



IntelliBus Network Systems

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INTELLIBUSTM
NETWORK SYSTEMS

The IntelliBus Solution



The Solution

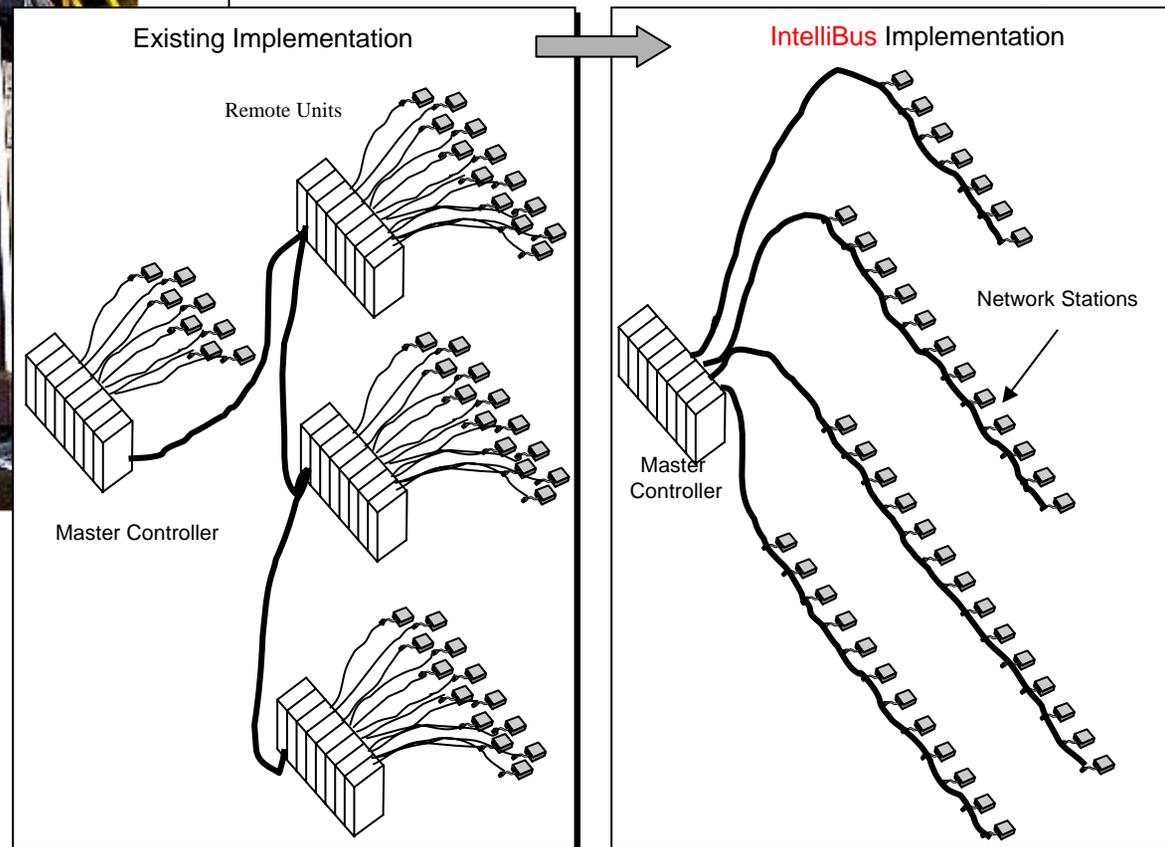
The Problem



Issues:

- Cost (design, material, support)
- Weight & Complexity of Wiring
- Reliability & Performance
- Efficiency of Data Management

- 25% Hardware Cost Savings
- 40% Wire bundle fabrication
- 50% Weight reduction
- 12% Reduction mechanical & electrical design



The Mission of IntelliBus



“By creating common standards, the primary impediment to networking the growing number of sensors and actuators will be removed, resulting in an accelerated adoption rate into new applications and technologies”

- Designed to control and monitor sensors, actuators, and subsystems on a single 2-wire bus.
- Originally developed for In-Vehicle Health Management and & Flight/Ground Test applications
- IntelliBus has won it's way onto Boeing platforms such as J-UCAS, F-15 Training Systems, Multi-mission Maritime Aircraft.
- Outside suppliers are licensing the IntelliBus IP and designs to create and produce the IntelliBus hardware and software products
- New licensees will help standardize the technology, provide lower cost products



IntelliBus Network Interface Controller (INIC)



- IntelliBus bus controller (Bus Master)
- Runs network schedule & membership service functions
- Provides synchronous trigger time-base
- Multiple NICs creates a scalable system
- Multiple form factors
 - cPCI with Ethernet streaming port, PMC, PCI, PCMCIA, L3 NetDAS, and Ethernet (end of 2006)



cPCI NIC



PMC NIC

L-3 Communications NetDAS unit & IntelliBus NIC



PCMCIA NIC



Gen 3 PCI NIC

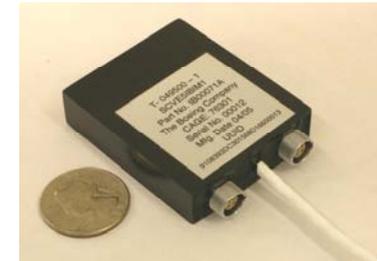
IntelliBus Interface Module (IBIM)



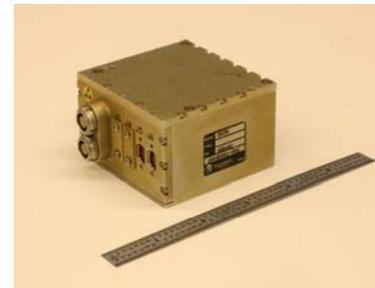
“IBIMs provide interfaces to a very wide variety of sensors and actuators”.

