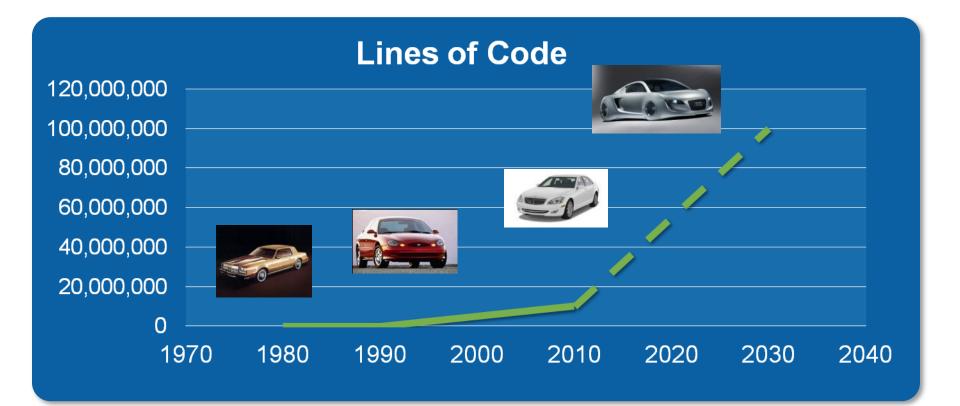


## Embedded Software Quality Challenge

### John Wilson HIL & Real-Time Test Sales Manager john.wilson@ni.com



## Embedded Software Quality Challenge



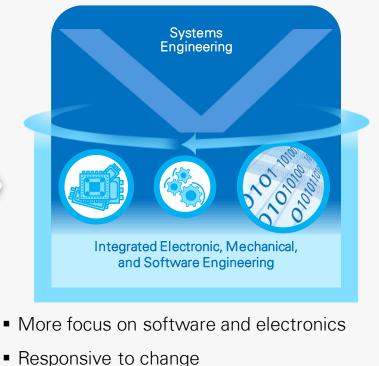
### The complexity is growing at an increasing pace



## Smarter Products Require New Technology



#### Next Generation Product & Systems Development



 Systems engineering methods optimize product designs and engineering collaboration

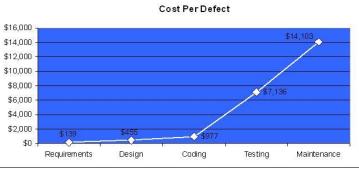


## Managing the Cost of Software Errors

	Smart Washing Machine	Commercial Aircraft	Luxury Automobile
Lines of Code	100k	6.5 Mil	10 Mil
	10-20 defects pr	oduced per 1,000	lines of code*
Defects	1k – 2k	65k - 130k	100k – 200k
			Cost Per Defect
	bug which costs \$1 to		\$14,103

Software Assessments, Benchmarks, and Best Practices

...a bug which costs \$1 to fix on the programmer's desktop costs \$100 to fix once it is incorporated into a complete program, and many thousands of dollars if it is identified only after the software has been deployed in the field.





## **Diverging Challenges**

Quality

Innovation

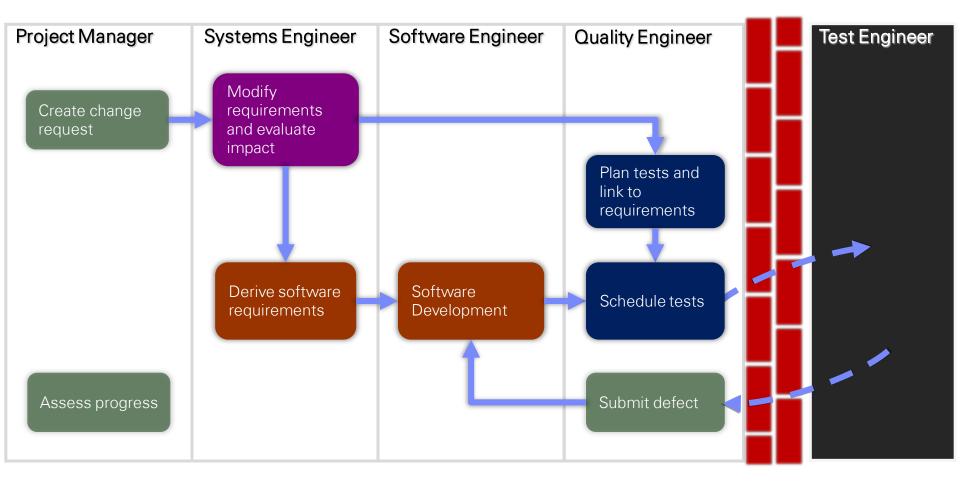
The quality challenge is growing, but timelines and budgets are not increasing proportionally

Engineers must continue to **innovate and harness the latest technologies** to remain competitive



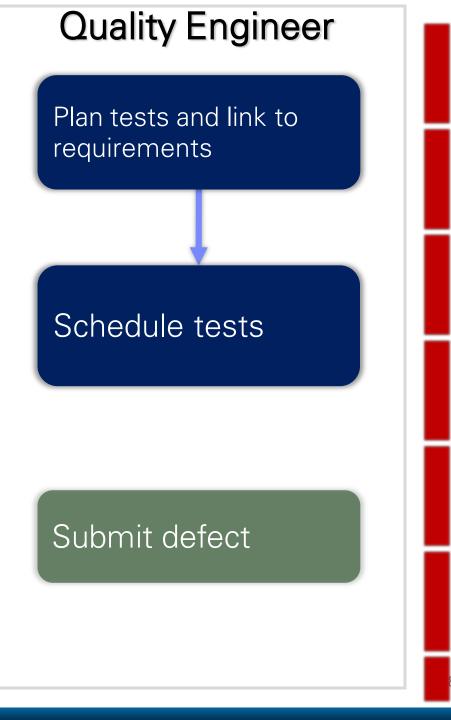
Cost

### **Traditional Development Process**









### Test Engineer

#### **Requirements Documents**

(DOORS, .docx, .xlsx, ...)



