Ingo Foldvari
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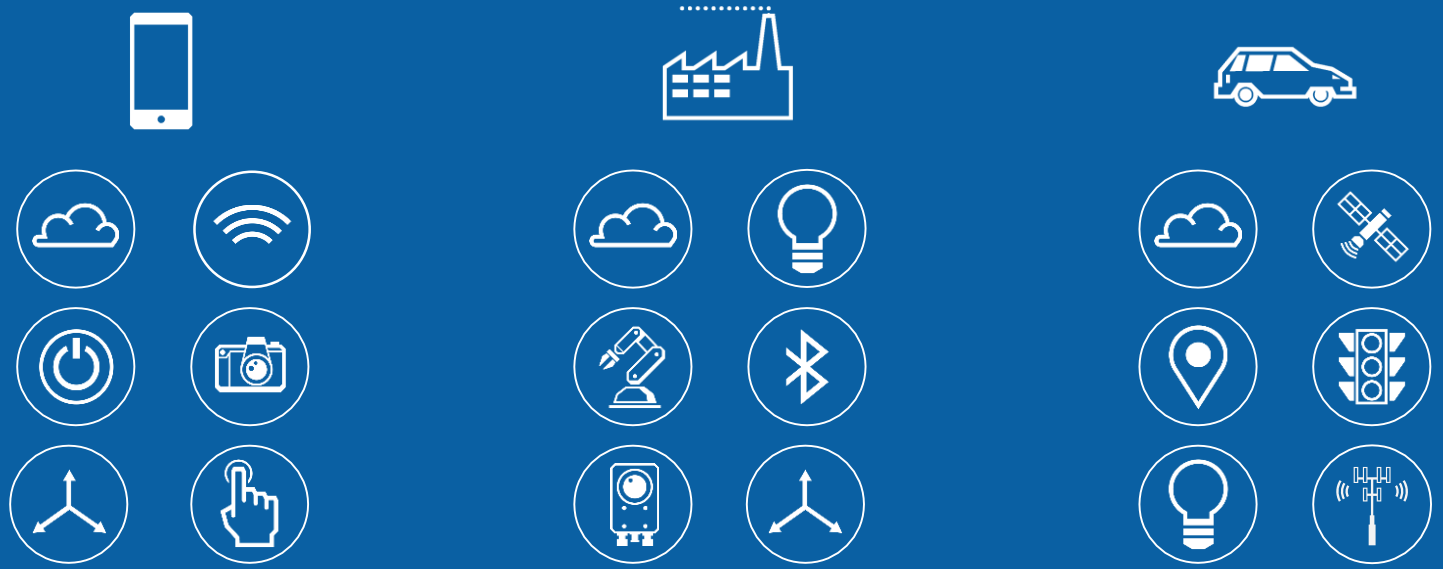
NI Technical Seminar

Developing Embedded DAQ, Monitoring and Control Applications

The World of Converged Devices



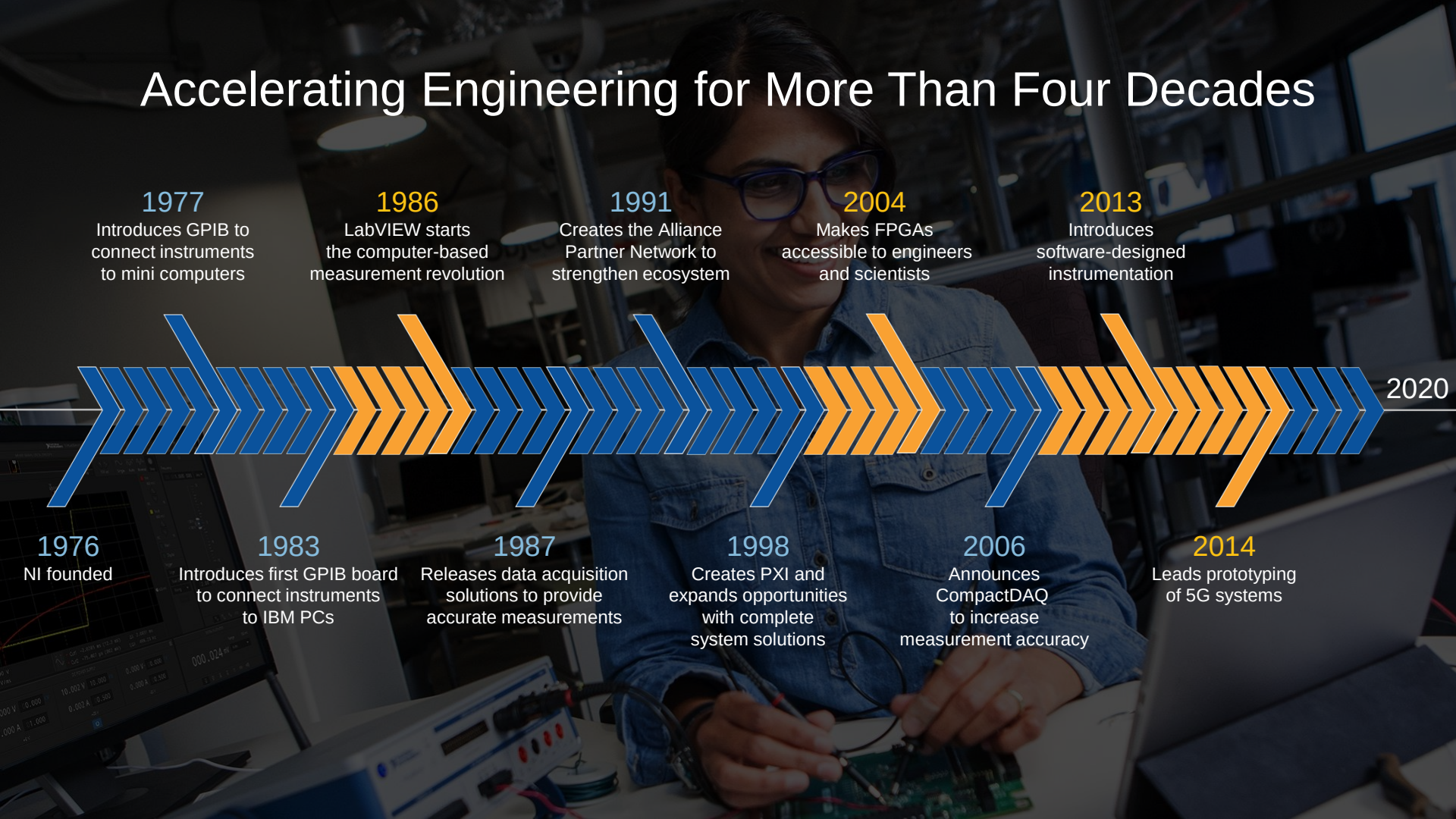
More capability defined in software - Functions change rapidly - Increasingly complex to design and test

NATIONAL INSTRUMENTS

Mission Statement

NI equips engineers and scientists with systems that accelerate productivity, innovation, and discovery.

Accelerating Engineering for More Than Four Decades



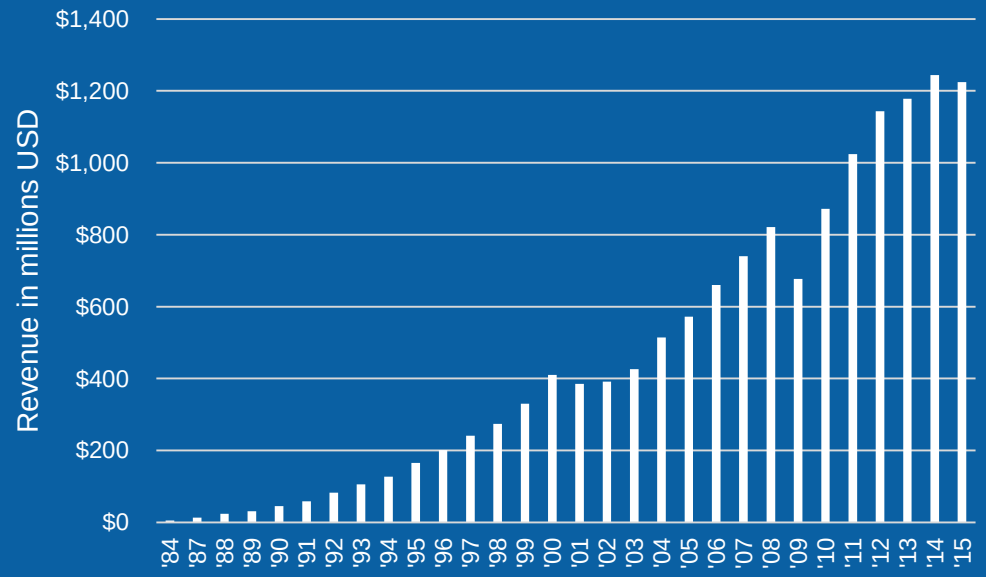
7,500+
EMPLOYEES
50+ COUNTRIES

$1.23
BILLION
IN 2015

35,000+
CUSTOMERS WORLDWIDE

OVER 18%
INVESTMENT IN R&D

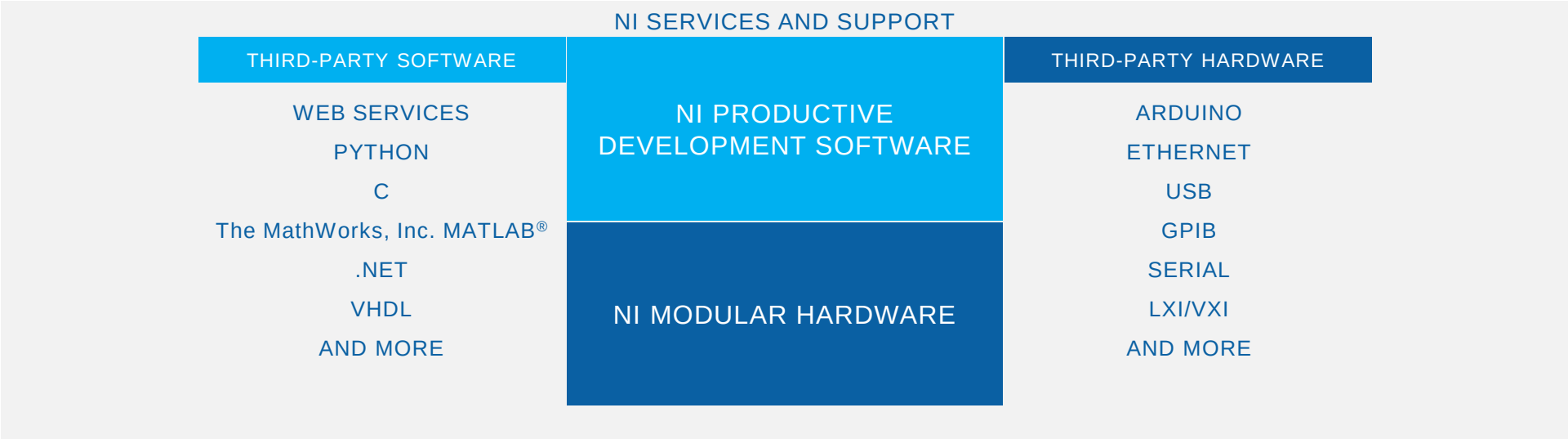
Long-Term Track Record of Growth



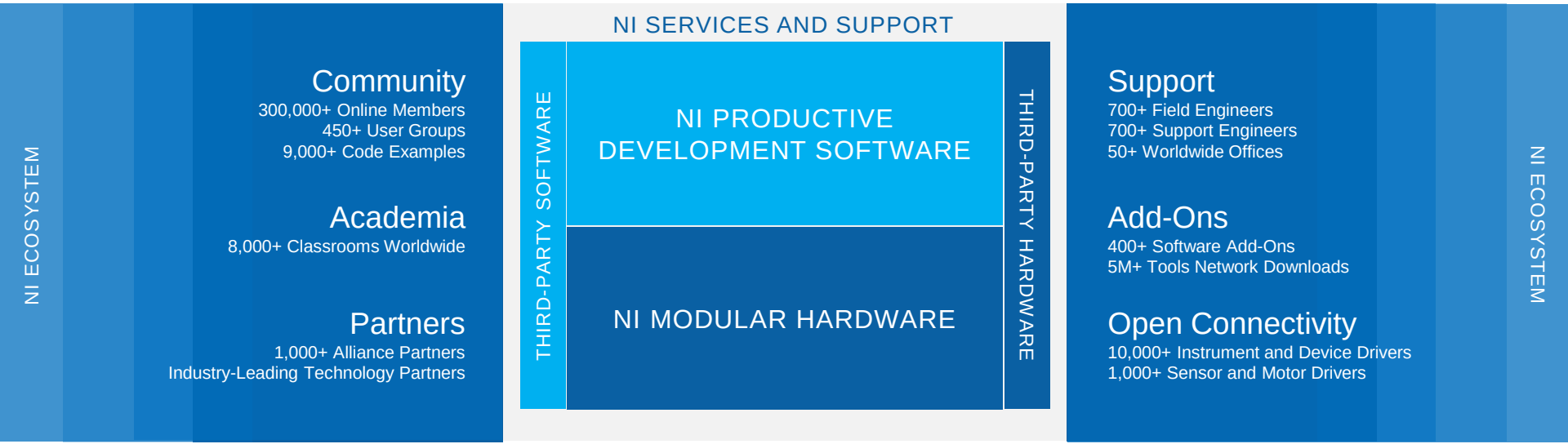
NATIONAL INSTRUMENTS

A software-centric platform approach to accelerate the development of any system that needs test, measurement, and control.

