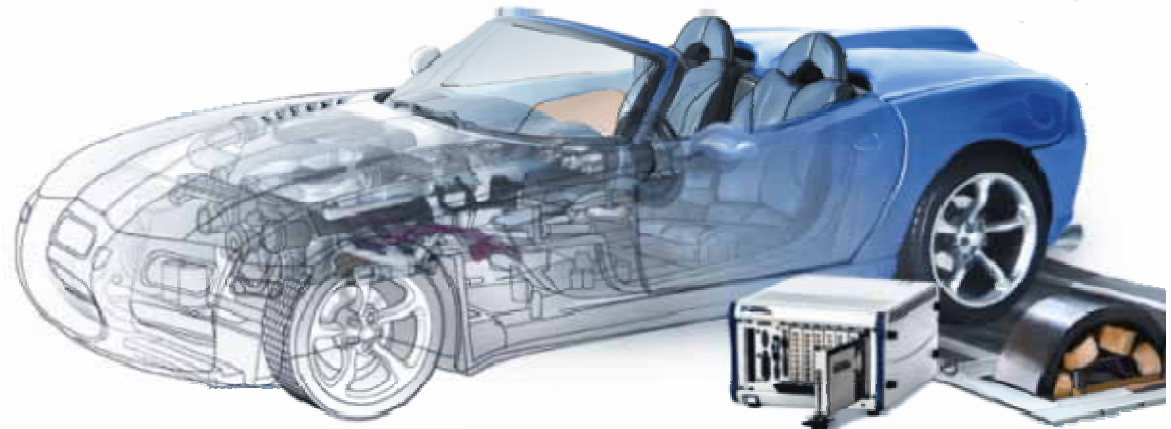


Using LabVIEW for Automotive Communications and Diagnostics

Tristan Jones
Technical Marketing Engineer

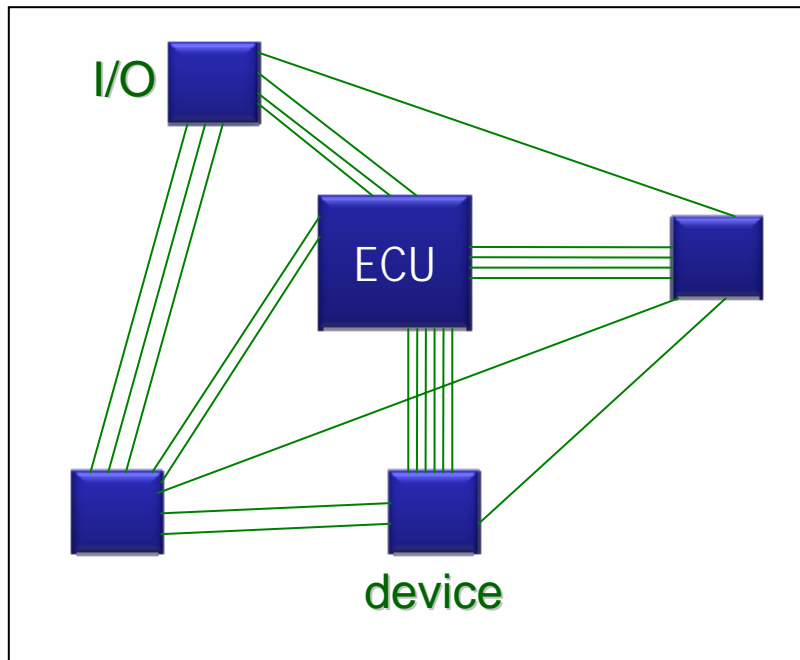


Agenda

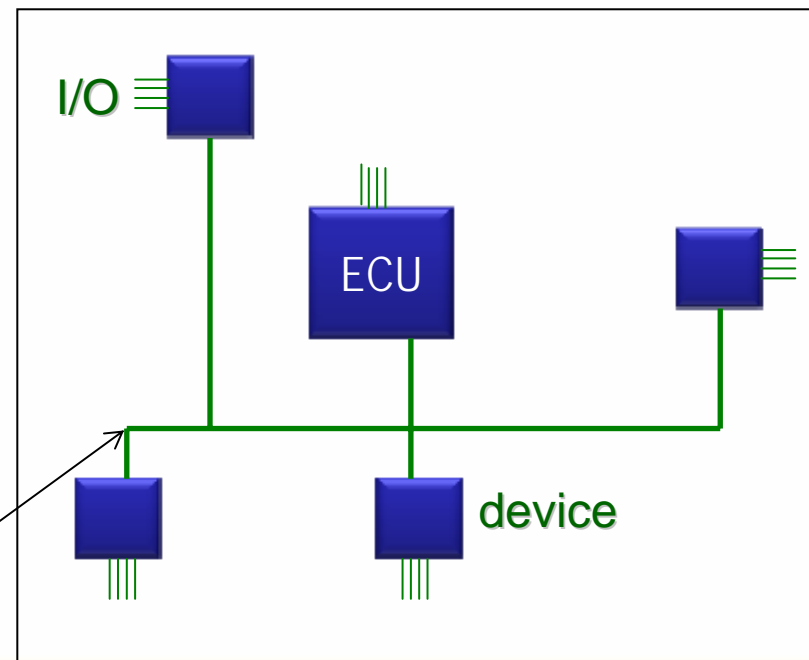
- Introduction to embedded networks
 - CAN, LIN, Flexray
 - National Instruments Hardware
- On-Board Diagnostics
- Conclusion

What are Embedded Networks?

