Optimizing Pre-Flight Checkout by Leveraging IOT enabled FTI and Augmented Reality

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Abstract: Pre-flight checkout is one of the most time critical stages in any flight test program. Delays and in-efficiencies during checkout can lead to aircraft being grounded for unnecessarily long periods of time, increasing costs and program schedule slippages.

With the dawn of augmented reality wearables, smart sensors, wireless sensors and next generation Flight Test Instrumentation (FTI), today’s technological advances can be leveraged to transform pre-flight checkout into an interactive, self-diagnostic and operationally efficient essential step in your flight test program. These same technologies can also be used to optimize the day to day operations of airlines, MRO’s and aircraft maintenance companies, taking advantage of the current ‘data rich’ generation of aircraft.

This paper describes how pre-flight checkout can be optimized by combining best in class Internet of Things (IOT) enabled FTI and augmented reality wearables.

Keywords: IOT, Augmented Reality, Flight Test

1. Introduction

Flight line checkouts

There are many systems used in today’s FTI systems, including IP cameras, network switches, recorders, data acquisition units (DAU), wireless sensors and smart sensors. Capturing 1,000s of parameters from both sensors and avionic busses, checking all of the required sections for correct operation before a test flight can be a lengthy and laborious task.

The traditional approach to this would involve plugging a laptop into the onboard system or using one of the onboard flight test stations to view the real-time data from various elements of the system, comparing the data to expected values for the stationary conditions of the aircraft in the hangar / on the runway and then creating work orders for technicians to address any issues found.

Some examples of how systems must be verifies include

- IP cameras must be correctly focused and positioned to ensure video feed is captured cleanly each time.
- Network switches must be checked to ensure all links are up and operational. Grandmaster Switches should be checked to ensure synchronization to GPS is active and in lock.
- Recorders must be checked to ensure there is sufficient recording space available on its media for the upcoming flight.
- The DAU’s themselves capture a myriad of data from multiple sources, all of which should be verified for correct operation prior to flight. DAU’s can be distributed throughout the airframe in in-accessible areas making them hard to individually test.

With the advent of Wireless sensors and Smart sensors, that can be positioned in very hard to reach locations, information like battery power of the sensor and validity of the data become critical pieces of information to be verified before flight.
Figure 1: Flight Test Equipment

Utilizing IOT and Augmented Reality

IOT and augmented reality can be leveraged to optimize pre-flight checkout, minimizing the level of human interaction required to perform tasks\textsuperscript{[2]}, decreasing delays and increasing efficiencies.

To be considered an IOT device an FTI installation must have the ability to be accessible over the internet. This may mean a lot of different things to different people, anything from the live Ethernet data being streamed from the cloud to DAUs with Web accessible interfaces so they can be queried and configured. However, cloud accessible FTI raises a lot of concerns with respect to data integrity and cyber security, so this will not be considered in this paper.

However, there are DAUs that run a Web accessible REST-API\textsuperscript{[1]} onboard. From here it is possible to directly query the DAU itself or any of the parameters on any of the modules in real-time. This way the status of the DAU itself, or any analog channel or avionic bus data can be checked without having to include the status information in the live FTI data stream.

Today’s IP cameras are capable of outputting multiple streams of data at different resolution and compression schemes from a single source camera\textsuperscript{[3]}. If we consider three sources or streams of data from the one camera, one high rate stream can be sent to the recorder for post flight analysis, another at a lower rate could be sent to the RF link for telemetry via an IRIG-106 Chapter 7 data stream and the third stream could be fed to a local server from where an augmented reality wearable device could access the live feed when required.

switch. Recording status of any onboard recorder or networked attached server (NAS) would also be accessible using SNMP GET commands. Not only are the statuses of these switches and recorders able to be checked over SNMP they can also be configured and reprogrammed through in built Web interfaces designed into the hardware.

Wireless sensors and smart sensors are often placed in inaccessible places and powered off batteries. Therefore the ability to query the device to check its operational status and battery life is essential. For example, Lord Microstrain’s latest generation of wireless sensor nodes run an API through which it is possible to query the built-in test status and battery status of each node. The data from these nodes is also accessible via WebGL to create HTML canvas displays of the data for real-time viewing.

Now that we have considered the latest generation of FTI equipment, and what they are capable of, how augmented reality (AR) wearables can be used to interface to all of these elements to create an interactive, self-diagnostic and operationally efficient pre-flight checkout process will be discussed.

There are many varieties of AR wearables on the market today, including DAQRI’s Smart Glasses, Microsoft’s Hololens, Magic Leap’s Lightwear and Google Glass Enterprise Edition (EE). For the purposes of this discussion, we only consider those targeted at enterprise operations and those that offer “hands free” operation for safe use.
The best balance of these two requirements is met by DAQRI’s Smart Glasses as they offer completely hand free operation, without requiring hand gestures or remote hand held controllers. Additionally, the DAQRI Worksense Tag application tailors easily configurable augmented reality displays to real world devices, displaying the critical information in context where it is needed.

**Figure 2:** DAQRI’s Smart Glasses offer many features useful for FTI flight line checkouts

### Implementing AR

During the development phase, a model of all the elements of the FTI as installed on the aircraft is created and tied to a Marker located inside the cabin or on the engine nacelle of the aircraft.