ONE-PLATFORM APPROACH



ONE-PLATFORM APPROACH



NATIONAL INSTRUMENTS

Flexible Software Protects Your Investments

LabVIEW

TestStand | VeriStand | DIAdem | NI InsightCM™ Enterprise

Multisim | LabWindows™/CVI | Measurement Studio | Third-Party Software

NATIONAL INSTRUMENTS

Modular Hardware Allows You to Customize

Complete I/O Coverage
With More Than 600 Modules

Highest Data Throughput
With PCI Express

Software Extensibility
With Apps, IP, and Toolkits

Parallel Measurement Execution
With Latest Multicore Processors

Real-Time Measurements
With Timing and Synchronization

Measurement Acceleration
With User-Programmable FPGAs

Reduced Size, Power, and Weight
With Form Factor Variants

Increased Measurement Range
With Latest ADC/DAC

NATIONAL INSTRUMENTS

Our Customers' Success

Industrial Machinery

Aerospace and Defense

Electronics and Semiconductor

Academic and Research

Wireless

Transportation and Heavy Equipment

Automotive

Energy

NATIONAL INSTRUMENTS

INDUSTRIAL MACHINERY

SIEMENS

“LabVIEW graphical system design allows us to design modular software that can be easily scaled to meet the growing requirements of rapidly evolving wind energy technology.”

—Morten Pedersen, CIM Industrial Systems A/S

AEROSPACE
AND DEFENSE

g systems

“Through the use of advanced software architecture and NI hardware, G Systems was able to provide Lockheed Martin Aeronautics with a highly configurable, expandable system to meet current and future requirements of the F-35 VSIF.”

—Michael Fortenberry, G Systems, Inc.

NATIONAL INSTRUMENTS

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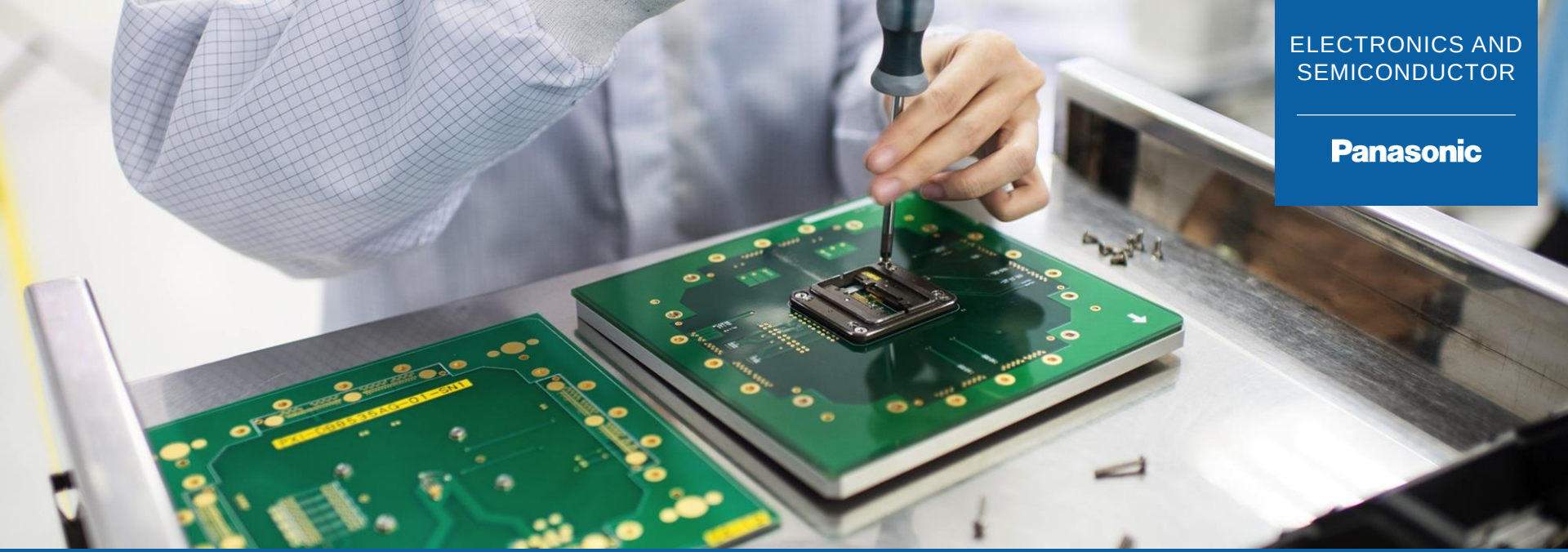

ELECTRONICS AND SEMICONDUCTOR

Panasonic

“The key to choosing NI products for Panasonic was the all-in-one compact enclosure, combinations of modules, the option to easily add features depending on our needs, and the ability to develop a program that has an intuitive graphical interface.”

—Takeuti Isao, Chief Engineer, Electronics Appliances

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ACADEMIC
AND RESEARCH

MANCHESTER 1824
The University of Manchester

“Electronics used to seem so cryptic to me, but using NI tools in the new labs made everything so much more understandable. It’s given me the confidence to experiment with electric circuits and try out some of my own projects.”

—Joshua Elijah, Second-Year Student, The University of Manchester

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WIRELESS

NOKIA

“Together, NI and Nokia Networks are reinventing the future of wireless communication and powering the fastest cell phone networks ever.”

—Lauri Oksanen, Nokia Networks

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TRANSPORTATION
AND
HEAVY EQUIPMENT

FireFly EQUIPMENT

"[The NI platform] just brings a level of control that I don't know exists in any other platform."

—Steven Aposhian, FireFly Equipment

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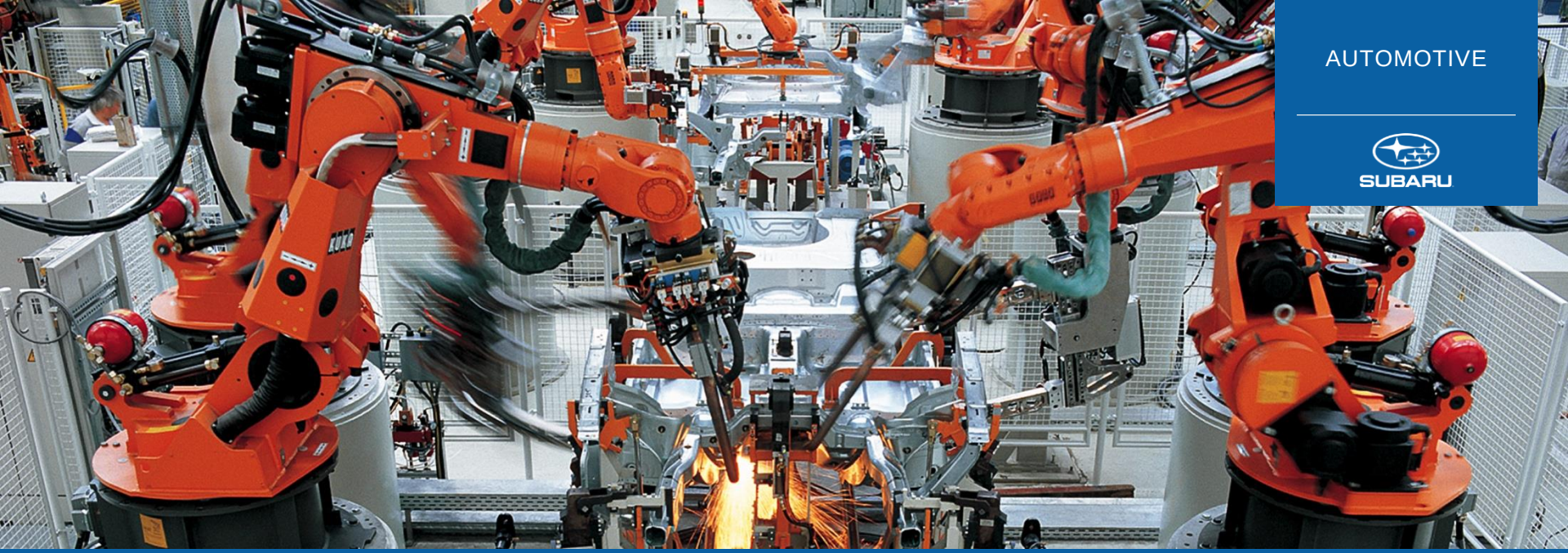

AUTOMOTIVE

SUBARU

“By adopting FPGA-based simulation using the NI hardware and software platforms, we achieved the simulation speed and model fidelity required for verification of an electric motor ECU. We reduced test time to 1/20 of the estimated time for equivalent testing on a dynamometer.”

—Tomohiro Morita, FUJI Heavy Industries, Ltd.

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ENERGY

nationalgrid

“The high processing power of CompactRIO allows us to gather and analyze large amounts of data from anywhere on the grid as well as compile and analyze all the data to see grid-wide trends to optimize our investments to meet the energy needs of the next generation.”

—Peter Haigh, National Grid UK

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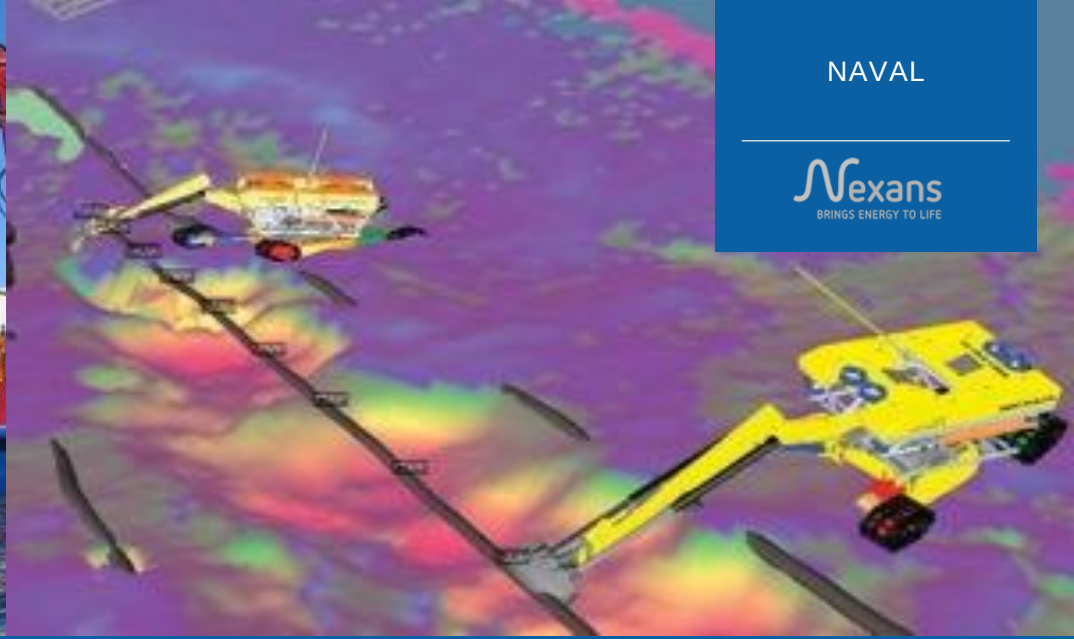
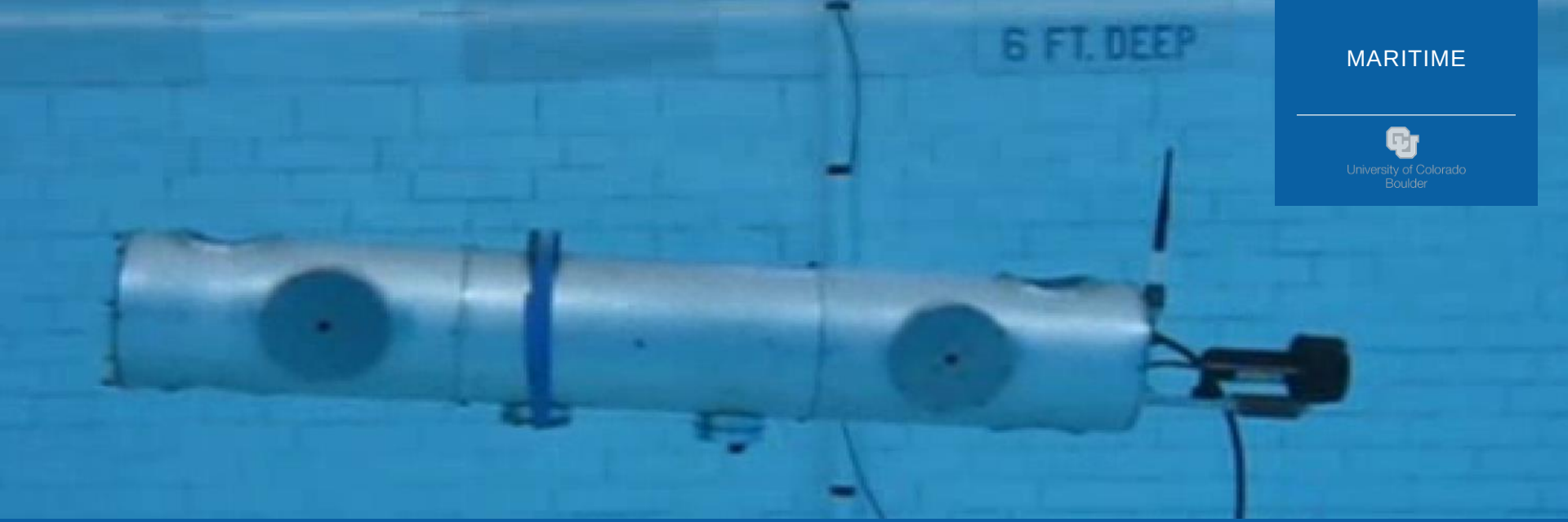


NAVAL

Nexans
BRINGS ENERGY TO LIFE

“The LabVIEW platform has helped Nexans develop a system that is easy to maintain due to the consistent programming paradigm for both HMI and embedded control, even in extreme conditions.”