#### IBM Rational Quality Manager

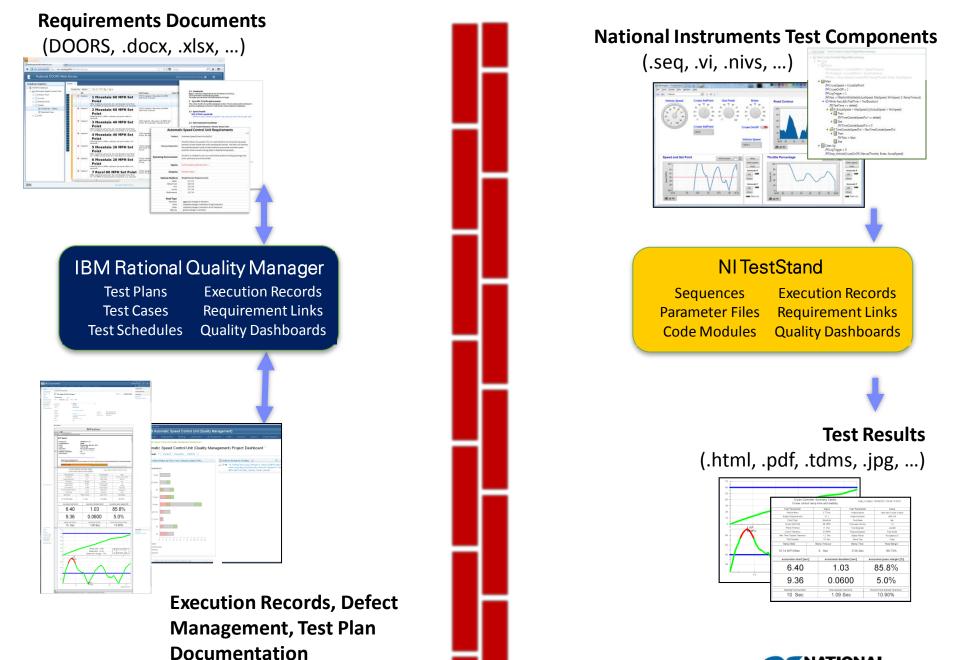
Test Plans	<b>Execution Records</b>
Test Cases	Requirement Links
Test Schedules	Quality Dashboards

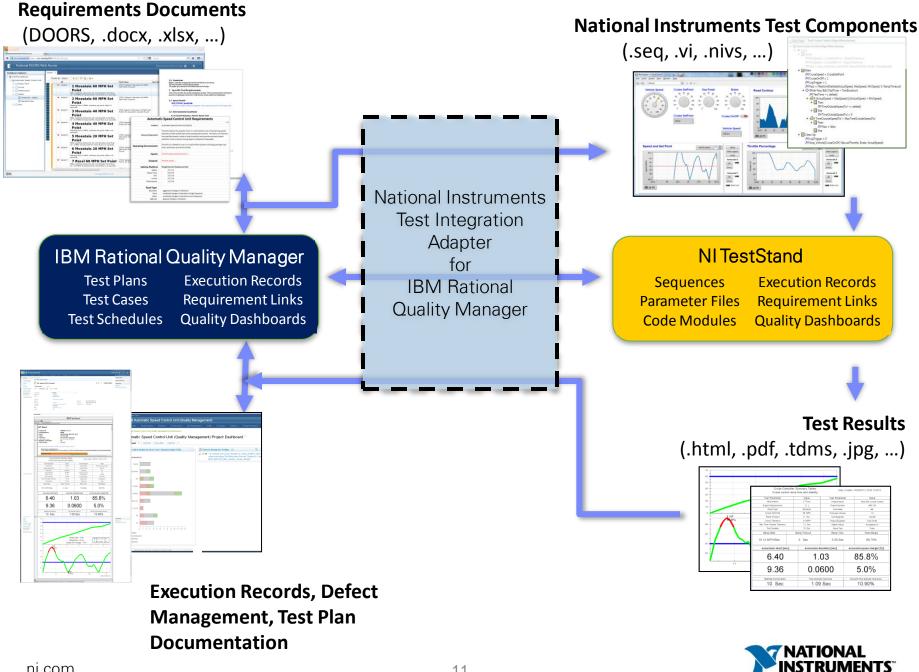
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**Execution Records, Defect** Management, Test Plan Documentation

