

**Workshop on Simulation for European Space Programmes (SESP)
24-26 March 2015**

ESA-ESTEC, Noordwijk, The Netherlands

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INTRODUCTION

This paper introduces the Airbus Defence and Space (Airbus DS) global approach in the Space Systems business line for deploying the EGS-CC (European Ground Segment - Common Core) in all the Airbus DS Space Systems applications used to support tests and operations for satellites, launchers and orbital systems. The approach suggested here is relying on a global Space Systems project taking benefits of all potential commonalities and recent Airbus DS optimization initiatives.

After an introduction concerning the motivation for an Airbus DS industrial approach based on deploying an EGS-CC based product policy, the paper will concentrate on the presentation of the ACCEPTO vision and the high level technical description of this EGS-CC based product line. Considering the EGS-CC schedule and development approach, the identified Airbus DS pilot project candidates are NEOSAT and ARIANE 6, a unique opportunity to achieve the convergence of the tests and operations ground systems product lines between the launchers and satellites domains.

EGS-CC, THE AIRBUS DS BASELINE FOR FUTURE PROGRAMS

As for other actors in the European Space business, Airbus DS baseline solutions used for tests and operations applications have reached their end of life or shall be considered obsolete in the coming years. These systems are often using old software technologies and hardware platforms that are difficult to modernise. Moreover, considering the many different systems used for monitoring and control by other companies and agencies for space system operations and Assembly Integration and Testing (AIT), the exchange of information with other internal or external systems is also often difficult leading to little synergy across missions and project phases.

For these reasons, from the very early phase of the European Ground System – Common Core (EGS-CC) initiative, Airbus DS was fully invested to contribute to the definition and design of this initiative, a unique collaboration between ESA, European National Agencies and European Prime Industry in this domain. The EGS-CC major drivers and objectives are fully addressing the Airbus DS challenges for both institutional and commercial activities:

- ✓ Support space systems monitoring and control during pre-launch and post-launch phases for all mission types including launchers, satellites and orbital infrastructure.
- ✓ Seamless transition from spacecraft/launchers Functional Validation (FV) /Assembly, Integration and Testing (AIT) to mission operations (Ground Control systems)
- ✓ Enable overall cost reductions by sharing development, sustaining and maintenance of a single infrastructure in an European wide developer community
- ✓ Facilitate cost and risk reduction when implementing space projects
- ✓ Enable the modernization of legacy EGSE CCS and MCS systems for both satellites and launchers
- ✓ Enable synergies in the validation of software and operational artefacts (spacecraft databases, procedures, etc.) throughout the complete life-cycle of space projects
- ✓ Improve and ease cooperation with agencies and industrial partners on institutional programs
- ✓ Fully compatible with Airbus DS Space Systems business cases for both institutional and commercial projects

As shown in the following figure, EGS-CC is embracing the full scope of business applications that Airbus DS Space Systems needs to fulfil its internal projects and external customers' needs. The other legacy or emerging solutions were only partially mapping to the global business perimeter, thus preventing to achieve the foreseen lifecycle improvements on future programmes.