—Halvor Snellingen, Nexans

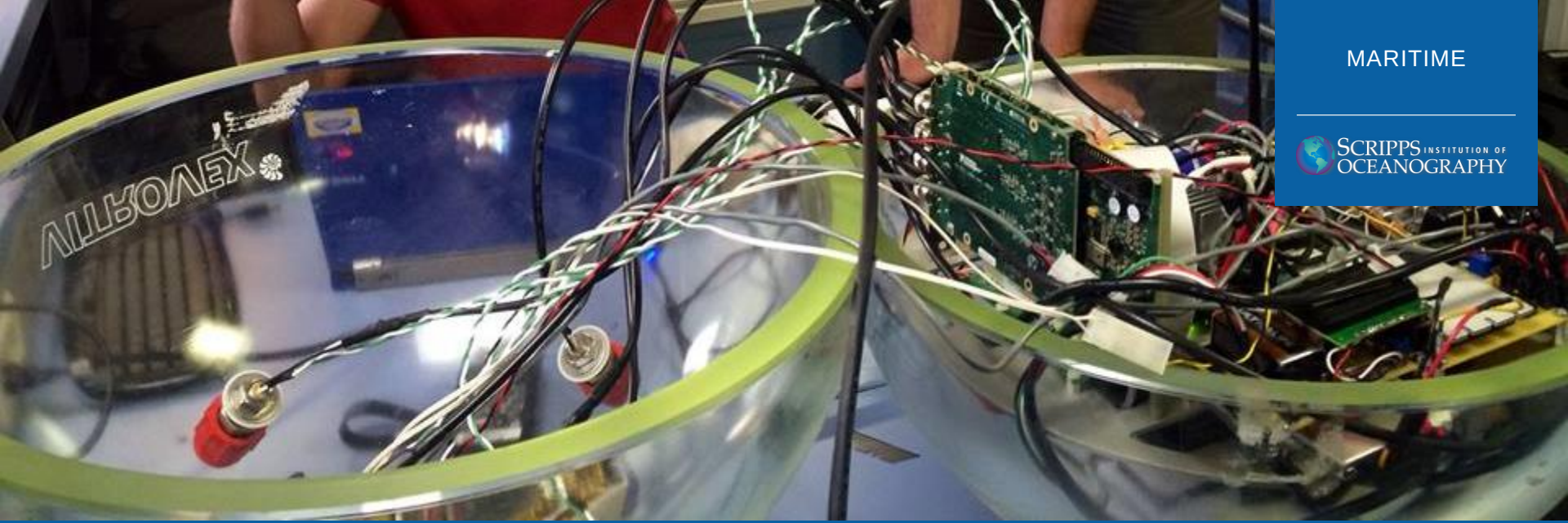


MARITIME

University of Colorado Boulder

“The CUBOAT project is an underwater acoustic network, that reduces size and cost by leveraging NI COTS technologies. It’s unbelievable to put something to work, see it in real life and then win an award for it.”

—Dan Ambrosio, CU Boulder



MARITIME

SCRIPPS INSTITUTION OF OCEANOGRAPHY

“DeepSound is a high-bandwidth acoustic recording, free-falling system designed to profile ambient noise from the surface to depths of 12 km. DeepSound MK I, II and III are all featuring a NI PCI-4462 sound and vibration measurement device. Offering 4 simultaneously sampled analog inputs, with a sample frequency of 204.8 kHz and 114 dB dynamic range at 24 bit resolution.”

—Buckingham Lab, UCSD SIO

NATIONAL INSTRUMENTS

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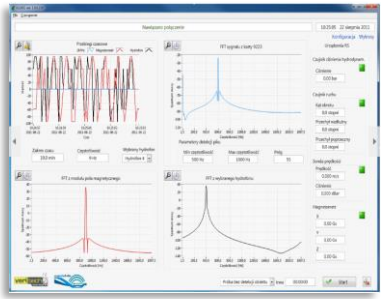
Additional Customer Solutions

- Measuring Underwater Radiated Noise With PXI and LabVIEW
- AUV: Underwater Acoustic Localization
- Measuring Underwater Environmental Variables With CompactRIO
- Hydrophone Calibration System
- Using LabVIEW to Automate an Underwater Drilling Mud-Pump Control System
- Using NI LabVIEW and CAN to Control an Underwater Remotely Operated Vehicle
- Smart ROVLATIS: Flexible Survey Platform for Surface and Underwater Operations
- Controlling a Remotely Operated Vehicle for Underwater Oil and Gas Operations
- Inspecting Deepwater Oil Pipelines With an Underwater Autonomous Vehicle



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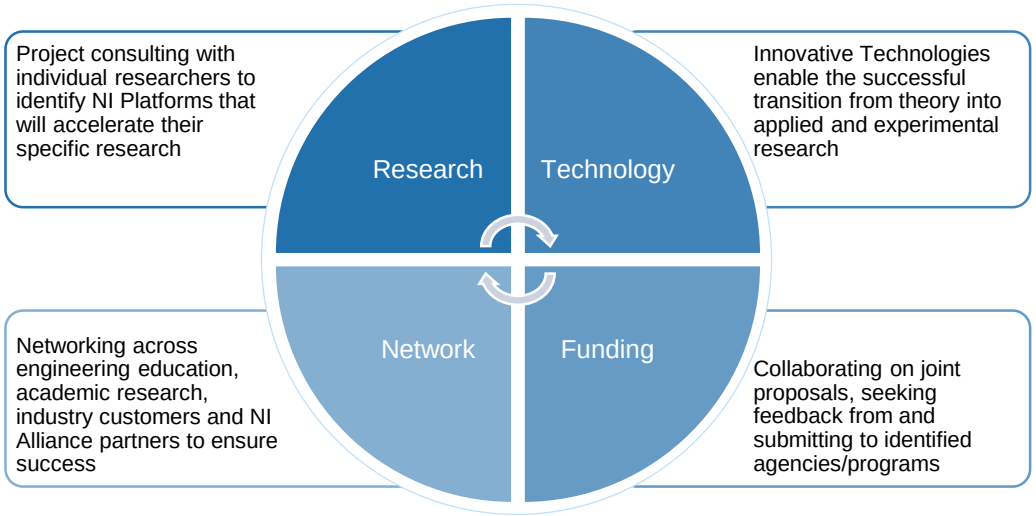
Research Collaboration

NATIONAL INSTRUMENTS

Focused to Support Academic Research

Engineers, researchers and scientist around the world rely on the NI Platform to accelerate innovation and discovery in a variety of academic research applications across a multitude of disciplines in order to advance, if not transform, the frontiers of knowledge.



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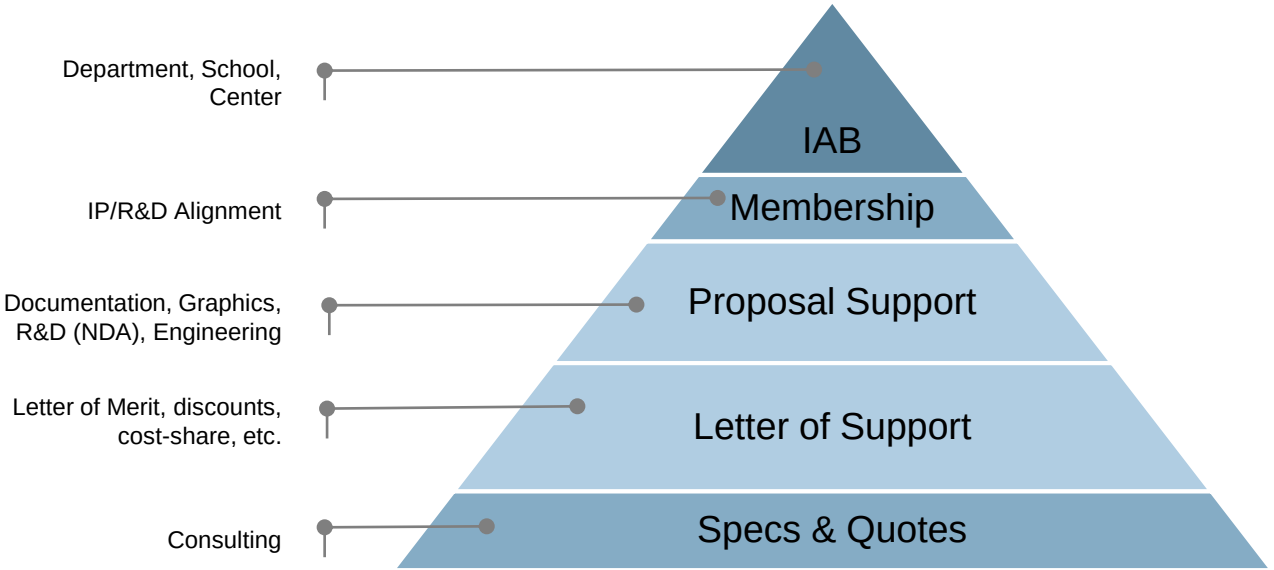
Collaboration Opportunities to Apply for (more) Funding



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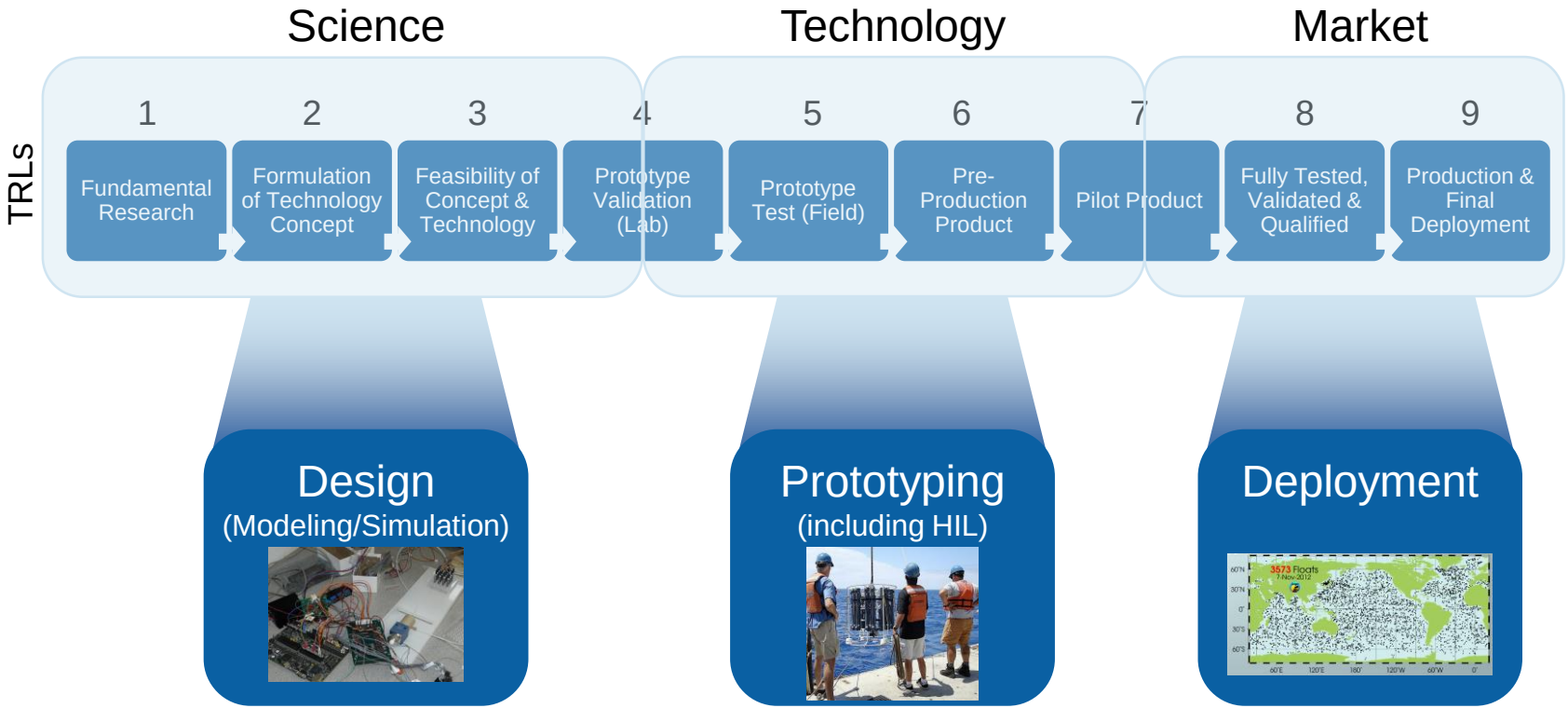
Industry Expertise for Academic Research

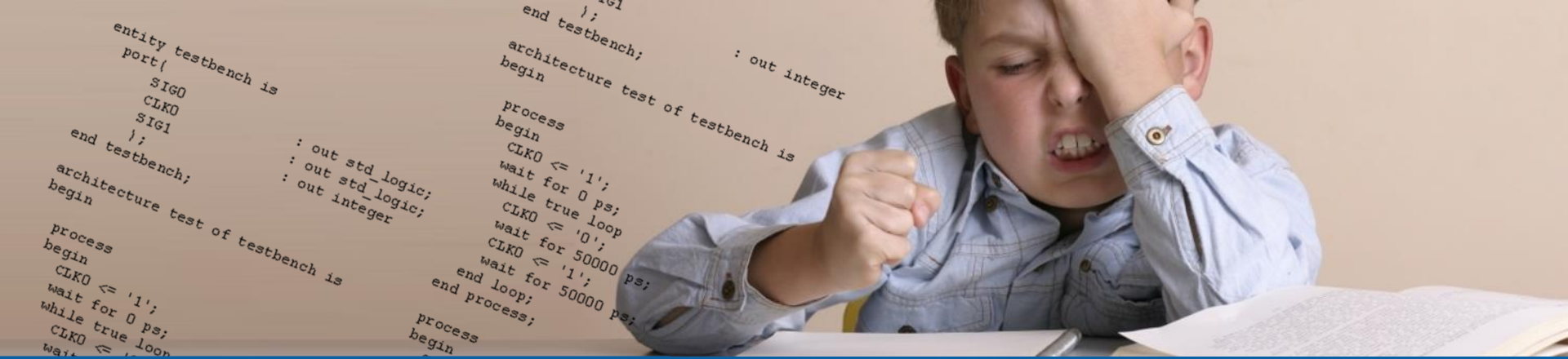
Research – NI Application Thrust

Power Conversion and Smart Grid Control	Wireless Prototyping / SDR	Robotics, Automotive & Advanced Manufacturing	Medical & Scientific Instruments	Advance & Embedded Measurements
Measurement and high-speed control Out-of-the-box experience	Rapid algorithm design and prototyping on FPGAs Wide range of apps and frequency	Full “V” Model support – smart machine design to test platform Rapid Prototyping for Robotics and Mechatronics Augmenting exiting control systems	Synchronous high-speed/high-channel systems with In-line FPGA-processing Rapid Prototyping of Medical Devices	Any sensor High-speed/high-channel Sync & Trigger