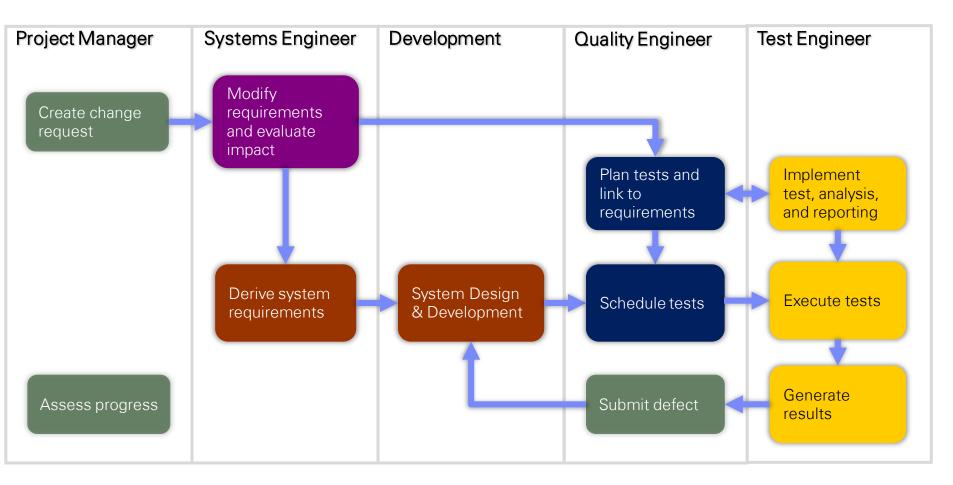


### **Test Engineer**



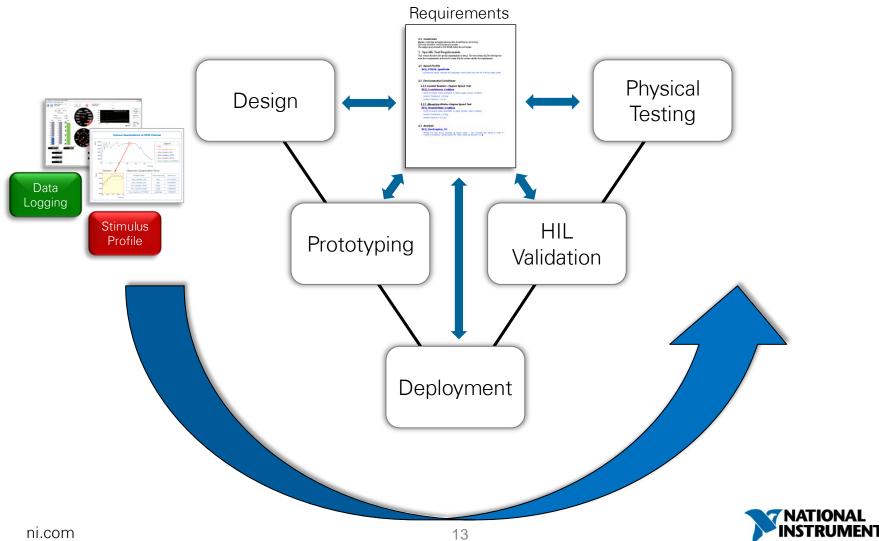


### **Next Generation Development Process**

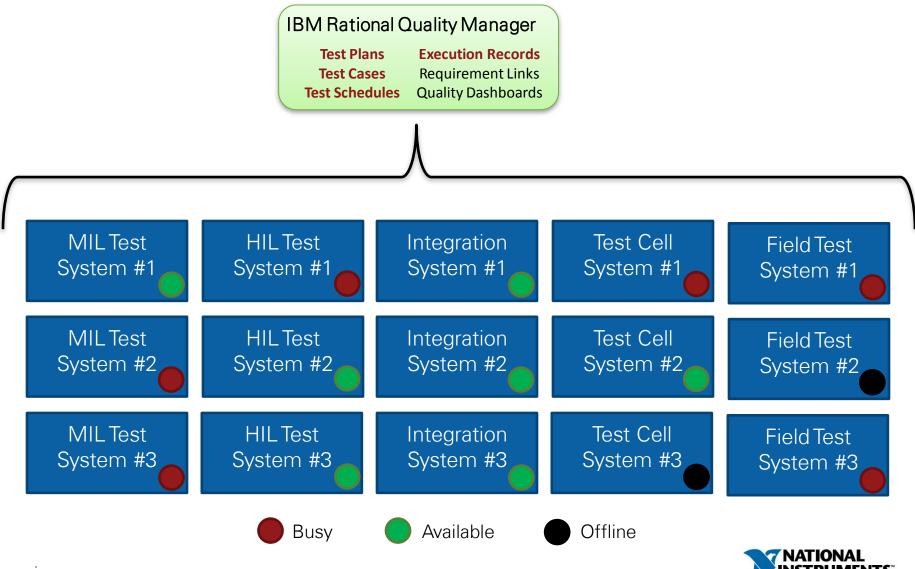




## Consistency and Efficiency throughout the Process



### Test Asset Management and Automation



### Defect Management

#### IBM Rational Quality Manager

Test Plans Test Cases Test Schedules **Execution Records Requirement Links** Quality Dashboards

