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Distributed Testing using VISTAS (ED-247 RevA)

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Abstract:

Virtualization protocols, like EUROCAE VISTAS ED-247, provide new possibilities for designing future test benches architectures but also redefining test strategies. As the standard is more largely accepted and promoted, commercial off the shelf (COTS) equipment become available simplifying the setup and implementation of this technology for new or existing test rigs.

One of the possibilities brought by the signal virtualization is the possibility of interconnecting benches in different locations in a simple and non-intrusive way. This can lead to great benefits and cost reductions: more efficient use of available resources, limits the need of building additional benches and allows earlier system integration between suppliers and integrators.

Nevertheless these new possibilities come with their set of constraints: Transmission Latency, IT restrictions, Cybersecurity concerns, signals adaptation needs.

This paper will show the different possible setups for interconnecting benches in different rooms, buildings and even sites and the possible solutions to overcome the encountered problems.

Key words: VISTAS, ED-247, Distributed Testing, Signal Virtualization, Test Benches

Distributed Testing

The need of testing full complex systems as soon as possible in the development cycle is clear for all the stakeholders in the industry. Doing so is not so simple. Different partners located on different sites are often developing different parts (sub-systems) belonging to a complex system. Each partner uses its own benches for testing different subsystems and, when the time comes to test everything together, a full integration bench needs to be designed, developed and manufactured. A lot of the work in this stage goes to verifying interfaces and communication protocols between the different subsystems, limiting the time available for verifying functional and logical requirements.

Usually the historical tendency was to build integration benches on both sites, more or less centered in the subsystem under test. However, the cost is often a showstopper and the project milestones and the contract between parties usually don’t allow for an efficient workshare.

A recurrent solution is building simple mobile benches that can easily be moved between locations, allowing to complete the missing part on the other side. But this comes with its own limitations: reduced representativeness, additional costs, logistics and export control constraints, remote maintenance and support, etc.

The ideal solution for anticipating integration activities would be interconnecting the different subsystem benches together, but avionic protocols are not often meant to cover long distances. This is where the signal virtualization enters the game. The main principle is: acquiring the avionic signals, transposing the avionic data into a long-distance compatible bus and rebuilding and synchronizing the avionic signal back to their physical state on the other site.

The VISTAS revolution

The use of virtualization buses allows the exchange of avionic data over long distances with reduced cost while letting a good flexibility to adapt to system evolutions.

The approach is nothing new. Field buses are extensively used in the industry to interconnect production tooling and Programmable Logic Controllers (PLCs) for exchanging measurement data. But none of these industrial field buses is meant to transport avionic data (A429, AFDX, MIL1553, etc.). Adapting them to

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that purpose would require developing specific drivers and boards.

Airbus has been doing this for several years now, between their own sites and with suppliers with very good results. Nevertheless, since no simple and open standard was available, implemented solutions where based on proprietary protocols and limited equipment.

With the arrival of EUROCAE ED-247 standard [1], the door was open for the use of a simple, open and shared avionic signals virtualization protocol. We took this opportunity inside Airbus Helicopters to implement some of the long-dated required interconnections between our different benches at minimal cost and with maximum flexibility.

Among a large portfolio of equipment compatible with ED-247, the choice considered that the developments should be reusable later, avoiding one-shot investments.

Technological choices

In order to setup our tests, the aim was to use COTS equipment, compatible with ED-247 and allowing the use of a large choice of input/output types. In the past Airbus Defense & Space has used NI CompactRio systems as described in [2]. In our case, UEI was the logical choice since it complied with all these criteria. In addition, it was already deployed on our test benches so we had all the required equipment already in site. On top of that UEI allows for very flexible network configurations and EAP/TLS authentication to connect them to IM infrastructure.

In order to overcome network infrastructure IM constraints Scalian Nodes were selected as network interfaces since they allowed stablishing secured VPNs internally and externally and their reliability had already been proven by Airbus Commercial Aircraft to establish permanent links between their sites.

Inter-Building benches connection use case

One of our first needs was to be able to connect our avionic integration benches with our mechanical vehicle rigs. Indeed, for safety, infrastructure and historical needs these benches are placed in different buildings. Until now mobile benches approach was in place, but we were looking for a solution that could be reusable and easier to implement and adapt.

The first application was the coupling of the Landing Gear (LDG) with the Helicopter Zero (HC0), a very high representativeness systems integration bench (see Fig.1).