- IntelliBus Network Device Interface (NDI)
- Analog IBIMs:
 - strain gages, accelerometers, pressure transducers / scanners, thermocouples, synchro / resolver, vehicle voltages/currents/frequencies.
- Digital IBIMs
 - Mil-Std-1553, ARINC 429, CAN bus, Digital Discretes.
- Single or multi-channel modules based on needs
- Channels have simultaneous sampling capability
- Smart sensors provide additional options

MMA 1 ch IBIM



L3 8 ch IBIM



12 ch Thermocouple IBIM



TSS Trainer IBIM

JUCAS 2 ch CAN IBIM

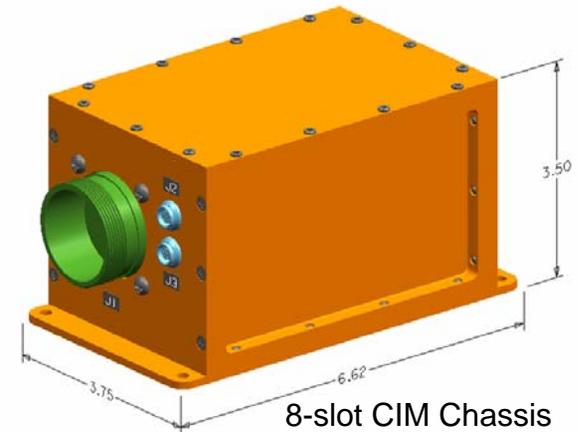
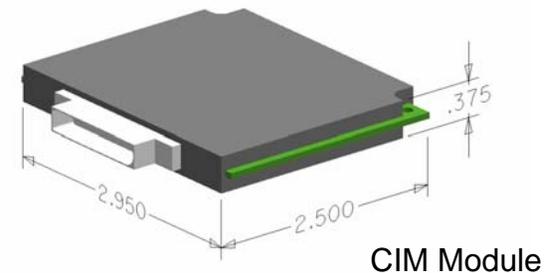


IntelliBus Chassis Interface Module (CIM)



“CIMs provide a method to have high concentrations of signal conditioning channels on an IntelliBus bus”.

- Basically IBIMs in a chassis.
- Analog CIMs:
 - strain gages, accelerometers, pressure transducers / scanners
- Digital CIMs
 - Mil-Std-1553, ARINC 429, CAN bus.
- Entire chassis is one bus load
- Chassis can contain up to 8 CIM modules.
- Typically each CIM supports 3 IntelliBus Channels

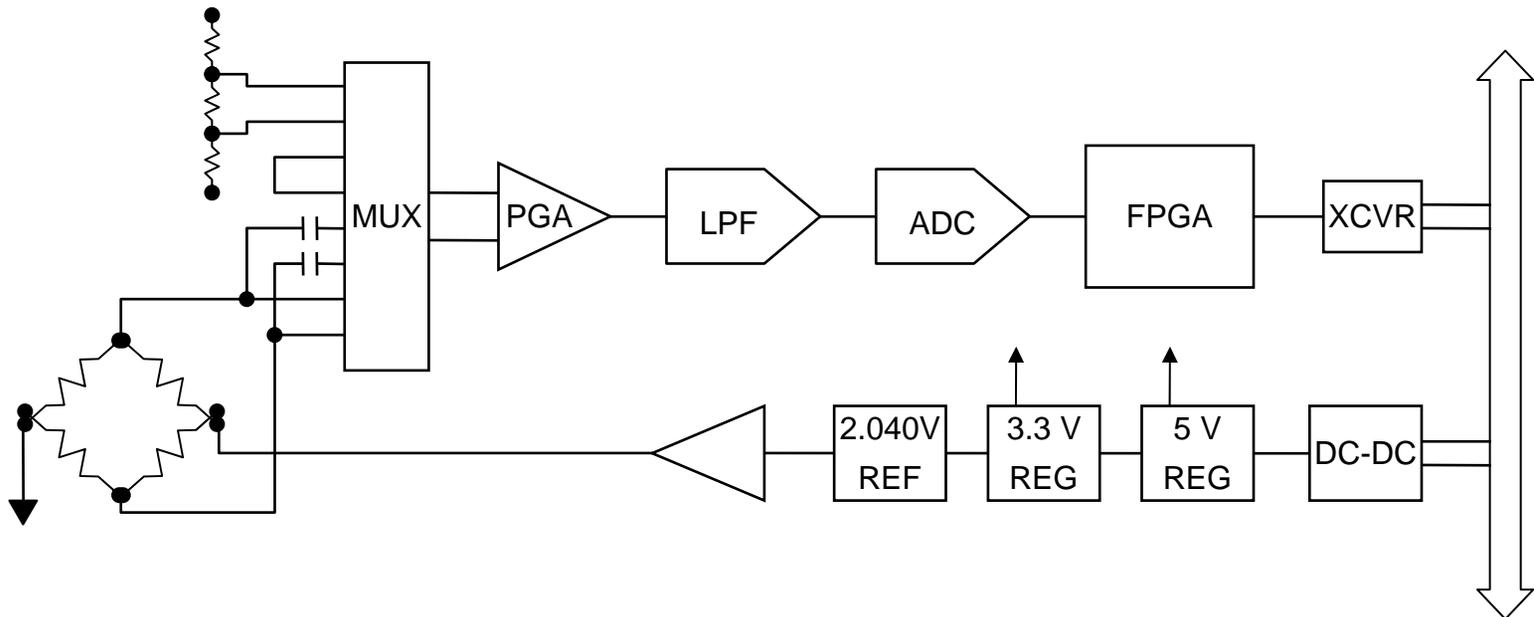
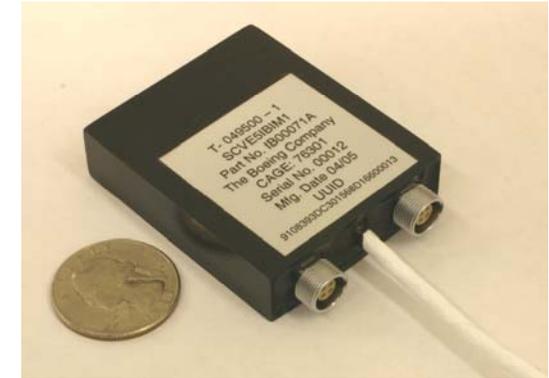


MMA IntelliBus Signal Conditioning IBIM



The IBIM design integrates into a single package:

- Programmable Gain Amplifier (PGA)
- Programmable Low Pass Filter (LPF)
- Precision voltage excitation
- Integrated power supply
- IntelliBus compliant digital protocol processor



Boeing IntelliBus Suite of IBIMs and CIMs



SCVE5I1	1 Channel pigtailed Bridge IBIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCVE5I3	3 Channel pigtailed Bridge IBIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCVE5BI3	3 Channel pigtailed $\frac{1}{4}$ bridge IBIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCVE5C3	3 Channel Bridge CIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCVE5I6	6 Channel pigtailed IBIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCVE5BI6	6 Channel pigtailed $\frac{1}{4}$ bridge IBIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCVE15I3	3 Channel Transducer IBIM,	$\pm 5/10V$ input with $\pm 15/26V$ excitation
SCVE15C2	2 Channel Transducer CIM,	$\pm 5/10V$ input with $\pm 15/26V$ excitation
MVE5I1	1 Channel Acoustic Microphone IBIM,	$\pm 2.5/5V$ input; $\pm 2.5/\pm 5$ volt excitation
SCCE4I3	3 Channel Current Excitation IBIM,	4 mA
SCCE4C3	3 Channel Current Excitation CIM,	4 mA
A429C3	3 Channel ARINC 429 Bus Monitor CIM	
DII32	32 Signal (1 Channel) Digital Input Monitor IBIM	
TCI16	16 Signal (1 Channel) Thermocouple IBIM	
SRI3	3 Channel Synchro/AC-VDT IBIM with AC excitation	
FFI	Fuel Flow tachometer IBIM with pressure and RTD input	
SCVI24	24 Signal (3 Channel) Aircraft Voltage Input IBIM, 300 Vrms Input	
CANI2	2 Channel CAN RT/BM IBIM	
AVI1	1 Channel MPEG2 Video/Audio IBIM	

Analog IBIM/CIM Specifications



	SCVE5	SCVE15	MVE	SCCE4	TCI16
Use	Full/1/4 Bridge, Piezo-Resistive, Capacitive	Capacitive, Servo, DC VDTs	Acoustic Microphone	PEIE	Thermocouples
IBIMs	1, 3, and 6 Ch	3 Ch	1 Ch	3 Ch	16 signals (1 ch)
CIM	3 Ch	2 Ch	na	3 Ch	na
Input	±2.5, 0-5 volt	±5, 0-10 volt	±2.5, 0-5 volt	±2.5, 0-5 volt	J, K, E, T
Coupling	AC (200KΩ, 2.35uF) or DC (100MΩ) Differential	AC (200KΩ, 2.35uF) or DC (100MΩ) Differential	AC (200KΩ, 2.35uF)	AC (200KΩ, 2.35uF)	
Excitation	CV; ±2.5, ± 5 volt; 20 mA	CV; ±15, 26 volt; 120 mA	CV; ±2.5, ± 5 volt; 20 mA	CC; 4mA, 20 vdc compliance	
Filter	6P Butterworth	6P Butterworth	6P Chebyshev	6P Butterworth	Butterworth
Filter Steps	14, 48, 120, 360, 2390 Hz	14 Hz			
Gain Steps	1, 2, 4, 8, 10, 20, 40, 80, 100, 200, 400, 800	1, 2, 4, 8, 10, 20, 40, 80, 100, 200, 400, 800	1, 2, 4, 8, 10, 20, 40, 80, 100, 200, 400, 800	1, 2, 4, 8, 10, 20, 40, 80, 100, 200, 400, 800	

Analog IBIM Performance Specifications



COMMON MODE REJECTION:	> 90 dB CMRR @ DC
CROSSTALK:	Better than -90 dB
SYSTEM GAIN ACCURACY:	< $\pm 0.3\%$ total error at all gains, AC or DC coupling, over temperature.
AC OFFSET DRIFT	< 2% span error over temperature
FILTER ACCURACY:	<ul style="list-style-type: none"> • ± 0.15 dB to $0.7f_c$, • $+ 0.15 / -0.17$ dB to $0.8f_c$, • $+ 0.15 / -0.22$ dB to $0.85f_c$ amplitude match and • ± 5 degrees phase match to $0.85f_c$ of theoretical Butterworth response. • 0.5 dB attenuation point at $0.85f_c$. • > 60 dB anti-alias protection
CODING:	Offset binary 16-bit integer plus valid data bit
SAMPLE RATE:	<ul style="list-style-type: none"> • Up to 100 KSPS per channel (filters limit useful sample rate). • Simultaneous sample ($< \pm 9$ nS cycle-cycle and period jitter). • Channel sample rates independent.
RESOLUTION:	16-bit SAR conversion
TEMPERATURE	-55 to +93 degrees C (-67 to +199 degrees F) case temp operating

