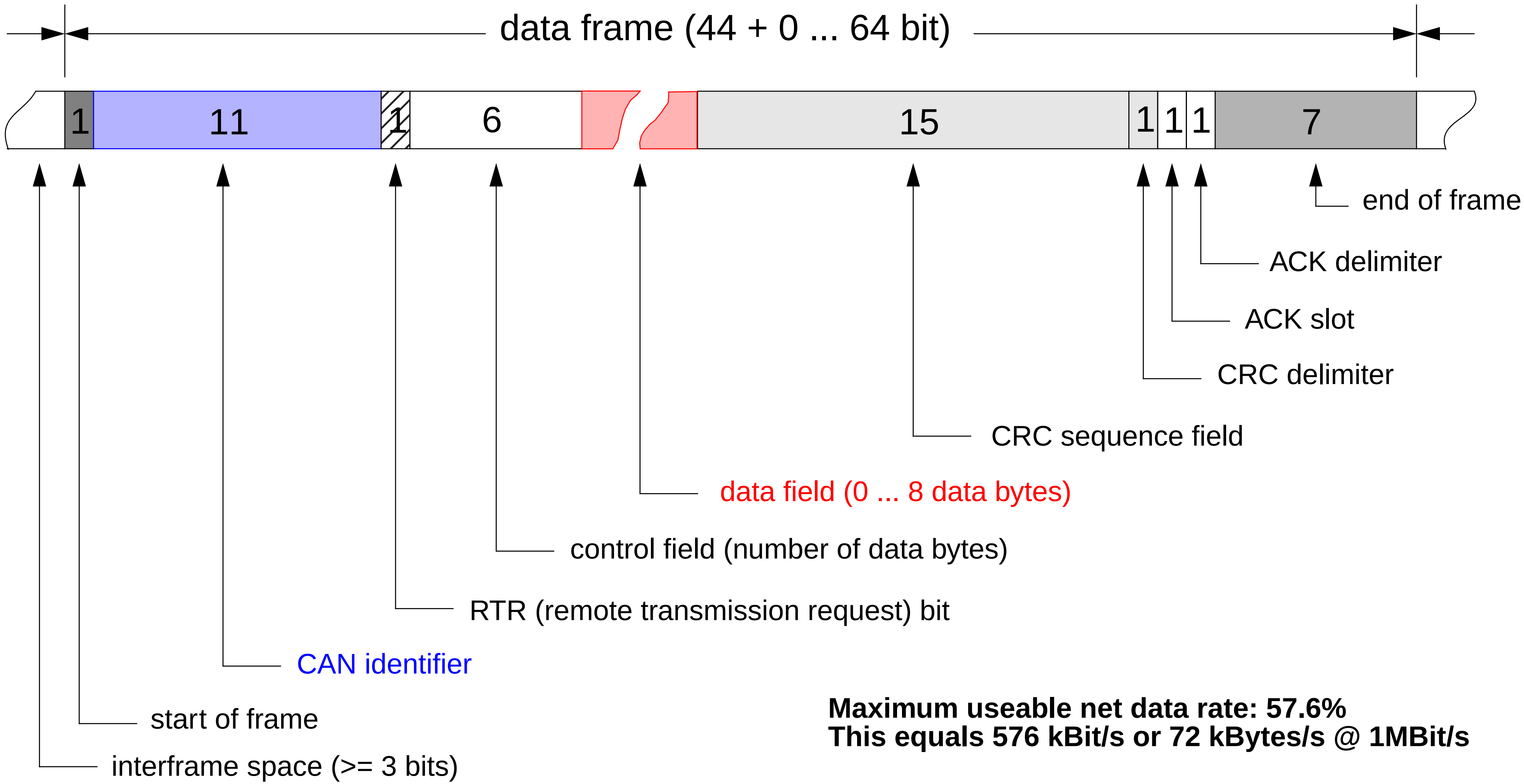
CANaerospace - Questions and Answers

CAN Aerospace

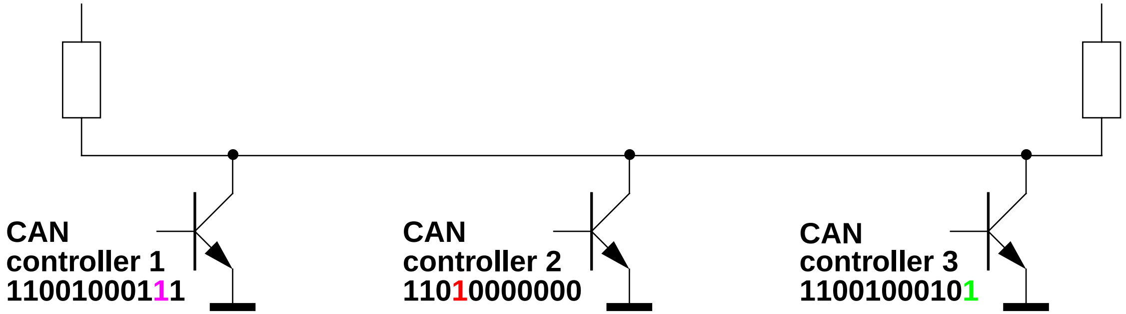
What does a CAN serial transmission data frame look like?