The advantage was that the LDG could be installed on a mechanical rig, stimulating efforts on the system or climatic chamber, while the control computer could be in a full representative avionics environment with closed loop simulation of flight conditions. As a first trial it had the advantage of being relatively simple, only the power supplies and the control and monitoring discrete signals needed to be distributed.

The challenging part was the transmission latency. The control computer expected the system to acknowledge and react to control commands in a limited time. In parallel an additional constraint was that, while one of the LDGs was set apart in another building, the other two remained close by. These could lead, depending on the transmission latency, to discrepancies on the signal feedback from the three LDGs as seen by the control computer and leading to discrepancy failure modes.

The next difficulty to overcome was the network configuration. Indeed, the ED-247 standard encourages the use of UDP multicast for packet exchange, since it eases the distribution, monitoring and debugging while limiting the use bandwidth. Modern IM constraints usually forbid or limit the use of multicast in internal LANs. Although we could have configured the ED-247 to use only unicast UDP, we preferred using multicast since it allowed connecting monitoring tools to the setup without using mirroring switches or other tapping methods.

The last topic to cover was the signal adaptation on both sides of the setup. In

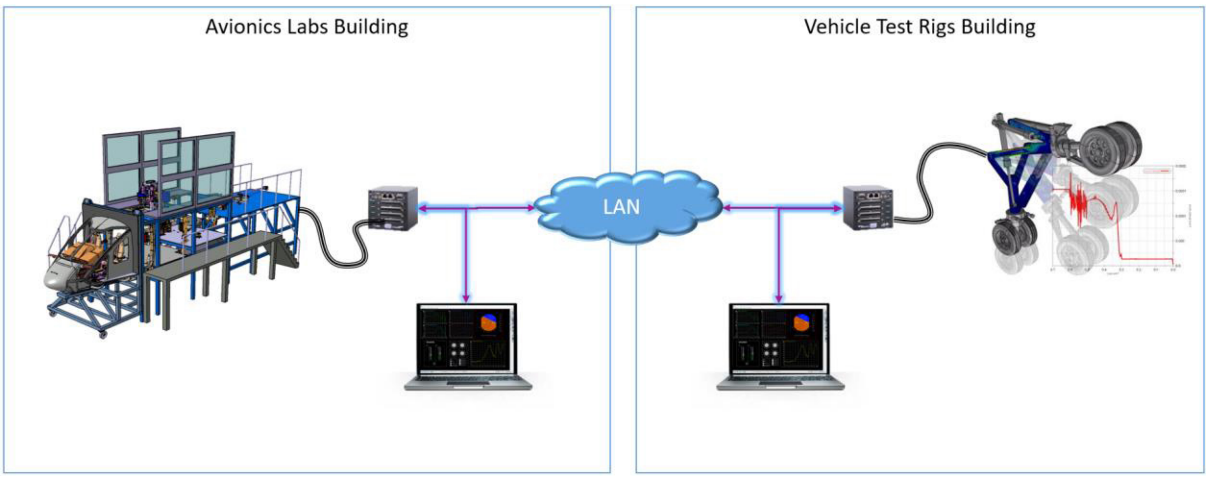

Fig. 1 Landing Gear Distributed Testing Setup

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particular for the discrete signal and power supplies, the introduction of a cut and visualization in the middle of the lines requires reviewing the signal polarization and the power lines reconstruction on the other side of the cut.

As an example, the typical setup for a 0V/Open line relies on the circuit shown on Fig 2.

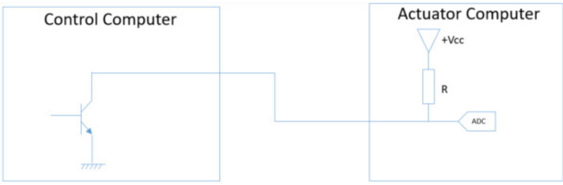

Fig. 2 Typical simplified 0V/Open discrete signal circuit

In the producer side, the control computer, usually uses an open collector design to set the line value to high impedance or ground. On the receiver side, the actuator computer, shall include a pullup resistor (R) that polarizes the producer transistor and brings the voltage to +Vcc for the receiver to be able to read the open state.

When the signal distribution is introduced (see Fig 3.), this mechanism cannot work anymore, and the pull up resistor has to be introduced on the producer side in order to keep the transistor polarization and allow the signal switching.

