Solving the Top 5 Challenges of Bringing your Embedded System to Life with NI's RIO Platform

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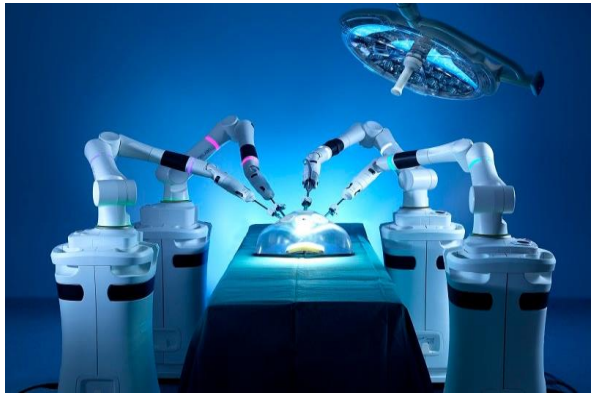
Our Plan Today

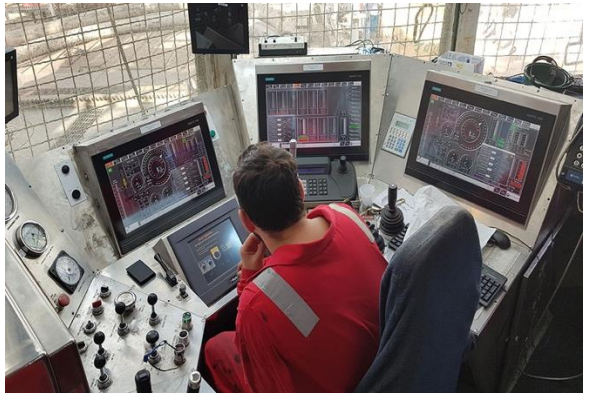
Introduction	Define “high-complexity”, “low-volume systems”
5 Challenges	Prototyping, validating, manufacturing, market forces, personnel
Why RIO	How the RIO platform helps solve (most) of the challenges
Success Cases	Examples of how CompactRIO has been used in system design

What Does “High Complexity” Look Like?