IntelliBus Bus Performance Specifications

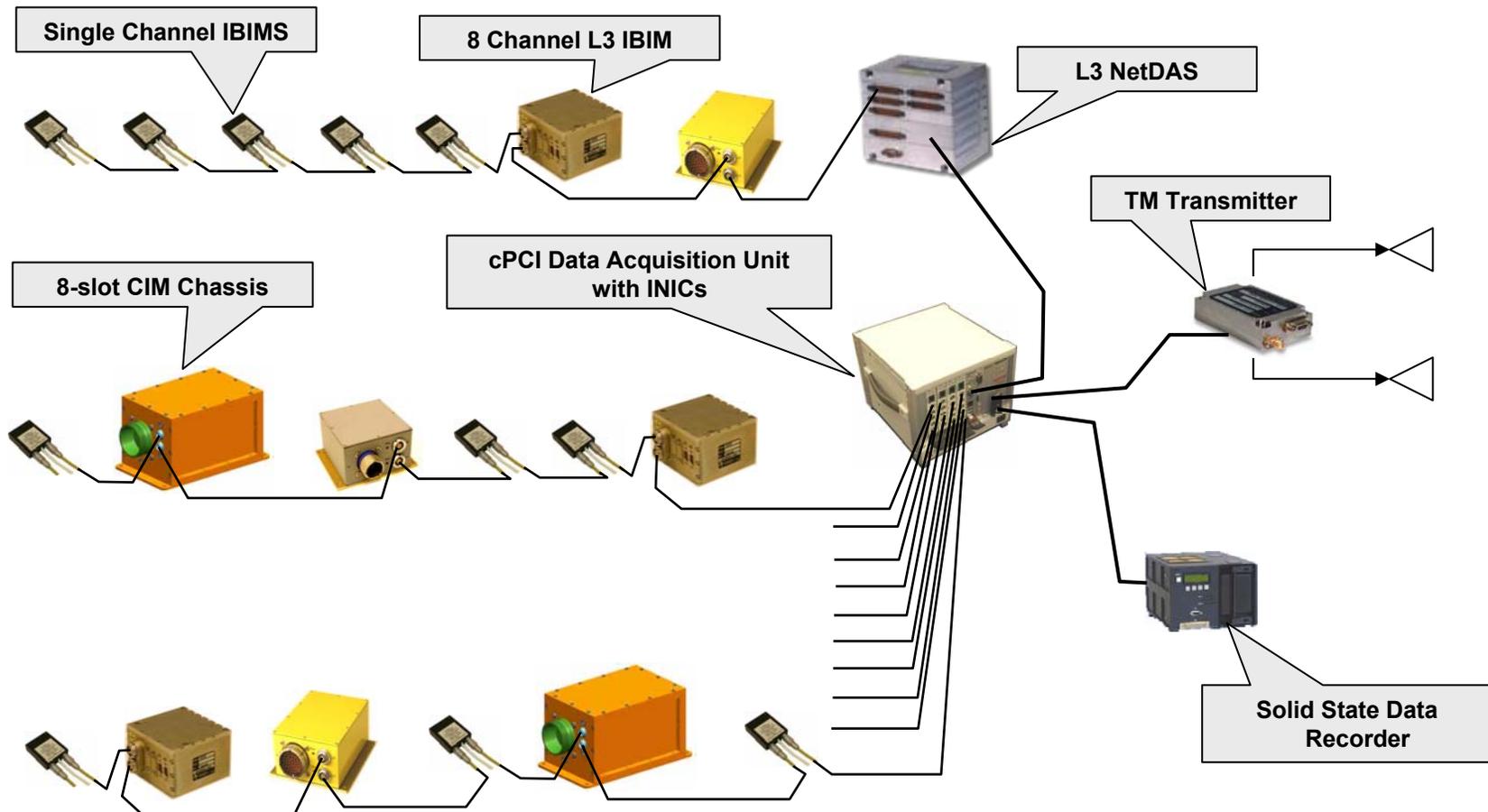


Feature	Description
Network Bit Rate	7.5, 15, and 30 Mbps Isochronous
Number of Physical Channels	PHY Layer Dependent (32 nodes MLVDS, 64 nodes RS-485)
Number of Logical Channels	510 (512 total; Address 0 is global, 512 is null)
Fault Avoidance Error Detection	Sync, Parity, Message Time Out, and Invalid Data Flag Bit
Membership Services	Device Inventory and Plug and Play through null detection
Info-Centric	Client supported function catalog, EDS and boot
Physical Topology	Half-Duplex, Serial Multipoint
Physical Devices vs. Distance	25 nodes at 600 feet to 64 nodes at 300 feet (15 Mbps)
Cabling	(2) Shielded-Twisted-Pairs (STP) data & power
Distributed Bus Power	28 vdc nominal (12 to 32 vdc operating range), 7 Amps
EMC Compatibility	FCC, MIL-STD-461, ANSI/IEEE-C63.14
Environmental Compliance	MIL-STD-810