NATIONAL INSTRUMENTS

Advance Academic Research through TRLs

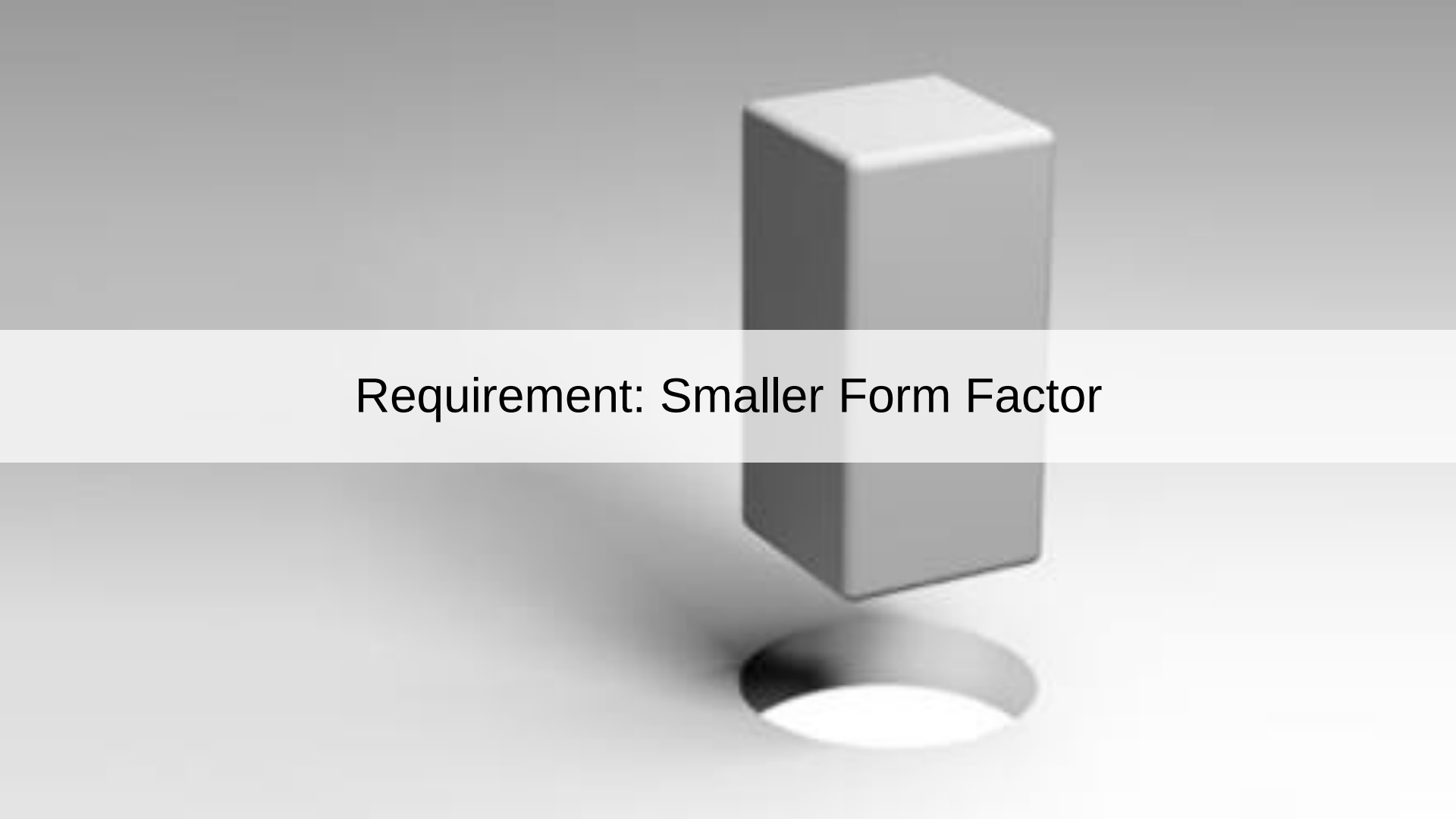




Why go Embedded?

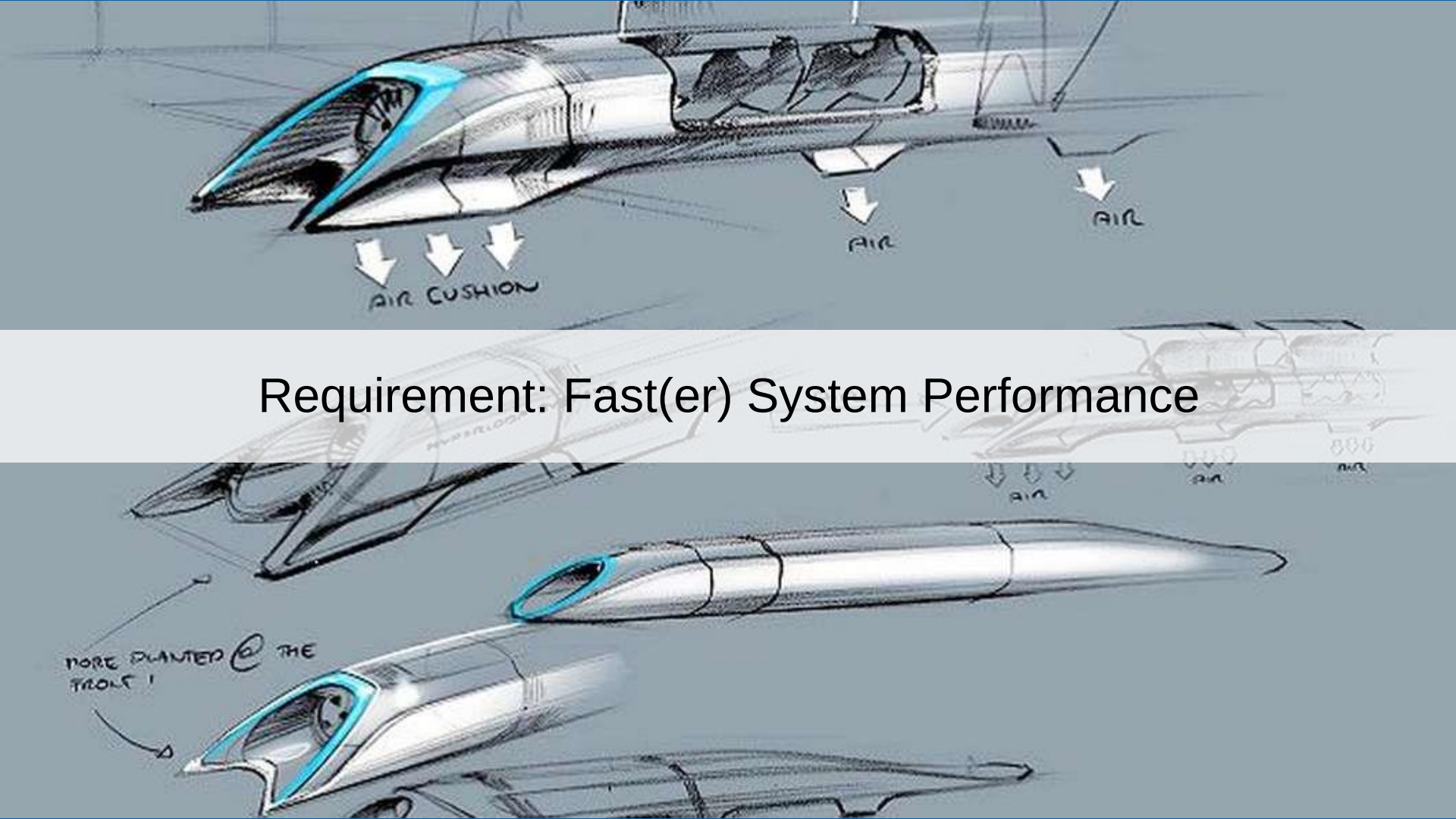
NATIONAL INSTRUMENTS

Requirement: Reliable Up-Time



Requirement: Smaller Form Factor

Requirement: Survive in Harsh Environments



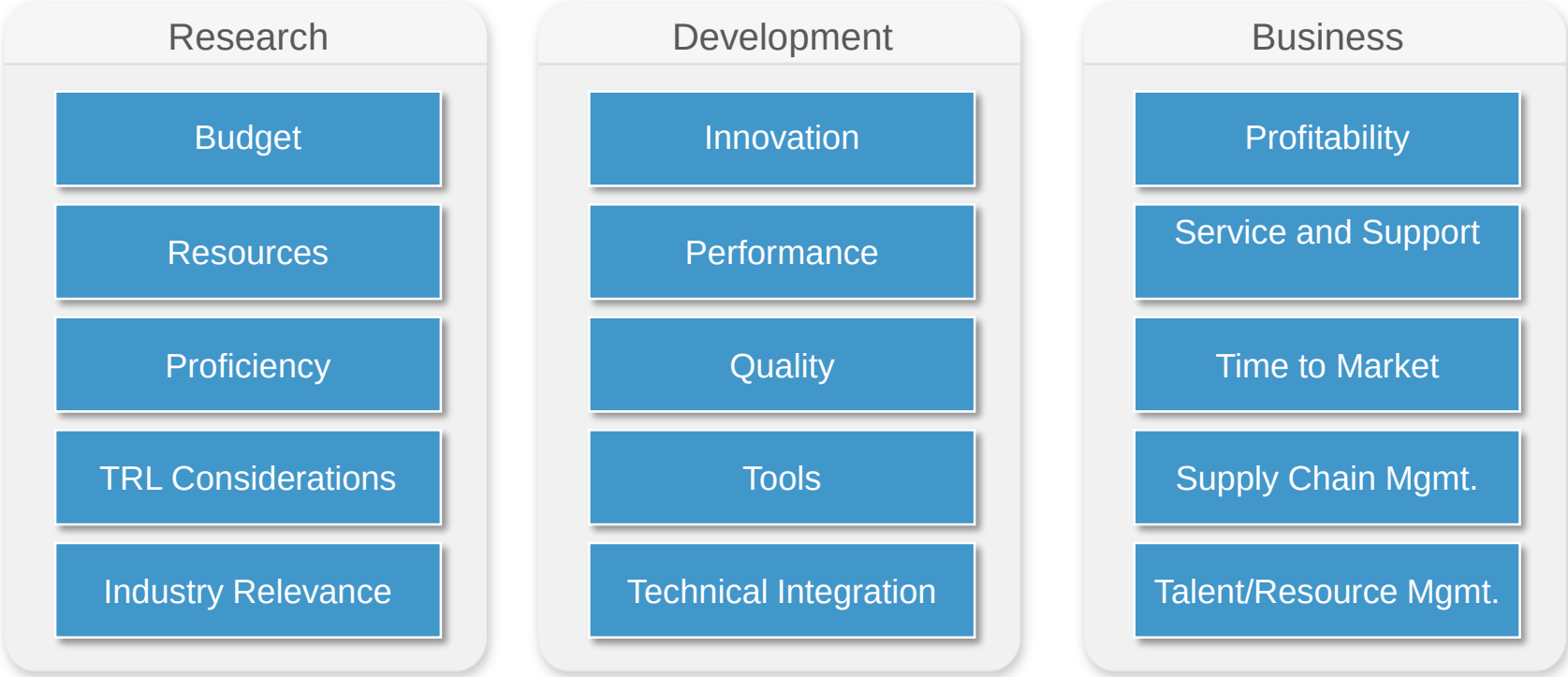
Requirement: Fast(er) System Performance

Requirement: Enable Real-Time/In-Line Processing

Design Approach for Embedded Systems

NATIONAL INSTRUMENTS

Today's Engineering Challenges



NATIONAL INSTRUMENTS

The Choice: Build or Buy?