DNA Synthesizers



Surgical Robots

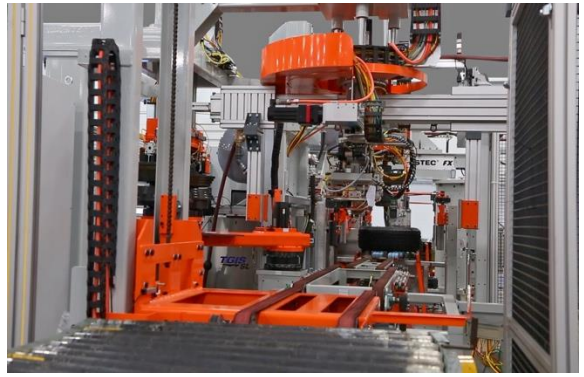


Control/Monitoring

Autonomous Vehicles

MRI Machines

Hydraulic Fracturing

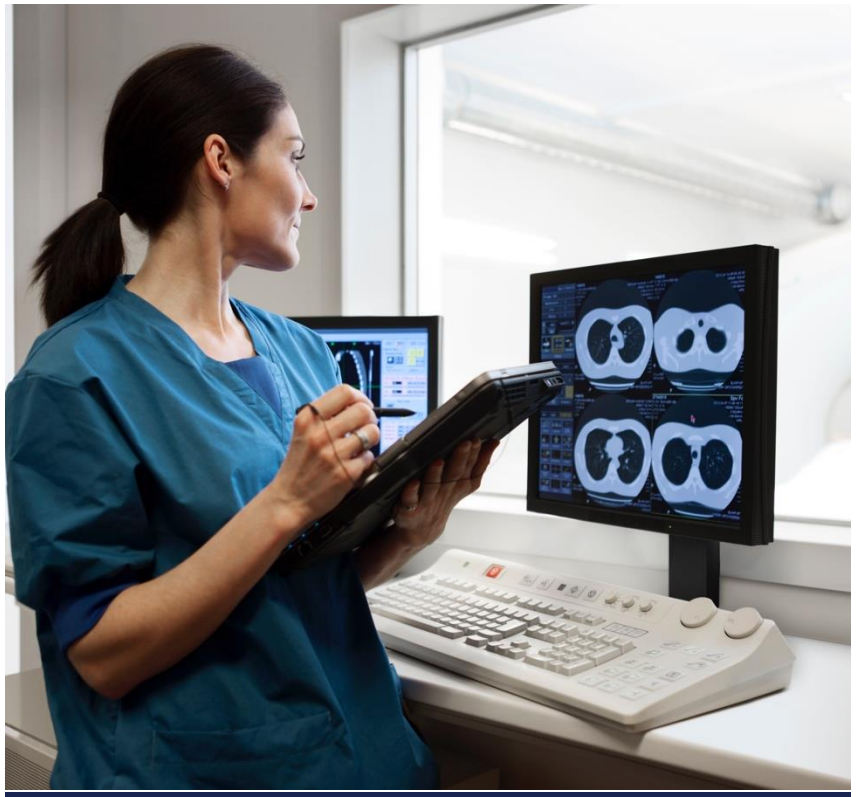


Industrial Machines

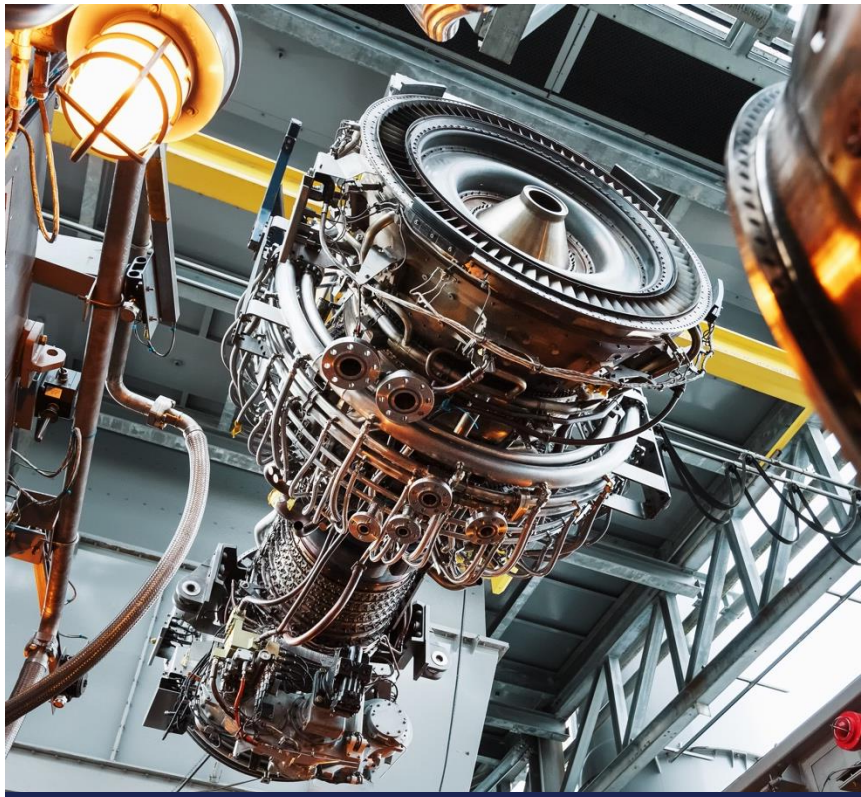
Launch Control

Significance of High-complexity, Low-volume Systems

Societal Impact



Technological Advancement



Evolving Business Models

What is “Low Volume”?

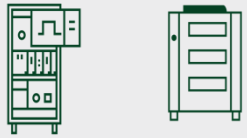
Low Volume	Medium Volume	High Volume
2- 2000	2001 – 10000	10000+
Systems per year	Systems per year	Systems per year

