Engine Test Technologies and Approaches

May 2022

NI Connect, Austin Texas

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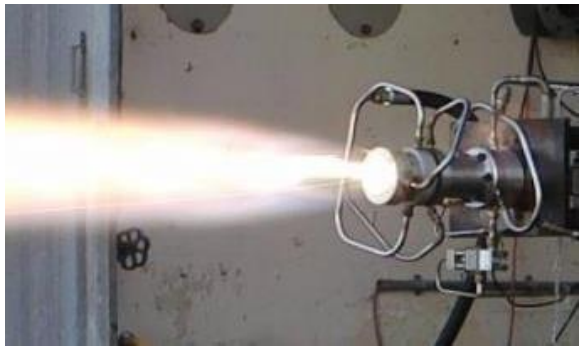
Mechanical Systems & Structural Test

Static structural test

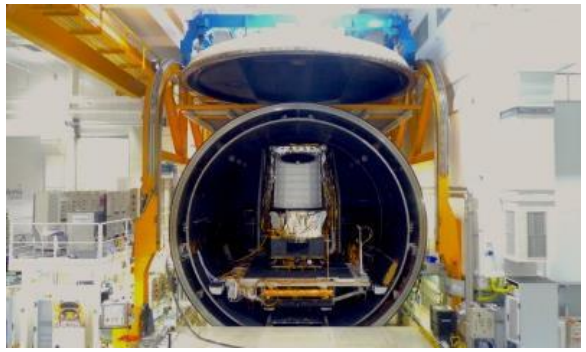
Engine test

Gearbox Test



Propulsion Test

Condition monitoring



Thermal/vacuum control

Dynamic test

Actuation test

Acoustic test

Flight test

Wind tunnel control

Security

Two types of “engine” test

Rocket Engine Test

Turbine Engine Test

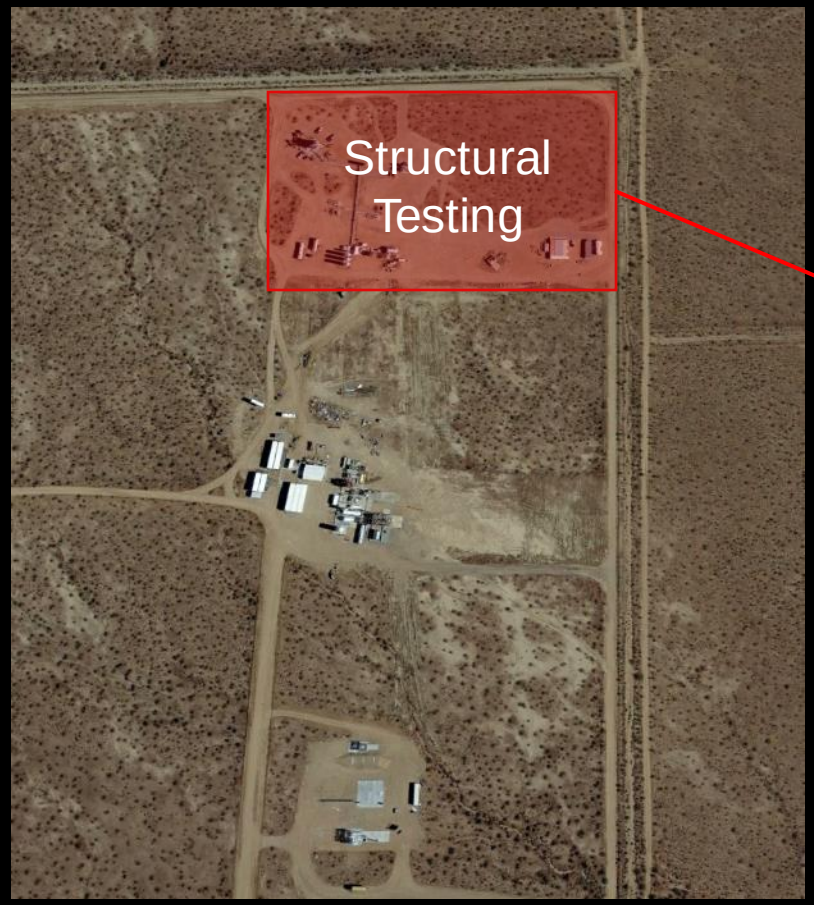
A Virgin Approach to Rocket Engine Test

Zach Collins – Senior Principal Data Systems Engineer

1. Virgin Orbit
2. The Necker Test Site
3. Challenges
4. Key Principles
5. Examples

The Necker Test Site

Mojave Air and Space Port, California



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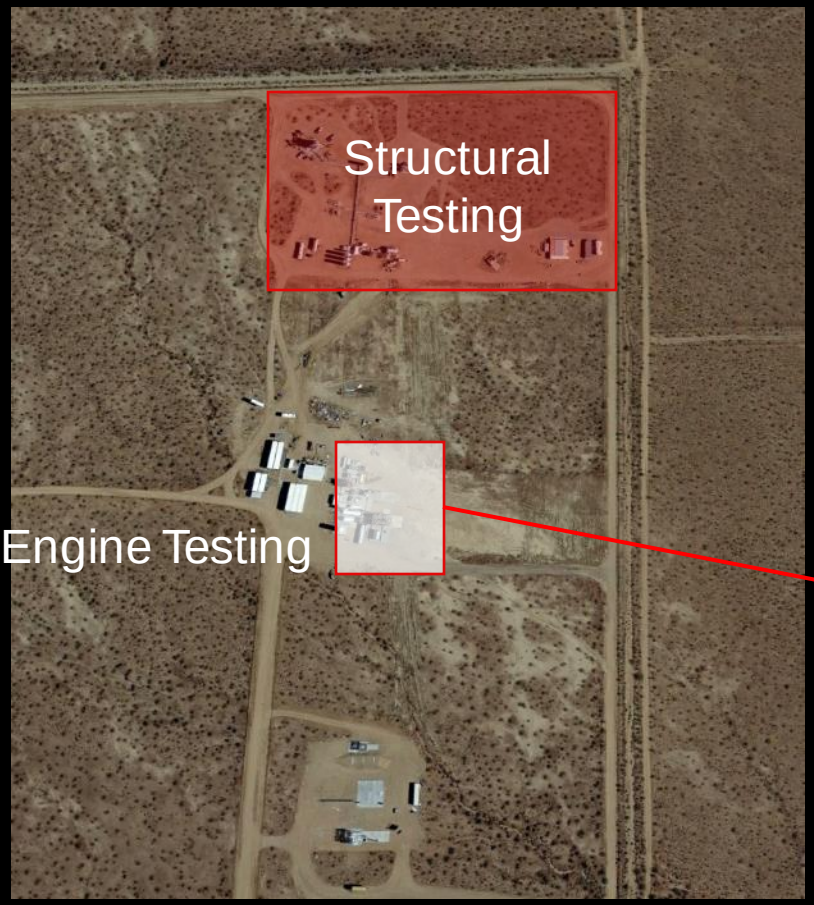
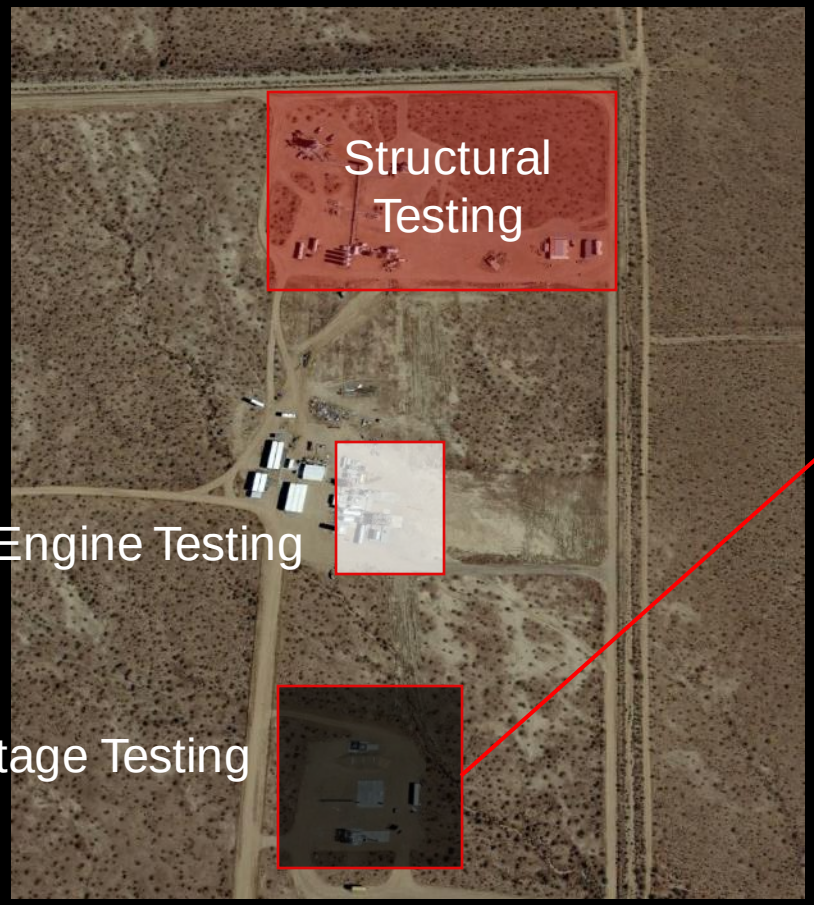


