TECHNOLOGY WHITE PAPER

Mitigating Flight Data Recorder Modification Issues using Modular FDAUs

CURTISS-WRIGHT

DEFENSE SOLUTIONS

Read About

Flight Data Recorders

Flight Data Acquisition Units

Modular Data Acquisition Systems

Internal

Rapid Prototyping

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Introduction

Flight Data Recorders (FDR) are necessary for many aircraft to provide valuable information to accident investigators following an incident. FDRs have, for the commercial world, usually been developed in accordance to ARINC 747 which describes a 1/2 ATR chassis form factor with a standard ARINC 717 FDR interface. ARINC 747 defines recorder characteristics that should be followed so that installers and users can interchange from one recorder to another. However, for lighter aircraft, including rotorcraft, smaller and lighter solutions are desirable. Adjustments are required not only so they meet an aircraft's interface requirements or current regulations but possibly to accommodate additional data for other applications. Such modifications may be costly or require additional flight data acquisition units (FDAU) to fulfil requirements due to the high cost of changing out critical safety equipment. This white paper discusses different strategies and how these can speed up deployment time, increase system flexibility to cope with changes and work across a fleet of diverse aircraft.

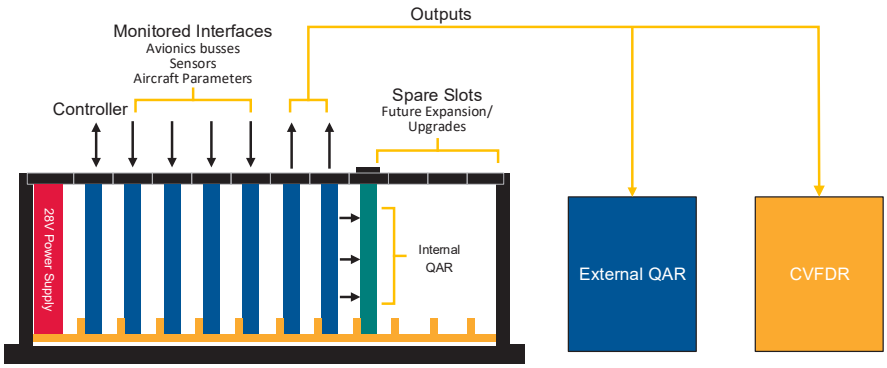

Figure 1: Not everyone needs the same recorder – outsourcing data collection and conditioning to an FDAU opens up new possibilities

Evolution of Flight Data Recorders

FDRs, sometimes called 'black boxes', are invaluable tools for accident investigators to help determine what has happened following an incident. They typically gather flight data, cockpit voice and datalink messages (image data is becoming more common and could be a common requirement in the future). They are constructed so they can survive crash events that results in extreme environmental conditions, such as high impacts and long exposure to high temperatures. Most large commercial aircraft have been mandated for several decades to have one or more recorders installed. Today, many other aircraft choose to install them for safety and maintenance reasons.

The first FDR is attributed to Dr. David Warren in 1954 who conceived the idea while investigating a mysterious crash. In 1955, Professor Penny and Mr. Giles created the first magnetic FDR. In 1960, FDRs start spreading into more and more aircraft, and in 1963 the UK Ministry of Aviation mandated that all civil carriers must carry one.

Today, the regulations concerning features and environmental specification continue to evolve to help improve safety within the industry. The most recent regulation changes are in reaction to recent incidents where finding 'lost' aircraft took an excessive amount of time. This includes new regulations for Underwater Locator Beacons (ULB) to test for sheer and tensile strength, and to increase the transmission duration from 30 to 90 days. Also, on the horizon is the European Aviation Safety Agency (EASA) requirement for airplanes with a Maximum Certified Take-Off Mass (MCTOM) of more than 27,000 kg (59,500 lb) to have a CVR recording duration of 25 hours.