Why NI for High Complexity Systems

Research — Design and Validation — Production — In-Use

SYSTEMS

Scalable, Modular, and Software-Centric Systems



PRODUCTS AND PLATFORM

Application and Development Software

LabVIEW™ SystemLink™ C#/.NET Python

Modular Hardware

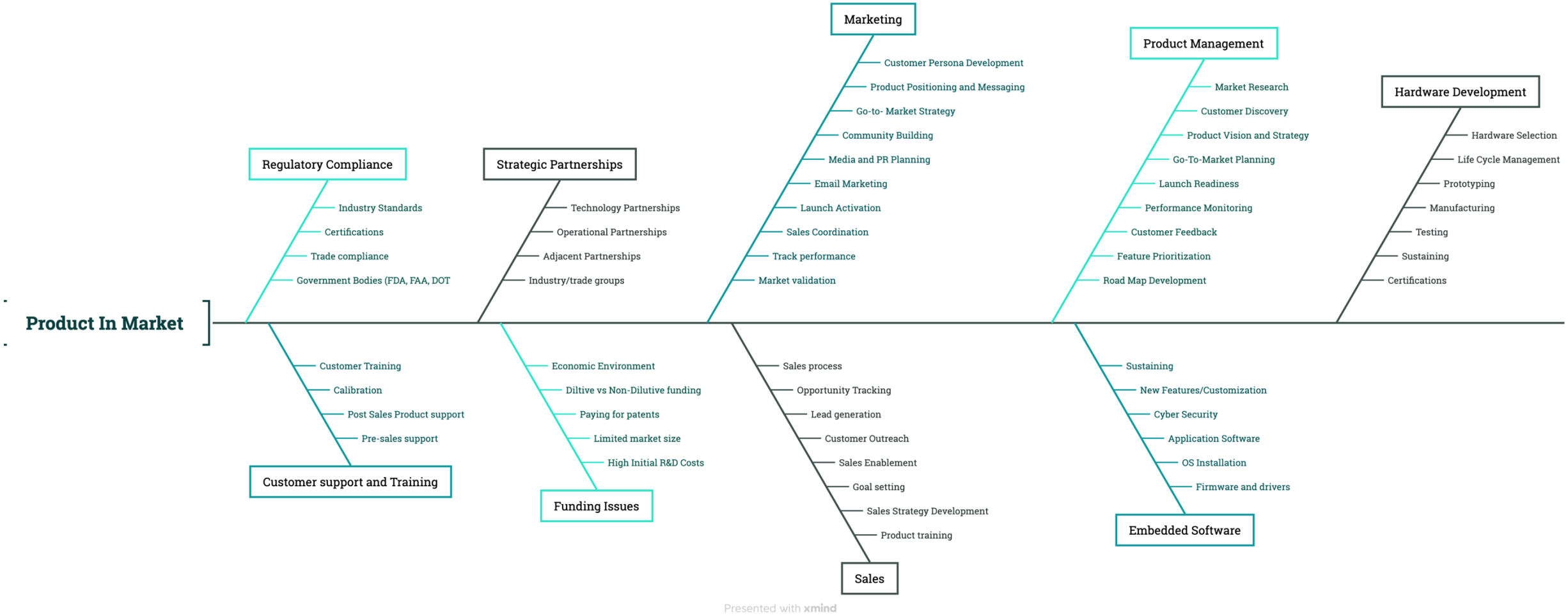
PXI CompactDAQ CompactRIO USRP …

ECOSYSTEM AND COMMUNITY

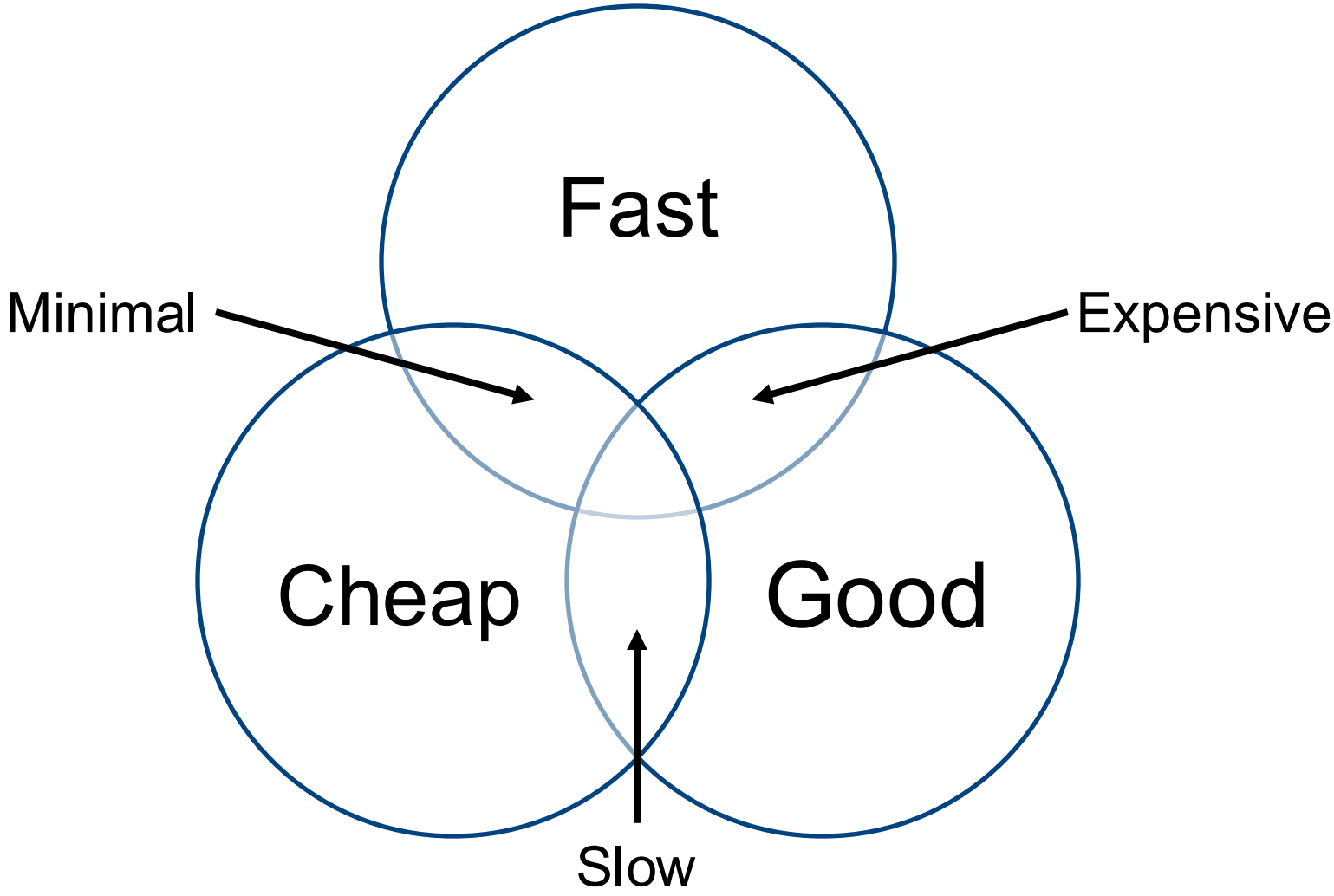
Challenge 1

Getting to your Minimum Viable Product (MVP)

Complexity Can’t Be Understated



The Triple Constraint Problem When Designing MVPs



Economies of Scale: Benefits vs. Risks for MVPs

