Virtual Reality in Satellite Integration and Testing

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INTRODUCTION

It is well known that an important part of the satellite validation process is made in a visual environment that allows the test engineer to represent the satellite using synoptics. These synoptics are linked to telemetry and telecommand parameters and display in real time the satellite status.
The graphical visualization of the satellite is left to the EGSE designer that can freely choose various layouts using the elementary objects included in the existing synoptics tools to represent the equipment under test. Yet the task of defining and implementing this kind of representation of the EUT is not always straightforward and might well imply a considerable effort as well as knowledge of the environment. Furthermore different AIV test engineers might have different preferences on the way data are represented.

On the other hand, before the electrical and functional satellite verification, the engineering team is defining the satellite mechanical layout (including harness) using a CAD program, and this representation, detailed at component level, is already used to support and de-criticize satellite mechanical Assembly and Integration using a virtual environment

Purpose of this article is to present a Virtual Reality based, advanced synoptic system that links the parameter representation with the satellite physical layout: in this system the telemetry status can be associated to the physical point of measure, so that in case of anomaly it is extremely straightforward to identify and inspect the location of the measured parameter (equipment, connector, pin…), to quickly react thanks to “a visual inspection” of the virtual satellite taking advantage of the strong coherence between the CAD model, virtual technology and the real satellite.

Thanks to the available functionalities, while the design stage of the synoptic is strongly reduced, it is also easy to configure the visualization according to operator preferences (different setups can be created and managed), adding/removing visualized parameters in

real-time, or to navigate the CAD model to focus on a subsystem to highlight tested paths vs. untested ones, and even present multiple displays of the same test to better cope with the different needs emerging at runtime.

CURRENT STATUS FOR EGSE MAN MACHINE INTERFACE AND SYNOPTICS

We do not want to treat the matter deeply because any AIV Operator in order to integrate and verify a satellite is using an EGSE that foresee a Man Machine Interface based on the following concepts:

- Raw data display: both telemetry and telecommand data are presented in raw format leaving the interpretation to the user itself. See Fig. 1

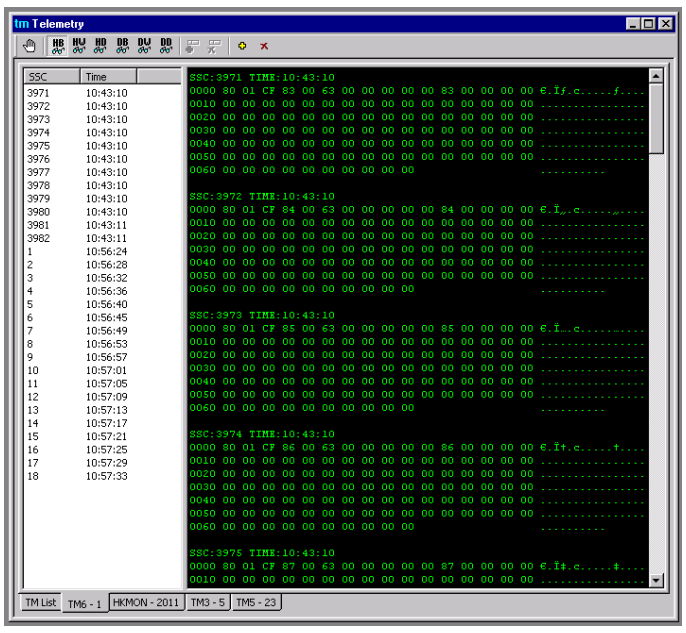

Fig. 1 Example of Telemetry Raw data display

- Parameter display: the next level is the engineering transformation of raw data into parameters that are displayed with engineering value, format, units and monitor status. The Operator has no need in further interpretation of the parameter value, because the display information is complete and self standing.. See Fig. 2

