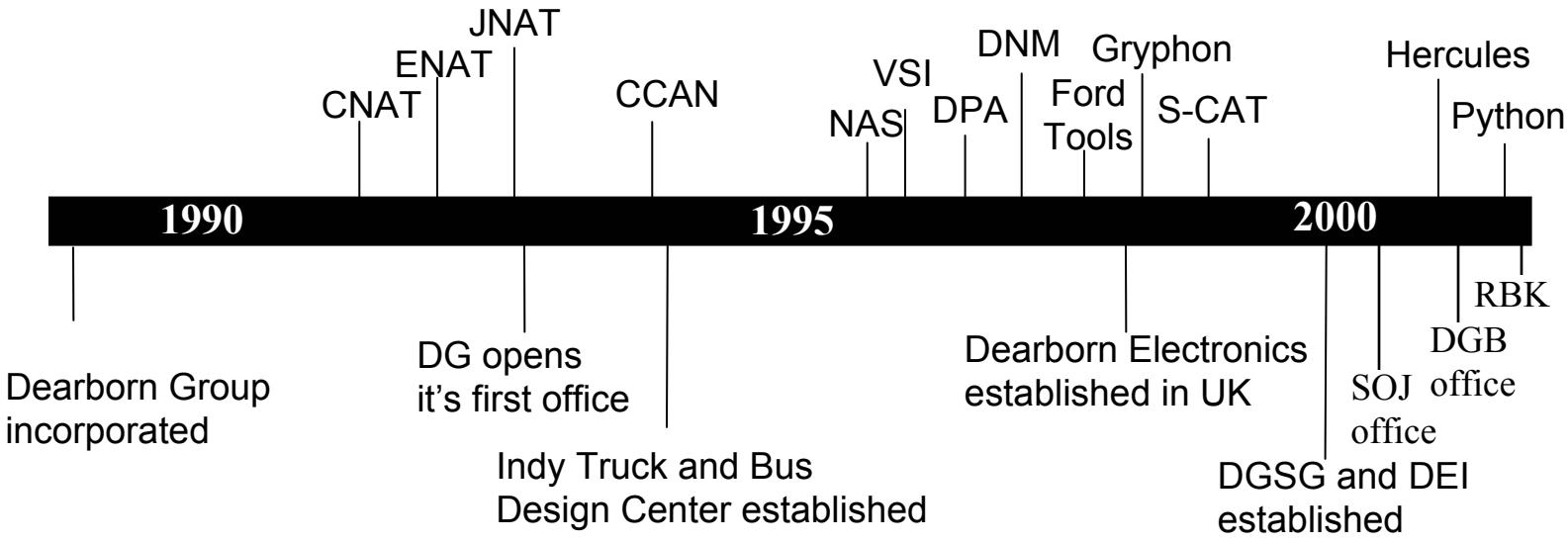
Trends in Networking

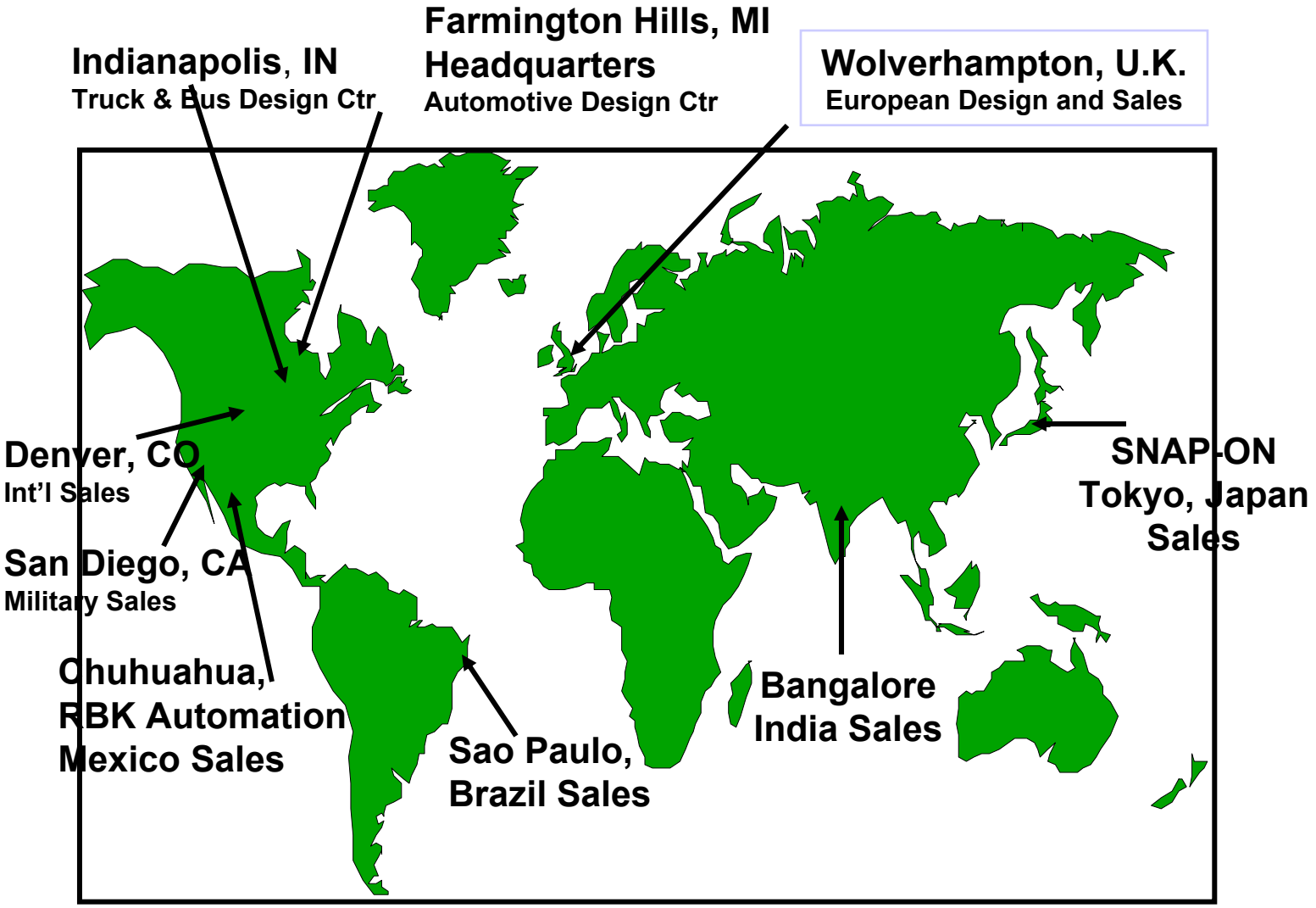
www.dgtech.com

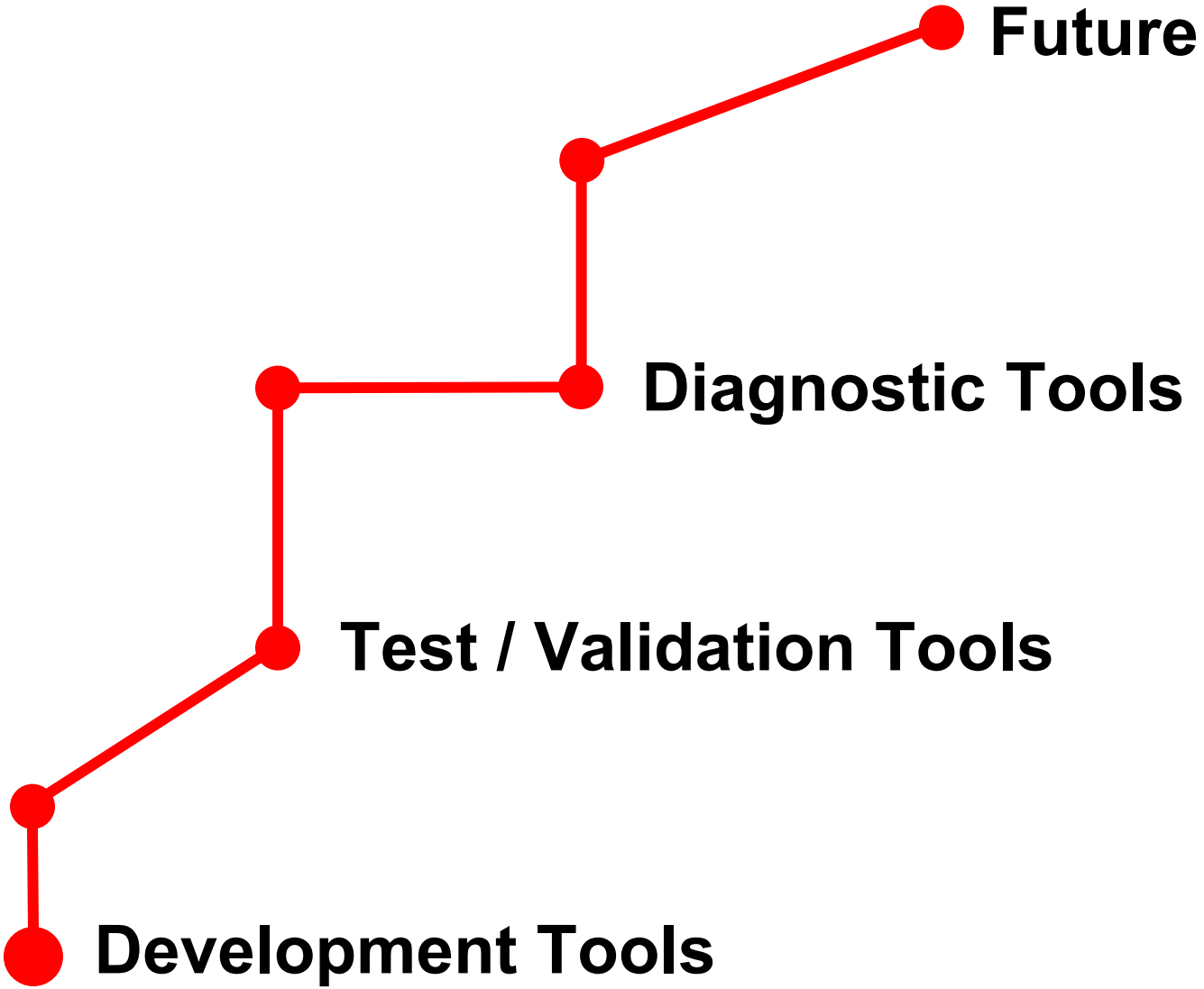
Experience

- First in-vehicle networking tool company in the U.S.
- More than 10 years of expertise creating products and solutions.