Advantages of Economies of Scale

- Lower unit cost as production grow
- Higher profit margins
- Competitive pricing & market share
- Greater efficiency
- Lower marketing & distribution cost per unit

Risks of Chasing Scale Too Early

- High upfront investment required
- Increased complexity and overhead
- Less flexibility to adapt quickly
- Risk of diseconomies of scale
- Limits from technology or resources

→ Your MVP Design is Not the Time to Optimize for Cost

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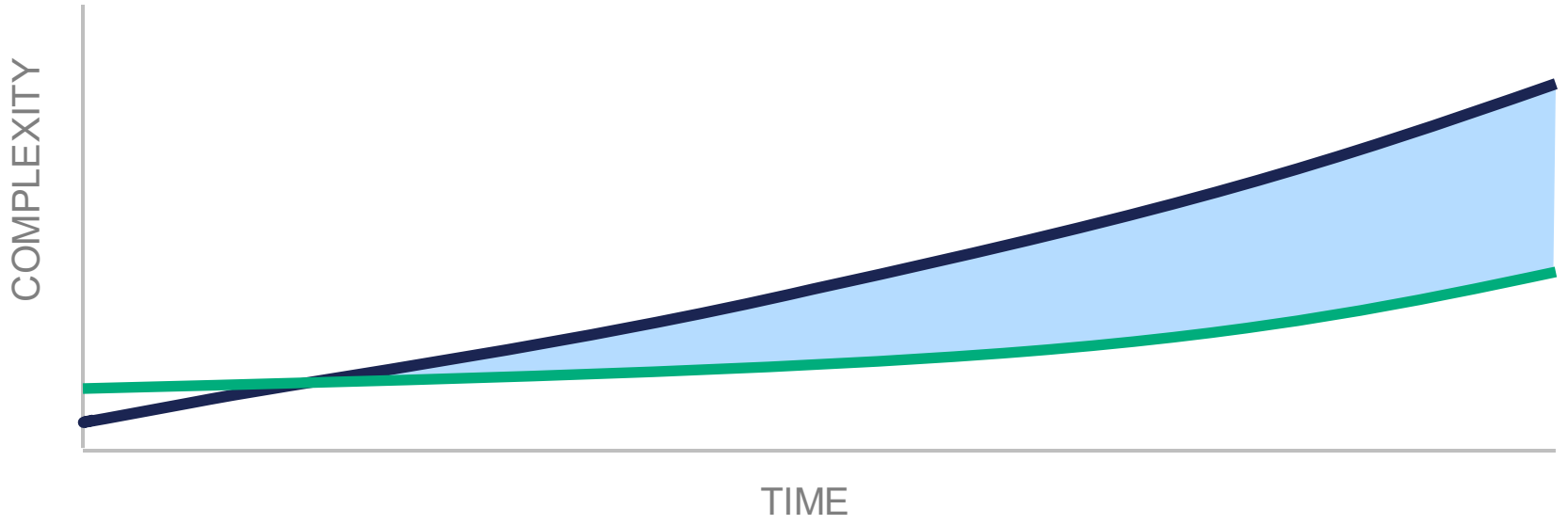
At MVP Stage, Optimize for Time-to-Market and Flexibility, Not for Cost

What Drives the Complexity Gap?



Complexity

Ability to Manage Complexity

Complexity Gap

Source: Fast Growth = Complex & Runaway Technology
point.Co/the-it-complexity-gap/

Requirements

Timeline

Scope Creep

Tech Decision

Budget

Challenge 2

Ensuring Quality

Don’t Over Invest in Test Automation Too Early: Optimize Testing for YOUR Volume

Product Test Best Practices

Foster a quality mindset

Document as you build

Make documenting everyone’s job

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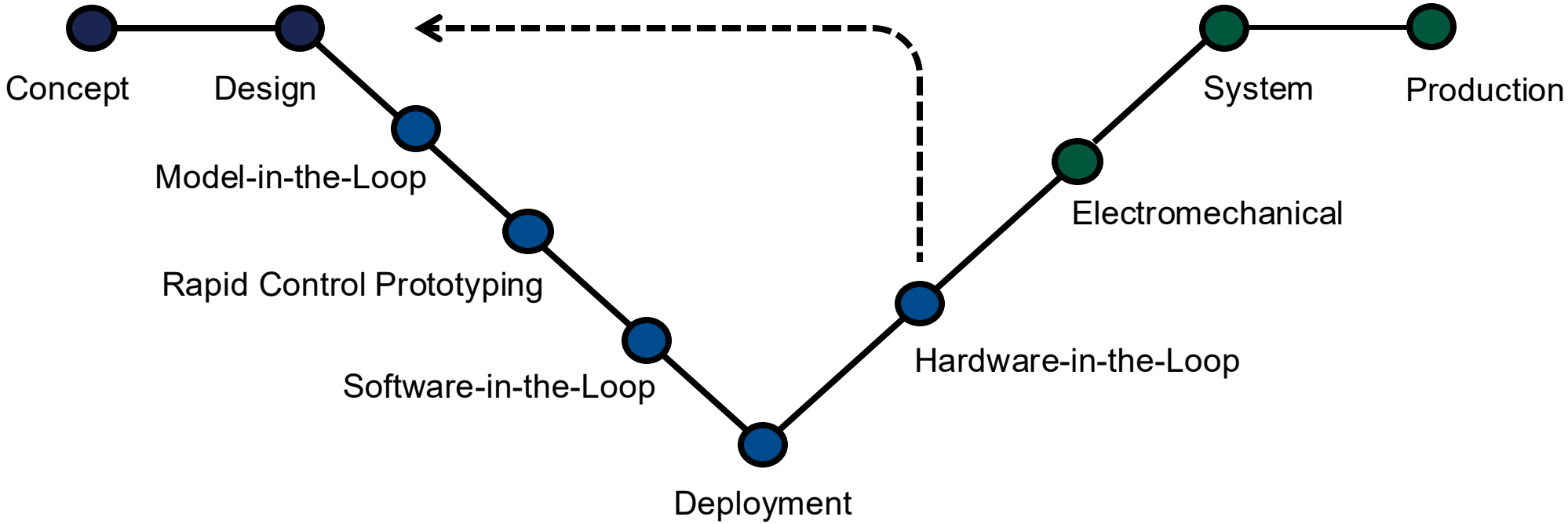
Final Product Quality Starts at the Beginning



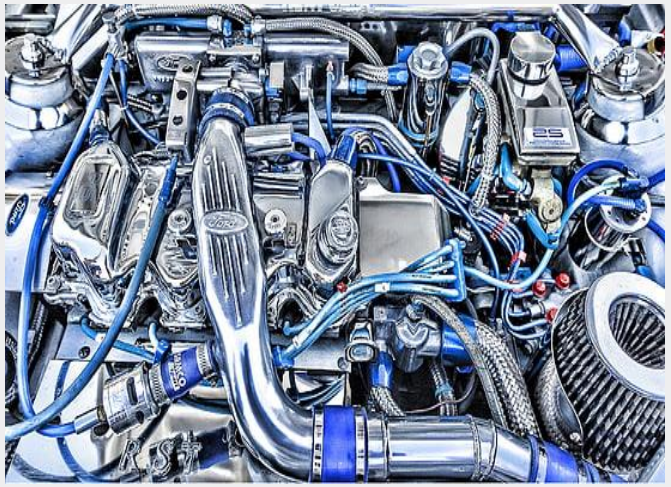
Development Stage:	Design	Virtual Prototype	Controller Test	Physical Test
Controller	Simulated	Prototype	Real	Real
Plant	Simulated			Real