Mojave Air and Space Port, California

The Necker Test Site

Mojave Air and Space Port, California



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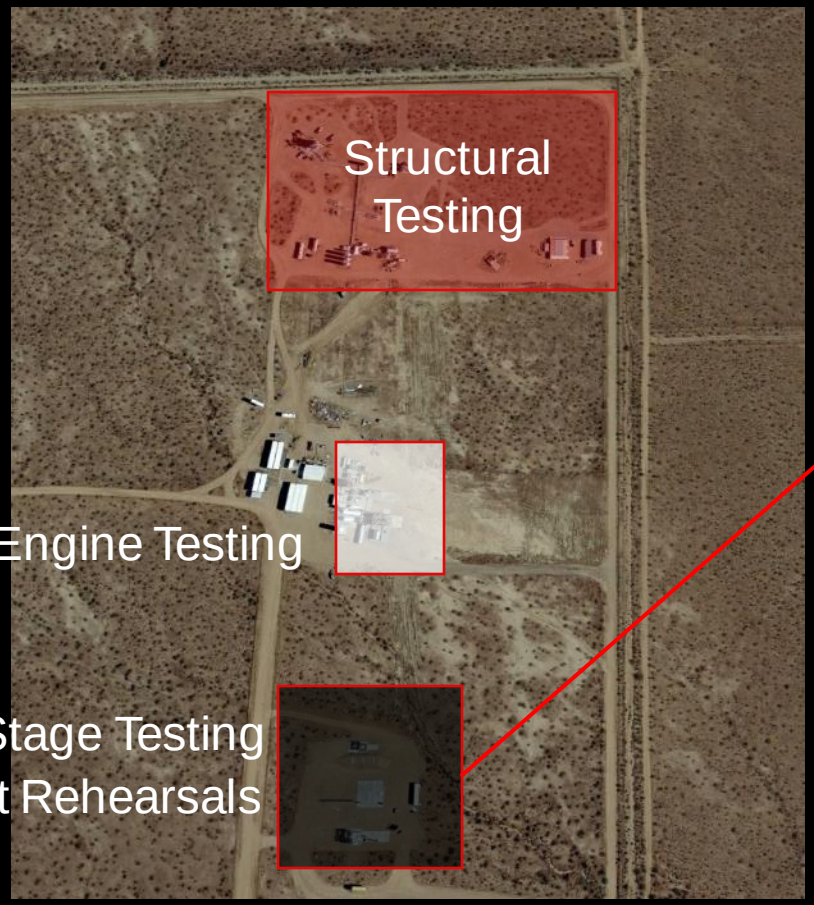


Mojave Air and Space Port, California

Challenges

- High Desert Environment
- Shifting Requirements
- Modularity for Replication
- What do we do with all that data?

Key Principles for Transformation

Standardized parts for common tasks

Design with expansion and reuse in mind

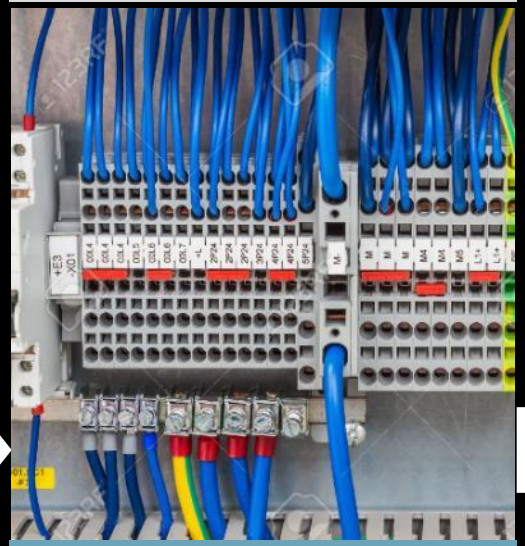
Build in ways to troubleshoot and test

Interfaces to DAQ/Control Hardware

Barrier Blocks

- Lowest “barrier” to entry
- Low hardware cost
- Ubiquitous
- Labor intensive
- One conductor per mate provides flexibility at the cost of reliability.
- Configuration management is nearly impossible

DIN Rail Terminal Blocks

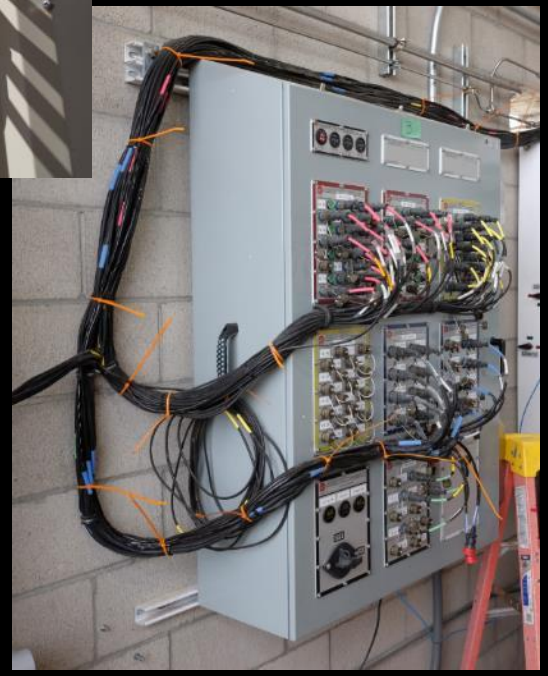


- Increased density over barrier blocks
- Faster to assemble
- Added integrated capability (bus bridges, diodes, indicators, fuses, etc…)
- One conductor per mate provides flexibility at the cost of reliability.
- Configuration management is nearly impossible

