CANaerospace/AGATE data bus
What is the Controller Area Network (CAN)?

- Two-wire multi-transmitter serial data bus
- Designed by Bosch in 1985 as automobile network
- No central bus controller required
- Configurable data rate (5kBit/s ... 1MBit/s)
- Bus length 0.2m to 10.000m (with linear data rate reduction)
- Realtime capabilities (guaranteed transmission times)
- Message oriented transmission (2031 message identifiers)
- Network wide data consistency through broadcasting principle
- > 200 bus participants
- More than 100 million nodes installed today
The major characteristics of CAN

- Effective data rate max. 576 kBit/s (<= 40m bus length)
  -> adequate for most realtime control systems
- No overhead for bus arbitration, known response times even for high bus loads
  -> bus performance independant of number of participants
- Extremely low probability of undetected data corruption (~ $1 \times 10^{-13}$ per transmission)
  -> suitable for safety critical applications
- Very low chip cost, easy and straightforward application programming
  -> even small systems can benefit from network technology

Due to these characteristics, CAN is used in several aircraft applications already and selected for many new aircraft:

- Grob Strato-2C High Altitude Research Aircraft: “throttle-by-wire” databus
- NH90 helicopter: Audio system intercommunication
- Airbus A340-600: Environmental control system databus, water&waste management
- Fairchild-Dornier 728JET: Primary/secondary flight control actuator databus, secondary power supply system intercommunication, smoke detection system databus
- A380: Environmental control system databus, cockpit cursor control device/MFD communication bus, electric power supply control databus, ......
CAN hardware

CAN controllers and Microcontrollers with integrated CAN interfaces:

- Motorola
- Intel
- Philips
- Infineon
- Toshiba
- NEC
- Texas Instruments, ..... 

CAN boards for various bus systems:

- VME
- PCI/PMC
- ISA/EISA
- SBus
- PC104/PC104+
- IP, M-modules, PC-MIP, .....
CAN data rate vs. bus length

data rate (kBit/s)

usable area
CAN and the ISO open systems interconnection reference model

- Layer 1 (physical layer): Connectors, cables, voltage levels, ...
- Layer 2 (data link layer): Error detection, login, session dialog, data block synchronisation, ...
- Layer 3 (network layer): Logical channels, data representation, routing, data packet flow control, ...
- Layer 4 (transport layer): Transmission retries, data packet flow control, ...
- Layer 5 (session layer): Login, session dialog control, ...
- Layer 6 (presentation layer): Data representation, data standardization, ...
- Layer 7 (application layer): Set of user-defined application functions

CAN Application Layer
- CANopen, DeviceNet, CANaerospace, CAN Kingdom, ...

CAN 2.0/2.0A/2.0B
What is CANaerospace?

• The CAN specification itself does not cover issues like data representation, station addressing or connection-oriented protocols.

• Using CAN networks in aerospace demands a standard targeted to the specific requirements of flight or mission critical airborne applications.

• Based on experience in flight control and guidance systems, Stock Flight Systems created the CANaerospace interface definition in 1997. CANaerospace is an open standard and may be used by anybody free of any charge. CANaerospace has also been standardized by the US National Air and Space Administration (NASA) as “AGATE data bus” in 2001 (document AGATE-WP01-001-DBSTD, Langley Research Center).

• CANaerospace is a slim software layer that turns CAN into an easy-to-handle data bus meeting the specific requirements of avionic systems.

• CANaerospace is used and supported by some major European aerospace companies (EADS, Eurocopter, Aero Vodochody, Rotax-Bombardier, Kayser-Threde, ....).

• CANaerospace networks are installed in several aircraft since 1998 and have demonstrated excellent reliability in a harsh environment.
CANaerospace at a glance

- **Democratic network**: No master/slave relationships for normal operation
- **Self-identifying message format**: Information about data type and transmitting station
- **Message numbering**: Support for coherent data processing in redundant systems
- **Message status code**: Continuous integrity monitoring support
- **Emergency event signalling mechanism**: Information about CBIT detected failures
- **Node service mechanism**: Addressing of specific stations for integrity monitoring, data download, time synchronisation, ..... 
- **Identifier assignment**: Proposed default identifier distribution (similar to ARINC429)
- **Ease of implementation**: Reduction of work required for certification
- **Openness to extensions**: Minimum of fixed definitions to provide flexibility
- **Free availability**: No cost for use, free source code, free specification and tutorials
CANaerospace basic message format

