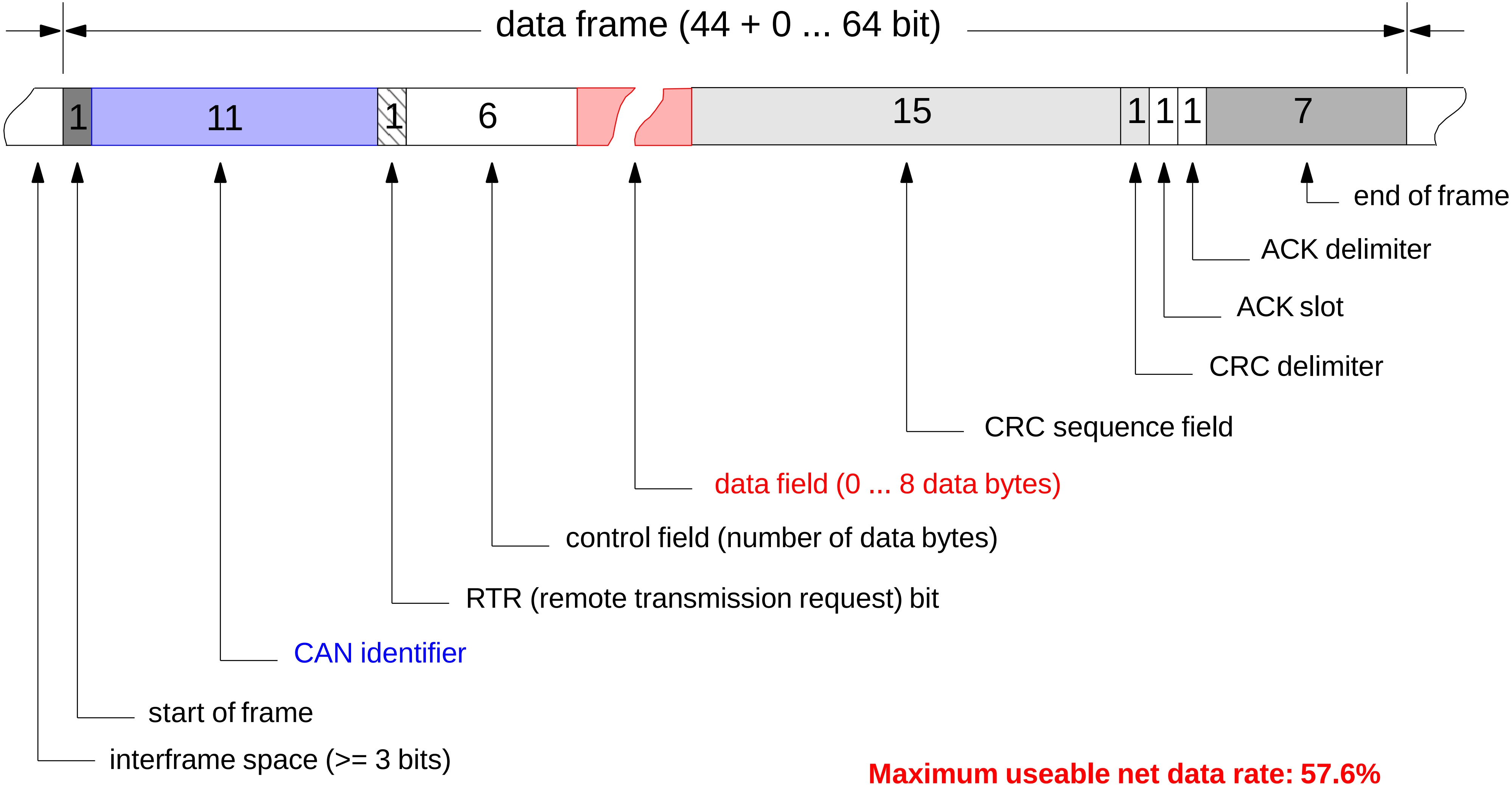
CAN Aerospace

Questions & Answers

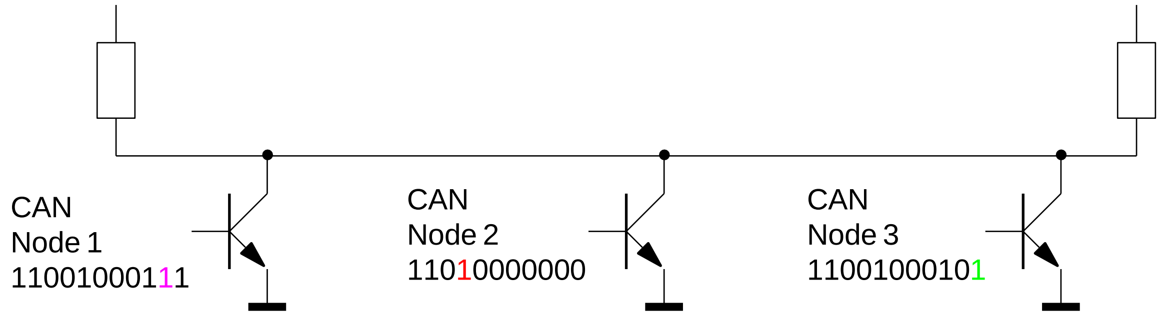
Q: What does a CAN serial transmission