Global Locations




Future
Diagnostic Tools
Test / Validation Tools
Development Tools

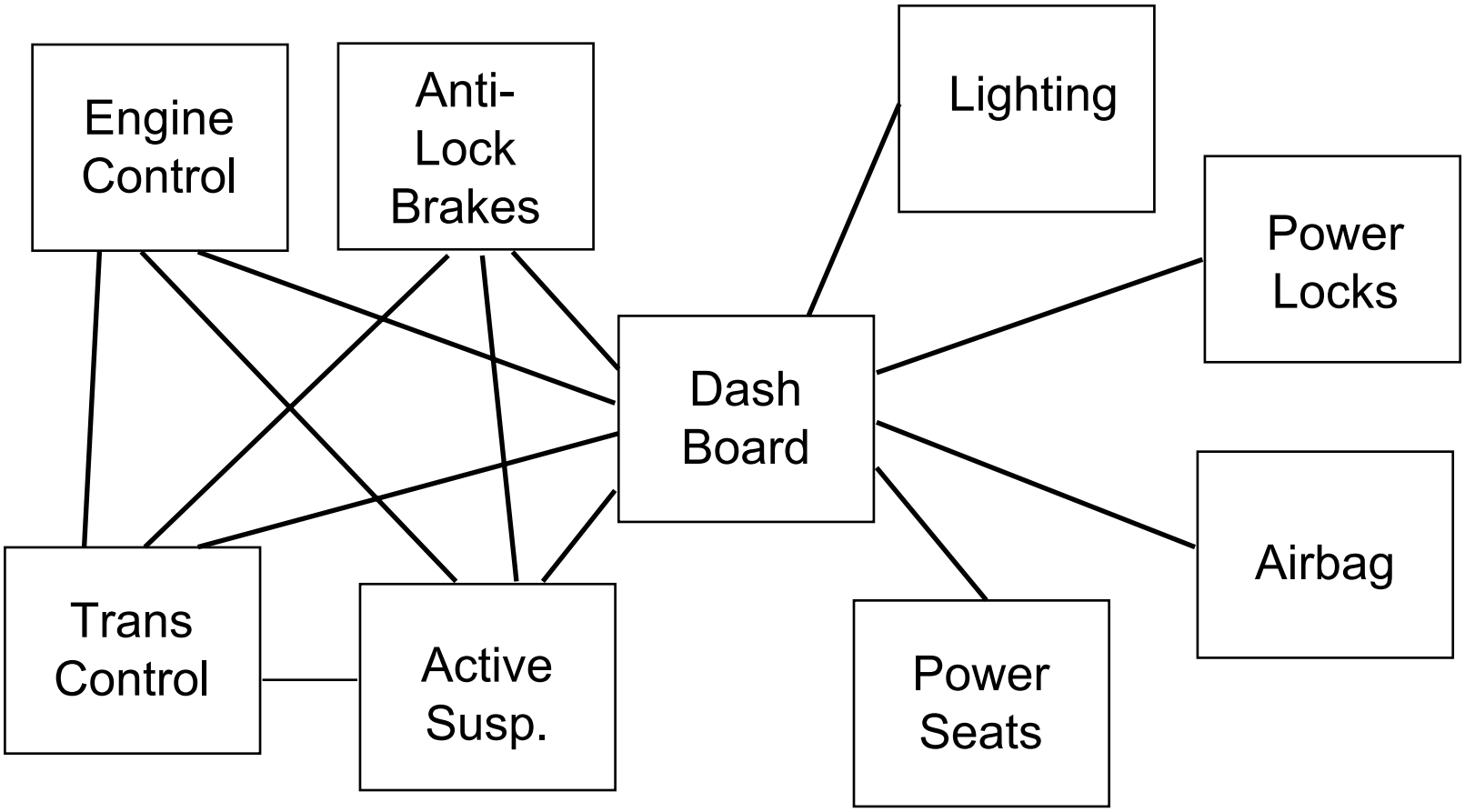
Committee Participation

Standard	Name	Relationship
J1699-1 J1850 Verification Procedures	Mark Zachos	Chairman
J2480 Diagnostics CAN (OBD)	Rich Means	Member
SAE Multiplex committee	8 DG Employees	Members
SAE Diagnostics committee	7 DG Employees	Members
J1930 E/E Systems Diagnostic Terms, etc.	Rich Means	Member
J1962	Rich Means	Member
J1699 J1850 Verification Procedures	Mark Zachos	Chairman
J2008 Electronic Information	Rich Means	Member
J2012 Diagnostic Trouble Codes	Rich Means	Member
J1978	4 DG Employees	Members
J1979	4 DG Employees	Members
J2178	Mark Zachos	Chairman
J2186 E/E Data Link Security	Rich Means	Member
J2190	Richard Price	Member
J2284 High Speed CAN	Mark Zachos	Member
J2356 Interactive Distributed Control	Rich Means	Member
J2366 – ITS Data Bus	Rich Means	Member
J2367 – IDB Gateway	Rich Means	Member
J2411 Single Wire CAN	Rich Means	Member
ISO 9141-1989 & -2	Jim Samuel (DE)	Chairman
ISO 9141-2	Richard Price	Member
ISO 9141-3	Richard Price	Chairman
ISO 14230 -1,2,3,4 KWP 2000	Richard Price	Member
ISO TF2 (Diagnostics on CAN)	Richard Price	Member
ISO TC22/SC3/WG1	Richard Price	Member
J1939 – Compliance	Bob McClure	Member
J1939 – IDB	Mark Zachos	Chairman
RP1210	S. Prasad	Member
SAE Con-Ag Multiplex Committee	Mark Zachos	Member
ODVA DeviceNet Conformance SIG	Cyrilla Dalstra	Member
CiA CAN Conference Committee	Cyrilla Dalstra	Member
J2534 Pass-Thru Programming	S. Prasad	Member
J2561 Bluetooth Wireless Protocol for Automotive	Mark Zachos	Chairman
IDB Forum Committee	Mark Zachos	Member
USCAR Restraints Communications bus committee	Rich Means	Member

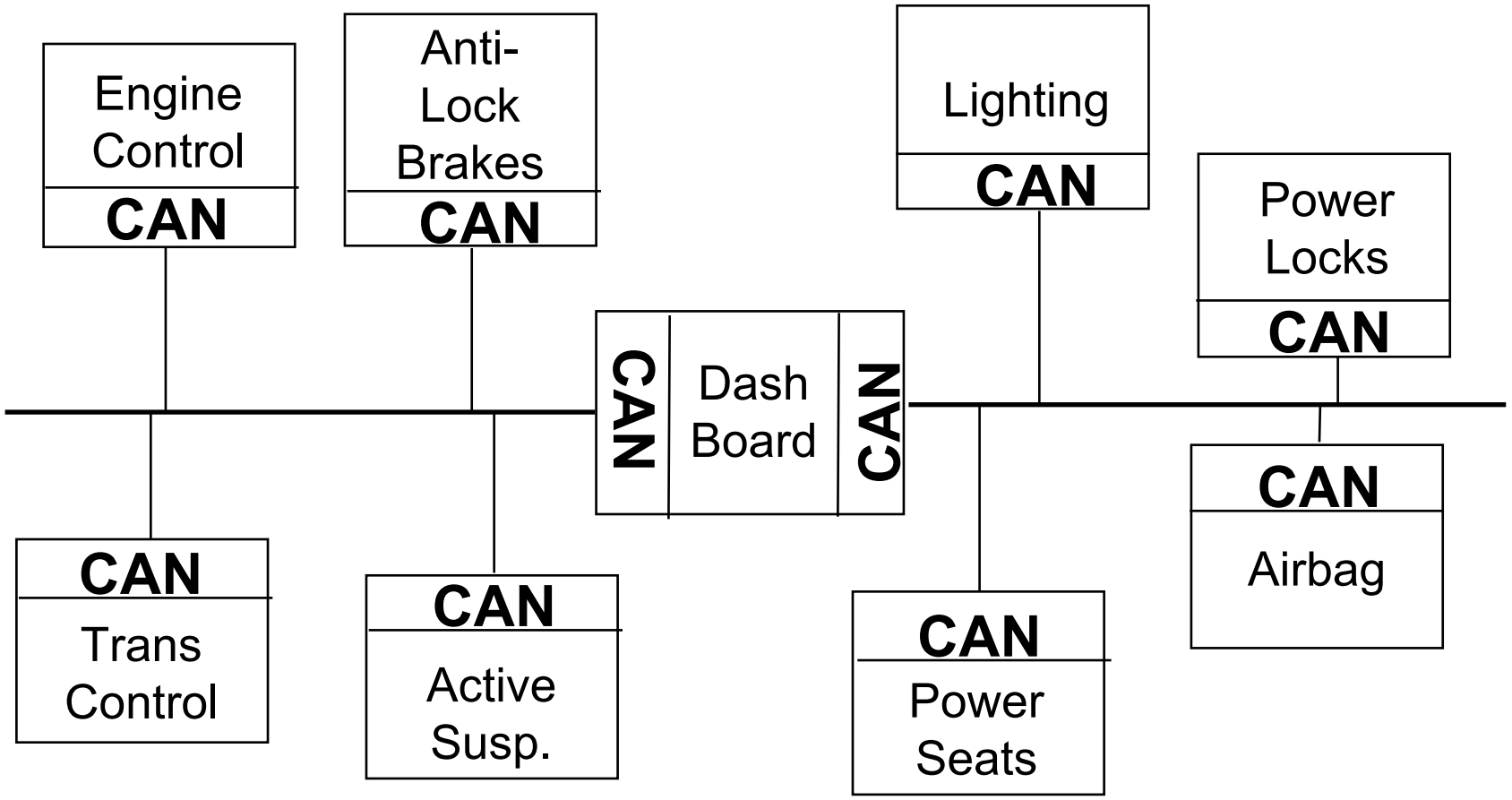
Committee Participation

- Keeps DG on leading edge of in-vehicle networking (multiplex) development
- Maintains high level of knowledge of multiplex standards
- Allows DG to develop solutions for our customers' multiplex needs

