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- ▲ To enable **audio**, activate your PC **speakers** or connect **headphones** to your PC.
- ▲ All participants' **microphones** are **muted** during the webinar.
- ▲ If you have any questions, please use the '**Questions and answers**' window.



- ▲ Questions will be answered **at the end** of the presentation.
- ▲ The webinar is being **recorded** and will soon be made available on our website together with the **presentation materials** – you will then receive an e-mail notification.
- ▲ The webinar will start shortly.

Mixed Signal Measurement in Full-scale Aircraft Testing (Iron Bird)

WEBINAR

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2020, February 21st

Presenter

Sandro Di Natale

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- ▲ Diplom-Physiker (graduate physicist)
- ▲ Application manager for Aerospace
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- 1. Introduction**
2. Testing Requirements
3. HBM Solution
4. Reference Story

Avionics

- ▲ Portmanteau of “aviation electronics”
- ▲ Includes
 - **Aircraft flight-control system**
 - Communications
 - Navigation
 - Monitoring
 - Fuel systems
 - Collision-avoidance systems
 - Flight recorders
 - Weather systems
 - Aircraft management systems
- ▲ Modern military aircraft/rotorcraft can have a share >50% of budget for avionics.



F-105 Thunderchief with avionics laid out

Fly-by-wire

- ▲ Motivation: Replacement of long runs of mechanical and hydraulic connections by wires and electric servos
- ▲ Started in the 1930s with the Soviet Tupolev ANT-20
- ▲ Milestones for analog fly-by-wire: Apollo LLTV*, Avro Canada CF-105 Arrow, Concorde
- ▲ Transition to digital fly-by-wire in 1972: Vought F-8 Crusader
- ▲ 1984: Airbus A320 first commercial aircraft with all-digital-fly-by-wire control system
- ▲ Future/further development:
 - Fly-by-optics
 - Power-by-wire
 - Fly-by-wireless



Avro Canada CF-105 Arrow



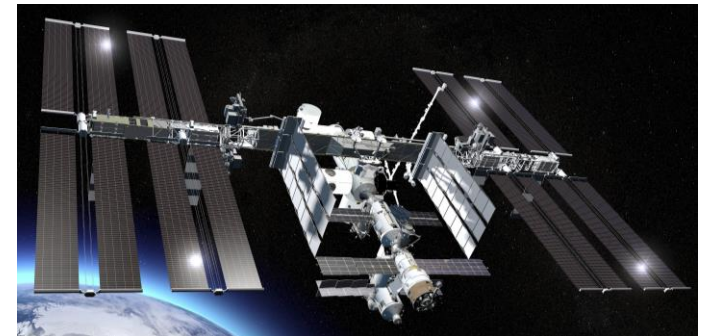
A319 cockpit



Kawasaki P-1

Commonly Used Avionics Buses

- ▲ MIL-STD-1553
 - First draft in 1968, published as US Air Force standard in 1973
 - MIL-STD-1553C, latest revision from 2018
- ▲ Speed: 1 Mbps
- ▲ Predominant avionics data bus in military and spacecraft
- ▲ Dual-redundant and bi-directional (half-duplex)
- ▲ Highly reliable with one word fault per 10 million words
- ▲ Aircraft with MIL-STD-1553: F-16 Falcon, F/A-18 Hornet, AH-64 Apache, Panavia Tornado, Eurofighter Typhoon, Saab Gripen, MiG-35
- ▲ Spacecraft with MIL-STD-1553: ISS, Ariane 5, VEGA, Space Shuttle