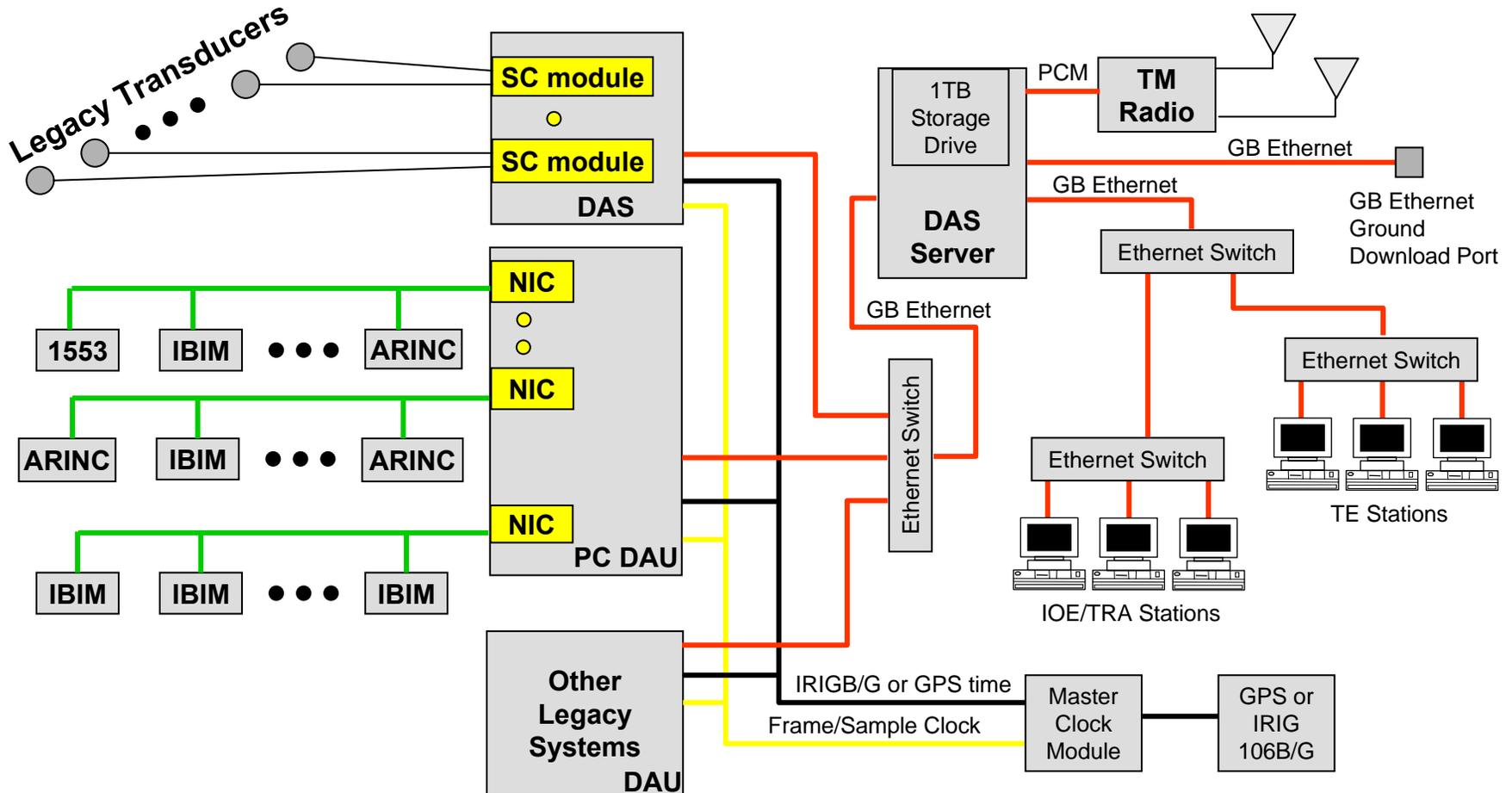
IntelliBus Data Acquisition Illustration



“The IntelliBus architecture adapts to many types of smart networkable devices from smart sensors to high channel count chassis”



