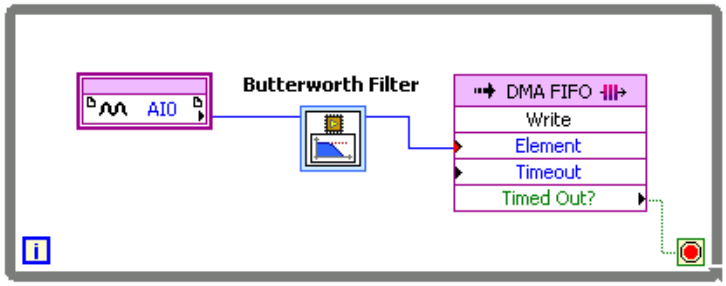
PAC Process Automation corp.

ZODIAC AEROSPACE

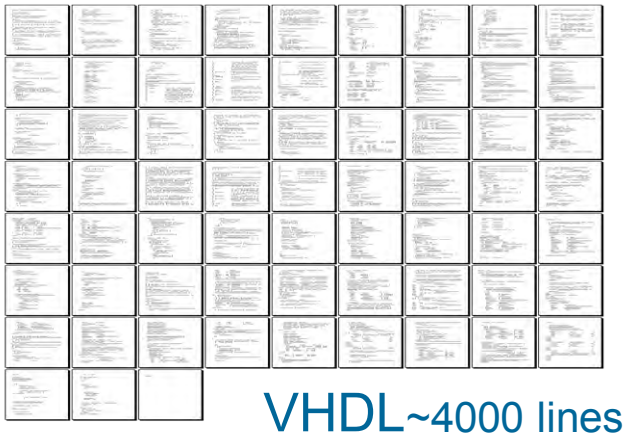
HIL I/O Components

- AI (force), DI (stop), DO (limits)
- Loads (brake motors)
- Power Supplies
- Buses: fiber (ARINC, CAN, …)
- **Sensor Simulation** (Encoder, TC, LVDT, …)
- **Fault Insertion Unit**