Challenge 3

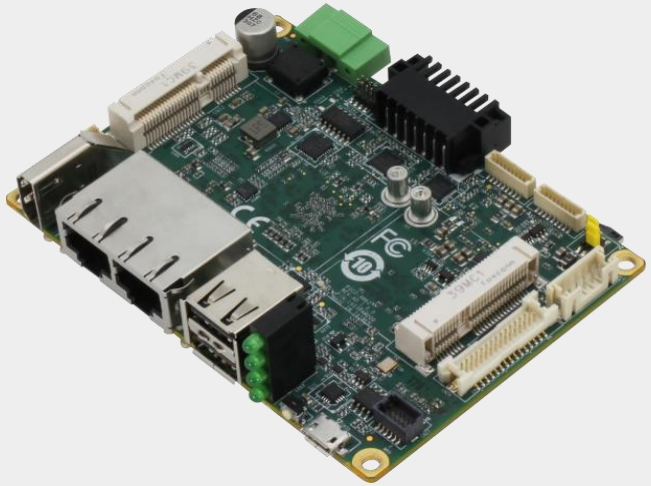
Design for Manufacturing

Design for Assembly, Not Just for Cost

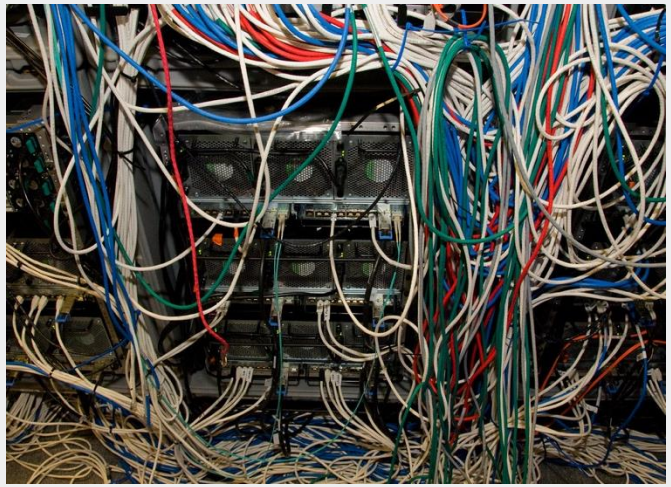
(Dis)Assembly Speed



Form, Fit, and Function

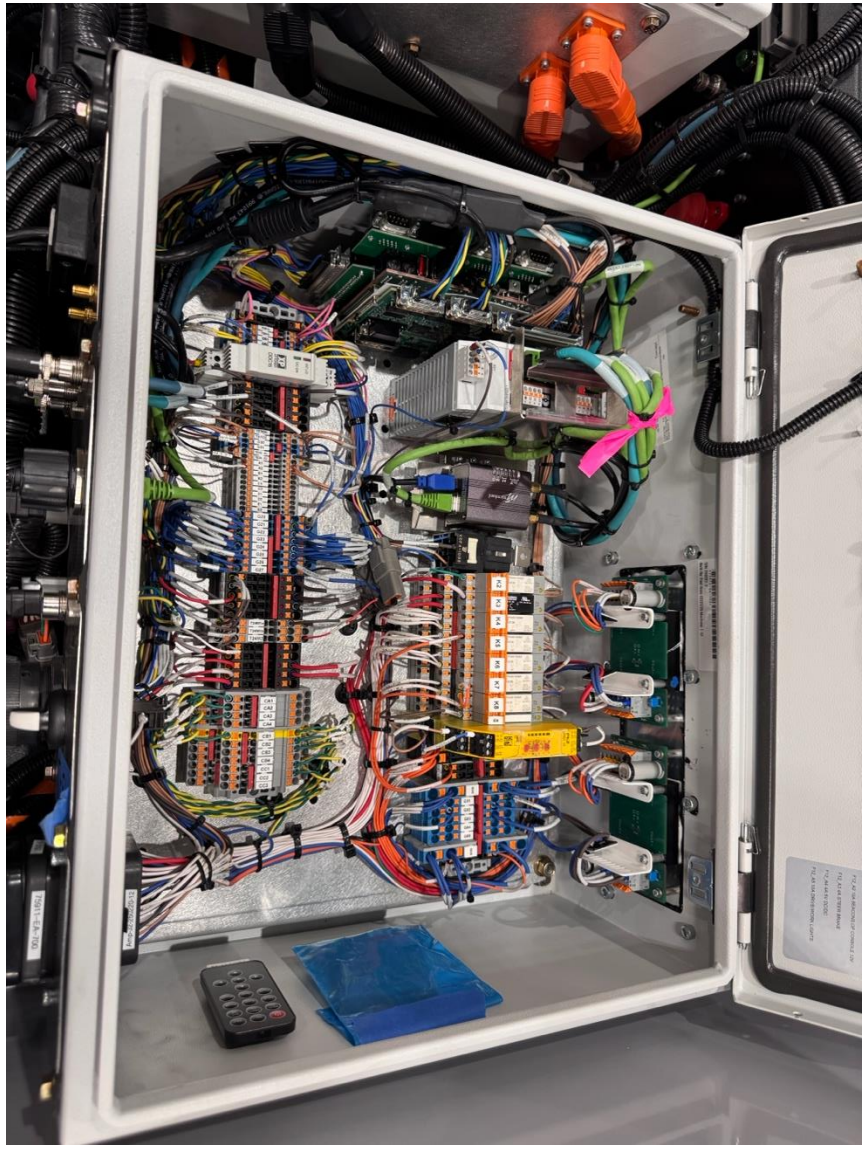


Cabling and Breakouts



Design Today for Tomorrow's Manufacturing

- Leave room
- Design for manufacturing
- Design for test
- Design for repair



Challenge 4

Overlooking market considerations

Design for Flexibility and Customer Feedback

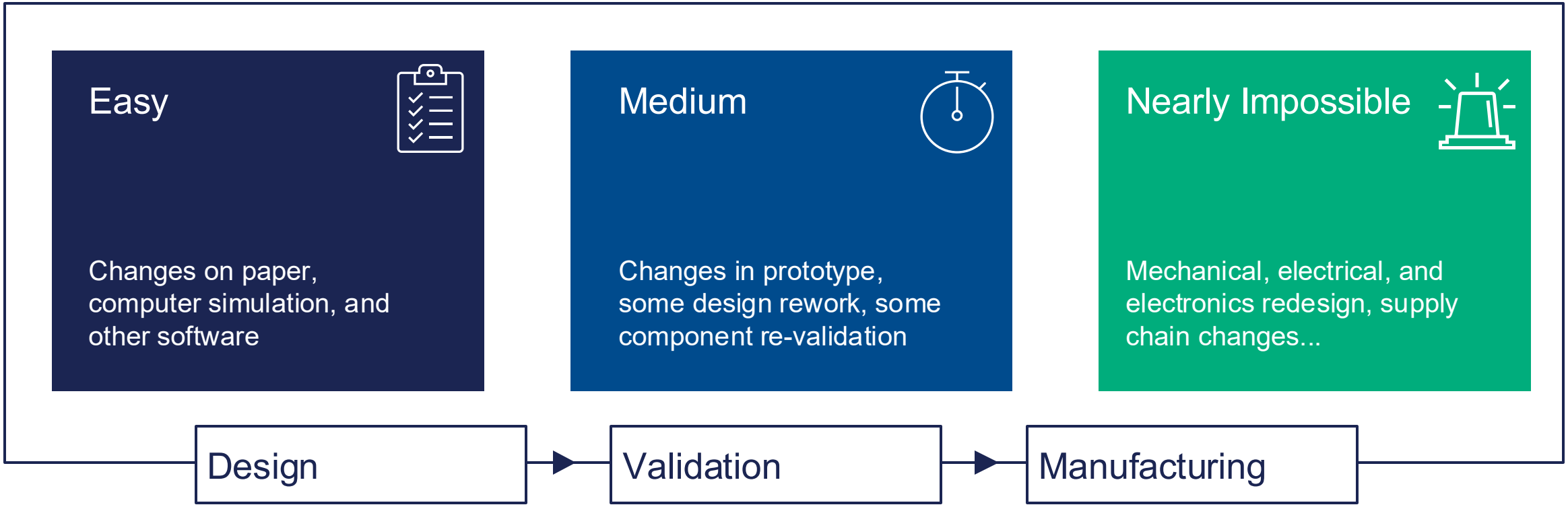
"No battle plan ever survives contact with the enemy."

Helmuth von Moltke the Elder

"no business plan survives the first contact with customers"

Steve Blank,
entrepreneur & author

Early Changes Are Easy, Late Changes Are Painful



Challenge 5

Personnel and project management

Don’t Hide Schedule Problems

Reward Schedule Honesty Above Accuracy

- Communicate early and often
- Build in time for documentation
- Have a project manager
- Be okay with raising the flag first
- Plan realistically for team availability

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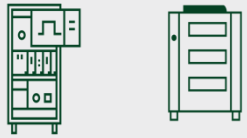
Optimize for Time-to-Market, With The Right Platform

