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A BRIGHT IDEA

'Orange' avionic dataloggers log CAN bus data for flight tests in pursuit of sporadic errors

BY ARNE BREHMER AND CARSTEN KELLNER

Commercial airplanes are entering a new era in terms of the growing number of electronic components they contain. The systems, which are becoming increasingly more complex, need to be tested extensively in the laboratory and in flight trials. Dataloggers can make an important contribution in debugging and error analysis. However, they must fulfill the stringent technical and regulatory requirements of the aerospace industry.

Many requirements need to be considered in the development of modern aircraft cabins. First and foremost, all safety standards must be satisfied. Passengers have come to expect a very high level of comfort and comprehensive infotainment services, the crew needs ergonomic workplaces, and airline companies need fuel-efficient and economical aircraft. This can only be achieved by the continually growing use of electronic modules, in which the various functionalities are implemented in software.

USE AREAS OF CAN

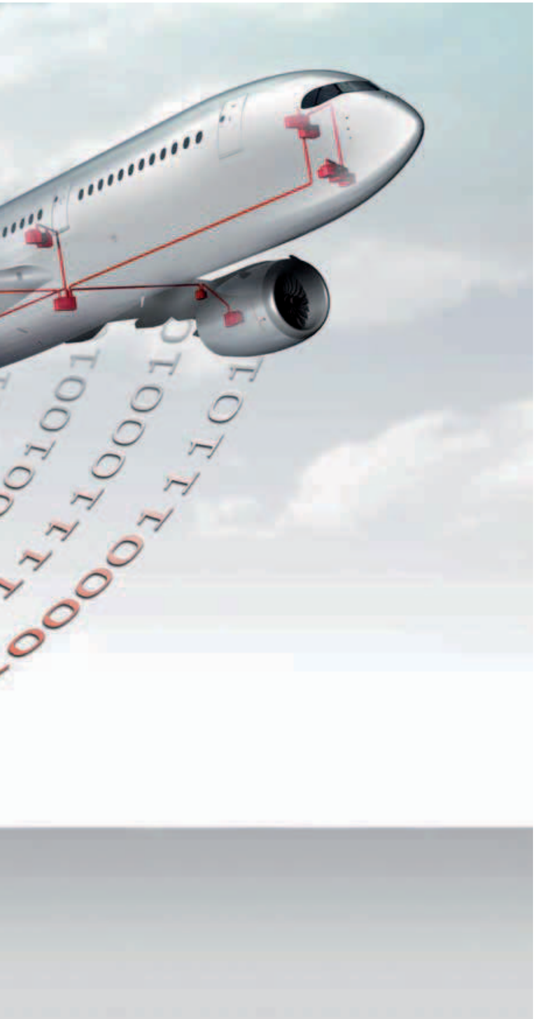
The CAN bus continues to gain in importance in networking LRUs (line-replaceable units) for cabin and aircraft systems. CAN is typically used in the system areas of air-conditioning, doors, fire detection, cabin management, aircraft galley and waste water.

The galley has a number of noteworthy electrical consumers with its refrigeration compartments, convection ovens, coffee makers and trash compactors. However, the amount of electrical energy that can be generated on board the aircraft is limited. That is why an intelligent power management system is used to prevent galley modules from all running at full load simultaneously. The Galley Master Control Unit does this by controlling all galley electrical consumers over the CAN-based Galley Databus. Power management distributes the available electrical energy within milliseconds, so that food and beverage services can run without interruption while not exceeding the defined maximum power consumption limit. The communication system is specified by the ARINC standardization organization and is used in the development of new civil aircraft. ARINC 810 defines the physical interface, while ARINC 812 defines services and protocols for coordination of the galley modules.

GROWING COMPLEXITY

Along with an increase in the number of subassemblies, the number of potential sources of error increases as well. The growing complexity is not only a challenge to development and production, but also to debugging and error analysis efforts. In addition to laboratory tests, wide-ranging flight tests are necessary. Here, the systems are tested, systematically and reproducibly, under the use conditions in which they will later be tested with customers.

