# Avionics Databus Networks from ARINC 429 to ARINC 664: Embedded and Test Software Configurations

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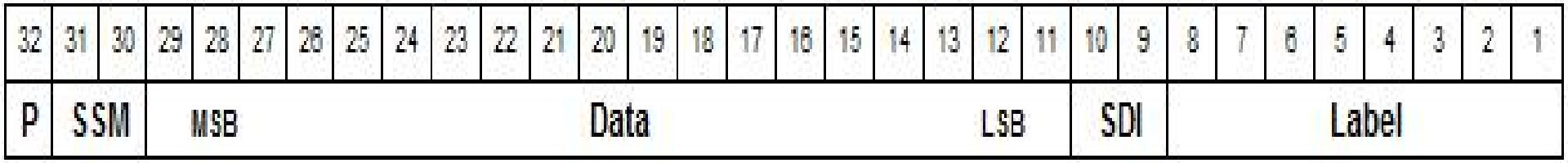
# ARINC-429 Databus

- ARINC-429 is the most commonly used databus for commercial aircraft systems.
  - Embraer E-Jet, ERJ, Legacy
  - Boeing B737, B747, B757, B767, B787
  - Airbus A330, A340, A380, A350
- ARINC-429 use is ubiquitous and it is still designed into new programs and mixed architectures that also utilize ARINC-664/AFDX®
- The standard was developed originally in 1977
- Serial bus, simplex operation
- Transfers 32-bit words with 100 KBit/Sec and 12.5 KBit/Sec data rate options available

# ARINC-429 Databus

- Point-to-Point and Multi-Drop connections are typically used
- Signaling is differential and uses bipolar return-to-zero encoding scheme
- All data is transferred using 32-bit words
  - 8-bit label identifies type of data
  - Odd Parity
  - SSM and SDI Fields are optional
- Some aircraft applications have used even parity or none

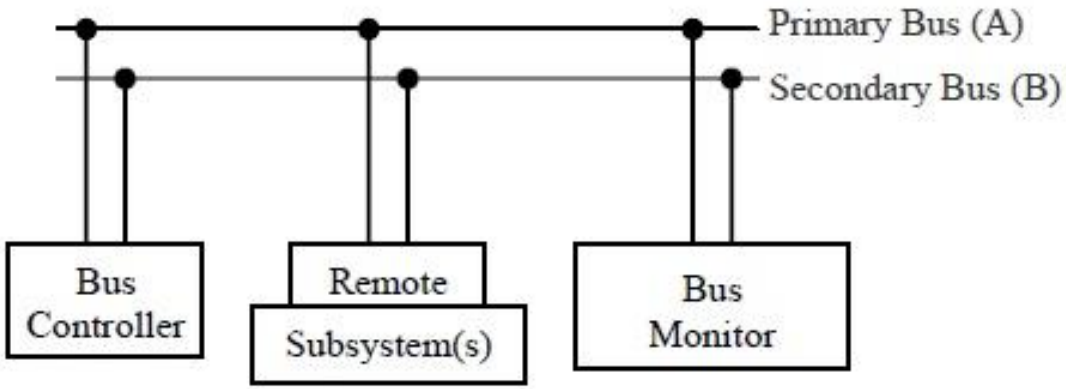


# MIL-STD-1553 Databus

- Field Databus used in Military avionics applications
  - F-16, F-18, B-1B, B-2, AH-64 Apache
- MIL-STD-1553 is still being designed into new programs
  - F-35 (JSF), and new UAV systems
- Specification was first published by U.S. DOD in 1973. Now maintained by both DOD and SAE
- Defines a redundant shared bus architecture with a single bus master (controller) supporting 1Mbit/sec data rates
- Supports up to 31 nodes (Remote Terminals) and a bus monitor
- Aircraft systems typically utilize multiple MIL-STD-1553 busses
  - Example: An F-16 uses at least 5 MIL-STD-1553 busses

# MIL-STD-1553 Databus

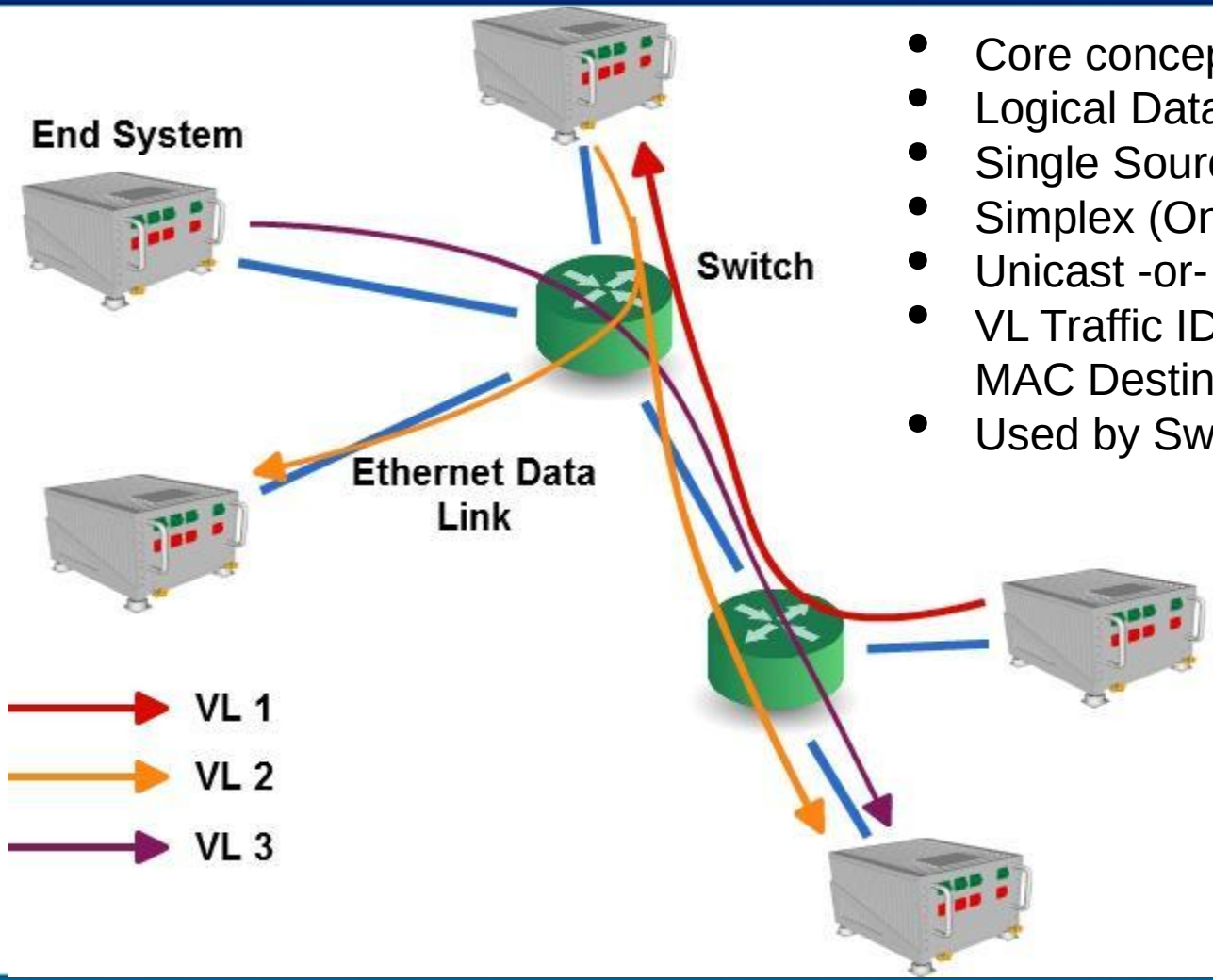
- Dual-redundant shared bus
- A single Bus Controller (BC) initiates all data transfers
- Up to 31 individually addressable Remote Terminals respond to BC Commands
  - BC-to-RT Data Transfers
  - RT-to-BC Data Transfers
  - RT-to-RT Data Transfers
- RT responds on the bus (A or B) from which command is received. BC retries on alternate bus if no response
- Bus Monitors (passive) are also allowed to monitor and capture all bus traffic