### Defect Resolution Collaboration

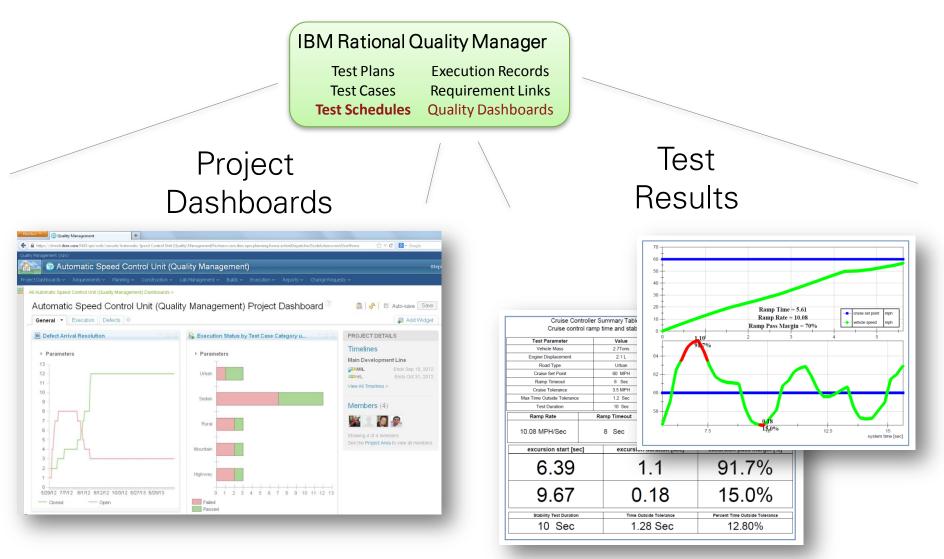
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### Defect Results and Verification Items

Firefox * (5) Exe	ecution Result - Quality Management	+			
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	TestStand Report				
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### Project Documentation and Tracking





## Breaking the Quality Management Silos with Enhanced Collaboration and Traceability

IBM Rational and National Instruments are teaming together to provide an end-to-end quality management solution.

**Traceability** all the way to test and back with **Collaboration** between ALL teams, including test

- Test components and assets linked to and managed with quality plan test cases
- All test results available to all teams and linked to test cases and requirements

Promotes quality and test consideration from the outset, not an afterthought, **reducing cost and risk** of identifying and correcting defects

Enables test component re-use throughout project phases and between projects providing operational efficiency and accuracy





## Questions?



Trends in Advanced Powertrain & In-Vehicle RF Communications Research

- Fast
- Parallel
- Connect math to real world quickly
- Interactive, integrated systems (complexity)



## Advanced Powertrain Trends

- Fuel efficiency
- Fast control of traditional technologies
  - Fast analysis
  - Fast decision making
  - High speed I/O
- Electrification



## **Oak Ridge and Argonne National Labs**

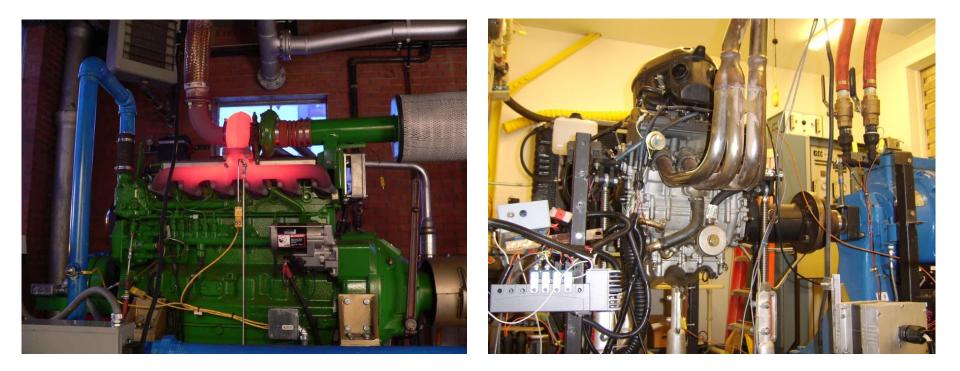
Full authority engine control system with DCAT combustion analysis for same-cycle and next-cycle control





## **University Research**

Diesel, gasoline, natural gas, and alternative fuel research systems in 19 universities around the world