data frame look like?

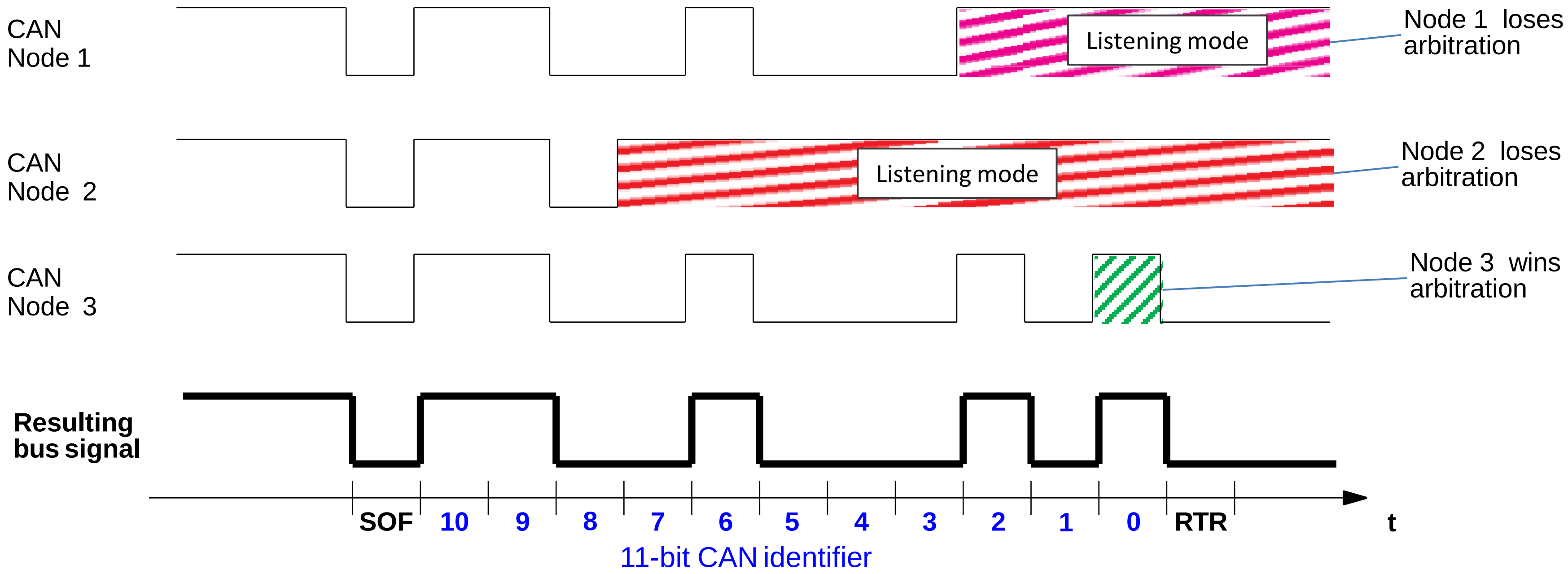


Maximum useable net data rate: 57.6%
This equals 576 kBit/s or 72 KBytes/s @ 1MBit/s