Commonly Used Avionics Buses

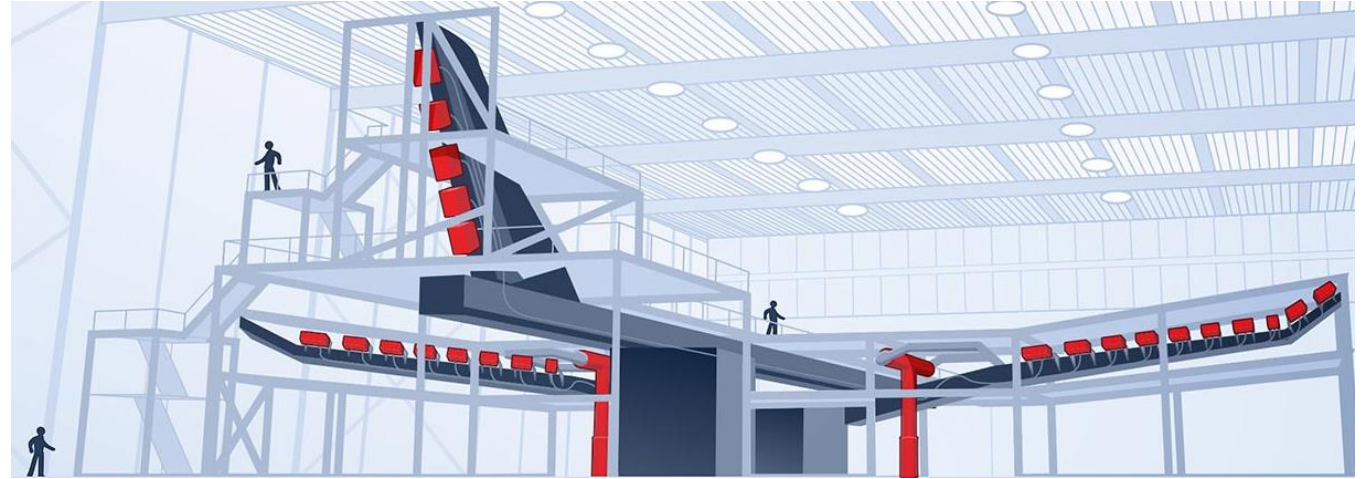
- ▲ ARINC429
 - First spec released in 1978 (version 1)
 - Latest spec released in 2004 (version 17)
- ▲ Two speed levels: 12.5 kbps and 100 kbps
- ▲ Predominant avionics data bus in commercial and transport aircraft
- ▲ Simplex communication, bi-directional transmission requires two channels or buses
- ▲ Simple architecture, almost point-to-point, is highly reliable
- ▲ Used in federated avionics generating rather high weight (wires), approx. one wire per device
- ▲ Aircraft with ARINC429: A320, A330, A340, B737, B747, B757, B767, B777



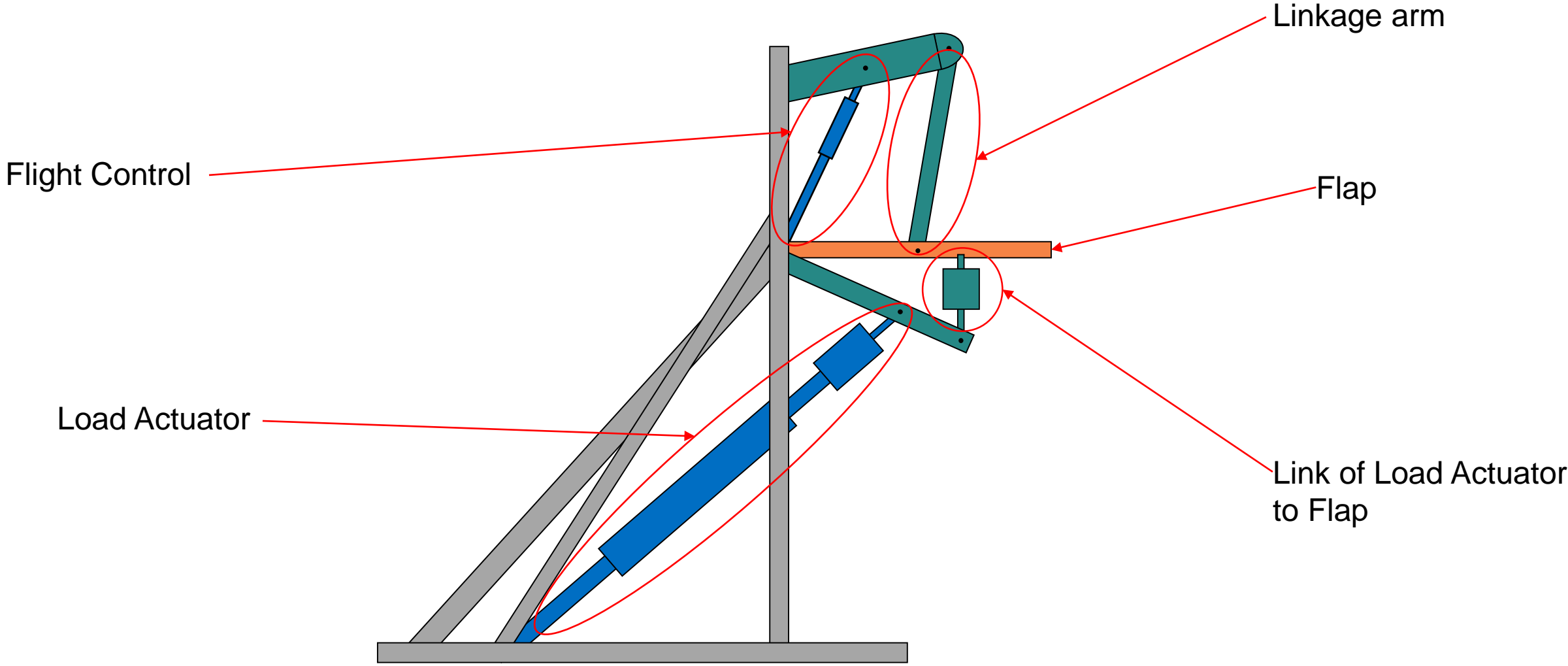
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Iron Bird Testing