Without Embedded Networks

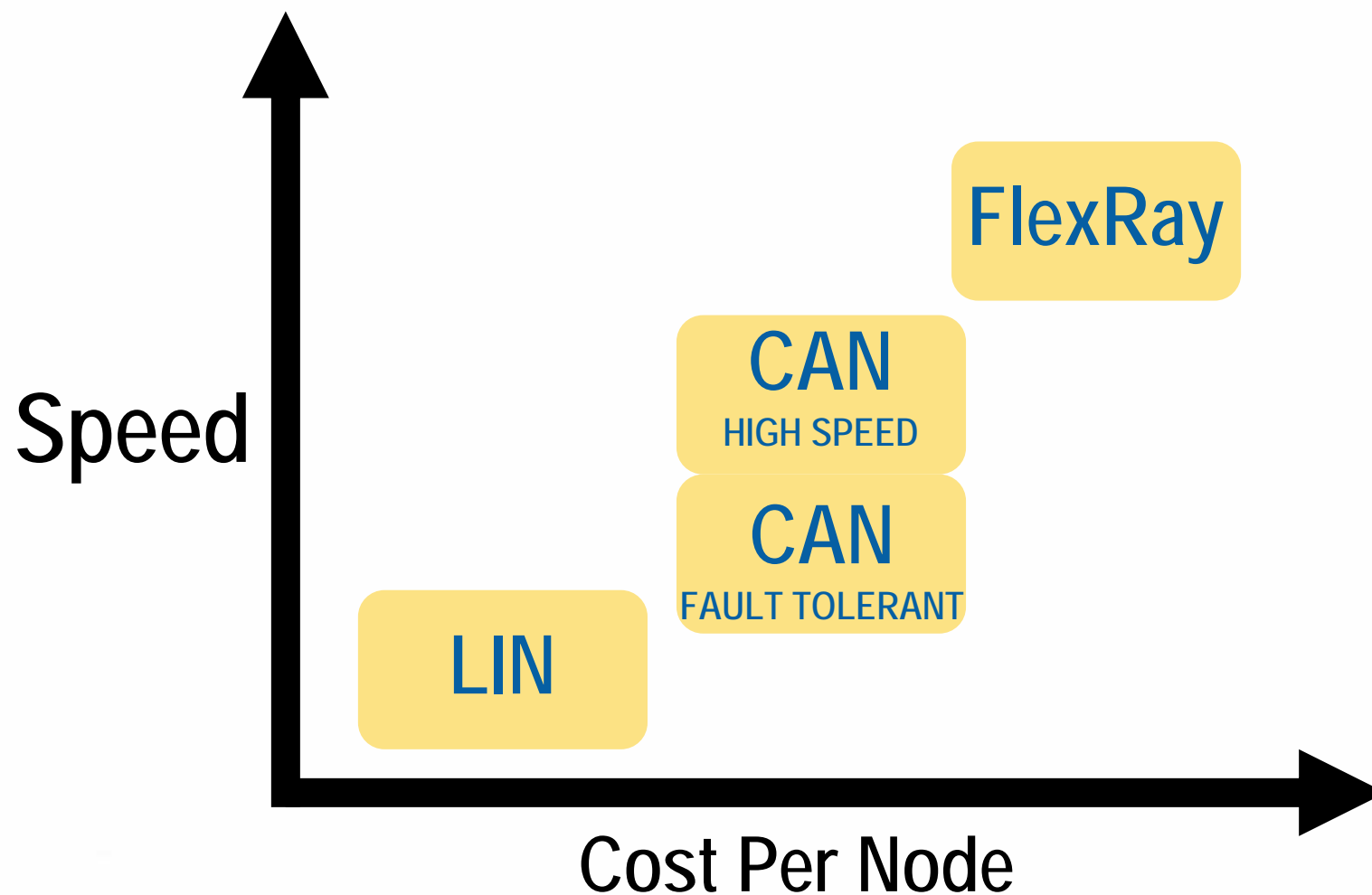


With Embedded Networks



Embedded Network Bus

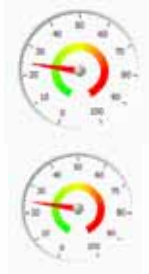
Scope of Automotive Embedded Networks



Controller Area Network (CAN)



Peer-to-Peer



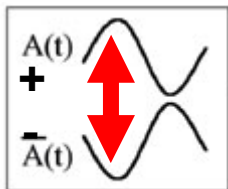
High Speed: 1 Mbps



Fault Tolerant: 125 kb/s

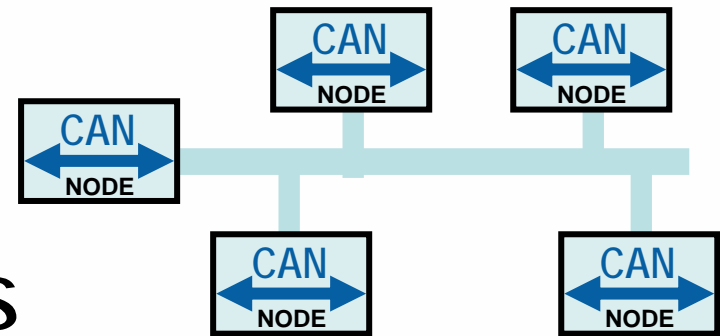


Medium Cost



Differential Signaling

Currently Most Popular



NI-CAN Driver Software

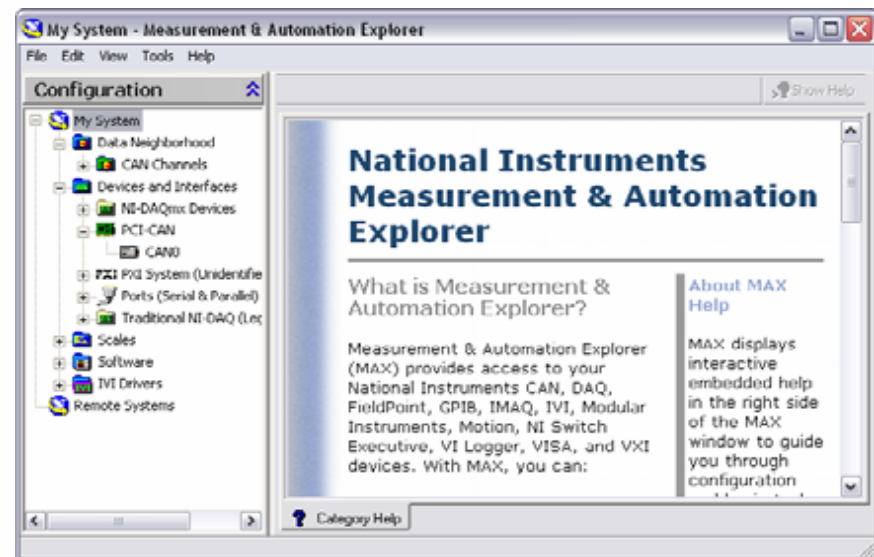
- Supports all NI PCI, PXI, and PCMCIA CAN Interfaces
- Supports LabVIEW, LabVIEW Real-Time LabWindows/CVI, Microsoft Visual Basic, Microsoft Visual C++, and Borland C/C++ programming environments
- Exposes 100% of the CAN interfaces functionality
 - Develop your own custom applications
 - 2 Built-in APIs
 - Frame API
 - Channel API

CAN Software

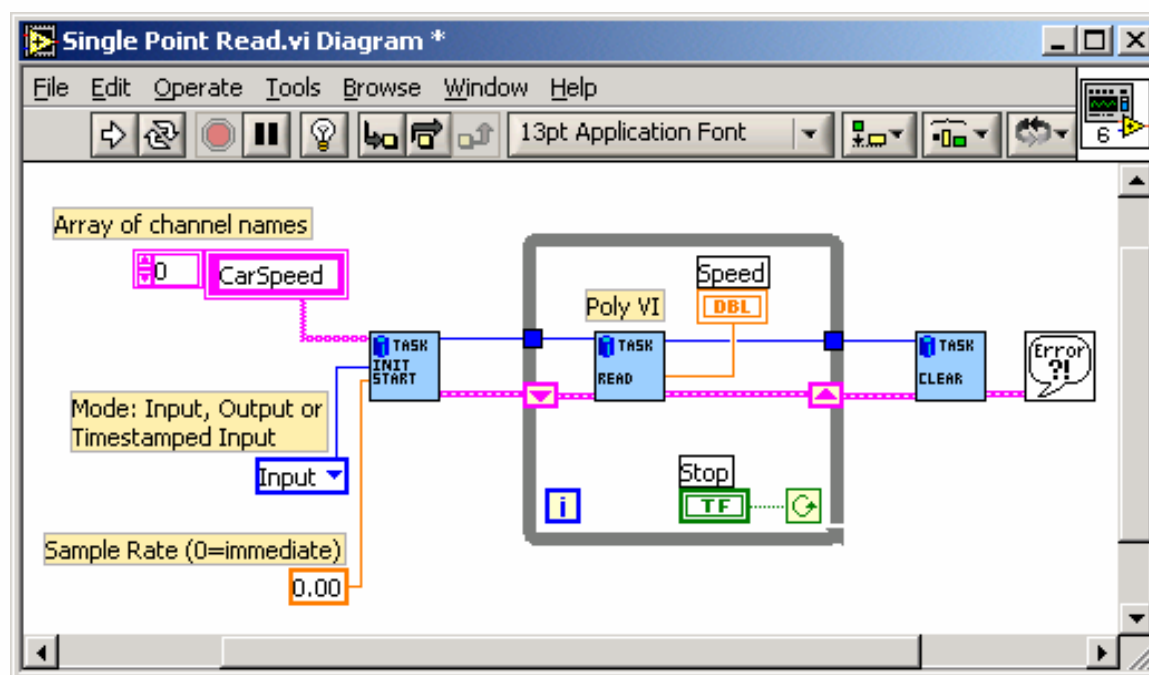
- CANopen LabVIEW Library
- Automotive Diagnostic Command Set
 - KWP2000, Diagnostics On CAN, ISO 15765-2,
- ECU Measurement and Calibration Toolkit
 - CCP and XCP