FPGA Sensor Simulation

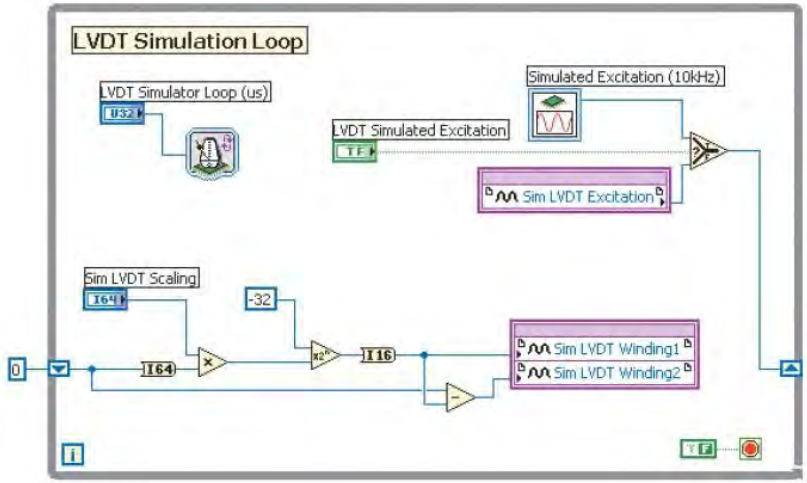


LabVIEW FPGA

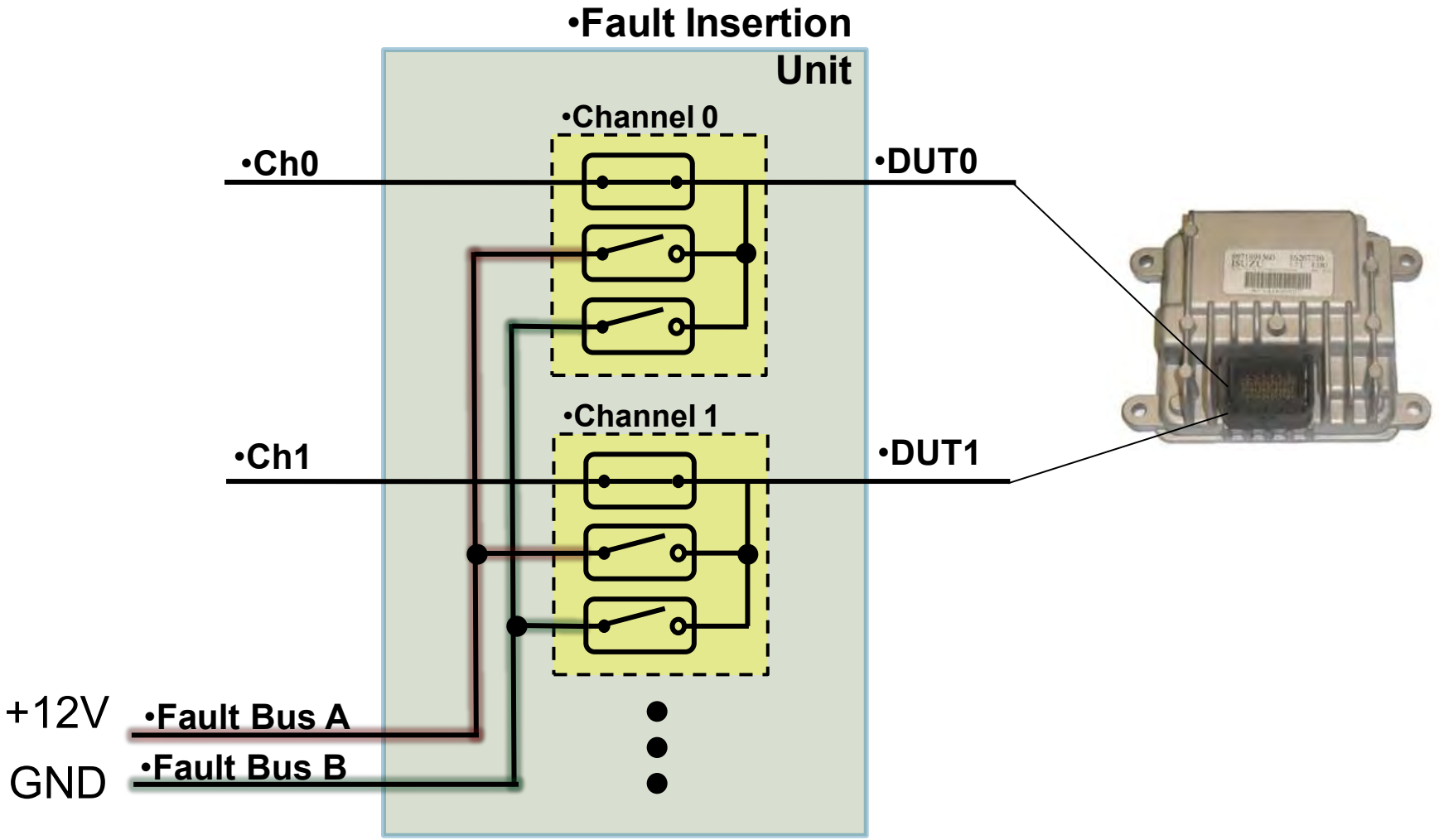


VHDL~4000 lines

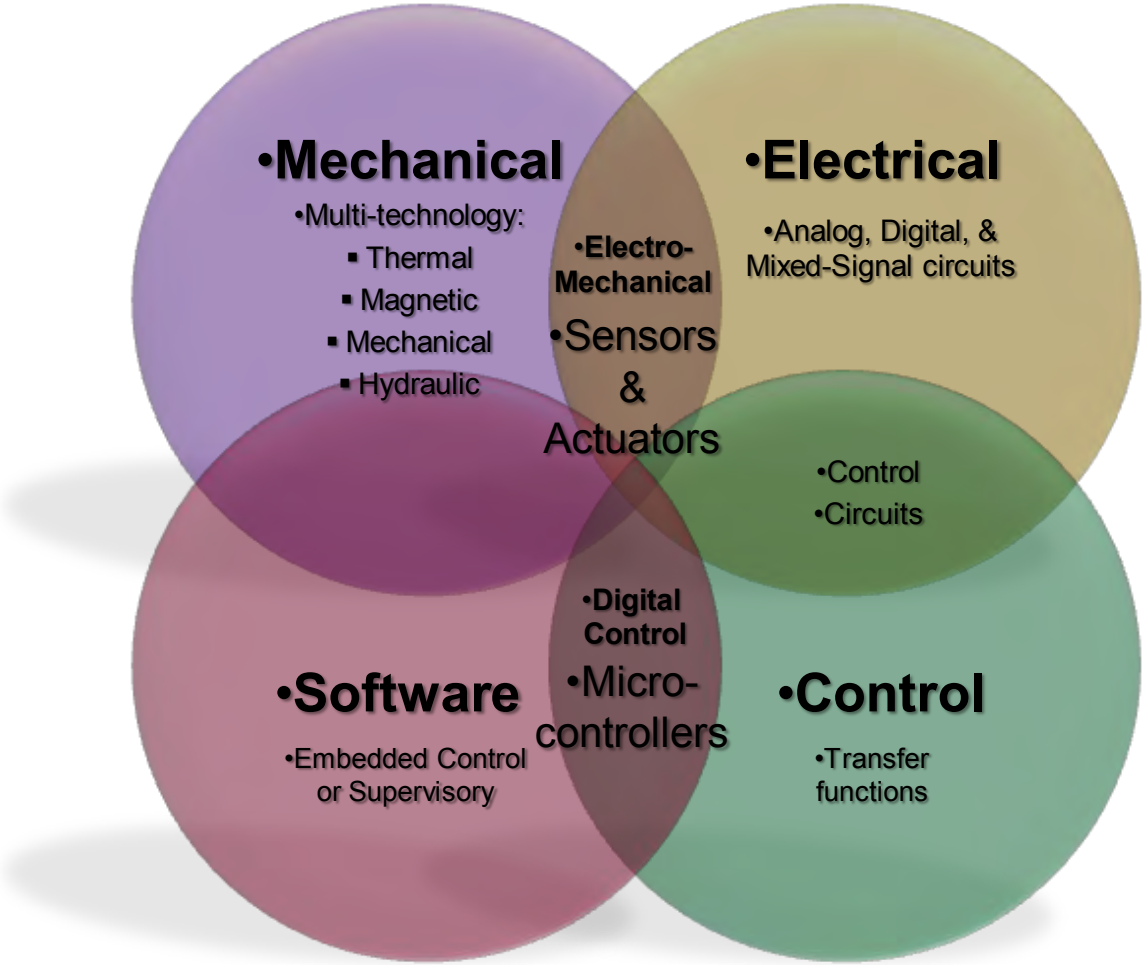
LVDT Simulation



Fault Insertion Unit (FIU)



The Challenge: Testing Your Multi-Domain System

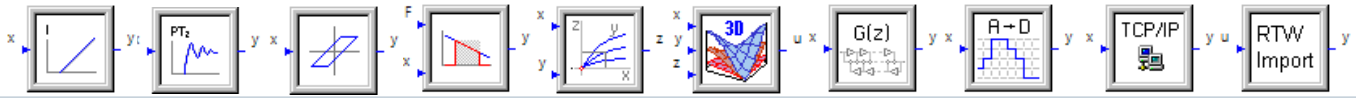
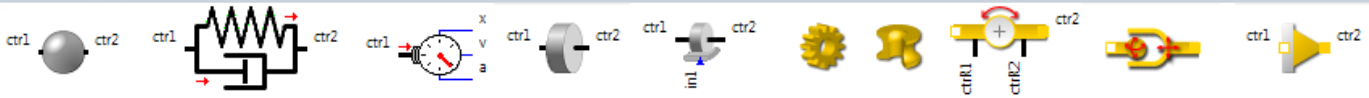
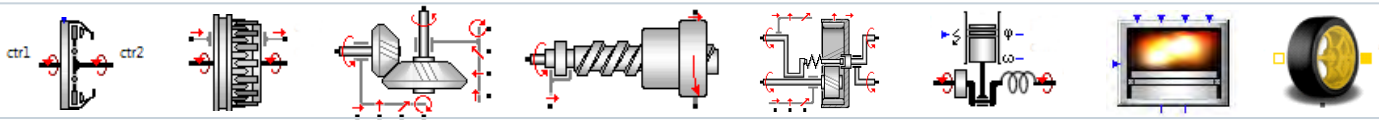
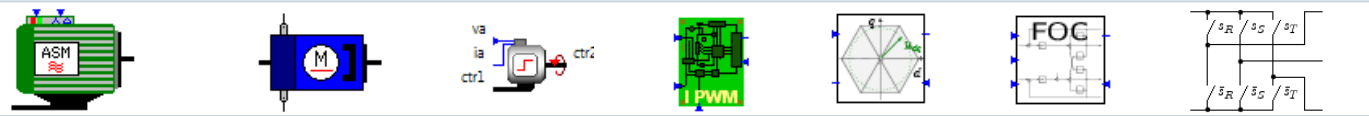
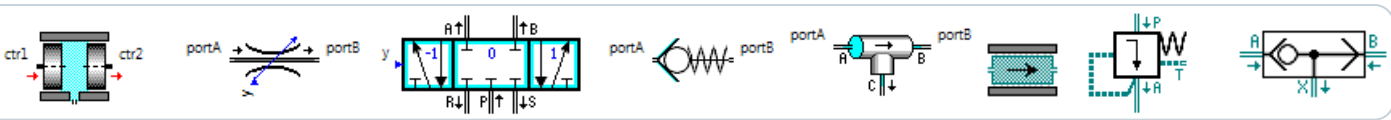
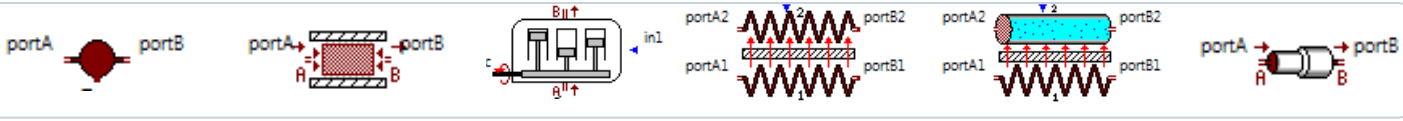