Build

Advantages
- Custom HW/SW solution
- Maximum flexibility
- Ability to get exactly what you want

Disadvantages
- Long lead times for new product
- Significant resource requirements
- Higher life-cycle costs

Buy

Advantages
- Off-the-shelf HW/SW solution
- Use fewer resources because systems are pre-built
- Shorter time to market
- Lower life-cycle costs

Disadvantages
- Often pay for more than you need
- Limited flexibility (vendor defined)
- Limited functionality (vendor defined)

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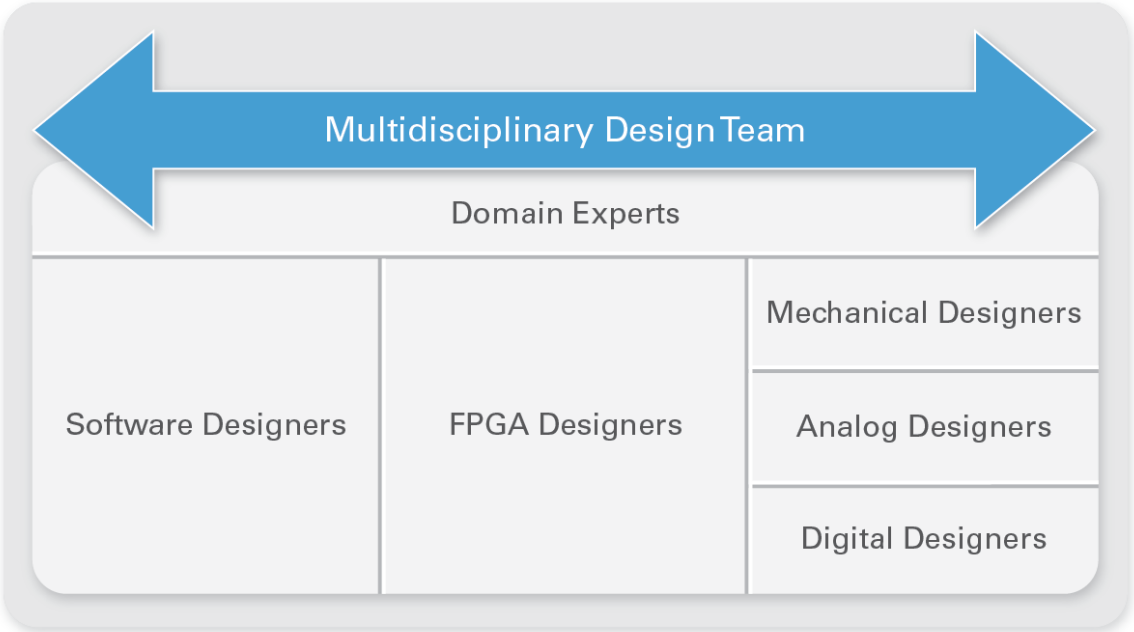
The Complexity of a Custom Build

- Hardware and software costs
- Mechanical components (non-electronic)
- EDA development tool costs
- Design specification and component selection
- Prototyping
- Hardware design
- Hardware test and verification
- Software development
- Software test and verification
- Mechanical design
- Manufacturing setup and tooling
- Manufacturing test
- Compliance and environmental engineering
- Documentation, training, and customer support
- Inventory management and EOL issues
- Sustaining engineering
- Opportunity cost

NATIONAL INSTRUMENTS

A Custom Build Requires Large Specialized Teams



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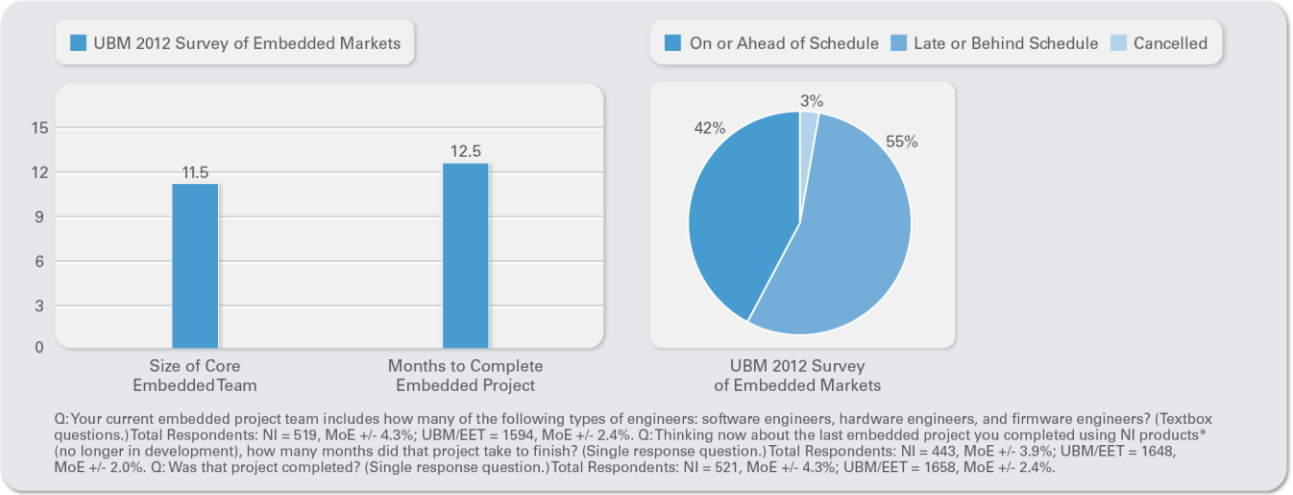
The Reality of Embedded System Design



Q: Your current embedded project team includes how many of the following types of engineers: software engineers, hardware engineers, and firmware engineers? (Textbox questions.) Total Respondents: NI = 519, MoE +/- 4.3%; UBM/EET = 1594, MoE +/- 2.4%. Q: Thinking now about the last embedded project you completed using NI products* (no longer in development), how many months did that project take to finish? (Single response question.) Total Respondents: NI = 443, MoE +/- 3.9%; UBM/EET = 1648, MoE +/- 2.0%. Q: Was that project completed? (Single response question.) Total Respondents: NI = 521, MoE +/- 4.3%; UBM/EET = 1658, MoE +/- 2.4%.

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The “Buy” Option

Commercial Off-the-Shelf (COTS) Technologies

Shorter Time to Market

- Extend time in market
- Start on next project sooner
- Be more responsive to customer demands

Lower Development and Maintenance Costs

Lower Life-Cycle Management Cost

Reduced Risk Over Time

Easier Migration Paths to Future Technologies

NATIONAL INSTRUMENTS

The Dilemma: Build or Buy?

Build

Advantages
- Custom HW/SW solution
- Maximum flexibility
- Ability to get exactly what you want

- Higher life-cycle costs

Buy

Advantages
- Off-the-shelf HW/SW solution
- Use fewer resources because systems are pre-built

- Often pay for more than you need
- Limited flexibility (vendor defined)
- Limited functionality (vendor defined)

Build **AND** Buy!

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NI Embedded System Design

The Benefits of Off-the-Shelf Technology With the Flexibility of Custom Design

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NI RIO Hardware powered by LabVIEW

NI myRIO, NI CompactRIO and NI Single-Board RIO

Student

Value

Performance

PXI & PC R Series, NI FlexRIO

High Performance

Expansion I/O

EtherCAT RIO

Ethernet RIO

PXI

Wireless

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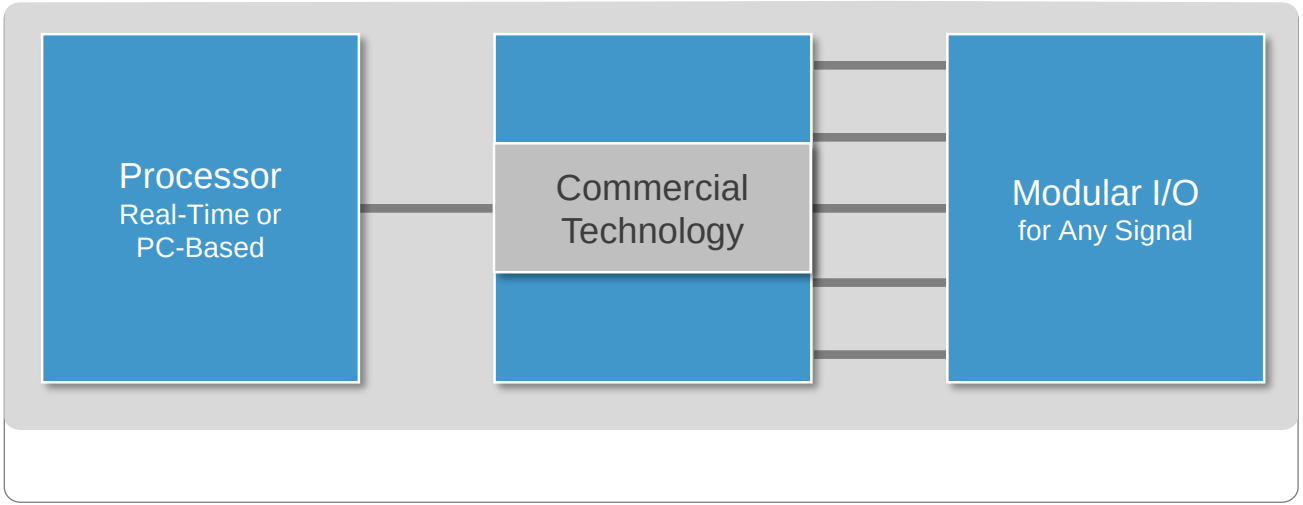
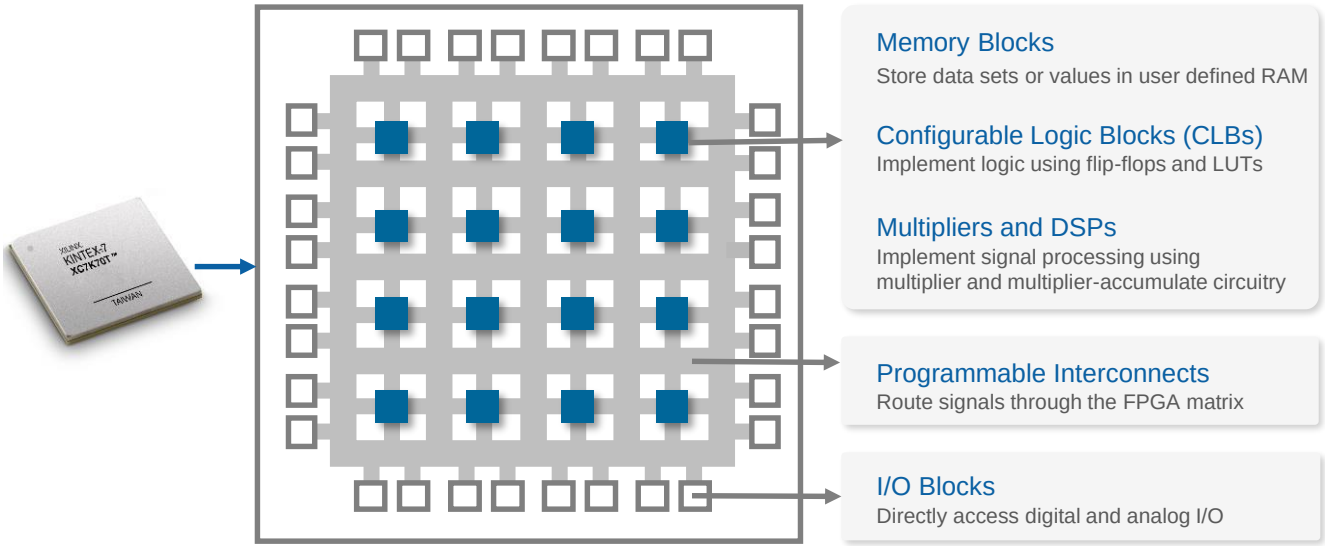
The NI Approach to Flexible Hardware



Field-Programmable Gate Array (FPGA)



Memory Blocks
Store data sets or values in user defined RAM

Configurable Logic Blocks (CLBs)
Implement logic using flip-flops and LUTs

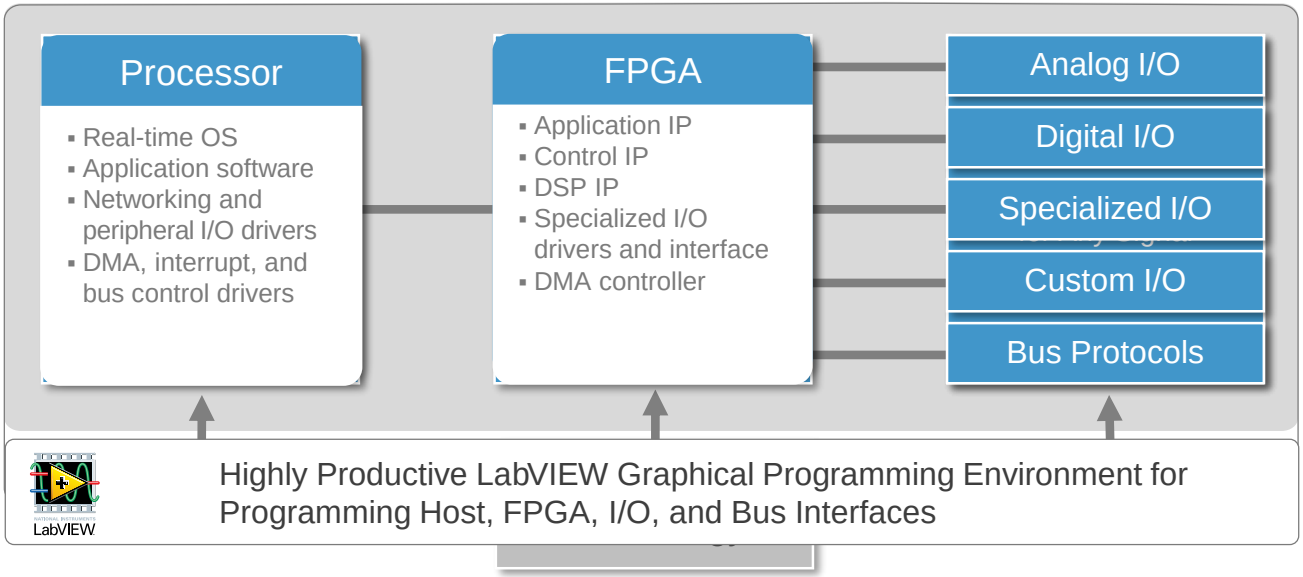
Multipliers and DSPs
Implement signal processing using multiplier and multiplier-accumulate circuitry