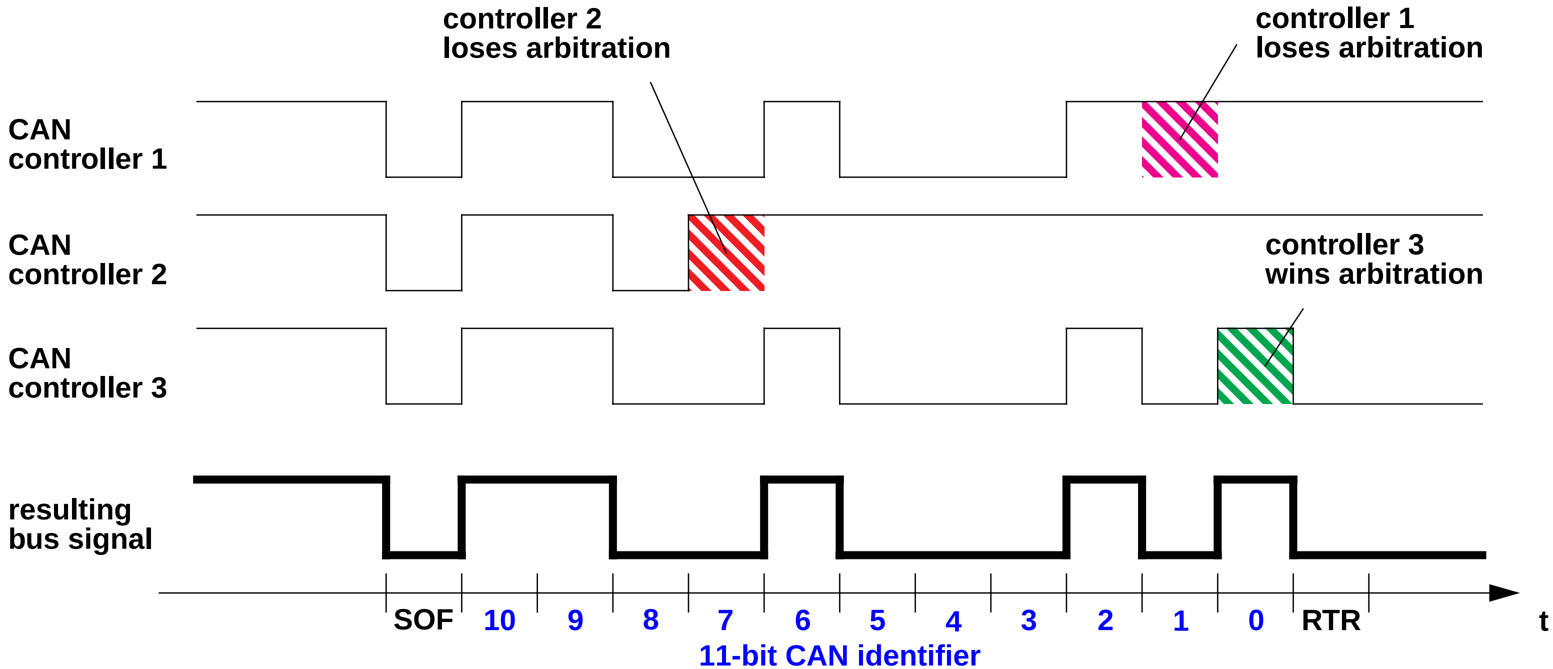


Maximum useable net data rate: 57.6%
This equals 576 kBit/s or 72 kBytes/s @ 1MBit/s

How does the “non-destructive bitwise bus arbitration” for CAN work?

A bit pulled low
is a “dominant”
bit





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

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.

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.

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

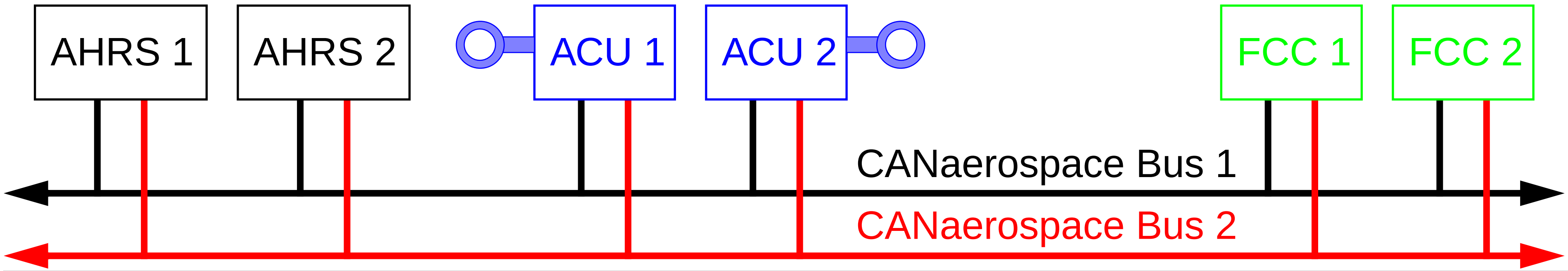
- Unlike other aviation buses like ARINC429, ASCB or MIL-STD-1553B, CANaerospace is a dynamic network with a bus schedule that varies within certain limits.
- Certification in flight safety critical applications requires to demonstrate the proper function of the data transmission under all conditions.
- 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 VISTA2D from Wetzel Technology) 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.

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%.

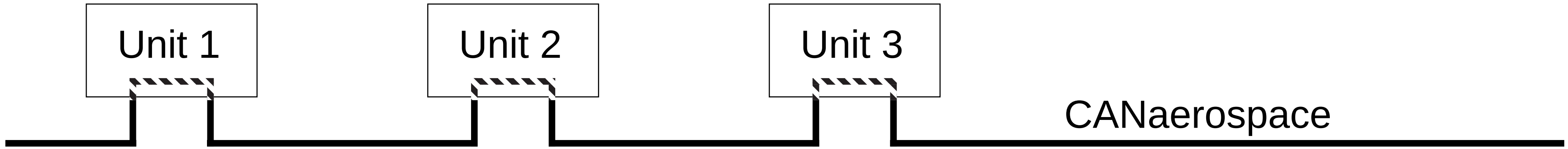
CANaerospace: Does it support redundancy?

- 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.

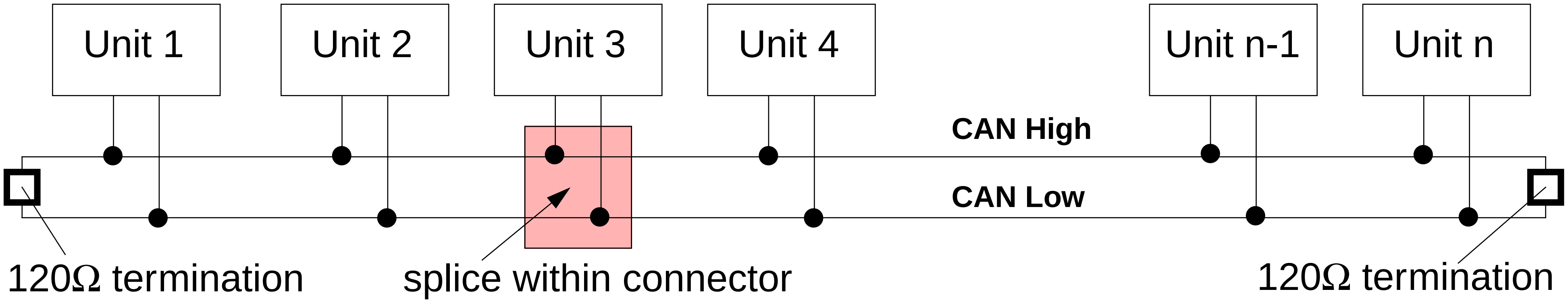


The physical interface: How is it realized for CANaerospace?