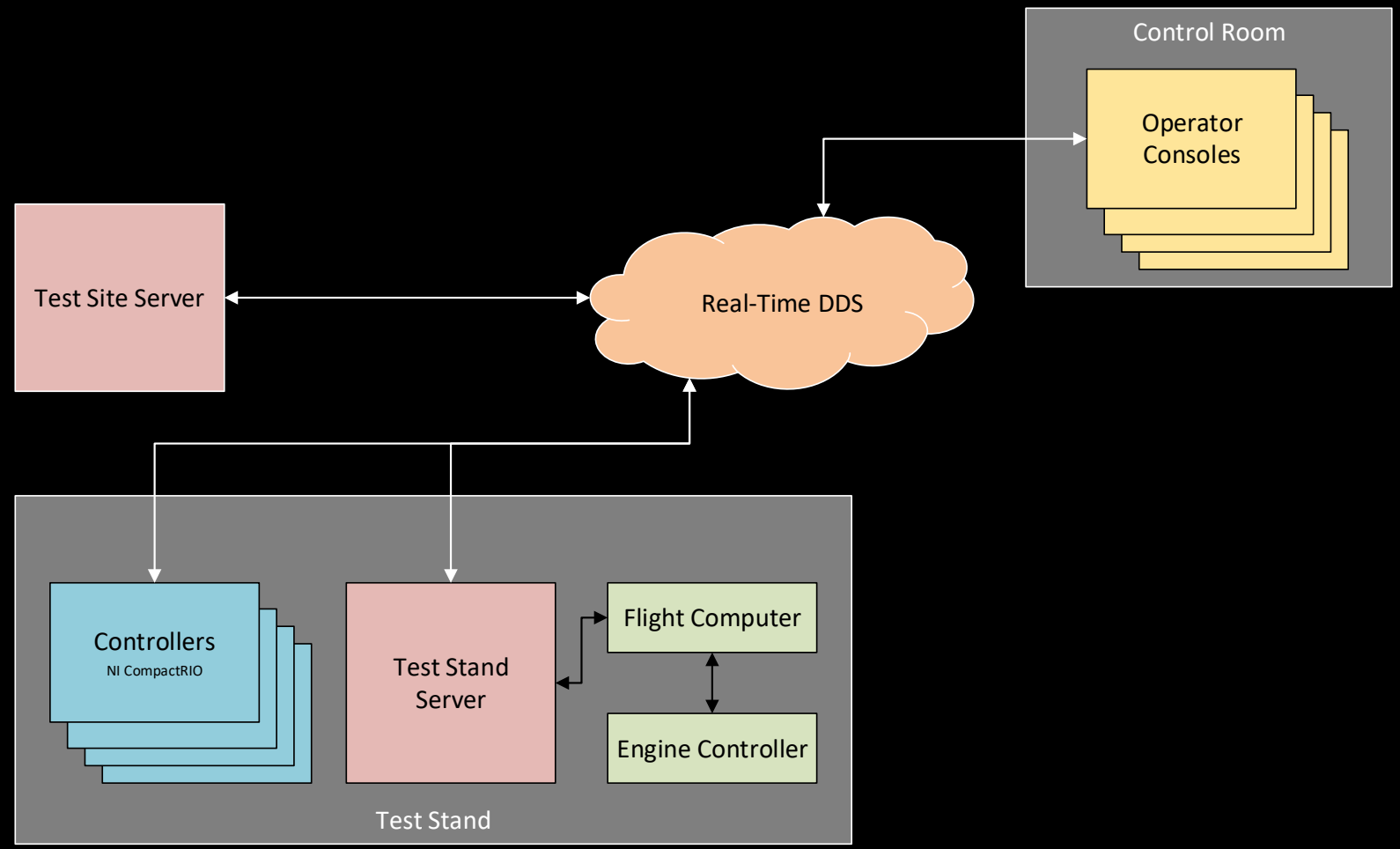
PCBs

- High barrier to entry (need a PCB designer, software license) + lots of NRE
- Mass Producible
- Highest I/O Density
- Add any integrated features needed (fuses, current monitoring, BIT, etc…)
- Multiple conductors per mate provides higher reliability with less flexibility.

