

DIANA

Claude NERCY, Dassault Aviation
Jacques FERRIER, I2E / Digilog

1. Introduction

The DIANA product is the result of an industrial joint-venture between DASSAULT AVIATION, GIAT Industries and DIGILOG.

For more than 50 years, DASSAULT AVIATION has been a leader among military airplane manufacturers. This company has since diversified, developing a range of private commercial airplanes.

GIAT INDUSTRIES is the French manufacturer of armored vehicles and equipments for ground troops.

Over the last 25 years, DIGILOG has specialized in the development of electronic and software systems for on-board applications.

Launched less than 3 years ago, the DIANA product was initially developed in response to the need to overcome obsolescence on acquisition hardware used by DASSAULT AVIATION.

The first system was enhanced with a set of sensor acquisition boards in order to fulfill new specifications from GIAT INDUSTRIES.

DIGILOG followed up with developments on the software, video and audio acquisition modules, of which the first application developed for the AIA targeted the HAWKEYE.

2. Needs

An acquisition system is made of information gathering equipments, time-stamping modules and data transfer channels.

This system must be associated to ways of configuring, controlling and processing data.

These 3 main functions address different use cases matching precise operational requirements. Thus, a telemetry system uses both acquisition and radio transmission hardware. An acquisition module associated with a transfer module, e.g. ARINC 717/573, turns into an accident logger. If data transfer is achieved later on, with the help of storage support, we can use it as a recording system for mission analysis or for maintenance operations.

Considering the important number of possible applications and to take advantage of advances in off-the-shelf technologies, the design of such systems must make full use of standard and open industrial solutions.

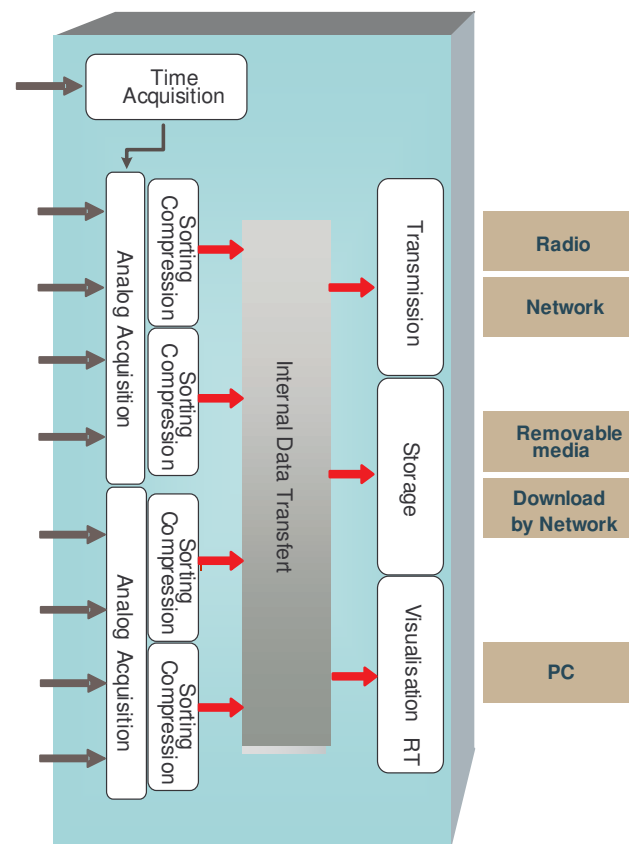
Among these technologies, those that are retained must offer :

- high speed, from 100 to 400 Mbits/s to process modern avionic bus links or the acquisition of high frequency sensors,
- a reduced form factor (about 1 dm³),
- and ruggedness to match harsh warfield environments: thermal, mechanical and electromagnetic.

The need to associate an accurate clock to the different events makes the transfer of a time reference mandatory.

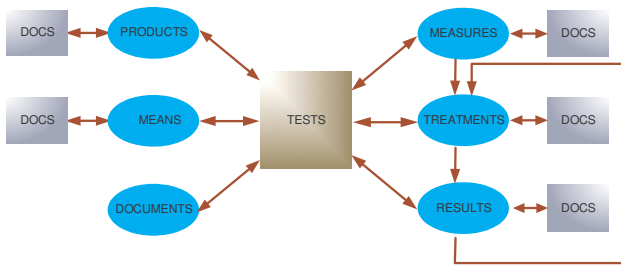
Considering the broad range of functions associated with DIANA, it is essential to dispose of a modular and easily configurable equipment.

The following chart features the expected main functions and performances of an acquisition system.