- 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:

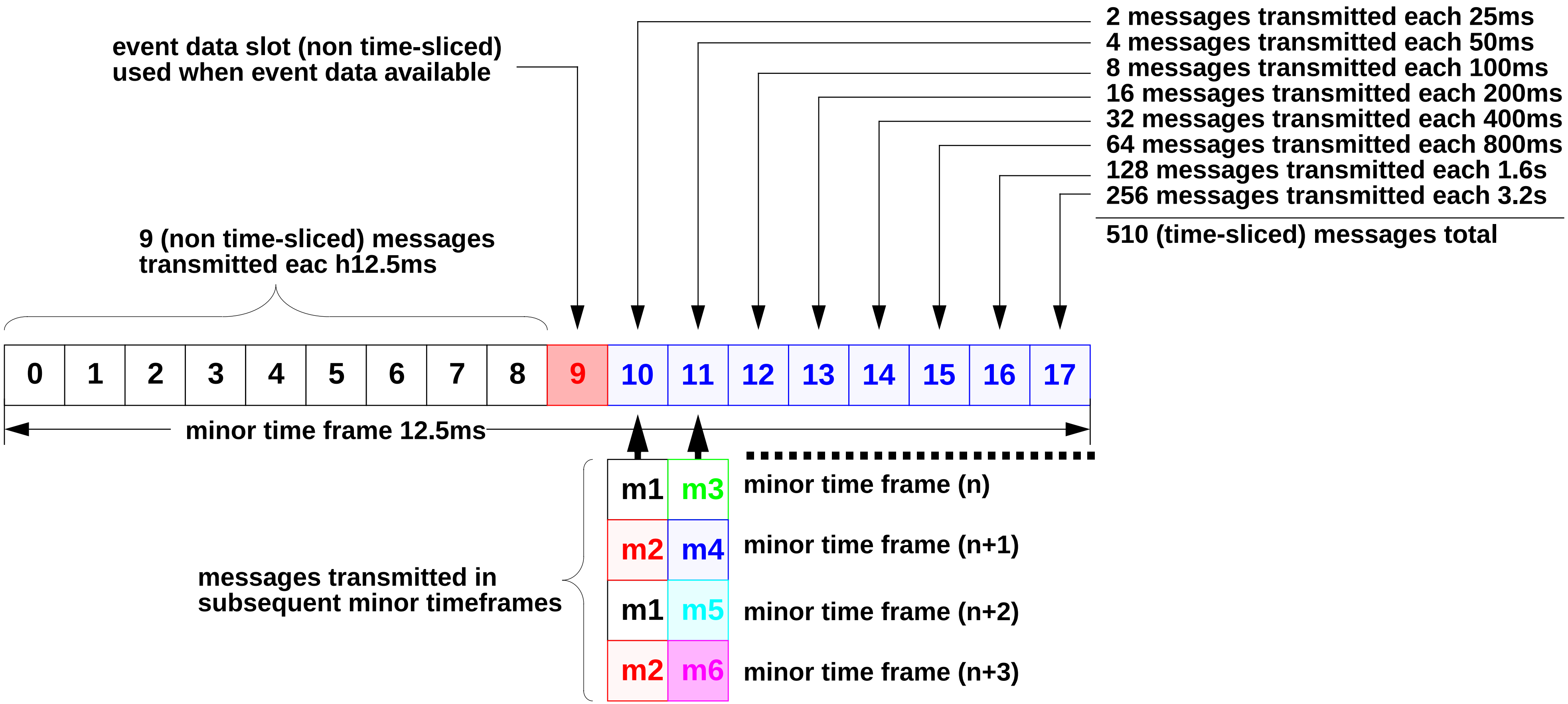


- CANaerospace defines MIL-C-38999 standard connectors as well as D-Sub connectors for this purpose.Optionally, power supply lines may be routed with the data lines.
- Units may also be connected via splices within the connector. Using this method, removing a unit from the bus (or reattaching it) will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



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



Gateways between RS-232/RS-422/ARINC429/ analog/... and CANaerospace: Do they exist?

- Stock Flight Systems 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 RS-232/422 or ARINC429 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 maintenance port. All software is delivered in source code.