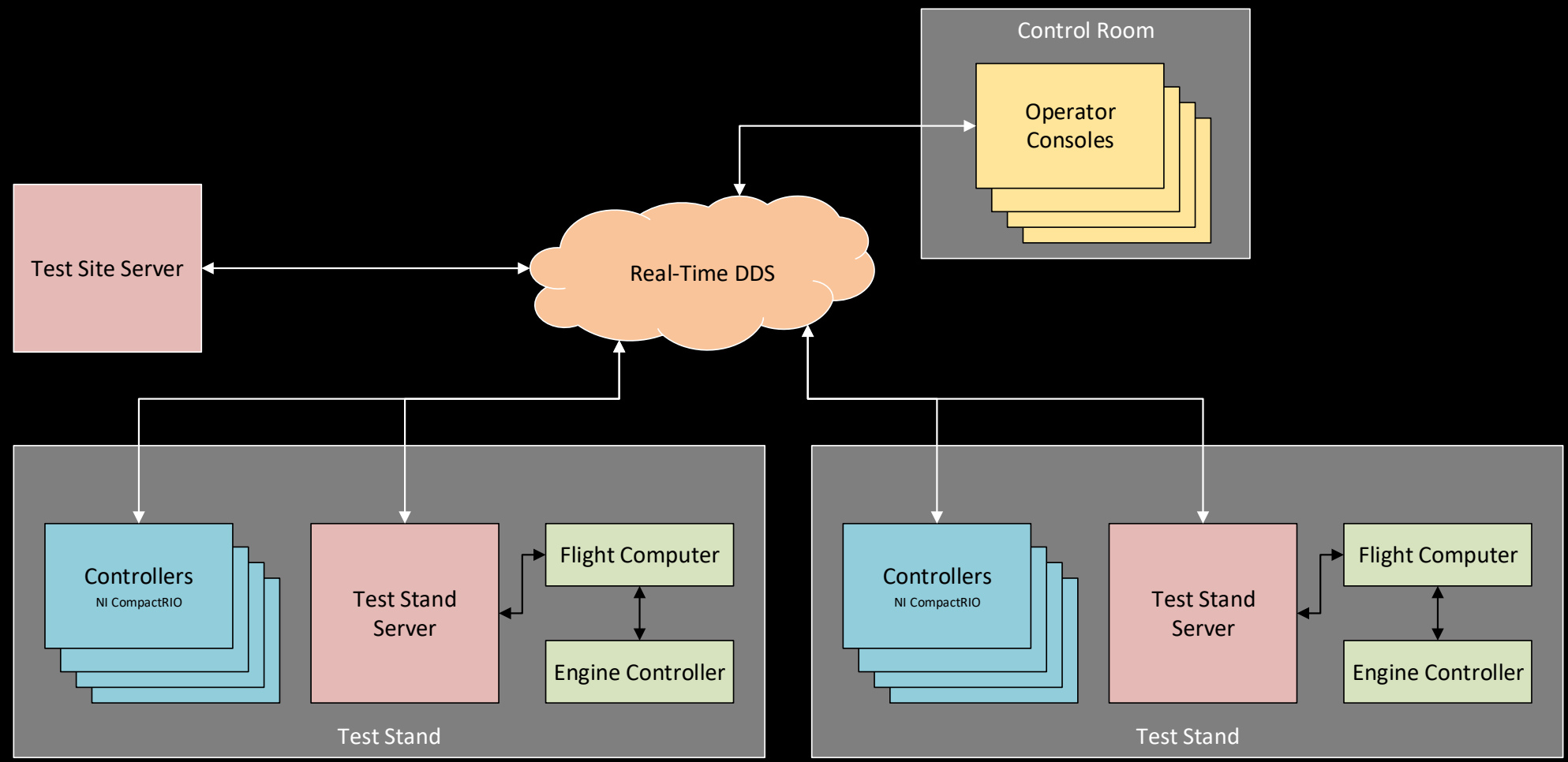
Harness Routing to Controllers



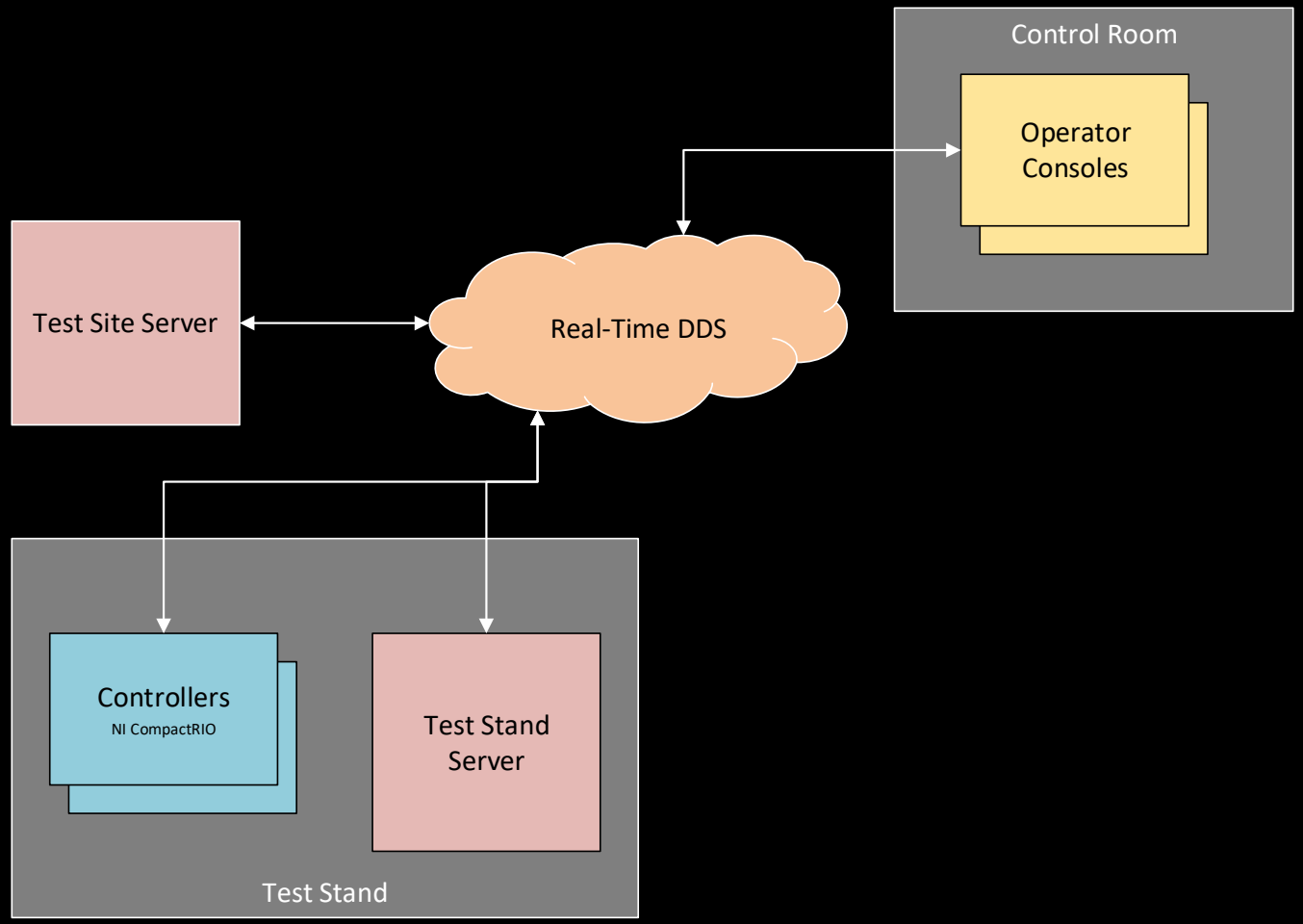
Modular Software Architecture



Modular Software Architecture



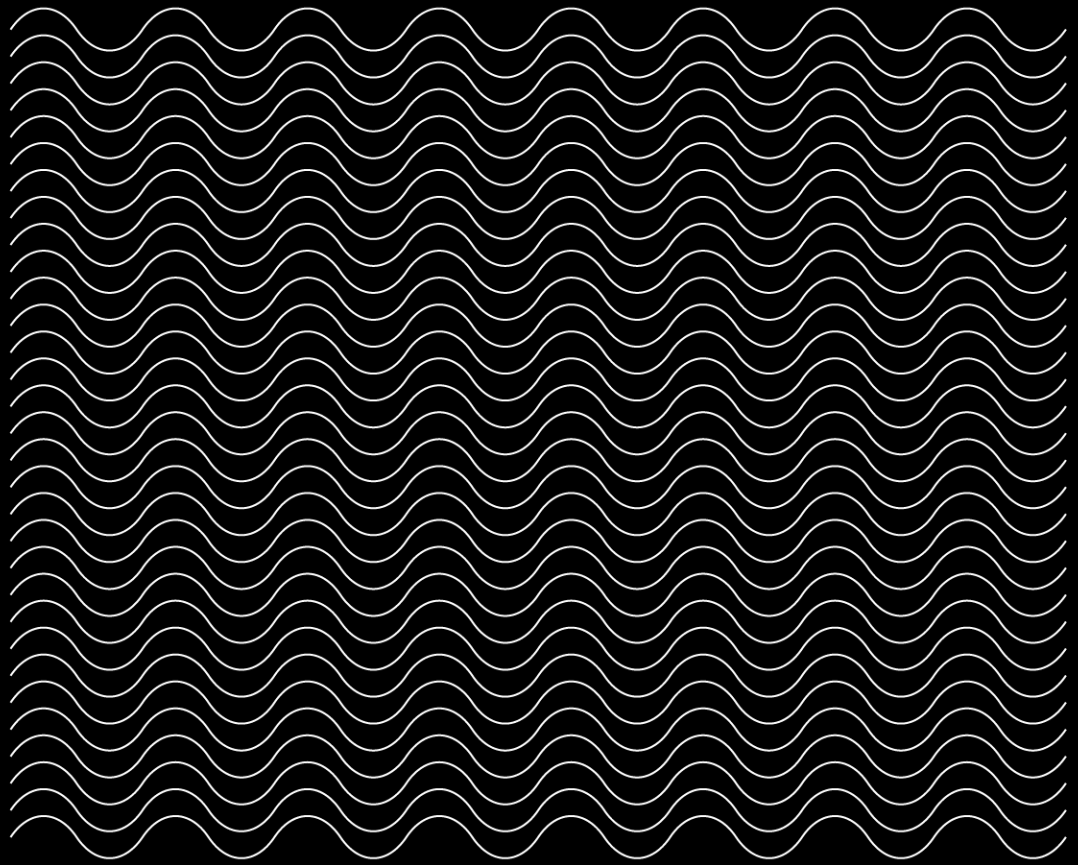
Modular Software Architecture



- Combine elements of architecture without worrying about the interface
- DDS allows for distribution & abstraction

- Reuse for Structural Testing
- Reuse for Components Testing

- Built-in Automated Health Diagnostics
- Built-in Automated Checkouts
- Built-in Safety Monitoring



Introduction to Rolls-Royce Engine Test

For NI Connect

Gethyn Longworth, Technical Project Manager (Experimental Test)

25th May 2022

About Me

#NoFilter… Avert your eyes!