Measurement and Automation Explorer (MAX)

- Hardware and software configuration utility
- Import CAN database files (.dbc or .ncd)
- Create and edit CAN channels
- Test panel for CAN Channels
- CAN bus monitor utility
- Update National Instruments software



Quick Demo – Channel API



Local Interconnect Network (LIN)



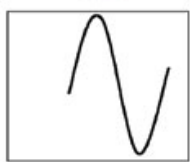
Master-Slave



20 Kbps



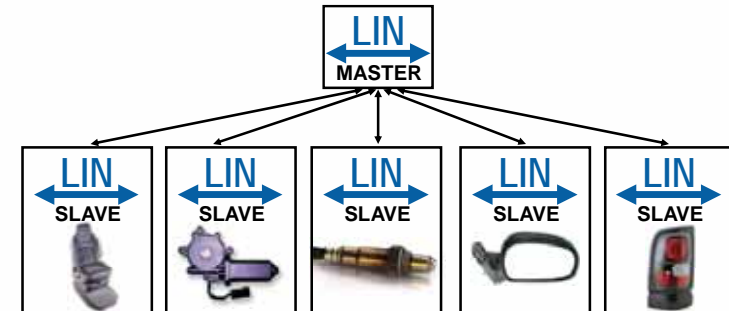
Cheap!



Single Wire

Similar to RS-485

New and Lightweight



GOOD: Low-cost USB-CAN/LIN (New!)



USB CAN and LIN

- Low-Cost solution starting at £215
- Offered in HS, LS, and LIN versions
- HW sync options available from £315
- **Frame API only**



USB CAN and LIN Targeted Applications

- Automotive
 - In-Vehicle Data Logging (Via MAX)
 - Bus monitoring
 - Automotive Diagnostics
 - OBD-II
 - Reading Trouble Codes
 - Initiating Tests
- Benchtop



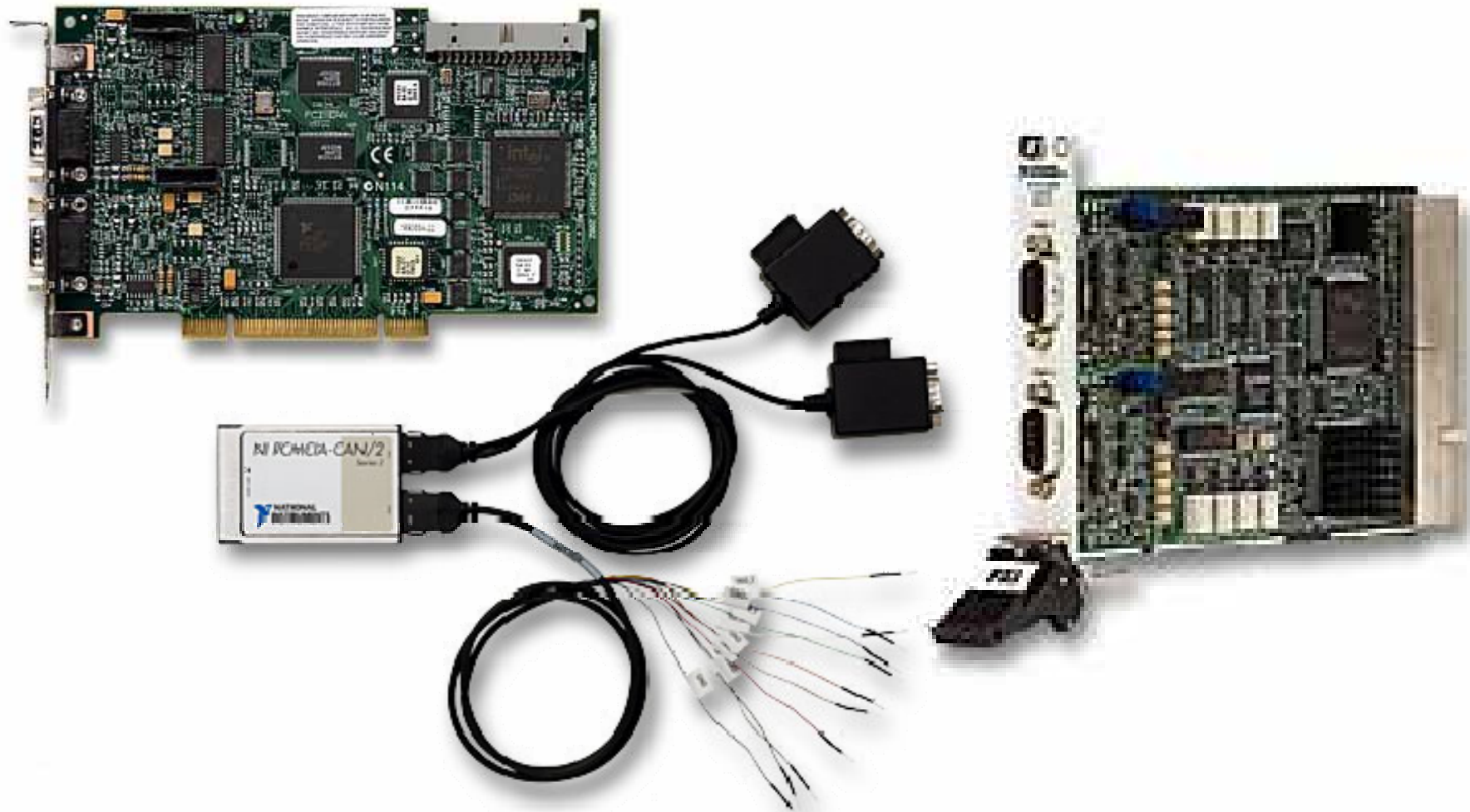
Synchronisation (USB-847xS models)



- 3-pin COMBICON connector
- Shared timestamp clock, and start trigger
- Slave: Auto detection of 20 Mhz, 10 Mhz, or 1 Mhz external clocks
- Master: Generates 1MHz clock



Better: Series 2 CAN

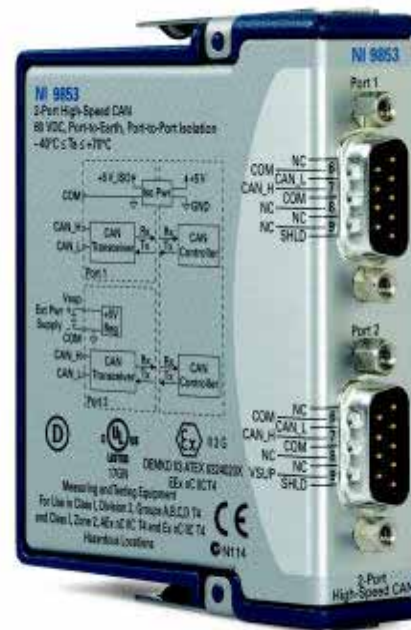


National Instruments Series 2 CAN Hardware

- High speed CAN
 - Max. Baud rate 1Mb/s
- Low speed/Fault-tolerant CAN
 - Max. Baud rate of 125kb/s
- Single Wire CAN
- Software Selectable CAN
 - High, Low, or Single Wire