Systemvision

Mentor Graphics

SIMULATION X®
Powered by ITI

SimulationX Model Libraries

•Domain	•SimulationX Model Elements (Samples)
•Signal Blocks	
•Mechanics	
•Powertrain	
•Electro- •Mechanics	
•Magnetics	
•Pneumatics •Hydraulics	
•Thermo	

Open Platform

- The MathWorks, Inc. Simulink® software
- NI LabVIEW
- C/C++
- MapleSim models from Maplesoft
- SimulationX from ITI
- Tesis DYNA models
- NI MATRIXx SystemBuild

- Esterel SCADE Suite
- C/C++

- CarSim from Mech Sim Corp.
- GT-POWER engine models from Gamma Technologies Inc.
- AMESim models from LMS
- VI-grade

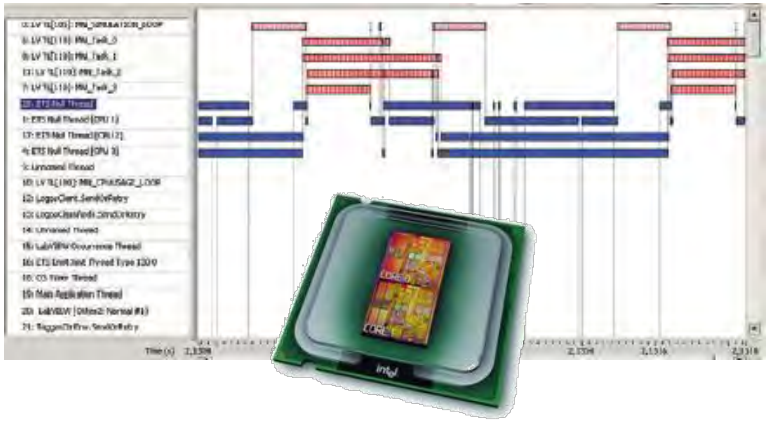
•Simulink is a registered trademark of The MathWorks, Inc®.

Real-time Multicore Simulation

Efficiently harness the data and task parallelism provided by the latest processor technologies

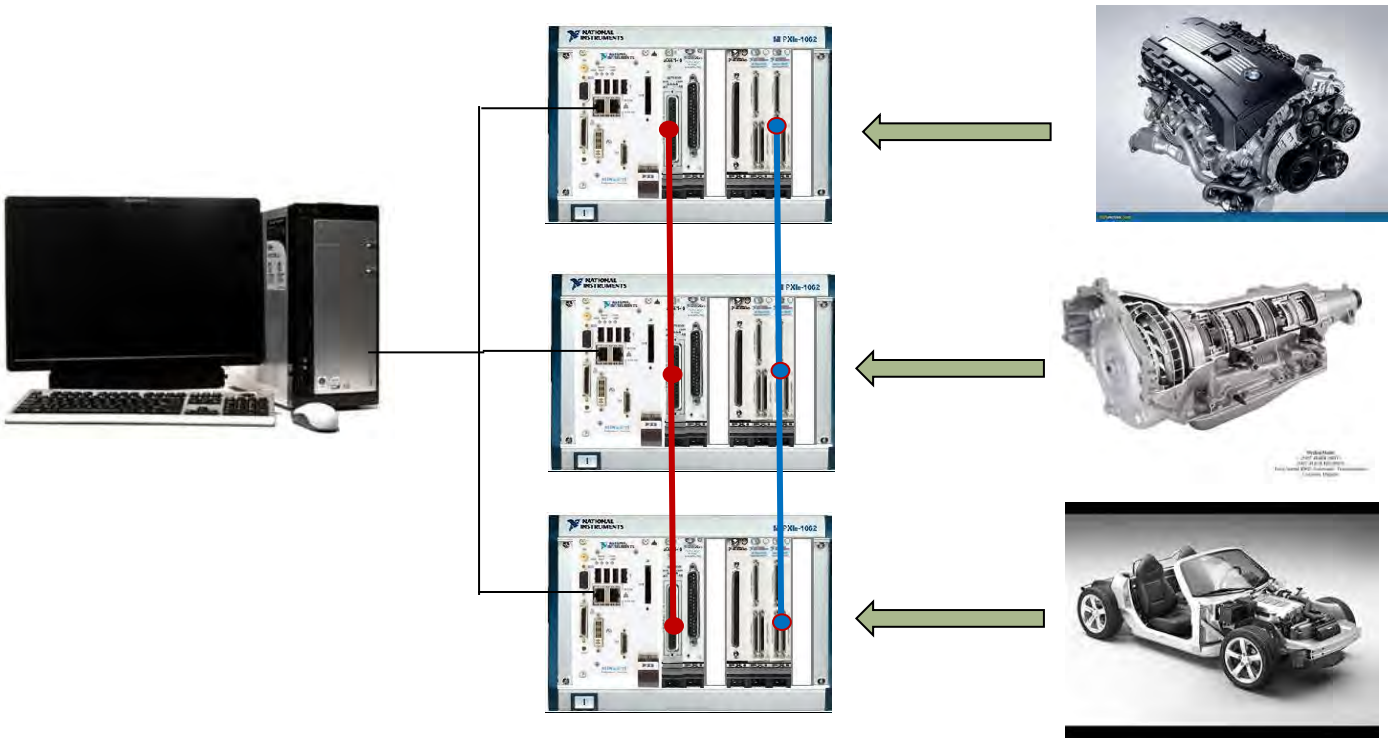
Distribute test system tasks across cores to increase system bandwidth

Execute models in parallel on multiple cores to improve performance



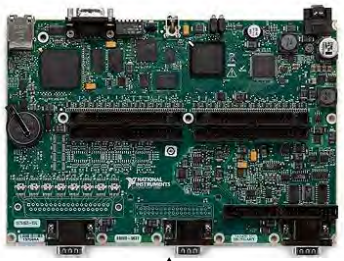
www.ni.com/multicore

Multi Chassis Simulation

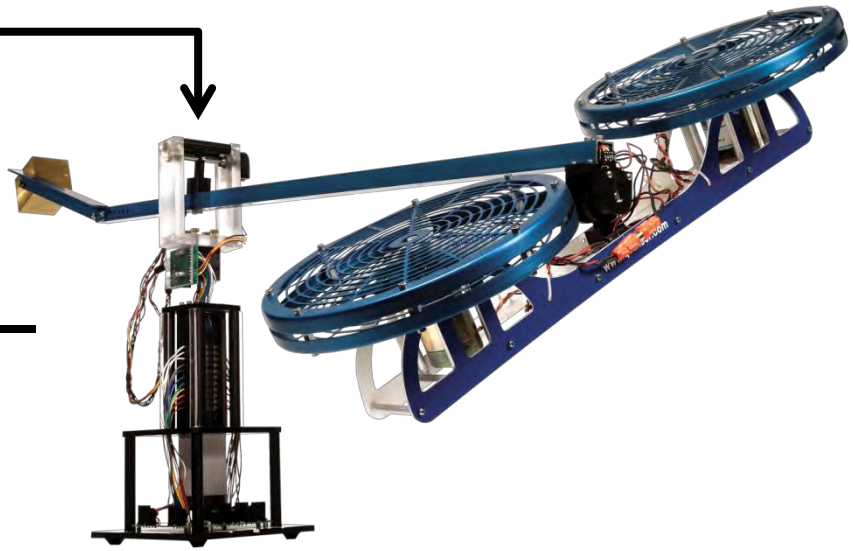


Demo: Helicopter Controller Test System

Position Set Point
[PWM]