Programmable Interconnects
Route signals through the FPGA matrix

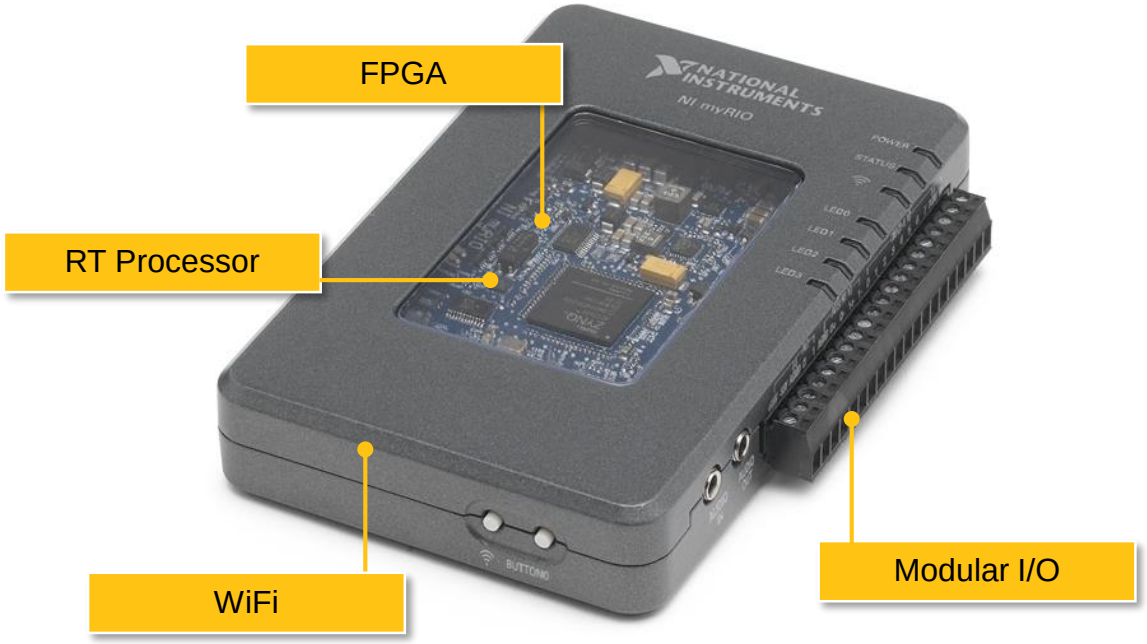
I/O Blocks
Directly access digital and analog I/O

The NI Approach to Flexible Hardware

We call this the LabVIEW RIO Architecture.



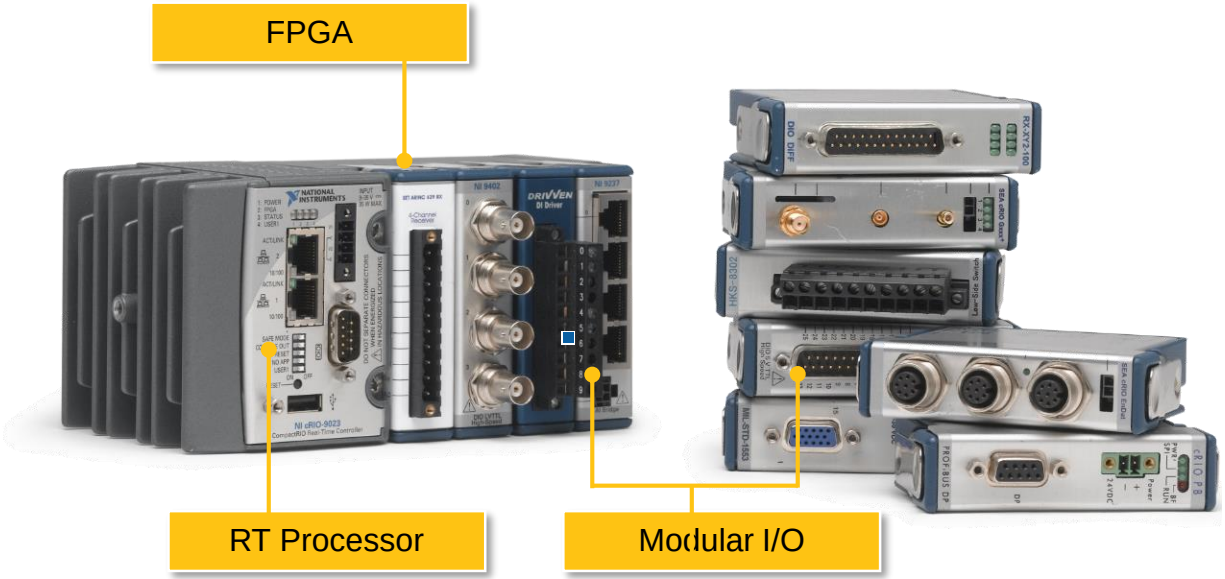
NI myRIO



Student Device
LabVIEW FPGA-based
Hands-On Engineering Education
Portable & Connected

NATIONAL INSTRUMENTS

NI CompactRIO



Extreme Ruggedness:	-40 to 70 °C temperature range; 50 g shock, 5 g vibration
Real-Time Processor:	Up to 1.91 GHz Quad-Core CPU
Comprehensive I/O:	Analog, digital, custom, specialty, bus communication

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Connect to Any Sensor on Any Bus

100+ Industrial I/O Modules

- Accelerometer
- Strain gage
- Resistance
- Load cells
- Digital I/O and protocols
- Microphone
- Bus communications
- Thermocouples
- 4 to 20 mA
- Storage media
- RTD
- GPS & Sync
- Industrial vision
- Motion control

NATIONAL INSTRUMENTS

NI CompactRIO

LabVIEW

Highly Productive LabVIEW Graphical Programming Environment for Programming Host, FPGA, I/O, and Bus Interfaces

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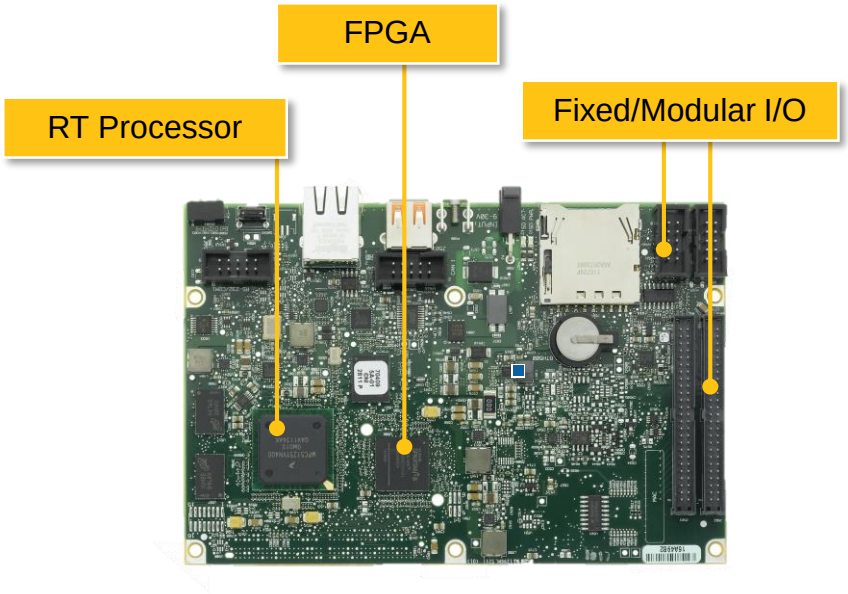
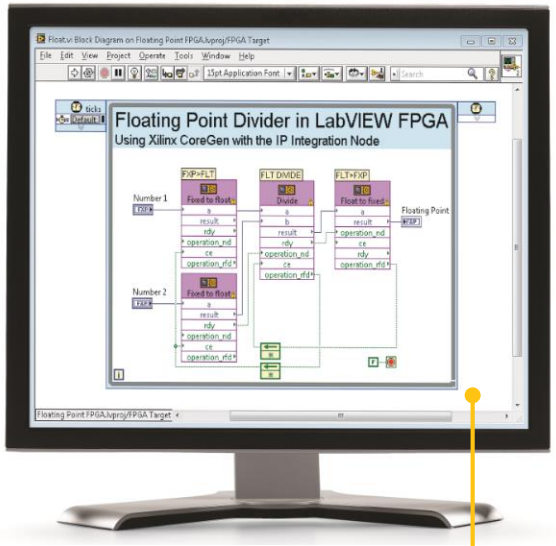
NI Single-Board RIO



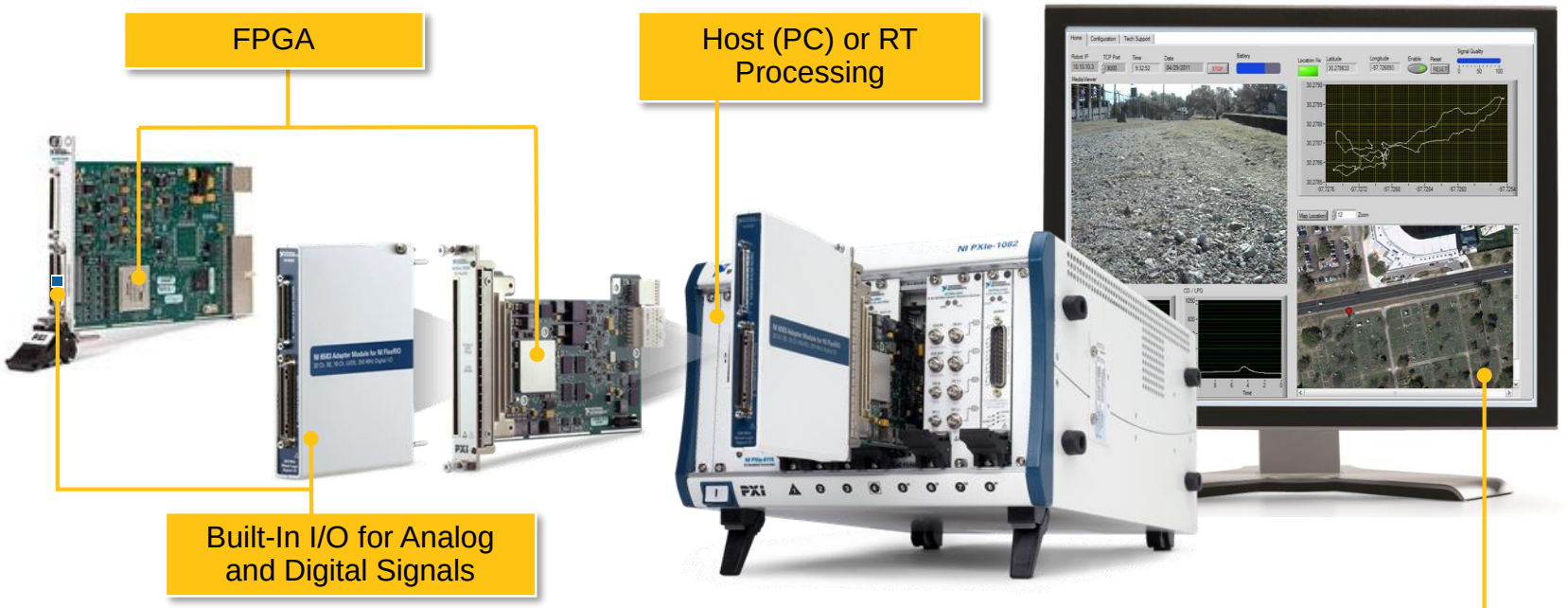


LabVIEW

Highly Productive LabVIEW Graphical Programming Environment for Programming Host, FPGA, I/O, and Bus Interfaces

NATIONAL INSTRUMENTS

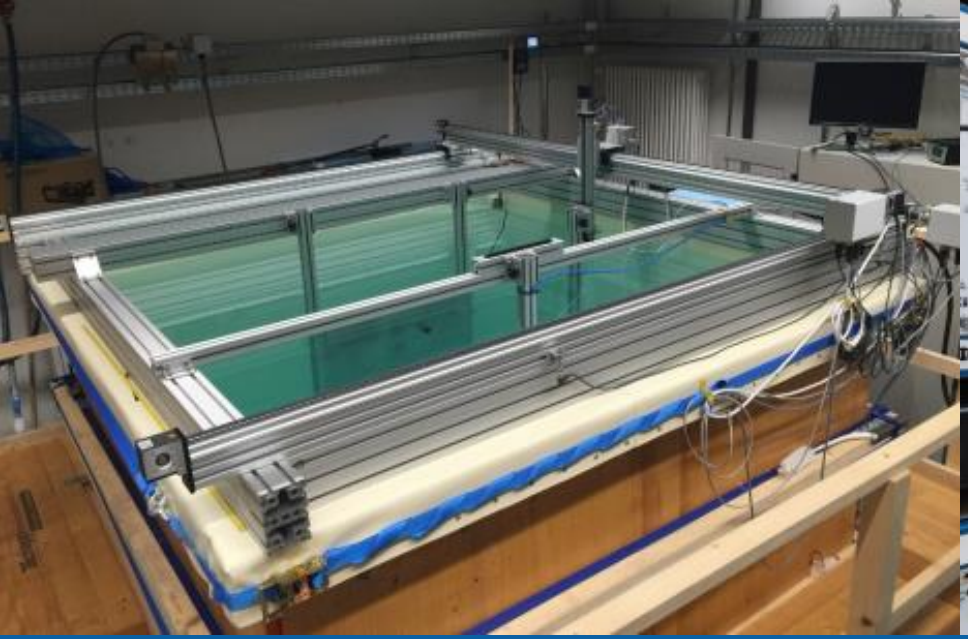
NI R Series and NI FlexRIO



LabVIEW

Highly Productive LabVIEW Graphical Programming Environment for Programming Host, FPGA, I/O, Bus Interfaces and GUI

NATIONAL INSTRUMENTS



ACOUSTIC

ETH zürich

“800 sensors, 800 actuators & 800 partial differential equation solved within the 170µsec. You don’t run this sort of computational load on a desktop PC. Clearly, you need a lot more computational horsepower. For this experimental setup, the researchers are using over 500 FPGAs.”

