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Heterogeneous Acquisition Systems Managing

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Abstract:

When someone coming from the industrial environment arrives to Aerospace Industry suffers a shock because of the very different type of acquisition systems used.
Industrial equipment is usually reliable over the years and cheaper than aerospace equipment.
We will find here why it is very difficult to adapt industrial equipment to FTI environment.

Key words: FTI, Data Acquisition System, SCADAS, Database, PLC(*Programmable Logic Controller*).

Introduction

Automation is a very well known subject in every industry environment. When coming from industry environment to the aerospace industry one wonders why it is not generally used COTS industrial hardware and software. Here we'll find the answer.

Automation equipment shares many features with FT(*Flight Test*) ones, however FT has special characteristics that makes it difficult to use COTS automation software and hardware packets to do the work.

Some reasons have to be with special characteristics that FT projects deal with.

Test/Automation systems are made of hardware for data acquisition and control.

Another part of the system is the display and recording software.

Both hardware and displaying/recording software are configured by databases. We'll find if it is better to use your own database.

A good example would prove the differences between using external tools and your own ones.

Finally, conclusions show the convenience or not for using, FT oriented hardware, your own databases and displaying/recording software. In fact we find that FT oriented hardware is usually the best option. And that SCADAS can't be used in our field.

Industrial/FT projects´ differences

FT projects features are the following:

Some of them last long time, so it makes that requirements, equipment and staff change during the project.

Some others last shorter, so it urges a quick answer.

The aim of a Flight Test is to record the evidences to certificate a system or a whole aircraft.

In the industrial environment, you usually have a project which is developed, installed and will remain there while it is economically feasible or it had an opportunity cost when not updated. The goal in an industrial project is to have the installation payed-back as soon as possible while giving a competitive advantage. Reliability is also a must because the production has to be stable all the time.

Differences between FTI and Industrial Hardware

The industrial hardware for automation is usually the PLC, although there are other systems designed mainly for Process Industries, called DCSs (Distributed Control Systems).

We'll focus on PLCs because they are the most similar to the FT hardware called DAUs (Data Acquisition Units).

In their origins PLCs were aimed to substitute the old relays installations of the industries. Later on, they evolved to be used in many different situations. They usually have a lot of digital I/O (Inputs/Outputs), a certain quantity of analogical I/O, very low amount of control loops (PID) and a small memory to make calculations. They don´t usually have in sum more than 4 Mbytes. These amounts are approximate as they change a lot from low to high-end equipment.

The inputs use to be 4-20 mA or 0-10 V in PLCs. Since sensors can be very far away, up to hundreds of meters from the PLC, they are commonly joined to equipment called transmitters that convert signal levels into 4-20 mA levels.

The rates for pooling inputs can be high, but when the number of I/O increase, the acquisition cycle can increase a lot too. This acquisition cycle can also dramatically vary due to the internal calculations when PIDs or other modern controls are used.

PLCs are aimed to be reprogrammed by the maintenance staff that is used to dealing with electrical equipment and also understand digital logic made from relays. Although every vendor usually has a proprietary language for its PLCs, they commonly have options to program their equipment with languages complying with some industry standard. The most common language is Ladder. Sometimes reprogramming is necessary to be carried out by very skilled engineers due to the complexity of the systems.

In the industrial field temperatures are neither too high nor too low as in aerospace, although in special cases it could happen. The same thing happens with vibrations. Wet environments can be found also in the industry. Placing the hardware in a suitable enclosure controls both the temperature and humidity.

In the vast majority of cases in the industry, the hardware can be installed apart to avoid suffering from harsh conditions.

Synchronization is not a big concern here, but it can be in special situations. i.e. A Net Time Protocol server can be enough for this purpose. The goal of PLCs is to control an installation over time.

In FT one finds DAUs, equipment designed for acquiring data, which have many inputs and a very small number of outputs for some important functions. They can be suitable for the laboratory, the workshop and the field. FTI Data Acquisition Units also have special characteristics due to the environment they are in.

DAUs usually have dedicated inputs for every kind of sensor, such as PT-100 resistors, Bridges, +/- 10 volts, etc. There also can be some adaptors, mainly installed to protect the aircraft installation. A DAU can carry different kinds of inputs by means of different kinds of available cards, such as those for the PLCs.

In DAUs, data acquisition rates have a high variability, from temperatures, needing around 1Hz, to pressures or electrical parameters needing above kHz.

As previously said PLCs can have high rates but the number of I/O signals can change the acquisition cycle. In DAUs the acquisition rate for every signal is defined and maintained forever as long as the requirements are not changed.

The characteristics of Acquisition rates and synchronization are very important in FT but not as demanding in the industries. The usual acquisition rates in FT go from 1Hz to several kHz. The industrial environment usually does not have such high acquisition rates or even synchronization for their purposes.