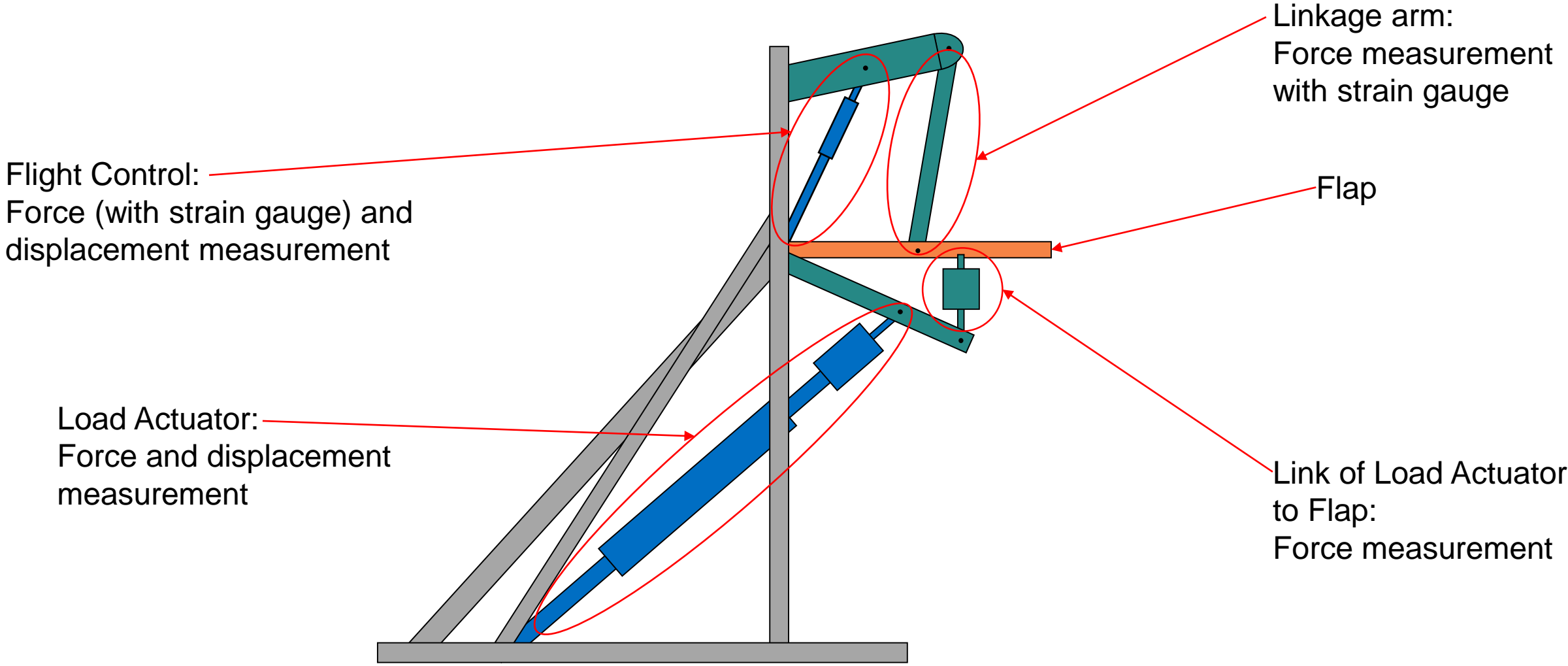
- ▲ Test of all major flight controls, hydraulics and electrics
- ▲ Giant test rig with corresponding distances to real aircraft for realistic testing
- ▲ Synchronized measurement of avionics bus data and analog sensor data
- ▲ Scalability in number of acquired avionics buses and number of analog sensors
- ▲ Validation of functionality, performance and reliability