—Xilinx about ETH Zurich WaveLab,

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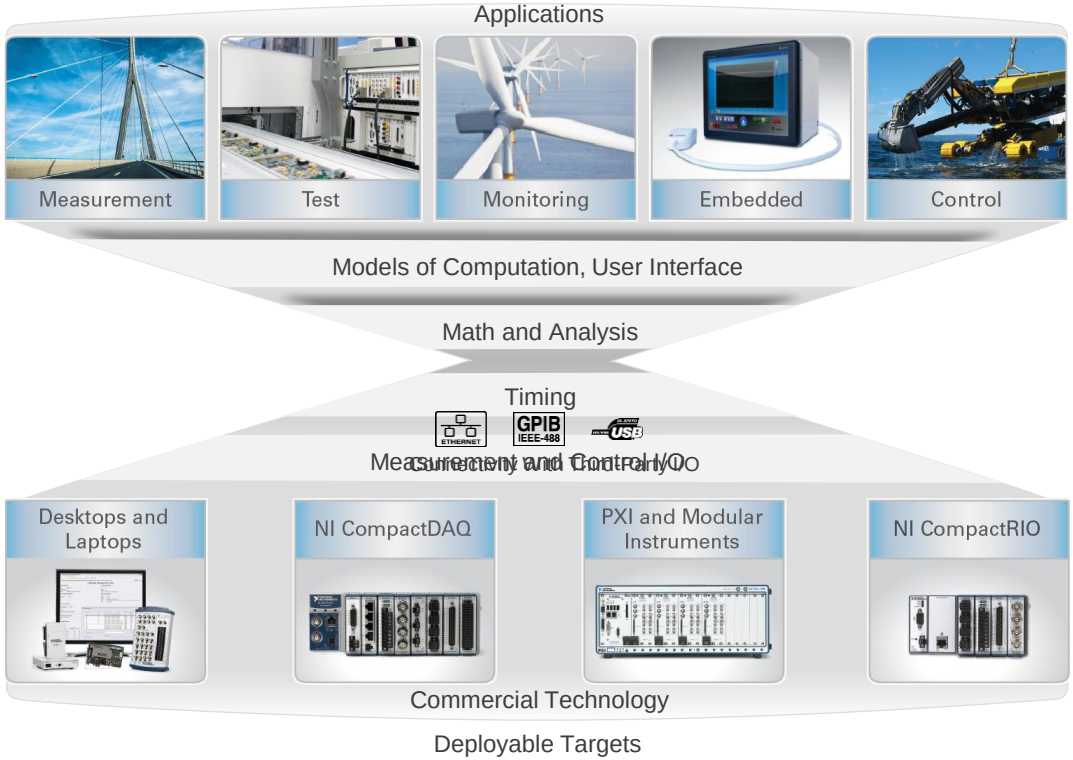
Graphical System Design

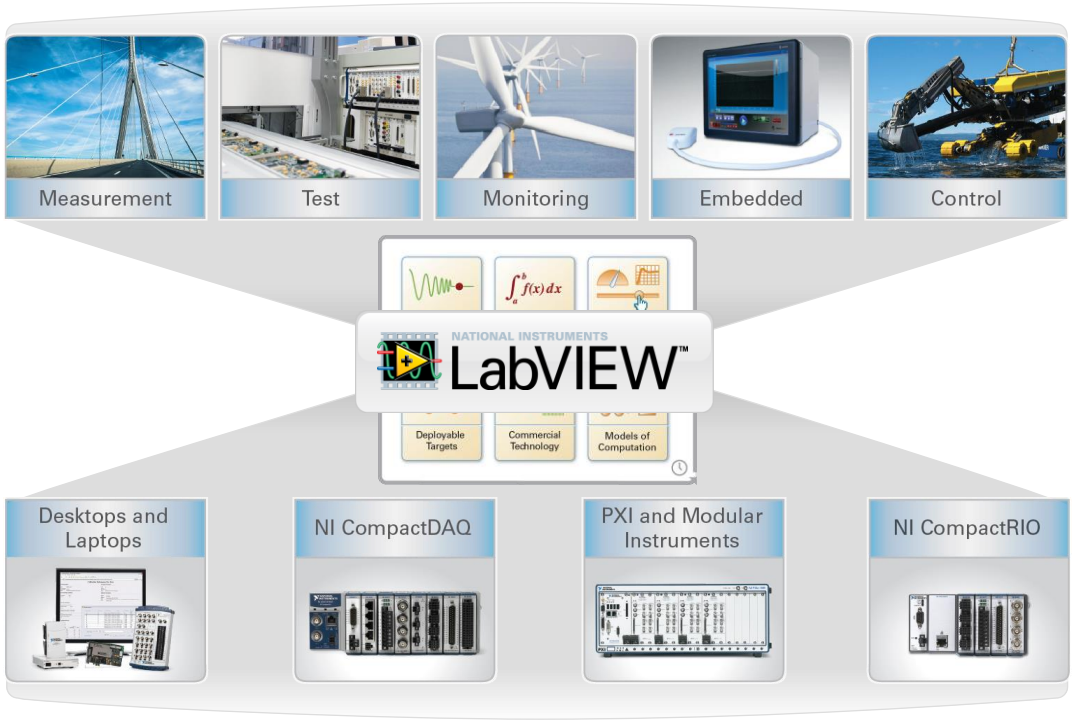
A platform-based approach for measurement, control and monitoring



NATIONAL INSTRUMENTS

Graphical System Design

A platform-based approach for measurement, control and monitoring



NATIONAL INSTRUMENTS

LabVIEW System Design Software

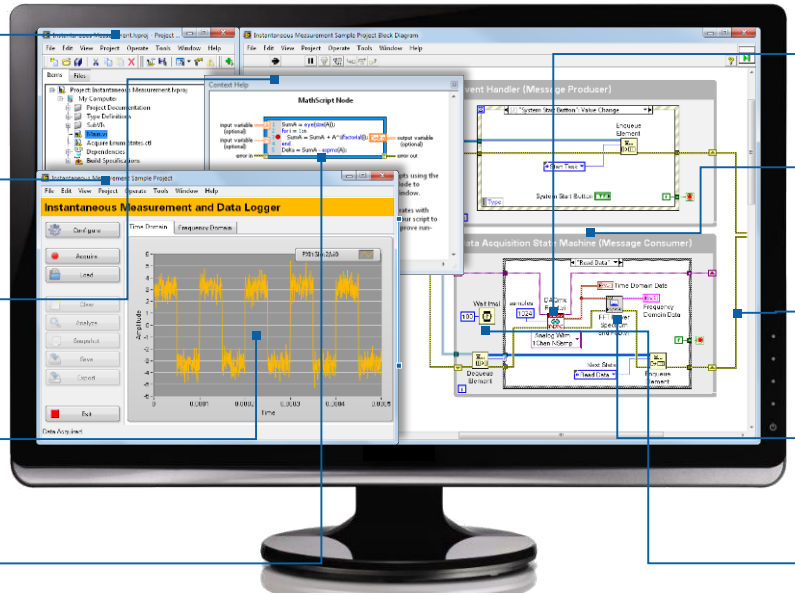
Project Explorer
Manage and organize all system resources, including I/O and deployment targets

Deployment Targets
Deploy LabVIEW code to the leading desktop, real-time, and FPGA hardware targets

Instant Compilation
See the state of your application at all times, instantly

Front Panel
Create event-driven user interfaces to control systems and display measurements

Models of Computation
Combine and reuse .m files, C code, and HDL with graphical code



Hardware Connectivity
Bring real-world signals into LabVIEW from any I/O on any instrument

Parallel Programming
Create independent loops that automatically execute in parallel

Block Diagram
Define and customize the behavior of your system using graphical programming

Analysis Libraries
Use high-performance analysis libraries designed for engineering and science

Timing
Define explicit execution order and timing with sequential data flow

Accelerates Your Research

By abstracting low-level complexity and integrating all of the tools you need to build any measurement, control or monitoring system

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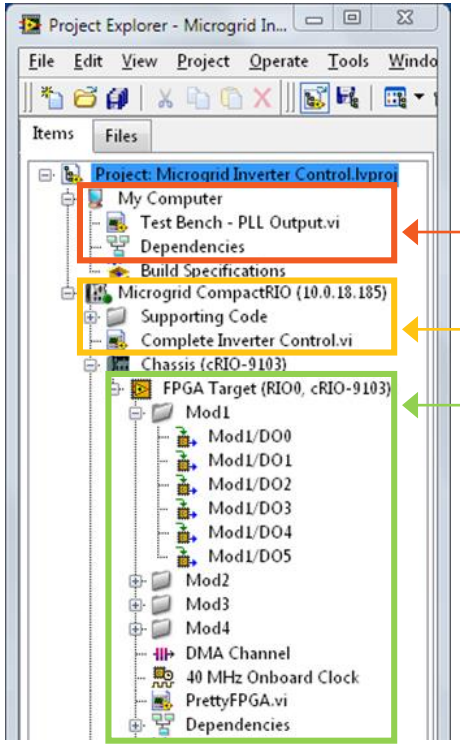
LabVIEW **Embedded** System Design Software



Windows + Desktop PC Application

Real-Time OS + Processor Application

FPGA Configuration/Application

Simplified and integrated System Design Tool

NATIONAL INSTRUMENTS

SPOT – Self Paced Online Training

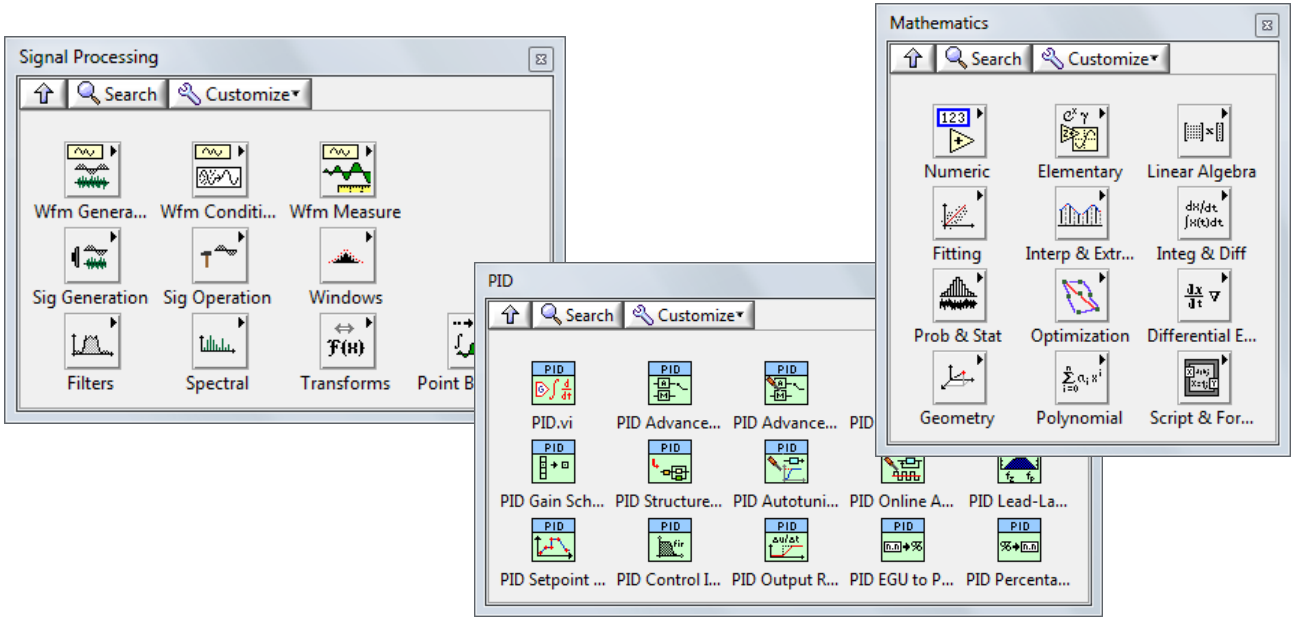
Course Title and Description	Who Should Attend	Prerequisites	
LabVIEW Core 1	New LabVIEW users and users preparing to develop applications using LabVIEW or NI Developer Suite	Experience with Microsoft Windows and writing algorithms (flowcharts, block diagrams)	Course Details
LabVIEW Core 2	New LabVIEW users and users preparing to develop applications using LabVIEW or NI Developer Suite	LabVIEW Core 1 or experience navigating and programming small applications in LabVIEW	Course Details
LabVIEW Core 3	Engineers who need to learn best practices for application and project design in LabVIEW	LabVIEW Core 1 and 2 or experience programming small to medium LabVIEW applications	Course Details
Object-Oriented Design and Programming in LabVIEW	Experienced LabVIEW users interested in using object-oriented programming architectures	LabVIEW Core 3 or experience programming medium to large LabVIEW applications	Course Details
Advanced Architectures in LabVIEW	Experienced LabVIEW users architecting medium to large applications	LabVIEW Core 3 or experience programming medium to large LabVIEW applications	Course Details
LabVIEW Real-Time 1	Developers of applications using LabVIEW Real-Time and PXI, CompactRIO, or Single Board RIO	LabVIEW Core 1 or experience navigating and programming small applications in LabVIEW	Course Details
LabVIEW Real-Time 2	LabVIEW Real-Time Module users who need to develop and deploy medium-to-large, professional real-time applications with maximum reliability and extended run times.	LabVIEW Real-Time 1 or experience developing small to medium applications in LabVIEW Real-Time	Course Details
LabVIEW FPGA	New users with applications with I/O less than 5 MHz, incorporating LabVIEW FPGA and R Series, CompactRIO, or Single-Board RIO targets.	LabVIEW Core 1 or experience navigating and programming small applications in LabVIEW	Course Details
Developing Test Programs Using TestStand	New NI TestStand users or those evaluating the software; engineers creating or maintaining test sequences	Familiarity with LabVIEW, LabWindows™/CVI, or C programming	Course Details
DIAdem Basics	New DIAdem users	Experience using Windows; programming experience is helpful but not essential	Course Details
DIAdem Advanced	New DIAdem users who have taken the DIAdem Basics course	DIAdem Basics or previous DIAdem experience	Course Details
Multisim Basics	New Multisim users and designers who need learn how to capture, simulate, and analyze circuits	Experience with Microsoft Windows and circuit design	Course Details
Ultiboard Basics	New users of NI Ultiboard and designers wanting to learn how to lay out, route, and export PCB designs	Experience with Microsoft Windows, NI Multisim, and circuit design	Course Details