- Joined RR in 2013
- Worked on:
  - TEDS Real-Time Systems
  - Large Power Gearbox Facility
  - Test Bed 80
  - Other Test Facilities related projects

Currently:

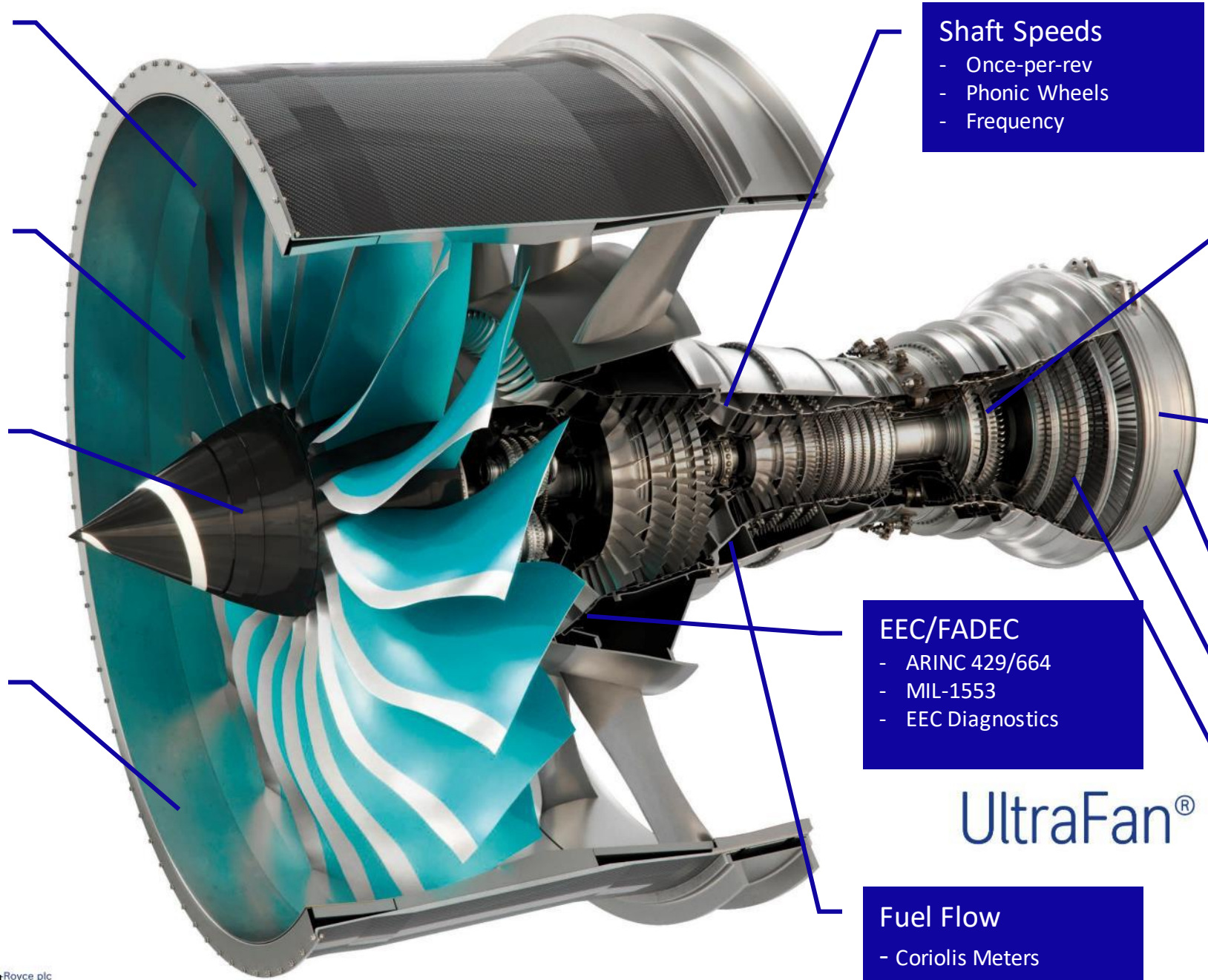
- Technical Project Manager working for the Global Chief of Test Facilities
- Responsible for Facility Real-Time Systems strategy

Fan
- Vibration
- Alignment / Flutter
- Timing
- High-Speed Photography

CCTV
- Video
- Vibration Cameras
- Thermal Cameras

Rotating Telemetry
- Bearing noise / vibration
- Core Temperatures
- Shaft Strains