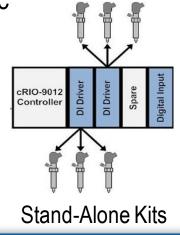


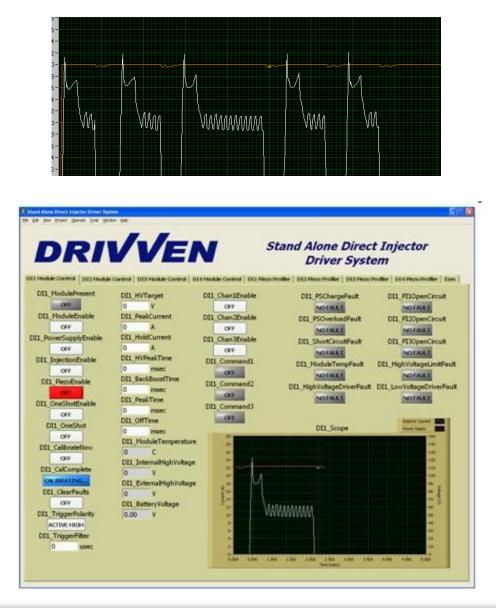
22

## **Injector Driver Kits**

#### **Direct Injector Drive Kit**

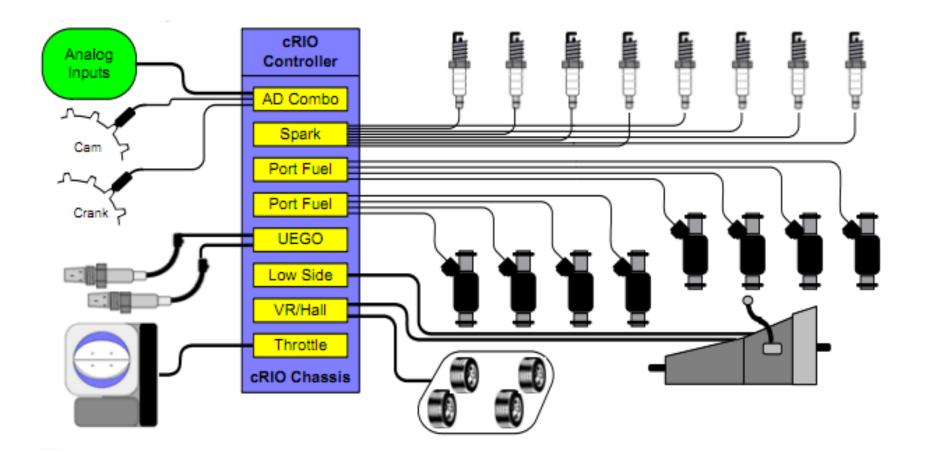
- Driver stage to interface with existing controller commands
- Ready to run out-of-box at powerup
- Calibration interface over Ethernet
- Add custom I/O for rail pressure control, etc







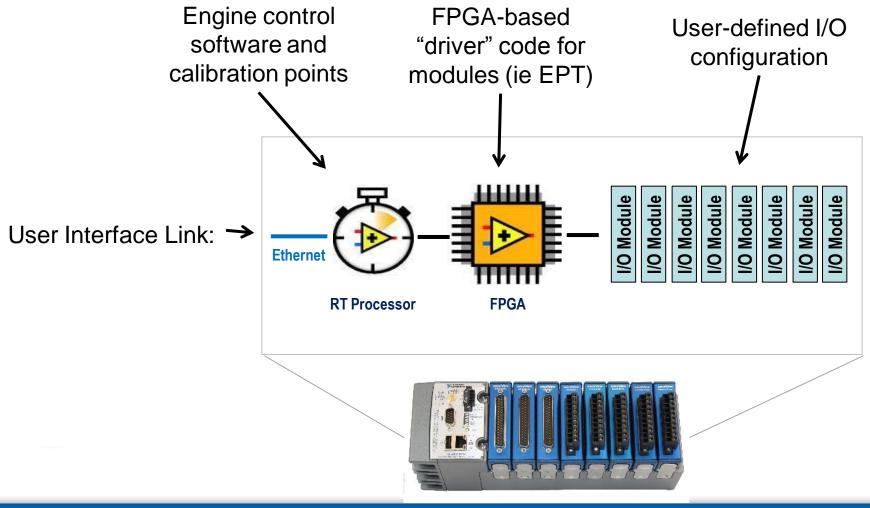
## **Typical Engine Control Application**