Networking

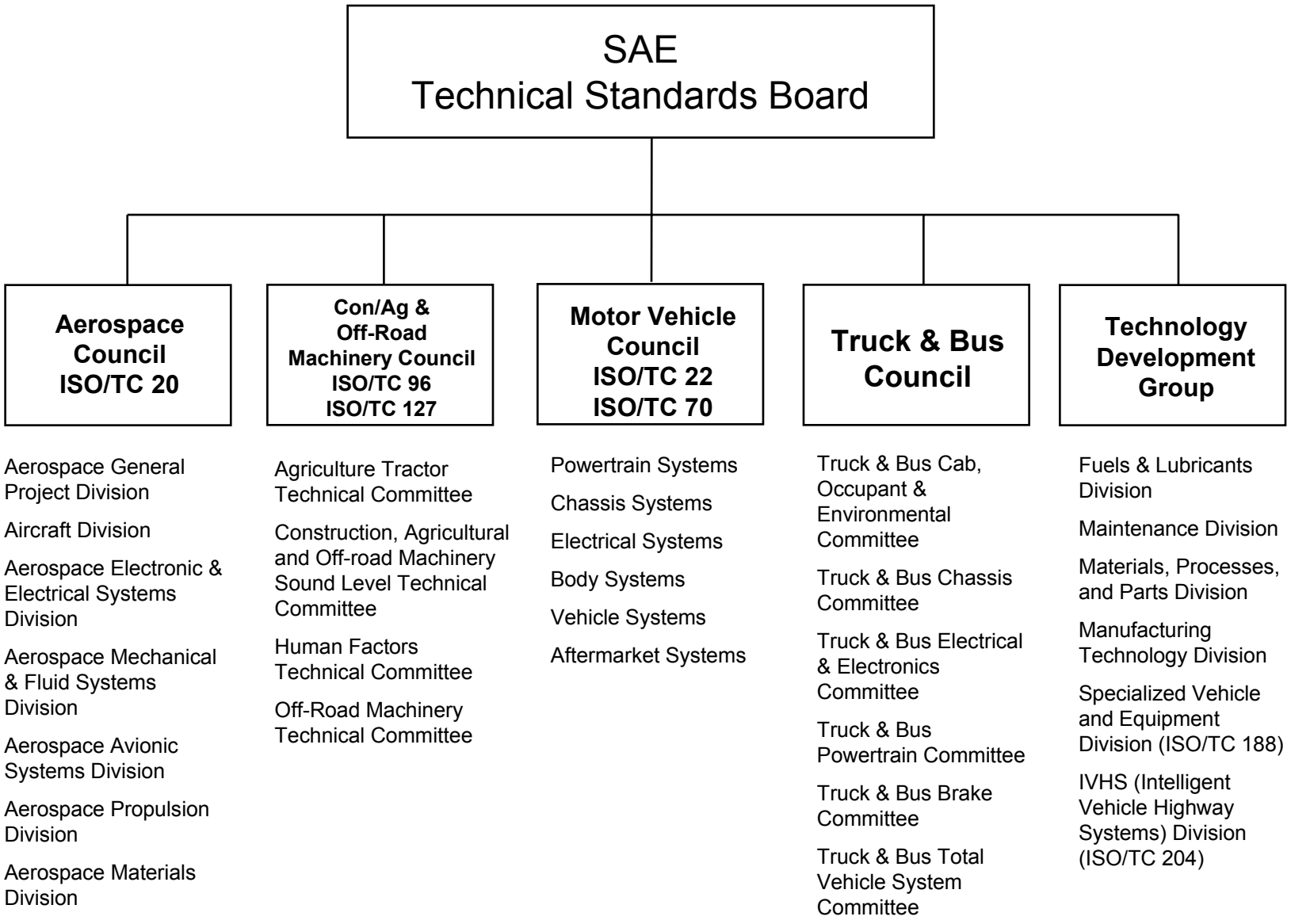

Engine Control
Anti-Lock Brakes
Lighting
Power Locks
Dash Board
Airbag
Trans Control
Active Susp.
Power Seats

Networking


Engine Control
CAN
Anti-Lock Brakes
CAN
Lighting
CAN
Power Locks
CAN
CAN
Dash Board
CAN
CAN
Trans Control
CAN
Active Susp.
CAN
Power Seats
CAN
Airbag

Six Classifications

- Class A
- Class B
- Class C
- Emissions/Diagnostics
- Mobile Media
- X-by-wire


SAE
Technical Standards Board
Aerospace Council ISO/TC 20
Con/Ag & Off-Road Machinery Council ISO/TC 96 ISO/TC 127
Motor Vehicle Council ISO/TC 22 ISO/TC 70
Truck & Bus Council
Technology Development Group
Aerospace General Project Division
Aircraft Division
Aerospace Electronic & Electrical Systems Division
Aerospace Mechanical & Fluid Systems Division
Aerospace Avionic Systems Division
Aerospace Propulsion Division
Aerospace Materials Division
Agriculture Tractor Technical Committee
Construction, Agricultural and Off-road Machinery Sound Level Technical Committee
Human Factors Technical Committee
Off-Road Machinery Technical Committee
Powertrain Systems
Chassis Systems
Electrical Systems
Body Systems
Vehicle Systems
Aftermarket Systems
Truck & Bus Cab, Occupant & Environmental Committee
Truck & Bus Chassis Committee
Truck & Bus Electrical & Electronics Committee
Truck & Bus Powertrain Committee
Truck & Bus Brake Committee
Truck & Bus Total Vehicle System Committee
Fuels & Lubricants Division
Maintenance Division
Materials, Processes, and Parts Division
Manufacturing Technology Division
Specialized Vehicle and Equipment Division (ISO/TC 188)
IVHS (Intelligent Vehicle Highway Systems) Division (ISO/TC 204)

Network Classification
SAE J1213/1

Class A

A multiplex system whereby vehicle wiring is reduced by the transmission and reception of multiple signals over the same signal bus between nodes that would have be traditionally accomplished by individual wires in a conventionally wired vehicle. The nodes used to accomplish multiplexed body wiring typically did not exist in the same or similar form in a totally conventionally wired vehicle

Class B

A multiplex system whereby data is transferred between nodes to eliminate redundant sensors and other system elements. The nodes in this form of a multiplex system typically already existed as stand-alone modules in a conventionally wired vehicle.

Class C

A multiplex system whereby high data rate signals associated with real time control systems, such as engine controls and anti-lock brakes, are sent over the signal bus to facilitate distributed control and to further reduce wiring.

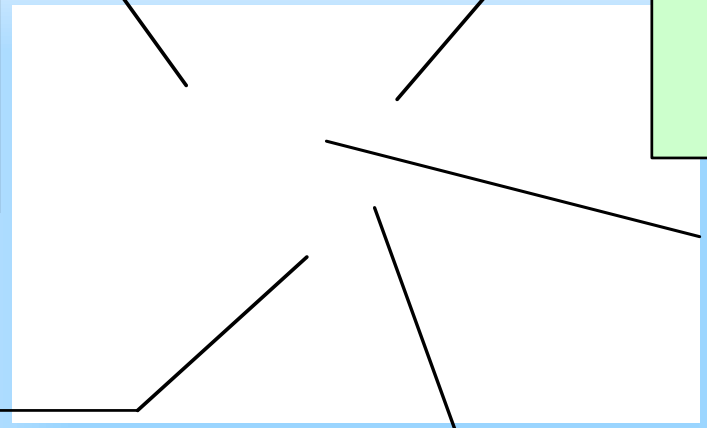
Class A Protocols

NAME:	USER:	MODEL USAGE:	YEARS:	COMMENTS:
Assembly Line Diag. Link (ALDL)	GM	Many	1985 - 2005+	UART; being phased out
Sinebus	GM	Audio	2000+	Radio steering wheel controls
Entertainment & Comfort (E&C)	GM	Audio/HVAC	1987 - 2002+	Being phased out
I2C	Renault	HVAC	2000+	www.bdsltd.co.uk/teletext/i2c.htm
J1708/J1587/J1922	T&B	General	1985 - 2002+	www.sae.org
Chrysler Collision Detection (CCD)	Chrysler	HVAC, audio, etc.	1985 - 2002+	SAE paper 860389
Audio Control Protocol (ACP)	Ford	Audio	1985 - 2002+	SAE paper 940142
Body Elctrncs Area Netwrk (BEAN)	Toyota	Body	1995+	SAE paper 970297
UART-Based Protocol (UBP)	Ford	Rear backup	2000+	General purpose UART
Local Interconnect Network (LIN)	Many OEMs	Smart Connector	2003+	www.lin-subbus.org

Typical LIN Applications

Roof:
(high amount of wiring)
Rain Sensor, Light Sensor, Light Control, Sun Roof
…
(Rain Sensor needs to be interrogated every 10-20ms)

Steering Wheel:
(very many controls are going to be positioned on the steering wheel)
Cruise Control, Wiper, Turning Light, …
Optional: Climate Control, Radio, Telephone, etc.

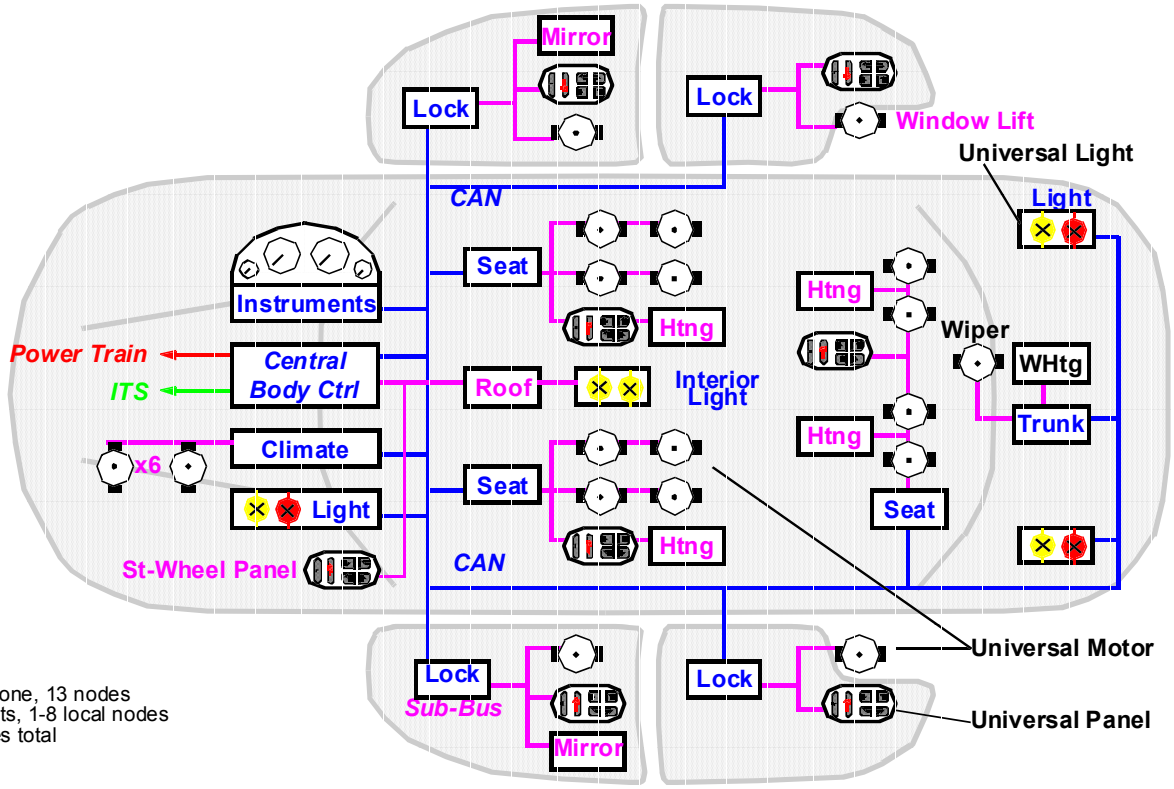


Seat:
many Seat Position Motors, Occupancy Sensor, Control Panel

•Door:
Mirror,Central ECU, Mirror Switch, Window Lift,
Seat Control Switch, Door Lock, etc.

