History and trends:

CAN in air and space

The CAN Newsletter magazine reported already in its cover story of the December 1996 issue about the FDR1-CAN flight data recording system. Nowadays, CAN is used in Boeing and Airbus aircrafts, in helicopters, in drones, and even in satellites in the outer space.

(Source: Adobe Stock)

In 1996, the Aviat Pitts Special S-2B aircraft tested the CAN-connected flight data recorder for 28 flight hours without any problems. The modular system was developed by Michael Stock. He is also the main inventor of the CANaerospace higher-layer protocol. It is suitable for airborne systems employing the line-replaceable unit (LRU) concept. In order to avoid unacceptable frame transmission delays, CANaerospace recommends to limit the bandwidth usage to 50 percent. This means even in case of error frames, there is enough margin to overcome temporary fault situations.

CAN has also been used in flight simulators for entertainment or training purposes. These systems reproduced the cockpit of an aircraft as realistically as possible. Traditional architectures of flight simulators use several personal computers and point-to-point connections to link the cockpit devices with the simulation software. A paper from CAN in Automation's (CiA) 16th international CAN Conference (iCC) from 2017, described the development of CAN-based modules for A320 flight simulators. The recorded presentation can be watched here. The used application layer is based on the above-mentioned CANaerospace and provides users with the ability to ask for the identification of the devices, to change the Node-ID, to configure some of the modules and to automatically configure the bit rate. Another paper of the 16th iCC introduced CAN FD in aviation. It can be watched here. The international CAN Conference is a platform for presentations of CAN developments. Experts from all over the world and from the most-diversified application areas have met for years at this international event.

Another iCC paper in 2006 from Airbus introduced CAN-connected smoke detectors. The company, explained: Within the fire protection system on an Airbus, smoke detectors are installed in various areas overall in the pressurized zones of the aircraft such as lavatories, equipment bays, and cargo compartments. As the CAN defines only layers 1 and 2 of the OSI communication model, additional higher layer features are necessary to achieve the level of operational assurance required for a safety critical application, namely fire protection on an aircraft. This paper particularly focused on the development of a safety critical CAN network with strict configuration control of smoke detectors in the scope of an aircraft application.

In 2012, Airbus again was part of the iCC and reported about the standardization of CAN networks for airborne use through Arinc 825. The Arinc 825 higher-layer protocol is based on some ideas from CANaerospace. The first usage was in the Airbus A350 aircraft. Of course, applicable regulatory documents published by the FAA, EASA and/or other regulatory bodies need to be considered, too. In some aircrafts such as the Airbus A380 and Boeing 787, are about 80 to 250 CAN networks in duty. They are often connected to an Ethernet-based backbone network compliant with the Arinc 664 (AFDX) specification. Arinc 825 uses only the data frames with 29-bit identifiers. In the Supplement 4 of the Arinc 825 the usage of CAN FD is specified. The bit rate is 4 Mbit/s.

CAN in drones

Modern unmanned aerial vehicles (UAV) debuted as an important weapon system in the early 1980s. Israeli Defense Forces fitted small drones resembling large model airplanes with trainable television and infrared cameras and with target designators for laser-guided munitions, all downlinked to a control station. Nowadays, many of such combat drones use embedded CAN networks, the CAN Newsletter Online reported. But also drones for leisure purposes are equipped with embedded CAN networks. The drone community has developed the open-source UAVCAN higher-layer protocol. It is a simple application layer. DroneCAN was created to continue the development of the UAVCAN v0 protocol. The proposed introduction of the UAVCAN version 1 protocol involved changes to UAVCAN that increased complexity and did not offer ▷

Figure 1: In 2017 at iCC, Ana Antunes from Instituto Politecnico de Setúbal, introduced a paper which described the development of CAN-based modules for A320 flight simulators (Source: Adobe Stock)

Figure 2: In some aircrafts such as the Airbus A380 and Boeing 787, are about 80 to 250 CAN networks in duty (Source: Adobe Stock)

a smooth migration path for existing deployments. DroneCAN is the CAN-based high-layer protocol used by the Ardupilot and PX4 projects for communication with CAN peripherals. It is an open protocol with open communication, specification, and multiple open implementations. It supports CAN FD as well as Classical CAN.

The included DroneCAN transport layer supports unconfirmed multi-segment broadcast communication as well as a confirmed multi-segment communication. In the multi-segment approach an embedded CRC (cyclic redundancy check) sequence is transmitted in the first segment. Additionally, a toggle-bit ensures the detection of double-transmission of frames in case of a dominantly-detected last bit of the End-of-Frame field by the sender.