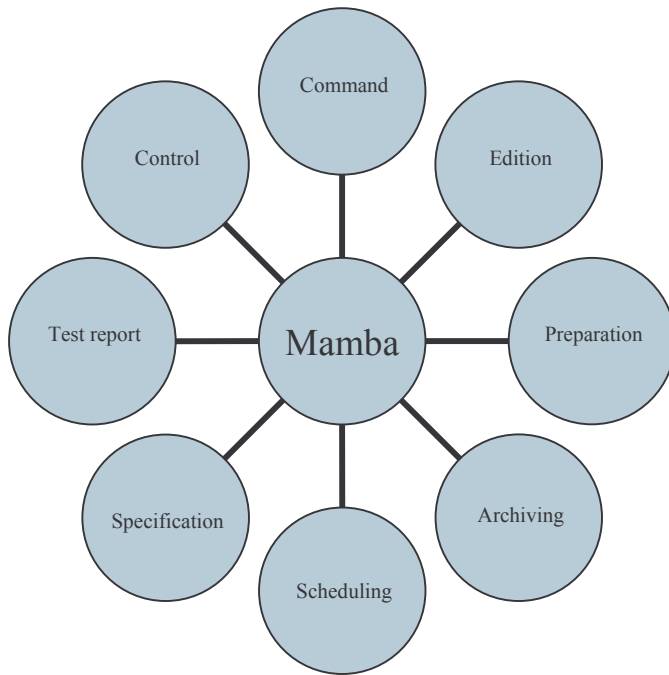


These acquisition modules can take place in a full test management system. In which case, the simple acquisition and control functions must be taken into consideration by software that handles the tests (test conditions and results, test equipments), offers test analysis functions (statistics, mathematics), presentations (display, report), and data management (archives, search and data recovery).

The following diagram shows how a test management software is coupled with an acquisition system.



For the typical user, testing equipments have the following functional requirements :



3. Solutions

3.1. Technology

The DIANA product is based on recent communication and software standards. The PXI bus is used for board to board communication and LINUX is the operating system.

This solution is benchmarked. The transfer size has been optimised to reach a data rate meeting performance requirements without any PXI rules violation. Our product supports 400 to 500 Mbits/s transfers, in line with typical needs for on-board acquisition systems.

The second technical strength is the product operating system. To get access to the widest range of services necessary to make such a versatile product, an open and content-rich solution is a must. This choice should remain compatible with “real-time” performance level often found in acquisition systems. We have validated LINUX version 2.6. This solution includes modern network communication functions and services streamlining product operation and ease-of-use.

Last but not least, these products may process very different data sources. Therefore, it is mandatory to have the widest range of acquisition boards. To fulfill this need, DiGiLOG designed DIANA with a consistent hardware and software set in mind. Indeed, all PCM acquisitions or transfers make use of a mother-daughter board set.

Only 2 types of mother boards are necessary : the digital and the analog mother board. On the last one, isolated and filtered power supplies are available to insure proper analog to digital conversion of sensor signals.

The DIANA product is the base for acquisition systems covering a large array of digital bus links and analog inputs. For example, we implemented data acquisition modules on Mil-STD 1553 bus, Digibus, STANAG 3910, ARINC 429 & CAN bus, RS232 & RS422 serial lines, PCM interface,... This product can also build inputs on digital signals, perform frequency measurements or pulse counting.

A wide choice of conditioning boards allows to digitize most analog information. We have measurement solutions for voltage, current, thermistors, gauge bridges, thermocouples, ICP accelerometers and LVDT.

The data acquisition family also includes solutions for video and audio acquisition and compression. For the latter, compression algorithms have been chosen among well known standards (MPEG-2 and ADPCM or CVSD).

Data acquisition capabilities are given below for the different board types :

Analog		
Designation	Channel number	Comment
Voltage/current	16	individually isolated
Variable resistor	6	individually isolated
Thermistor	16	individually isolated
ICP	12	individually isolated
Thermocouple	46	J, K, S, T
Gauge bridge	6	½ , ¼ full bridge
LVDT	12	5 and 3 wires
Video	2	MPEG 2 + 2 audio
Audio	16	CVSD / ADPCM
ARINC 429	16	

Digital		
Designation	Channel number	Comment
DIGIBUS	2	GAMT101
1553	4	MIL-STD 1553 B
3910	1	STANAG 3910
Manchester	4	M88-BTM-IPS-UMP33
CCE	3	external control
CAN	4	SAE J1939 / Devicenet
Serial lines	8	RS 232 / RS 422
Digital Input	16	isolated inputs with adjustable threshold
Frequency	12	isolated inputs with adjustable threshold

These equipments are driven by a software package. First, we have developed a front-end module which prepares data acquisition. This piece of software displays a Graphical User Interface to define equipment configuration, to set data sorting functions, to enable data output, to check configuration on the fly (data rate, measurement values,...), to perform maintenance and calibration operations on acquisition boards.

