Evolving System Integration Labs in the Age of Digital Transformation

A brief primer on Digital Transformation and its implications for test systems in SILs

Bill Eccles, Principal Engineer

Bloomy Controls, Inc.

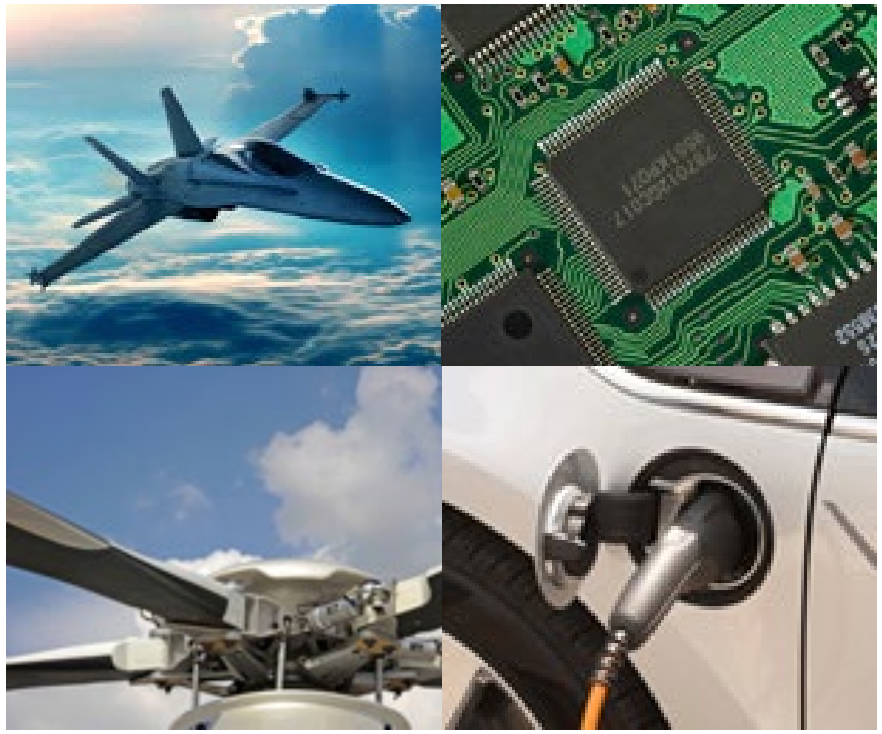
Overview

- Introductions
- A brief introduction to Digital Transformation
- Implications for Test Systems
- Adapting current test technologies for Digital Transformation
- A brief case study

Bloomy

A brief company overview

- Founded in 1992, currently ≈50 full-time employees
- Provide automated test systems and services
- Delivered 37 fully-integrated test systems and 240 Bloomy products in 2020
- Average ≈130 customers and ≈160 projects per year
- Product lines
  - Simulation systems (SIMS)
  - Electronics functional test (UTS Platform)
  - Battery test and simulation (BTS)
  - Custom turnkey automated test systems
  - Software consulting and training



Digital Transformation

What is it?

> “Digital transformation is the process of using digital technologies to create new—or modify existing—business processes, culture, and customer experiences to meet changing business and market requirements. This reimagining of business in the digital age is digital transformation.”
>
> salesforce.com