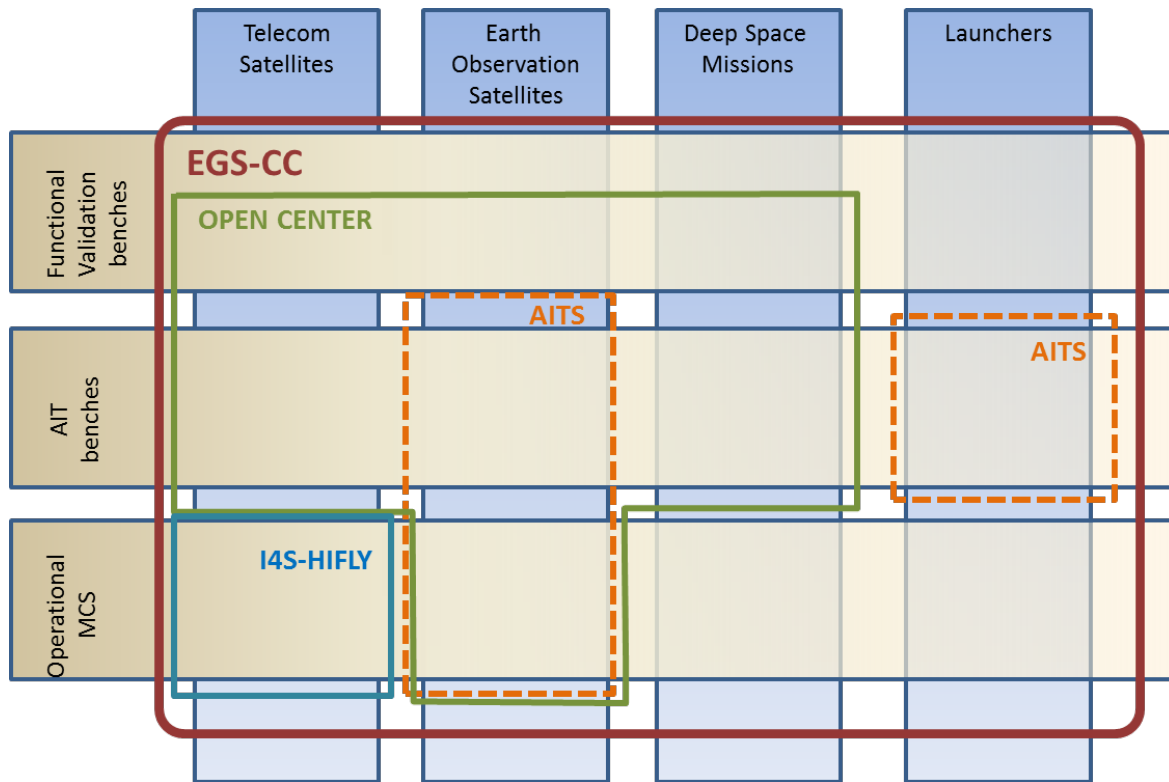


Figure 1: The EGS-CC usage domain encompasses the complete set of Airbus DS business applications

The Airbus DS Space Systems contribution to EGS-CC also hugely benefited from AITS - Advanced Integration and Test Services, an initiative also led in collaboration with ESA and the German space agency (DLR). This development was intended to provide end-to-end services and programmatic benefits:

- ✓ Enable lean Assembly, Integration and Tests (AIT)
- ✓ Reduce cost of ownership and risk for space systems development, qualification, production and operations
- ✓ Enable seamless transfer of mission information between stake holders

The experience and achievements of the AITS project have been injected by Airbus DS in the EGS-CC initiative where relevant:

- ✓ AITS specification was provided to EGS-CC as part of the EGS-CC User Requirements Documents (URD) inputs
- ✓ AITS provided results of technology assessments to the EGS-CC System Engineering Team (SET) to feed the preliminary technology selection process
- ✓ AITS team members supported the EGS-CC System Engineering Team (SET), in particular for the major Phase A and B technical reviews
- ✓ AITS implemented and evaluated selected technologies identified in the EGS-CC concept, and contributed back to EGS-CC with lessons learned
- ✓ AITS agile ECSS software process tailoring provided lessons learned and best practices to the EGS-CC Steering Board (SB) and System Engineering Team (SET) to establish the project development baseline for Phase CD.

FROM EGS-CC TO ACCEPTO

EGS-CC is not a complete integrated and ready to use system, even if it covers the major core functionalities expected for the addressed domain. In addition to the EGS-CC functional perimeter, Airbus DS Space Systems has identified a number of additional common building blocks which are shared between all the possible EGS-CC based business applications needed to support its institutional and commercial projects.

The following figure describes the customization process to build an EGS-CC based system. The ACCEPTO project, Airbus DS Command & Control EGS-CC based Product line for Tests and Operations, aims at providing the SW elements and tools which support this customization process. This is the Airbus Defence and Space deployment project of the EGS-CC for all business applications used to support tests and operations for satellites, launchers and orbital systems.