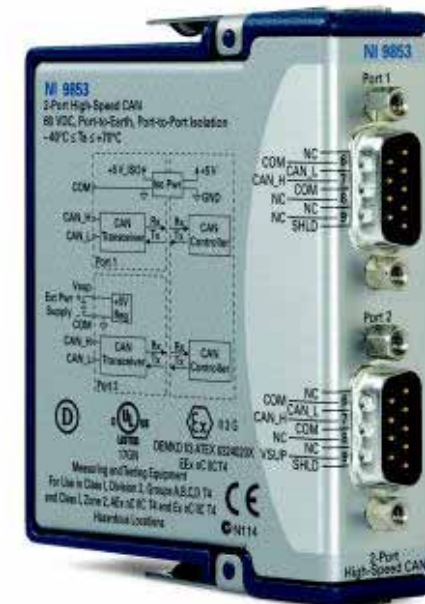


BEST: CompactRIO CAN module



CAN on CompactRIO

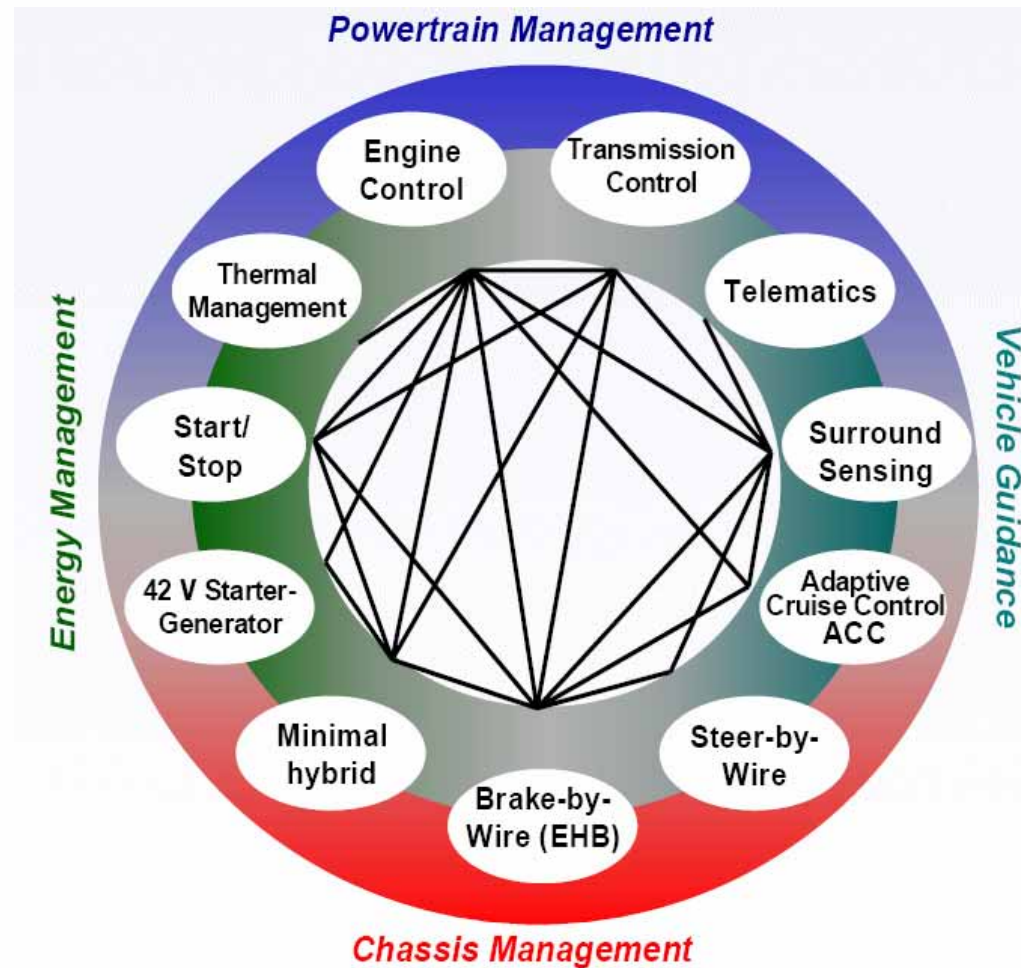
- 2 Port High-Speed & Low-speed CAN Modules
- Transmit / Receive 100% bus load at 1 Mbps
- ISO 11898-compliant for standard (11-bit) and extended (29-bit) arbitration IDs
- Hardware Synchronisation with any CompactRIO I/O Module



FlexRay



Increased Communication Across Subsystems



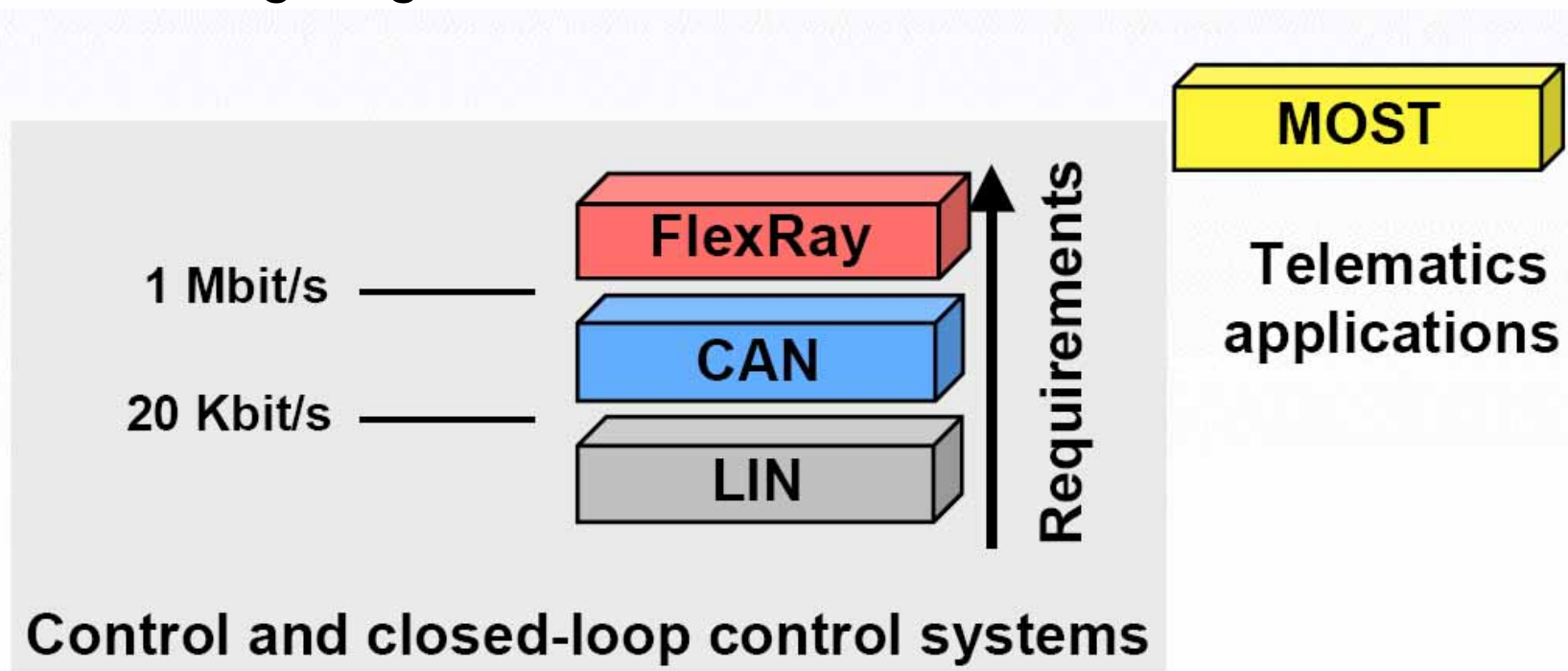
FlexRay History: 1990's



- CAN too limited for X-by-wire
 - Bandwidth: bits per second
 - Determinism: frame at precise time
 - Redundancy: tolerate failures in cable or ECU
- Assumption: Standard protocol
- Various contenders
 - TTCAN, TTP, Byteflight, ...
 - Byteflight used as basis of FlexRay 1.0 standard

Will FlexRay Replace CAN?

- No: Ongoing Cost/Benefit tradeoffs



BMW Ships First Car with FlexRay

- 2007 BMW X5
- AdaptiveDrive: Controls roll and dampening
- Uses single FlexRay channel



NI FlexRay Solutions

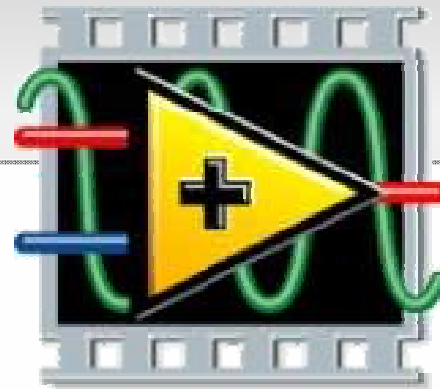
- Currently NI does not make FlexRay Interfaces
- Recommended boards:
 - TZM FlexRay PXI Interface
 - Used by MicroNova in BMW Engine Simulator



On Board Diagnostics (OBD)