DroneCAN does not require nodes to undergo any specific initialization upon connecting to the network – a node is free to begin functioning immediately once it is powered up. The only application-level function that every node needs to support is the periodic broadcasting of the node status message.

The open-source higher-layer protocol references some CiA documents such as CiA 303-1 for connector pin-assignments and CiA 103 for the physical layer. It is recommended to provide two identical parallel connectors for each CAN interface per device, so that the device can be connected to the network without the need to use ▷

Figure 3: For example, the Phantom 2 drone from the company DJI provides CAN connectivity (Source: DJI)

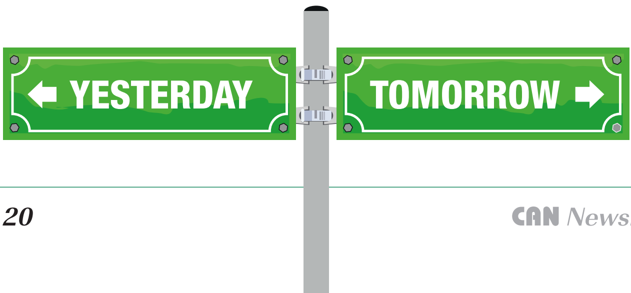
Figure 4: CAN is also found in space; ESA has chosen CAN as embedded network in some of its satellites. Additionally, ESA and satellite suppliers have developed a CANopen subset as higher-layer protocol. (Source: Adobe Stock)

T-connectors. They should be avoided, because they add an extra point of failure, increase the stub length and weight.

Mission-critical devices and non-mission critical devices often need to co-exist on the same DroneCAN network. Therefore, all devices should be connected to the primary CAN network. The mission-critical ones are connected to one or two additional backup CAN networks. DroneCAN is bit rate agnostic, so technically any bit rate can be used as long as it is suitable for the chosen network topology. However, only the recommended bit rates (1 Mbit/s, 500 kbit/s, 250 kbit/s, or 125 kbit/s) should be used to ensure compatibility. The sample-point should be located at 75 % of the bit time. The given maximum network length recommendations seem to be optimistic. Designers are encouraged to implement automatic bit rate detection with reference to the CiA 801 application node. CiA 801 CANopen automatic bit rate detection, describes the recommended practice and gives application hints for implementing automatic bit rate detection in CANopen devices. With the layer setting services (LSS) it is possible to change the bit rate in CANopen networks.

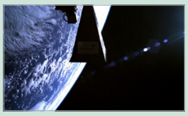
CAN in the outer space

The European Space Agency (ESA) has chosen CAN as embedded network in some of its satellites. Additionally, ESA and satellite suppliers have developed a CANopen subset as higher-layer protocol. This subset is specified in the ECSS-E-ST-50-15C document. ESA organized several "CAN in space" workshops. In summer 2017, they organized one in the south of Italy. It took place in the facilities of CiA member Sitael implementing CAN and CANopen completely in Asics. About 60 engineers from ESA, satellite suppliers, device makers, and semiconductor vendors participated in the three-day event. "CAN for space is a true ESA success story," said ESA's Gianluca Furano. Since several years, CiA member ESA develops jointly ▷



CAN Newsletter Online

The CAN Newsletter Online already reported several times about applications and products regarding CAN in the air and space. Here a few examples:



Aerospace

"Selfie" of CAN in space

Surrey Satellite Technology (SSTL) has announced the successful launch of TechDemoSat-1, an in-orbit technology demonstration mission for UK spacecraft equipment and software. The satellite's internal communication runs via a CAN network.

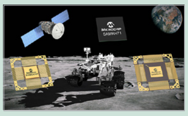
Read on

Sensor box

Teaching cars to fly

Bosch supports flying taxis by its sensor box originally developed for automotive applications. CAN or CAN FD connection is provided as well as SAE/Arinc 825-4 functionality.

Read on



Radiation-hardened MCUs

CAN FD micro-controllers for space systems

Microchip expanded its Arm Cortex-M7 MCU (micro-controller unit) family for space applications by the SAMRH707 MCU and the SAMRH71 MPU (micro-processor unit).

Read on

Servo drive

CANopen controls helicopter drone rotor

The TD220 unmanned aerial vehicle (UAV) uses Hornet CANopen servo drives from Elmo (Israel).