# ARINC-664/AFDX Network

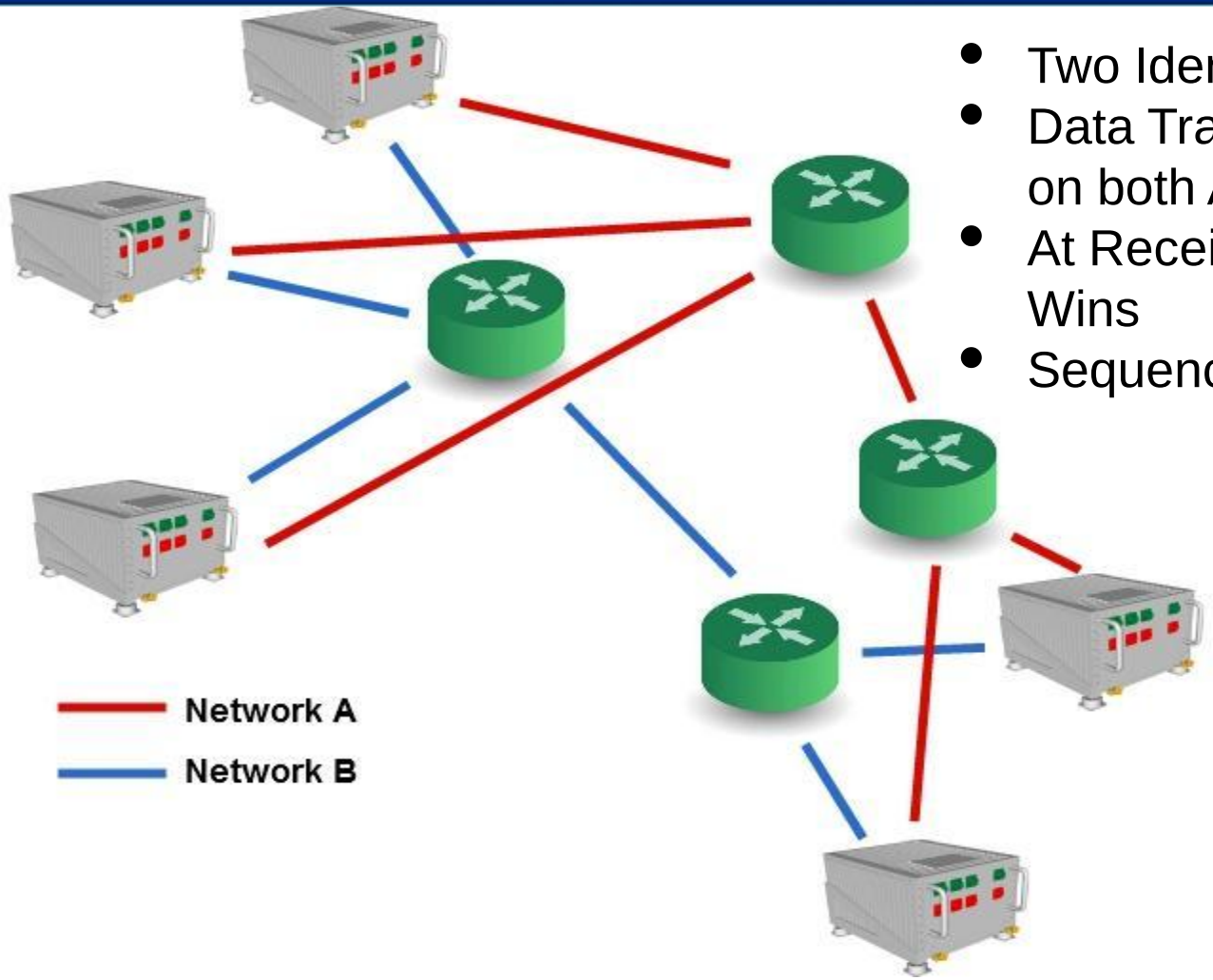
- ARINC-664 defines the use of IEEE 802.3 Ethernet and Internet Protocols (IP, UDP, SNMP, ....) for Avionics applications.
- AFDX is a specific, deterministic implementation of an ARINC-664 network developed by Airbus for the A380, A350, A400M
- Other deterministic implementations and variants of ARINC-664 are in use today

# Virtual Links




- Core concept of Deterministic Ethernet
- Logical Data Path through Network
- Single Source
- Simplex (One Direction)
- Unicast -or- Multicast
- VL Traffic ID'd by 16-bits in Ethernet MAC Destination Address
- Used by Switches for routing frames

# ARINC-664 Redundancy




- Two Identical Networks
- Data Transmitted Simultaneously on both A & B (Ethernet MAC)
- At Receiver -- First Valid Frame Wins
- Sequence Numbers Per VL used

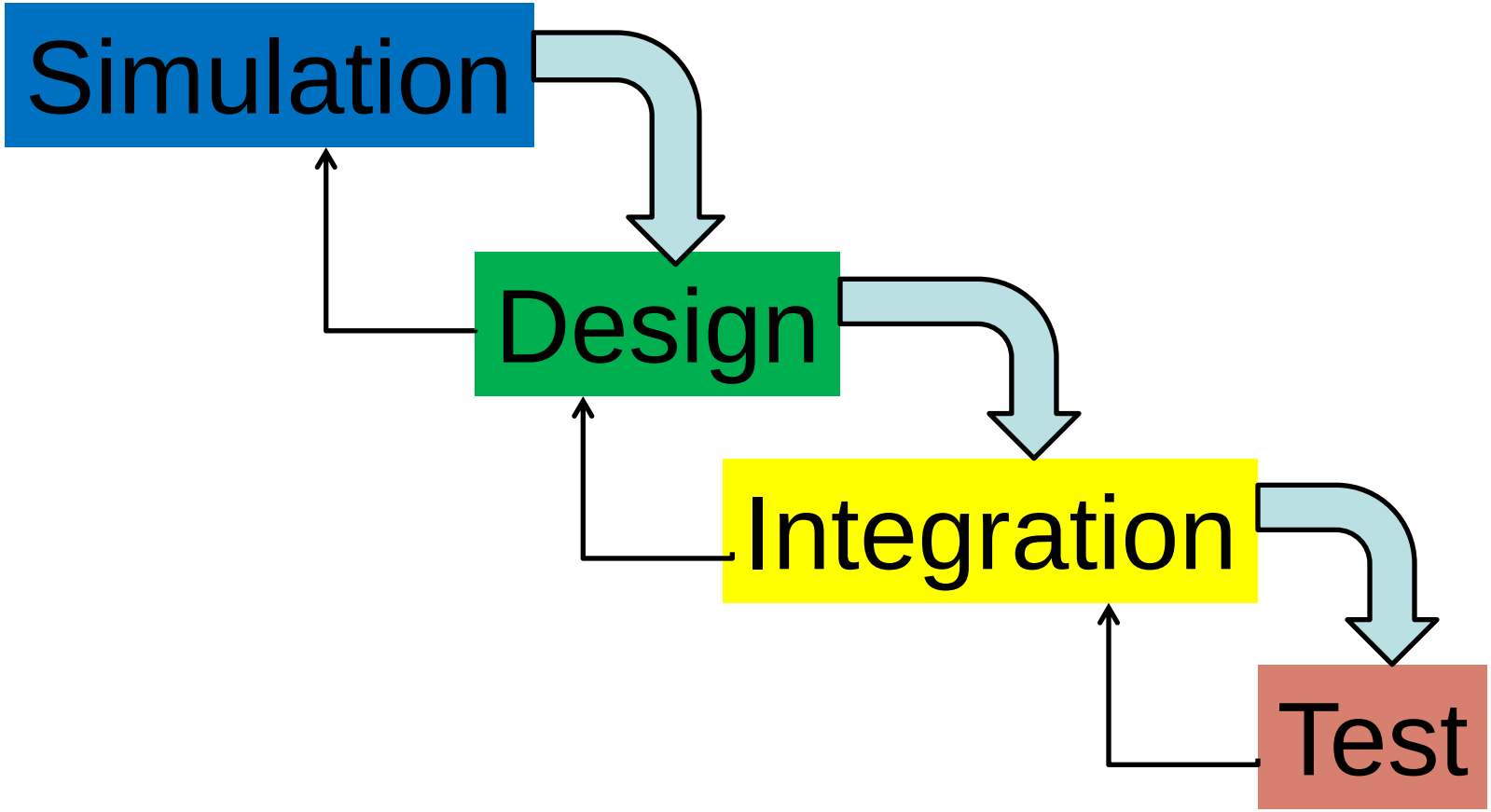
# Fibre Channel Network

- Fibre Channel is specified in the T11 family of standards produced by INCITS
- Fibre Channel is used as a carrier protocol for several avionics specific protocols
  - FC-AE-ASM (Anonymous Subscriber Messing)
  - FC-AE-1553 (MIL-STD-1553 over Fibre Channel)
  - FC-AV / ARINC-818 (Avionics Video for Displays over Fibre Channel)
- Currently used on F-18, F-35, F-22, and in commercial aircraft for displays interface (B787, A380)

# Avionics Protocols Summary

| Protocol | Topologies | Physical I/F | Data Rates | Primary Application |
|---|---|---|---|---|
| MIL-STD-1553 | Shared Bus | Electrical (Manchester) | 1Mbit/sec | Military Avionics Field Bus |
| ARINC-429 | Point-to-Point | Electrical (Bipolar RZ) | 12.5Kbit/sec<br>25Kbit/sec<br>100Kbit/sec | Commercial Avionics Field Bus |
| ARINC-664 | Switched Network | Electrical<br>Optical | 10Mbit/sec<br>100Mbit/sec | Commercial Avionics Core Network |
| Fibre Channel | Point-to-Point<br>Ring<br>Switched Network | Electrical<br>Optical | 1Gbit/sec<br>2Gbit/sec<br>4Gbit/sec | Military Avionics Core Network, Stores Interface, Avionics Displays |

# Test and Simulation Avionics Development



# Test and Sim Applications

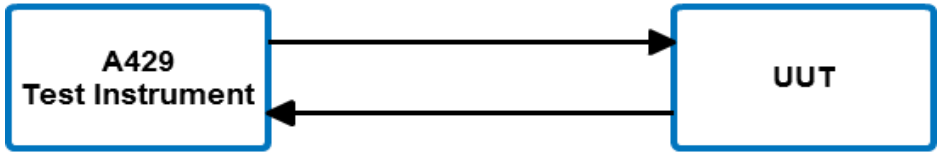
- Multiple use cases must be supported in software by ARINC-429, MIL-STD-1553, ARINC-664, and Fibre Channel Test instruments

- Additional functions are also required
  - Data Acquisition and Analysis
    - Data Recording
    - Post Capture Analysis
  - System Integration & Troubleshooting
    - Databus Analyzer

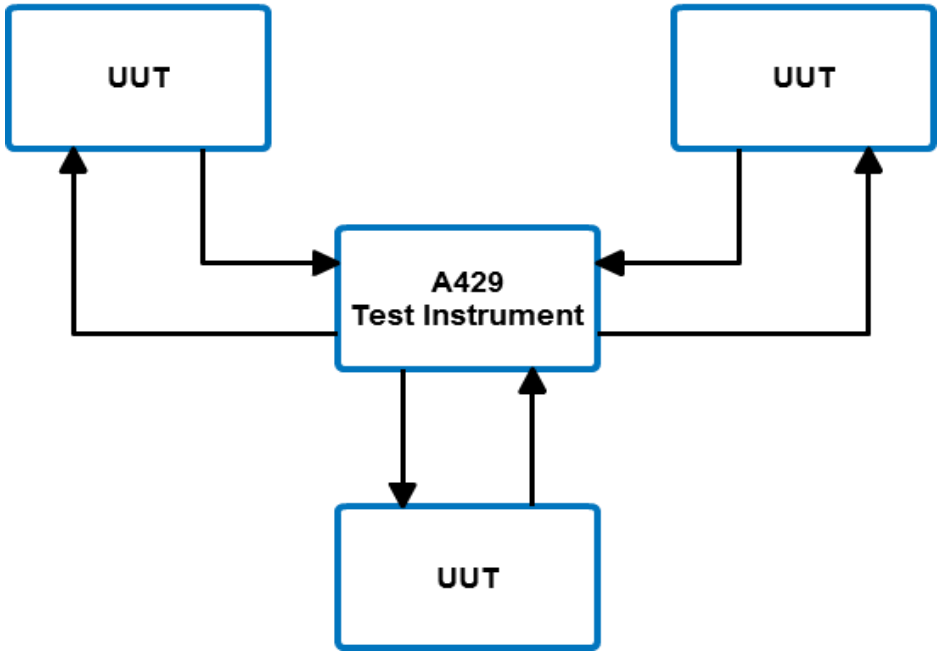
- **The large amount of configuration data associated with an aircraft system must also be considered**