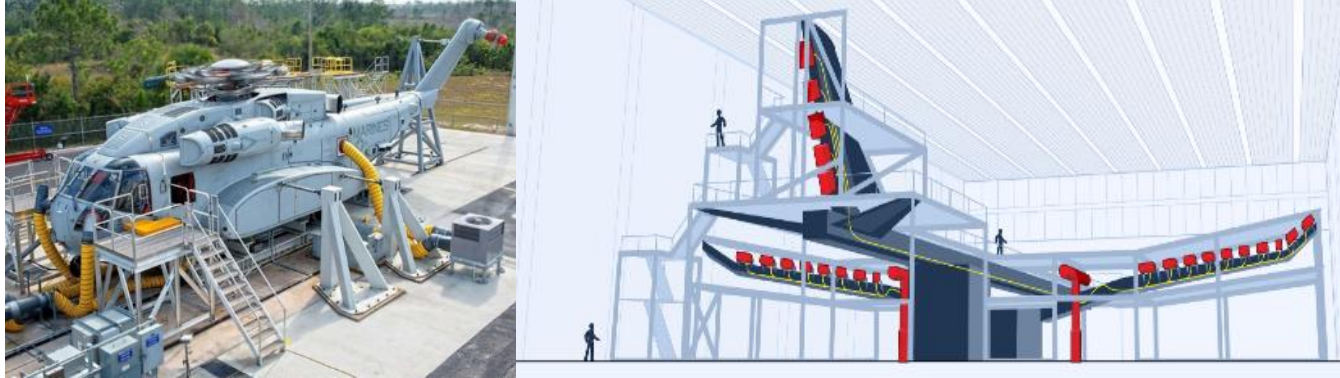
Iron Bird Testing on Component Level



Iron Bird Testing on Component Level

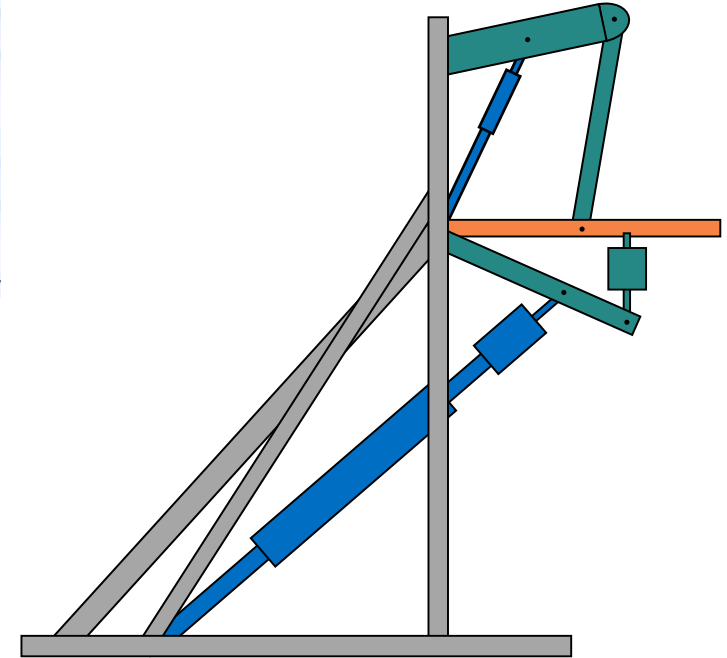


System Testing – Full-scale (Iron Bird) and Components



Key features

- Sensor flexibility: pressure, force, displacement, torque, strain
- Scalability in channel number and speed on hardware and software level
- Distributability of the DAQ system
- Avionics bus integration (ARINC 429, MIL-STD-1553)
- Connection to actuation system
- Synchronization with actuation system and avionics bus logger



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HBM Solution – Hardware and Software

Higher channel number →



QUANTUM^X MGCplus

- ▲ Wide variety of sensor inputs incl. strain gauges, LVDTs, IEPEs, thermocouples
- ▲ Patented strain gauge circuits
- ▲ Autocalibration and auto adjustment routines to ensure long-term stability
- ▲ Scalable in multiples of 8/16 channels
- ▲ TEDS technology
- ▲ Experienced custom systems department for turn-key solutions