- **Node-ID (Byte 0)**: Some system architectures employ backup units which become active if the main unit fails. The Node-ID allows to immediately identify this situation and react accordingly (i.e. mode change within redundancy management).
- **Data Type (Byte 1)**: CANaerospace supports multiple data types for every message. Backup units (or units from different vendors) may use different data types while performing identical functions. Specifying the data type with each message allows automatic system configuration, even during runtime.
- **Service Code (Byte 2)**: For Normal Operation Data, this byte should continuously reflect the status of the data (or the transmitting unit) to support data integrity monitoring within receiving units. With this information, the validity of data is known at any given time.
- **Message Code (Byte 3)**: Message numbering allows to detect if messages are missing and if the transmitting unit is operating properly. Also, it can be used to compare the "age" of messages from redundant sources.
## CANaerospace identifier range definitions

<table>
<thead>
<tr>
<th>Category</th>
<th>ID Range</th>
<th>Data Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Event Data</td>
<td>0 - 127</td>
<td>128 data objects</td>
</tr>
<tr>
<td>High Priority Node Service Data</td>
<td>128 - 199</td>
<td>72 data objects (36 com. channels)</td>
</tr>
<tr>
<td>High Priority User-Defined Data</td>
<td>200 - 299</td>
<td>100 data objects</td>
</tr>
<tr>
<td>Normal Operation Data</td>
<td>300 - 1799</td>
<td>1500 data objects</td>
</tr>
<tr>
<td>Low Priority User-Defined Data</td>
<td>1800 - 1899</td>
<td>100 data objects</td>
</tr>
<tr>
<td>Debug Service Data</td>
<td>1900 - 1999</td>
<td>100 data objects</td>
</tr>
<tr>
<td>Low Priority Node Service Data</td>
<td>2000 - 2031</td>
<td>32 data objects (16 com. channels)</td>
</tr>
</tbody>
</table>
# CANaerospace default identifier distribution (examples)

<table>
<thead>
<tr>
<th>CAN identifier</th>
<th>System parameter name</th>
<th>Data type</th>
<th>Units</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>317 ($13D)</td>
<td>Calibrated airspeed</td>
<td>FLOAT SHORT2</td>
<td>m/s</td>
<td></td>
</tr>
<tr>
<td>321 ($141)</td>
<td>Heading angle</td>
<td>FLOAT SHORT2</td>
<td>deg</td>
<td>+/-180°</td>
</tr>
<tr>
<td>401 ($191)</td>
<td>Roll control position</td>
<td>FLOAT SHORT2</td>
<td>%</td>
<td>right: + left: -</td>
</tr>
<tr>
<td>500-503</td>
<td>Engine #n N1 (1 &lt; n &lt;= 4) ECS channel A</td>
<td>FLOAT SHORT2</td>
<td>1/min</td>
<td>N1 for jet, RPM for piston engines</td>
</tr>
<tr>
<td>1008 ($3F0)</td>
<td>Active nav system track error angle (TKE)</td>
<td>FLOAT SHORT2</td>
<td>deg</td>
<td>service code field contains waypoint #</td>
</tr>
<tr>
<td>1070 ($42E)</td>
<td>Radio height</td>
<td>FLOAT SHORT2</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>1205 ($4B5)</td>
<td>Lateral center of gravity</td>
<td>FLOAT SHORT2</td>
<td>% MAC</td>
<td></td>
</tr>
</tbody>
</table>
CANaerospace proposal for the physical interface

Power +28VDC 1
CAN Low 2
unused 3
RS-232 TxD (maintenance/service) 4
Power Gnd 5

6 RS-232 RxD (maintenance/service)
7 CAN High
8 unused
9 RS-232 Gnd (maintenance/service)

MIL-24308/8 CANaerospace connector
CANaerospace proposal for the physical interface (contd.)
CANaerospace proposal for MIL-C-26482 and MIL-C-38999 connectors

Proposed pinout:

**Internal**
- Pin 1/B +28VDC
- Pin 2/E CAN Low
- Pin 3/F unused
- Pin 4 RS-232 TxD
- Pin 5/A DC Gnd
- Pin 6 RS-232 RxD
- Pin 7/D CAN High
- Pin 8/C unused
- Pin 9 RS-232 Gnd
- Pin 10 +28VDC
- Pin 11 DC Gnd
- Pin 12 CAN Low
- Pin 13 CAN High

**External**
-shielded twisted pair or quadruple (CAN or CAN/power)

Connectors:
- MS3476L1006SN
- D38999/26FB35SN
- D38999/26FA35SN
Example for a suitable CANaerospace cable
Requirements: 120Ω impedance, low capacitance
CANaerospace projects (1)

Eurocopter All-Weather Rescue Helicopter (AWRH)

- CANaerospace as interface between navigation system, flight state sensors and pilot’s control units
- Flight tests proved reliability and performance of CANaerospace data communication
CANaerospace projects (2)

Stock Flight Systems Data Recording System (FDR1-CAN)

- Modular, CANaerospace-based flight data recording system
- Installed in Pitts S-2B as continuous testbed
- Used in Eurocopter helicopters and various research aircraft
CANaerospace projects (3)

Stratospheric Observatory For Infrared Astronomy (SOFIA)

- NASA/DLR program for high altitude infrared astronomy
- CANaerospace used for communication between star tracking system and realtime control computers for telescope control
- CANaerospace network length 40m
- System integration in 2002, first flight planned for 2004
- Website: http://sofia.arc.nasa.gov
The “System of Aviation Modules (SAM)” has successfully passed CAA (Cz) certification for the Ae270 business/small transport aircraft developed by Aero Vodochody a.s. (www.aero.cz) and AIDC Ltd. of Taiwan.

SAM comprises of seven intelligent units which communicate under each other using CANaerospace. All SAM units are qualified according to RTCA DO-160D/DO-178B and meet the HIRF (High Intensity Radiated Fields) requirements. The certification is based on FAR part 23.

The SAM functions include electric power supply monitoring, fuel distribution and supply control, hydraulic system control, propeller heating control, airframe load monitoring, deicing control, etc.
CANaerospace projects (5)

Bombardier-Rotax V220/300T aircraft engines

- Fuel-injected, watercooled, 120-degree V-6 engine line with dual redundant electronic engine control unit and CANaerospace data bus
- CANaerospace-interfaced Engine Monitoring Unit providing the pilot with all engine data already installed in several aircraft
- FAA/JAA certification expected 2003, first deliveries in 2004
- Website: www.VaircraftEngines.com
NASA Small Aircraft Transportation System (SATS) program

- SATS is a partnership among various organizations including NASA, the Federal Aviation Administration (FAA), US aviation industry, state and local aviation officials, and universities.
- The target is to develop all weather operations within the entire US airspace for general aviation.
- CANaerospace/AGATE databus serves as the central avionics backbone network in the research aircraft used for the SATS program flight tests.
CANaerospace projects (7)

Various Flight Simulators

- Dornier-Fairchild 728JET engineering simulator
- Eurocopter TIGER simulators
- Eurocopter BO105 procedure trainer
- Eurofighter Typhoon simulator
- EADS Mako demonstrator
- NH90 engineering simulator
CANaerospace products and services (1)
Stock Flight Systems

Products/Services:

- CANaerospace specification
- Flight data recordering systems
- Embedded realtime control computers
- CANaerospace network installations
- CAN interface boards and driver software
- Consulting services

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CANaerospace products and services (2)
Reiser Systemtechnik

Products/Services:

- Night vision compatible simulation cockpit instrumentation
- Design and manufacturing of entire simulation cockpits including ejection seat mock-ups
- Design and manufacturing of test facilities

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CANaerospace products and services (3)
Wetzel Technology

Products/Services:

• CANaerospace tools
• Data visualization
• Digital map applications
• Operator stations
• Instrument simulation

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- Innovative Control Systems, Inc (ICS) was established in 1991 as a provider of aerospace engineering services and equipment to High Technology Aerospace Companies.

- Their customer base includes companies such as Honeywell, Raytheon, Dornier Luftfahrt, Hamilton Sundstrand, B.F. Goodrich, Aircraft Braking Systems, Vibrometer, Smiths Industries, and many other aircraft manufacturers and equipment suppliers.