# ARINC-429 Test Scenarios

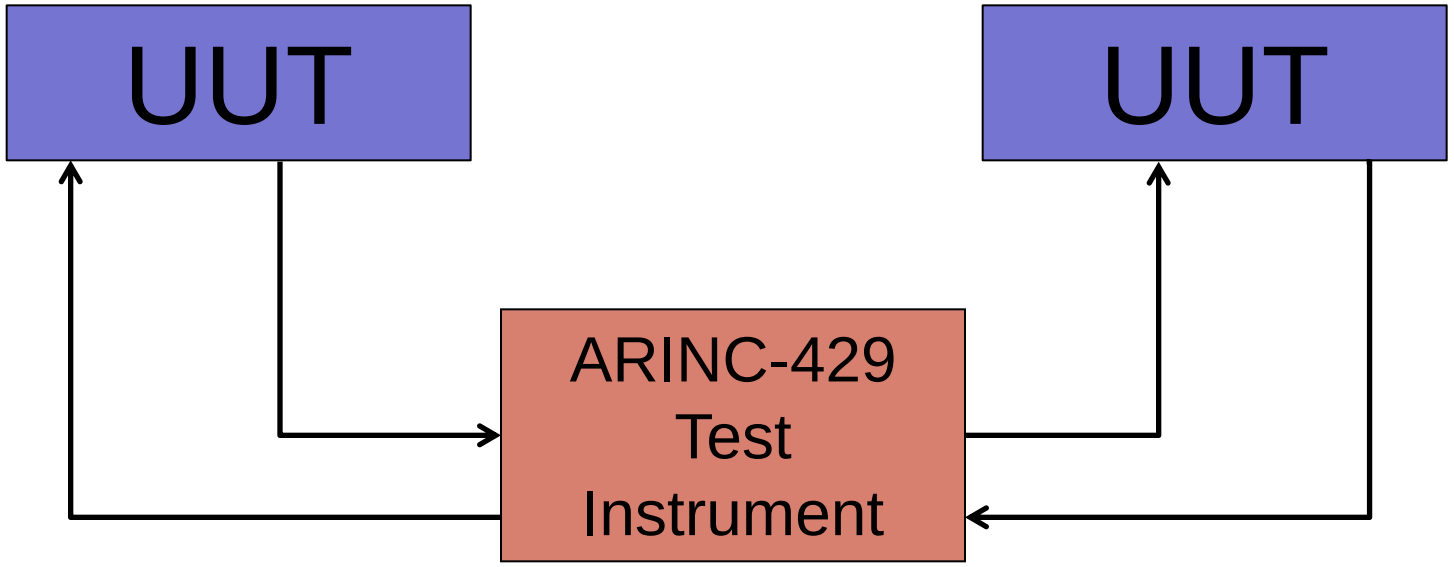
Point-to-Point Single UUT Tests




System Tests & Integration



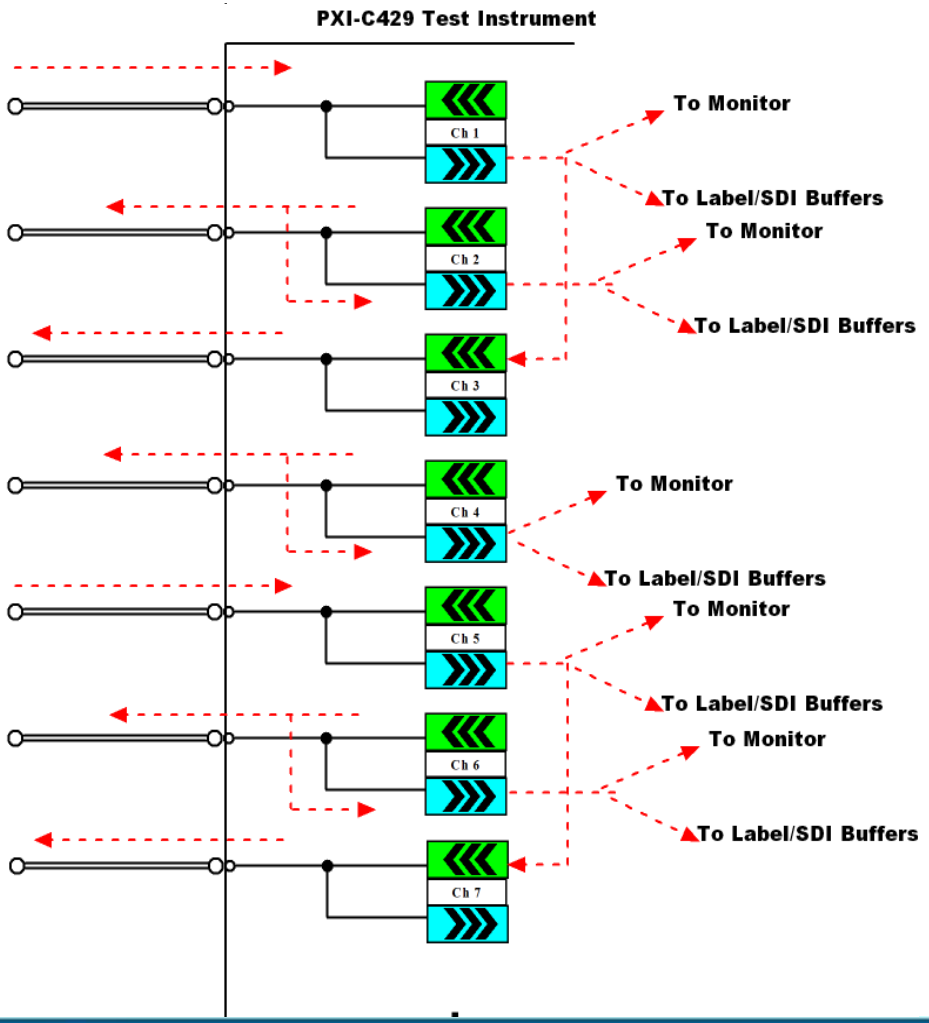