Pressures
- Static / Dynamic Gas Pressures
- Liquid / Gas Transducers



Shaft Speeds
- Once-per-rev
- Phonic Wheels
- Frequency

Temperatures
- Thermocouples
- PRTs / RTDs

Thrust
- Load Cells
- Non-Contact Thrust

EEC/FADEC
- ARINC 429/664
- MIL-1553
- EEC Diagnostics

Emissions

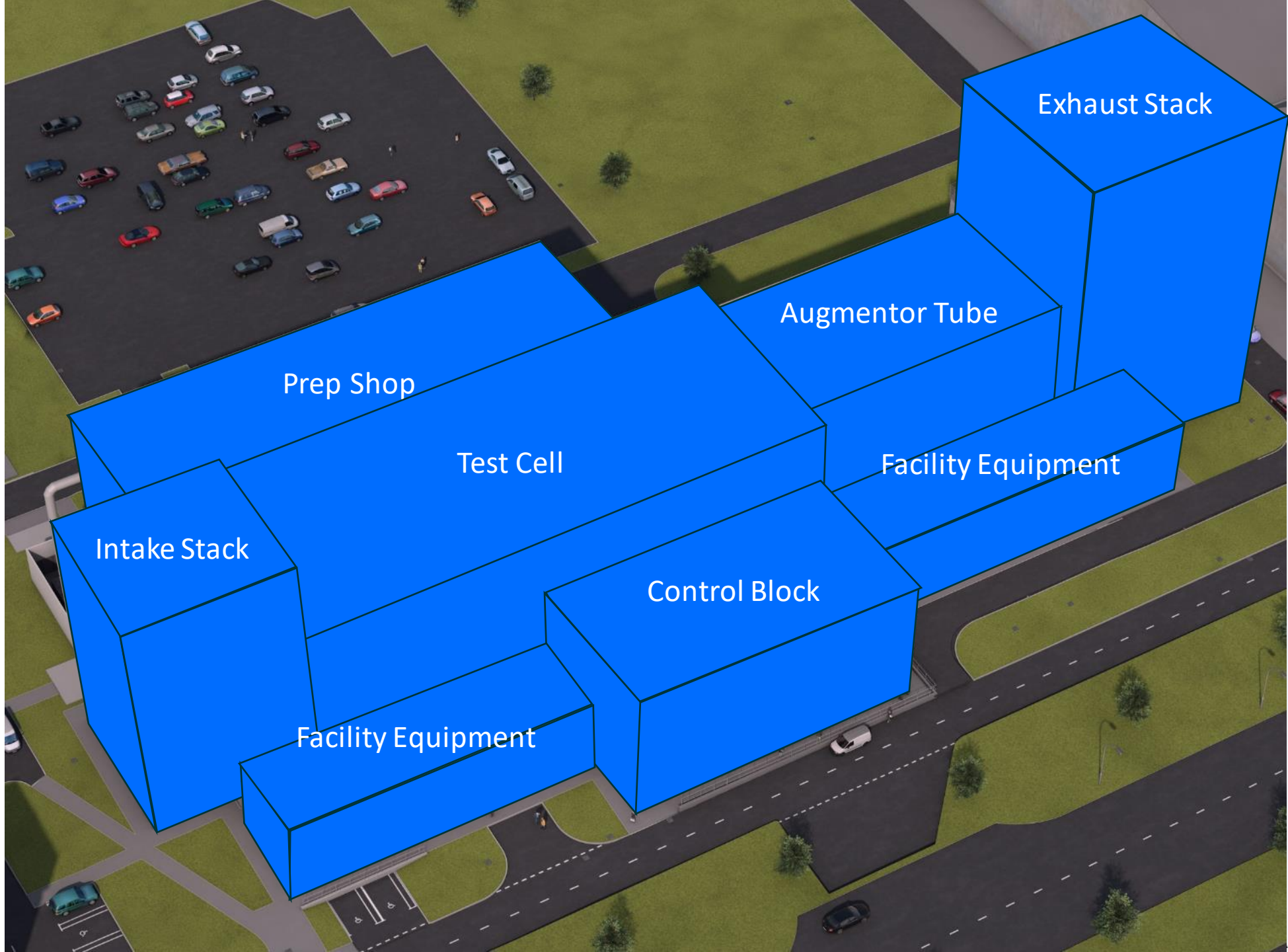
X-Ray

Noise

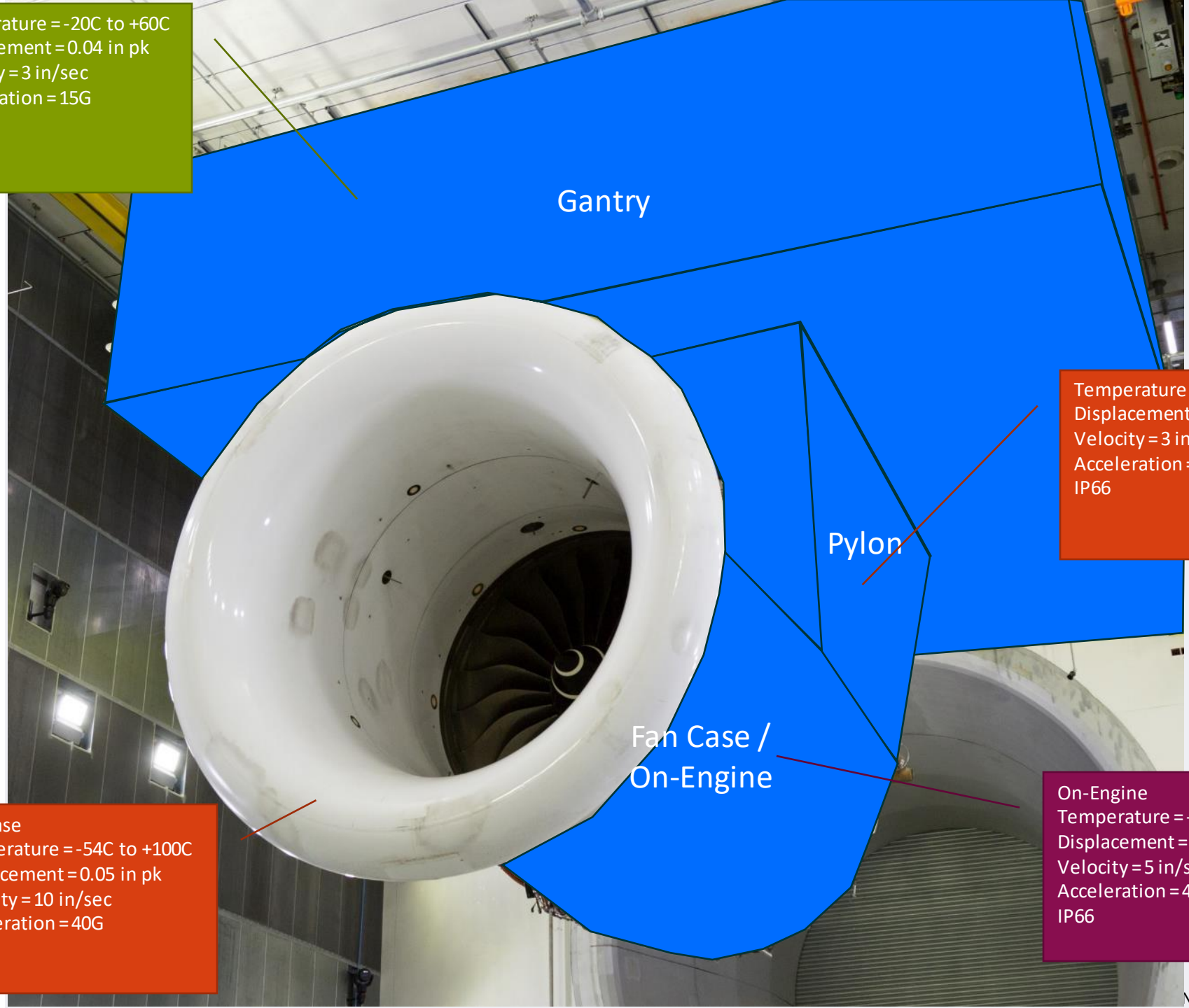
Fuel Flow
- Coriolis Meters

UltraFan®

Anatomy of a Test Facility



Test Cell Measurement Locations



Challenges

Acquire Signals Closer to the Measurement

Reduces cable/pipe lengths = better measurement, lower latencies

Timestamp at Source

More accurate acquisition time

New Architectures / Technologies, More Complex

Measurement Technologies advancing

Introduce new technologies quickly and cost effectively

Challenges

Increased Engine Throughput

Need to reduce time in the facility with no running. Flexible for both Dev and Prod.

Cost of Fuel

Maximise value of test – more experiments on each engine

Facility Uptime

Adaptive maintenance schedules

Increase Value from Data

More measurements = longer analysis times

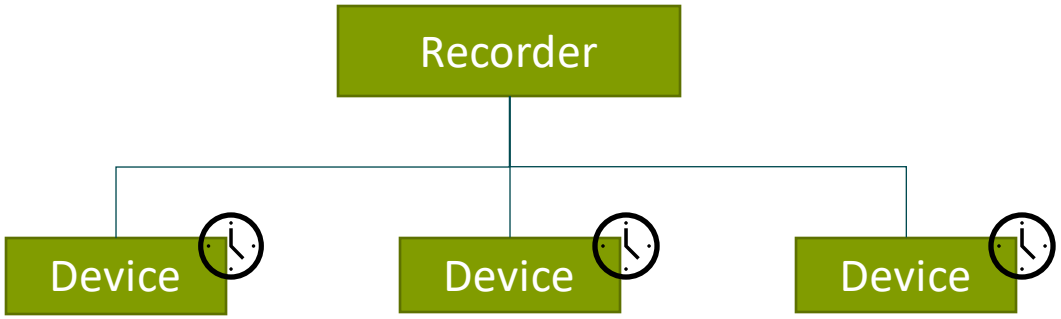
Solutions – New Measurement Technologies

