Generic Portable Virtual Reality Satellite Swarm Ground Station

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ABSTRACT

In the space community, there is a huge challenge in the complexity of satellite swarm missions at either ground station control or data reception. Virtual reality (VR) technology could open the door to a new concept of satellite operation. Such technology is the future of these space mission cost reduction and portability. In this paper, this approach is presented with the state of the art technology of the VR (Oculus drift) with a communication module functionality of the ground station will be implemented by a software defined radio (The cortex machine by Zodiac Company) which contains all the physical and data link layer: modulation, coding and CCSDS packing .The verification of the operational scenario is fully implemented and tested for a constellation of 5 satellites around the earth using the model based system engineering (SysMl language) . In addition, SysMl is used to describe the system engineering model of the space mission VR environment. Operator visualizes the telemetry of the concurrent satellites swarm in presence of a specific actor (Avatar gloves) to interact with the space mission status with that virtual ground station, thus facilitating the portability of the ground station with a complex graphical user interface presenting the command and telemetry of the satellites constellation.

BACKGROUND

Starting from 1998, Egyptian space programs own different ground stations from Cairo to Aswan city shown in figure 1 and 2 and 3.The stations covers most common small satellite bands UHF, VHF, S and X band. Furthermore, Egyptian space programs has a constellation of small satellites. For instance , The cube satellite EUS university satellites, NARSS cube constellation and Nexsat series of satellites. However, the communication subsystem is changed based on the payload mission and required data rates. In addition, African Space Agency hosted in Egypt makes a new demand for more generic ground station shown in figure 4. Consequently, Cortex machine provided by Zodiac Company solves this problem since the machine is software defined radio based. An example of this machine is presented in figure 5 and 6 which based on configurable block diagram and the GUI presented the actual transmitted and received signals from the satellite.

Figure 1: Cairo Control Station S band

Figure 2: Aswan Receiving Station X band

Figure 3: UHF –VHF Cube Satellite Ground Station

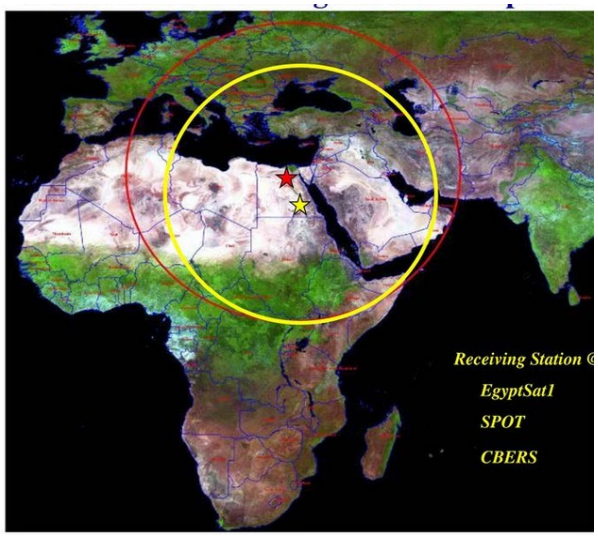

Figure 4: African Ground Stations Constellation

Figure 5: Cortex Machine

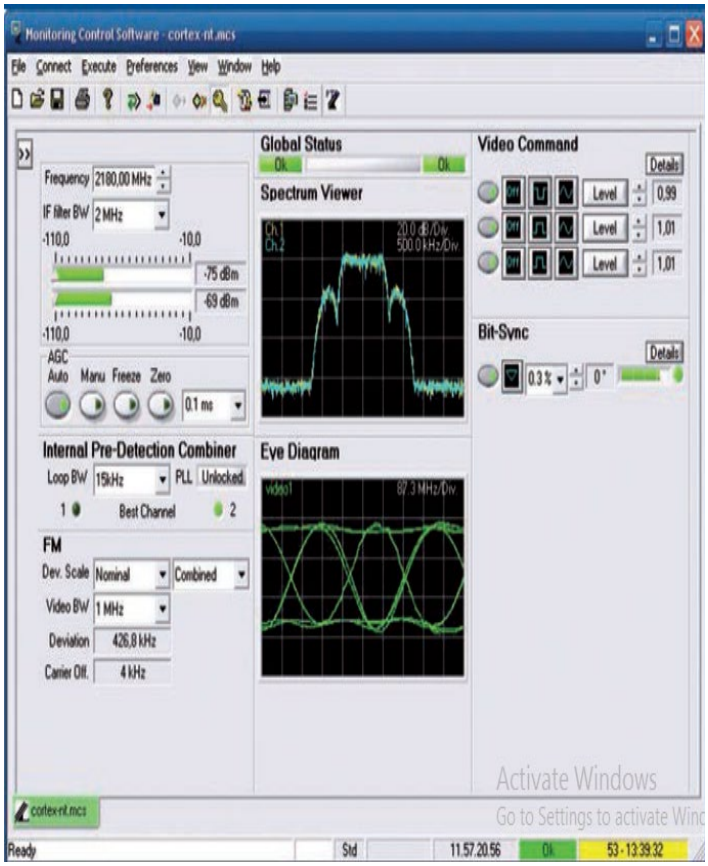

Figure 6: Sample GUI Cortex Machine

DESIGN AND IMPLEMNTATION

Model based System Engineering Sysml for cube satellite constellation

Sysml CubeSat Ground System consists of physical and logical Parts based on Sysml language which provide uplink, (command, and control) and downlink capabilities for the CubeSat. Ground System Logical Components block.The Framework models this functionality through the CubeSat Ground System Physical Components block. The CubeSat Ground System is structurally composed of a CubeSat Ground Station, which further decomposes into radio and antenna, as well as a CubeSat Ground Information System. The Information System provides the infrastructure for data planning and commanding,. These physical components interface with the uplink and downlink functionality of the Ground System.

Virtual Reality in Ground Control Station

It is not a new concept about virtual reality in ground station and figure 7 illustrated one example of VR in ground station. Hence, huge varieties of visual tools and definitely easily acceptability make it more suitable for swarm satellites. On one hand a list of telemetry of each satellite presented in table 1 which packetized based on CCSDS standard. On other hand, VR can be used to visualize the telemetry parameters for the all constellation without extra hardware. Cortex machine accepts configurable file for each satellite in the constellation. SDR makes automatically changes of the configuration based on the GPS location of the satellite constellation.

Table 1: Telemetry parameters of one small satellite

TELEMETRY	Value	Unit
Satellite ID	0x001	
GSD	2.7	meter
Cloud Cover	25	%
Satellite Altitude	500	Km

Figure 7: Virtual Ground Station Example

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Haptic actuator and new concept of Ground Station

The dream of touch the untouchable makes the portability and operability of the satellite ground station with infinite solutions. Gloveone Company uses the haptic actuator to prove this concept shown figure 8 as Piano music player example. New concept is based on visualize the user interface of the ground station and be touchable. Portability of the ground station came from the wireless solution offered by the embedded processor inside the glove.

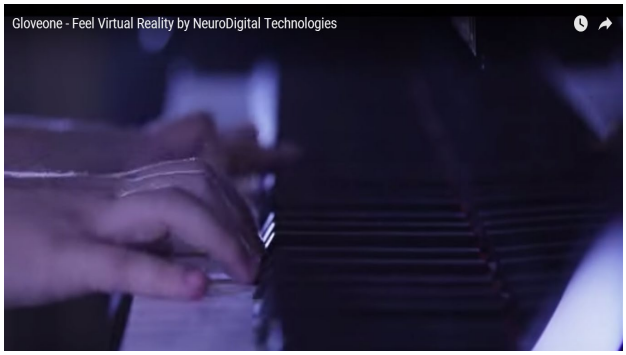

Figure 8: The new concept of virtual sensation

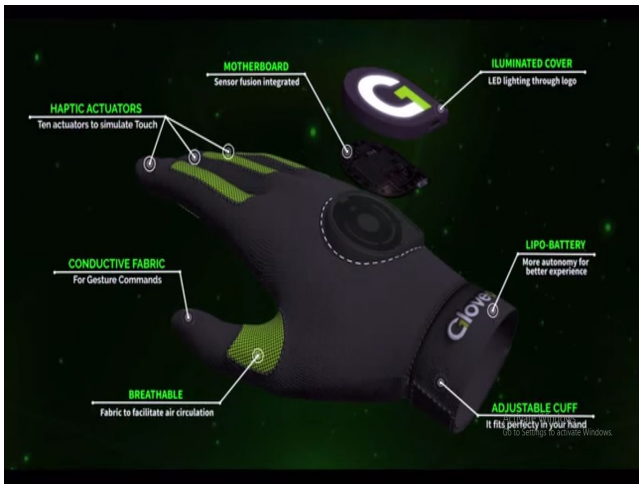

Figure 9: Haptic Actuator Example

CONCLUSION

Virtual reality (VR) technology with haptic actuator makes new concept of satellite operation. This paper presented with the state of the art technology of the VR (Oculus drift) with a communication module functionality of the ground station implemented by a software defined radio (The cortex machine by Zodiac Company) and haptic actuator is used to prove this new concept. Operational scenario verifies the new concept on a satellite constellation.

Acknowledgments

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