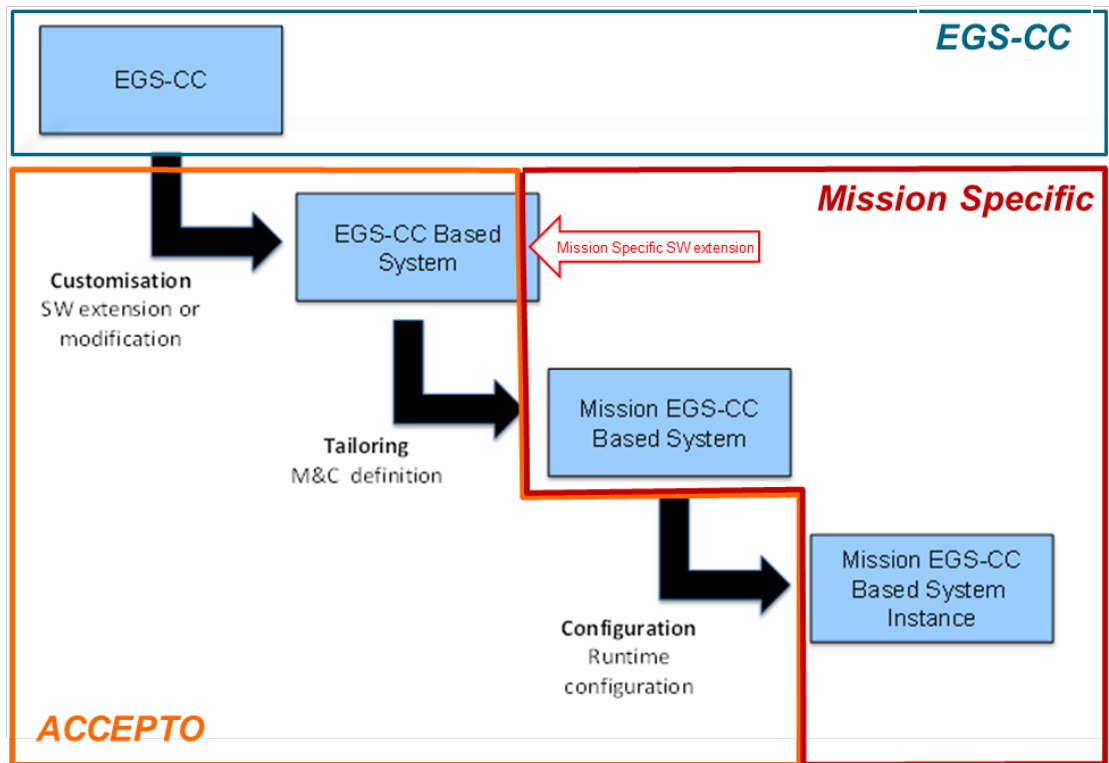


Figure 2: ACCEPTO contributes to the Airbus DS Space Systems EGS-CC customization process

The approach selected by Airbus DS is relying on a global Space System project taking benefits of all potential commonalities. As such it also inherits from other Airbus DS Space Systems internal initiatives aiming at sharing product solutions and best practices.

In this figure above, the complete customization process is addressed and covers both the non-recurring activities which are covered by the ACCEPTO project and are performed once, and the recurring - mission specific - activities which must be completed for each new mission and which are not part of the ACCEPTO product line.

Then, ACCEPTO aims at adapting and integrating with EGS-CC existing Airbus DS Space Systems common buildings blocks and verify its adequacy to the major Airbus DS internal and customer business applications which consist of generic systems build by aggregating and integrating unitary building blocks/products to satisfy a business case (e.g. spacecraft MCS - Monitoring & Control System -; spacecraft/launcher avionic test bench; I-EGSE CCS - instrument test bench -; Satellite EGSE CCS...).

Even if tailoring and configuration is more related to recurring tasks to be endorsed by each specific project, it is fully part of the ACCEPTO project to engineer the process and develop the additional tools which are needed to achieve these activities.

ACCEPTO covers all the non-recurring activities related to the EGS-CC customization process:

- ✓ **Customization:** This encompasses the analysis of required EGS-CC SW adaptations and extensions for each business case and for all envisaged mission categories, as well as the high level architecture of each envisaged ACCEPTO instance - EGS-CC based system instance. Then, it mainly results in the corresponding SW elements but also includes the definition of the interface protocols to be integrated in the EGS-CC Reference Implementation to interface with all facilities connected to an ACCEPTO instance (e.g. SCOE, V&V framework for test systems; TT&C BBE, Flight Dynamics, User Ground Segment for operation systems).
- ✓ **Tailoring:** The related engineering activity shall address the management of all mission artefacts (i.e. Monitoring & Control Definitions management, Automated Procedures, user Defined Displays). For this, ACCEPTO mainly provides the process descriptions and associated supporting tool.
- ✓ **Configuration:** This aspect covers the EGS-CC based system/ACCEPTO instance assembly (reference architecture for each business cases for all envisaged projects) and the associated SW building and delivery process. It mainly consists of the high level architecture, including ICDs for each ACCEPTO instance, and specification and tools for the ACCEPTO SW factory which shall be derived from the EGS-CC product building process.