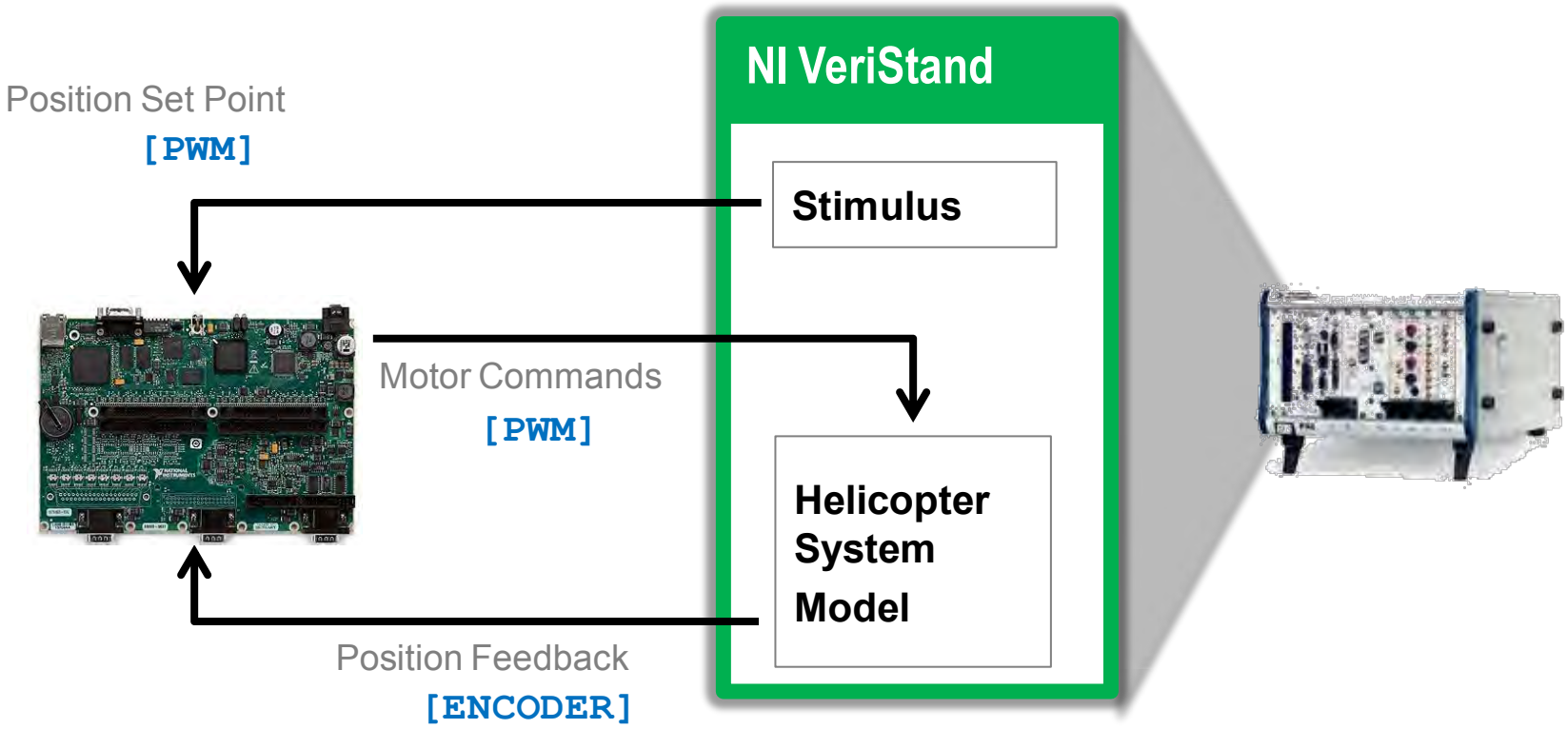


Motor Commands
[PWM]

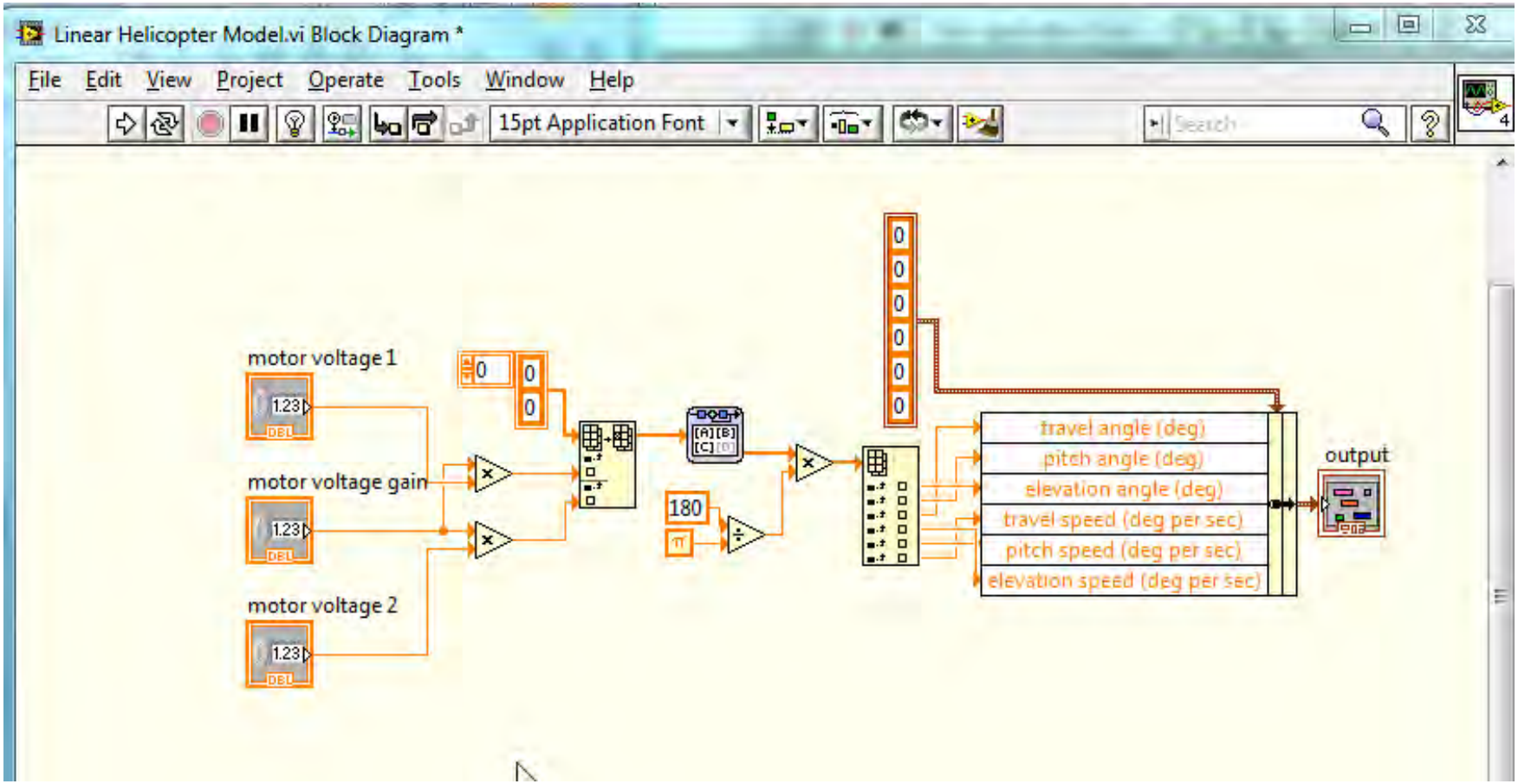


Position Feedback
[ENCODER]

