

NEW BOEING FLIGHT TEST DATA ACQUISITION SYSTEMS

Lee H. Eccles
Lawrence A. Malchodi
Boeing Commercial Airplane Group
Flight Test Engineering
Seattle, Washington

ABSTRACT

The Boeing Commercial Airplane Group's Flight Test Engineering organization is developing two new data acquisition systems. One of these systems will be used to investigate problems on aircraft which are being flown by the airlines in normal airline service. The second system is intended for use as the data acquisition system during the certification of the new 777 airplane. The two systems will differ in physical size, capacity and the recorder being used. They are expected to use as much of the same hardware and software as possible. This paper discusses the design of both systems.

INTRODUCTION

Boeing is developing two new data acquisition systems. One system is being designed for use on airplanes while they are in service with the airlines. Using the system while the airplane is in airline service requires that it meet the same environmental requirements as the normal avionics boxes on the airplane. This system must be small to fit into any available space on the aircraft and be installed and removed from the airplane with as little disruption of the airline schedule as possible. The second system is for use on airplanes which can be classified as "experimental." This system will not be qualified like an avionics unit for the aircraft. It will be installed in the cabin of the airplane in racks provided for that purpose so it does not have the same size constraints. There will be a variety of configurations available for each system depending on the needs of each airplane test program.

GENERAL SYSTEM ARCHITECTURE

The general approach in the development of these systems is to develop a series of building blocks. These building blocks are then assembled in a variety of ways to implement different systems as needed. Figure 1 is a diagram showing all of the

blocks. Dotted lines indicate that either of two blocks could perform the function. However, only one is normally installed in a system. The Central multiplexer, the Recorder and the Data Processor/Monitor will each exist in two different sizes. The small units with a limited capacity will be needed when a system must be installed in a customer's airplane. The large units will be used for major test programs with thousands of parameters being recorded for hours at a time. The different size units can be mixed as described in the following paragraphs to build any size data system.