This product generates output files describing the transferred data frames. The formats currently taken into account are Viper® and Magali®. Viper® is an analysis and data plotting software package developed by DiGiLOG. Magali® is the same type of software that was developed by HTS.

DiGiLOG proposes upgrades to match customer requirements through specific configuration files or to scan format changes of data files. The built-in outputs are compliant with IENA or PCM standards.

By the end of 2005, DiGiLOG will release a test management product. This product features functions such as test definition (carrier, test frame, conditions, ...), acquisition management (sensors, acquisition system, ...) and data management. The architecture, based on a relational data base, is open. Thus, it is possible to add other features such as data processing, presentation, and report generation. A data base makes acquisition systems more powerful by using for example very intricate queries.

3.2. Advantages

The four main advantages are:

- a wide range of acquisition functions for scalability,
- product versatility, which allows to match a specific application by module exchange or redesign,
- the solution meets various environmental conditions such as fighter, commercial or propeller aircrafts, armored vehicles, labs and integration benches,...,
- a full software package available for set-up, control, command and data acquisition processing.

It is worth remembering that the system has been completely qualified on-board with operational bus links. Prior integration and validation was performed on ground simulators to check equipment performances at maximum bus transfer rate. Acquisition boards are qualified with 16 ARINC 429 channels at full speed, 4 MIL-STD 1553 bus links, 1 STANAG 3910 bus link coupled to its MIL-STD 1553 control line ...

Beside its mother-daughter stack organisation, the acquisition modules are developed on a large printed circuit board. Thus, the whole product has maximum growth potential in terms of acquisition channels processed by board. The chosen solution also yields an important flexibility and makes the product more rugged.

The electronic boards are located in a rack enclosure which insures board protection against mechanical, climatic and electromagnetic aggressions. These frames include standard military connectors MIL C 38999, well suited to acquisition signals. Dedicated to record events on the vehicle, measurement sensors must be sufficiently rugged to guarantee faultfree operations in all situations encountered during testing. This is the reason for which we kept the external interfaces similar to operational flight equipments.

In order to achieve correct system monitoring, the DIANA product was designed to be invisible to the entire system observed. For example, the equipment matches bus impedance constraints and doesn't include the capacity to command monitored lines.

All start-up and configuration operations are done by software tool. DIANA doesn't need hardware configuration except to change the acquisition tape.

4. Applications

4.1. System Development

4.1.1. Dassault Aviation Falcon 7X

The DIANA system was first developed for the commercial airplane Falcon 7X certification tests. The first three planes are each equipped with 2 DIANA enclosures.

In this application, DIANA was integrated into a measurement system made of several acquisition cabinets communicating over a 1553 link bus. In this architecture model, The DIANA enclosure acts as a subscriber to communication links. At start-up, instructions to execute during testing are received from the link manager. In the acquisition phase, it receives a synchronizing clock maintained by the link manager and transmitted to all the connected centers. The link manager collects all data acquired by the centers in the form of independant PCM flows.

DIANA acquisitions are either from digital or analog sources. However, in this application, the analog sample conditioning and numbering are not achieved within the DIANA enclosure. These functions are given to small peripherals under control of the DIANA acquisition board.

These acquisitions are equally divided between the two DIANA enclosures. The strategic links are distributed between the 2 enclosures in such a way that the loss of information is minimal in case of breakdown of one enclosure.

The unit is configured to perform acquisition of :