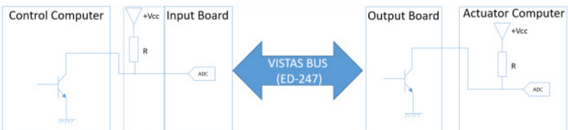

Fig. 3 Simplified 0V/Open discrete signal distributed circuit

For the power supply management, the difficulty comes from the impossibility to transfer the electrical power between both locations. It becomes necessary to use local power supplies on the receiver side driven by the power signal send by the producer. For this, there are several possibilities depending on the level of representativeness required:

- A first solution is acquiring the producer power output as a discrete and transmitting it to the receiver side where a relay commutes the local power supply. This solution has the advantage of being simple to setup, but has the inconvenience of poorly reproducing the power supply dynamic behavior.
- A second solution would be acquiring the producer output voltage as an analog signal and transmitting it to the actuator side. There the analog value is used to drive a programmable voltage supply connected to the receiver power input.

In both cases, if the controller computer monitors the outcoming current a resistor could be added to the power output to simulate the receiver consumption.

In our case, as a proof of concept, we chose the first simple solution (See Fig 4).

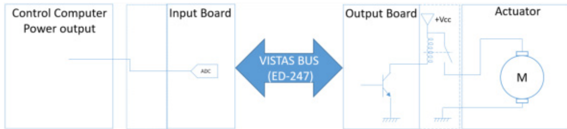

Fig. 4 Simple power output distribution

The results were very satisfactory. The distributed actuator was controlled in parallel to the local ones and the control computer raised no alert.

The average network transmission time was below 1ms. Due to the acquisition period of the input/output boards, running at 1 kHz, a maximum electrical transmission time of 3ms was measured.

Inter-site benches connection use case

The second trial was focused on the interconnection of benches between two different company sites. In this case we wanted to evaluate the feasibility of connecting our Marignane benches in France to our Donauwörth benches in Germany. It was also the opportunity to test the performance of the A429 lines distribution.

This time the goal was to be able to control the Automatic Flight Control System (AFCS), running in the German avionic bench in closed loop with a local flight simulation, from an Automatic Pilot Control Panel (APCP) located in France. At the same time we wanted to display the results in one of the Multifunction Displays (MFD) relocated in Marignane while the other two remained in Donauwörth (See Fig. 5)

From the signals point of view the setup require the bidirectional exchange of 20 A429 lines and 20 discrete lines.

The challenging part in this case was the network setup, since we needed to stablish a robust multicast exchange between to different countries with a much more important latency than the previous case.

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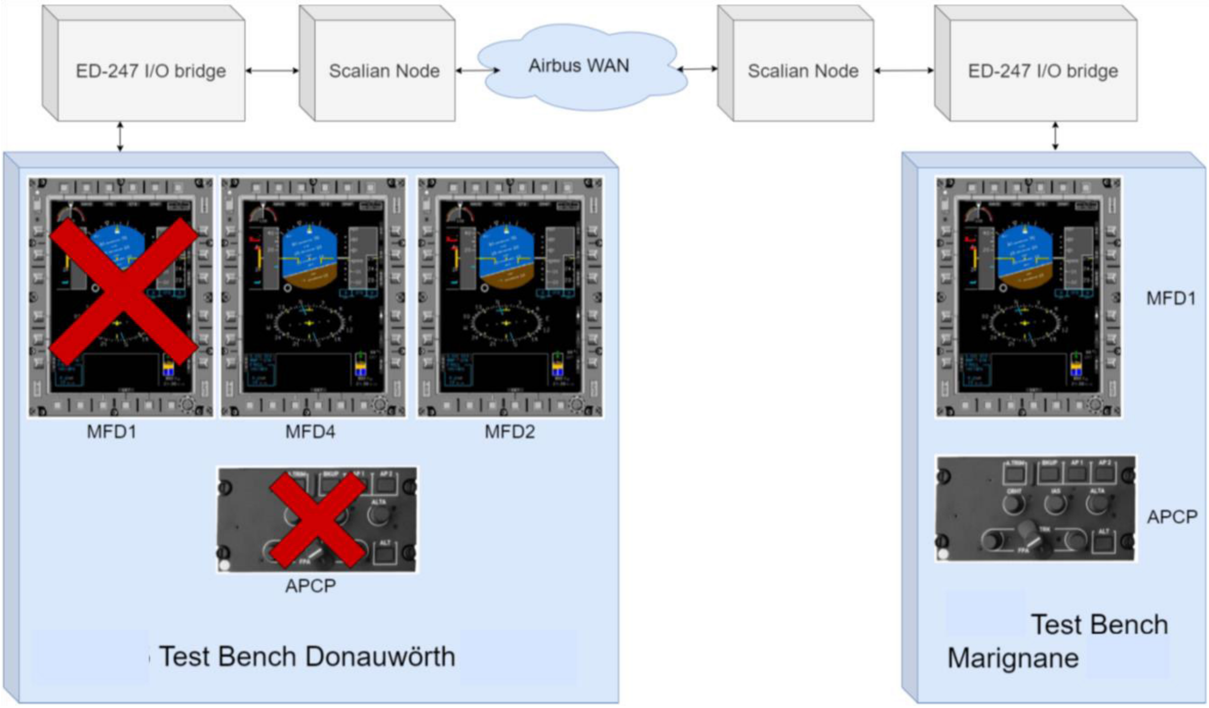