While such changes in regulations help improve flight safety for everyone, it also means that older designs of FDRs are not suitable for most new or retrofitted aircraft – at least without modifications. This can incur cost as the high requirements for safety and environmental protection mean that even a small change can be costly.

Challenges of Meeting Interface Requirements

There are many FDRs on the market, but while most will meet aviation requirements, any choice of recorder may need some level of modification for a specific aircraft. This modification may be as simple as changing mounting brackets to as complex as an extensive redesign to meet new crash survivability regulations.

Operators also tend to look for ways to enhance operational readiness, improve flight efficiency, increase safety and reduce maintenance costs. This has led to a trend towards using the flight recorder system as an active component in aircraft maintenance, expanding its role to include Flight Operations Quality Assurance (FOQA), Condition Based Maintenance (CBM) and other programs.

Regardless of regulatory requirements, it is most often the case that modifications will be needed simply to ensure data can be gathered. This could be as simple as changing a connector but it will often require some level of data conditioning (for mandated or additional desired information). Modifications to an FDR can cause delays beyond engineering rework as some level of qualification testing may be needed to ensure the recorder still meets requirements.

One common problem is that aircraft systems, or data collection requirements, can change late in the development cycle for an FDR or FDAU. Even if the change is minor, it can take a significant amount of time to make the change, perform integration testing, etc., not to mention the additional cost.

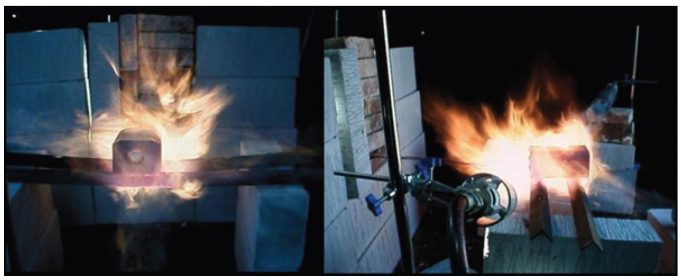

Figure 2: FDRs must meet challenging regulations that may result in a high cost if the program requires modifications

Using FDAUs

A common approach is to use an intermediary unit to gather the required data and send it to the recorder in a compatible data stream. Such a unit is commonly called an FDAU and it acts as a translator between the aircraft data sources and the FDR. The regulations specify what parameters must be gathered (such as altitude, airspeed and so forth) but it does not specify the source i.e. the avionics bus, sensor type, etc. This means that no one design of FDAU can meet the aircraft requirements without some level of modification itself, although as the FDAU does not need to survive a crash event, it has far less stringent standards to adhere to and thus, in general, costs less to modify.

These units can be off-the-shelf solutions, custom built or a combination of both (modified COTS). Such products have a proven track record of meeting application requirements and offer more flexibility but they are stand-alone units and thus take up space, add weight and increase installation and logistics overheads. In situations where space is at a premium, modifications to the FDR may be a better approach.

Modular off-the-shelf DAUs have the advantage of being more flexible and faster to deploy versus custom developed units. They can also be upgraded in the future to support new or altered data collection requirements. The disadvantage is they tend to be larger and more costly – at least for larger quantities.

FDAUs can also be used as a quick access recorder (QAR), so any additional data gathered can be transferred post flight using removable storage devices or by downloading via a standard interface (Ethernet, USB etc.) for use in monitoring and operational applications. Some FDRs have enough storage and an appropriate interface to allow data to be stored and downloaded rapidly.

Integrating an FDAU functionality into an FDR

Another approach is to integrate an FDAU into an FDR. Thanks to the continual reduction in size and the increased speed of modern electronics, it is now possible to pack significant capability in a small volume. Compared to the necessarily well protected recording media, additional electronics have relatively little impact on the weight or size of the recorder.

FDR are available that can accommodate modular plug-in boards that can add extra functionality. The advantage of this is that only the daughterboard requires qualification when functional changes are required or extra data acquisition or processing capability is needed. Testing modules is less time consuming than testing a new motherboard, which enables quick time to market. It also means saving weight and space.