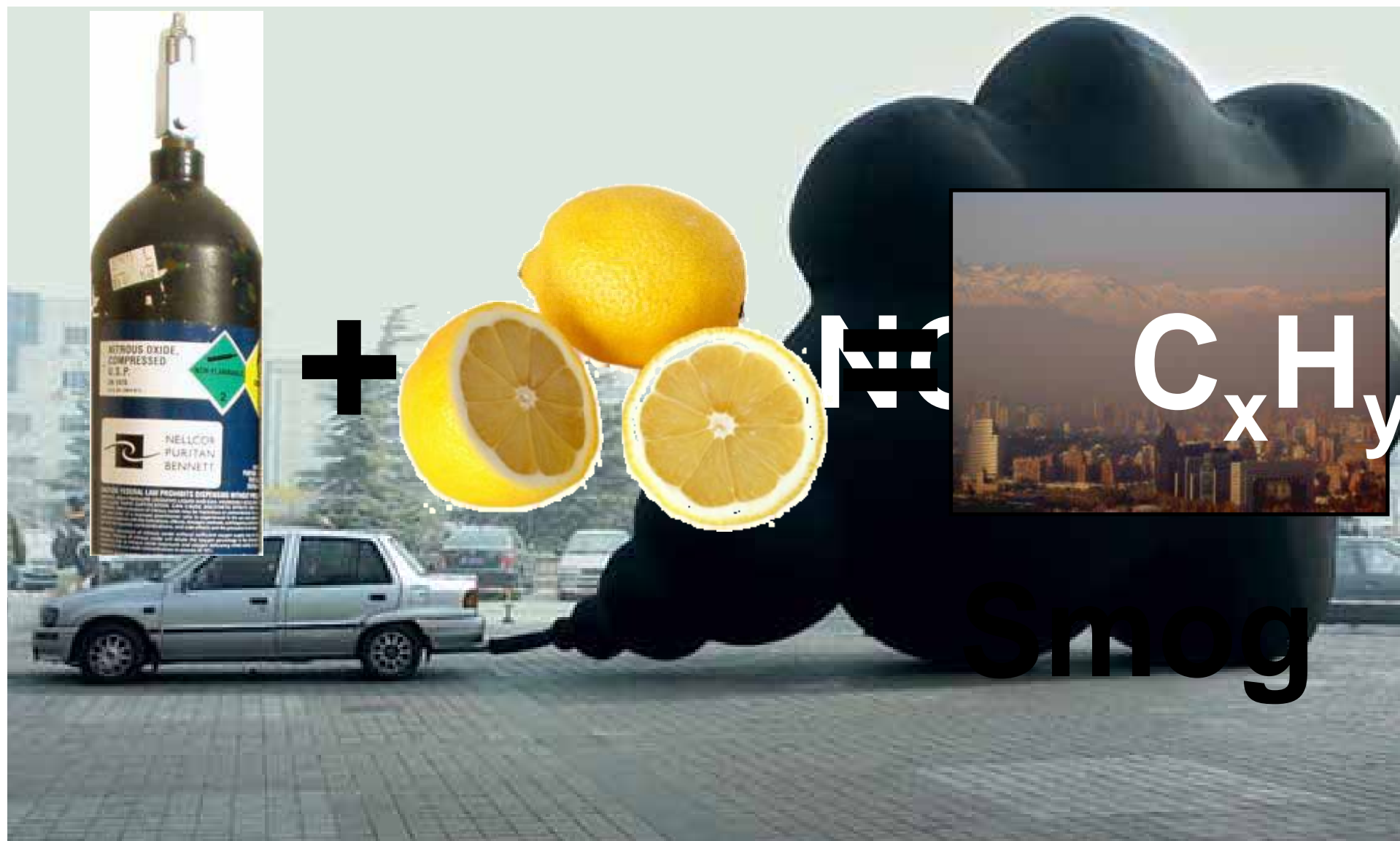
USB CAN
Interfaces

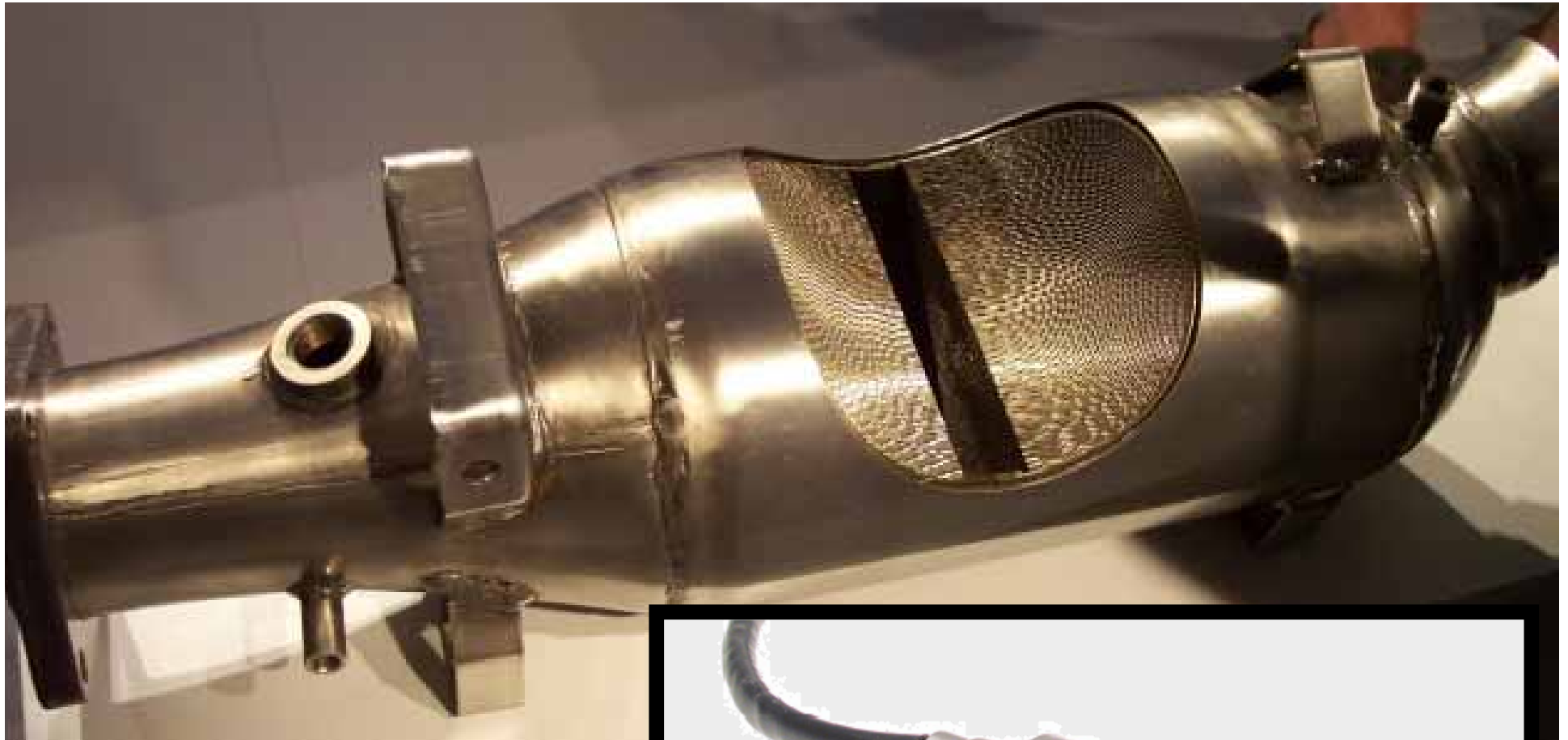


Automotive
Diagnostic
Command Set

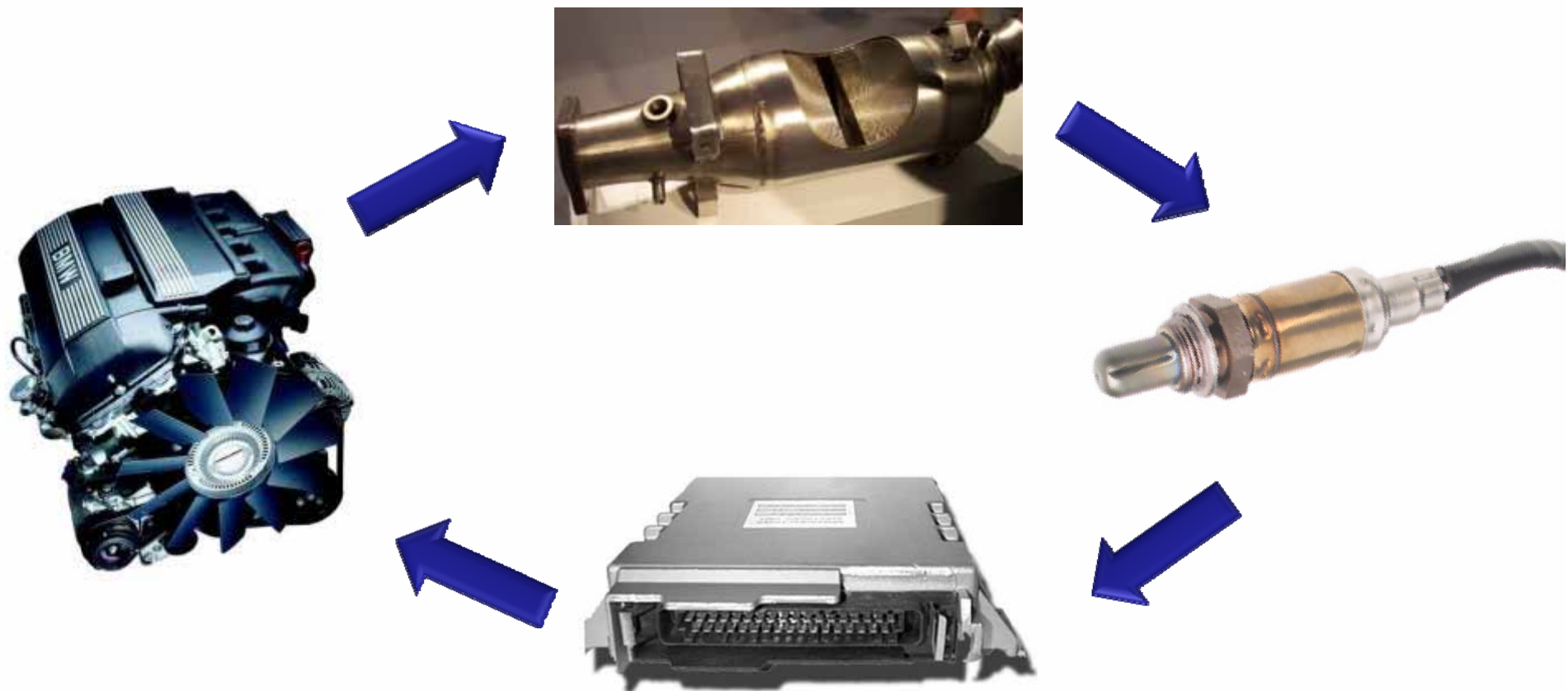








Closed-Loop Emissions System



Problem: How do regulators test and enforce functioning emissions systems?

Solution: On Board Diagnostics Standards

- Emissions
 - Move the testing from garage to the car
- Test tools
 - Reduce variety of tools & costs for repair centers
- Fringe benefits for Engineers
 - Universal access to engine parameters and trouble codes

History of On-board Diagnostics

- 1970 – Clean Air Act
- 1982 – GM OBD-I Systems
- 1988 – CARB OBD-1 Requirement
- 1996 – Federal OBD-II Requirement
- 2001 – EU adopts EOBD
- 2008 – CAN-based OBD-II

Diagnostics are good for Manufacturers...