# ARINC-429 Test Scenarios



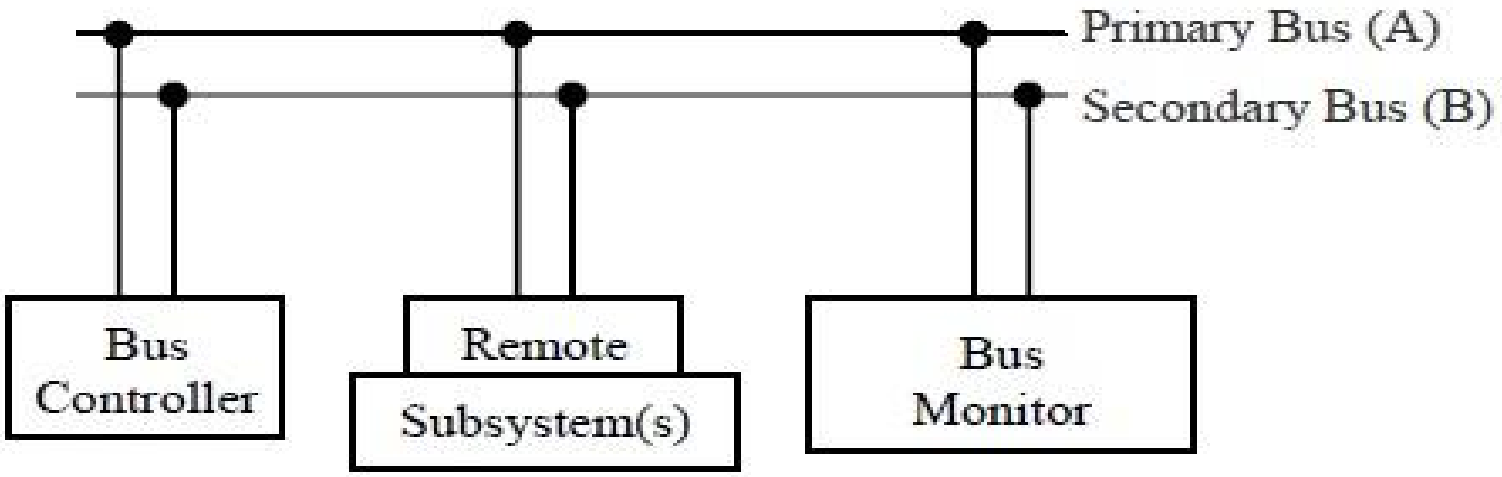

## Data Corruption

- Insert label
- Modify label
- Delete label

# ARINC-429 Test Scenarios



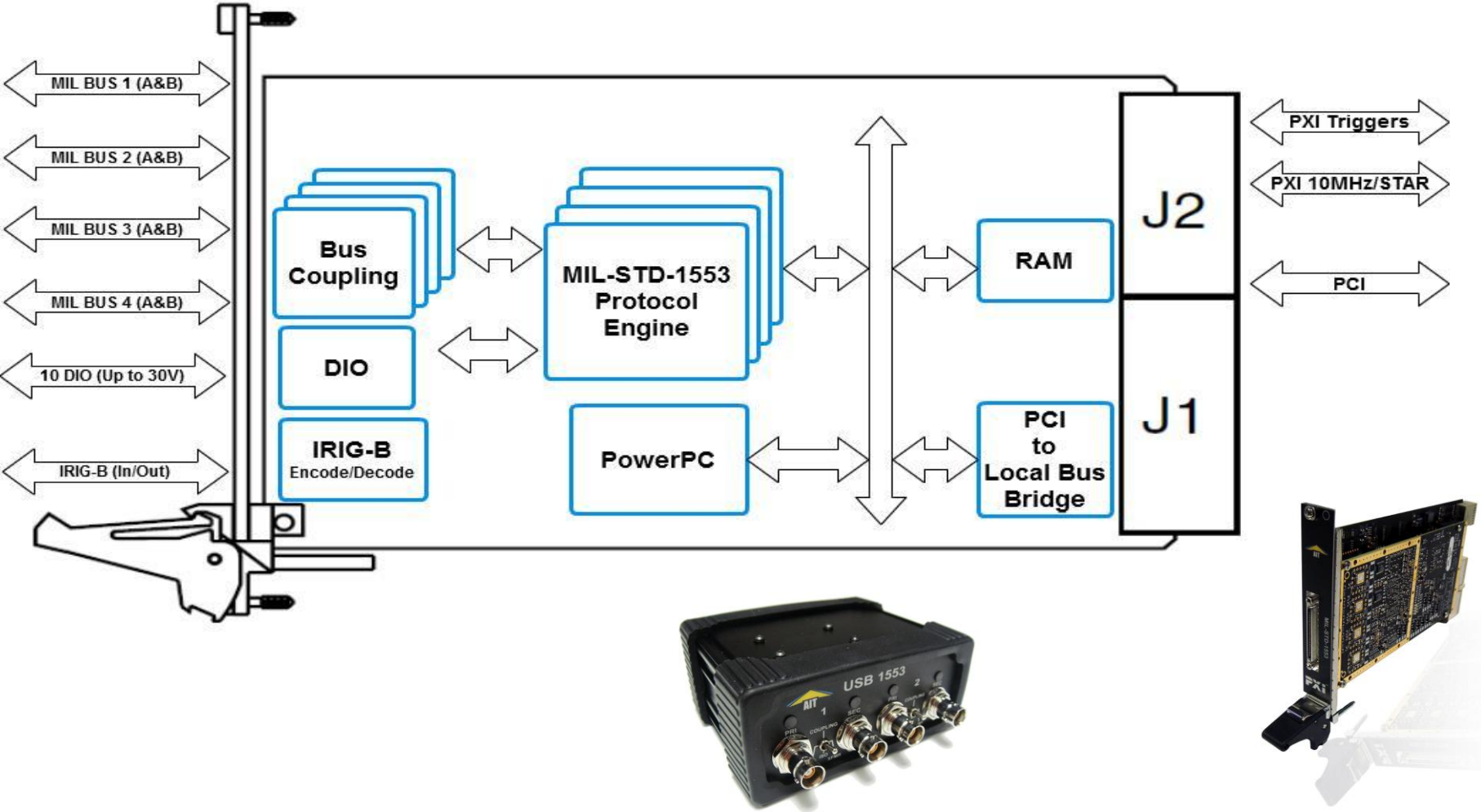