The downside of this approach is similar to using custom FDAUs in that late changes to requirements can cause headaches to program schedules. In addition, these boards are likely more expensive than a similar customized external FDAU (although not necessarily so depending on volume of production).

Upgrade Paths and Managing Logistics

The more commonality between equipment across a fleet, the easier it is to manage equipment logistics, training and software requirements. Larger operators will typically have a mixed fleet of aircraft and thus may require several different FDRs. It is also possible to have one type of FDR and used modified FDAUs instead.

Change tends to happen slowly for FDRs, and it can take years for regulatory bodies to formulate recommendations and implement them as mandated requirements. This means it is possible that an operator continue to use the same FDR for a long time – more likely if the FDR met current and anticipated regulations at the time of purchase.

Modular FDAUs are ideal for mixed fleets as it means lower spares requirements and logistics overhead as spares can be shared amongst aircraft. Additionally, they can quickly be upgraded across platforms if, say, a new avionics bus is being added to the entire fleet.

Curtiss-Wright Modular FDAU and FDR Solution

Curtiss-Wright provides FDAUs in both modular external line replaceable unit (LRU) variants and through customization of modules within our FDRs. These modular FDAUs can acquire data from modern (and not so modern) analog and digital interfaces. This approach can help mitigate obsolescence and maintenance risks for platforms and results in a reduction of recurring and non-recurring costs.

Our FDAU LRUs are built using a standard catalog of modules and are pre-configured by our applications integration team. Since all components are off-the-shelf, the non-recurring effort is just related to configuration capture, resulting in a very affordable solution for small fleet operators. These can be later modified using off-the-shelf modules removing the cost of bespoke designs, lowering the cost of ownership and minimizing inventory requirements. Internal storage is also offered for QAR capabilities.

Curtiss-Wright also has the most modern FDR on the market – the Fortress. It meets all current and anticipated regulations and has features to provide for simplified modification and future proofing. It has a high data recording rate and capacity and an interface for modules that allows it to host an internal FDAU.

Axon Data Acquisition Unit (DAU)

Curtiss-Wright has been providing its Acra KAM-500 in FDAU applications for many years where it has proved itself valuable as a robust and rapid solution. It has modules that allow it to acquire data from almost every source commonly encountered on an aircraft. A custom data acquisition solution can therefore be built, or modified, very quickly using off-the-shelf modules. The Axon is our latest DAU that builds on our heritage as the leading supplier of aerospace

DAUs and adds many new features while reducing size and weight.

AXON

Figure 3: Different chassis sizes available and can remote locate modules for flexible and compact installations.

The Axon uses hardware-based acquisition engines to minimize data loss, support deterministic operation and ensure rapid recovery in the case of a power brownout. Axon uses a high-speed serial backplane (1 Gbps dedicated link per module) to ensure future high data rates are supported. This design also allows off-the-shelf data acquisition modules to be placed in ultra-miniature "Axonite" housings and located remotely. These can be separated from the chassis by up to 15 meters. Locating data acquisition closer to the sensors can significantly decrease the installation time and cost of the instrumentation while simultaneously reducing wiring weight.

Further flexibility is provided by Axon's dual Gigabit Ethernet outputs, which simplify the addition of Ethernet nodes or allow multiple DAU chassis to be daisy chained together. An on-board processor speeds configuration, pre-flight checks and in-service firmware upgrading. All these features make Axon an ideal choice for a modular FDAU, as it has very flexible installation options and an ability to handle large amounts of data in a small footprint.

Fortress – Modern Flight Data Recorder

Curtiss-Wright has been designing cockpit voice and flight data recorders for over 60 years and has recently introduced its latest model – the Fortress. Fortress is a compact and lightweight combined voice, flight data, datalink and image recorder. It meets all current and anticipated FAA and EUROCAE requirements, including a 90 day ultrasonic locator beacon (ULB) and a CVR recording capacity of 25 hours.