Typical Data Acquisition Architecture

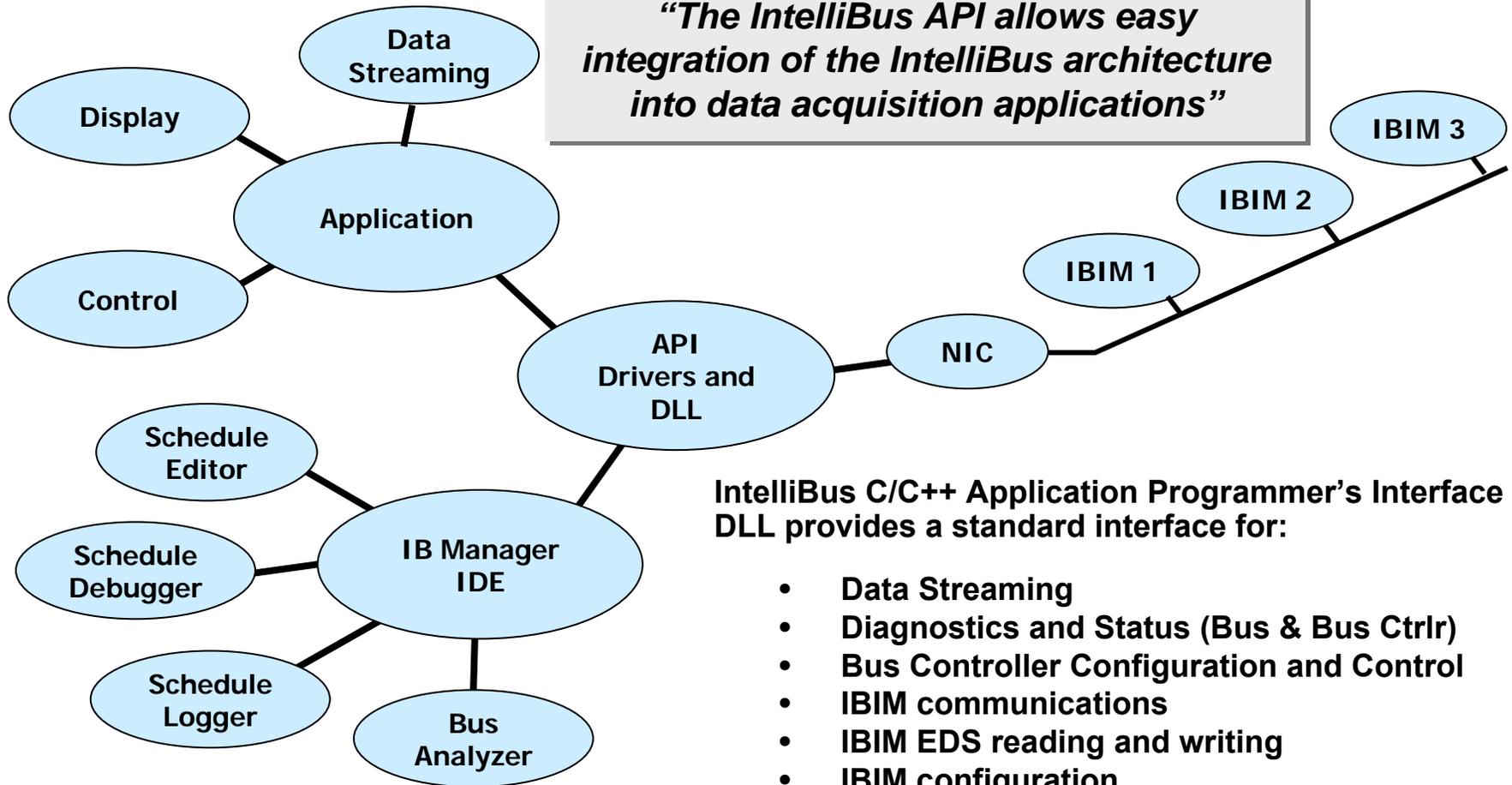


- System wide time stamp synchronization using distributed IRIG106B/G or GPS time
- System wide sample synchronization using frame and sample clock signal.
- Data transferred over Ethernet

IntelliBus Software Architecture



“The IntelliBus API allows easy integration of the IntelliBus architecture into data acquisition applications”



IntelliBus C/C++ Application Programmer's Interface DLL provides a standard interface for:

- **Data Streaming**
- **Diagnostics and Status (Bus & Bus Ctrlr)**
- **Bus Controller Configuration and Control**
- **IBIM communications**
- **IBIM EDS reading and writing**
- **IBIM configuration**
- **Schedule loading**

DLL and IB Manager Development Environment



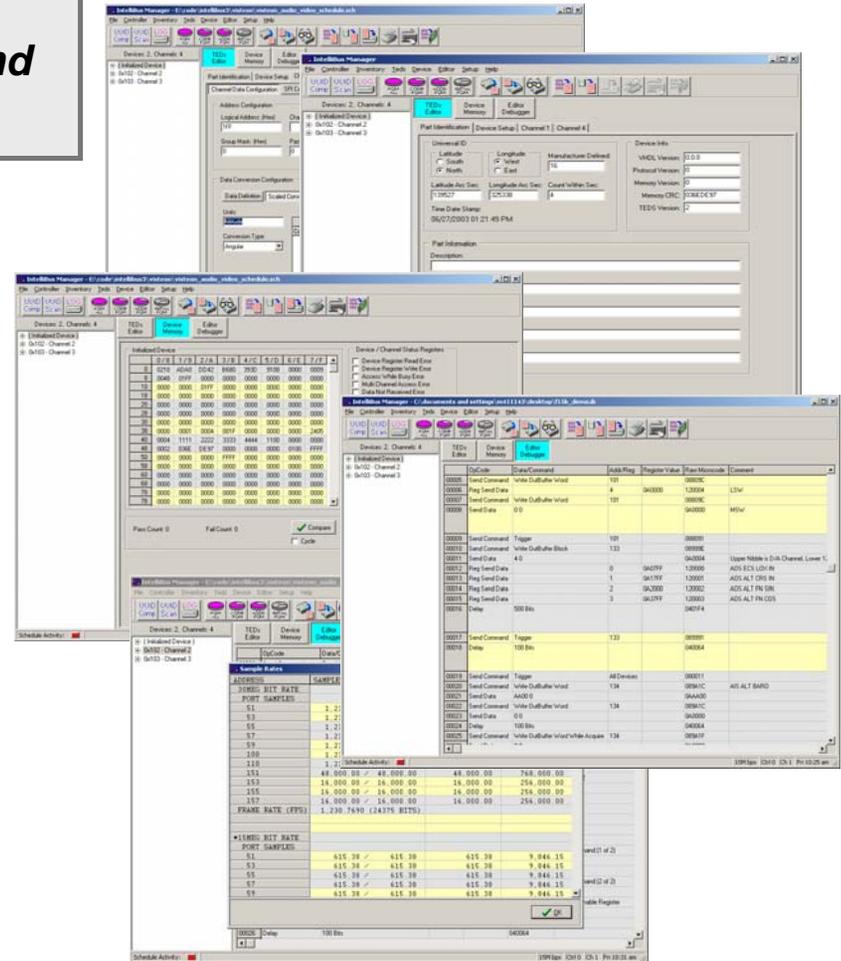
“IntelliBus software tools accelerate the development, debugging, testing, tuning and deployment of IntelliBus Networks”

C/C++ DLL Development libraries API

- High and low level routines for data conversion, data acquisition, and schedule integrity.
- Direct access to hardware allowing custom control of network and configuration.