Q: How does the "non-destructive bitwise bus arbitration" for CAN work?

A bit pulled low is a "dominant" bit





Q: How does CAN handle transmission errors?

CAN uses a highly sophisticated error detection protocol, consisting of:

a.) Cyclic redundancy check (CRC)
b.) Frame structure check
c.) Data acknowledge check
d.) Bus signal monitoring

If one station detects an error, it immediately sends an "error flag", which causes:

1.) the transmitting station to abort the transmission;
2.) all stations to disregard the current message;
3.) automatic retransmission of the message (after 23 bit periods);
4.) all stations to check if they are the cause of the error and if so, to increment their internal error counter;
5.) any station which detects that its internal error counter has exceeded the limit to go "BUS-OFF".

Probability of undetected data corruption: ~1* 10^{-13} per CAN message transmission

Q: CAN and safety critical applications: Does it match?

- The probability of an undetected data corruption for CAN is around 1 * 10^{-13} per message transmission. Assuming 100% bus load (around 8.000 messages per second at 1 Mbps), this will result in a probability of 2.9 * 10^{-6} undetected failures per flight hour.

- While this figure is better than for most other bus system available today, it shows that CAN (like all other buses) will require data bus redundancy for flight safety critical systems, especially for those requiring fail-operational behaviour.

- The (hardcoded) CAN protocol has demonstrated excellent reliability in more than 100 million chips installed today. CAN networks are usually exposed to a harsh environment.

- Due to the high quantities, the cost, size and weight of CAN interfaces is significantly lower than that of any other bus system. Therefore, adding a second or even third bus for redundancy will not cause unacceptable penalties.

- Honeywell Flight Systems (USA), IABG (Germany) and Unis (Czech Republic) have successfully developed and certified CAN-based aircraft systems according to FAR23 and FAR25.

Q: Why not using an one of the other higher layer CAN protocols instead of CANaerospace?

- Aside from CANaerospace, several “industrial” higher layer CAN protocols like CANopen, DeviceNet, CAN Kingdom, SDS have been designed by various companies.
- The “industrial” CAN protocols are purely focused on industrial applications and do not concern about specific aerospace requirements like system redundancy, single-mode failure prevention or system startup time limitation, to name a few.
- The “industrial” CAN protocols are mostly based on master/slave relationships requiring “boot procedures”. Master failures can potentially create hazardous conditions in systems requiring fail-operational (instead of fail-safe) behaviour.
- In an attempt to meet virtually all requirements of industrial applications, the “industrial” protocols have become quite complex. Specifications are cumbersome to read and often inconsistent. This is a questionable basis for the certification of flight critical applications.
- Many “industrial” CAN protocols are proprietary developments by companies that charge license fees for the use of the protocol.

Q: The 4-byte CANaerospace header: Is it really inevitable for Normal Operation Data?

- Unlike other aviation buses like ARINC429, ASCB or MIL-STD-1553B, CANaerospace is a dynamic network with a bus schedule that varies within certain limits.

- Certification in flight safety critical applications requires to demonstrate the proper function of the data transmission under all conditions.

- Monitoring CANaerospace messages during normal operation and processing the header information delivers the required information for certification.

- Additionally, the header information improves flexibility and supports dynamic network reconfiguration. Power down/up situations are handled gracefully, units may be added to the network without software changes.