# 1553 Test Scenarios



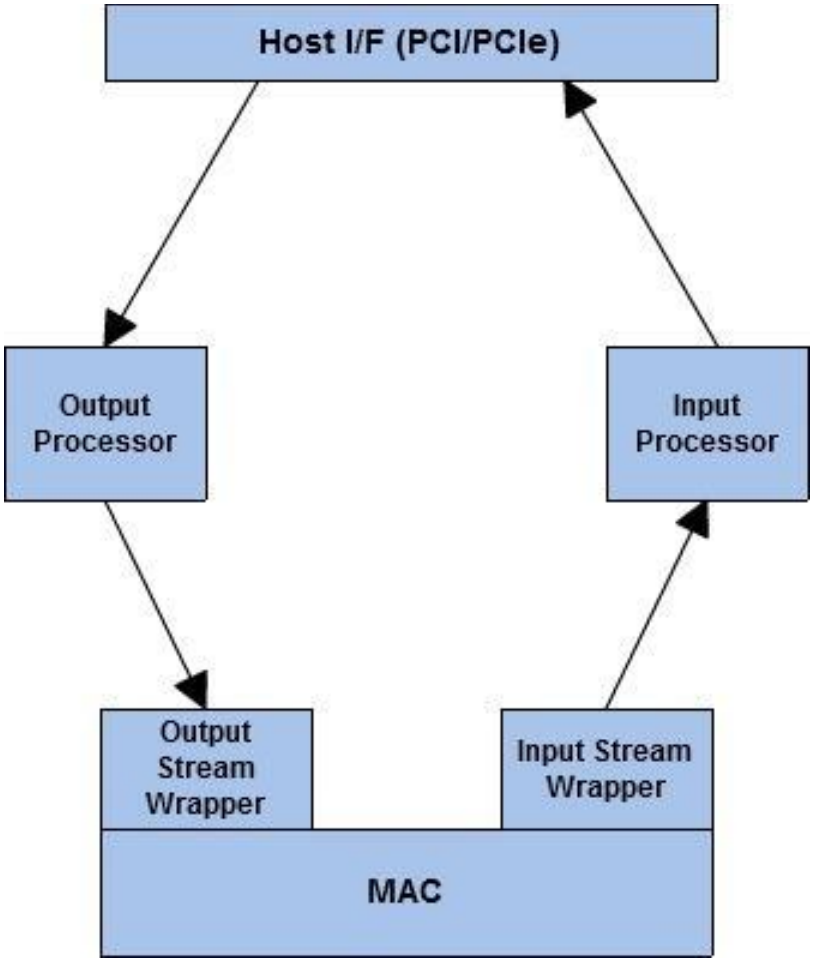

## Simulate

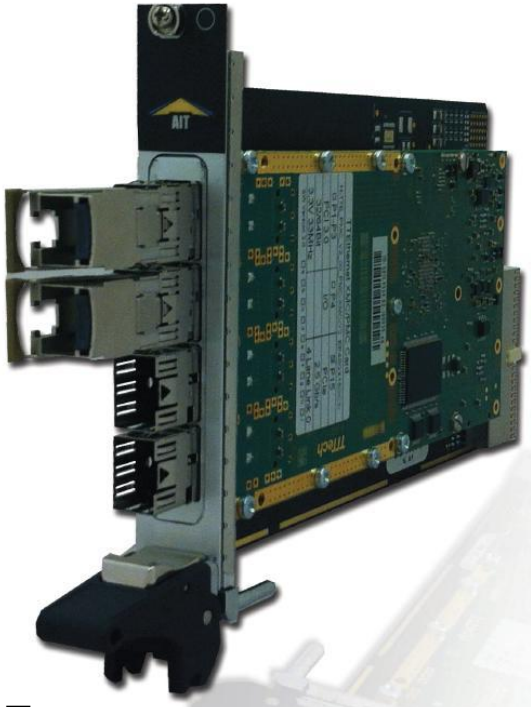
- Bus Controller
- Remote Terminal
- Bus Monitor