DAU configuration files usually are based on proprietary languages that each vendor creates for its equipment. Lately, however, there is a tendency to use some kind of standard file (xml) although not necessary.

An additional difference between PLCs and DAUs is that DAUs, specially the airborne ones, are ready to acquire Data Buses, while PLCs simply don’t have this possibility. For PLCs, buses are for internal/external communications, but they never are seen as a possible source for acquisition/measurement.

DAUs have to be hardened to support extreme environmental conditions. It is usual to find temperatures from -40ºC to 80ºC and even more. Hardware sometimes has to support very high vibrations due to engine and/or aerodynamic phenomena. The big difference

with PLCs is that aircrafts always lack room, so DAUs have to be placed wherever possible.

Displaying Software Differences

Displaying applications are necessary to check the acquired data.

These applications need to take the raw data from any data stream or CVT (Current Value Table), then make all necessary changes, and finally display them in a convenient way. Changes comprise calibration, bit extraction, mask application, etc.

The displays used go from simple numerical objects to moving graphics, representing the real instrumentation of the industry/aircraft.

The software used in the Industry to display data is the SCADA, a software packet aimed at supervising and controlling tasks. Also, it saves data in a database or any type of file.

Because SCADA is software that runs in computers, some hardware, such as a PLC is required to really control the system, to acquire signals and generate the outputs. (See Fig. 1) That data is taken from the PLC and served to the SCADA through some protocol, such as OPC[1], TCP/IP or any other.

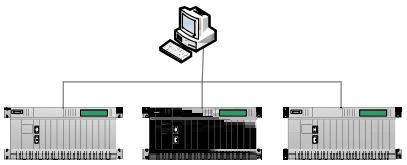

Fig .1.- SCADA-PLC installation

An example of a typical SCADA in the industry could deal with around 2.000.000 Data Tags. Each of them is acquired at 1 Hz or less. So the bandwidth that SCADA can manage is less than 32 Mbit/s. There are more data tags that can be managed by scalability, increasing the budget and the complexity of the system.

The standards used by SCADAs to communicate with the hardware are not compatible with standards used by FT.

In this sense, displaying specialized COTS software is there to help display data in the FT field. This kind of software complies with the standards used by the aerospace environment.

In FT, the GSS (Ground Station Software) takes the role of the SCADA and the DAU does the same with the PLC.

As said before, SCADAS save data into files or databases. The same thing happens with GSS. Each one will do exactly the same on its own. The big difference here is that GSS software will not control the system in any way like SCADAS do.

Databases Similarities

A great similarity between configurations for SCADA-PLC and GSS-DAU is that each one has its own configuration databases. All of them, SCADA, PLC, GSS and DAU have their own separate database.

SCADAs and PLCs need to be configured separately. Nowadays the tendency is to configure any software/equipment through GUIs (Graphical User Interface) that makes things easier. These tools have databases internally that have to be filled in. These databases schemes must represent their corresponding part of the measurement chain. Fig. 2 displays a measurement chain. From the sensor to the multiplexor included they belong to PLC and then, from the multiplexor to the PC they all form part of the SCADA.

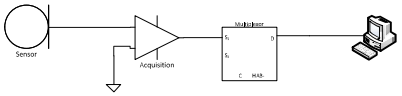

Fig. 2.- Measurement chain

FT Databases have a similar configuration. In this case we are talking about Instrumentation and Display databases. The main characteristic for an Instrumentation database is that it must represent the “Measurement Chain” for every parameter we want to acquire, including the multiplexer. See fig. 2.

Display Databases have to contain all the objects that can be seen on a screen, and they also must contain information for the Displaying Software, so that it can obtain the data from the streams sent by the multiplexor.

Therefore, Databases must have all the information about the configuration of a system.

Example using COTS vs Internal Tools

When someone starts thinking about the tools needed to comply with the customers’ requirements in FT field, many possibilities are found. We will answer a number of questions to show what can be done in FT field.

Industrial Hardware.

PLCs are not suitable for FT requirements, mainly due to the synchronization strategies used in FT. They don't support the standard synchronization buses that FT works with. Besides, their acquisition cycle is not easily predictable.

However there is a type of industrial hardware that is based on DSPs (*Digital Signal Processors*), is highly configurable with standard languages (i.e. C, C#) and can be used for a special purpose. At the same time, some FT DAU makers are offering similar acquisition cards. This shows that DSP based equipment can be very useful under certain situations, if they can bear the environmental conditions.

FTI Hardware.

Due to environmental conditions, electrical and communication standards this is the best solution for hardware.

Industrial Software.

Industrial Software can't be used because, at the present time, the communication standards are incompatible with communication standards used in FT. In addition, the bandwidth supported by SCADAs is not enough for the FT field requirements.

COTS Telemetry Software.