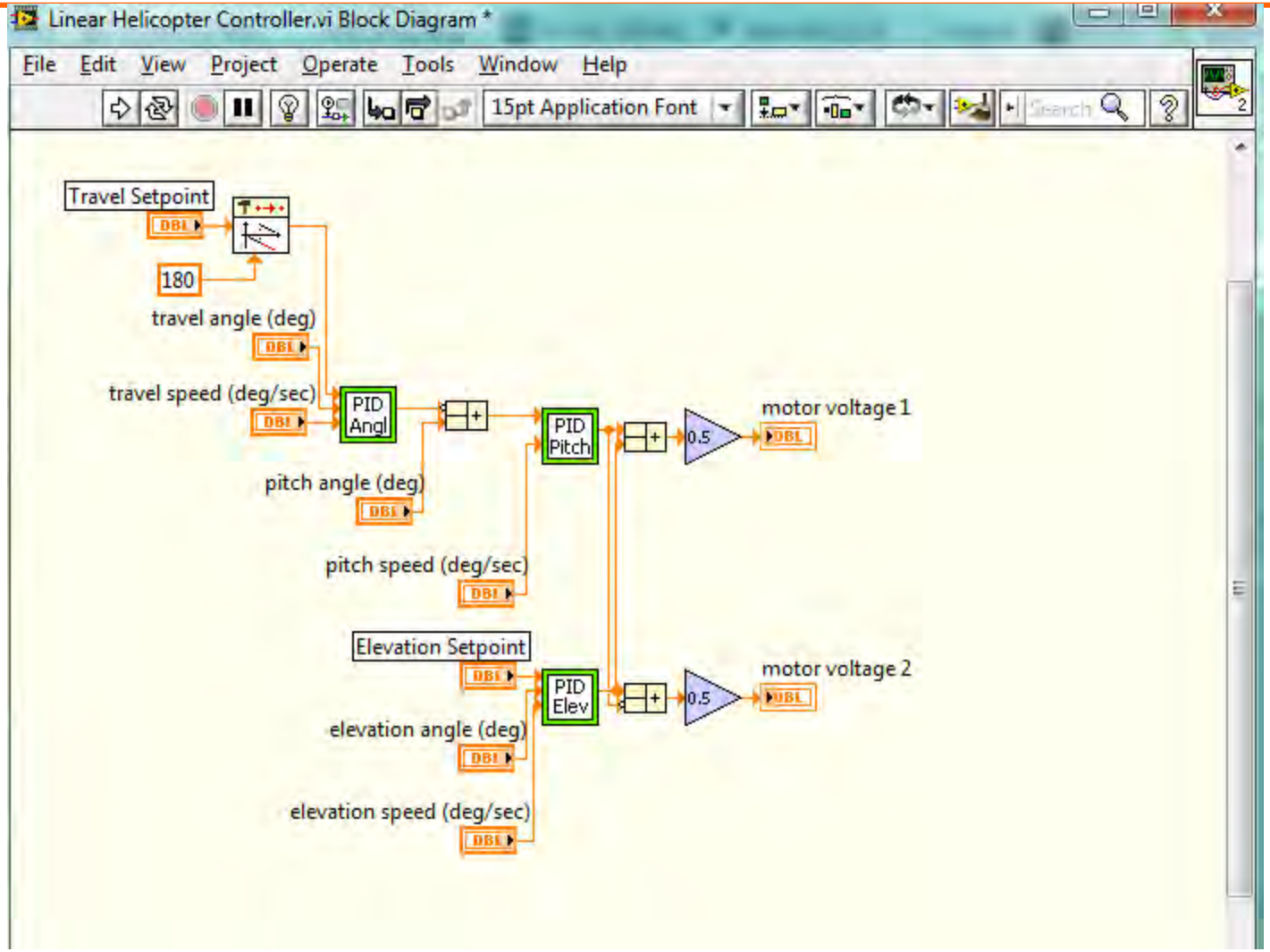
Demo: Helicopter Controller HIL Test System



Helicopter Model

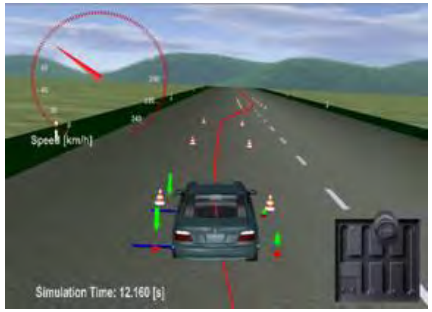


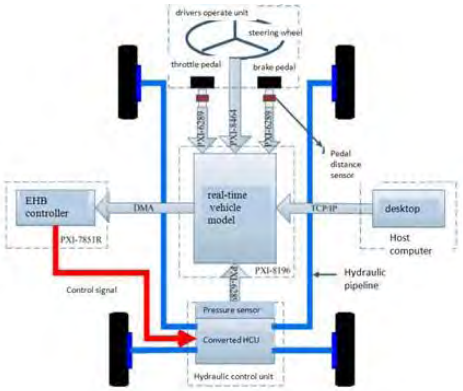
Helicopter Controller



Driver-in-the-loop Test Platform for EHB System Using NI PXI

- **The Challenge:** The key to develop an EHB (Electro-Hydraulic-Brake) controller is to know the performance of actuator through extensive testing experiments, reduce the difficulties caused by real road test through effective parameter simulation and software simulation, and use virtual reality technology to develop a hybrid simulation platform where the actual manipulation of the driver in different virtual environment can perform functional verification of EHB rapid prototyping controller and demonstration of product properties.
- **The Solution:** Develop a wheel cylinder pressure measurement and control system with LabVIEW to control the high-speed switching electromagnetic valve of EHB system. Implement data acquisition (DAQ) and communication of steering wheel, electronic throttle, brake pedal and wheel cylinder pressure in HIL test. Integrate the real-time vehicle model generated with DYNAware software to VeriStand software platform
- **Products:** NI VeriStand, PXI-6289, LabVIEW, PXI-8196 RT, FPGA Module, Real-Time Module, PXI-1042Q, PXI-7851R, PXI-8464/2, PID and Fuzzy Logic





"Using NI software and hardware, we successfully developed a test platform for EHB hybrid simulation."