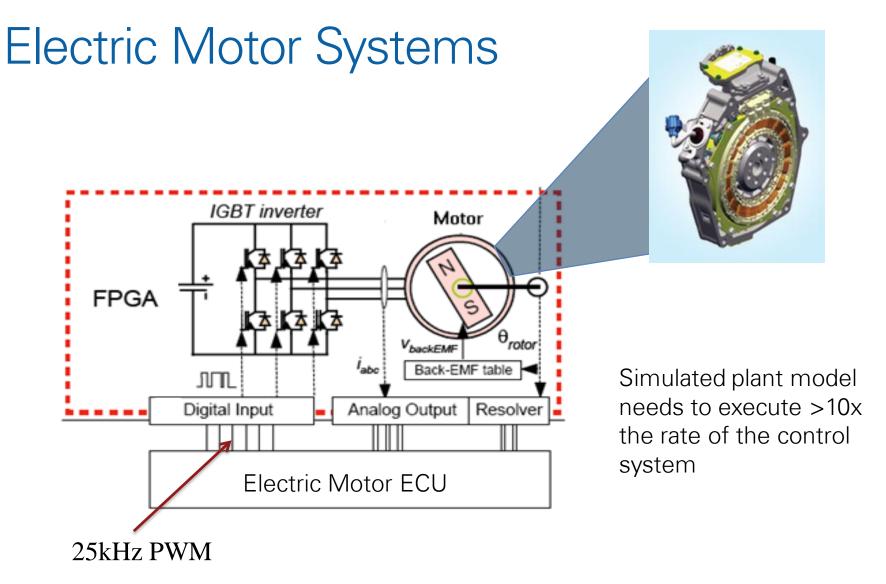


## System Diagram











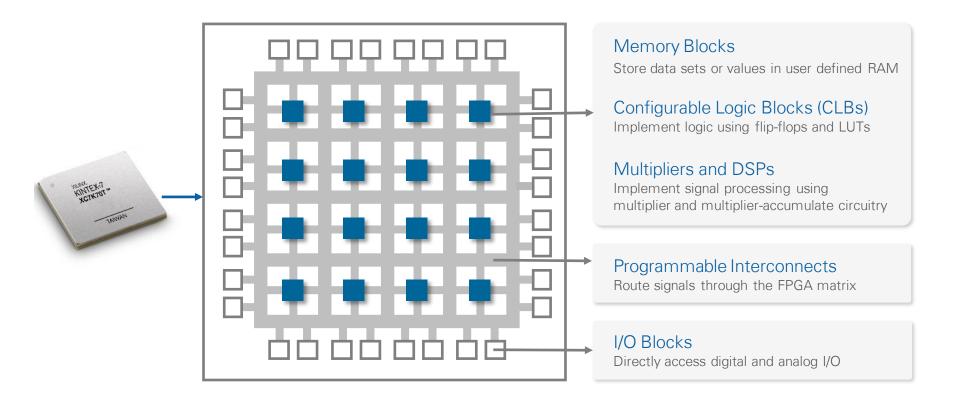
## **Operating System Characteristics**

	Loop Rate	Jitter
<ul> <li>General Purpose OS</li> <li>High-priority tasks can be preempted by lower-priority tasks</li> <li>Extraneous background programs <ul> <li>Screen savers, disk utilities, virus software, and so on</li> </ul> </li> <li>Peripheral Interrupts</li> </ul>	10-100 Hz	Unbounded
Mouse, keyboard, and so on Real-Time OS		
<ul> <li>Scheduler ensures high-priority tasks execute first</li> </ul>		
<ul> <li>Direct control over all tasks</li> </ul>	Up to 50 kHZ	Bounded
<ul> <li>Stand-alone</li> <li>no mouse, keyboard, and so on</li> </ul>		Dourraed

ni.com

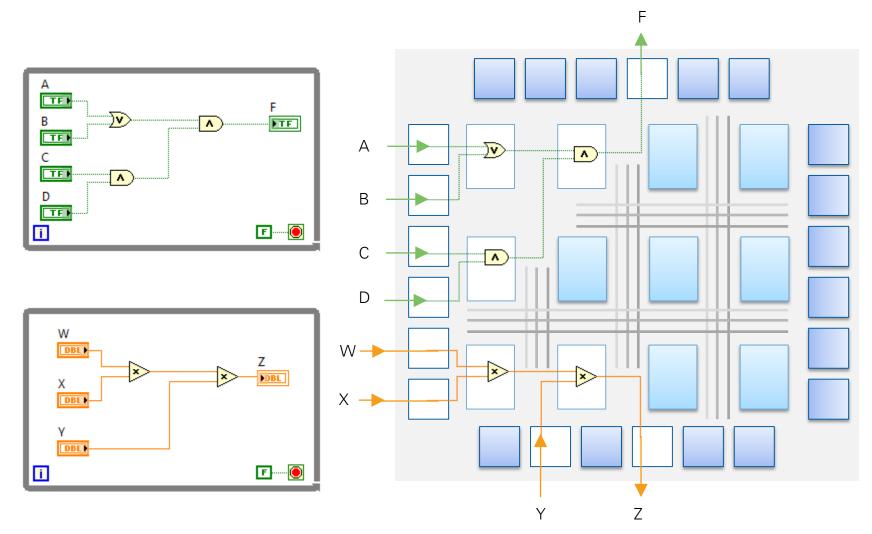
NAII

### Software Designed Hardware Field-Programmable Gate Array (FPGA)

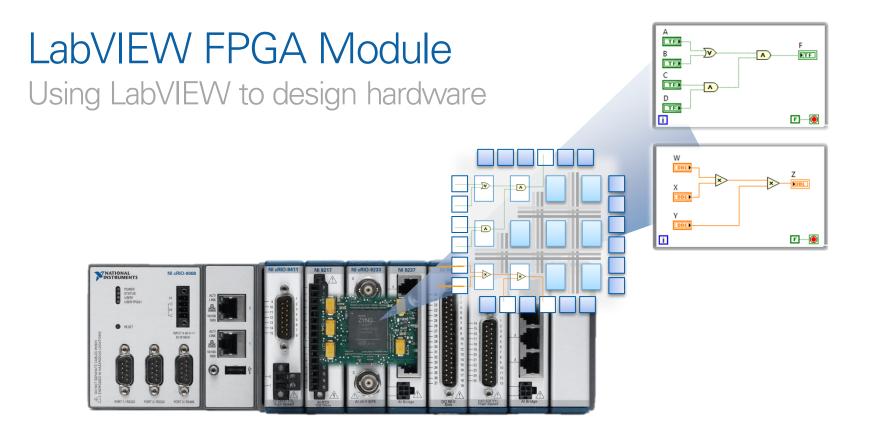




## **FPGA:** Parallel Processing





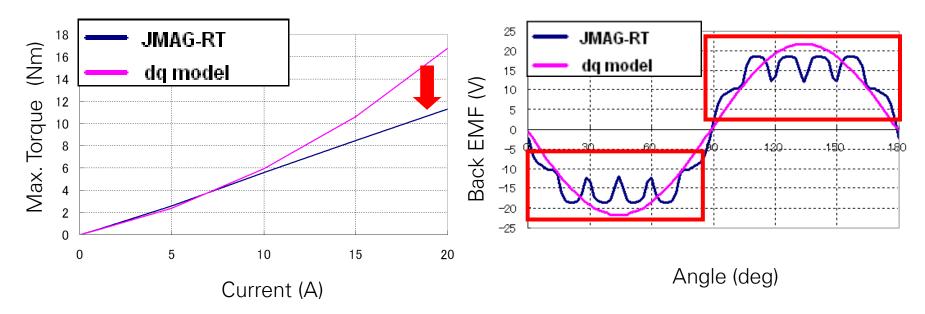


Replace custom circuitry with software-programmable FPGA logic

- High speed control: 1 MHz digital / counter-timer, 200 kHz motion control / analog PID
- Dedicated logic in silicon for highest reliability
- Custom timing, triggering, synchronization, counter/timers, PWM
- Pre-process data in parallel prior to execution on the CPU for high-throughput applications