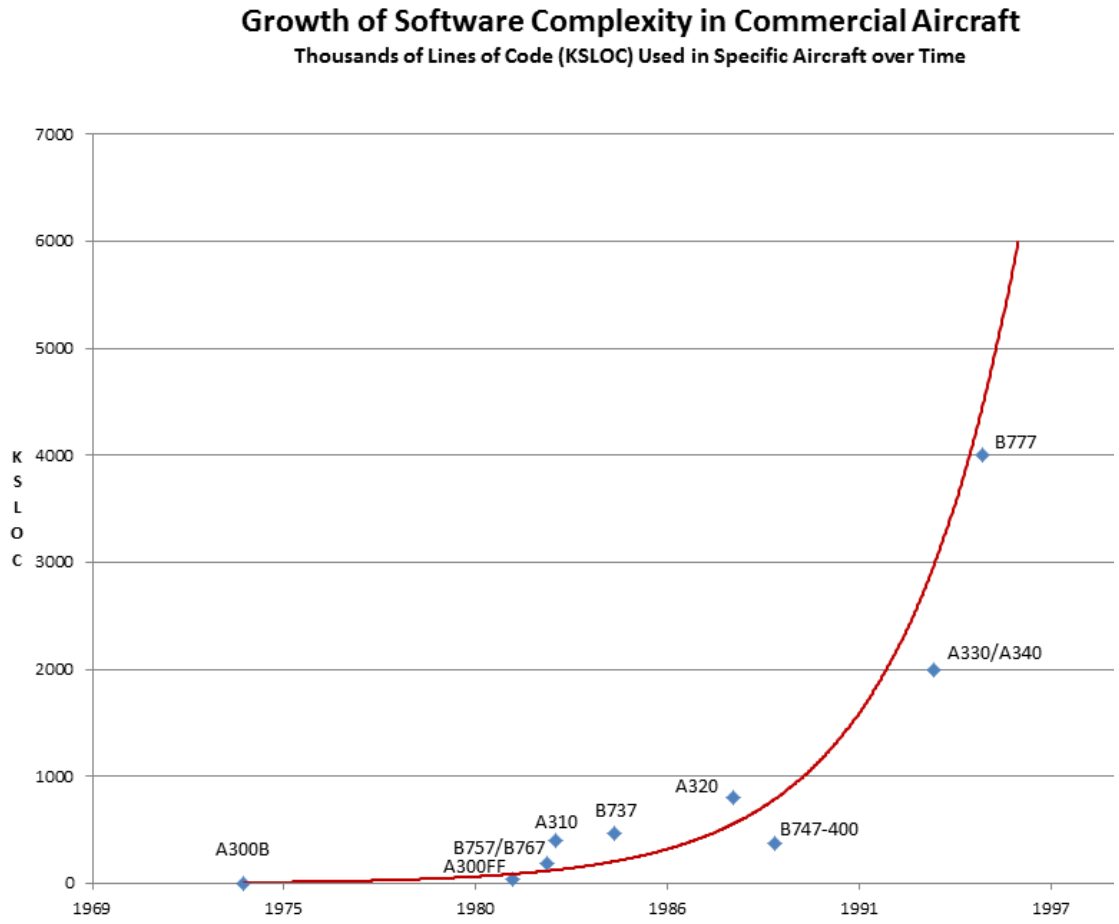
What it isn’t:

- a particular industry’s focus
- a particular technology
- a tool
- a buzzword
- a guarantee of success

Why Digital Transformation?

"...to meet changing business and market requirements..."

- What's changing?
  - Inherent product complexity increases
  - Industry 4.0: cyber-physical world (many-connectedness and self-adjusting networks)



> "Today more and more design problems are reaching insoluble levels of complexity.
> At the same time that problems increase in quantity, complexity and difficulty, they also change faster than before.
> Trial-and-error design is an admirable method. But it is just real-world trial and error which we are trying to replace by a symbolic method. Because trial and error is too expensive and too slow."