He Huang - Hefei University of Technology

HIL Software

NI VeriStand
Real-Time Testing and Simulation Software

- Single-point I/O
- Calculated channels
- Stimulus generation
- Test Automation
- Data logging
- Alarming

- Run-time editable user interface
- User management
- Multi-chassis synchronization
- Deterministic model execution

•RT PXI

•RT PC

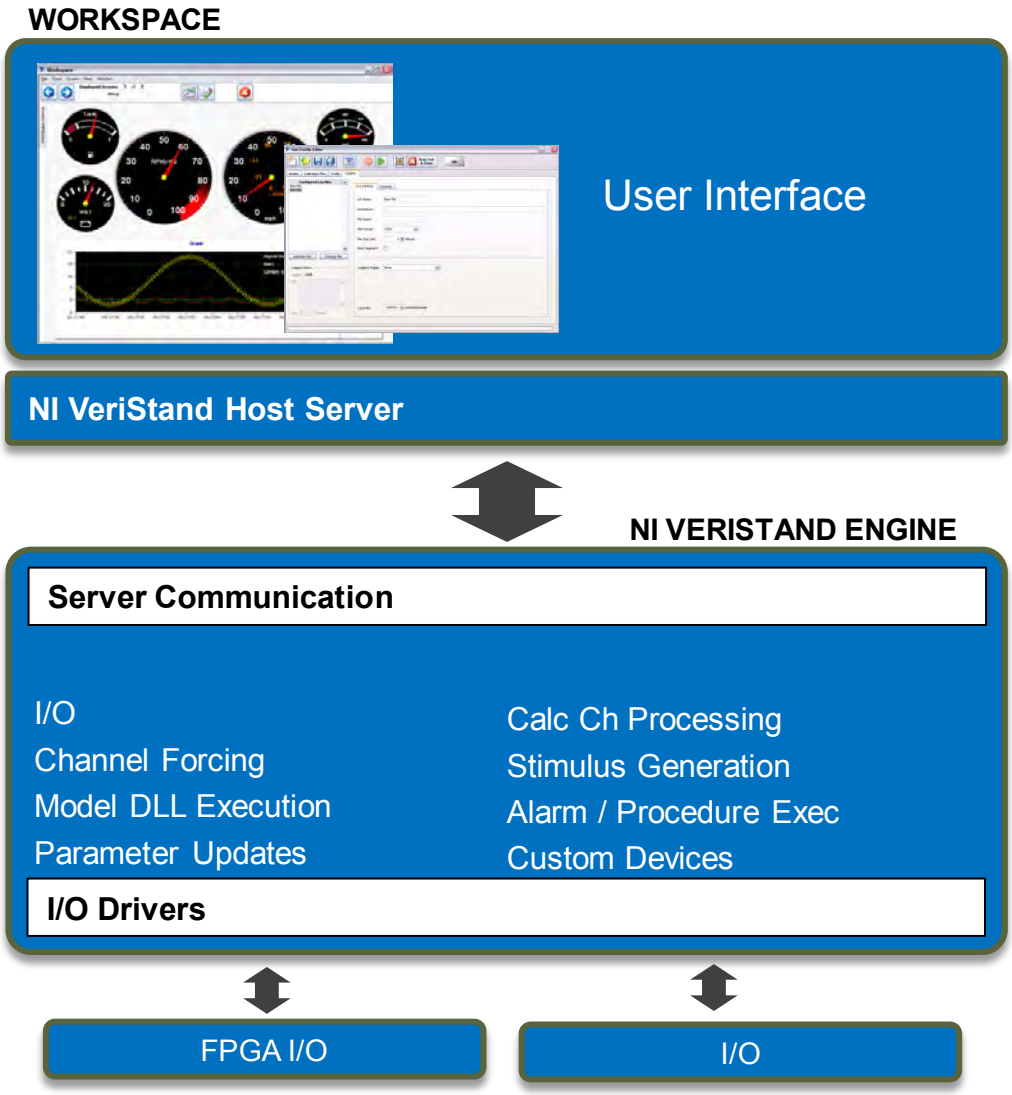
•Industrial Controller

•NI CompactRIO

•NI Single-Board RIO

• 128MB DRAM or great required*

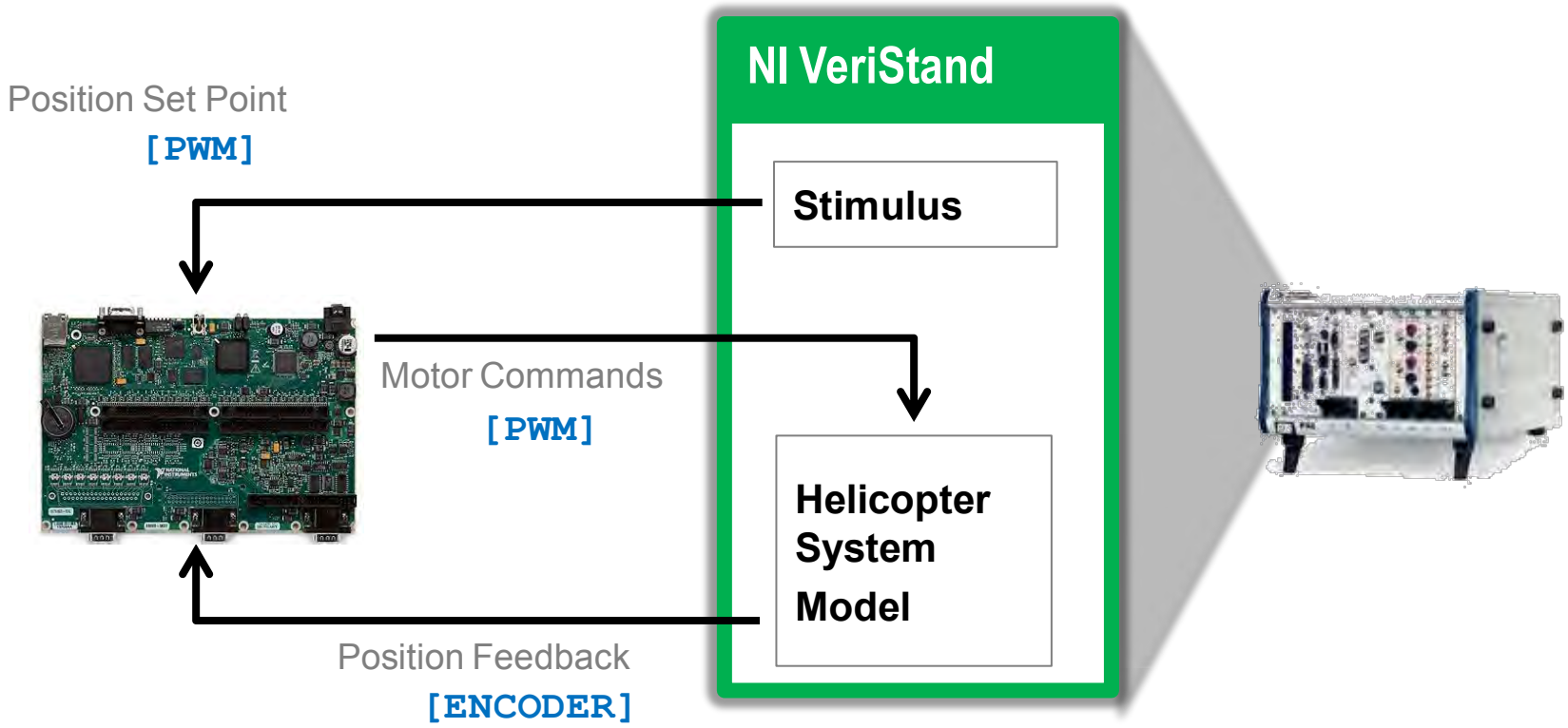
NI VeriStand Framework



Host PC

Real-time System

Demo 2: Helicopter Controller HIL Test System



Lear Electronics

LEAR CORPORATION

•Power •Distribution

- •Passive Junction Box
- •Smart Junction Box
- •Solid State Smart Junction •Box (S³•JB™)
- •Power Distribution Centers
- •Pre- •Fuse Boxes
- •Fuse Systems