# 1553 Test Scenarios



# ARINC-664 Test Instrument



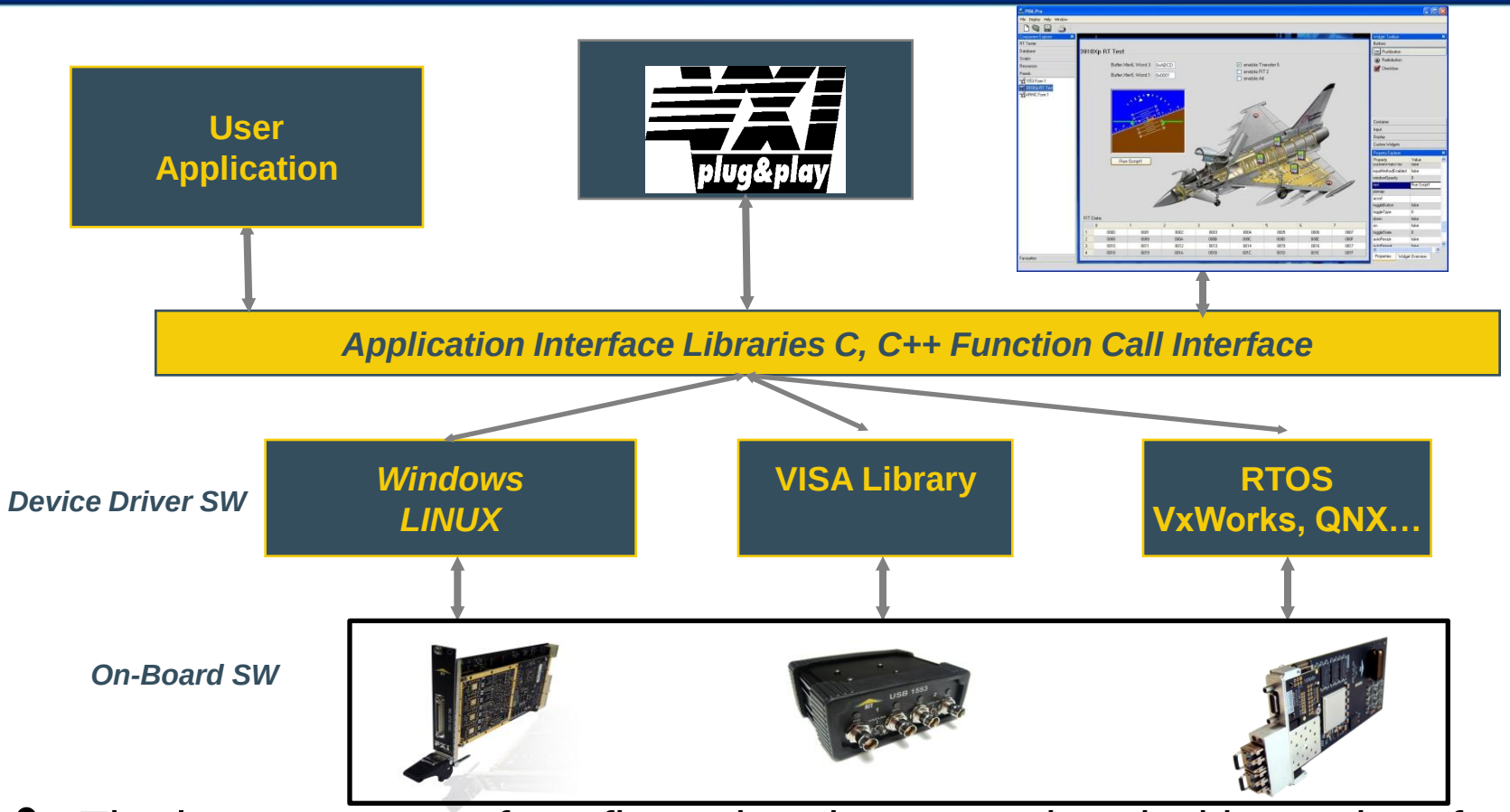



- Two ports
- Single or Dual redundant mode
- Multiple End-System simulation

# Avionics Test Software

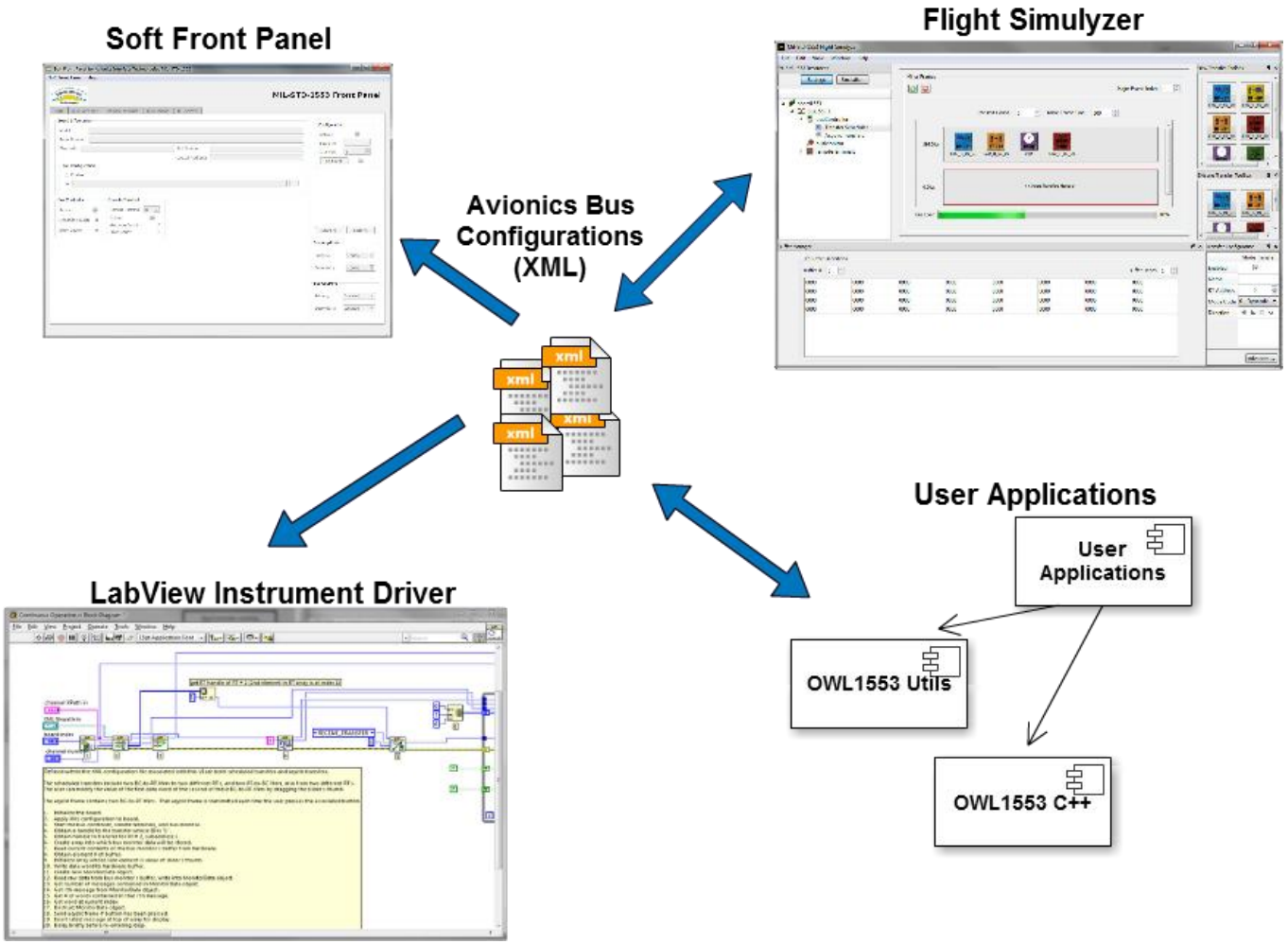
- Multiple use software environments are required for testing ARINC-429, MIL-STD-1553, ARINC-664, and Fibre Channel Test instruments
  - Integration into larger customer owned software development environments
    - C
    - C++,
    - .NET
  - Integration into multiple operating system environments
    - Windows,
    - Linux,
    - RTOS (VxWorks)
    - LabView
- The considerably large amount of configuration data associated with an aircraft system must also be considered

# Traditional Avionics Test Software




- The large amount of configuration data associated with an aircraft system is programmed per application, typically NOT re-used