Fig. 5 Inter-site Distribution Test Setup

I was decided to introduce the Scalian Nodes in order to stablish a secure and robust VPN between the two locations. The Nodes allow the precise monitoring and synchronization of packages and implement a retrial mechanism in case of package lost. For that an additional but configurable latency is introduced. An additional advantage is that, once the VPN is stablished it becomes possible to transmit any kind of traffic, regardless IM restrictions.

In order to monitor the exchanged data we used Sandra, our Airbus Flight Analysis tool, that is ED-247 Rev A compatible and able to decode and display the data on the fly.

While setting up the system and doing the first tests we realized that, depending on the I/O racks CPU technology and the packetization strategy, the conversion of signals to the VISTAS bus could take a considerable amount of interruptions and thus overload the CPU on UEI devices. In our test setup, while using a packetization of 10 labels per ED-247 package, the maximum number of A429 lines per CPU was sixteen. We therefore had to use a second rack and CPU to manage the additional lines needed.

The results were promising. The user could control the Autopilot from its control panel 1000 km away seamlessly with an average latency of 17ms. While observing the remote and local MFDs the time gap between screens was almost unnoticed with a loop latency of 34ms.

Conclusion

The use of ED-247 for distributed testing has proved to be an efficient way of interconnecting test means. The advantages are numerous:

- Easy setup and configuration
- Large portfolio of compatible I/O boards from a large range of suppliers
- Very simple monitoring setup, either with open source or proprietary network analysis

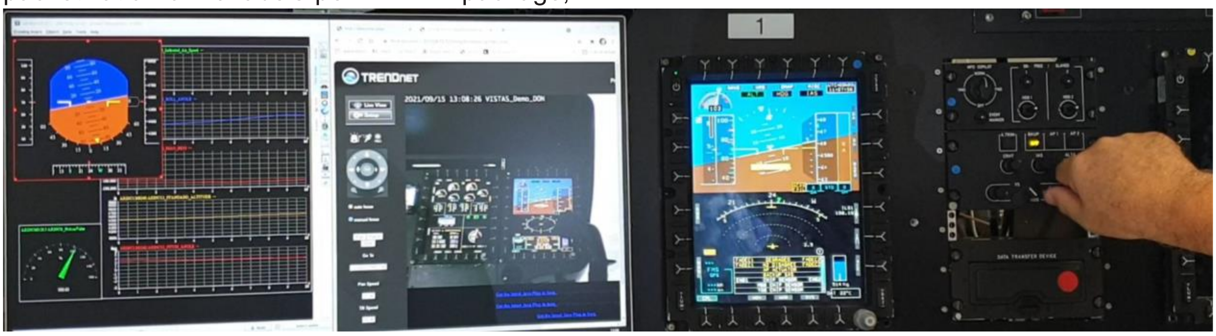

Fig. 6 Donauwörth-Marignane Interconnection Setup

tools.

Nevertheless, several limitations or constraints need to be taken into account:

- Electrical and impedance adaptation of distributed signals.
- IM configuration and filtering constraints.
- Depending on the CPU technology, a limited amount of signals can be managed by a single CPU. In this case using dedicated computation technologies like FPGA could help overcome this limitation.

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