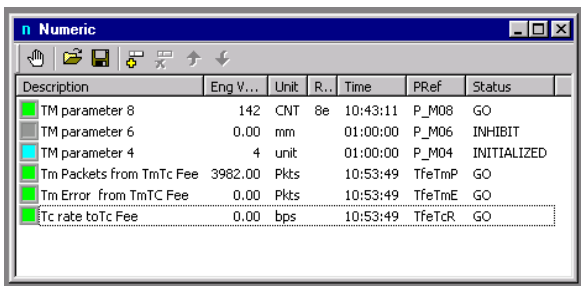

Fig. 2 Example of Telemetry Parameter display

- Synoptic display: the last stage of display is completely under operator control that using a graphical editor draw its view of the Unit Under Test mapping parameters values onto objects created by means of a elementary graphical library. See fig. 3

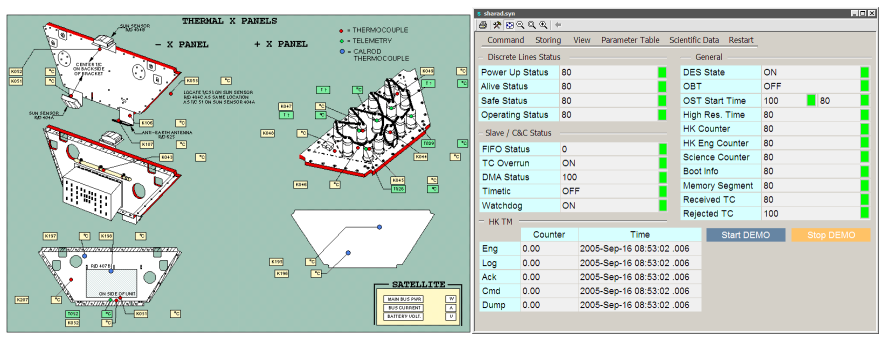

Fig. 3 Example of Synoptic display

Because the Synoptic Display is common to any EGSE / Control Centre used by Large System Integrator in Europe it is well know the effort that the creation of any synoptic panel requires, together with the fact that the representation of the Unit Under Test is filtered by the experience and feeling of the operator itself.

Moreover, despite the versatility of current synoptic editors, it is very difficult to define general rules to allow the Operator to create, in a simple way, complex object to clearly present the status of the Unit Under Test; so the synoptic design must be approach with the same formalism of any other component of the Test Environment.

VIRTUAL REALITY TECHNOLOGY STATUS IN THALES ALENIA SPACE

A proprietary tool aimed at de-risking the mechanical integration procedures is already in use since several years and has shown its usefulness on various programs where complex procedures could be rehearsed well in advance to the actual integration phase, in this way allowing to assess the most critical steps and to prepare, in a timely manner, workarounds or risk mitigation actions.
While being an internal development, this tool is able to import the CAD models created by the Engineering teams and to navigate inside it in stereoscopic, immersive 3D as well as to interact with it using human Interface devices, which allows to easily verify visibility, accessibility, clearances and more in general to assess operator-Hardware interactions. Due to this reason its use in Design for Manufacturing has proved successful already in the design phase, allowing to correct design solutions that could pose problems in the following integration phase.

The tool is based on an optimized 3D engine able to work on full scale models, without need of simplification to manage them in real time; this means that, once the CAD model has been finalized by the engineering team, its representativeness of the future satellite or component is extremely high, because it will be manufactured based on this model. Besides, it been already proven, even if through an offline interface between the tool and the laser scan used during the alignment stage, how the support of the virtual environment can help the operator to avoid error and speed up the real operations, even in the nominal case and not only in the emergency one.

INTEGRATION BETWEEN VR AND EGSE

Thus, it seemed reasonable to start from this basis to create a new User Interface for the Ground Support Equipment which would be capable of:

- *Connecting with the Monitoring System through a standard protocol yet remaining disconnected from the complexity associated to the measures;*

Associating the virtual 3d representation of the physical components to the values of the various parameters received from the Monitoring System; the display is dynamic and interactive, so that it can be reconfigured by the operator just by changing the visualization point of view and different operators can even display the same model from various points of view at the same time. The following features has been foreseen:

- *Adding or removing displayed parameters in real time from the display, as well as activating or deactivating objects, layers, components to configure the view;*

- *Manage different levels of privileges, from observer to supervisors up to administrators.*
- *Saving one or more views (layouts) for each test and operator.*

Starting from all those user requirements an on-line protocols was developed to connect the virtual environment to the real one.

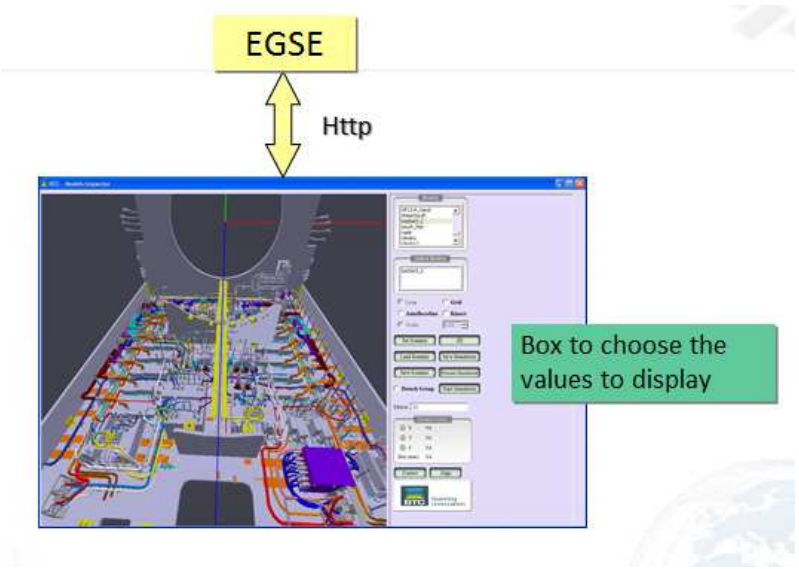

Fig. 6 Integration between EGSE and VR display

The UDP network protocol was chosen as base for the exchange of messages composed by packets. The packet format was defined in a way to be extremely flexible to avoid to change the whole architecture despite information coming from EGSE are slightly different. From the user point-view, the tool must be able to switch from a simple view to the advanced one. In the simple view, the most of the information are covered and only color- based blocks are displayed with the information status of the basic values of a specific test. Instead, in the advanced view, filtering option as well as the possibility to cover parts of the satellite are available to the user.

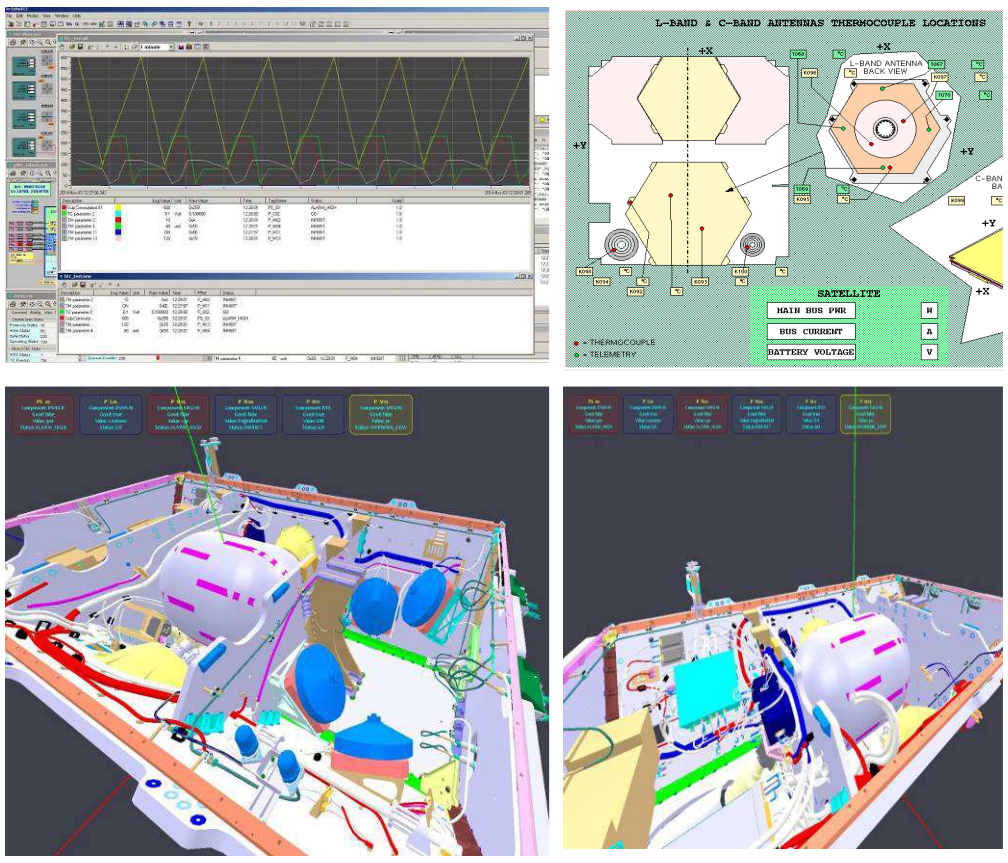

Fig. 7 Integration between standard synoptic display and VR dispkay

Thanks to Qt framework with OpenGL technology through an event-driven processing is possible to perform all these functions just by clicking on the screen.

In fact, on the model, it’s possible to highlight a component on the CAD model and hide it or, with a context menu, see more details related to the component or send a telecommand to active the test procedure (future work)

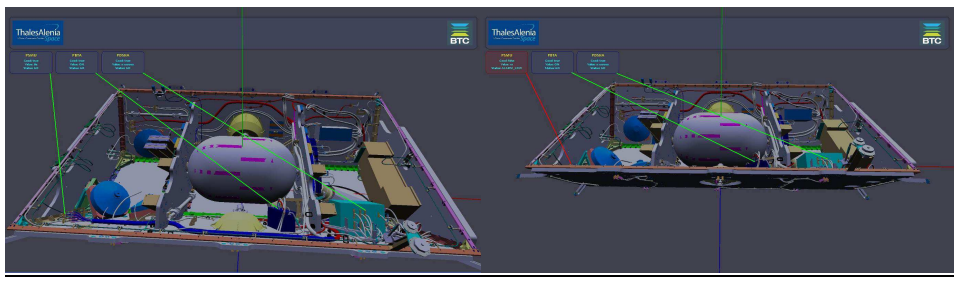

Fig. 8 Alarm visualization on VR display

ADVANTAGE OF 3D REPRESENTATION

The most important advantage of this type of representation is the usability of the display by the heterogeneous group of people that contribute to satellite design even if they are not AIT specialist: all electrical/thermal/mechanical designers and satellite system managers can contribute to AIV activities through their field of expertise looking to the real satellite/subsystem/equipment representation during tests.
Moreover the AIV operator can physically inspect the satellite harness to verify the status of existing connection (verified, to be verified, to be mounted ecc..) or change the observed parameters without recreating the synoptic. This last point is very important not only because makes the whole process less error prone, but even because reduces the cost of Satellite/Payload testing by avoiding to create a new synoptic thanks to the possibility of reconfiguring (i.e. by drag and drop) the graphical view activating additional parameters of interest or hiding ones that are not needed in the test under execution.

It is also to pointed out that the 3D representation is not an alternative to the standard synoptic display but integrates the synoptic display with VR functionalities. This means that the transition between the standard system and the new one can be seen as a natural evolution of the EGSE functionality without any need of operator training.