- 64 Arinc links,
- 4 Manchester links

8 RS232/422 serial links
and more than 1000 analogical parameters.

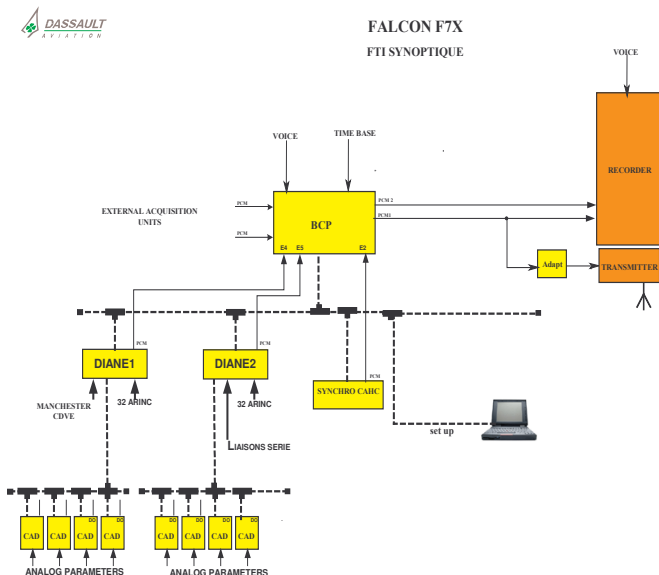
In this application, the unit also includes the growth potential for 4 acquisition boards, available to interface all types of links or to process any type of analog parameter.

Acquisition samples are inserted in the PCM flow produced by each DIANA enclosure. They are the result of a selection carried out by predefined criteria on the different links to process. This information is essentially transmitted to the ground station in real time via an airwave emission with a limited bandwidth of about ~1 Mbits/s. Simultaneously, each DIANA enclosure is capable of acquiring all the link exchanges and retransmit them in the form of UDP packets to a large capacity recorder via Ethernet links.

The software configuration is made through a graphical user interface, linked to our Oracle data base, which contains the whole list of parameters carried by each link.

The size of a measurement set-up is a crucial element in a combat airplane. It is also a determining factor in commercial airplanes, in order not to interfere with the cabin systems. The use of DIANA enclosures allows the significant size reduction. The 2 DIANA enclosures represent a volume of about 20 liters.

Since their installation in the airplane, the DIANA enclosures have not been taken out, except for some changes in the hardware set-up. The enclosure configuration is entirely defined by software. This limited handling improves the reliability of the measurement system.



The outcome for this first application is successful. 2 enclosures have been installed in the F7X airplane since September 2004. Since then, they have been constantly in use. They have participated in all ground testing campaigns that prototypes normally undergo before their first flight, in particular the “high fields” tests, as well as the different stand-by and taxiing sessions. To this day, only one anomaly has been reported, traced back to a dry solder spot on an acquisition board.

4.1.2. Dassault Aviation RAFALE and MIRAGE 2000

The DIANA enclosure has since been used on the Rafale and Mirage 2000 fighter jets. This new application required the developments of 3910, 1553 and Digibus acquisition boards.

The DIANA enclosure can be integrated into an architecture equivalent to the one described in the frame of the Falcon F7X. Then, it functions in coupled mode. This isn't the case in the instrumented airplanes Rafale C101 and Mirage 2000 N301.

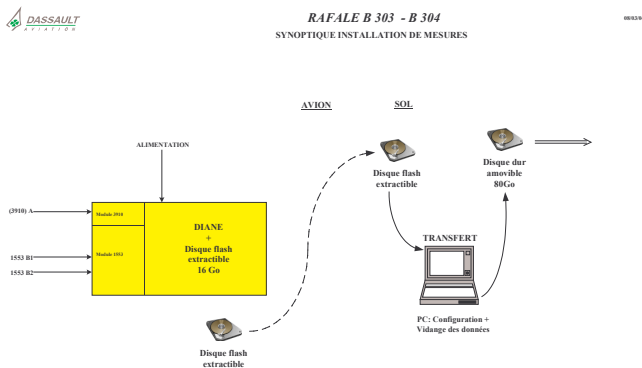
It can also function autonomously, which is the case of the Rafale B303 type set-up.

The Rafale C101 measurement set-up defined and achieved in 1998 is called the Daniel 2000 type. In this context, a DIANA enclosure was put in place of an acquisition center, obsolete since the beginning of 2005. The DIANA enclosure on the Rafale C101 is in charge of acquiring the 3910 links and the two 1553 links coming from the main airplane computer « EMTI ». Here again, the selective acquisitions from the DIANA enclosure are transmitted to the manager through a PCM port. All 3 acquired links are sent via an Ethernet line to an on-board recorder.