These flight test trials are extremely time-consuming and expensive. Airbus, for example, uses five test aircraft to conduct flight test trials and obtain approval for the new A350, and several thousand flight test hours are



conducted. Flight test installations (FTIs) for new aircraft programs are also extensive and complex. However, the initial focus of flight test datalogging is on safety-critical systems such as the Flight Control System and Environmental Control System. Convenience functions in the cabin are not tested until later. The FTI might not log all data, messages and signals of the convenience-relevant systems in their entirety, depending on the specific test strategy. Therefore, it makes sense to utilize additional small, mobile dataloggers. This enables acquisition of the specific and extensive test data that is needed to enable a detailed analysis. The test personnel can look for specific causes of functional errors and evaluate them in relation to specific operating states.

HIGH LEVEL OF REQUIREMENTS

Equipment that is used to test aircraft must meet the especially stringent requirements of the aerospace industry. Above all, they must assure conformance to requirements related to electromagnetic compatibility as formulated in RTCA DO-160E.

The test equipment must operate without any interference, and it must be constructed so that it does not affect systems aboard the aircraft under any circumstances. Furthermore, it must operate safely and reliably even under the extreme temperature and pressure conditions that occur in aircraft. A rugged housing must reliably protect the system from environmental factors such as dust and moisture, even under harsh ambient conditions. The test units must survive high-voltage surges caused by lightning without damage, as well as vibrations that can occur during tests on the runway, in turbine tests or in flight maneuvers. The same applies to the typical acceleration loads and fluctuations in temperature and pressure. The overall system must be designed so that no small parts such as screws or covers can detach and become lost in the airplane. Ideally, a mounting plate should be used to join the test equipment to the airplane. Paint in a signal color makes it easy to recognize which components are part of the test equipment and are not intended for regular operation.

In addition to the mechanical design, the device's electronics must conform to the special requirements of the aerospace industry – they must operate with absolute freedom from interference and must not influence bus communications under any circumstances. Suitable design measures must be taken to insure that the system does not start any activities on the bus, even in the event of hardware or software errors or total device failure. An unpredictable external influence also must not result in any effects on the communication technology. Freedom from interference is tremendously important, because otherwise removal of the test equipment would represent a system modification.

ABOVE: **The GL1020FTE datalogger is a special flight test device that is used to record avionic bus communication**

LOGGING MEASUREMENTS

Vector has more than 20 years of experience in the testing, simulation and analysis of individual control modules, networks and distributed systems in the CAN field. This comprehensive know-how was an ideal prerequisite for developing the GL1020FTE Avionic Logger (above figure). Serving as a foundation was the compact GL1000 datalogger, which has been used successfully in automotive field testing for many years now. It can log two CAN channels simultaneously plus an additional four analog inputs. The ring buffer lets users choose between long-duration logging and event-triggered logging.

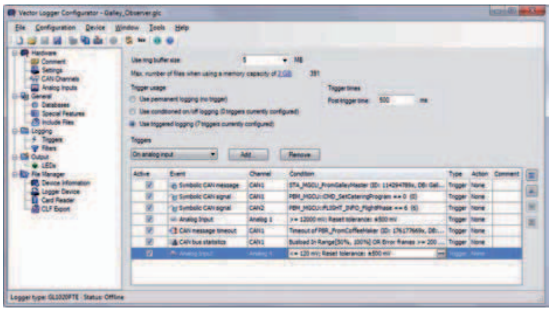
Engineers at Vector intentionally decided to base their logger design on a device series that had proved itself rather than develop an entirely new logger. The GL1020FTE underwent advanced development with regard to its housing, electronics and software so that it would fulfill the especially stringent requirements of aerospace engineering – maximum reliability and a very high level of electromagnetic compatibility (EMC).

The datalogger is equipped with a rugged housing, which was specially developed for use in aircraft, even outside of the pressurized cabin. The datalogger is easy to recognize as a piece of test equipment at a glance because of its RAL 2004 Pure Orange paint color. It is mechanically sealed. A welded Gore-Tex membrane which lets air through but not moisture is used for pressure equalization. The Avionic Logger is designed for ambient temperatures between -40°C and +85°C, and it can be operated up to a flying altitude of 36,000ft. It fulfills aerospace engineering requirements related to EMC. The datalogger itself does not emit any significant electromagnetic noise, and its operation is unaffected by typical ambient electromagnetic interference.

FLEXIBLY CONFIGURABLE

In test flights, the GL1020FTE is installed directly at the point at which the CAN communication should be logged. That may be in the cabin, in the cargo hold or in the wing. Its compact dimensions of 208 x 120 x 37mm, including assembly plate, allow the device to be installed in even the tightest of spaces.