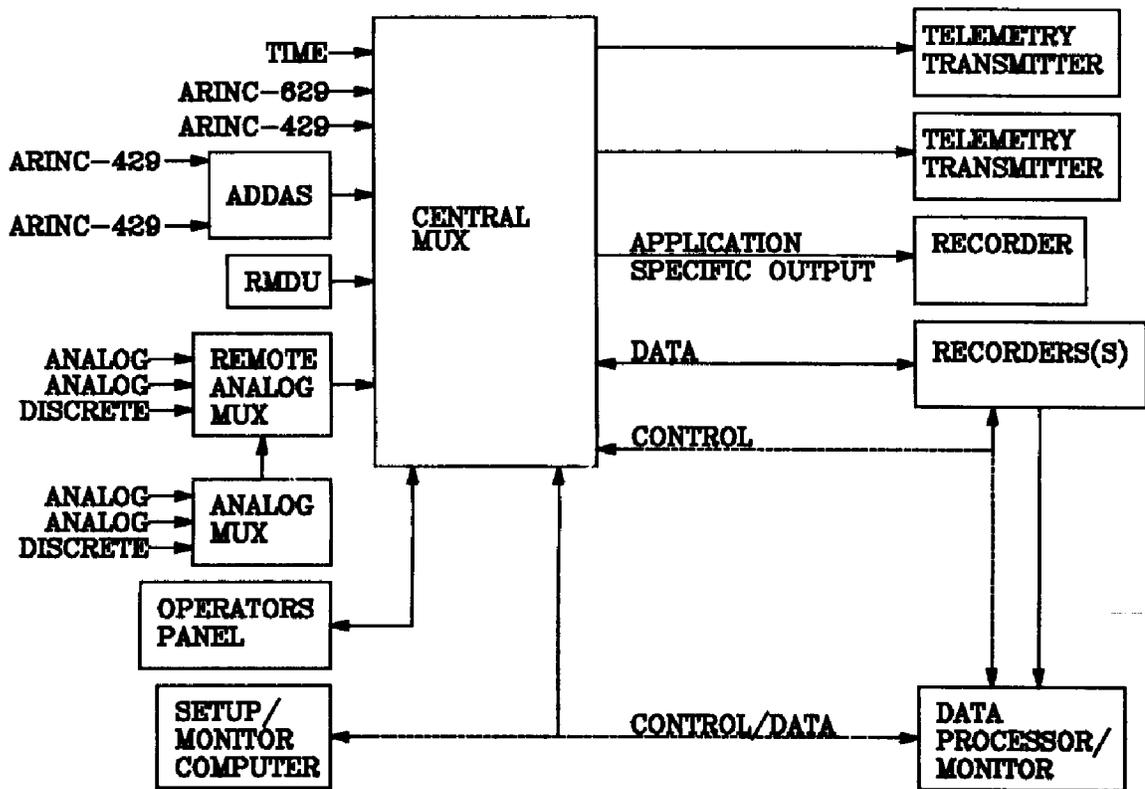


Figure 1 Building Blocks

SMALL SYSTEMS

Small systems will exist in two different forms. Figure 2 is a diagram showing an example of a system configured for airline service. The number and nature of the input data sources vary with each system. Some systems acquire data from ARINC-429 and ARINC-629 buses only. Others require the acquisition of analog and/or discrete data as well. The appropriate input modules are selected for the central multiplexer and the unit configured and checked out in the laboratory before it is taken into the field. A time input is not shown for this system since it is to have a built-in time source. An operator's panel, a Setup/Monitor Computer and a small data recorder complete the airborne part of the system. A small panel which is mounted in the airplane cockpit with a single data display and a few switches make up the operators panel. A laptop

computer, which is called the Setup/Monitor Computer, is used to load the system with the data bases needed to select the data for recording, the sampling rates, etc. It is next used to do a complete preflight test of the system. During actual conduct of a test the operator will use this unit to monitor a small number of parameters. In systems where an operator does not fly with the system, the Setup/Monitor Computer will be removed before flight. The Data Processor/Monitor unit will also be taken to the customer site. There it is set up in an office or hotel room and used to process the data which was recorded in flight.

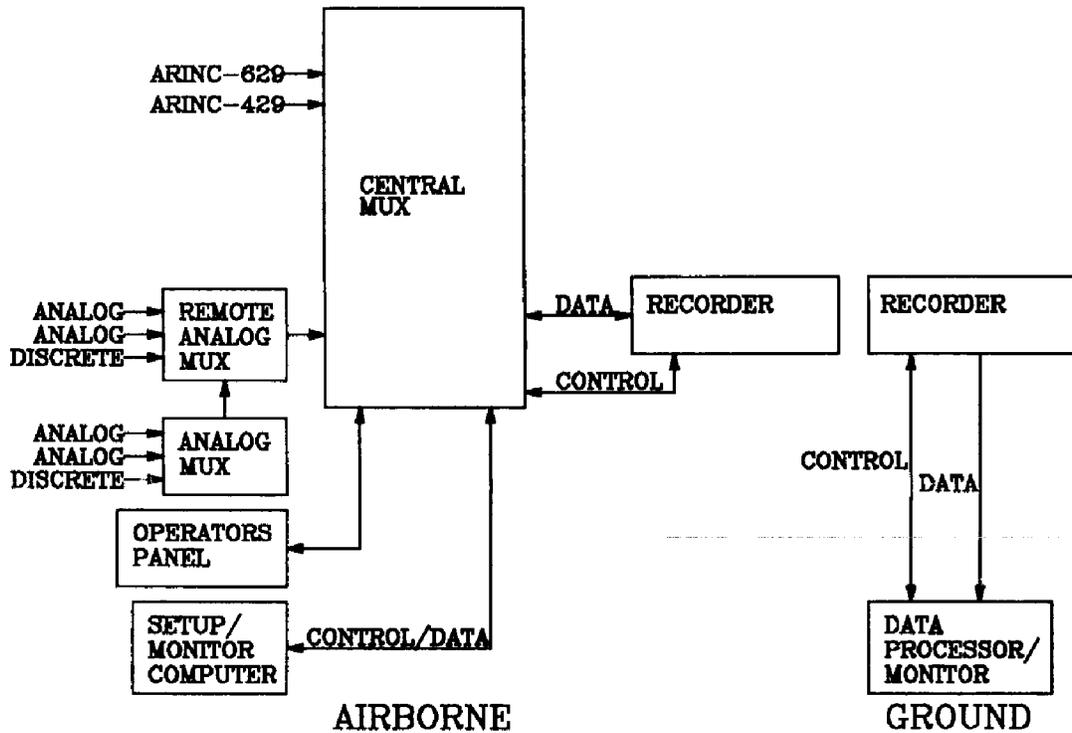


Figure 2 Small System for Airline Service

A second use for this same hardware is shown in Figure 3. In this case, a limited test is being conducted out of the factory. The only difference between these systems is that the Data Processor /Monitor is now installed in the airplane for real time data analysis, and the Setup /Monitor Computer is not needed since the Data Processor /Monitor can take over its functions. If the data rates are high enough it will be possible to use the large recorder with this system.

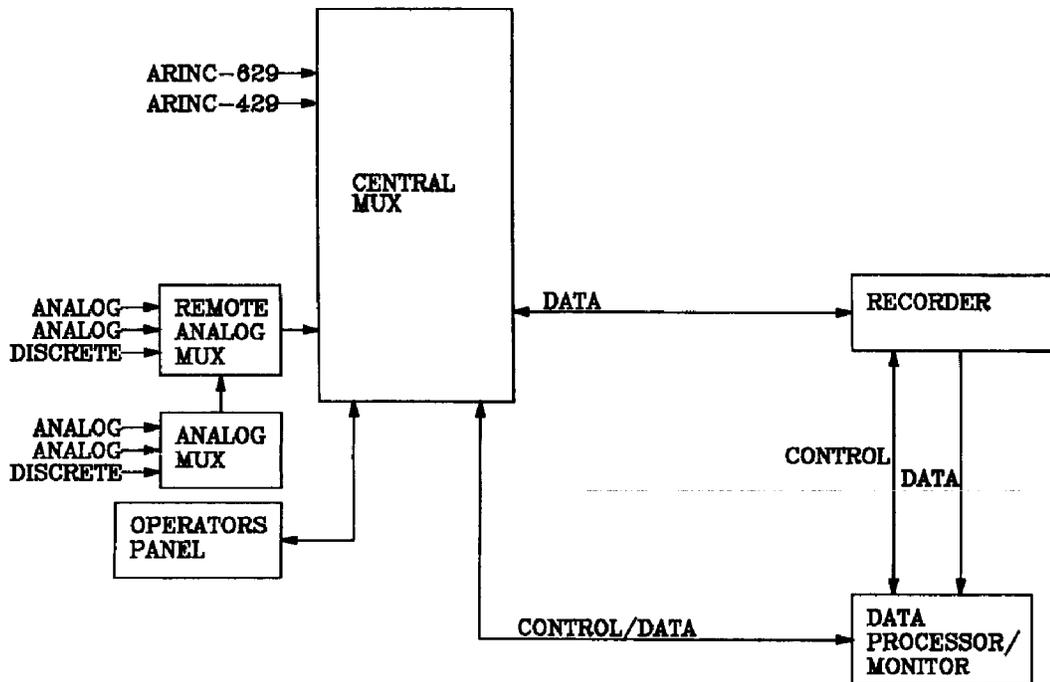


Figure 3 Small System in Local Service

LARGE SYSTEMS

A typical large system is shown in Figure 4. This system shows two additional types of data sources, the RMDU (Remote Multiplex Demultiplex Unit) and ADDAS (Airborne Digital Data Acquisition System). The RMDU is a classical PCM system built by Teledyne Controls which has been in use by Boeing Flight Test for about fifteen years. A great deal of hardware is on hand to support the RMDU, and it will continue to be used to acquire analog and discrete data. The difference between the Remote Analog Multiplexer and the RMDU is that the RMDU must be installed in the aircraft cabin while the Remote Analog Multiplexer may be installed on an engine or out in the wing.

ADDAS is a non-position dependent PCM system which Boeing built for use in acquiring ARINC-429 data. Since it is the subject of another paper it is not discussed further here. This system is normally slaved to an external time source.

More outputs are often needed on this size system. A limited subset of the data being acquired can be telemetered to the ground so telemetry outputs are provided. In addition, it is possible to add special output cards to provide data in different recording formats for specific applications.

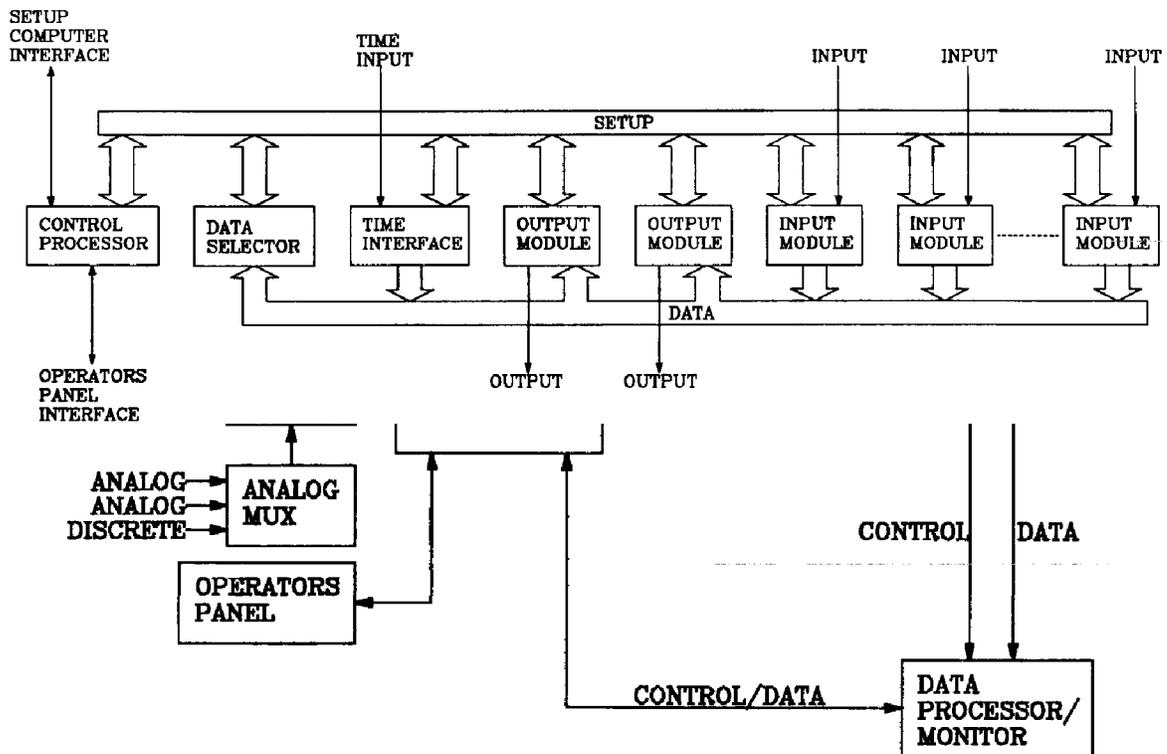


Figure 4 Large System

Both the data recorders and the Data Processing /Monitor are different from the small systems. The data recorder will be an Ampex DCRSi, ANSI ID1, or MIL-STD-2179 class of machine. The Data Processing/Monitor will be a modified ADAMS (Airborne Data Analysis/Monitor System). ADAMS is a multiprocessor system which Boeing began developing in 1974. It is used on board the airplanes for real time data processing and on the ground to process real time data during telemetry flights.

CENTRAL MULTIPLEXER

The central multiplexer is the heart of both systems. Figure 5 is a block diagram showing the general functions to be performed by this unit. It is being built around two buses, a set up bus and a data bus. The set up bus is a normal computer type bus. The data bus is designed to broadcast data at high speed to a number of data sinks. Input and output modules fit into the system functionally between these buses.

The control processor communicates with the outside world to obtain set up information. It then uses this information to set up the remainder of the modules in the system. The data selector provides a path which the control processor uses to read or

Figure 5 Central Multiplexer Functional Diagram

write a subset of the data on the data bus. One data word, normally Time, is selected and sent to the operators panel for display. The Time Interface provides the information necessary to accurately time tag the data as it is received. The Input Modules provide the interfaces to the various data sources on the airplane, and the output modules provide the logic necessary to drive the recorder(s) and telemetry links. The input modules do not have any data selection capability. When they receive data they immediately place it on the data bus with a tag. Data selectors on the output modules will select the data that is appropriate for that output module. Input modules are required for ARINC-429, ARINC-629, RMDU, ADDAS and the Remote Analog Multiplexer. Others can be added as needed.

OPERATOR'S PANEL

The operator's panel will be a small unit which is mounted in the cockpit of an airplane and used to provide a minimum level of control for the system. This panel contains a power on switch for the system, a recording armed switch and a recording override switch. The armed switch is used to tell the central multiplexer to watch for some event and begin recording. The software in the central multiplexer will then control the start of recording. The override switch is used to control recording when continuous recording is required. There will be a display on the operator's panel which is normally used to display system time to the operator. This is needed so the manual notes which the operator takes can be correlated to the time tags on the data. The operators panel is needed for tests being conducted on customer airplanes but is only used on large systems to control application specific recorders.

REMOTE ANALOG MULTIPLEXER

The Remote Analog Multiplexer (RAM) is required to acquire both analog and discrete data in a harsh environment. The diagram in Figure 6 is intended to represent a possible configuration of the RAM. The general functions of signal conditioning, amplification, presample filtering and analog to digital conversion are required on all analog input channels. Discrete inputs are applied downstream of the analog to digital converter. The formatter and output interface provide the interface to the central multiplexer. Other multiplexers may be attached with either analog or digital interfaces to form an array of interconnected units with a single output to the central multiplexer.

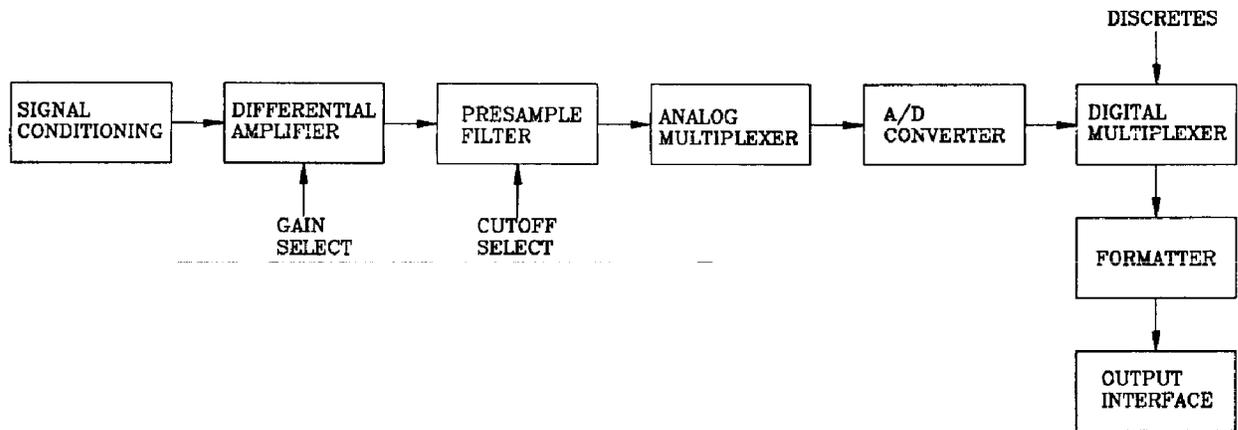


Figure 6 Remote Analog Multiplexer

SET UP /MONITOR COMPUTER

This unit will be a laptop computer which the operator takes into the cockpit of an airplane during in-service testing to set up the system and monitor the test. The unit interfaces to the central multiplexer over a serial link. System set up files on floppy disks are used to set up the central multiplexer and any remote analog multiplexers in the system. Once the system is set up and checked out, the operator will use software in the laptop to monitor data.

DATA PROCESSOR /MONITORS

Two different Data Processor/Monitor configurations are available. The Integrated Telemetry Analysis System (ITAS) is used with the small systems. It is small and rugged enough to be taken to a customer site and used as a ground station. The software has been developed to make the operator interface similar to the one on our large system. ITAS is also used for some tests which are being flown from the factory. For these applications it is installed on the airplane and used as a real-time data monitor.

For large systems the Airborne Data Analysis/Monitor System (ADAMS) is used. ADAMS was developed by Boeing beginning in 1974. It has since seen been upgraded several times. At present it is a multiprocessor system using an array of Intel 80268/80287 processors. This system has a front end preprocessor which was developed for Boeing by what is now Loral Data Systems. ADAMS is currently being modified to allow intelligent workstations to be added.

OUTPUT DATA FORMAT

The output data format will be similar to IRIG Standard 106-86 Chapter 8, "MIL-STD-1553 100 Percent Acquisition Standard". Each sixteen-bit data word will have an eight-bit tag appended to it. The tag identifies the source of the data and the class to which it belongs. Both telemetry links and data recorders will use this same format. The details of the format are covered in a separate paper.

RECORDERS

Two incremental recorders will be available for use with the system: a small recorder, suitable for use on a customer's airplane, and a large recorder for tests requiring large capacity and high bandwidth. The small recorder can record at least 2.4 Gbits at rates up to 2.4 Mbits per second. The large recorder can record over 300 Gbits at rates up to 40 Mbits per second. Both recorders have interface adapters to allow the recorder being used to be transparent to the system.

TELEMETRY OUTPUTS

For telemetry purposes the central multiplexer will output multiple data streams in the twenty-four bit format. The major difference between telemetry and recording is that telemetry requires that fill words be used if no data is available.

APPLICATION SPECIFIC RECORDERS

These are at the moment a dream. The idea being that if an application comes up for which our normal recorders are not suitable then a different recorder can be added to the system. The recorder and the data format can be unique. Since all data is available to all output modules and data selection is a function of the output module a new type of output module can be added on a non-interference basis.

CONCLUSIONS

The systems described in this paper are currently under development. They are expected to meet the needs of the Boeing Commercial Airplane Group's Flight Test organization for the next ten years. The systems are being designed for flexibility and expandability. The electronics within the systems will be the same; only the chassis and the recording media will be different. This will allow an operator to move from system to system with a minimum of training.

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