Climate:
many Small Motors
Control Panel

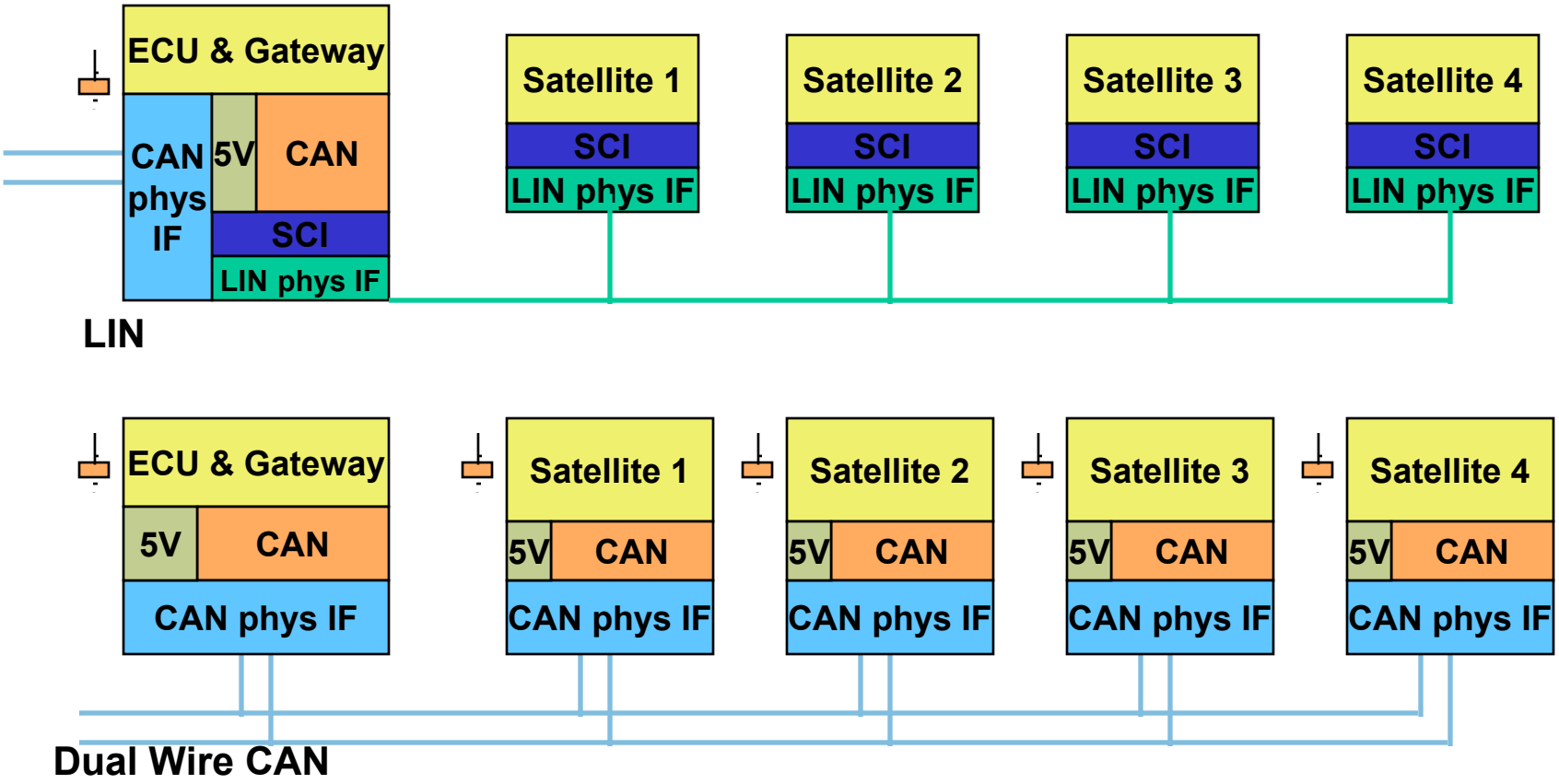
LIN
Automotive Body Network



1 backbone, 13 nodes
8 subnets, 1-8 local nodes
52 nodes total

LIN

Sub-Network: LIN vs. CAN



Cost Factors:	CAN Module Crystal 2nd Wire / Connector	Dual Wire Interface 5V supply for bus

Class B Protocols

NAME:	USER:	USAGE:	MODEL YEARS:	COMMENTS:
GMLAN (SWC)	GM	Many	2002+	33.33 Kb/s; J2411
GMLAN (mid)	GM	Infotainment	2002+	95.2 Kb/s; ISO 11898
ISO 11898	Europe	Many	1992+	47.6 Kb/s to 500 Kb/s
J2284	GM,Ford, DC	Many	2001+	500 Kb/s; ISO 11898
Fault-tol CAN	Europe	Many	2000+	ISO 11519-2
Class 2	GM	Many	Until 2002+	SAE J1850
PCI	Chrysler	Many	Until 2002+	SAE J1850
SCP	Ford	Many	Until 2002+	SAE J1850
J1939	T&B	Many	1994+	Replacing J1708, etc.

Class B Networks in Passenger Cars

- Body Electronics
- Reduction of wire harness size
- Interface with off-board computer systems

J1850 Overview

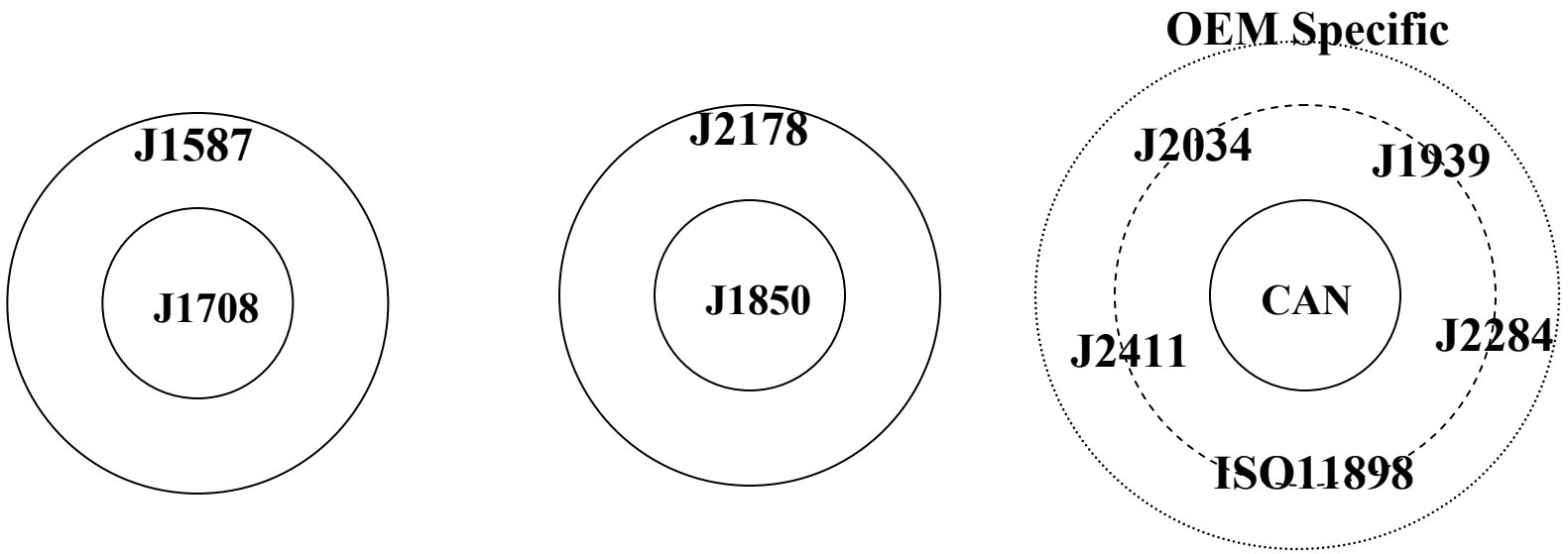
- First approved by the SAE Vehicle Network for Multiplexing and Data Communications Standards Committee in November 1988.
- Defines a minimum set of data communication requirements such that the resulting network is cost effective for simple applications and flexible enough to use in complex applications.
- Describes two physical layer data rates - 10.4K and 41.6Kbps
- It is assumed that manufacturers will focus specifically on either data rate.