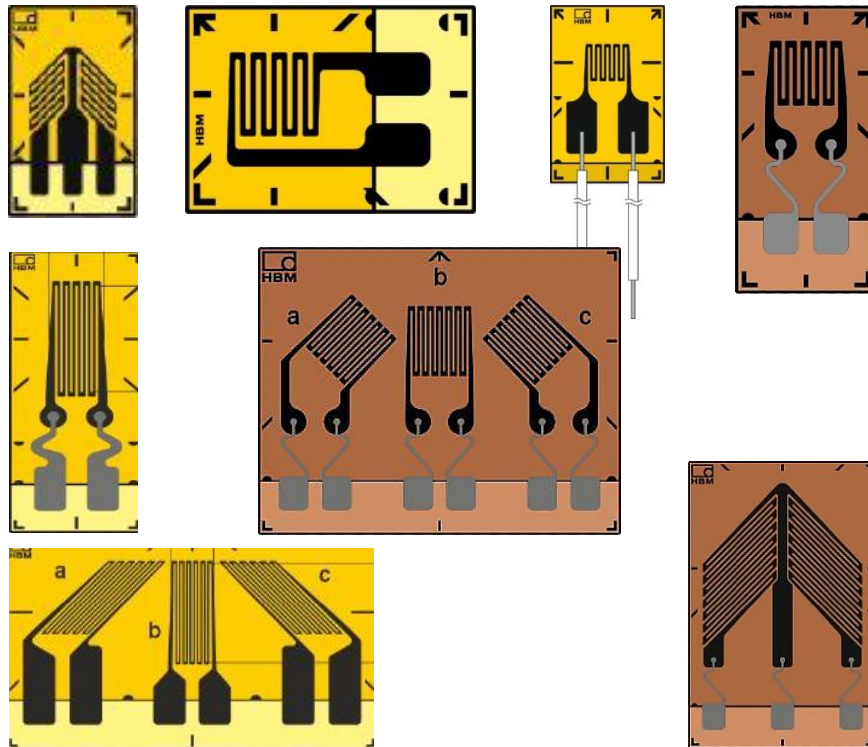


Higher channel number →

- ▲ Easy left-to-right workflow
- ▲ Synchronized acquisition of data from load control system
- ▲ Synchronized acquisition of data from avionics buses
- ▲ Intelligent triggering
- ▲ Script-based automation
- ▲ Application-specific visualization objects

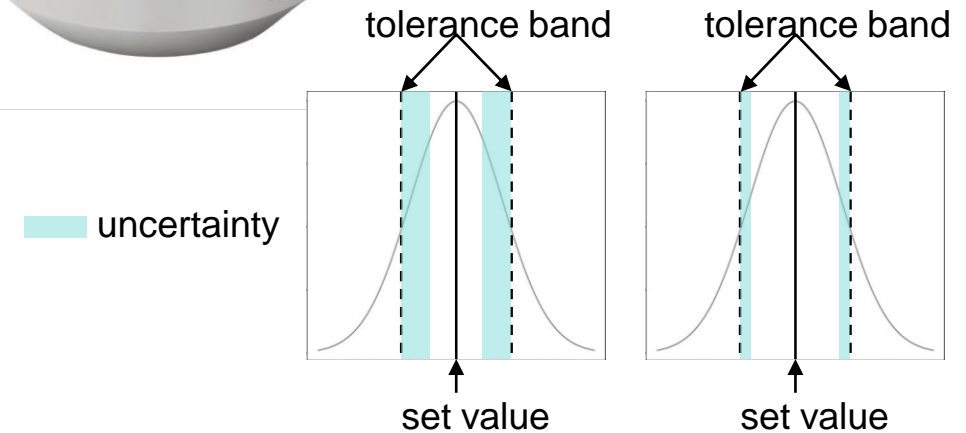
HBM Solution – Sensors

Strain gauges



- ▲ Proven in aerospace applications
- ▲ More than 2,000 variants available
- ▲ Polyimide or glass-fiber reinforced phenolic resin carrier material (with constantan or CrNi grid)
- ▲ High alternating loads, large temperature range

Force transducers



- ▲ Made from stainless steel
- ▲ Hermetically sealed for immunity against humidity
- ▲ Constructed as a real Faraday's cage, tested and optimized in HBM's own EMI lab
- ▲ Vibration and shock tested

HBM Solution – Avionics Buses

- ▲ HBM partners with leading Avionics Data bus specialist AIM from Freiburg, Germany
- ▲ Similar reference list to HBM in aerospace
- ▲ Several successful joint projects at renowned aerospace manufacturers
- ▲ Wide range of supported Avionics buses beyond ARINC429 and MIL-STD-1553, e.g. AFDX®/ARINC664P7, ARINC818, ARINC825 and many more