Body Electronics

- Core Body Control Modules
- Gateway Modules
- Smart Trailer Tow Module
- Door Zone Modules
- Seat Heat Modules
- Seat Memory Modules

Wireless

- Remote Start / Keyless Entry Systems
- Car2U™:
  - 2Way RKE System
  - Universal Garage Door Opener
- Passive Entry & Start
- IntelliTire® – Tire Pressure Monitoring System
- Vehicle Immobilizer
- Wireless Control Module

High Power

- DC-AC Inverter
- High / Low Voltage DC-DC Converter
- Battery Monitor
- Battery Charger
- Integrated Power Module
- High Voltage Power Distribution Center
- Charge Cord Set
- Manual Service Disconnect

Wiring

- Low / High Voltage Wire Harnesses
- Alternative Wire Technology
- Flex Fold Wire
- Signal to High Power Terminals & Connectors

Infotainment

- Sound System Tuning
- Amplifiers – Medium, Premium and Advanced Levels
- TV Tuner

Terminals & Connectors

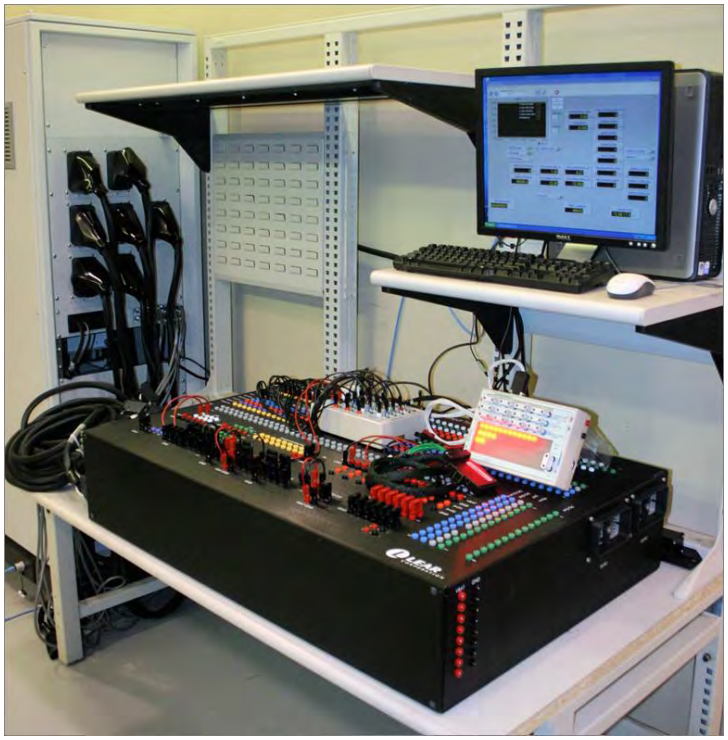
- Complete European Terminal & Connector Systems
- Signal to High Power Application Systems
- In-line and Board Edge Systems
- Sealed and Unsealed Systems
- Flat Cable Systems

Lear is among the global leaders in electrical distribution and has strong market positions in key electronics products totaling $1.9B in sales.

Lear Reduces Embedded Software Issues Using the NI HIL Platform

Learn more at ni.com

- **The Challenge:** Maintaining quality and reliability standards amidst the growing complexity of our embedded electronics products while meeting budget and schedule targets.
- **The Solution:** Adopting a new hardware-in-the-loop (HIL) test platform based on NI VeriStand real-time testing software and PXI hardware that provide the flexibility, efficiency, and intuitiveness necessary to address our current requirements with the ability to scale to future needs as we continue to expand our products.
- **Products:** Reconfigurable I/O Devices, NI PXI-8512 CAN/HS1, NI VeriStand Full Development System



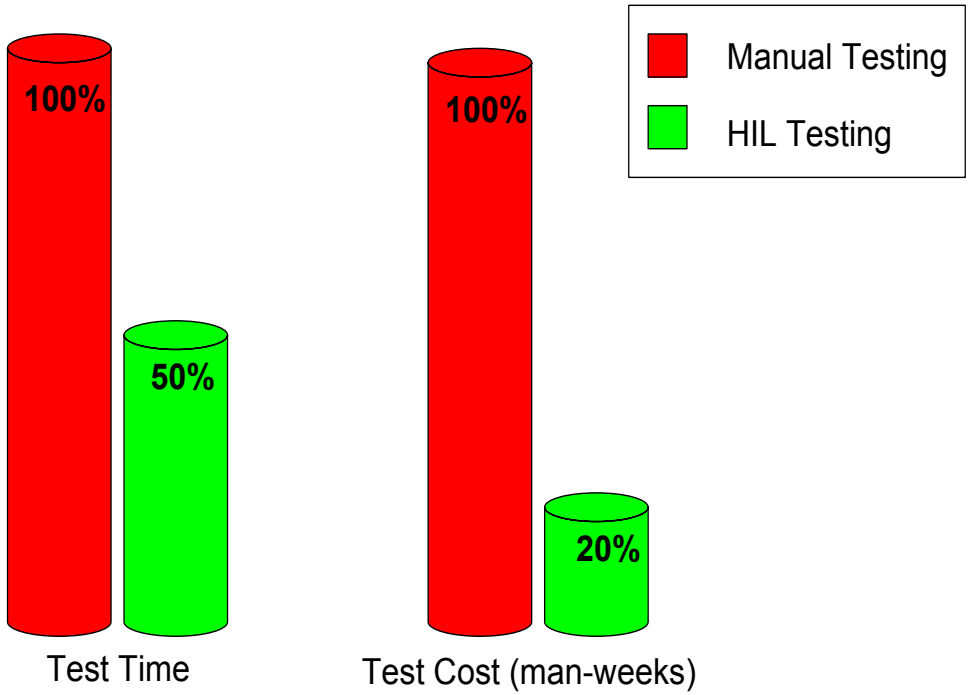
"NI VeriStand has played a significant role in achieving the quality and reliability standards that have helped us win new automotive business."--Jason G. Bauman - Lear Corporation