IBManager IDE

- Built on API
- IBIM/CIM personality programming
- Schedule creation/error analysis
- schedule debugging/real-time monitoring/simulation
- network/system analysis.



IntelliBus Program Applications



- **F-15 Training Systems/Simulators Network**
 - Panel switches, discrete I/O, analog I/O, and gages
 - 1600 I/O on single IntelliBus network
 - Delivered 15+ crew station & maintenance trainers

- **J-UCAS X-45C In-Vehicle Health Management (IVHM)**
 - Sensor and subsystem monitors for IVHM
 - Delivered flight qualified hardware for X-45C

- **Automotive Test**
 - Sensor hardware & software for automotive test
 - Delivered first thermocouple system in 2Q '05



Training Systems Cockpit I/O Network



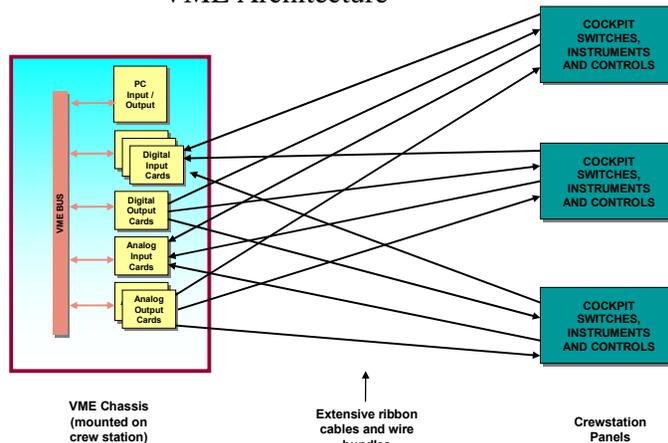
F-15C Crew Station Cockpit Trainer
With convention VME Rack I/O system



F-15K Crew Station Cockpit Trainer
With IntelliBus Network Electrical System

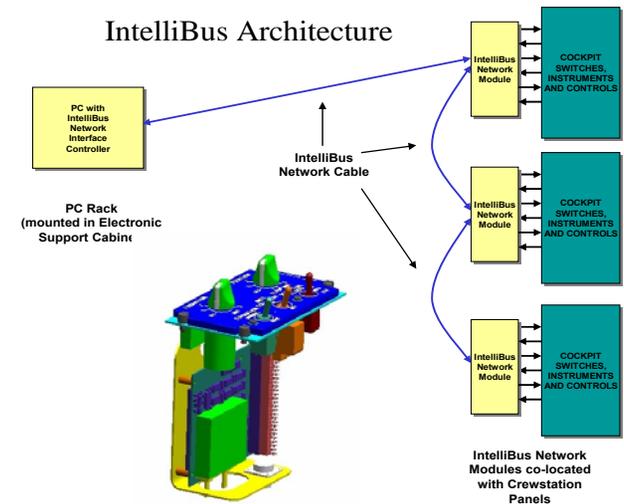


VME Architecture



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IntelliBus Architecture



IntelliBus Program Applications



➤ MMA Flight Test and Ground Test System

- Entire analog sensor, digital, & video instrumentation suite
- Over 6000 analog parameters on a single system
- First production systems will be delivered Q3 2006



➤ Automotive & Industrial Automation

- Worked collaborative automotive projects for in-vehicle networking & entertainment systems
- Worked collaborative development program addressing both aerospace IVHM and industrial control applications.



➤ Aeroflex UTMC IC Supplier

- Highly integrated IntelliBus NDIs
- Developing 2, 5, and 9 channel ASIC 3Q 2006
- Developing 32 channel filtered ADC version in 1Q 2007



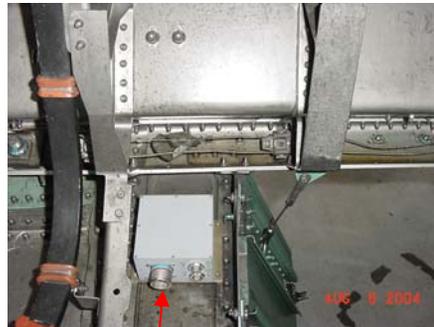
F-15E Oil Sensor with IntelliBus IBIM & NIC