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AIM ARINC429, MIL-STD-1553 modules

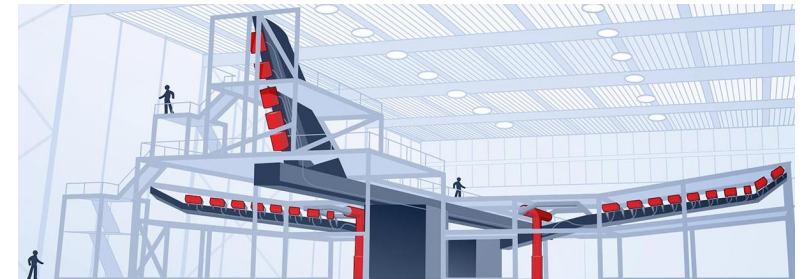
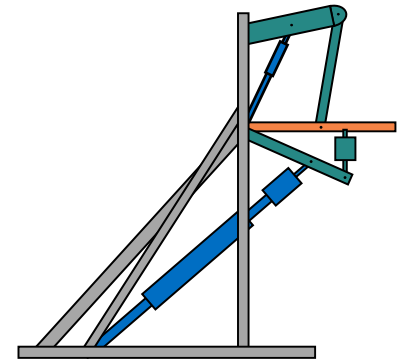


Image source: AIM GmbH

The Full DAQ Solution



GPS-based grandmaster clock
e.g. Omicron Ticro 100



Analog sensors



Avionics buses



Load control

One single file for

- ▲ Analog sensors / transducers
- ▲ Load control system / actuators
- ▲ Avionics bus data

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Use Case: Ground Test Instrumentation Division – Sikorsky



Dedicated **Ground Test Instrumentation Division**

Tests covered

- ▲ Static and fatigue testing of components, full airframes
- ▲ Powertrain dynamic tests
- ▲ Material coupon testing
- ▲ Other miscellaneous investigative and certification activities

DAQ Station

Entirely based on QuantumX hardware:

- ▲ Data recorder and data acquisition PC with catman AP
- ▲ Measurement modules can be easily and rapidly installed and removed allowing maximum flexibility.

Additional equipment:

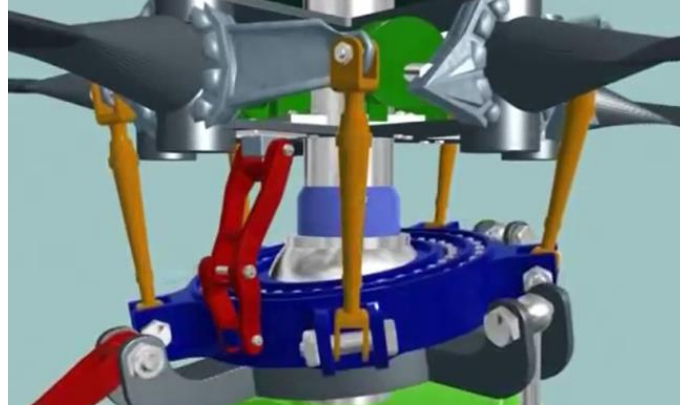
- ▲ UPS
- ▲ Ethernet switch / USB hub
- ▲ HD monitor, keyboard, mouse



Test Examples - Sikorsky



**CH-53K King Stallion
GTV (Ground Test Vehicle)**



**Helicopter main rotor hub
Fatigue Test**



**CH-53K King Stallion
Fuselage Full Scale Test**

Specific requirements

- ▲ Avionics bus recording (ARINC 429, MIL-STD-1553)

- ▲ Communication modules, custom calculations
- ▲ Integration with test control system

- ▲ High input flexibility
- ▲ High channel count
- ▲ System calibration solution from HBM

Testing purpose

- ▲ Testing the Fly-by-Wire Flight Control System (FCS)
- ▲ Testing of various components and subsystems of the FCS

- ▲ Qualification and certification of components and materials
- ▲ Record and analyze data for fatigue calculations

- ▲ Helicopter structure certification
- ▲ Correlation of FEM models with data from hundreds of SG

Any Questions?

- ▲ If you have any questions, please do not hesitate to contact us: webinar@hbkworld.com
- ▲ Or email the presenter directly: sandro.dinatale@hbkworld.com



Thank You