

# HIL & HTB – challenges and solutions

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## Abstract:

**Hardware in the Loop (HIL) and Hybrid Test Benches (HTB)** plays a key role in avionic testing and more data streams are introduced and need to be managed or simulated. There is clear industry need for more simulation to reduce cost and safe time. Nevertheless, the impact of real hardware can't be neglected and therefore it is essential to consider them also in future bench plannings. Detailed planning and alignment with all stakeholders are essential to achieve major milestones in a new development or program update. It's about the "what, why, and how" and potential challenges you might face. We will explore them in context of HIL Testing in an avionics environment, highlight how hybrid test benches can provide potential solutions, elaborate on the why it is important to consider various types of sensors and signals before setting up the test and what solutions are available to deal with these challenges. We will talk about specifics on RVDT's, LVDT's, strain gauges, Thermocouples and synchros. The paper will describe a typical HIL set-up and will help you to understand the potential challenges, give an idea how to manage and provide solutions for implementation and connectivity of modern & smart HIL testing.

**Key words:** HIL, HTB, Testing, Simulation, DAQ,

Time to Market (TTM) plays a key role in the success of a product or it's upgrades, and the known V-model is part of this approach as it directly describes the contributors from Concept to the final system. Hardware in the Loop (HIL) testing is part of this model and already quite common in the industry to get early feedback of the potential system set-up and functionality while Hybrid Testbenches (HTB) are just beginning to enter the industry. Hybrids can use different set-ups depending on the needs of the users like a mix of simulated and actual hardware or even dislocated hardware in other facilities. The challenge is now beside high expectations on shorter TTM also the integration of multiple sensors & signals within an already complex test scenario. We will discuss potential contributors in an Avionics test bench and what needs to be considered in the selection process for a successful bench test.

## Avionic Test bench

In a typical Avionic test bench, you will find the different data bus like e.g. MIL-Std.1553, AFDX, Arinc 429/708/453/825, General Purpose and Specific I/O's like e.g. Thermocouples, RTD's Strain Gauges, Synchro, Resolvers, LVDT, RVDT, Motion Sensing and of course, communication interfaces like e.g. RS-

232/422/485, SDLC/HDLC or Can bus. We want to focus Special I/O's in this paper to provide details on what needs to be considered in a good selection process and to set realistic expectations on your sensors/signals.

## Thermocouples

You will find many options on Thermocouples (TC) with a typical accuracy of +/- 1°C which is quite common except you go for a special one. Keep an eye on the Cold Junction Compensation (CJC) as it directly impacts the system. A CJC error can create directly errors in your signals. Don't specify your system to run at 1kHz if your TC constant sits at 500ms, align your expectations & selection. Prepare for an open-circuit simulation to test for open-TC circuit. Furthermore, be careful on grounding if you select isolated TC's you need to make sure your system does the same.

## RTD's

When using a Resistance Temp Detector (RTD) and board consider a RTD simulator before as this might be easier to get. The scale factor is getting greater as larger the resistance is. Most of the cryogenic users opt for 1000Ω and some of them are fragile. You need to have realistic expectations on your measurement speed. An

RTD with a rise-time (in air) of less than 1 sec is already a very fast one. Keep an eye on the wiring as this is typically the most critical one so your system should be able to detect and simulate short circuits as well.

### Strain Gauges

Most of the time well under control but watch for the correct selection  $\frac{1}{4}$ ,  $\frac{1}{2}$  or full bridge incl resolution and installation. Influencing factors are also the excitation voltage and you need to check the simulator's full scale output voltage.

### Synchros & Resolvers

In Aerospace application you will find mostly 400Hz ones but always double check, 28Vrms are the typical but you will find 90/115 Vrms as well. Some of them have only a 12-bit resolution so check whether that meets your expectations. Furthermore, check regarding isolation as some "real" signals coming off fully isolated coils.

### RVDT and LVDT

Typical sensors provide accuracy levels of 0.1% and they require a power output is around 7 Vrms and 0.35 VA. The excitation frequency has a direct influence on the sensor linearity.

### Control & Monitoring Computers

The most critical topic on this topic is the latency. Will the chosen I/O system match with the expectations of the real-time performance? The Windows operating system is most likely acceptable while the Linux one is typically lower and choose for the most critical RT tasks a VxWorks, QNX or RTLinux. Make sure that your system can be supported long enough to avoid obsolescence issues later.

### Potential Solution

They key for a successful set-up of your HIL or HTB system is carefully selected sensors, signals, and I/O configurations. A full understanding of the impact of the various

elements is essential to meet your expected output. One of the supporting elements are the chosen communication protocols. On Hybrid Test benches (HTB) the ED 427 Virtual Interoperable Simulation for Tests of Avionic Systems (VISTAS) could be one potential candidate to achieve these goals (fig.1). It can provide e.g. detection of anomalies and debugging, software integration tests, functional verification, fault injection and system limit testing. The idea of VISTAS is to create a protocol for testing avionics system. Very often a particular avionics device can't be tested alone – it requires other parts of avionics suite to be present and deliver information. To accomplish that, VISTAS allows easy substitution of missing parts to be emulated using hardware such as avionics interfaces. Additionally, it is possible to create a virtual bridge between test setup and an avionic device which could be in some remote area. To do that, one set of avionics interfaces talks to the device and another set talks to the test bench. Two sets are connected via a local or global TCP/IP network. Although the virtual link between the emulation and the emulation hardware could have latency or jitter, if set up correctly, the emulation hardware can use the hardware schedulers we discussed to solve these problems. Avionics are typically more sensitive to schedule than message content. Stale messages may be OK for one cycle. This is a perfect match for hardware-based message handling.

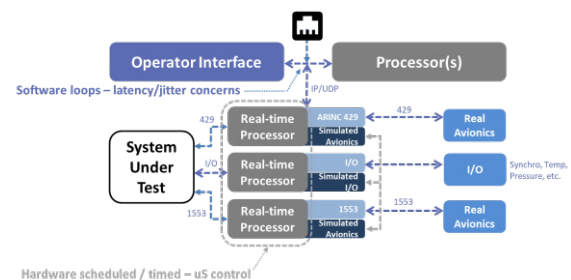


Fig. 1. Example of a ED247 (VISTAS) set-up.