Read on

CAN Newsletter magazine

Electric propulsion demonstrator

NASA and several partner firms led by Empirical Systems Aerospace have worked on the X-57 Maxwell electric propulsion demonstrator, which uses several CANopen networks.

Read on

Aerospace

CAN on Mars

After seven month, the Trace Gas Orbiter (TGO) of ESA's Exomars 2016 has reached the Red Planet. Contact with the mission's test lander from the surface has not yet been confirmed.

Read on

Flying cars

Driving in 3D

Flying is a very old human dream. In Monaco at the Top Marques event, two companies demonstrate flying cars.

Read on

Aircraft and other applications

CAN modules for unmanned systems

Innodisk recently released their latest CAN modules. The products come with various form factors and are suitable for use in unmanned systems such as aircraft applications. They also support J1939 and CANopen.

Read on

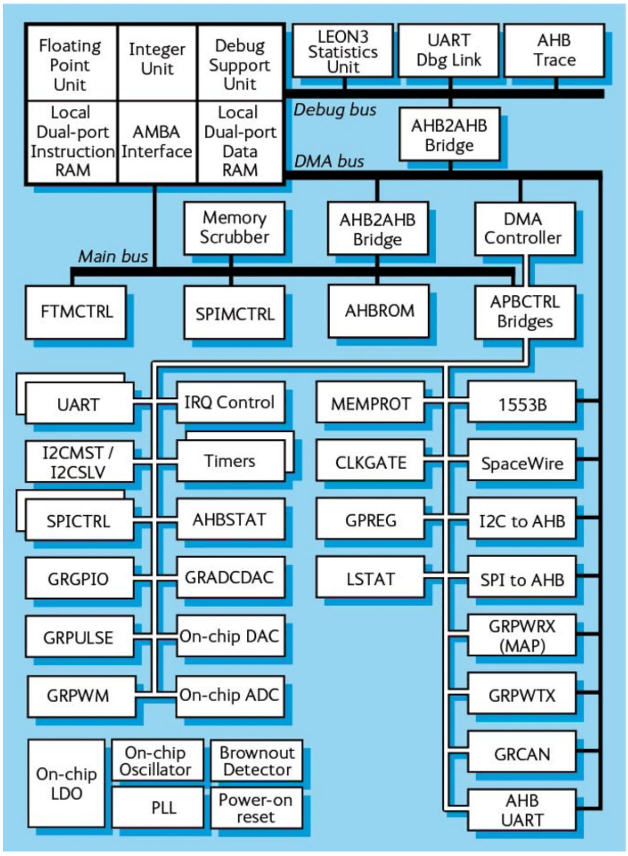


Figure 5: In 2019, the radiation-tolerant mixed-signal MCU GR716 by Cobham Gaisler has been introduced. It features two CAN interfaces (Photo: Cobham Gaisler)

with the supplying industry CAN-based solutions for satellite designs. For more details, read this article of the CAN Newsletter from 2017.

In June 2019, ESA and Cobham organized another CAN in space workshop in Gothenburg, Sweden (the CAN Newsletter Online reported). It focused on CAN micro-controllers and CANopen implementations. CiA provided a brief introduction into CAN FD and CANopen FD. Other speakers reported about their experiences of CAN and CANopen in space applications. About 80 participants joined the workshop. What was clear in all presentations is the trend to use ISO 11898-2 compliant transceivers. Of course, they needed to be radiation-tolerant. Cobham Gaisler, Microchip, and Renesas (formerly Intersil) showed their implementations.

As already mentioned, to use CAN in the outer space, it requires radiation-resistant micro-controllers with embedded CAN protocol controllers and radiation-resistant CAN transceivers. In the first satellites, EIA-485 transceivers have been used. Nowadays, several companies offer ISO 11898-2 compliant transceivers which are radiation resistant. In 2019, Cobham Gaisler introduced its radiation-tolerant GR716 micro-controller with CAN. It features on-chip A/D and D/A converters as well as other signal processing circuitry (the CAN Newsletter Online reported).

Next steps and outlook

CAN is in the air: Aircrafts, drones, satellites use CAN networks successfully since many years. First based on Classical CAN and now on CAN FD. Arinc 825-4 specifies the CAN FD usage for aircraft and DroneCAN supports CAN FD, too. Perhaps the airborne industry migrates to CAN XL, the third CAN protocol generation very soon. The reliability and robustness of the CAN lower layers are important features for these industries. ◀

Author

Cindy Weissmueller
CAN Newsletter
pr@can-cia.org
www.can-newsletter.org