

A secured path to an EGS-CC based future for AIRBUS space programs

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INTRODUCTION

This paper introduces the Airbus adapted approach in the Space Systems business line for deploying the EGS-CC (European Ground Segment - Common Core) in all the Airbus Space Systems applications used to support tests and operations for satellites, launchers and orbital systems.

After an introduction concerning the rationale for the ACCEPTO project, an Airbus Space Systems industrial approach based on the deployment of an EGS-CC based product policy, the paper will concentrate on the presentation of the Airbus Space Systems roadmap principle to achieve a secured deployment on the identified Airbus pilot project EUROSTAR Neo and ARIANE 6.

EGS-CC BASED ACCEPTO, THE AIRBUS SPACE BASELINE FOR ALL FUTURE PROGRAMS

In addition to the necessity to achieve a mid-term replacement of the existing solutions used for tests and operations applications, Airbus Space Systems is targeting a full convergence to a unique solution used all along the complete manufacturing and operational lifecycle. 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. Airbus Space Systems is expecting EGS-CC to provide with significant improvements for these exchanges.

The Airbus Space Systems motivation is mainly:

- ✓ Support space systems Monitoring and Control during pre-launch and post-launch phases for all mission types including launchers, satellites and orbital systems.
- ✓ 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 satellites, orbital systems 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 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, Airbus Space Systems has decided to extend the Common Core by integrating the other functionalities and process supporting tools which may be considered in a common shared set for all Airbus Space Systems applications. The ACCEPTO project, Airbus DS Command & Control EGS-CC based Product line for Tests and Operations, aims at providing this extended SW suite which allows the realization of the tests and operations applications for Satellites, Orbital Systems and Launchers.

The following figure 1 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

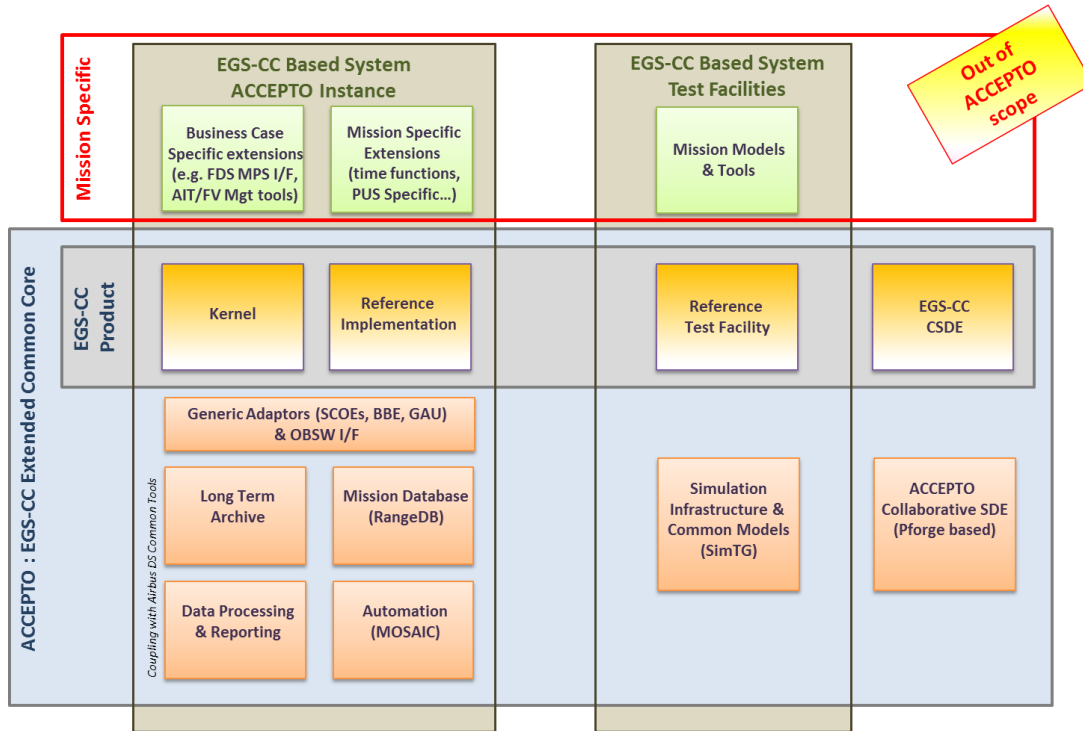


Figure 1: ACCEPTO – The Airbus DS Space Systems EGS-CC Extended Common Core

The major ACCEPTO elements integrated with EGS-CC are:

- ✓ **Mission Database:** The Airbus Space Systems Mission Database is based on the RangeDB SRDB (System reference Data Base) unique solution. The RangeDB model is fully compatible with the EGS-CC Conceptual Data Model (CDM).
- ✓ **Data Archiving & Analysis:** The new Airbus Space Systems solution for Data Archive and Analysis is currently under design and intends to embed the state of the art storage and big data technologies.
- ✓ **Simulation Infrastructure and Common Models:** The Airbus Space Systems simulators are based on the SimTG solution (simulation infrastructure, generic models and models development tools) interfaced through the native EGS-CC C&C protocol.
- ✓ **Automation:** The MOSAIC product already deployed on Telecom and Earth Observation MCS in Airbus Space Systems, will be deployed for AIT Systems in order to provide with test plan automation capabilities.
- ✓ **Generic EGS-CC adaptors:** In addition to the standard protocols already included in EGS-CC, 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).

MOTIVATION FOR A SECURED DEPLOYMENT OF EGS-CC ON AIRBUS PROJECTS

EGS-CC the European Ground System – Common Core is under development and several Integration Releases have been delivered for integration in the industry end-to-end application use cases. ACCEPTO, The Airbus Space Systems deployment project for the EGS-CC, has started to iteratively integrate the Common Core together with its other internal standard products. ACCEPTO is the Airbus Space Systems transnational industrial project aiming at providing a unique solution from tests to operations for the full set of space covered domains: satellites, orbital systems and launchers

The complexity of the EGS-CC development and the challenging schedule initially agreed to deliver early iterative versions for operational use is raising a number of risks which cannot be endorsed by the targeted Airbus Space Systems pilot projects EUROSTAR Neo and ARIANE6. A risk mitigation solution had to be analyzed and prepared to secure the deployment approach for the selected pilot projects, also insuring EGS-CC readiness for operations on these two key programs when a go decision would be taken.

On another hand, early involvement of the Airbus Space Systems end-users is a key success factor to establish an adapted and user friendly common core product which takes benefit from lessons learned and facilitates the buy-in of this solution. Consequently, the risk mitigation solution had to offer the capability to build a first EGS-CC experience from an end-user point of view which does not add significant constraints and workload. For this reason, any solution requiring refactoring of end-users preparation work was to be banned.

The adopted strategy is mainly relying on the following elements:

- ✓ Starting of the pilot projects operational tasks using a robust and well mastered solution for the Monitoring and Control framework (Open Center) enriched with the capability to develop and execute “EGS-CC like” end-users artefacts (procedures, displays, data definition).
- ✓ Population of the pilot projects RangeDB SRDB databases as per EGS-CC expectation, and early verification of the EGS-CC CDM completeness and validity by achieving the export of a flight proven data definition collection through the EGS-CC exchange format.
- ✓ Development of an APPG (EGS-CC procedure language) emulator allowing early EGS-CC procedures preparation to verify its operability for the various operational use cases. Airbus Space Systems has developed an EGS-CC Bridge for the preparation and execution over a legacy framework (open Center) of APPG procedures.
- ✓ Development of an UDD (EGS-CC User Defined Display) emulator allowing early development and utilization over a legacy framework (Open Center) of EGS-CC UDDs.
- ✓ Performing the EGS-CC framework ghost validation for the pilot projects by reusing the EGS-CC Automated Procedures and User Defined Displays from the Bridge solution in the context of an EGS-CC/ACCEPTO instance configured with the unchanged RangeDB M&C definitions exported through the EGS-CC exchange format

This strategy answers the key constraints identified for this risk mitigation solution:

- ✓ No propagation of any EGS-CC delivery delay on the pilot programs development.
- ✓ Early practice by end users of the EGS-CC tailoring capabilities (M&C definitions, Automated Procedure Language and User Defined Displays) allowing feedback to the EGS-CC engineering team.
- ✓ More representative operational validation based on the ghost replay of real pilot programs validated use cases
- ✓ No (or limited) refactoring costs for end-users artefacts when deploying the EGS-CC framework

ANTICIPATING THE EGS-CC CDM VALIDATION THROUGH A CONCRETE REALISATION

By experience the export of Monitoring and Control data definitions from a System Reference Data Base (SRDB) to a CCS/MCS has revealed to be cumbersome and taking time to stabilize. The main reasons are that the exchange format syntax is always complex and might introduce semantic discrepancies, and in addition the mapping of the SRDB elements to the exchange format open the door to misinterpretations.

To overcome these difficulties, the principle of a high level exchange API (Java) hiding this syntax complexity, fully aligned with the EGS-CC Conceptual Data Model (CDM), and usable by both ends of the import-export transaction has been selected and integrated in the EGS-CC baseline. The EGS-CC Java exchange API is automatically generated from the EGS-CC CDM, allowing a permanent alignment of this exchange API behaviour with any upgraded version of the EGS-CC CDM. The EGS-CC native exchange format is also automatically derived from the CDM (XML description of the model), which guarantees full consistency between the exchange format and the Java exchange API. The figure 2 here under summarizes this principle.

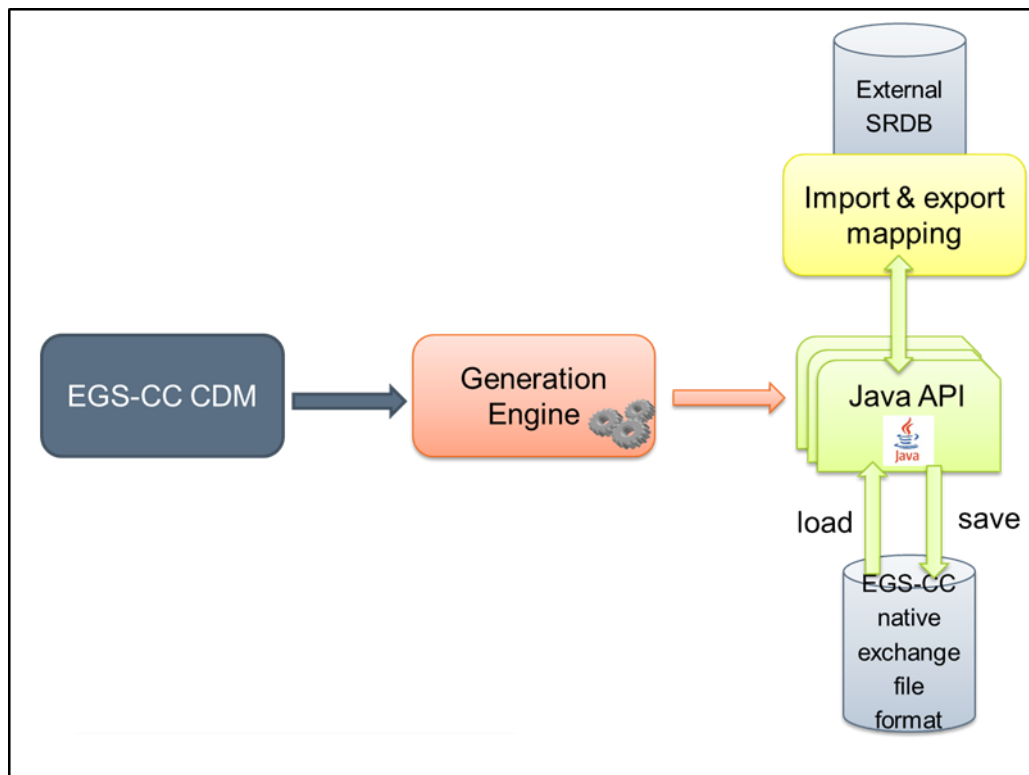


Figure 2: M&C data definition exchange using a model based EGS-CC Java API

Airbus Space Systems has taken the opportunity of the development of the export tool between its standard RangeDB SRDB and EGS-CC to validate the CDM consistency against a validated dataset and a flight proven CDM compatible implemented model within RangeDB.

First, the RangeDB model was mapped to the EGS-CC Exchange API which allowed achieving an operational validation of the CDM on a complete representative reference. The RangeDB to EGS-CC exporter has been experimented on an existing validated Monitoring and Control data set and imported in an EGS-CC system instance.

This early validation based on a concrete realization and using a mature Monitoring and Control data set, allowed to discover very soon EGS-CC CDM issues which might have had significantly impact on the EGS-CC integration and validation in a later phase.

PREPARAING FOR A NEW PROCEDURE LANGUAGE APPROACH

The EGS-CC Automated Procedures definition language is based on Java8 which allows taking advantage of an existing widely used language which is supported by numerous existing and mature tools (e.g. Eclipse IDE) with limited and riskless effort. However, this EGS-CC Automated Procedure language being intended for non-software programmers, it was necessary to guideline the native use of Java8 in order to facilitate the Automated Procedures development and get resulting procedures easily readable by any actor of the Airbus Space Systems manufacturing and operation process.

The EGS-CC designers have thus elaborated the Automated Procedure Programming Guide (APPG) establishing the rules (syntax) to achieve these objectives and providing the EGS-CC automation feature with adequate execution directives. One of the early concerns of Airbus Space Systems was to assess the completeness of the defined guideline for the manufacturing applications (satellite functional validation and AIT) through an appropriate prototyping of the EGS-CC APPG.

But the main motivation in Airbus Space Systems to develop the EGS-CC Bridge over Open Center was to deliver the EGS-CC Automated Procedure language ready to use at the beginning of the pilot programs EUROSTAR Neo and ARIANE6 in order to avoid a future refactoring of the procedures when switching to an EGS-CC validated framework. The EGS-CC APPG is the applicable specification for the EGS-CC Bridge over Open Center.