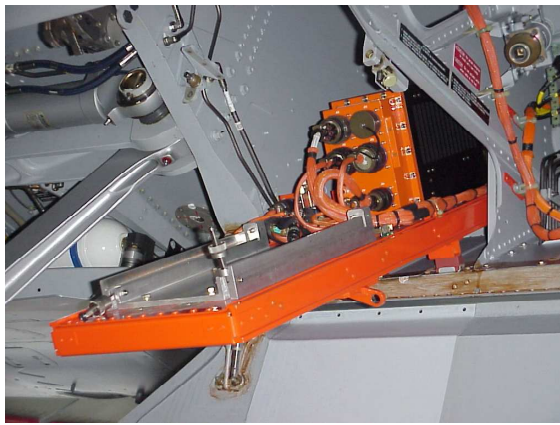
The measurement set-up on the Mirage 200 N301 is new. On this airplane, the DIANA enclosure operates in coupled mode. It is in charge of acquiring :

- 2 airplane Digibus,
- 2 1553 out-take links,
- 50 analogical parameters.

Finally, the first set of Rafale airplanes delivered to CEAM in Mont-de-Marsan (France) are prepared to receive an autonomous DIANA enclosure. Since December 2004, the DIANA kit has been installed on the Rafale B303, then on the B304 according to needs. The small size of the DIANA box allows easy monitoring on operational military airplanes. In this application, the DIANA enclosure is also a recorder. A large capacity (16 Go), internal, removable Flash disc receives all exchanges coming from the 3910 link and both 1553 links on the airplane computer « EMTI ». The recorded data are downloaded on a storage media upon mission return.



Again, the overall DIANA results for these 3 fighter plane applications are satisfactory.



DIANA enclosures mounted on B303 and B304 Rafales have logged more than 30 flights, whereas the C101 Rafale flew more than 28 times with another box. To this day, no equipment downtime has been reported.



4.1.3. GIAT industries VBCI

For this customer, the product goal is to support qualification tests on VBCI, the all-purpose ground troop transportation vehicle.

In this configuration, DIANA is set-up in coupled mode with an A5 spreadsheet PC designed by DiGiLOG. This laptop product is capable of acquisition configuration, command and control.

The acquisition system itself is made of 3 enclosures.

The first one is a data storage equipment with power supply back-up. This feature is very important to insure acquisition during energy sources switch-over.

The second box is dedicated to digital data logging on the different bus links (CAN, Serial lines,...).

The third cabinet takes care of analog sensors.

During this campaign, typical test configurations are found herebelow :

System validation

- 3 CAN bus links,
- 4 digital serial lines,
- 1 J1587 bus link,
- 16 binary inputs +/- 30 V @ 10 kHz,
- 16 voltage channels +/- 30 V @ 10 kHz,
- 3 pressure sensors @ 5 kHz,
- 3 temperature platinum sensors (PT100) @ 0.5 Hz,
- 6 acceleration transducers @ 10 kHz,
- 2 frequency measurements from 0 to 100 kHz.

Climatic testing

- 16 voltage channels +/- 30 V isolées,
- 2 frequency measurements from 0 to 100 kHz,
- 6 current loops (0 to 1000 A on shunts),
- 44 thermocouple channels.



This combination, originally dedicated to VBCI testing, offers all fonctions necessary to implement testing on all other GIAT systems (LECLERC and AMX tanks, mobile launchers,...).

Therefore, it is now the keystone equipment for qualification testing at GIAT industries.

4.2. *Hawkeye mission data logger: video and audio recorder*

For this application, the DIANA product offers acquisition and compression functions for video and audio sources. The product requirements are to record all communications and system views (radar, tactical,...) used by the Hawkeye crew during typical traffic control and thwarting missions. DIANA can playback in real time freshly recorded sequences for mission control purposes. Once back to base, mission analysis is possible since data are recorded on a removable hard disc drive. Detailed debriefing helps improve mission planning and overall operation success.

The solution proposed by DiGiLOG allows to process 16 audio and 3 video channels.



4.3. *Integration bench : Dassault Aviation*

Future integration benches on avionic systems will use an industrial version of the DIANA technologies. Cards will be identical to the ones found on-board. Only the enclosures and external connections will be different.

A unique hardware guarantees similar behaviour, simplifies maintenance and reduce spare part management.

In this application, DIANA continuously records on a disk all exchanges carried on selected bus links. Analysis may be performed in real-time or with a slight time shift, triggering on a particular event or anomaly. DIANA configuration is limited to a simple man-machine interface disconnected from the database, which let's the user define the bus link parameters.



4.4. *Deployment update*

Number of enclosures

F7X	7 enclosures
M2000	2 enclosures
RAFALE	6 enclosures with 2 recorders
VBCI	6 enclosures
HAWKEYE	4 enclosures
ATL2	1 enclosures

As a reminder, the number of carrier boards already produced is above 100.

Forecasts for 2006 are well over 100 enclosures, which represents typically about 500 boards.