Use Ruggedised Acquisition Equipment

Measurements on Gantry, Pylon and Engine rather than server room

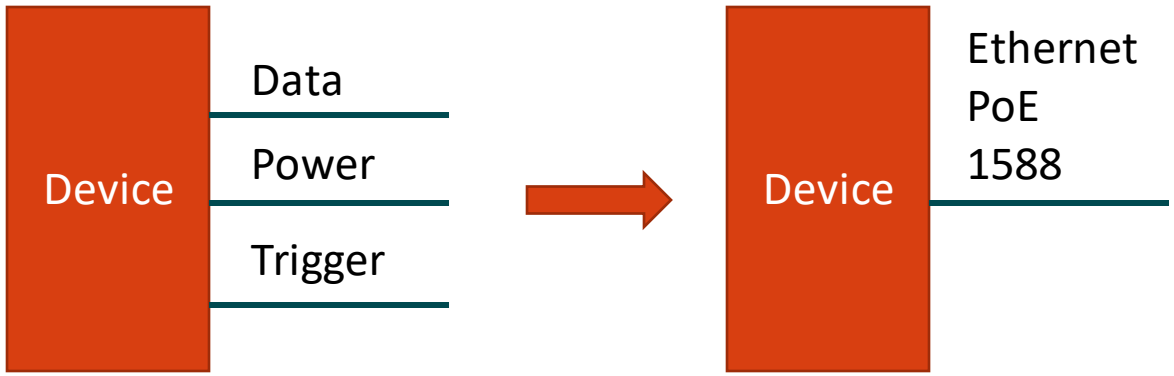
Use IEEE-1588 for Time Synchronization

Target 1% of sample period

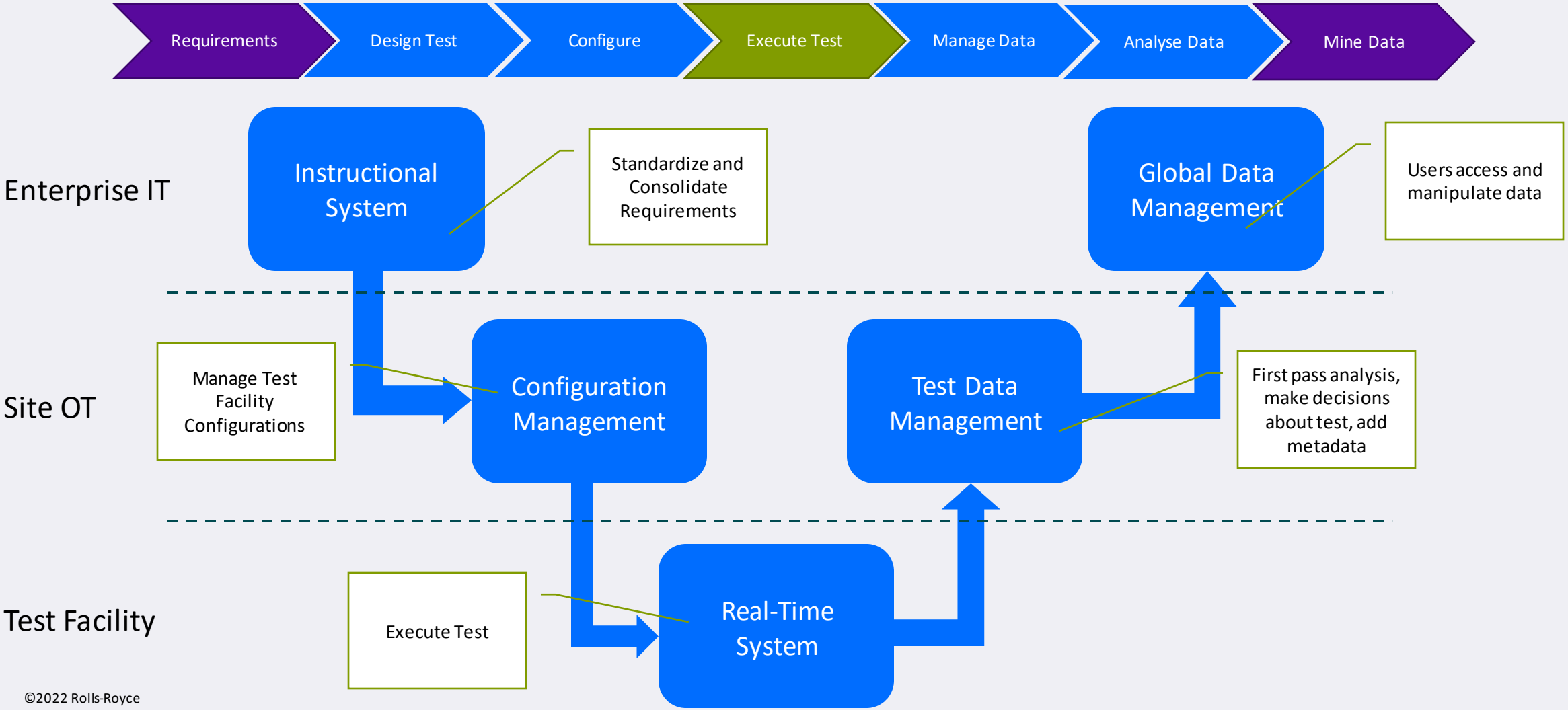


Use Power-over-Ethernet for Acquisition Equipment

Single-wire connectivity



Solutions – Planning and Enterprise Integration



Solutions - Standardization

What is iDDS?

Instrument Data Distribution System

Open Standard

iDDS is an open standard for the communication of measurement devices and systems

New RR Test Bed Standard

iDDS is the new standard for Devices and Systems connecting in to Rolls-Royce Test Facilities

Built on Robust Technology

DDS used on ships, autonomous vehicles, military vehicles by NASA, NATO, VW/AUDI and many others

In use on Test Bed 80

Integrates measurement systems and devices on Test Bed 80 – the largest indoor test bed in the world.

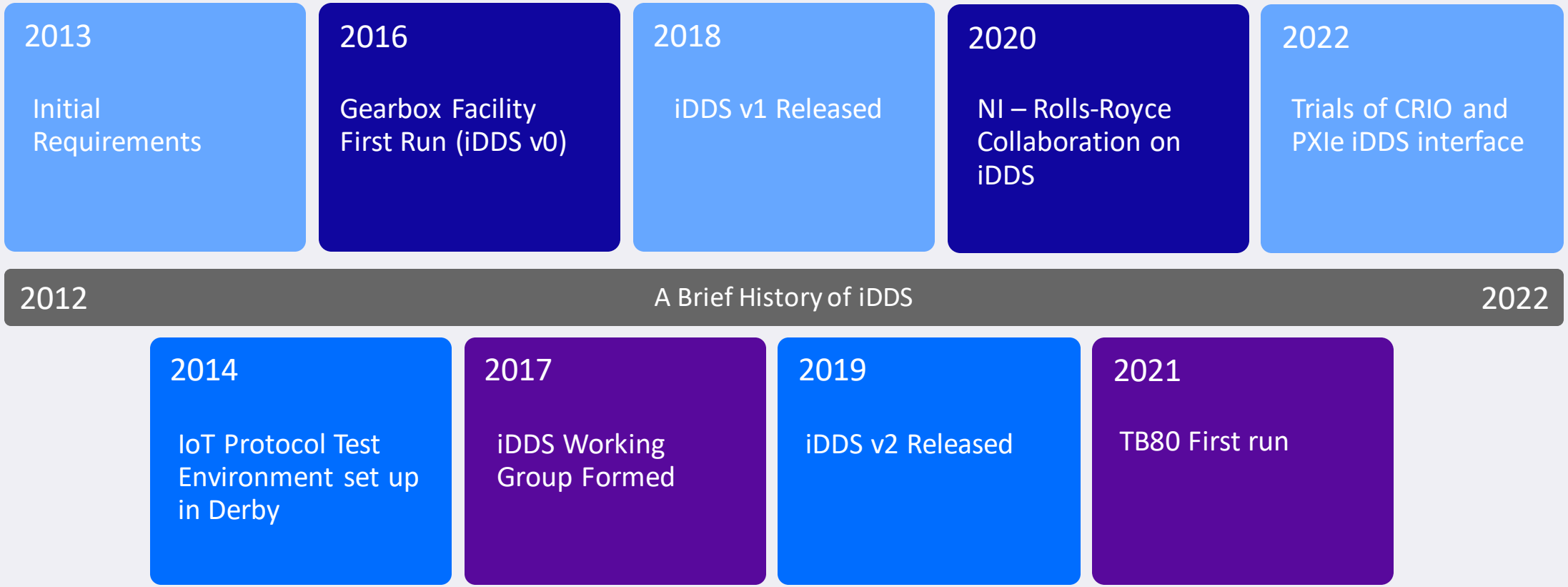
Data Centric

Abstracts Hardware and Network. Data transfer by parameter, no addresses or config knowledge needed.

Publish Subscribe

Brokerless Publish/Subscribe system

History of iDDS



iDDS Working Group

- MDS Aero Support
- **MTU Aero Engines AG**
- VTI Instruments Corporation (Ametek)
- United Electronic Industries, Inc. (UEI)
- **Rolls-Royce Derby**
- Rolls-Royce Indianapolis
- Safran Aircraft Engines
- Safran Aero Boosters
- Airbus
- Bombardier Aerospace
- ATCOM TELEMETRIE
- HGL Dynamics
- Müller-BBM GmbH
- Durham Instruments
- IPETRONIK
- Atec Inc
- MTI Instruments
- ADI
- CEL Aerospace
- Twin Oaks Computing
- Bustec
- Chell Instruments
- Applied Dynamics International (ADI)
- Scanivalve
- Evolution Measurement
- **National Instruments (NI)**
- TE Connectivity (PSI)
- Brüel & Kjær Measurement
- APEX Turbine Testing Technologies
- Kulite Sensors, Ltd
- ASE Holdings
- HBM
- dSPACE
- Hamersham
- Kawasaki Heavy Industries
- Yanos Aerospace Inc
- GE Aviation
- Aerotec

Interested in joining the iDDS Working Group?: don.pereira@mdsaero.com

Key Benefits

Data Centric

Data presented by parameter name – no config knowledge needed

EU Data transferred

Data is already in engineering units when in iDDS – no need for calibration knowledge

Timestamped Data

Data is individually timestamped so we get more accurate measurement times

More Capacity

Tested at 1.2MSa/s for low speed data.

High speed tested at 2.4 MSa/s per device.

Both Low and High Speed Data

Supports both Low speed (<1kHz) and High speed (100kHz+) data with the same format.

Data Quality with data

Data Quality assessment carried out on the device and transferred with the data

Standard Diary events

Diary entries can come from any system – better collaboration on test

Standard Commands

Devices support a common command set.

Standard across facilities

Shared inventory across facilities
New techniques available everywhere at once

iDDS Benefits

Benefits to the User :

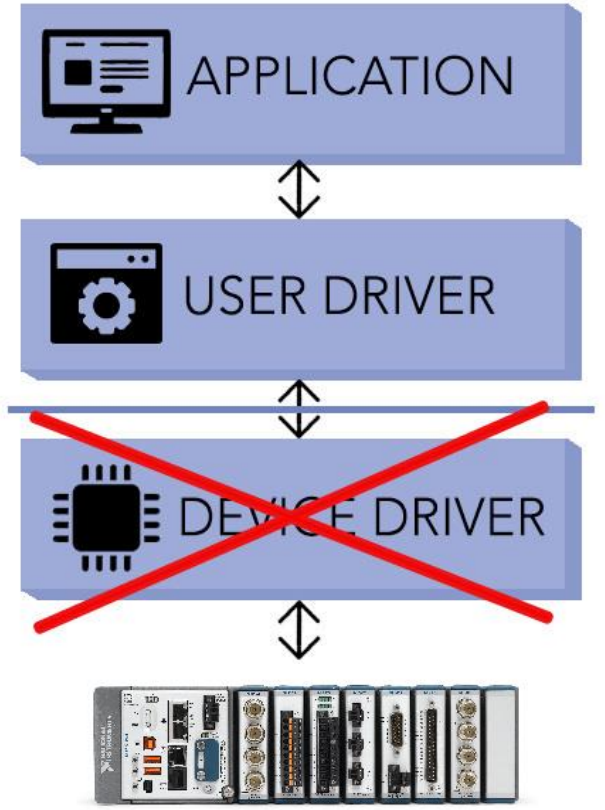
- Ability to add new iDDS hardware as it comes to market without changing software; scalable measurement system
- Not tied to a particular instrumentation vendor or DAS vendor
- Allows customers and third parties to write special/custom applications – provides customer with an increasing range of capabilities for both internal use or to even sell applications externally (Application Store)

Benefits to the Instrumentation Hardware Vendor:

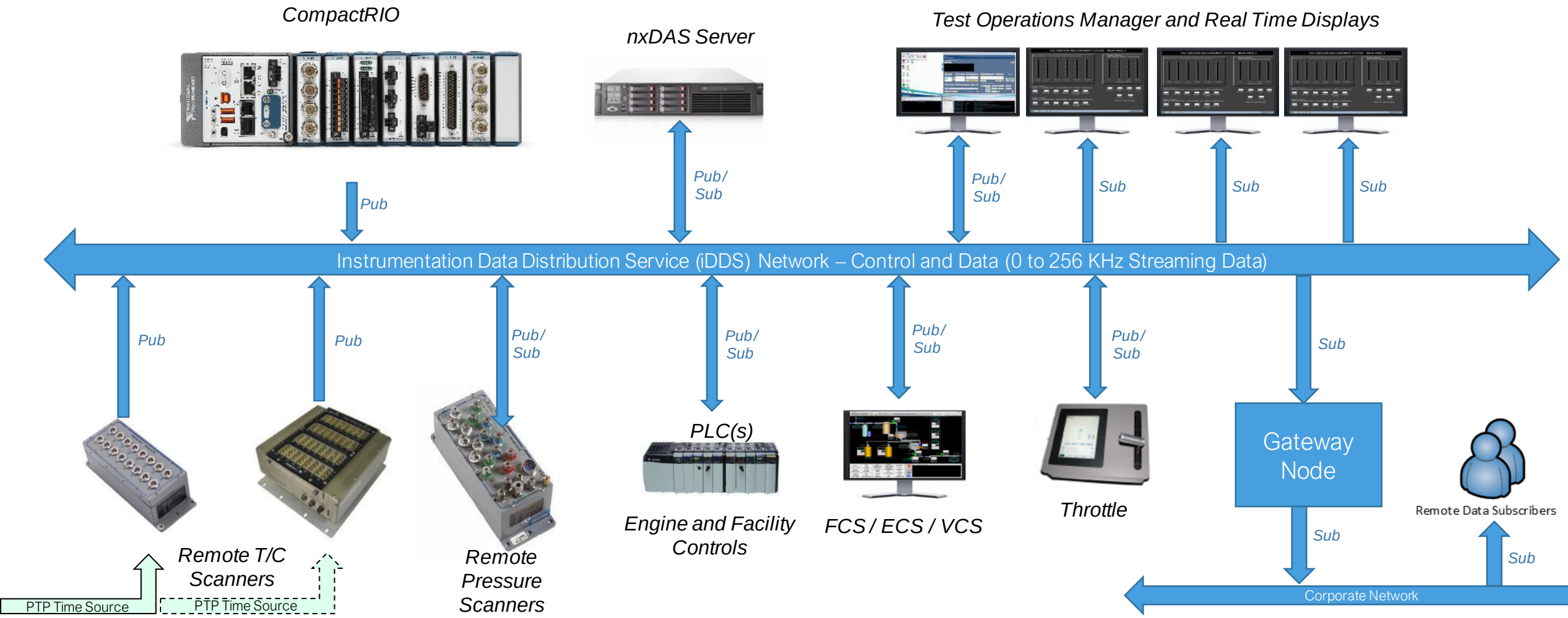
- Direct sales path to users of instrumentation
- Provide hardware without providing interfaces to varying software

Benefits to the DAS Provider:

- Have flexibility in hardware selection to provide best value to the customer
- Much lower cost to add new instruments



nxDAS – iDDS System Architecture



More information at ni.com/aerospace

steve.summers@ni.com

Thank You!

Backup Slides