- Longevity / accelerated testing
- Assist all testing procedures
- Diagnostic Trouble Codes
- Custom control of on-board devices
- Download ECU updates

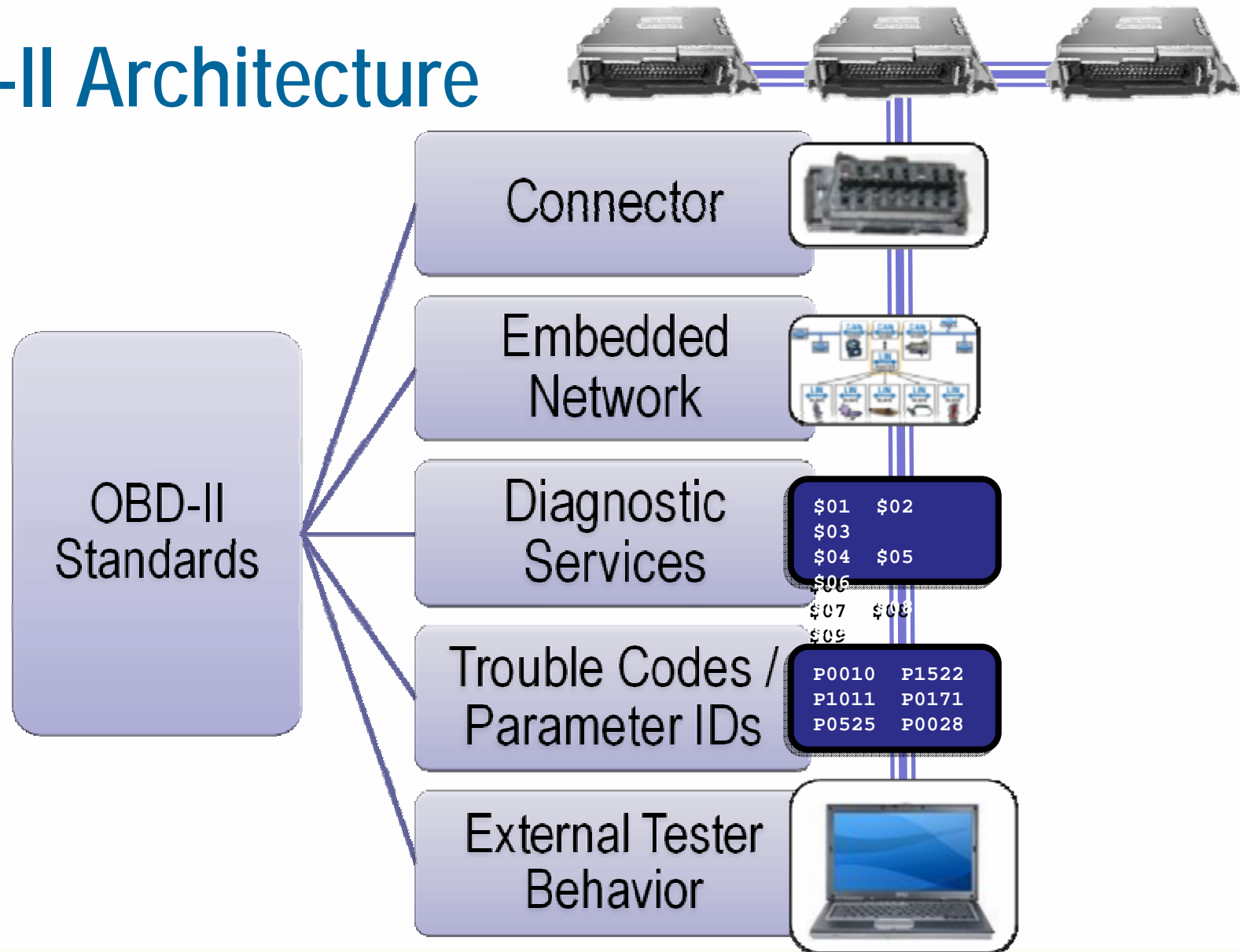
Diagnostics are good for the Aftermarket...

- Diagnostic Trouble Codes
- Logging vehicle data during tests
- Standard interface for all new automotives
- Wide Variety of data
- "Black box"

Not good for:

- Deterministic data
- High sampling rates (over 5-10 Hz)
- Model-specific data (without documentation)

OBD-II Architecture



Connector



Embedded
Network



Diagnostic
Services

\$01	\$02	\$03
\$04	\$05	\$06
\$07	\$08	\$09

Trouble Codes /
Reporting

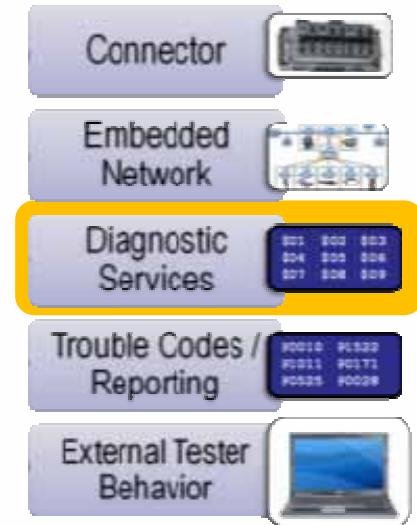
P0010	P1522
P1011	P0171
P0525	P0028

External Tester
Behavior



Diagnostic Services

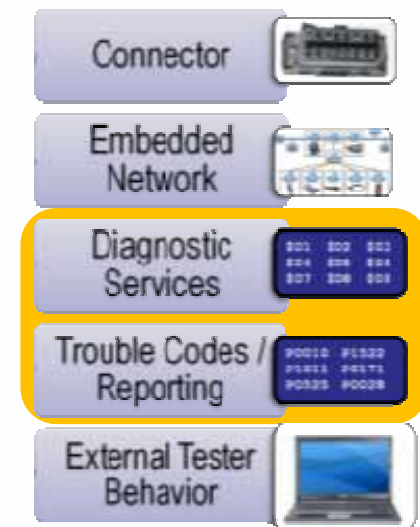
- Embedded Network Buses are simple:
 - 8-Byte Frames
 - No built-in large message handling
- What if we want to:
 - Not interrupt critical communications
 - Send messages, strings, or codes larger than 8 bytes?
 - Send new Firmware to the ECU?
 - Establish a session with the ECU?