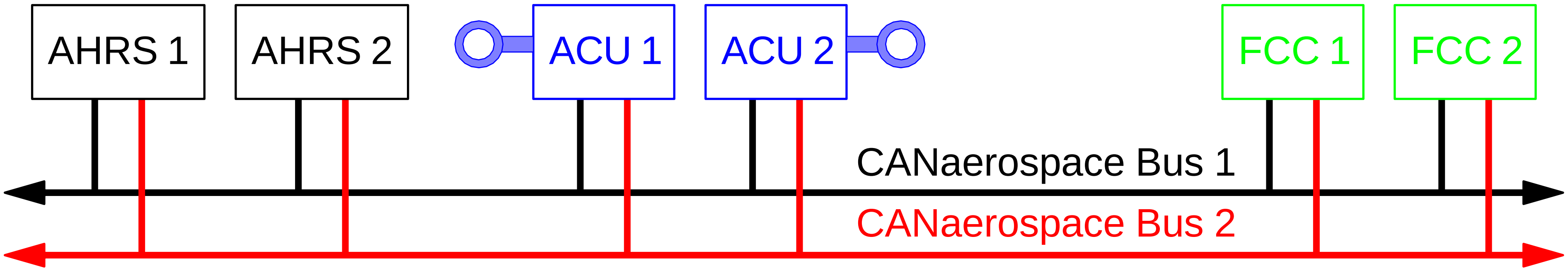
- Taking advantage of the header information, CANaerospace bus analyzers (like XTC from Stock Flight Systems or CANalyzer from Vector) and simulators can be inserted even into a running network and will immediately have all information about network structure, units and data. This ensures fast and cost-effective maintenance.

Q: The 11-bit CAN-identifier: Are 2031 different messages the absolute limit?

- With CAN Version 2.0B, two identifier groups are available: The 11-bit identifier group (“standard identifier”) and a 29-bit identifier group (“extended identifier”).
- Both identifier groups may coexist on the same bus, thereby creating two independant network layers.
- All newer CAN controllers (as well as CANaerospace) support both identifier groups at the same time.
- CAN messages of the extended identifier group create around 15% more bus load than messages of the standard identifier group.
- Extended identifier group messages can be used in addition to standard identifier group messages as required.
- A study has shown that the systems typically installed a single-engine, IFR-equipped general aviation airplane will generate a CANaerospace bus load of less than 50%.

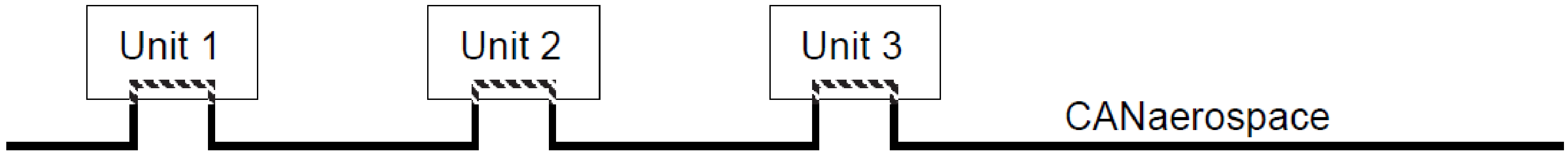
Q: CANaerospace - Does it support redundancy?

- A system architecture as used by many modern integrated avionics and electronic flight control systems is shown below.
- In this architecure, two redundant units of the same type communicate via an equal number of communication channels. Proper design provided, this system will prevent a single failure to cause a complete loss of function.
- Each CANaerospace data bus parameter has assigned a single, unique identifier. Only one unit is allowed to transmit a particular parameter on the bus.
- To support redundancy, using CAN 2.0B provides several CANaerospace identifiers for each parameter.