# Difference between DQ model and JMAG-RT model



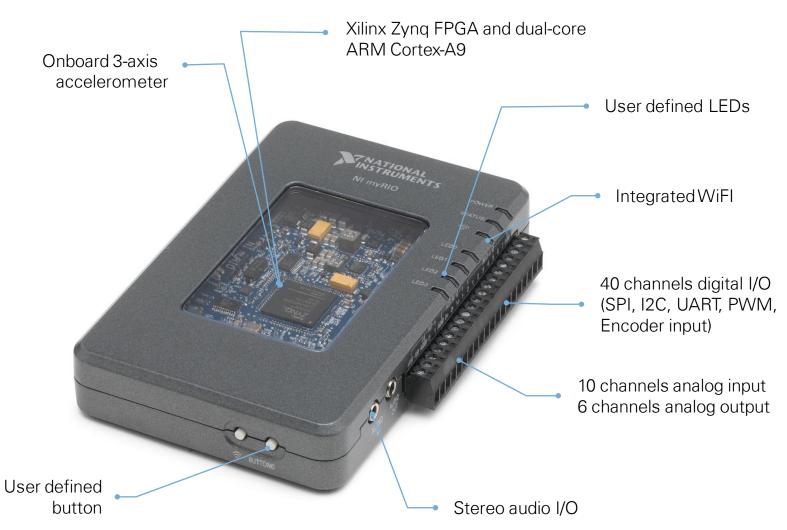
- Saturation effects are critical for the current control.
- Geometry effects are critical for the back EMF tracking.
- JMAG-RT models are accurate enough for the control design.



Model	Execution Target	Simulation Fidelity	Real-Time Simulation Speed
FEA with JMAG	Windows	High	Non-RT: Minutes to hours
DQ Model with JMAG-RT	Windows Real-Time	Medium	20-30 us
	NI FPGA	Medium	2-3 us
JMAG –RT FEA Model	Windows Real-Time	Medium	20-30 us
	NI FPGA Hardware	High	~1-2 us



## NI myRIO





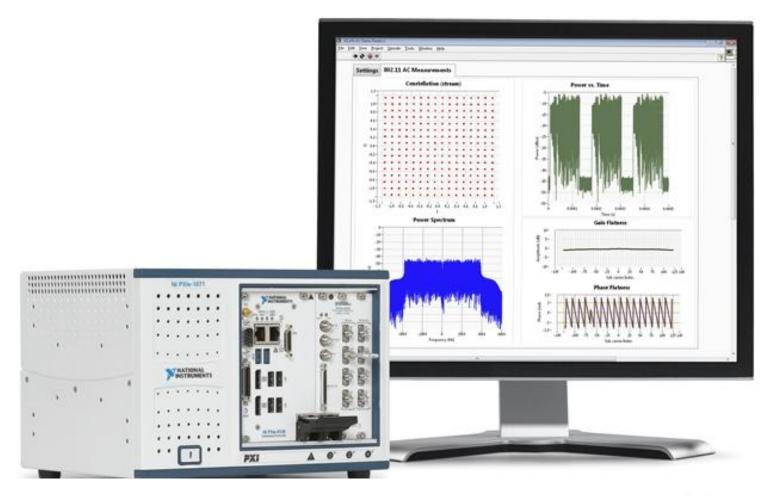
## Additional Features



- Fully programmable FPGA through LabVIEW FPGA
- Dual-Core ARM Cortex-A9 processor
- Expandable ecosystem of sensors and actuators
- Ready to use projects and courseware
- Deploy code to real-time processor and FPGA via USB or WiFi
- Minutes to first measurement
- Processor programmable in C/C++



## NI PXI-based System for RF Simulation & Test



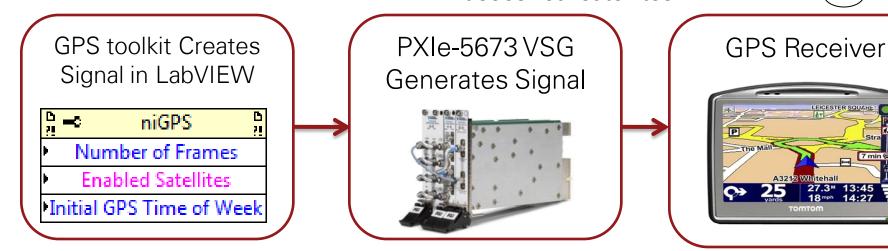


## **GPS Simulation Works**

### Things to Simulate

- Poor signal strength
- View of satellites obstructed
- Position constantly changing