Lear Systems Validation Results

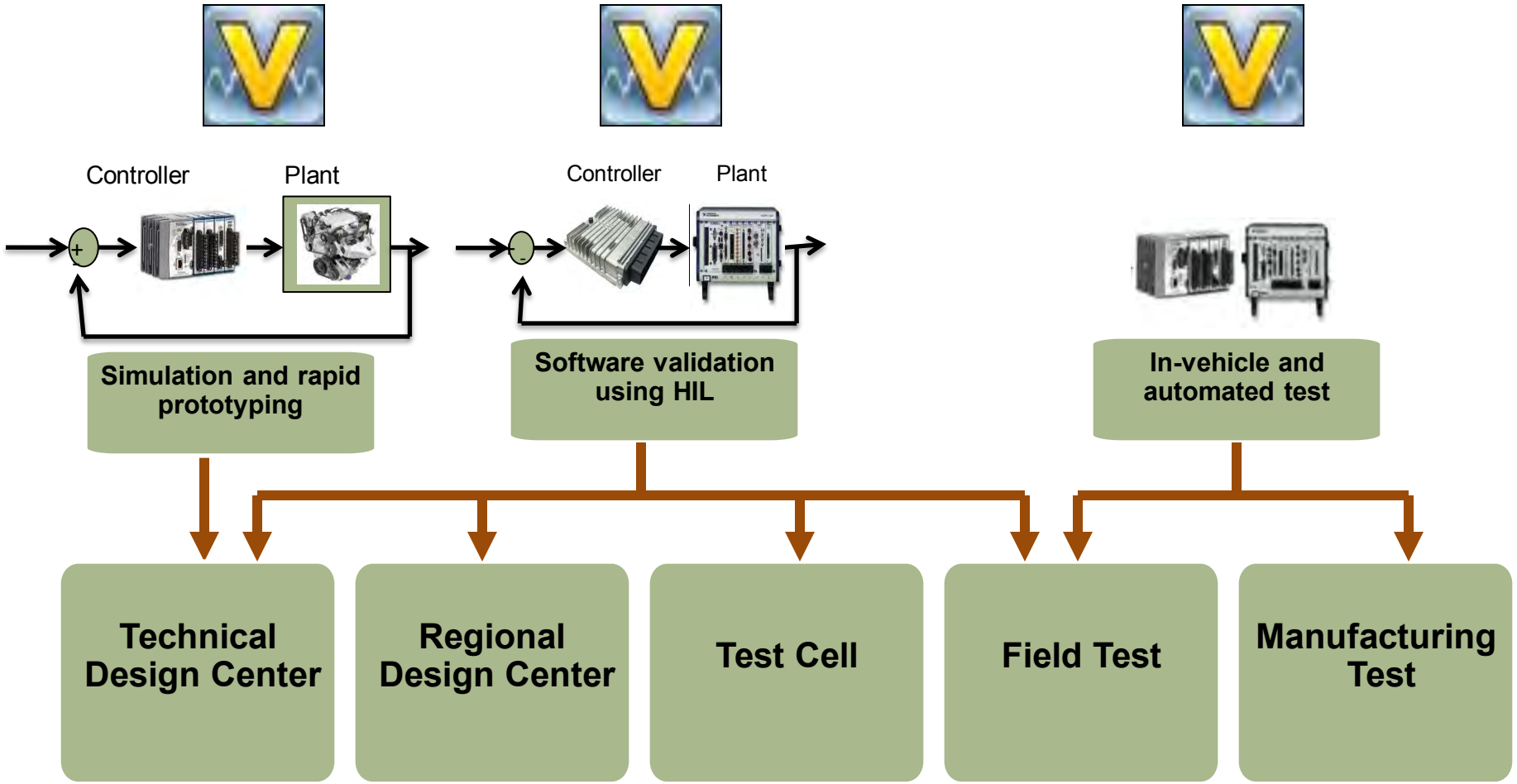
Testing Efficiencies

Test cycle time cut in half

Test resources reduced by 80% per validation cycle



Locations as Part of the Process



HIL System Requirements

- **Open** hardware & software platform
- Great variety, value, & availability of commercial off-the-shelf (**COTS**) products
- Easily integratable **I/O** & **FPGAs** & processing platforms
- **Multicore, Multisystem** support
- Test platform that extends **beyond HIL testing**
- **Global** services, support, & partner expertise

Session 5: HIL Simulators

Q & A

Additional Slides

NI Profile

Leaders in computer-based measurement and automation

Long-term track record of growth and profitability

More than 5,000 employees; operations in 40+ countries

Fortune's "100 Best Companies to Work For" 11th consecutive year

More than 500 alliance members worldwide

16% of revenue invested in R&D

40% ($50M) of R&D in real-time and embedded products

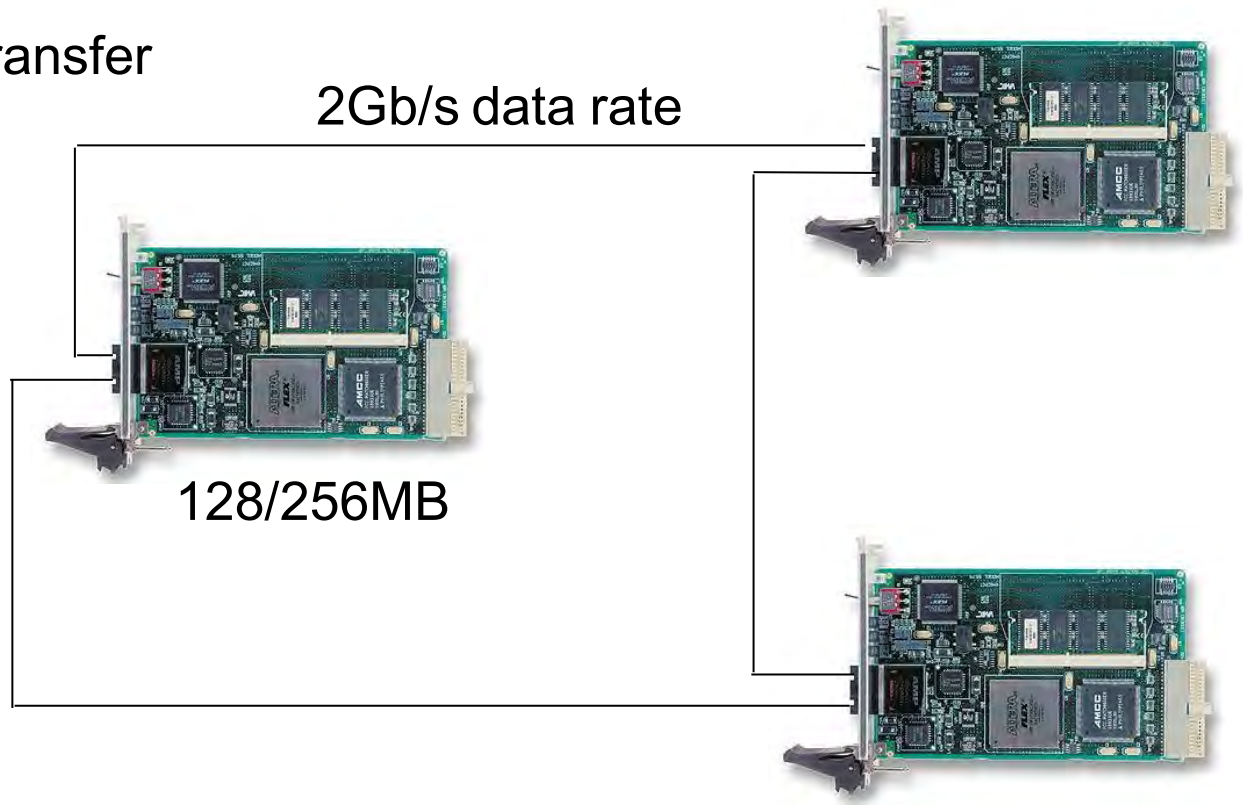
•Revenue of $872 Million in 2010

•Net Revenue in Millions

Reflective Memory

Deterministic

400-500ns transfer



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