Figure 3 here under depicts the architectural principle of the EGS-CC Bridge, which is tailored by a dedicated M&C definition export format from the RangeDB SRDB, allowing the same pre-compiled approach for TC and TM handling than in the EGS-CC preparation environment. The execution by the Open Center framework is insured by runtime invocations of Open Center services from the Bridge.

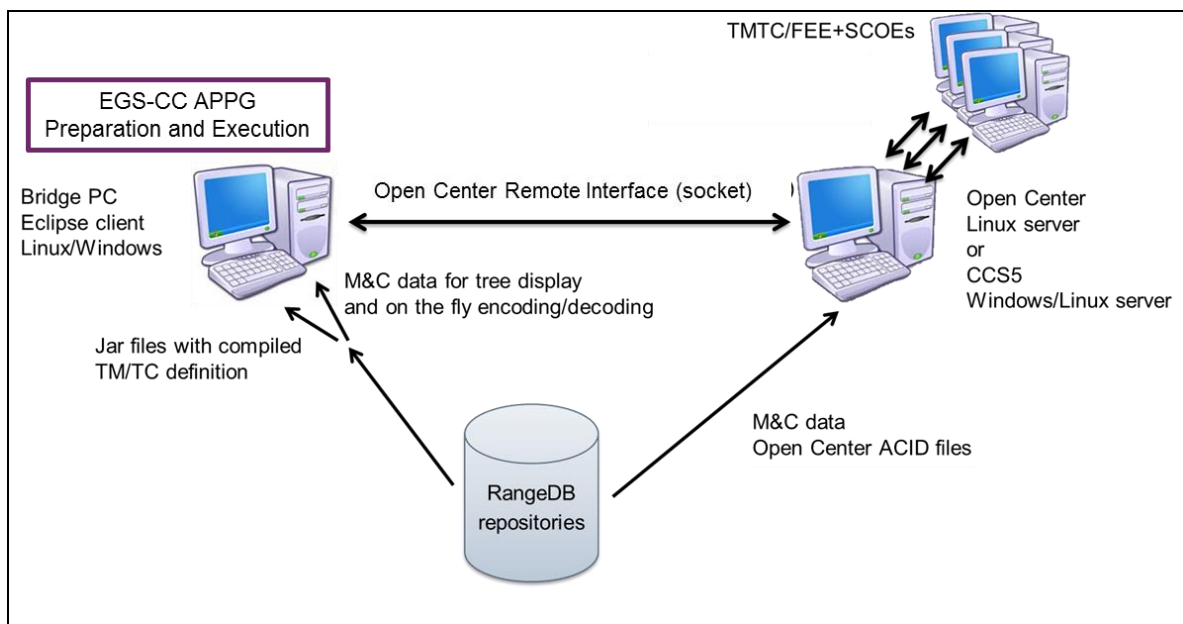


Figure3: Architectural principle of the Airbus EGS-CC Bridge over Open Center

This approach is currently followed for both pilot cases (EUROSTAR Neo and ARIANE6) to allow starting early validation activities using Open Center and the EGS-CC Bridge. This allows developing procedures immediately in EGS-CC language and validating the project Monitoring & Control data managed in RangeDB using the full EGS-CC CDM semantic.

It allows easy switch to a full EGS-CC based solution – No M&C definition reformatting nor procedure conversion is needed. Migration activities are limited to a re-run of tests in the context of ghost validation activity

The EGS-CC Bridge over Open Center is also offering an implementation of the EGS-CC Automated Procedure language allowing early detection of APPG issues and offering a lab platform to experiment the requested complements of the APPG with the involvement of end-users.

CONCLUSION

Considering the EGS-CC development status, Airbus Space Systems decided to adapt its ACCEPTO deployment strategy in order to maintain the convergence objective for test and operation facilities while insuring a nominal development schedule for its key pilot programs: EUROSTAR Neo and ARIANE 6.

The adopted secured path for the EGS-CC deployment on Airbus Space Systems pilot projects aims at a better evaluation of the EGS-CC new capabilities and an early preparation of the future EGS-CC end-users, while not propagating any EGS-CC development risk to the pilot projects and insuring smooth transition of end-users developed artefacts to an EGS-CC based system

The Airbus Space Systems strategy for the EGS-CC deployment is mainly relying on the described EGS-CC Bridge approach which allows both early application and feedback from Airbus Space Systems end-users to EGS-CC, and direct reuse of end-users developed artefacts when switching to EGS-CC. In parallel, the EGS-CC/ACCEPTO operational validation will be performed through a ghost testing activity based on replay of real EUROSTAR Neo test cases already passed on the EGS-CC Bridge solution.

As the targeted Airbus Space Systems pilots are key long term programs, the final replacement of the legacy solutions by EGS-CC cannot be envisaged before a full maturity and robustness of the common core is assessed. Nevertheless the latest shall be achieved in a reasonable time scale to confirm the convergence feasibility for other new Airbus Space Systems starting programs.