Christopher Alexander

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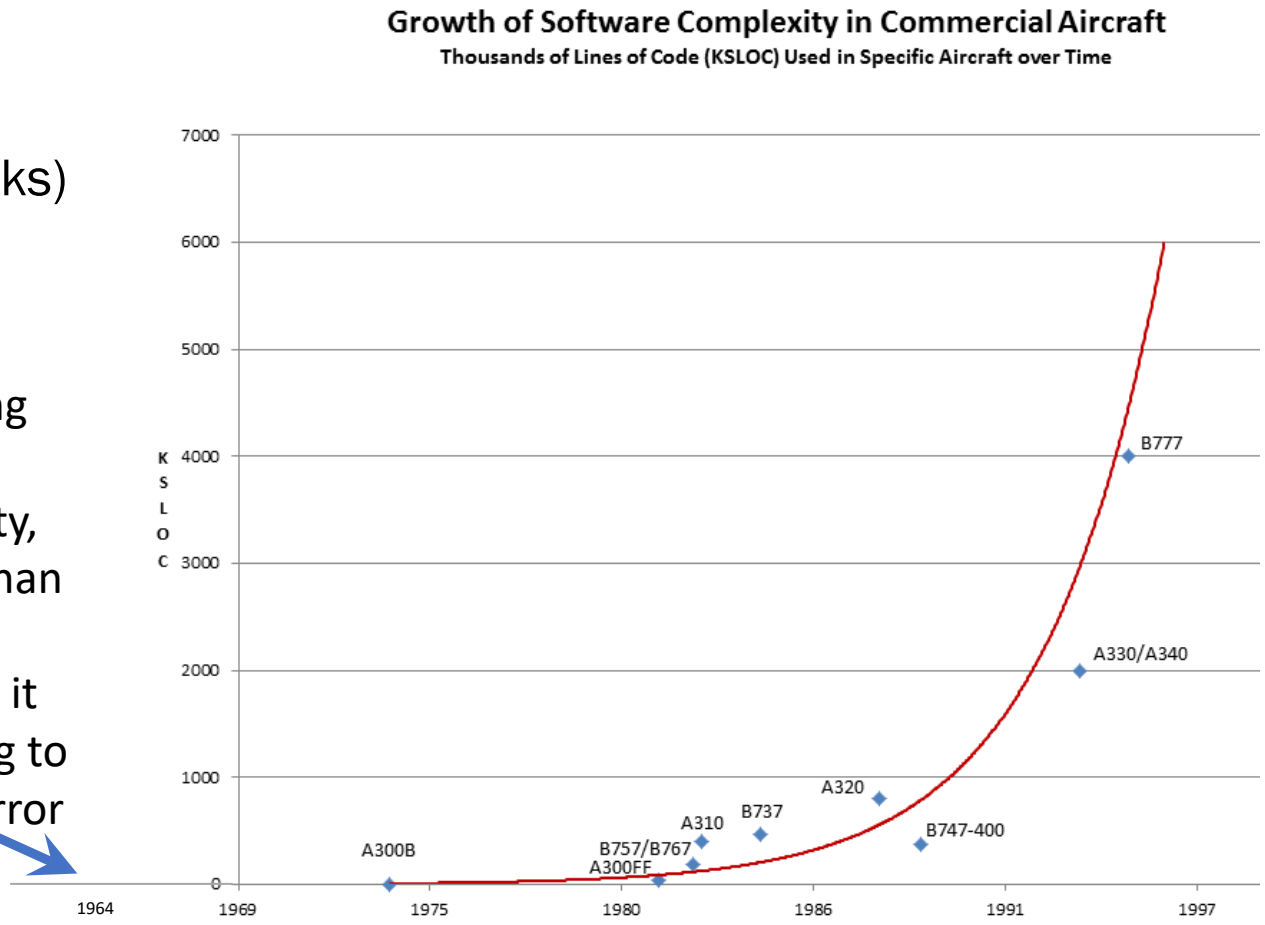
Christopher Alexander, *1964*



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Taming Complexity

Tools of Digital Transformation: Model-Based Systems Engineering

> “Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.”
>
> INCOSE (international council on systems engineering)

In *practice*, MBSE:

- is a replacement document-centric engineering (who’s got what, where, and how?)
- provides a *sole source of authoritative truth* for all information about a system
- uses a formal, *machine-parsable* language for keeping these data in the repository (SysML)
- may require a specialized tool, from free to five-figure prices.

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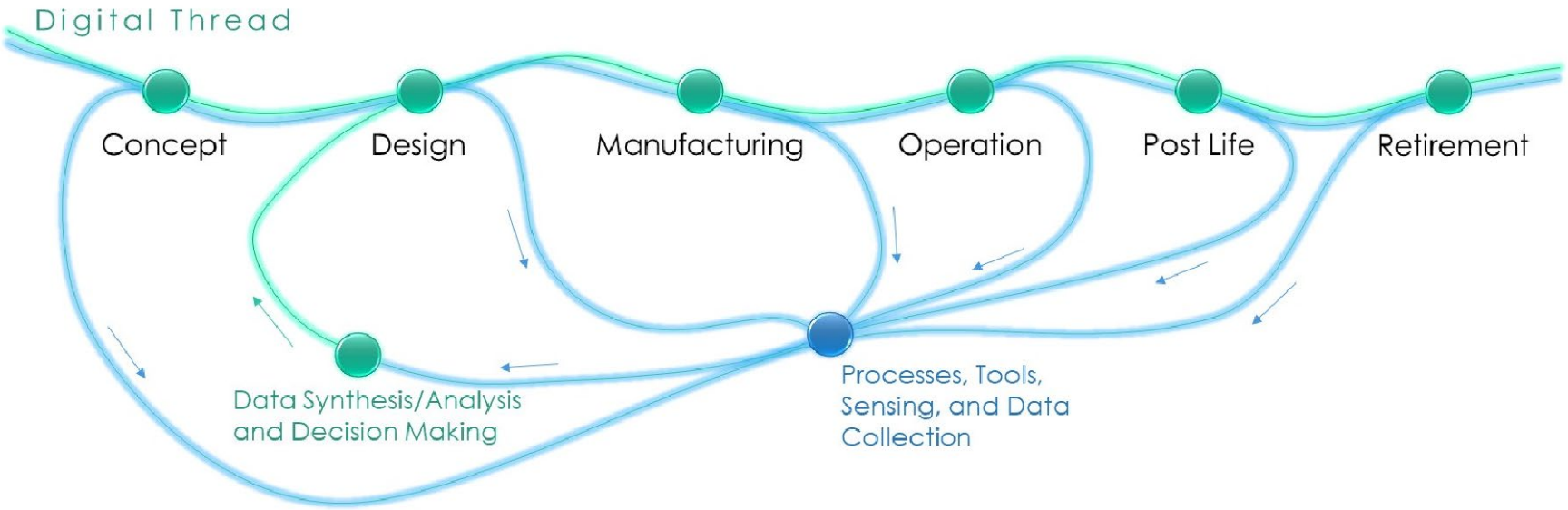
In *application*, MBSE allows:

- automated design of:
  - the system
  - test equipment and tests
- feedback of test results, customer feedback, actual costs, etc., to fine tune the model, improve the system
- artificial intelligence and algorithms to generate test vectors for best coverage of complex systems and analysis of results

Enabling Agility

Tools of Digital Transformation: the Digital Thread

> “…the physical piece is the result of an unbroken data link that stretches back to the original computer model of the part; the *unbroken data path* was the digital thread.”
>
> US Air Force, Global Horizons Final Report



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Enabling Agility

Tools of Digital Transformation: the Digital Twin

> “The ‘digital surrogate’ is a ‘physics-based technical description of the weapon system resulting from the generation, management and application of data, models and information from authoritative sources across the system’s lifecycle.’”
>
> US Air Force, Global Horizons Final Report

In summary:

- …is the data associated with a particular instance of the system (part number and serial number).
- …provides the ability to do trend analysis to react quickly to performance and customer satisfaction.

Characteristics of Well-Heeled Test Systems

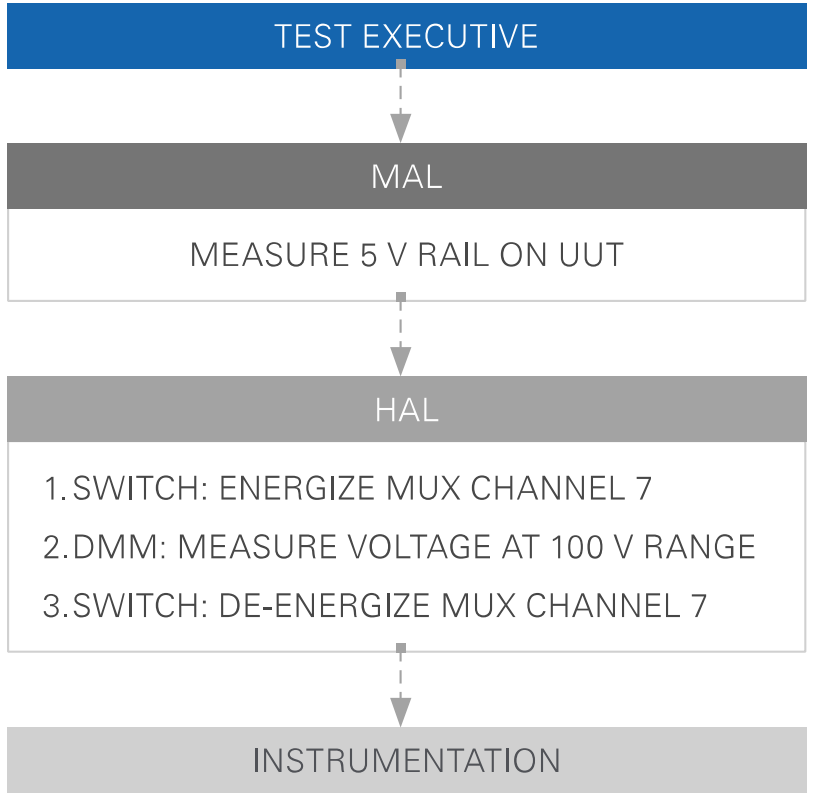
A distillation for digital-transformation-enabled test systems

1. The test system design must be able to be traceably derived and controlled directly from the digital thread.
2. The test system must be able to interact with the system model from the model and digital thread. The resulting tests must be traceable to an underlying requirement.
3. Changes to the model and/or digital thread must drive changes to the test system's hardware and software at acceptable cost of implementation.
4. Corollary: the underlying mechanisms of the hardware and software implementation should be agile and flexible in nature, easily changed quickly.
5. Data generated by test systems must be returned to the digital thread and/or digital twin and must be compatible with analysis tools which may be used to improve the system/product.
6. None of these requirements are dependent on any other, and any level of implementation of these requirements should yield an improvement to the product lifecycle.