In many situations this solution could be the best. Usually this COTS solution works with the corresponding de-multiplexing hardware. However, if this software needs to be adapted to the client's types of data streams, then the COTS solution would not be the best.

In this case, the best solution would be for the customer to develop its own GSS. This solution will give the customer a great flexibility to expand the software capabilities, and independence at the cost of developing hours. i.e. In Airbus DS-Getafe an internal GSS that can support 65 Mbits/s has been developed. This is much more than the figures shown previously by SCADAs.

Databases.

GSS used to come with their own database. In the case where the customers would choose to develop their own software, a database has to be acquired.

There are a lot of Databases suppliers. There are also Free/open databases available that can do the work exactly as very expensive proprietary ones.

In any case a scheme has to be developed for the database resembling the Instrumentation and Displaying functions. Additionally applications to fill in the tables from the database also have to be developed.

Comparative study.

At this time we have reached to the conclusion that almost always we'll have to use FTI hardware for our solutions.

Now we'll make a comparison to see whether it is more convenient to select internal databases from the hardware and display software or to use our own developed databases and display software.

Let's have a DAU with 30 analog inputs and 12 buses. Each bus it has 30 parameters.

In case A we'll use the GUI supplied by the vendor of the COTS hardware. The display software will be COTS too and we will fill it in by its GUI. We do this because internal databases are configured trough the GUI.

In case B we'll use applications to fill in our own database and the display software will be the one we developed.

We will do the exercise two times to see how much time it takes to do the work. The second time the voltage limits will be changed to analogic parameters and will change the parameters to acquire from the buses.

Tools to convert the output configuration from DAU to input configuration in GSS are supposed to last the same amount of time in case A and B.

In the second part of the exercise we will try to copy all we can from first part.

A)

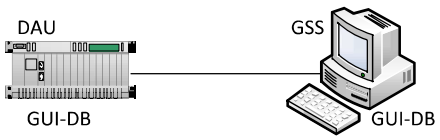

Fig. 3.- Internal databases

B)

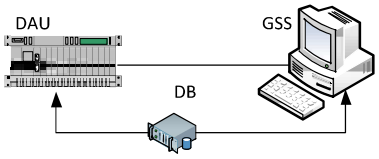

Fig.4.- External database

First part exercise:

Item	A	B
DAU	Time	Time
Place cards	5 min	5 min
Configure analog cards	30 min	30 min (1)
Configure buses cards	6 hour	6 hour (1)
Output	1 hour	1 hour
GSS		
Analog	30 min	30 min
Buses	6 hour	6 hour
Total	14h 5m	13h 5m

Second part exercise:

Item	A	B
DAU	Time	Time
Copy configuration	1 min	1 min
Place cards	0 min	0 min
Configure analog cards	30 min	30 min (1)
Configure buses cards	6 hour	6 hour (1)
Output	1 hour	1 hour
GSS		
Copy configuration	1 min	1 min
Analog	20 min	20 min (1)
Buses	5 hour	5 hour (1)
Total	12:52	12:02

(1) Cards' configuration can be done at the same time for analog and buses in case B, so Total Time is reduced. This can't be done in the GUI internal data base. The same is true for the GSS software.

Looking at the data we can tell that for configuring the DAU and the GSS it is better to use our own Data Base because in this case several people can work in a project at the same time. This is good for big projects but irrelevant for small ones.

Indeed is easier to reuse data for new projects and therefore shortening the configuration time, if we use our own database. This is good when a lot of projects are developed.

Conclusions

Although there are similarities between industrial and FTI applications, the industrial equipment of software hardly ever can be used in FTI.

Hardware.
We'll always have to use Aerospace hardware. Though, there is some cases where DSP based industrial hardware could be used.

Databases.
Internal Databases from GSS or Configuration Software for the Hardware can be used for companies doing small projects or a small number of them. However, if a company has to develop big projects and/or a large number of them, then it is better to adopt a general Database because it permits several people to work at the same time and data can be reused easily.

GSS.
Some of the differences using a GSS COTS or an internally developed one is that an Internal GSS gives:

- Ability to optimize the software for certain capability.

- Flexibility and reaction speed to implement new features as soon as they are required.

List of Acronyms

COTS - Commercial Off The Shelve.

CVT – Current Value Table.

DAU – Data Acquisition Unit.

DB – Data Base.

DSP – Digital Signal Processor.

FTI – Flight Test Instrumentation.

GS – Ground Station.

GSS- Ground Station Software.

I/O – Inputs and Outputs.

OPC – OLE for Process Control.

OLE – Object Linking and Embedding.

PID – Proportional Integral Derivative controller.

PLC – Programmable Logic Controller.

SCADA – Supervisory Control And Data Acquisition.

References

[1] OPC Foundation. https://opcfoundation.org