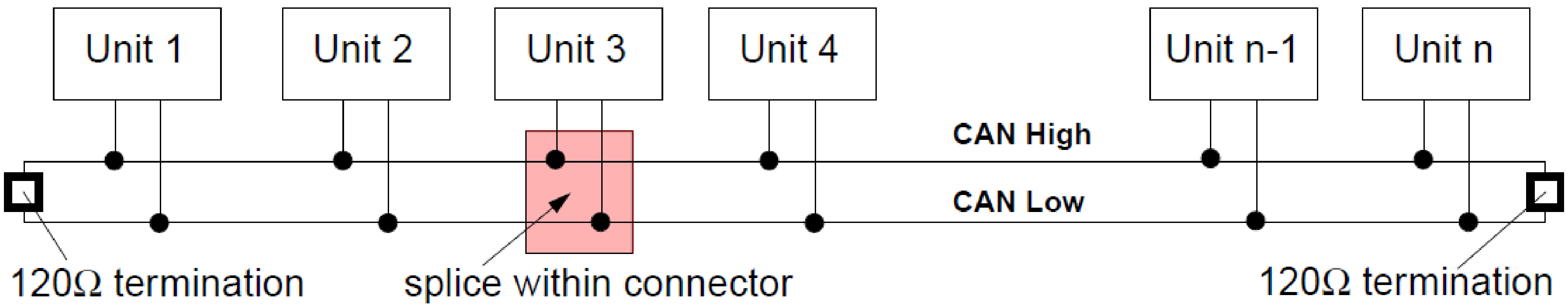


Q: The physical interface: How is it realized for CANaerospace?

- The CAN bus topology is a shielded, twisted pair single line, terminated at both ends. Usually, CANaerospace units are interconnected using CAN-IN/CAN-OUT connectors:

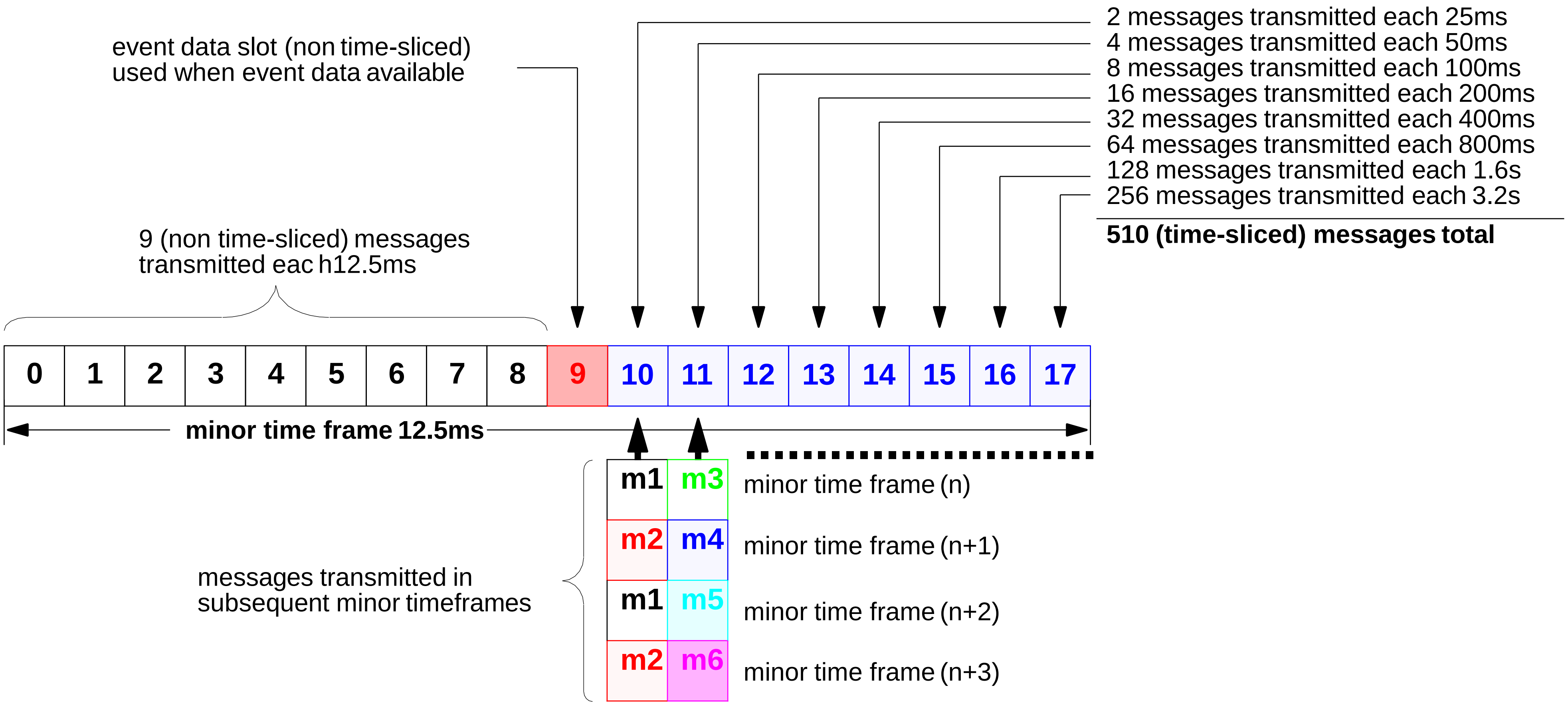


- CANaerospace defines MIL-C-38999 standard connectors, D-Sub connectors, as well as other rugged connectors for this purpose. Optionally, power supply lines may be routed with the data lines, simplifying intermodule cabling.
- Units may also be connected via splices within the connector. Using this method, removing a unit from the bus (or reattaching it) will not adversely affect the others (the bus will not be opened by unplugging a connector):



Q: CANaerospace channel capacity estimation: How is it done?

- In this example, 520 signals are processed. The minor time frame is set to 12.5ms (80Hz maximum update rate), the major time frame is 256* 12.5ms = 3.2s



Q: Gateways between RS232-422/ARINC429/Ethernet/... and CANaerospace: Do they exist?

- Stock Flight Systems and LikeAbird provides several small, lightweight yet rugged computer systems for this purpose.
- Configuration of the gateway functionality for analog and discrete information is possible via CANaerospace Node Service Requests. The configuration data can be permanently stored in internal FLASH memory.
- Realization of the gateway functionality for RS232/422 , ARINC429 or Ethernet information requires development of some high level “C” software for protocol translation.
- The driver libraries for the NECS (Network Extended Control System) family of microcomputer systems are tested and “bullet proof”. Software may be developed, downloaded and permanently stored in internal FLASH memory using the RS-232 or USB maintenance port.

NECS

CANflight

Q: What is the history of CANaerospace?

CANaerospace was developed by Michael Stock back in the late 90´s. He is an electronics engineer and became employed with a company called Messerschmitt-Bölkow-Blohm in the mid 80’s. He started to work on the helicopter flight controls division of what is now known as Airbus Helicopters (formerly Europcopter). And at that time they were not using many data busses, simply cause there were not to many available in the aviation world. Around that time, 1985, Bosch came up with a data bus that was originally designed for automotive use, call the Controller Area Network, or CAN bus.

Michael Stock immediately started to use that bus, initially for flight simulation. At that time they did not have any protocols based on that databus. So it was really a very rudimentary bus for transmitting information back and forth, but there was no standardization in any way. Standards came up later, but all of these were targeted towards the automotive industry or the factory automatization industry, so they were not really suitable for the aviation industry. In 1998 he finally went ahead and defined a standard that would turn CAN into a data bus that is really suitable for aviation purposes. And he called this protocol that sits on top of the CAN bus “CANaerospace” and it has been around since.

Q: What is the history of CANaerospace? – Cont.