# AIT Avionics Test Software Implementation

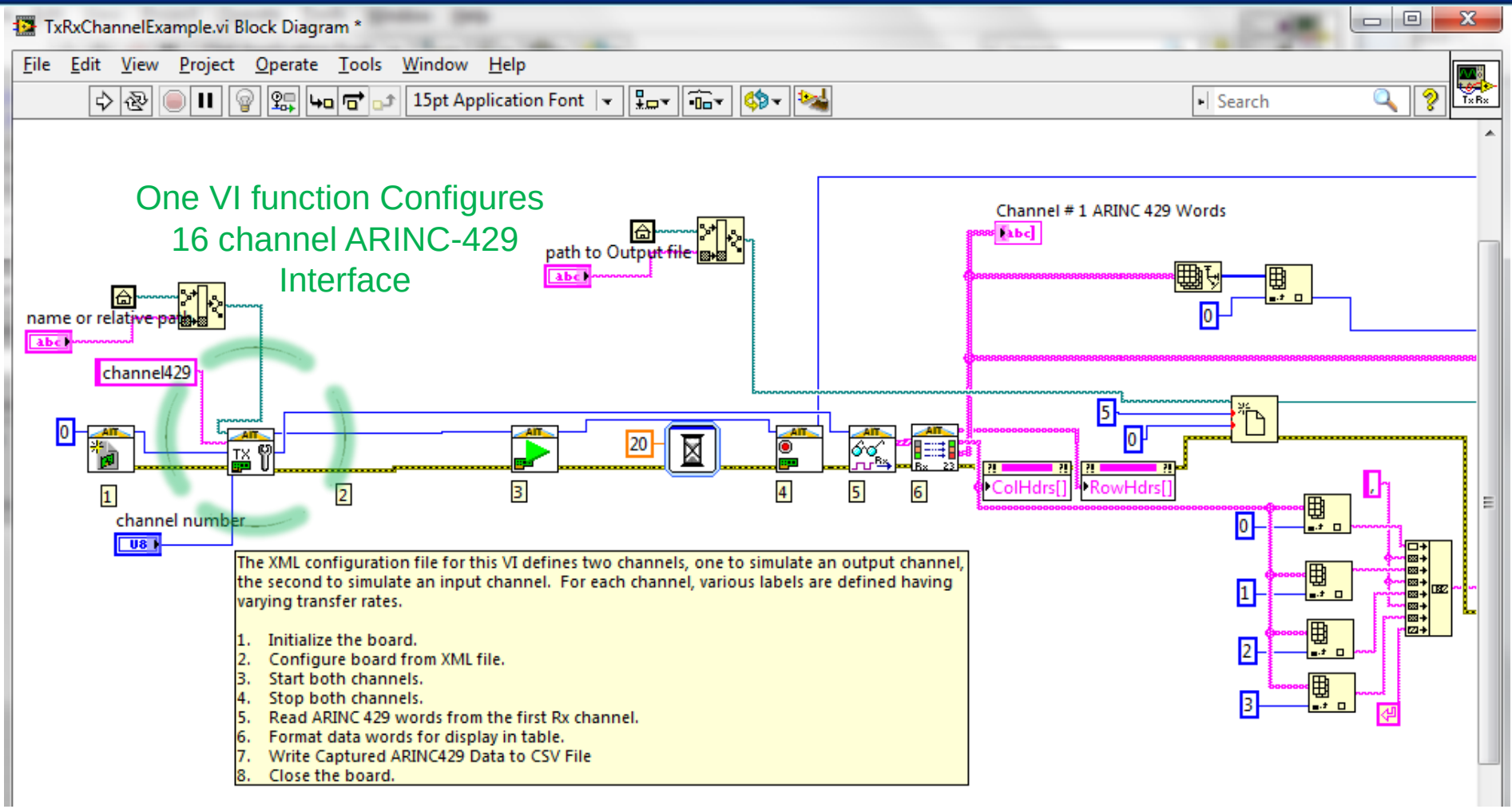


# AIT Avionics Test Software Implementation

## Advantages

- Define a portable Configuration
  - Based on Xml format
  - Used across various Development environments
  - Free toolsets for easy development and integration
- Automated software tool to build the data structure
  - Well documented GUI implementation
- Define Single functions to setup the End-System
    - Easy integration
    - Savings of up to 65% of applications
    - Can re-use simulation and test code
- Easily accommodates the configuration data associated with an aircraft system

# AIT Avionics Test Software Implementation



# AIT Avionics Test Software Implementation

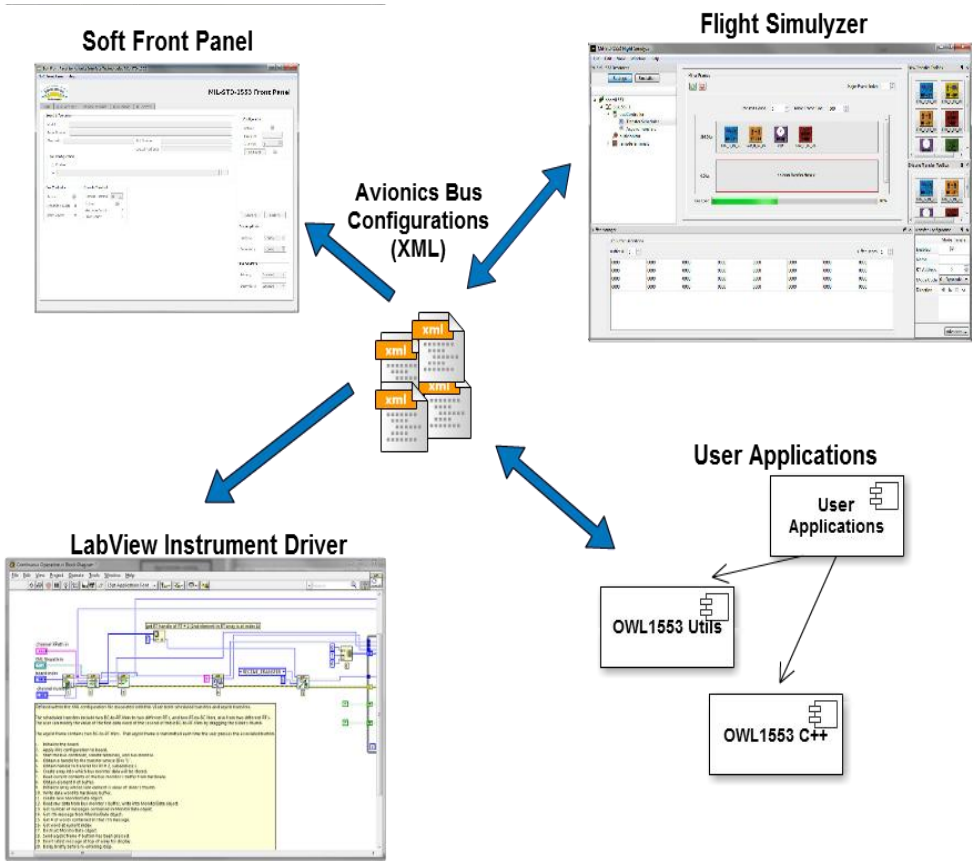
## Simple, one API call to load ARINC-664 E/S

```
/* Open the device */
   printf("\nOpening the device and resetting it...\n");
   CHECK_RETVAL(a664ESOpen(0, &esHandle));
   CHECK_RETVAL(a664ESReset(esHandle));

   /* Load the configuration file */
   printf("Loading a configuration file...\n");
   configurationFile = fopen(aFileName, "r");
   if (configurationFile == 0)
   {
    printf("Error opening file: %s\n", aFileName);
       return -1;
   }

   CHECK_RETVAL(a664ESConfigureEx(esHandle, configurationFile));
   printf("Device configured successfully!\n");
```

# AIT Avionics Test Software Implementation

Same Implementation used for different databus'

- ARINC-429
- MIL-STD-1553
- ARINC-664
- Fibre Channel



# Summary

## AIT Avionics Databus Interface Products

ARINC-429, MIL-STD-1553, ARINC-664/AFDX, Fibre Channel

- Embedded
  - IP CORE
  - Boards (PMC, XMC, PC/104)
- Test and Simulation
  - Boards (PCI, PXI, USB)
  - Multiple Operating System Support
  - NI resells AIT's PXI Products
- All Avionics Interface Products include a Software Development Kit
  - Common Configuration Database
  - Simple one function for End-System(s) setup – Easy integration
  - Includes software toolsets for easy development and integration
    - Savings of up to 65% of application code
    - Software re-use across projects (no end-system specific software)