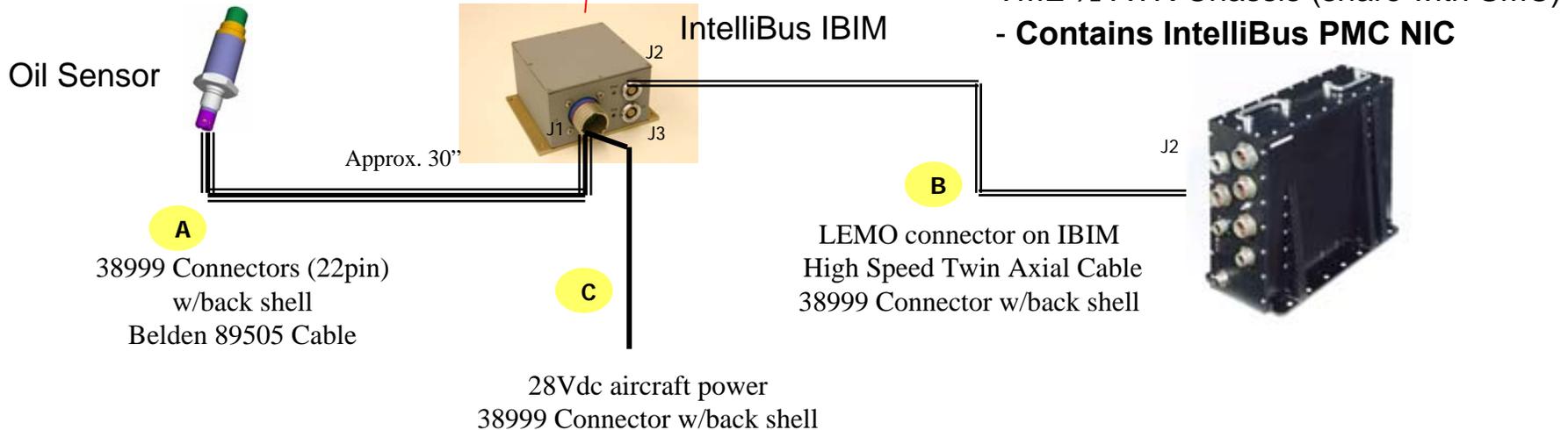
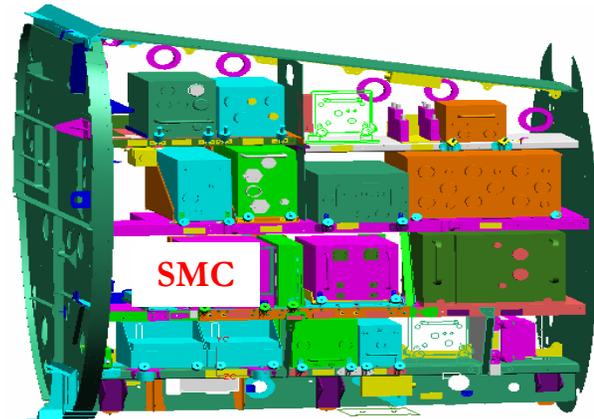
JOAP Port Engine Oil Manifold



R/H Forward Engine Bay



Right Hand Side Nose Barrel



IntelliBus NDI ASSP (Application Specific Std Product)



- Targeted for smart sensor and small IBIM applications
- Single 3.3 VDC supply, 5 volt tolerant.
- Built in programmable trigger-based clock multiplier regenerator PLL.
- Built in 8 kbyte non-volatile flash memory including memory protection.
- 2, 5, and 9 channel variants, available 4Q06
- ASIC with integrated A/D plus filters planned for same foundry run

	Aeroflex ASSP Part Number			
	AX30NDI02-Q56	AX30NDI05-B100,- L100	AX30NDI09-B144	Protocol
Package Type	QFN56	BGA100, LQFP100*	BGA144	
# of Channels	2	5	9	16
SPI/I2C Ports	1	1	1	
SPI/I2S Ports	1	3	4	
SPI/UART Port		1	1	
SPI Only Port			3	
FIFO Depth/ch	16 words	16 words	16 words	64K words
Ext Flags	2	2	2	2 / channel
Service Flags	8	8	8	8 / channel

* Not Pictured



2ch, QFN56



5ch, BGA100



9ch, BGA144

IntelliBus Licensees

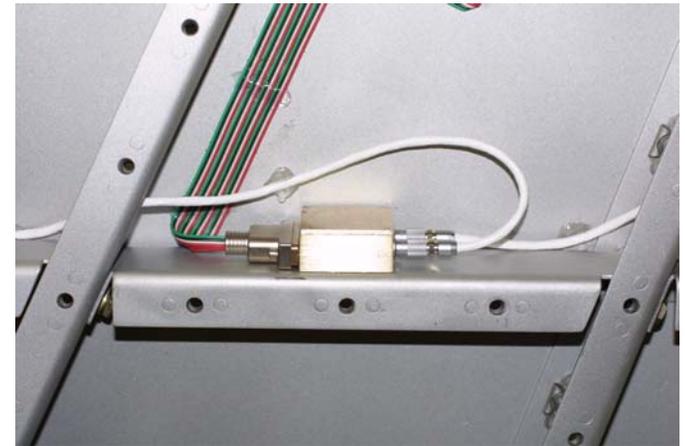


communications

INS Technology



- **Communication, and EDS Protocol**
 - **NDI – Network Interface Client Logic Core**
 - **NIC – Network Bus Controller Logic Core**
 - **Common Serial Interface Logic Cores**
 - **NIC Software Drivers and API**
 - **IBManager Integrated Developers Environment**
 - **UTP Automotive EMC Physical Layer**
 - **STP Aero/Industrial Physical Layer**
 - **IBIM Reference Designs**
-
- **18 US Patents filed, 8 International**



“The INS technology introduces an innovative suite of hardware and software built around a philosophy of simple yet powerful and efficient communication.”

Summary



- Boeing owned IntelliBus IP assures long term availability
- IntelliBus IP available to Boeing suppliers
- Current IntelliBus licensees provides additional supplier alternatives
- IntelliBus core compatible with FPGA-based implementations
- ASIC implementation provides path to a low cost and miniature solution
- Family of IBIMs and NICs available today.
- New partners & licensees will generate new products and services