Research — Design and Validation — Production — In-Use

SYSTEMS

Scalable, Modular, and Software-Centric Systems



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ECOSYSTEM AND COMMUNITY

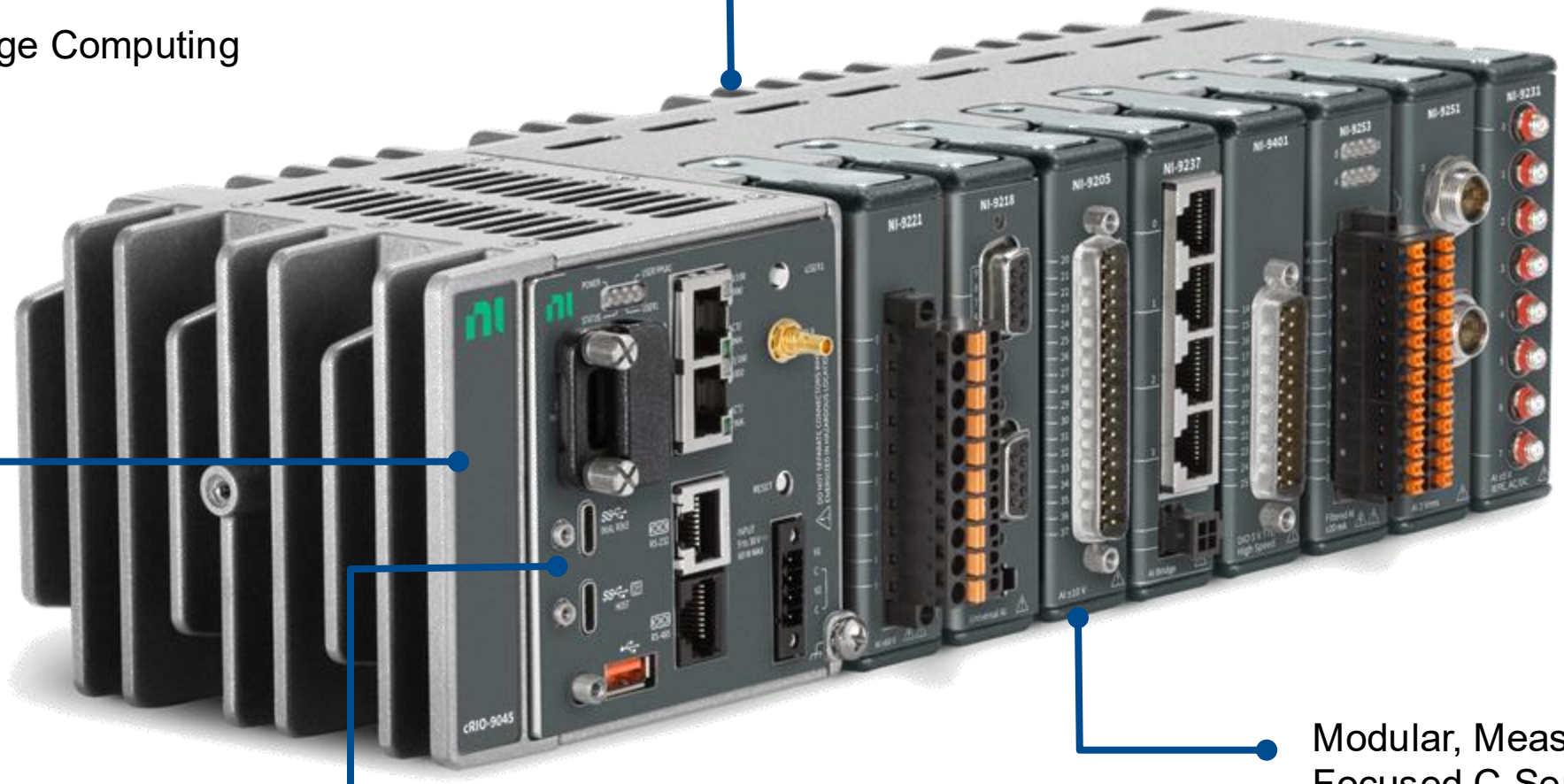
NI RIO Platform

To Maximize Flexibility and Get Your Product to Market Faster

The NI CompactRIO

Rugged Chassis Featuring
FPGA and ASIC Technology

Powerful Edge Computing



Modular, Measurement-
Focused C Series I/O Modules

Extensive Interface Options

NI CompactRIO Platform Features

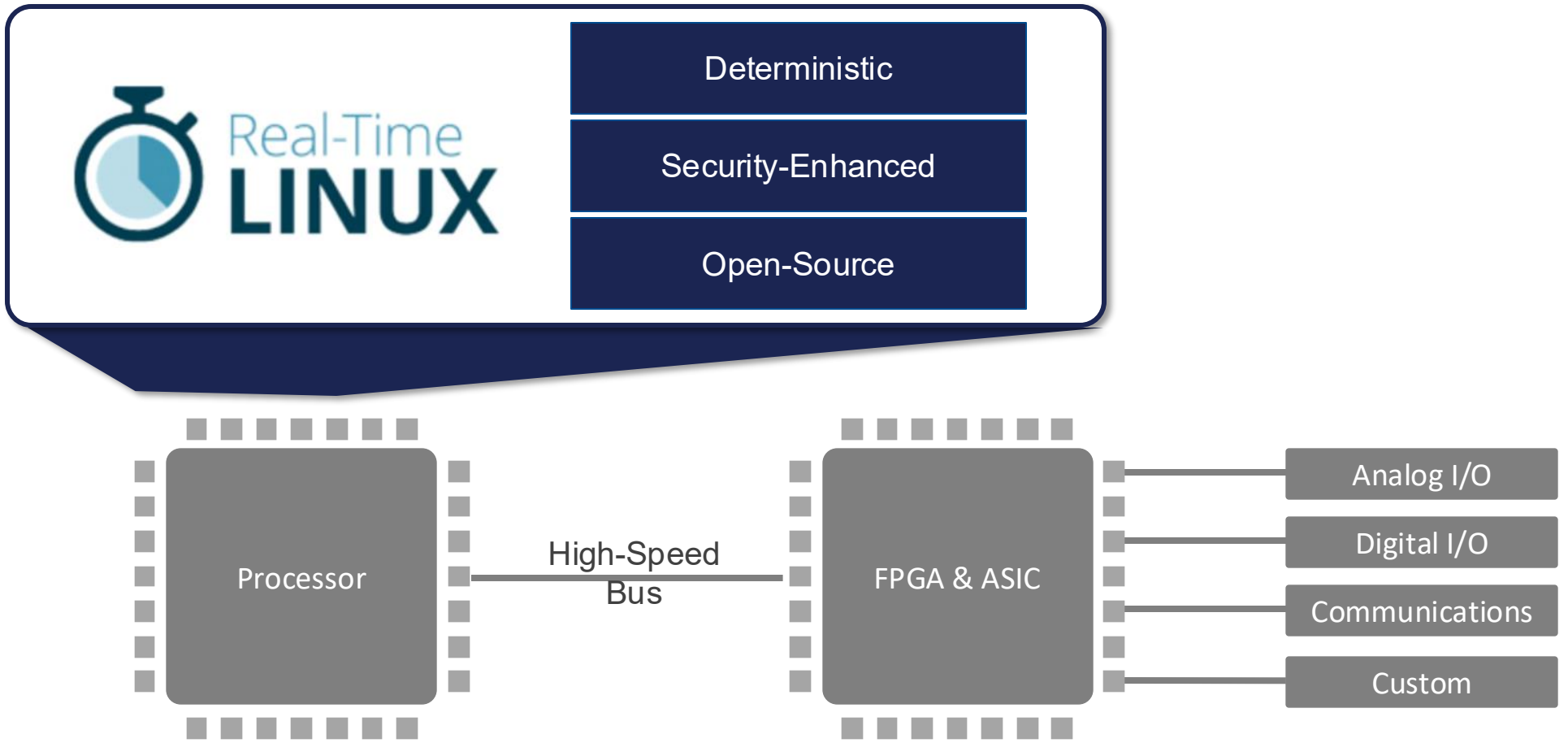
Performance and ruggedness

- NI Linux Real-Time OS on up to 1.91 GHz quad-core processors
- -40 °C to 70 °C operating temperature range
- 50 g shock and 5 g vibration operating range
- Conformal coating