Considering the close interdependency with the EGS-CC phase CD developments and the need to adopt a similar iterative approach, the ACCEPTO project is based on the same phasing than EGS-CC:

- ✓ **Phase 1: Engineering Consolidation phase**
 - Overall ACCEPTO development and deployment activities and strategy definition
 - System engineering, including the business applications reference architecture
 - Integration concepts, including the definition of the ACCEPTO integration platform
 - Validation strategy covering the optimal validation plan based on the actual EGS-CC delivery plan and the pilot projects milestones.
- ✓ **Phase 2: Development and deployment phase**
 - Iterative based on EGS-CC increments
 - Coordinated with mission specific activities

THE ACCEPTO SCOPE

As already stated above, EGS-CC is not a complete Monitoring & Control Ground System SW, but aims at providing the major common functionalities for all or part of the facilities which are related to the addressed domain (See Figure 1), together with the infrastructure allowing for EGS-CC based systems building, deployment and running.

In addition to the common functional perimeter agreed between EGS-CC stakeholders, there are other needed functionalities and process supporting tools which may be considered in a common shared set for all Airbus DS Space Systems applications. ACCEPTO intends to clearly assess and promote this extended common product line for any Monitoring & Control application in the satellites, launchers and orbital infrastructure perimeter.

The figure in this section introduces a high level view of the foreseen ACCEPTO - EGS-CC Extended Common Core. It includes apart from EGS-CC itself a number of building blocks which shall interoperate with EGS-CC and a collection of EGS-CC extensions (e.g. adaptors) and are considered as non-recurring developments.

- ✓ **Mission Database:** The Airbus DS Space Systems Mission Databases used for new ongoing and future programs are based on the RangeDB shared solution (SRDB NG for satellites and ELSE for launchers). Additional development and integration is needed to exchange Monitoring & Control definitions between RangeDB and EGS-CC. This contributes to the tailoring process of Figure 2. It is foreseen to fully align the RangeDB model with the EGS-CC Conceptual Data Model (CDM).
- ✓ **Data Archiving & Analysis:** The archive and analysis solution trade-off is still ongoing in Airbus DS Space Systems and is considering adaptations of existing internal solutions together with extensions of the EGS-CC

design. EGS-CC compatibility may eventually impose technology related evolution for the current internal building blocks.

- ✓ **Simulation Infrastructure and Common Models:** The Airbus DS Space Systems simulators used for new ongoing and future programs are based on the SimTG shared solution (simulation infrastructure, generic models and models development tools). The EGS-CC adaptor to the remote Control & Command and Data interface with SimTG will be part of the ACCEPTO product line.
- ✓ **Project Collaboration Platform and SW Development Environment (ACCEPTO CSDE):** This platform will inherit from the internal PForge project used on AITS, whose technology stack is very similar to the one used for the EGS-CC CSDE and benefit from enhancements proposed by the internal harmonization initiative SDE-NG (SW Development Environment – New Generation). In addition, the ACCEPTO project collaboration and SDE infrastructure shall include the synchronization process towards the EGS-CC reference repository – EGS-CC CSDE - which will be hosted in ESA (ESTEC).
- ✓ **Automation:** The MOSAIC product already deployed on Telecom and Earth Observation MCS in Airbus DS Space Systems, will be deployed for AIT Systems in order to provide with test plan automation capabilities.
- ✓ **Visualisation:** The USS synoptic display system is a component that presumably has more advanced capabilities than what is foreseen in EGS-CC and is already familiar to many users inside Airbus DS Space Systems and thus may increase user acceptance of ACCEPTO and reduce training effort. It is envisaged to offer this capability where no exchange with external stake holders is needed.
- ✓ **Generic EGS-CC adaptors:** The EGS-CC phase C/D SoW request for the development of the CCMS protocol already used to handle some satellite EGSE SCOEs, and SLE which is the standard communication protocol used by some but not all agencies to interface with ground stations. The GESI front-end protocol developed for ARIANE 5 ME upper stage EGSE may need to be implemented depending on a decision on reuse within ARIANE 6. A few other protocols shall be added in order to allow backward compatibility with existing SCOEs and other industry de facto standard for ground station (i.e. CORTEX).
- ✓ The EGS-CC component management technologies impose to establish the process and provide with the associated tooling to allow various deployment configurations depending on the targeted business application. This contributes to the configuration phase of Figure 2. These processes and tools are part of the ACCEPTO product line.

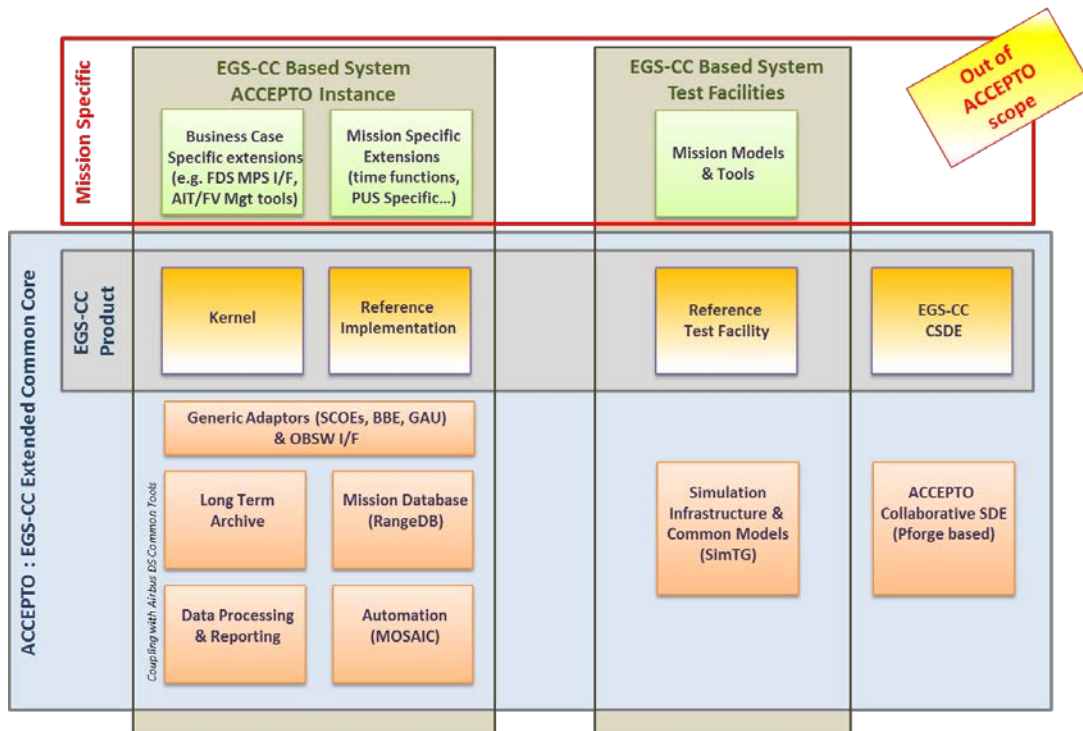


Figure 3: ACCEPTO – The Airbus DS Space Systems EGS-CC Extended Common Core

ARIANE 6 AND NEOSAT, THE ACCEPTO PILOT PROJECTS

The current identified pilot and/or candidate projects are mainly NEOSAT, METOP SG and ARIANE 6.

- ✓ **NEOSAT:** ESA has requested to consider EGS-CC as the baseline to build the testing facilities which support the NEOSAT development. A preliminary analysis of the EGS-CC incremental approach in line with NEOSAT needs has been conducted between Airbus DS and the Phase B consortium, in order to assess the compatibility of the EGS-CC iterative strategy with the NEOSAT project milestones. The figure hereunder indicates how Airbus DS Space Systems intends to integrate the EGS-CC releases in the NEOSAT integration strategy.

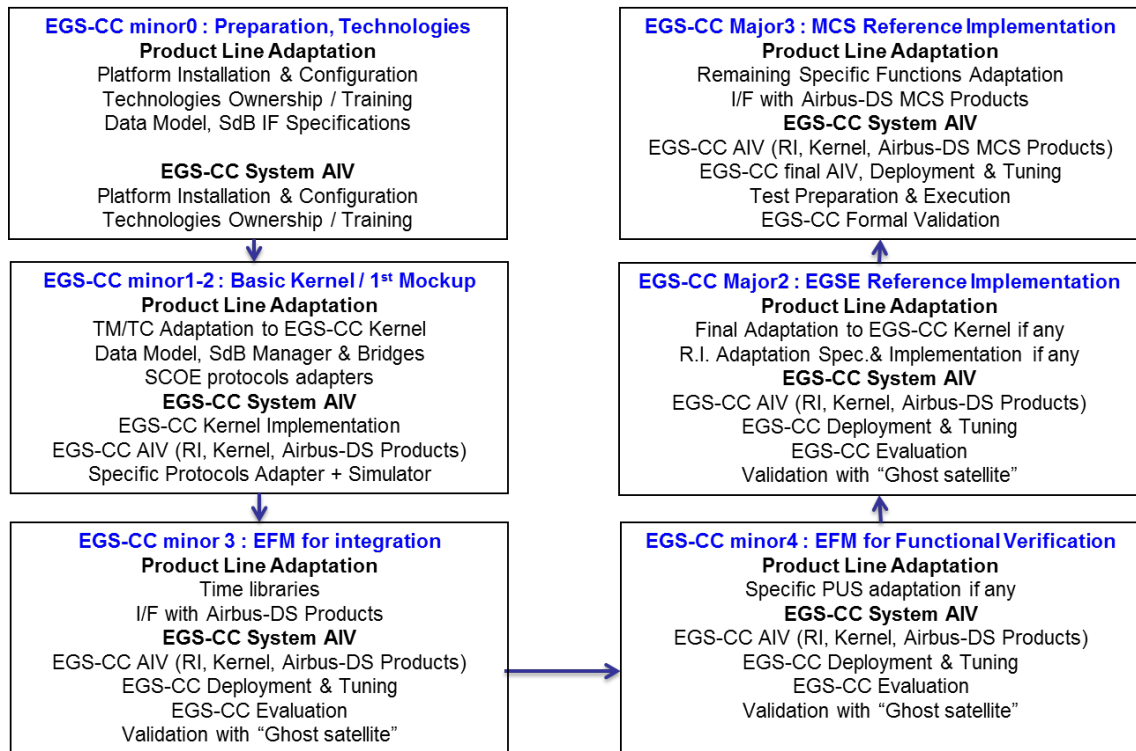


Figure 4: EGS-CC integration mapping to NEOSAT key milestones

- ✓ **METOP SG:** Considering the long duration of this project, the adopted baseline shall guarantee sustainability and maintainability of the manufacturing facilities for more than 15 years. The MCS is not in the scope of the METOP SG contract. The decision to base the Metop SG test facilities on ACCEPTO/EGS-CC will be analyzed in 2015.
- ✓ **ARIANE 6:** The Airbus DS proposal for Ariane 6 ground systems proposes a solution based on ACCEPTO. This proposal is currently being further refined in close collaboration with the programme team to find the best design meeting the customer needs. This work will also benefit from prior results from Avionic-X, Airbus DS work on future test facilities, and concepts already developed for ground systems within Ariane 5 ME scope.

CONCLUSION

The rare conjunction of a new launcher program and the design of a next generation telecom spacecraft platform provides Airbus DS Space Systems with the opportunity to take benefit of the synergies between both programs for what concerns the tests and operations facilities. It allows the option of an industrial approach instead of a project oriented strategy. It also opens the door to a smooth continuity between tests and operations in all applications domains.

The challenging development schedule to satisfy the envisaged pilot projects imposes to take full benefit of the EGS-CC Phase CD iterative approach and to align the ACCEPTO development strategy such as to integrate and validate each EGS-CC delivered release as soon as it is available. However, the EGS-CC delivery plan has to be thoroughly analysed and discussed in order to map the ACCEPTO development needs.

In addition to the targeted pilot projects, the success of the ACCEPTO project is also key for future Earth Observation turnkey export programs led by Airbus DS Space Systems and to gain trust in EGS-CC based applications from the commercial stakeholders, among which are the telecom service operators.