In the meantime, we are approaching version 2.0 and initially it was used at Airbus Helicopters and then he made it available on the internet and finally with the AGATE programme conducted in the USA, around the year 2000, NASA got involved with Michael and standardized the CANaerospace Protocol as the AGATE Databus. The whole thing moved up to the general aviation world and then starting from this it took about 10 years until companies in GA were using it, and nowadays they are a couple of glass cockpit panel manufacturers using CANaerospace in their products. Today some entire avionics suites in General Aviation uses CANaerospace within their system.

Q: What about some negative rumors?

Negative 1: CANaerospace has more than 50% of payload overhead which makes it unfit for high speed data streams that are so common for UAV (especially for light machines where the controlled system requires high update rates and low latency).

Answer: In aircraft systems you will need at least some portion of the message payload for the purpose of what CANaerospace defines anyway. The CANaerospace header provides information required to monitor message integrity and time relationship, and allows to detect missing messages and time skews. Signal update rates may be higher for small UAVs than for manned aircraft, but CANaerospace works perfectly in the Red Bull Air Race for the complete flight state, air data, engine and parameters (120 different messages) transmitted at 100Hz.

Negative 2: CANaerospace does not provide an easy way to pass multiple values in one bunch, which is also very common task in the UAV field.

Answer: CANaerospace provides User-Defined sections for identifiers, data types and all other means to design multi-value combinations of any type. Due to the fact that the requirements concerning that differ widely, no fixed definition was made. CANaerospace deliberately provides the means to define non-standard data types while not narrowing it down.

Q: What about some negatives rumors – Cont.

Negative 3: CANaerospace does not provide adequate means for some extremely common higher-level tasks, such as node configuration handling, firmware update, time synchronization, etc.

Answer: CANaerospace provides the Node Service Interface which has already been used in hundreds of systems for data upload/download, configuration handling, firmware update and time synchronization. Like for specific data types, the User has the freedom to design these services based on the existing protocol. A definition for a specific purpose (like UAVs) can easily be made.

Summary:

CANaerospace has become a de facto standard in military flight simulation in Europe, and the entire line of fuel injected Rotax aero engines is based on this protocol. Then, companies like iMAR Navigation (www.imar-navigation.de) and Volz Servos (www.volz-servos.com) provide CANaerospace interfaces for their products. The number of companies supporting this protocol is growing rapidly.

About Stock Flight Systems – Inventor of CANaerospace

Stock Flight Systems has been established in 1993 as an aerospace industry support company. We have focused on the development, manufacturing and integration of flight data acquisition, recording and inflight test and control systems for aerospace applications. As a service to our customers, we also do flight testing of sensors, actuators and data communication and processing equipment. Stock Flight Systems is also a partner in international aeronautical research programs. The projects we already completed successfully include inflight test, instrumentation and closed loop control systems, test stands and flight simulator cockpit units. Our products are designed to operate in harsh environments and can be qualified to highest standards.

SFS Customer Base using CANaerospace

- NASA Langley Research Center - USA
- NASA Dryden Flight Research Center - USA
- Airbus Defence & Space - Germany
- Kayser-Threde GmbH - Germany
- Airbus Helicopters - Germany
- Airbus Helicopter - France
- IAGB - Germany
- ESG - Germany
- MT Aerospace – Germany
- BRP Powertrain GmbH - Austria
- DLR - Germany

About LikeAbird S.L.

LikeAbird is a R&D Think Tank company providing innovative CANaerospace systems, products and solutions in the field of the unmanned (air/land/sea) and robotic industry. Our products and solutions are aligned with the current and future needs of our customers and address emerging challenges in key areas, such industrial grade remote piloted systems, human machine interfaces, electronic equipment, software packages and related services.

Innovations is the key to new technologies - technology is the door to innovation. Our mission is to bring to our clients solutions based on the best available technology bundled with innovation. Our continuous effort in the observation of existing and emerging new technologies allows us to engineer and to realize innovative solutions, and is demonstrating our ability to innovate our product portfolio and services.

Contact us for more infos

www.stockflightsystems.com

www.likeabird.eu