Fortress was designed to accommodate plug-in modules. This modularization facilitates additional functionality to help lower weight and free up space when integrating the FDAU into the recorder as appropriate. This also allows makes it more future proof as it can implement additional functionality in the recorder itself to protect against obsolesce due to unanticipated future regulatory changes.

Fortress

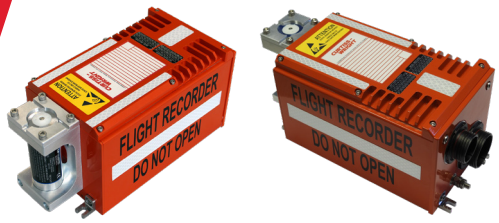

Figure 4: The most modern and capable FDR available today.

Large Production Runs

Avionics developers who have the ability to rapidly prototype and adapt to evolving requirements are able to quickly validate multiple design iterations in hardware. This dramatically reduces program risks and costs. Curtiss-Wright facilitates this with our "AviBlocks" development approach, which leverages are off-the-shelf DAUs. This is perfect for situations where large production runs are required and the cost of late changes is high, but the per-unit cost for a modular COTS system is also too much.

Within the AviBlocks framework, the extensive collection of DAU interface modules act as "avionics building blocks" which allow for

- Rapid prototyping of new systems
- Low risk development of production units

The AviBlocks paradigm retains the adaptability of the DAU system allowing unique specification FDAUs to be realized without the costs typically associated with new bespoke developments.

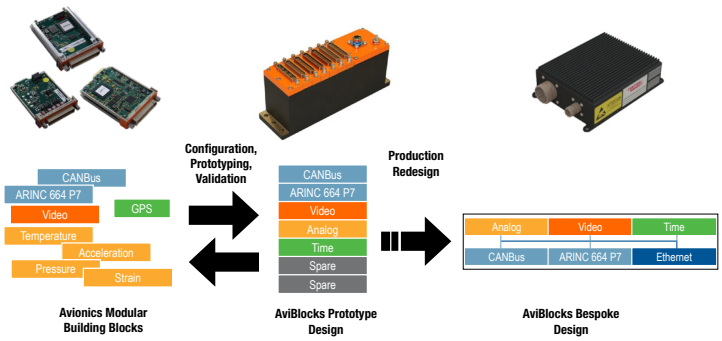

Figure 5: Modular DAUs are perfect for prototyping designs before mass production where large numbers are required

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Conclusion

FDAUs are designed to interface to one or more avionics systems, busses and sensors to gather and convert the required data into a compatible data stream for storage on an FDR. They can be internal to an FDR, custom external units or modular off-the-shelf FDAUs. Internal units offer the best size and weight benefits while custom external units are suitable where little additional development changes are required. Modular COTS are ideal for small fleets and where requirements, short and long term, are likely to change. They are also perfect for prototyping systems prior to mass production of custom units.

Curtiss-Wright has found FDR customers around the world commonly experience unplanned specification changes late in the recorder integration phase. This can be disastrous to maintaining schedules and budgets. Using a modular system drastically reduces this risk. Our customers who have used this approach have all been able to continue their programs without delays or additional development. This is because an interface change simply means a module swap in the FDAU instead of a redesign of an entire system.

The recent availability of the Fortress FDR and the Axon modular DAU offers operators the best and most modern FDR and FDAU on the market today with options for internal or external FDAUs. This ensures size and weight are minimized while providing high data recording rates and data acquisition capacities. Flexible installation and future-proof designs helps to protect the investment against forthcoming needs and regulatory requirements.

Learn More

Case Study: Replacing an Obsolete Custom Flight Data Recorder with an Off-the-Shelf Solution

White Paper: AviBlocks: Adapting to Modern Avionics Development

Video: The History of Flight Data Recorders

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