NATIONAL INSTRUMENTS

LabVIEW System Development Environment

Complete System IDE

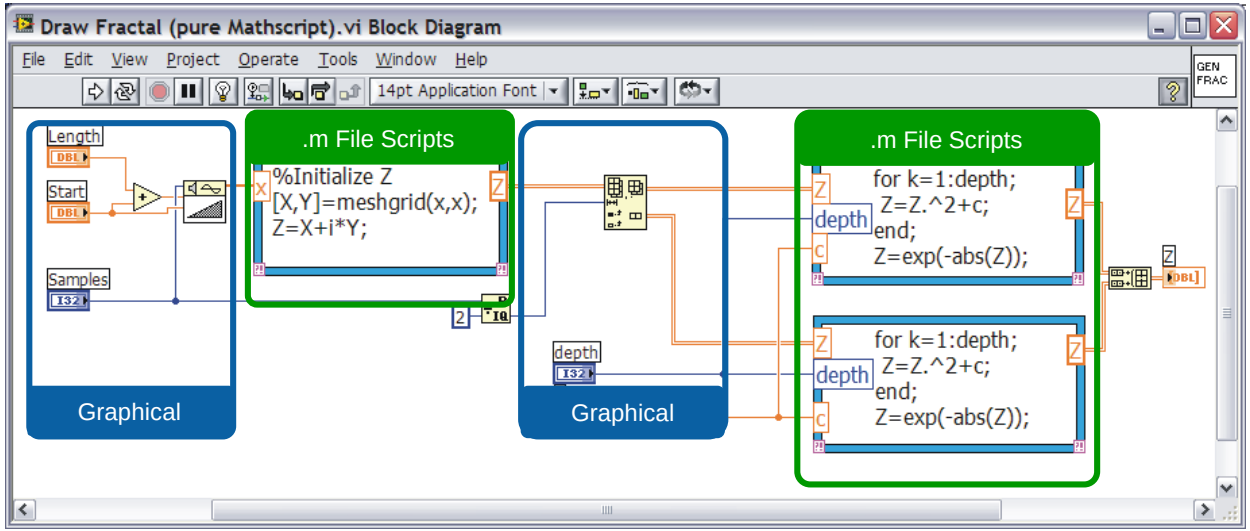
Math and Analysis



NATIONAL INSTRUMENTS

LabVIEW System Development Environment

Complete System IDE	Math and Analysis	Reuse of Existing Code



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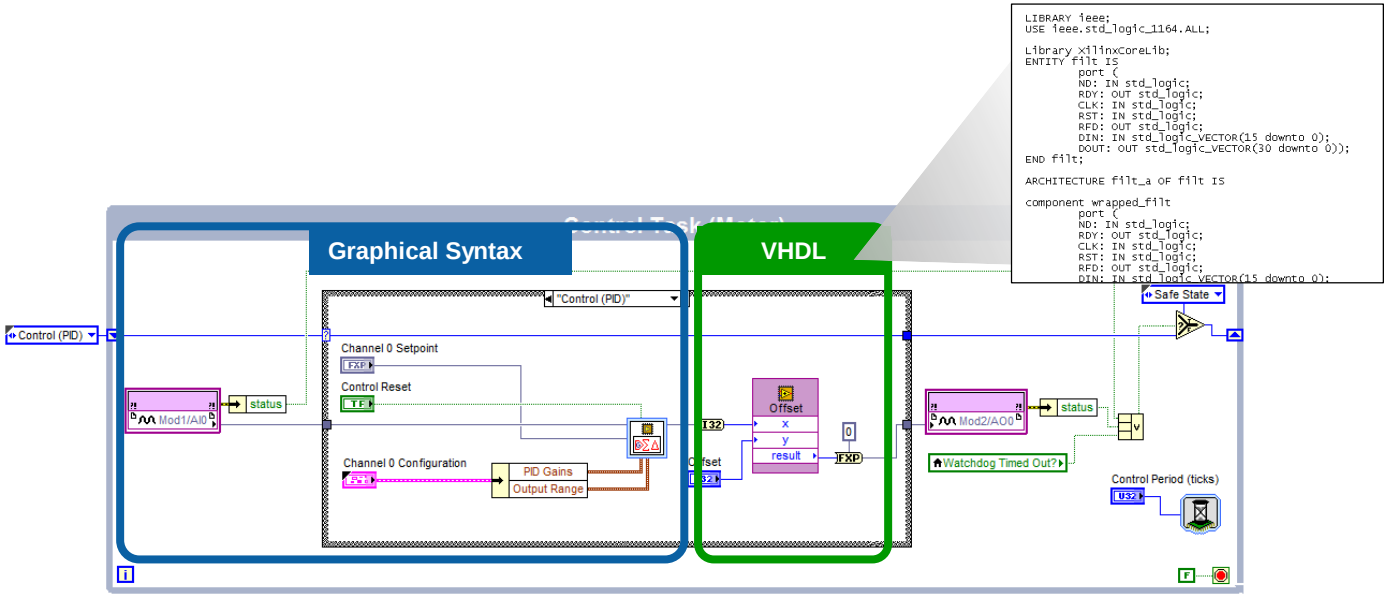
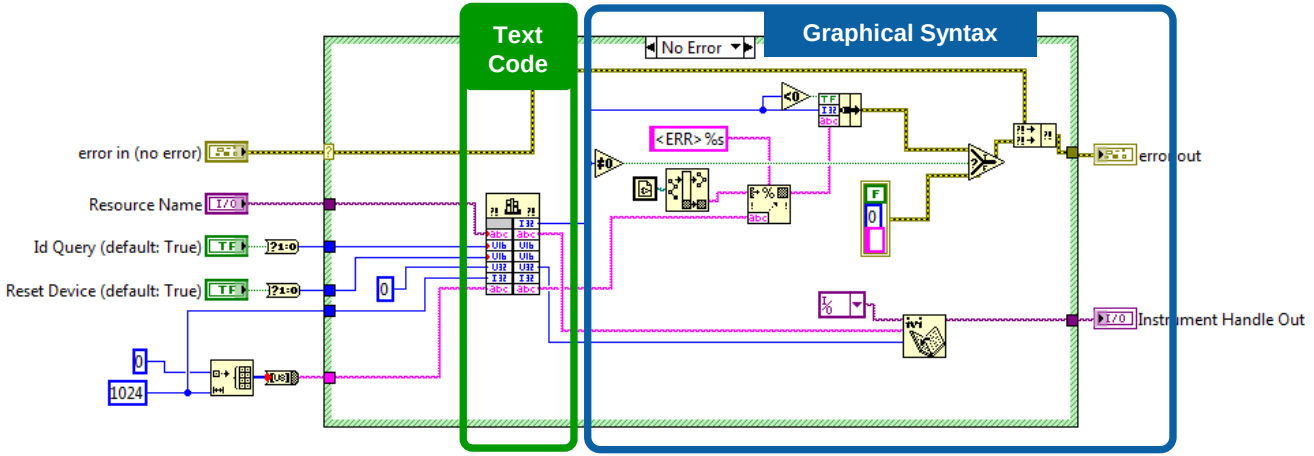
LabVIEW System Development Environment

Complete System IDE	Math and Analysis	Reuse of Existing Code



LabVIEW System Development Environment

Complete System IDE	Math and Analysis	Reuse of Existing Code



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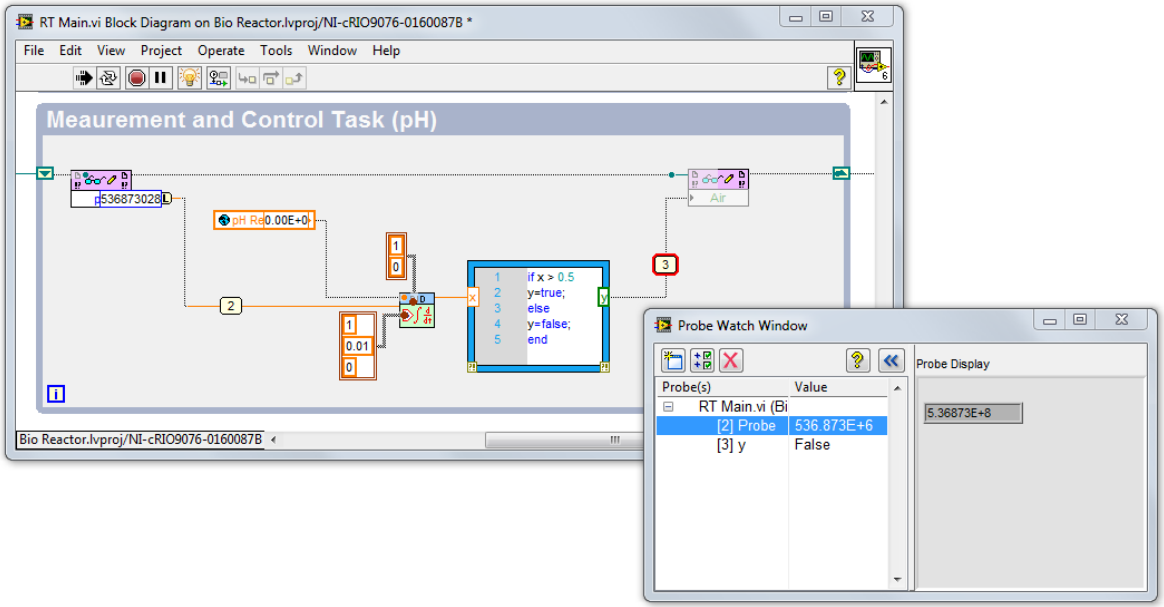
LabVIEW System Development Environment

Complete System IDE	Math and Analysis	Reuse of Existing Code	Graphical Debugging



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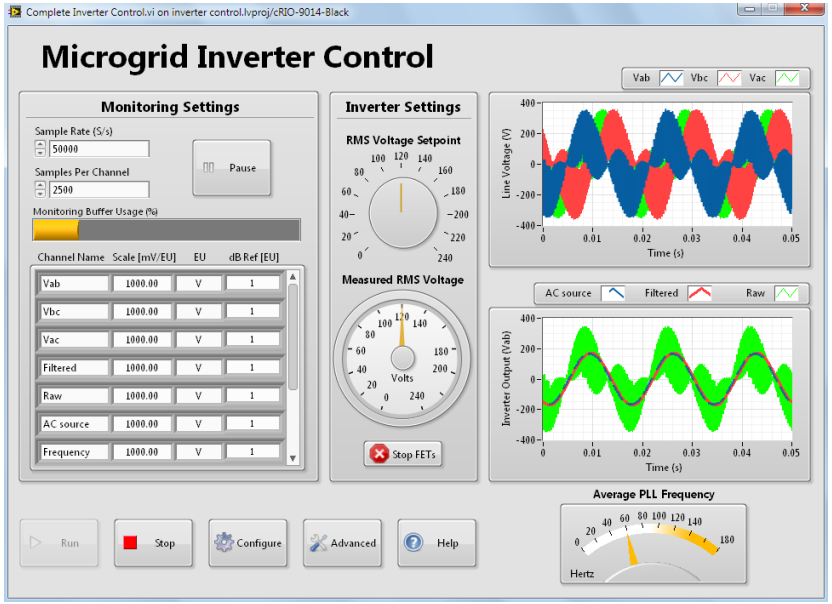
LabVIEW System Development Environment

Complete System IDE	Math and Analysis	Reuse of Existing Code	Graphical Debugging	User Interface



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Live Programming: LabVIEW RT and FPGA

NI Embedded System Design

Use COTS Hardware and integrated Software Development to build customized systems that will advance academic research

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Advance Research Through Integrated Hardware and Software Platform

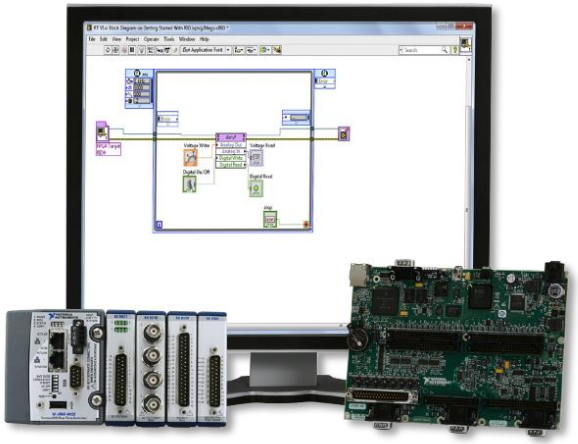
Language Designed for Measurement and Control Applications

Software that is hardware aware

- One-click deployment and execution
- Seamless, visual debugging
- Hardware timing in the LabVIEW language
- Consistent development despite CPU and FPGA variants

Abstraction of fundamental components

- Host > Real-Time > FPGA > IO
- Common I/O abstractions across many I/O modules and devices
- Scalable across NI Hardware architecture




AI / AO / DIO


Communication


Motion


Wireless


HMIs


Third-Party I/O


Vision

Alliance Partners

IP for Control, Analysis, etc.


Training

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Next steps

- Q&A
- Contact me to discuss current technical projects
- Contact me to discuss proposal collaboration

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Thank you.

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