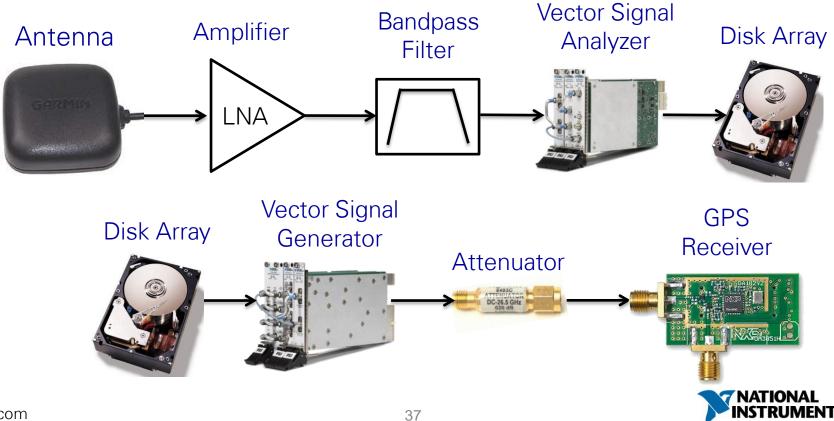
GPS receiver behaves as if it sees real satellites





## **RF Record and Playback for GPS**

- RF record and playback produces a repeatable field test
- Signal can be played back from disk with a vector signal generator
  - 2 TB raid drive can playback 25 hours of GPS signal



## Think Platform.

#### Simplify

Integrated software and hardware that simplifies system integration of processing, I/O, and data

#### Customize

Flexible, modular platform that scales to changing needs and integrates commercial technology

#### Reuse

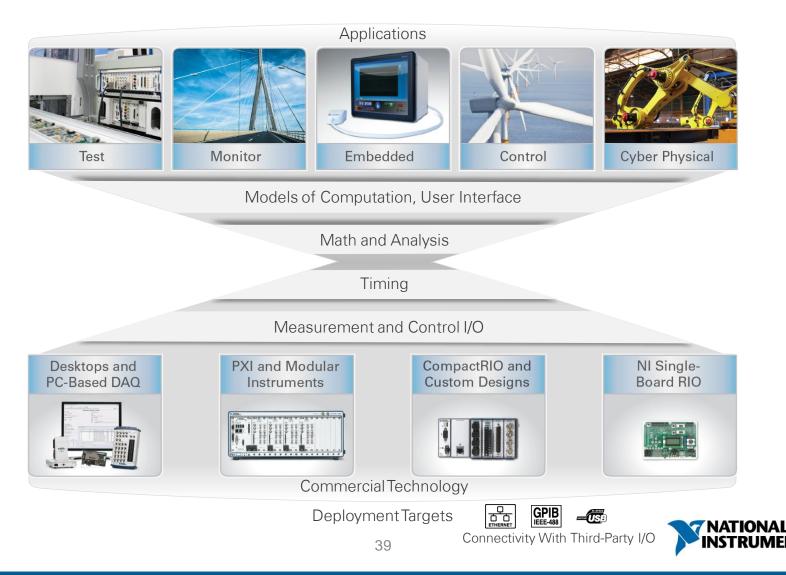
Supported by a community of users, partners, products, and examples



## Graphical System Design

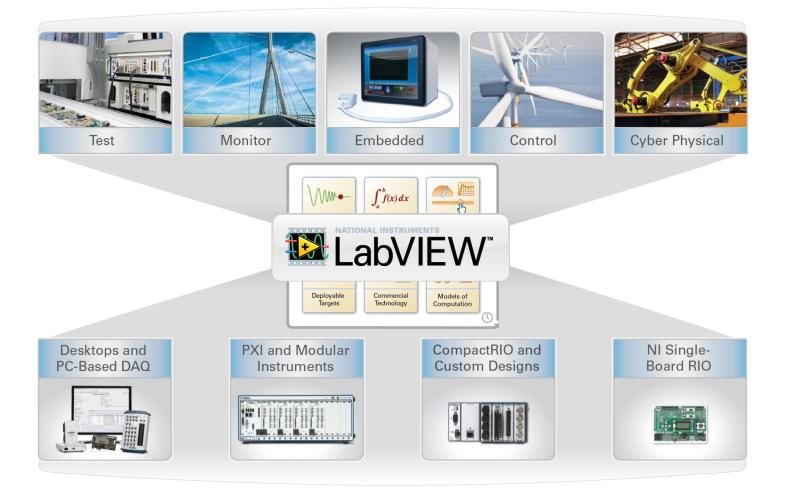
ni.com

A platform-based approach for measurement and control



## Graphical System Design

A platform-based approach for measurement and control





Real-Time Testing and Simulation Software

- RT Stimulus Generation
- Data Logging
- Test Automation
- Single-Point I/O
- Alarming
- Calculated Channels

- Deterministic Model Execution
- User Account Management
- Multi-Chassis Synchronization
- Multi-Chassis Data Sharing
- Closed-Loop Control
- Scaling and Calibration



**Multi-Chassis Systems** 







Single-Board RIO\*

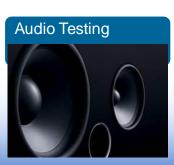
\* 128MB DRAM or great required

## Multimedia Testing and Simulation

Navigation









CD/DVD/HDMII



# **NI VeriStand**



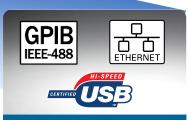
Desktops and PC-Based DAQ



PXI and Modular Instruments



RIO and Custom Designs



Open Connectivity with 3<sup>rd</sup> Party I/O