CAN Overview

CAN (Controller Area Network) Protocol developed by Bosch in the early 1980s for automotive in-vehicle networking

- Intel was the first CAN licensee and introduced the 82526 in 1987.
- First production car to use a CAN network - 1991 Mercedes S-Class
- CAN Specification 2.0 released 1991
  - Extended (29-bit) identifier
  - Standard (11-bit) identifier

In-Vehicle Multiplexing
Current SAE Specifications

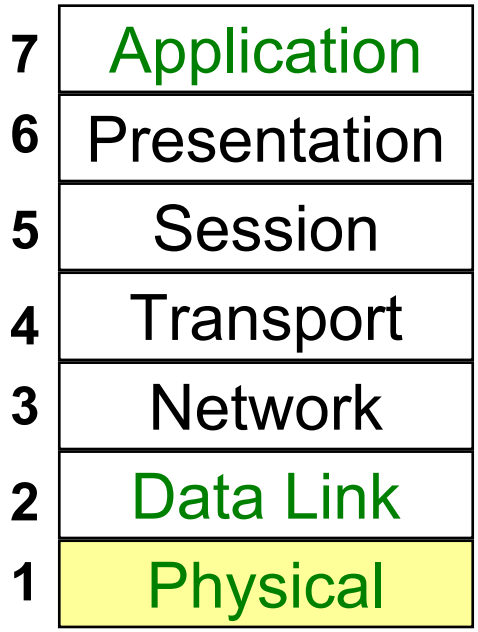


Inner circle is the core network protocol definition
Outer circle fills in the missing application definitions
for the various industries - several different physical layers for CAN

Passenger Cars

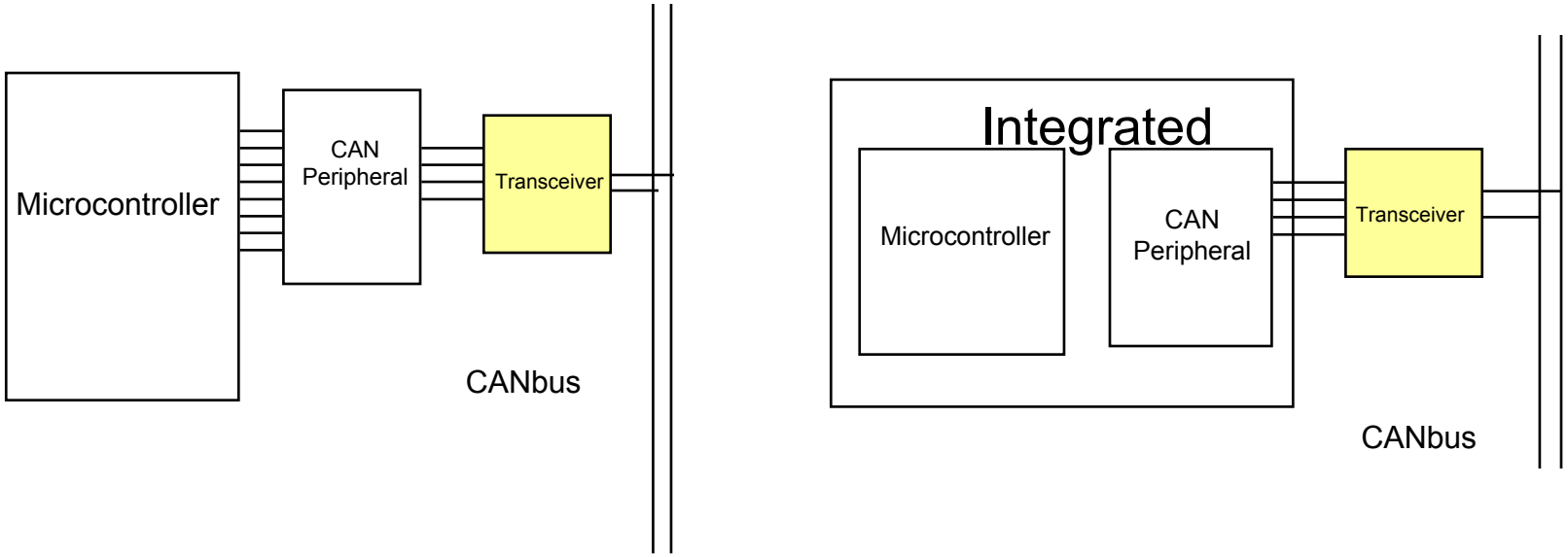
- No standardized messaging for control and informational data with passenger cars.
- Some standardization in process for common signal definition.

CAN Overview

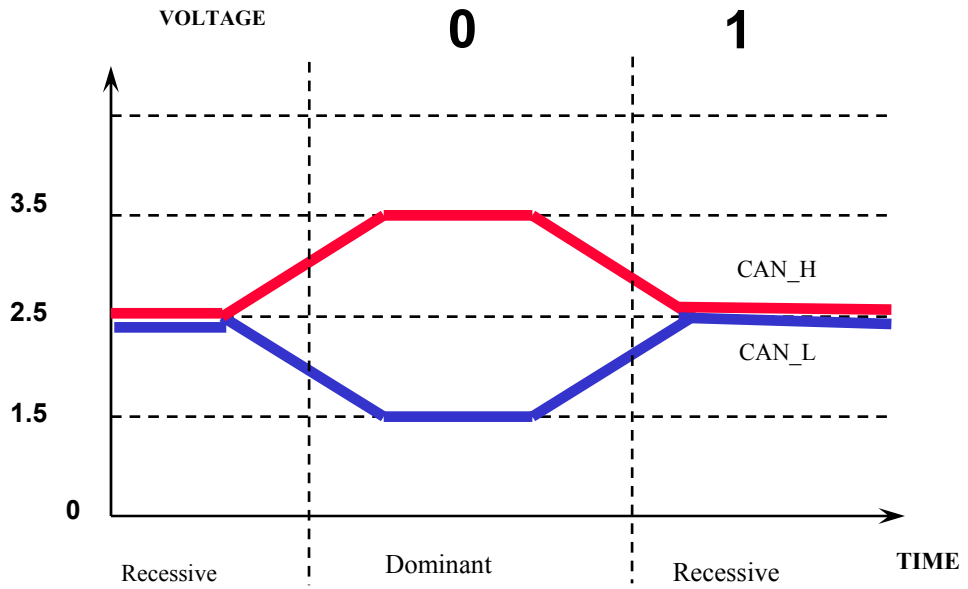


CAN Physical Layer

Hardware Components Overview



ISO 11898-2



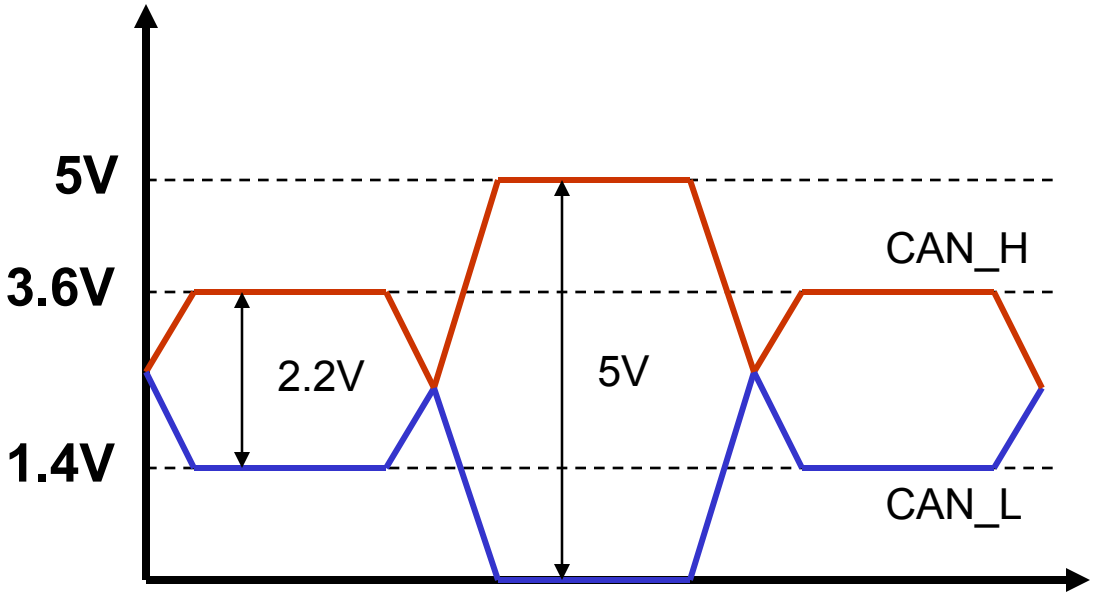
-Two-wire differential bus

-Termination placement

- Dominant and recessive bit definition

ISO 11898-3

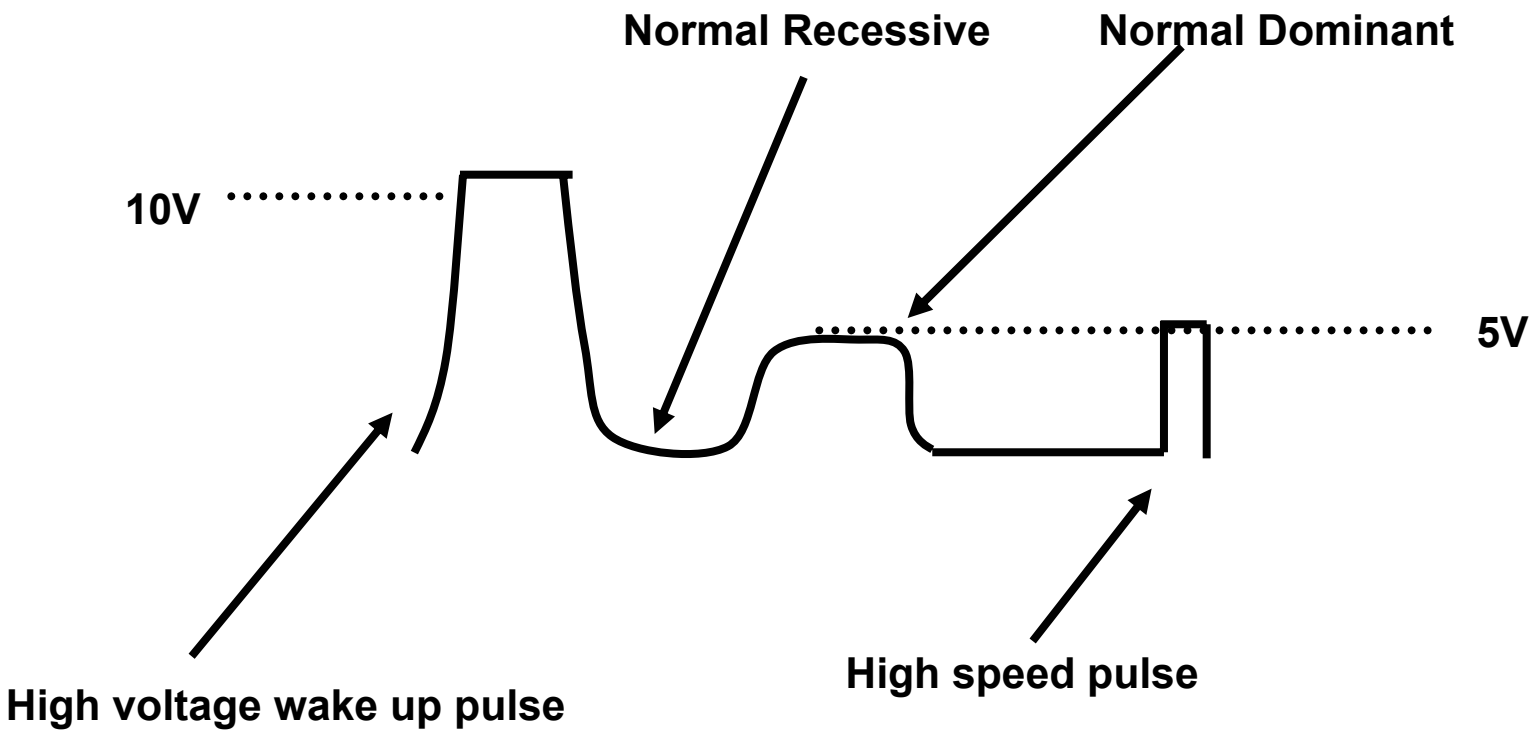
Fault Tolerant



J2411
Overview

- Single unshielded-wire CAN
- 33.3Kbps (normal),
  - 83.33 Kbps (high-speed)
- Supports 11-bit and 29-bit identifiers
- Maximum number of nodes - 32
- Maximum bus length - 40 meters
- No bus termination necessary

J2411
Bus Timings



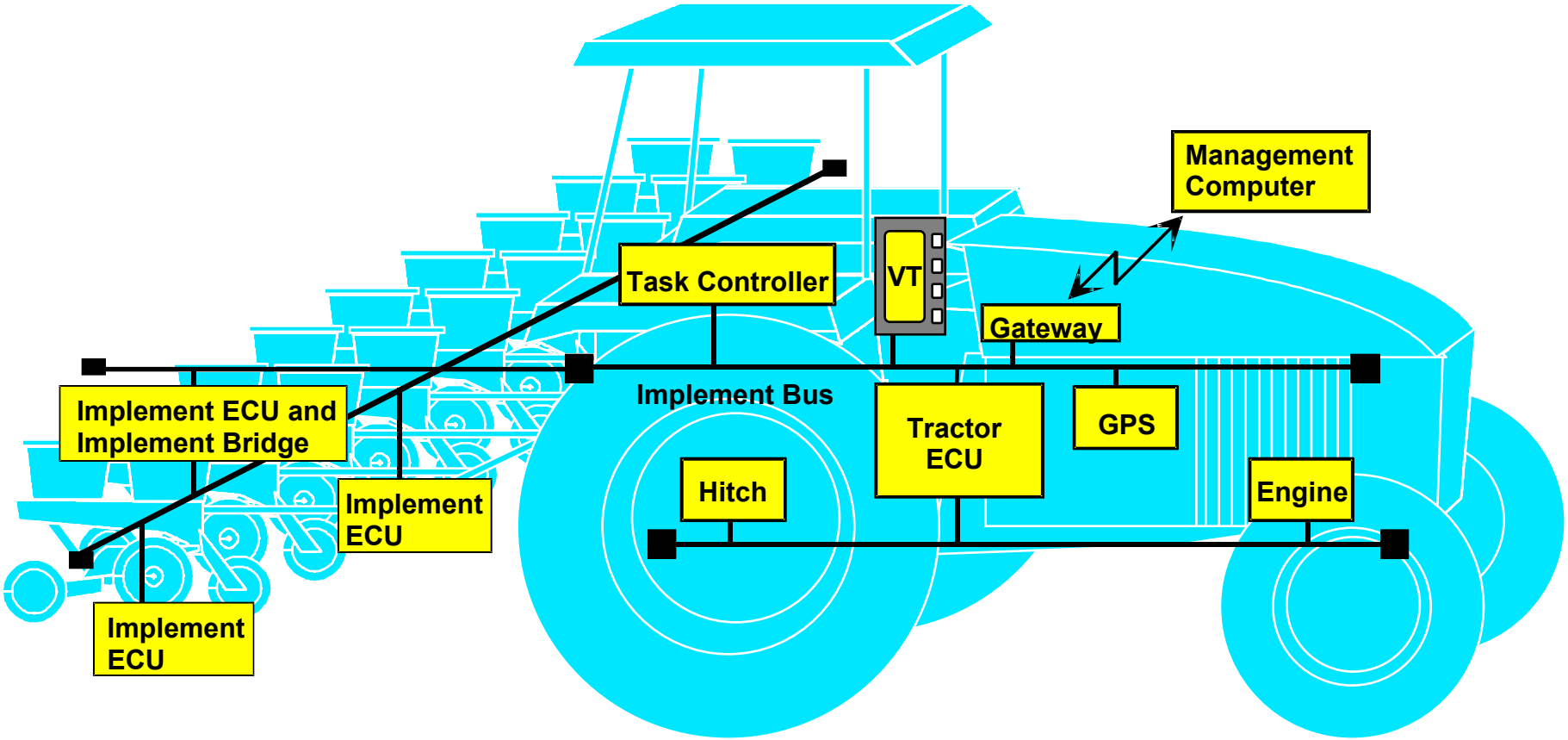
Class C Protocols

NAME:	USER:	USAGE:	MODEL YEARS:	COMMENTS:
GMLAN (high)	GM	All	2002+	500 Kb/s; ISO 11898
ISO 11898	Europe	Most	1992+	Various speeds of CAN
J1939	T&B	Most	1994+	250 Kb/s CAN

Class C Networks in Heavy Truck & Bus

- Powertrain Control
- Interface to towed equipment and trailers
- Reduction of wire harness size
- Navigation, radar, & GPS
- Virtual Terminal applications
- Interface with off-board computer systems

Bus Topology and Components



Emissions/Diagnostics

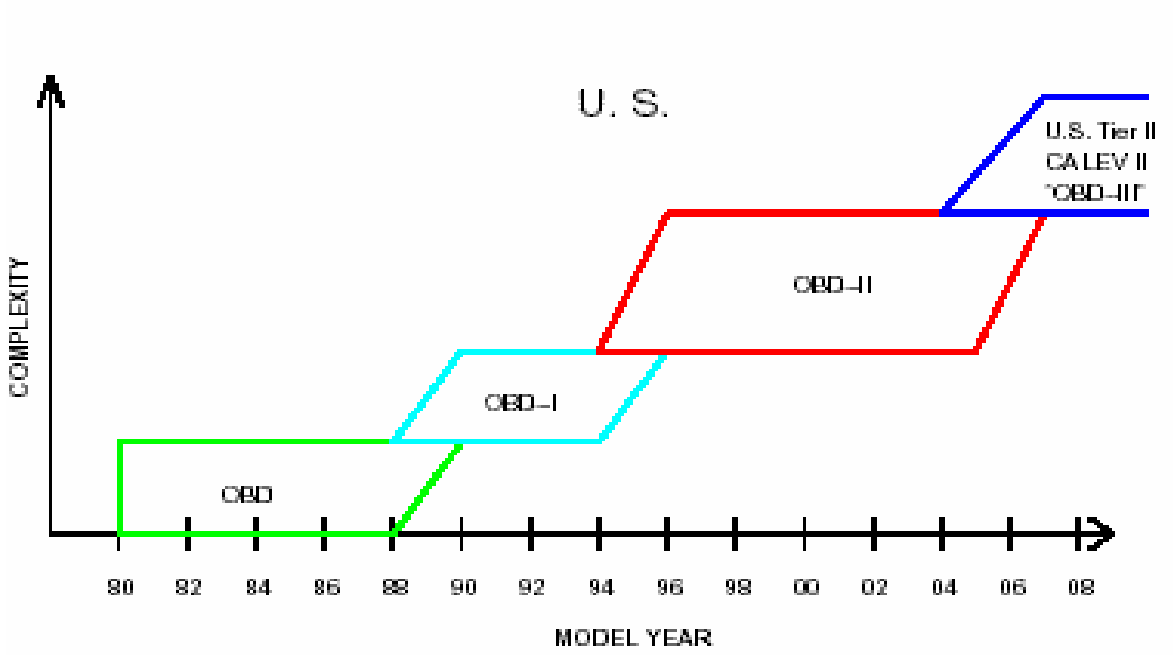
NAME:	USER:	USAGE	MODEL YEARS:	COMMENTS:
J 2480	GM, Ford, DC	OBD-III	2004+	U.S. CAN for car use
ISO 15765-4	Europe	E-OBD	2000+	E-OBD CAN
J 1850	GM, Ford, DC	OBD-II	1994+	Not accepted in Europe
ISO 9141-2	Europe	OBD-II, general	1994+	Old OBD-II UART
ISO 14230-4	Many	OBD-II, OBD-III	2000+	Keyword 2000

Diagnostics

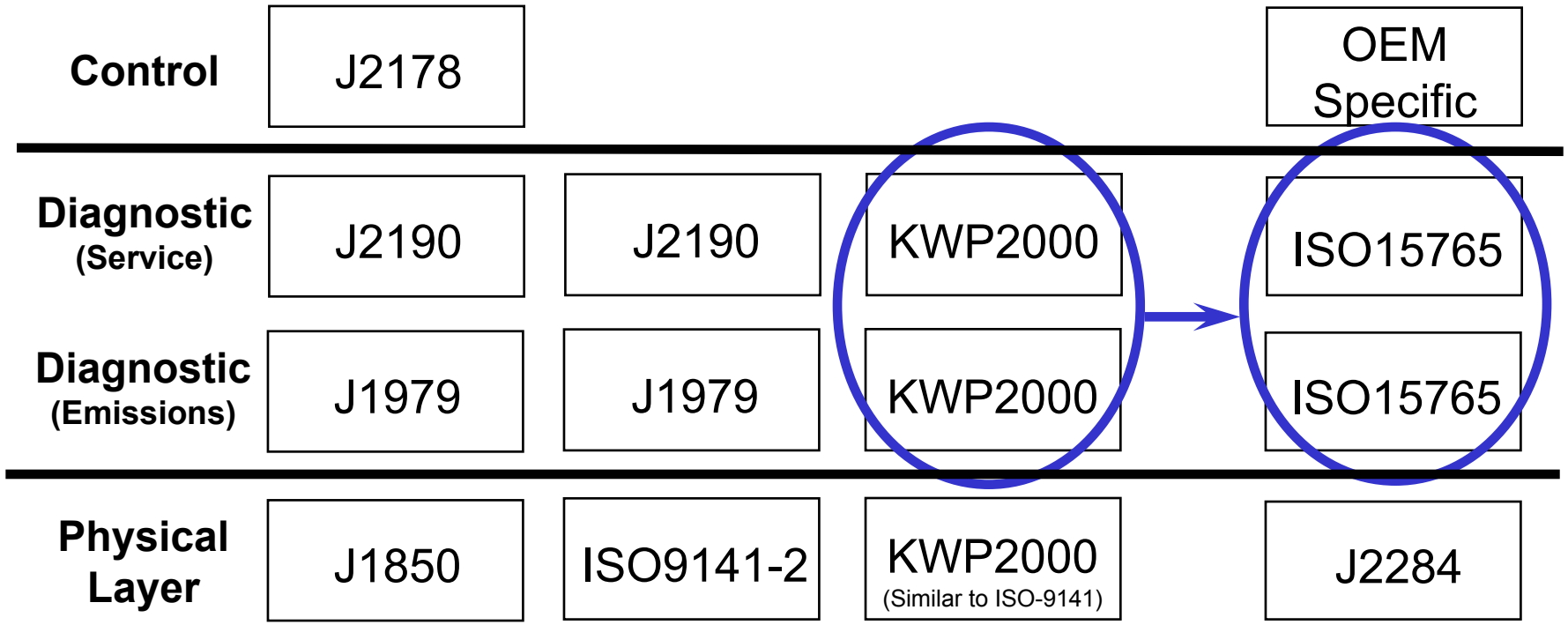
- Two types:
  - Legislated emissions-related diagnostics
  - Proprietary service-related diagnostics

Emissions Diagnostics

- In-Vehicle Emissions Test Capability
  - On-Board Diagnostics (OBD) U.S. Timetable



US Diagnostics



After 2008 only CAN is allowable as the OBD Diagnostic Network.

ISO 15031

Relationship to SAE Standards

ISO		SAE	
ISO 15031-1	General information	<no equivalent standard>	
ISO 15031-2	Terms, definitions, abbreviations and acronyms	J1930	Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms
ISO 15031-3	Diagnostic connector and related electrical circuits: specification and use	J1962	Diagnostic Connector
ISO 15031-4	External test equipment	J1978	OBD II Scan Tool
ISO 15031-5	Emissions related diagnostic services	J1979	E/E Diagnostic Test Modes
ISO 15031-6	Diagnostic trouble code definitions	J2012	Recommended Practice for Diagnostic Trouble Code Definitions
ISO 15031-7	Data link security	J2186	E/E Data Link Security
ISO 11519-4	Low-speed serial data communication - part 4: Class B data communication network interface (J1850)	J1850	Class B Data Communications Network Interface

ISO 15031

- ISO 15031 consists of seven parts. Taken together, these provide a coherent, self-consistent set of specifications to facilitate emission-related diagnostics of road vehicles.
- It is neither necessary nor sufficient to adopt all seven parts of ISO 15031 in order to achieve a useful, standardised mechanism for emission-related diagnosis.
- ISO 15031 parts 2 - 7 are based on recommended practices developed by the Society of Automotive Engineers (SAE). It was the intention of the ISO drafting committee that any vehicle meeting the requirements of these SAE recommended practices would also meet the corresponding requirements in ISO 15031.

E/E Diagnostic Test Modes
J1979

- Legislated emissions-related diagnostics
- Request/response - specific parameter requests supported
- Information not broadcast on bus for normal messaging in common format

J1979 Message Format Header

Header Bytes (Hex)			Data Bytes									
Priority / Type	Target Address	Source Address	#1	#2	#3	#4	#5	#6	#7	#8	ERR	RSP
Diagnostic Request at 10.4 Kbps (SAE J1850 and ISO 9141-2)												
68	6A	Fx	Maximum 7 Data Bytes								Yes	No
Diagnostic Response at 10.4 Kbps (SAE J1850 and ISO 9141-2)												
48	6B	Addr	Maximum 7 Data Bytes								Yes	No
Diagnostic Request at 10.4 Kbps (ISO 14230-4 – KWP2000)												
11 LL LLLL b	33	Fx	Maximum 7 Data Bytes								Yes	No
Diagnostic Response at 10.4 Kbps (ISO 14230-4 – KWP2000)												
10 LL LLLL b	Fx	Addr	Maximum 7 Data Bytes								Yes	No
Diagnostic Request at 41.6 Kbps (SAE J1850)												
61	6A	Fx	Maximum 7 Data Bytes								Yes	Yes
Diagnostic Request at 41.6 Kbps (SAE J1850)												
41	6B	Addr	Maximum 7 Data Bytes								Yes	Yes

J1979 Message Format
Data Field - Mode

Header Bytes (Hex)	Data Bytes							
	#1	#2	#3	#4	#5	#6	#7	#8
Request Current Powertrain Diagnostic Data								
Request Powertrain Diagnostic Data	01	PID						
Report Current Powertrain Diagnostic Data								
Report Powertrain Diagnostic Data	41	PID	Data A	Data B (opt)	Data C (opt)	Data D (opt)		

J1979 Message Format
Data Field - PIDs

Modes*		PID (hex)	Description	Min ($00) Or ($0000)		Max ($FF) Or ($FFFF)		SI (Metric) Scaling/bit and display	English Scaling/bit and display
$01	$02								
	X	02	Trouble code that caused required freeze frame data storage (2 byte value - $0000 indicates on freeze frame data)	00	00	F9	F9	Pxxxx Bxxxx Cxxxx Uxxxx	
X	X	03	Data A: Fuel system 1 status Data B: Fuel system 2 status ($00 if not used) For each data byte, no more than one bit at a time can be set to a 1 to indicate the status of the that bank, where: Bit 0 = Open loop – has not yet satisfied conditions to go closed loop Bit 1 = Closed loop – using oxygen sensor (s) as feedback for fuel control Bit 2 = Open loop due to driving conditions (power enrichment, deceleration enleanment) Bit 3 = Open loop due to detected system fault Bit 4 = Closed loop, but fault with at least one oxygen sensor – May be using single oxygen sensor for fuel control Bit 5-7 = reserved (report as 0)						
	X	04	Calculated load value	0%		100%		100/255% xxx.x%	
X	X	05	Engine coolant temperature	-40C		215C		1 C with –40C offset xxx C	xxx F
X	X	06	Short term fuel trim – Bank 1	-100.00% (lean)		99.22% (rich)		100/128% (0% at 128) xxx.x%	

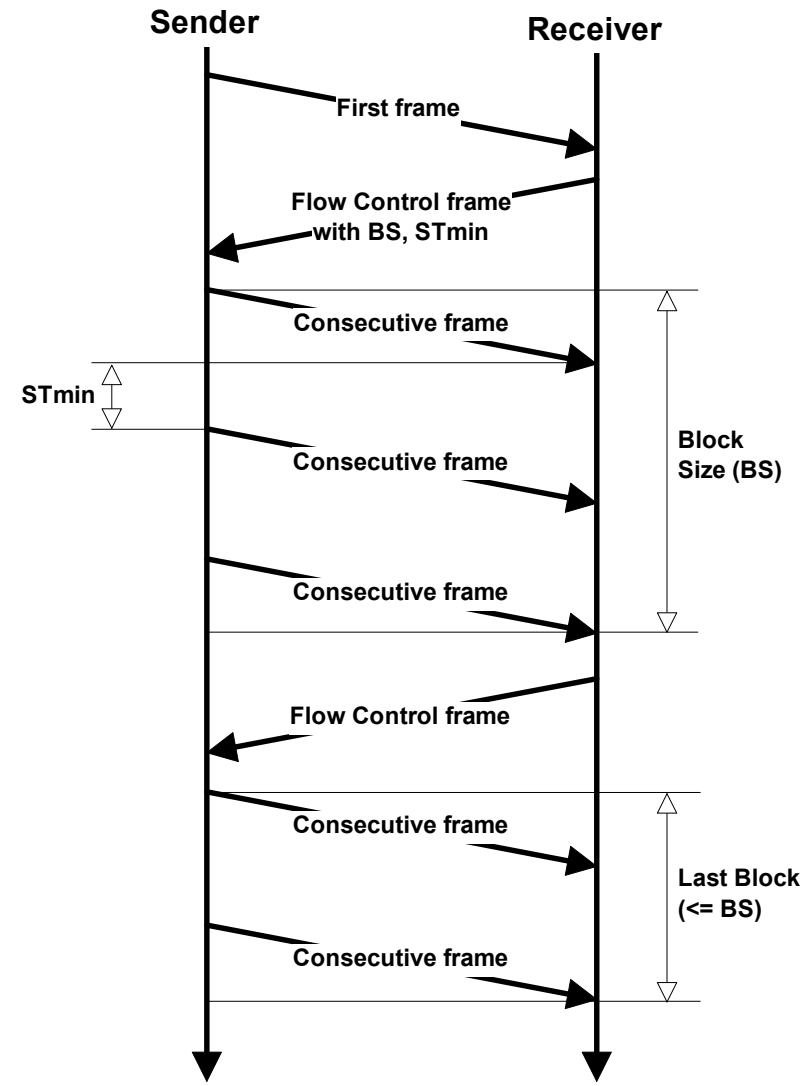
ISO 15765

- Applicable to vehicle diagnostic systems implemented on a Controller Area Network (CAN) communication network as specified in ISO 11898.
- Established in order to define common requirements for vehicle diagnostic systems implemented on a Controller Area Network (CAN) communication link as specified in ISO 11898.
- Although primarily intended for diagnostic systems, ISO 15765 has been developed to also meet requirements from other CAN based systems needing a network layer protocol.

ISO 15765 Part 2

Diagnostics on CAN

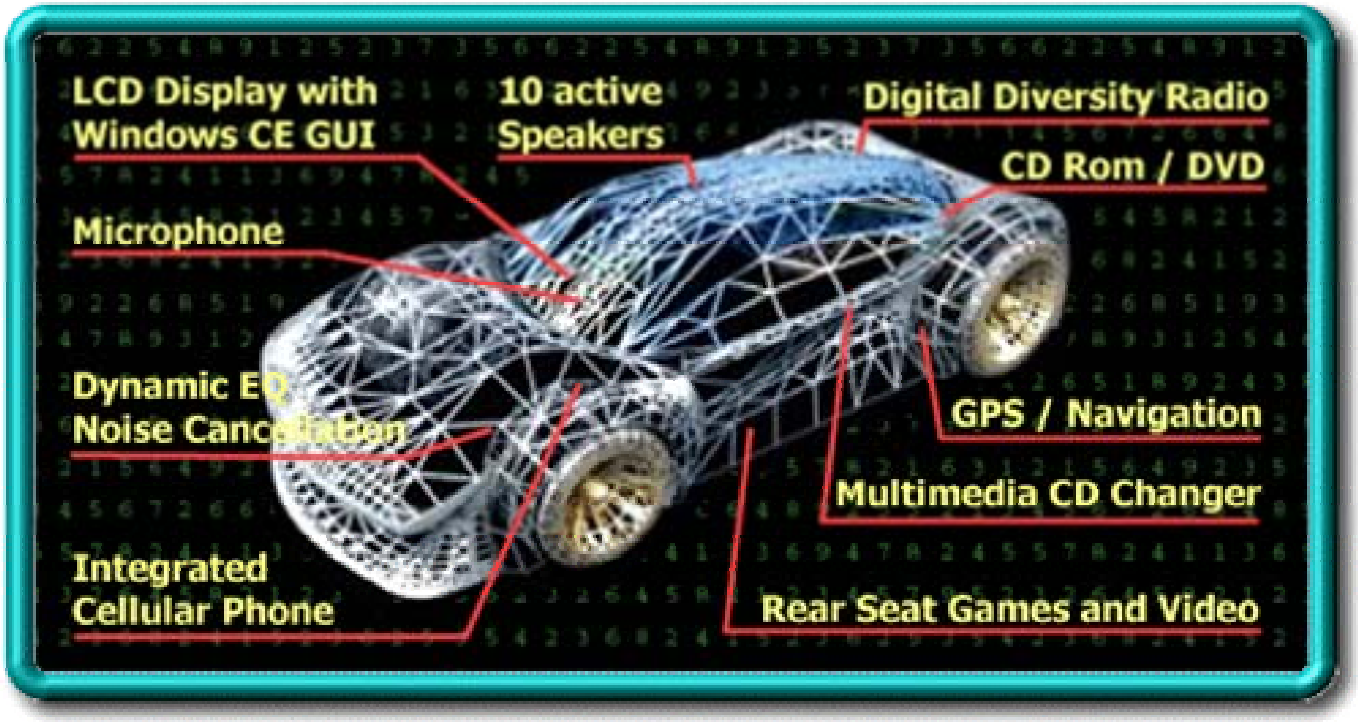
Multiframe Transfer



Mobile Media

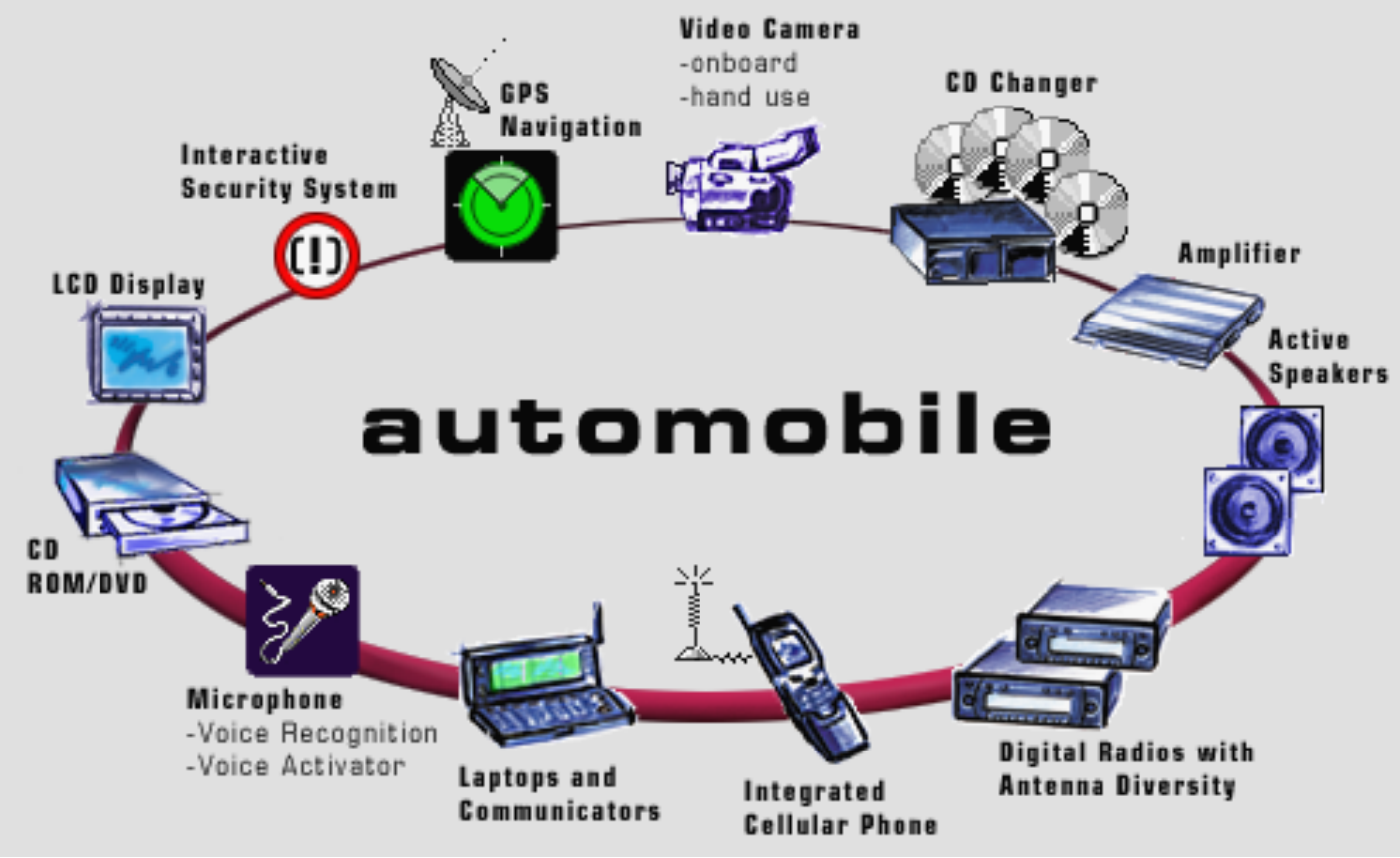
NAME:	USER:	USAGE:	MODEL YEARS:	COMMENTS:
IDB-C	many OEMs	Many	2002+	www.idbforum.org
MML	GM	tbd	2004+	Delphi-D only
D2B	Mercedes	tbd	1999+	www.candc.co.uk/candc_company
MOST	Saab, etc.	tbd	2000+	www.mostcooperation.com
Firewire	unknown	tbd	2000+	www.1394ta.org
USB	Clarion	Aftermarket	1998+	www.autopc.com
Bluetooth	tbd	tbd	2005+	www.bluetooth.co

MOST
Use in the Car



MOST

Use in the Car



X-By-Wire

NAME:	USER:	USAGE:	YEARS:	COMMENTS:
TTP	BMW	tbd	2004+	www.tttech.com
TTCAN	tbd	tbd	tbd	www.can-cia.de
SI (Byteflight)	BMW	tbd	tbd	www.byteflight.com
TTFlex	BMW&DC	tbd	tbd	Still under development
FlexRay	BMW&DC	tbd	tbd	www.flexray-group.com

FlexRay

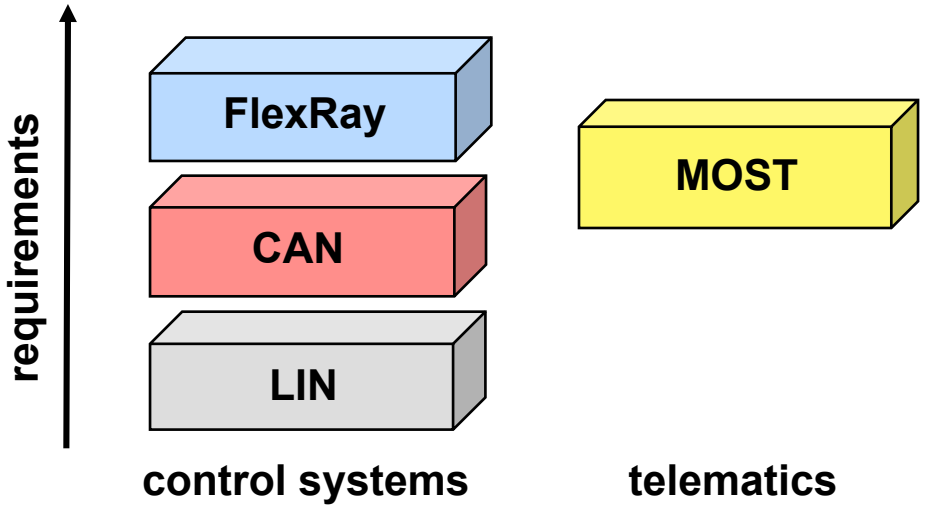
- Developed by Daimler-Chrysler, BMW, Motorola, Philips starting in early 2000
  - DC focussed on being first to market with steer-by-wire, product architecture already mostly determined
  - DC-requested changes to TTP not immediately adopted by TTTech
  - BMW heavily invested in protocol R&D, developed alternative protocol Byteflight, which was not adopted by the market
  - Bosch and GM have joined recently
- Flexray combines features of TTP, CAN, and BMW Byteflight
- DC and BMW are currently technology leaders in X-by-Wire
  - Seek competitive advantage
  - Have significant experience internally

FlexRay

- Protocol specification only recently “frozen”
  - Software tools and hardware available only to members
- Flexray consortium intended to be open, but all technical decisions were made by four initial members
  - Delphi and others invited to join as associates
- Each message in Flexray has time-triggered-part and “flexible” part
  - Simplifies rapid development of systems
  - Can be more efficient than TTP for some applications and architectures
  - Can complicate safety case
- Flexray does not incorporate fault-tolerant system services
  - Must implement in software
  - Improves efficiency when not needed but reduces efficiency when required
- Features must be revalidated for every application

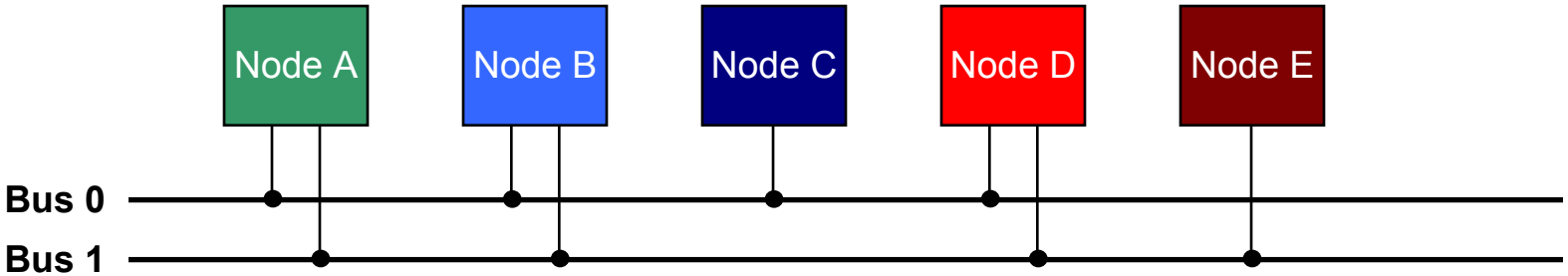
FlexRay
Motivation

- **Demand for a bus system with high data rate**
- **Deterministic and fault tolerant bus system for advanced automotive control applications**
- **Support from the bus system for distributed control systems**
- **Limited number of different communication systems within vehicles**



FlexRay
Basic Concepts

Network Topology:



- The protocol supports two serial busses
- A node can either be connected to both or only one of the busses

- PHY bit coding
  - transmission speed up to 10 Mbps (gross, optical)
  - NRZ 8N1 for optical transmission (byteflight compatibility)
  - electrical coding not defined