The Avionic Logger can simultaneously log two CAN channels and up to four analog inputs. Simultaneous means time-synchronous, so that the user can directly evaluate the time relationships between different events. Vector offers various software tools for this purpose. The logger works on Layer 2 of the CAN protocol and can also acquire error frames, bus load and bus timing (time sequence of messages). The baud rate and the CAN channels to be logged are parameterized as fixed values. The logger has a maximum start-up time of 300ms to ensure that all data is acquired from the start. To save data, the logger has a permanently installed SD (HC) memory card with 8GB of memory, or it can be equipped with memory for storage of a maximum 32GB.



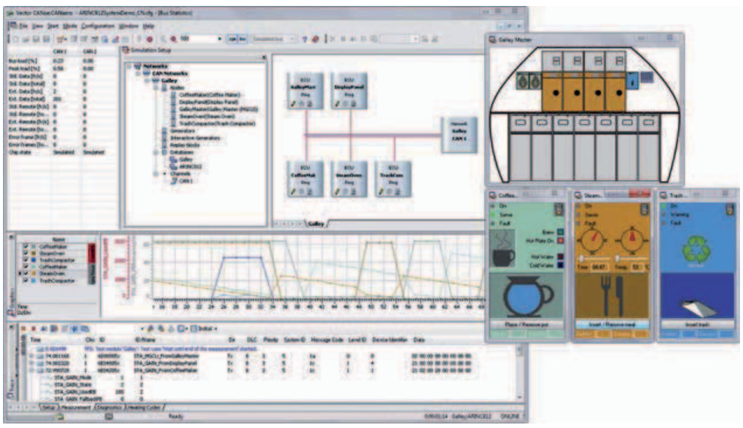
LEFT: **Setting up trigger conditions in the Vector Logger Configurator**

The data is logged either continuously or event-triggered. Continuous long-duration logging is used if an entire process needs to be acquired, or if sporadic errors have not yet been localized. This type of logging results in larger volumes of data. In event-triggered data acquisitions, the user defines extensive filter and trigger conditions. In this method, the data is acquired continuously and is constantly written to a ring buffer until the defined event occurs. The user can define the size of the ring buffer and the action to be executed when the trigger event occurs. If this action is to immediately close ring buffer and save its data, then the saved data, which is available for later evaluation, precisely matches the data stream up until the trigger event. If a post-trigger time was parameterized, the signals in the ring buffer are logged after the trigger so that data before and after the trigger time point is saved. Writing to the ring buffer is continually repeated until the next trigger event. This logging principle reduces data volume significantly compared with continuous logging.

User-defined states can be indicated directly on the device by four configurable status LEDs. The logger has four analog inputs for acquiring analog values such as temperatures. They are led to a plug connector and have an input range of 0-16V. The maximum sampling rate is 1kHz.

The GL1020FTE is configured using the Vector Logger Configurator (above figure). This user-friendly software can be run on any standard Windows computer. Its connection to the logger is via a USB 2.0 interface. The user can quickly and easily configure logging tasks with triggers, filters and ring buffers using the configurator's graphic user interface. CAN identifiers, symbolic messages and signal values may be selected directly for use as filter and trigger conditions. The Logger Configurator also supports CANdb databases. CANdb has become established as a de facto standard that is broadly used for symbolic description of communication relationships in a communication matrix. The user can work much more efficiently with plain text names and symbols than with cryptic byte values. The data can be read out over the connection to the logger and be converted to different formats, for example BLF, ASC and MS Excel. Various analysis tools such as CANoe, CANalyzer, CANape and CANgraph from Vector, as well as suitable solutions from third-party suppliers, may be used for offline evaluation of the logged data.

The datalogger is supplied with 28V DC over the electrical system and is designed for voltage peaks of up to 33V. In addition, it can buffer voltage drops lasting as long as 200ms, such as those that typically occur when switching over the aircraft's systems from ground power to the generator of the auxiliary turbine (auxiliary power unit). Specially developed for use in aircraft, the datalogger works autonomously in the background, and it does not require any test personnel to be on board to operate it. Together with modern analysis tools, it lets engineers perform efficient error analysis, and it supplies feedback for further development steps. ∎



ABOVE: **Simple observation of the data traffic and comprehensive network analysis with CANoe.CANaero**

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