A pre-flight check application is created using DAQRI’s Worksense Tag application. In this application the critical information for any device can be made accessible right at the device location via the use of virtual tags placed throughout the model.

The tags can be configured to read specific data in real-time from the devices under inspection. For IP cameras the TAGs can be configured to display one of the three IP video streams so the correct focus of the camera can be confirmed. For the switches, via either the Web interface or SNMP, the port status and GPS sync can be confirmed. For the recorders, again via the Web interface or SNMP, its status and remaining disk space can be confirmed.

The volume of different information that DAUs collect is vast, given that they essentially act as data concentrator units. For example, in the Axon DAU, any system parameter can be queried directly off the chassis via the REST-API running on the controller in each chassis. Some examples of what is possible are

- Thermocouple channels: the current reading of each channel can be displayed, and using the thermocouple open status parameter, the cause of anomalous readings can be debugged. The cold junction status can also be debugged, given that it is built into the top block of the Axon modules.
- RTD channels: the current reading of each channel can be displayed and checked.
- Bus monitor channels: the active status of any channel can be displayed and report parameters used to debug any potential issues
- DAU: there are multiple built-in test parameters and temperatures throughout the DAU, from the PSU to any user module, can be displayed and checked.

Smart sensors generally use an API for configuration and data download, therefore this can be used to directly access the smart sensor status. The latest generation Lord Microstrain wireless sensor nodes, integrated into an Axon module running the Lord radio, can be queried through the API get the built-in test and battery status of each node.

One of the other features that could be offered by a system such as DAQRI’s Worksense Tag application is the ability for a user to dynamically tag any issues seen during pre-flight checks. Such tags can include positional indicators and text or audio or pictorial descriptions of the issue or to change the status of the tag to indicate there is an issue (e.g. incorrect current value on an RTD). These can be automatically uploaded onto the model and work orders created for technicians to address the issue.

What this means is that the inspector can, during pre-flight checks, place tags anywhere to highlight new
issues spotted, at the location of the issue and this new information would be displayed for a technician to address.

DAQRI’s Worksense also offers the ability for the inspector or technician to call for expert help directly at the location of the issue. The Worksense Show application has the ability to video call a remote expert directly from the Smart Glasses. The remote expert can see exactly what the inspector sees and dynamically add indicators, directly from their PC or laptop that appears on the inspectors display overlaid on precisely the equipment the remote expert needs the inspector to look at.

**Figure 4: AR allows remote located technicians to view an issue in a very involved way**

**Figure 5: AR view of remote technician interaction**

**Example Possible Use Case**

An organization is flight testing their latest eVOTL platform. Their FTI installation includes IP cameras to record the moveable rotor positions during the various stages of flight, DAUs to measure the vibration and strain of the flight control surfaces, monitor battery load and to gather Avionic bus data from the flight control computers, and wireless sensor nodes to measure the G-forces on the rotor blades. All this data is networked to a central PTP Grandmaster switch and bulk recorded during flight. A sub set of this data is sent in real time over a PCM link to the ground station.

Due to the physical size of the vehicle this FTI installation must be distributed throughout the airframe into the tightest of spaces. The organization has a local wireless network that the test vehicle can connect to while in the hangar or on the runway. They create an application on their DAQRI Smart glasses that gathers critical information from the various components of their FTI installation, displays it virtually over each device on board the test vehicle.

During pre-flight checks the FTI engineer launches the application on the glasses, scans a target on the side of the test vehicle which then launches the relevant external tags for the devices located on the outside of the test vehicle. The engineer then walks around the outside of the test vehicle and inspects the tags displayed for the wireless sensors, checking the battery life is sufficient for the upcoming flight. The FTI engineer can also access the feed from the IP camera to check that it is focused correctly.

Inside the vehicle the engineer can scan another landmark which will activate the tags for the critical FTI equipment inside the vehicle. Now the engineer can check that the readings from the vibration and strain measurements off the control surfaces are as expected, the battery power is as required and the links to the network switch are all active and PTP sync to GPS is OK. The recorder can be checked to ensure there is enough media space remaining for the upcoming flight.

During these checks the FTI engineer notices that the strain measurements for one of the sensors are out of alignment with the expected value. They then access the DAU’s configuration to verify that the excitation and channel gain is set to the correct value, seeing that they are they then decide to contact the wiring expert in real time. The wiring expert asks the FTI engineer to look closely at the exact location of the particular strain gauge and notices that the surface mounting is starting to peel away, leading to incorrect readings for that channel. The FTI engineer then places a tag at the location of this issue and a work order is created for a technician address the issue.

The technician, when arriving at the test vehicle sees the tag at the indicated issue location, with the
engineers assigned work instruction associated with it. Addresses the issue, remounting the gauge. The technician indicated the work instruction is complete, the FTI engineer re-checks the channel readings, approves the fix and clears the vehicle for flight.

**Conclusion**

This paper shows, that the latest generation of IOT enabled FTI, including IP cameras, DAUs, switches, recorders and wireless sensors, combined with industry focused augmented reality wearables, applications can be created to dynamically perform pre-flight checkout and many other tasks. This has the potential to save valuable time by increasing the efficiency of checks.

References: