THE EGSE AND CCV FOR THE ESA VEGA LAUNCHER

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ABSTRACT

The present paper aims at describing the main functionalities and the peculiar architectural aspects of the two systems developed by Vitrociset to support the VEGA launcher Program in both launcher integration & validation and ground operations.

The EGSE (Electrical Ground Support Equipment) is used during the assembly and integration of the stages at ELV premises, while the CCV (Centre de Contrôle VEGA) is used on the VEGA launch pad during Launch Vehicle (LV) final integration and count down at the CSG (Centre Spatial Guyanais).

The paper briefly outlines and compares the VEGA EGSE and CCV major characteristics and architectural choices, highlighting their innovative and peculiar design, the differences and commonalities.

INTRODUCTION

In the frame of VEGA Launcher Program, two ground equipments have been conceived and developed to accomplish two critical different program missions: the EGSE for Launcher on-factory test campaign, and the Control Bench (CCV) for on-site operations and Launch campaign.

The EGSE is designed to support the electrical operations during the Assembly, Integration and Test (AIT) phases of the VEGA launcher, in particular:

- Acceptance tests of single stages
- Integration process between LV sub-systems
- Simulation of missing LV stages/parts
- HWIL (Hardware in the loop) test

The CCV system is devoted to perform control and command operations toward the VEGA Launcher and Ground process in two main phases:

- VEGA First Stage (P80) acceptance (not accepted in Industry premises by EGSE)
- Launch campaign operations, from LV integration until final countdown.

Thus, it can be considered as a "stage" bench during P80 reception and “operational” bench during launcher integration and the whole campaign.

The two systems share some common drivers which are reflected on a similar high-level architecture, while specific needs led to different design choices that are summarized in the following sections.

CCV ARCHITECTURE

The CCV (as shown in figure) is composed by the following subsystems:

- Computer Centre (CdC)
- CCV Functional Sub-System (BCVF)
- CCV Emergency Sub-System (BCVE)
- Common Devices (COMDEV)

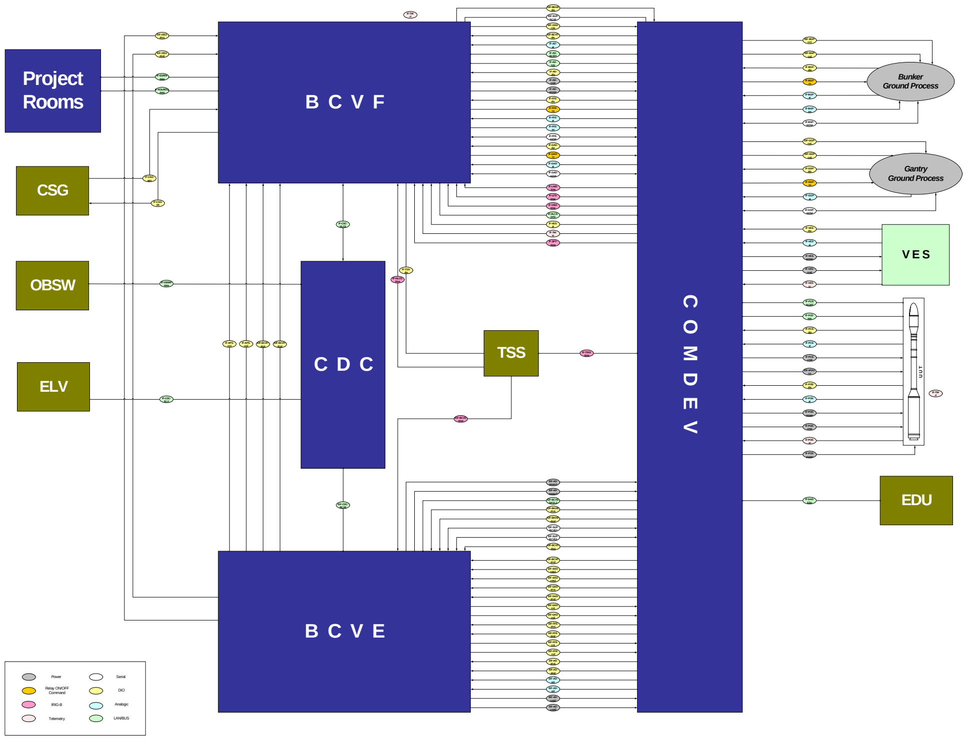

Fig. 1. CCV high-level System Breakdown

It is a distributed system, deployed in the so-called ZLV (Zone de Lancement VEGA, now Carlo Buongiorno Pad) and in the Control Center shared with A5, so called Centre de Lancement n° 3 (CDL3).

BCVF

The BCVF represents the core of the CCV nominal activities. It executes all the necessary operations to ensure the CCV functions.

It is composed by two main elements:

- High Level Control System (HLCS)
- Low Level Control System (LLCS)

HLCS ensures interaction with the operators. It allows the loading of Automatic Procedures and sending requests to the LLCS.

The LLCS is composed of modular subsystems that are interfacing with the Launcher or Ground Segment allowing the acquisition of parameters, the sending of commands and the Launcher Equipments power feeding. The LLCS has specific subsystems managing the various types of interfaces, as the:

- Hardwired data (wiring and fluid SCOE)
- 1553 bus data (1553 SCOE)
- Telemetry data (TLM SCOE)

BCVF is also in charge of launcher equipments powering. For this purpose it is endowed with power supplies and the specifically designed power distribution facilities.

Data related to BCVF operations can be archived on the BCVF itself and immediately analyzed through an Immediate Off-Line Analysis (TDI) capability.

In addition, during operations, a Supervision function is always active in order to control the health of the BCVF and to recognize eventual serious failure that requests the BCVE intervention.

BCVE

The BCVE is an autonomous emergency sub-system independent from the BCVF and is devoted to put the launcher, the P80 (during stage acceptance) and the ground process in a configurable safe conditions in case of failure of the BCVF.

The BCVE is composed by two redundant Siemens PLC chains, satisfying the Fail Operational criterion. Total coherency between the two chains is guaranteed by the system design.

Computer Centre (CdC)

The Computer Centre or Centre de Calcul (CdC) is the separate CCV facility designed for preparation, unit testing and configuration of procedures and data required for operations conducted on the BCVF and on the BCVE, independently from other activities conducted on VEGA ground checkout equipment.

The CdC can ideally be split up in two parts: the functional and the emergency elements in order to generate in a independently way the operational configuration relevant to the BCVF and relevant to the BCVE. They are based on different technology solution (Java and Siemens simatic) as well as BCVF and BCVE.

Common Devices (COMDEV)

The Common Devices (COMDEV) are the CCV facilities devoted to:

- Allowing the interfaces switch between the VEGA launcher (to the Prise Ombilicale Electrique, POE) and VES with no difference from the BCVF/BCVE point of view
- Allowing the interfaces with Ground processes

- Distributing the time signals TU (Temp Universal) to the equipments that require them in the Bunker and in the Mobile Gantry
- Performing Off-Line Analysis on CCV session data generated by both BCVF and BCVE
- Providing a RF network able to allow the reception of the telemetry from the LV by the BCVF

EGSE ARCHITECTURE

The EGSE design has been achieved around the concept of having three separated environments having peculiar characteristics and needs, in relation to the AIV / AIT approach. These three functional elements, or subsystems (SS), are:

- Test Configuration System (TCS)
- Test Execution System (TES)
- Post Processing System (PPS)

The EGSE breakdown is shown in the following figure:

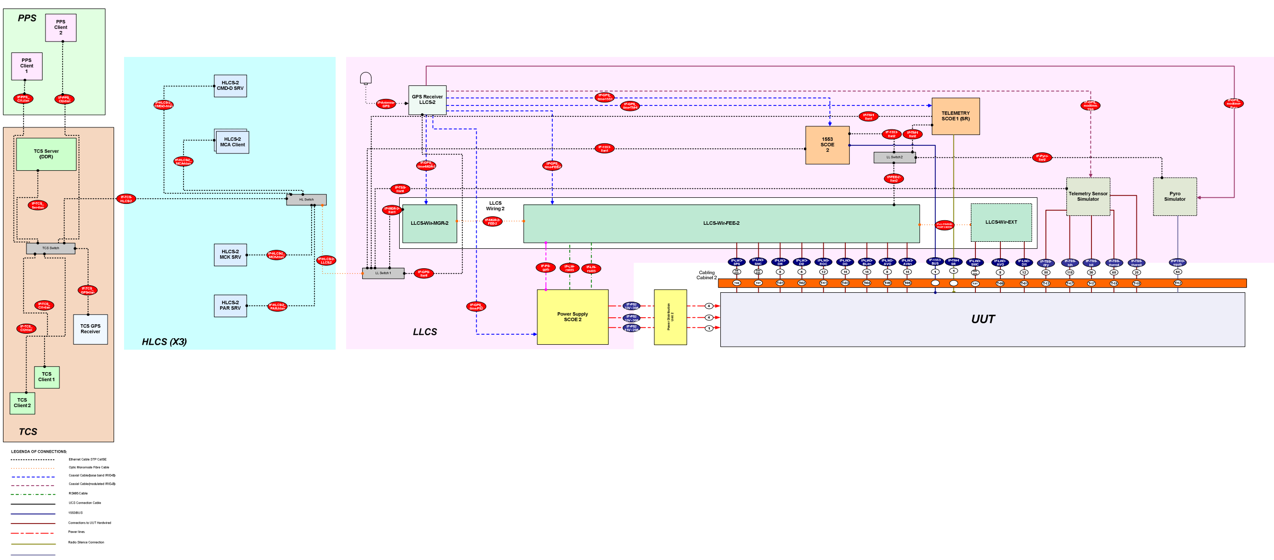

Fig. 2.EGSE chain breakdown

Test Configuration System (TCS)

The TCS is mainly dedicated to the configuration and validation of test environment data. In particular, it includes a number of functionalities devoted to the environment definition, database creation and editing and a set of generic functions.

Test Execution System (TES)

The TES is the part of the EGSE in charge to execute the tests, directly connected to the Unit Under Test (UUT).

The TES is composed by three core chains and a set of devices that can be aggregated implementing three modular test chains.

Every chain is composed by two main components: HLCS and LLCS. The modular part is the LLCS.

The HLCS is devoted to allow the interaction with operators. Test Sequences specification is based on ESA SW Products and standards (datamodel access ECSS-E-70-31[3], frameworks SCOS-2000 & ASE, scripting language ECSS-E-70-32[4]) developed through the last decade with the support of Industry, where Vitrociset played a key role.

As said, the LLCS can be configured aggregating the SCOEs and Avionic Simulators necessary for the specific test scenario, according to the one defined and validated in the TCS.

Post Processing System (PPS)

The post processing function is aimed to guarantee the analysis and post processing of the test results collected during the test sessions, and to produce reports

CCV-EGSE MAIN COMMONALITIES AND DIFFERENCES

Both EGSE and CCV have been developed in the frame of the Vega Program to ensure the monitoring and control of the Launcher, from the early assembly phase to the launch. From a temporal point of view, the EGSE conception, design, development and validation preceded the CCV, which has maintained some of the choices of the previous project and introduced some specific features driven by mission specificity and industrial context.

Commonalities

The commonalities between the two systems are several, and can be classified as follows:

- Architectural
- Technological

Architectural Commonalities: The commonalities at architectural level are driven by generic requirements leading to the choice of a segmentation of the system to implement defined interfaces, and to segregate functions in a predictable and defined way. To this end, a first level decomposition, common to the two systems, is shown hereafter:

- Data Preparation and Management Environment (CdC for CCV, TCS for EGSE),
- Tests/Operations Environment composed by HLCS and LLCS (BCVF for CCV, TES for EGSE),
- Data Post Processing Environment (Data Analysis System or "COMDEV-DAS "for CCV, Post Processing System or "PPS" for EGSE).

This system decomposition provides a number of benefits, as the control of operations flow, consistency of validated procedures, and operations parallelization.

At lower level, it is worth to be mentioned the common breakdown of the Tests/Operations Environment: in both systems, the Tests or Operations Execution Environment is composed by an High level System (HLCS) providing manual and automatic human interfaces capability and centralizing the management of the Tests/Operations, and a LLCS that is composed by several SCOEs, each one interfacing with the Launcher by a different interface technology.

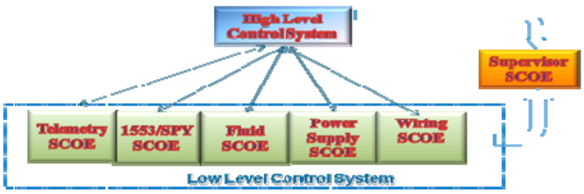

Fig. 5. CCV/EGSE common architecture

In itself, the communication is based on a two layers TCP/IP architecture, while CCSDS protocol communications, provides an abstraction infrastructure able to guarantee scalability, to treat and manage, in a same manner, data coming from heterogeneous SCOEs.

Technological Commonalities: CCV and EGSE System have been designed according to their requirements, but using a common rationale for the HW& SW technologies selection**.**

In fact, each SCOE type has been conceived by implementing the same SW Languages, Operating System and HW, e.g. the 1553 SCOE and TM SCOE are provided by the same manufacturer and coded in C Language and use Linux OS and respectively AIM 1553 boards and the same custom telemetry boards, Wiring SCOE on both systems is coded in LabVIEW Language and use Pharlap OS and NI HW Technology.

Moreover, in order to guarantee high availability reducing the risks related to usage of not consolidated solutions and provisioning of spare parts for the mid-long time of project life, an extensive usage of COTS has been adopted as main guide line.

Differences & Peculiarities

The main differences between the EGSE and the CCV are determined by

- development timeline and industrial context (program related)
- the specificity of their mission (mission related)

Program-related differences

For the EGSE, full flexibility has been a strong driver, leading to a certain level of complexity to allow the adaptation of the system to the needs, not completely assessed at the time of requirements definition. This is reflected in the high configurability, the ability to change parameters run time, to compose the test scenario aggregating the devices necessary for that particular test session.

Vice versa, the CCV was designed having in mind the countdown operations, where strict adherence to rigid and heavily defined environment required emphasis on system stability, performance and determinism. Besides, the maturity of the program was higher and requirement awareness was stronger.

Among the differences driven by the development context and different flexibility need it is worth to mention the technological Solution used for HLCS:

- The HLCS of EGSE is based on the SCOS-2000 framework. Originally developed by ESA, is now being promoted and requested as product for ESA mission control system software [6]
- The CCV HLCS is. a fully developed High Level Control System with a Java-based architecture, completely developed by its manufacturer

This choice was justified at one side by the more stringent performance requirements of CCV, while, at the other side, from System Engineering and Industrial considerations on proprietary SW reuse. The use of a new Java system has implied a revision of HLCS architecture, based on the fact that CCV HLCS is only an execution environment for LN3 code, subjected to a preliminary specification and validation process, while EGSE HLCS allows modifying runtime test sequences, which is more effective for a "test" environment.

In both cases deterministic real time behaviours are guaranteed at LLCS level by LLCSW, 1553 and PS SCOEs performing a UUT closed-loop monitoring

Mission related differences

As stated, the mission of CCV is to ensure the conduction of LV integration and launch campaign, including ground operations like propellant filling and stages pressurization, while EGSE is used for industry AIT on Launcher.

This introduces some specificity in CCV design, which takes into account some additional features to be added on the "common core" identified earlier.

- External Interfaces: CCV interfaces both Launch Vehicle and Ground Segment, while EGSE external interfaces are mainly related to Launch Vehicle equipments. Among the ground signals also some control signals, like CGS status and Countdown need to be managed by the CCV. This implies to consider in the Test Preparation Environment a more complex database, which is a merge of two database validated and delivered by two different providers according specific processes (Ground Process database and LV database)

- Safety Requirements: the CCV is used in an operational environment which may include integrated launcher and/or hazardous operations like propellant filling. Thus, it is subject to risk potentially impacting human life or in general concerning personnel damage. In order to avoid uncontrolled operations, a dedicated security system has been implemented which allows the Functional system to monitor the health status of its own internal units, and, in case of failure, to trigger the dedicated Emergency subsystem (BCVE)which put in safe status the LV or Ground

- The topological needs of the installation sites: EGSE system is installed in Factory Premises, while CCV system is a distributed system deployed in the so-called ZLV (Zone de Lancement VEGA, now Carlo Buongiorno Pad) and in the Control Center shared with A5, so called Centre de Lancement n° 3 (CDL3) at a distance of more than 2 kilometers. Within the ZLV itself, systems are distributed in several locations, from the Bunker (a concrete building re-used from Ariane 1, 2 and 3 missions and adapted to VEGA needs) to the Mobile Gantry, (a 60 m high and over 1300 t heavy steel tower).

CONCLUSIONS

Conceived to ensure the monitoring and control of the Launcher, from the early assembly phase to the launch, Vega CCV and EGSE have a set of architectural, functional and technological commonalities, which can be considered as the “core” of a generic launcher monitoring and control system. The specificity of respective missions led to the choice of different technological solutions, reflecting also the different development context, being the EGSE system conceived before Vega CCV.

Among them, it is relevant the transition from the EGSE HLCS into a completely new High Level Control System with a Java-based architecture in CCV assumed a high relevance. Another important difference is the introduction of Supervision/Emergency function as one of the most critical features of the CCV. The tuning of such capability, based on Siemens Simatic S7 technology has been one of the many challenges of the solution.

REFERENCES

[1] ESA PSS04-103 Issue 1 September 1989: Telemetry Channel Coding Standard

[2] ESA PSS-04-106 Issue 1 January 1988: Packet Telemetry Standard

[3] MIL-STD-1553B Notice 2: Digital Time Division command/response multiplex data bus

[4] ECSS-E-70-31A: Space engineering - Ground systems and operations - Monitoring and control data definition (9 October 2007)

[5] ECSS-E-70-32A: Space engineering - Test and operations procedure language (24 April 2006)

[6] http://www.egos.esa.int/portal/egos-web/products/MCS/SCOS2000/