Adapting to a Digitally-Transformed World

Using Bloomy's EFT Module for Test Stand for Software Agility, MBSE

- Provides multiple levels of abstraction
- Hardware Abstraction Layer (HAL)
  - Lowest level of abstraction
  - Decouples software from hardware implementation
  - Enables some agility to adapt to hardware changes
  - Cannot be used with MBSE without modelling test system
  - Most common form of abstraction
- Measurement Abstraction Layer (MAL)
  - Higher level of abstraction
  - Completely decouples measurement from underlying system
  - Allows agility to adapt to test system changes
  - Can be used with MBSE, digital thread
  - Not observed at our customers



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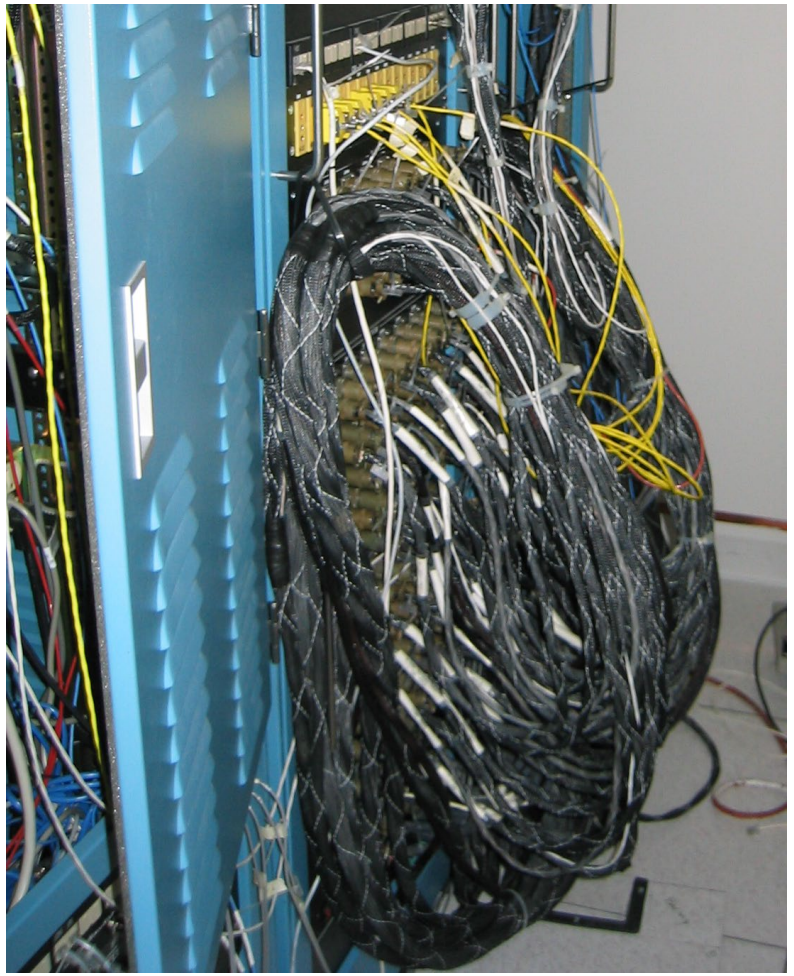
Adapting to a Digitally-Transformed World

Using Bloomy's Reference Architecture for Hardware Agility

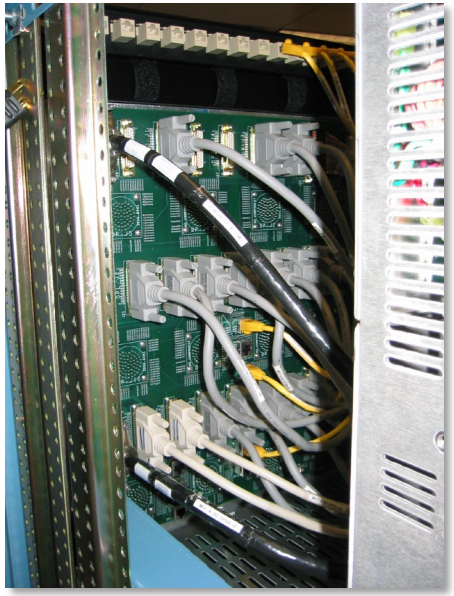
- Validation Test
  - Often last to get funded, sometimes forgotten
  - Needs to be able to be built in advance
  - Or quickly
  - Or both
- System builds of 80s and 90s
  - Built at wire level
  - Considerable labor for design and build
  - Prone to errors
  - With patience, somewhat agile
  - Large changes possible, but frustrating