Automotive Diagnostic Command Set

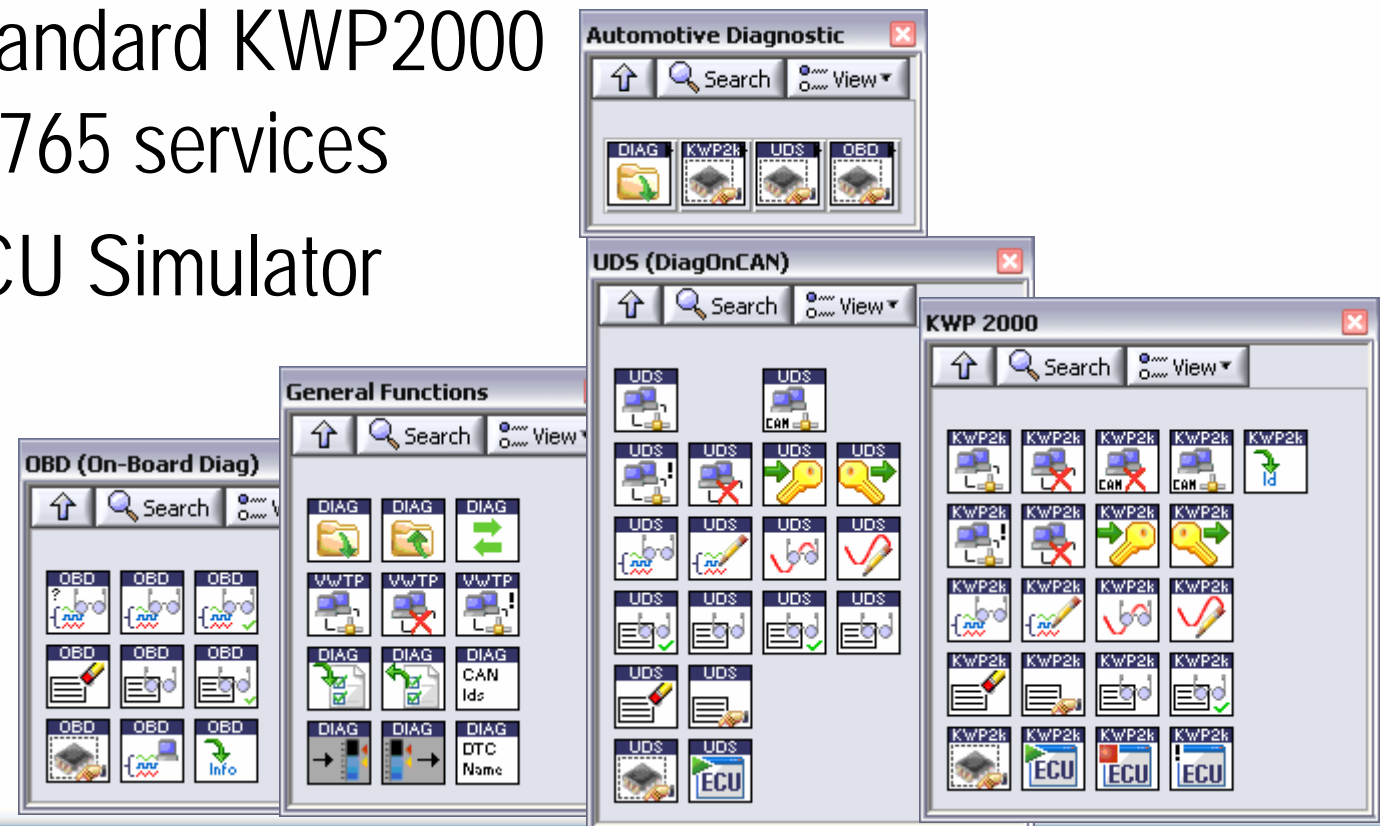


- Set of functions for automotive protocols
- Implement automotive diagnostic protocols in LabVIEW and C/C++
 - KWP2000 and Diagnostics On CAN
- Works with all NI CAN interfaces
- Develop and deploy custom diagnostic applications




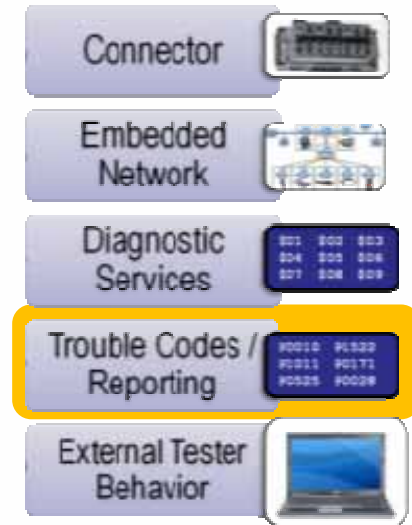
Automotive Diagnostic Command Set

- <http://ni.com/can/>
- Supports standard KWP2000 and ISO-15765 services
- Includes ECU Simulator example



Test Services

- SAE J1979 (ISO 15031-5): Defines test modes and parameters
- Services of interest:
 - \$01 – Get Real-Time Diagnostic Data
 - \$02 – Get Freeze Frame data
 - \$03 – Get Trouble Codes 
 - \$04 – Clear Trouble Codes
 - \$06 – Specific system monitoring Results
 - \$09 – Current Vehicle Information



Applications

- Real-time display of parameters not on dashboard
- Logging vehicle data
- Correlating vehicle data measurements to other measurements (Sound, Vibration, Acceleration, voltage, etc)
- Custom garage test-tools

NI Tools for Automotive Diagnostics



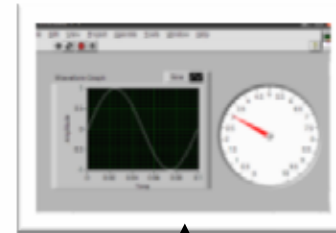
NI Automotive Diagnostic Command Set



NI USB-8473(s)
CAN interface



DB9 to J1962
adapter cable



Primary
Engine ECU





NATIONAL INSTRUMENTS

LabVIEW™



NI Automotive Diagnostic
Command Set



NI USB-8473(s)
CAN interface



DB9 to J1962
adapter cable



- Full compiled, graphical programming environment
- Target desktop, mobile, industrial, and embedded
- Thousands of out-of-the box mathematics and signal processing
- Seamless connectivity with millions of I/O devices

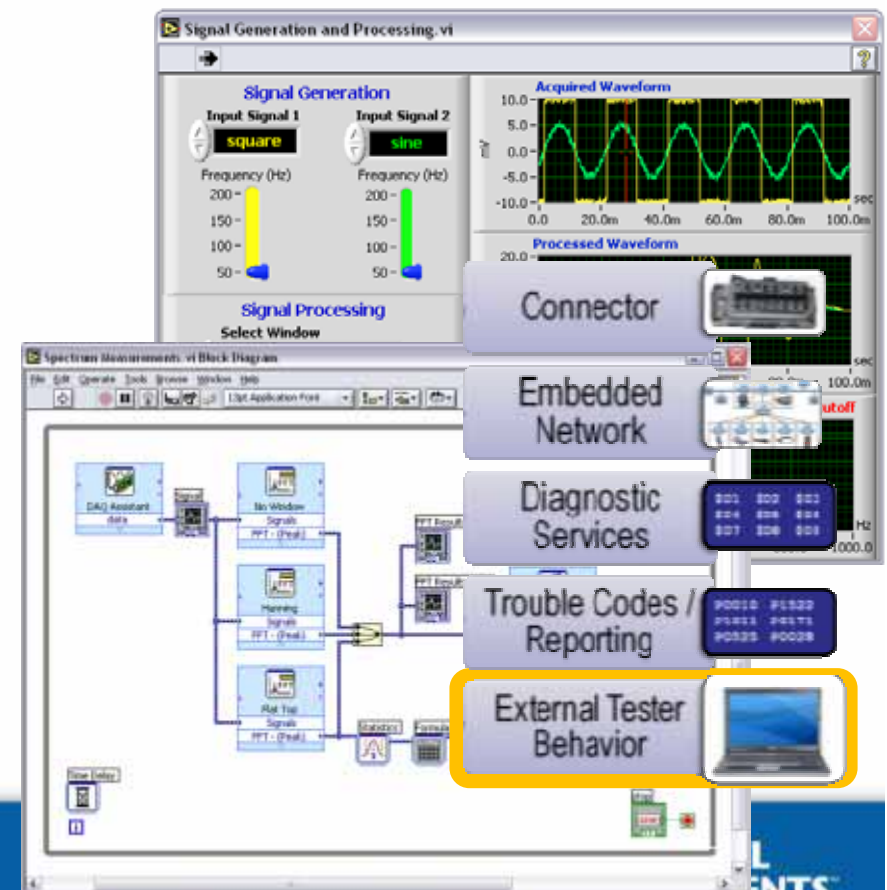




Fig 1. The "Subject"





Summary

- Introduction to embedded networks
 - CAN, LIN, Flexray
 - National Instruments Hardware
- On-Board Diagnostics
- Conclusion