I/O, programmability, and communication capabilities

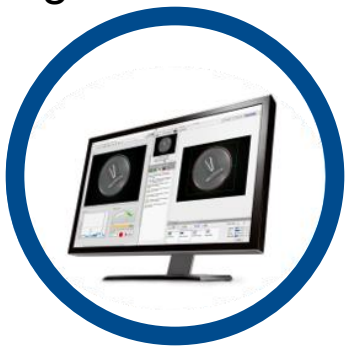
- LabVIEW-programmable Xilinx Kintex-7 FPGAs
- 200+ modules sensors, signals, and protocols
- Up to 16 GB of on-board SSD for data logging
- Display, USB, gigabit ethernet, RS232, and isolated RS485 Port

NI CompactRIO Real-Time Operating System



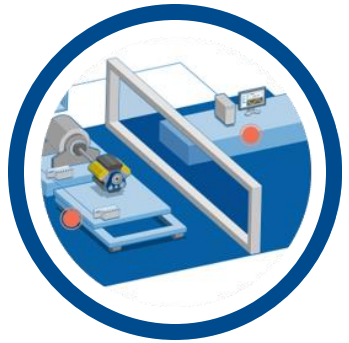
Key CompactRIO Platform Benefits for System Design

Reduced Development Time with Integrated Software



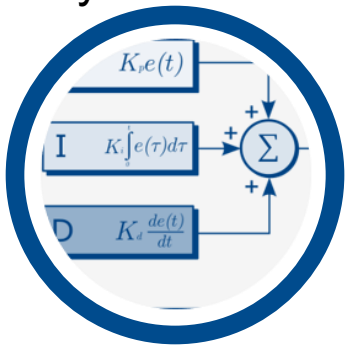
Make Effective Downstream Decisions with Trusted Data

Reduce Wiring Overhead with Time Sensitive Networking



Deploy Systems that Last With Rugged Hardware

Perform High Performance Analysis & Control



Leverage an Open & Secure Platform

Single-board RIO: Optimized for OEMs and Embedded Systems

Advantages:

- Smaller Size: Ideal for applications with limited physical space
- Cost-Effective: Lower price point compared to CompactRIO
- Integrated I/O: Includes digital I/O and a built-in multifunction I/O module

When to use sbRIO:

- Embedding device into products and larger systems
- Managing space or system footprint constraints
- Optimizing for cost as designs start being deployed

What can you do with CompactRIO?

Embedded Test and Monitoring

- Structural health monitoring with distributed, synchronized vibration and strain measurements
- Novel electrical power monitoring applications such as deploying algorithms for fault detection, equipment maintenance, and power quality.
- Industrial sensor measurements at the edge that need more speed, precision, processing, or synchronization than available from PLCs/PACs.
- Mobile or portable test systems that need quality measurements, logging, and processing in a rugged environment.
- Small-scale HIL

Control

- Engineer-designed, high-speed automation systems for high-cost assets deployed to fewer than 1,000 units.
  - Oil and gas applications
  - Off-highway ag equipment and Earth movers
- Rapid control prototyping
- Control test equipment and combine with data acquisition
  - Don’t add a PLC with ladder logic, use cRIO with LabVIEW.
  - Great for academic research

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Embedded Test Systems with Control

Safety Testing of London's Underground

Thales UK Tests London's Underground Rail Network with CompactRIO and LabVIEW

Thales UK revolutionized rail testing for the London Underground system by leveraging NI CompactRIO hardware and NI LabVIEW system design software. They automated rail testing using virtual test trains (VTTs), saving time and costs compared to traditional methods. The VTTs, powered by CompactRIO, mimic passenger trains and provide efficient, bidirectional testing.

High-Voltage Transient Root Cause Analysis

Siemens Uses CompactRIO, LabVIEW, and DIAdem to Determine the Root Cause of Damaging High-Voltage Transients

Siemens addressed recurring issues with light-rail transit vehicles by developing a rugged monitoring system using NI CompactRIO (cRIO) hardware and LabVIEW software. They identified voltage transients - missed by earlier equipment - as the root cause, significantly reducing costly failures and operating delays for their customer.

Railway Lab Test Benches

Creating Railway Laboratory Test Benches Based on NI LabVIEW, PXI, and CompactRIO

CETEST S.L. developed railway rolling stock integral laboratory solutions, focusing on conducting structural integrity and fatigue resistance tests. They used NI LabVIEW software and cRIO hardware to monitor critical parameters, ensuring safety, performance, and durability.

Structural Health Monitoring Case Studies

Monitoring the Xiamen Jimei Bridge in China (10 km)

Building a Large Bridge Structural Monitoring System Based on CompactRIO and LabVIEW

CCCC Highway Consultants used CompactRIO hardware and LabVIEW to create a distributed signal acquisition system for the Xiamen Jimei Bridge. This intelligent solution ensures safety and durability by monitoring various aspects, including load, wind, temperature, humidity, and structural dynamics.

Structural Academic Research (In the field)

Discovering the Dynamic Properties of Civil Structures with Wirelessly Synchronized, Highly Distributed Data Loggers

The University of Exeter's Vibration Engineering Section (VES) developed bespoke vibration data loggers. These loggers, using LabVIEW and CompactRIO, enabled sub-microsecond synchronization across large structures without long cables or RF transmissions. By measuring ambient vibrations of the Jiangyin Suspension Bridge in China, they estimated its modal properties and created a novel monitoring system for civil structures.

Structural Academic Research (In the classroom)

Using LabVIEW and CompactRIO to Continuously Monitor a Footbridge

Tufts University deployed a CompactRIO-based continuous monitoring system on the Dowling Hall Footbridge. The system collects eight acceleration channels and ten temperature channels. The university uses remote access to the system as a live lavatory for research and as a teaching tool for vibration analysis courses.

Questions?

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