Adapting to a Digitally-Transformed World

Using Bloomy's Reference Architecture for Hardware Agility

- Turn-of-the-Millennium Technology
  - Replaces wires with cables and printed circuit boards
  - More labor required for design
  - High cost of errors
  - More expensive "routing" component
  - Less expensive build
  - Excellent for multiple, identical systems
  - Minimally agile, large changes impractical



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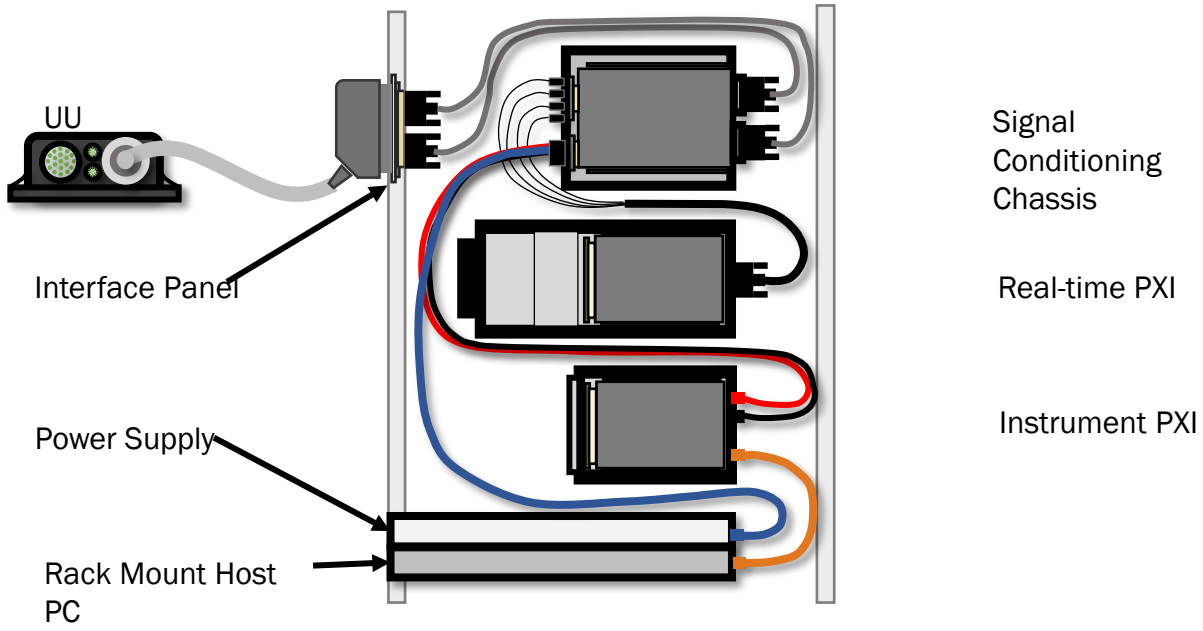
Adapting to a Digitally-Transformed World

Using Bloomy's Reference Architecture for Hardware Agility

- Current Technology
  - Replaces wires with COTS cables
  - Uses PXI and signal conditioning chassis
  - Designed by spreadsheet or algorithm
  - Fast build, simple checkout
  - Highly reconfigurable and agile
  - Embodied in Bloomy Simulation Reference System



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A Brief Case Study

Showing that a little investment goes a long way

- Platform:
  - Vertical lift, about 59 years old
  - Various control systems in a multi-system SIL
- Technologies employed:
  - NI PXI, SLSC, VeriStand, TestStand and Requirements Gateway
  - IBM Rational DOORS
  - Bloomy's HAL/MAL (EFT), numerous device drivers, and other integration hardware and software
- Benefits
  - Tied requirements directly to tests and test results
  - Reduced test time by 30%

Contact Bloomy

Learn more!

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Sources

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