Integrating TOPE with EGS-CC

Workshop on Simulation and EGSE for Space Programmes (SESP)
26 - 28 March 2019

ESA-ESTEC, Noordwijk, The Netherlands

Rui Barradas Pereira[(1)], Daniel Santos[(2)] , Isabel del Rey[(3)]

[(1)]GMV
Av. D. João II, 43
Torre Fernão de Magalhães, 7º
1998-025 Lisboa
Portugal
Email:Rui.Pereira@gmv.com

[(2)]GMV
Av. D. João II, 43
Torre Fernão de Magalhães, 7º
1998-025 Lisboa
Portugal
Email:Daniel.Santos@gmv.com

[(3)]GMV
Isaac Newton, 11
P.T.M. Tres Cantos
E-28760 Madrid
Spain
Email: idelrey@gmv.com

INTRODUCTION

European Primes and Agencies have embarked in the development of a new generation of monitoring and control infrastructure: the European Ground Systems Common Core (EGS-CC). This is an entirely new development that is expected to replace existing systems for pre- and post-launch applications.

In the case of ESA, two flavours of SCOS are in use: SCOS-2000 for operations at ESOC and SCOS-EGSE for EGSE applications at ESTEC. The latter includes the TOPE environment for development and execution of automation procedures. Currently TOPE is used in different environments and repositories of TOPE procedures exist as well as expertise by engineers that would like to continue developing procedures in TOPE. With the introduction of EGS-CC these legacy procedures would, in principle, need to be migrated to the automation language in EGS-CC.

This migration of existing TOPE script repositories to EGS-CC is foreseen to be conceptually, technologically and architecturally far from trivial, given the conceptual differences between SCOS and EGS-CC. The amount of work that can be needed for this can add a significant cost to the transition to EGS-CC and even delay the EGS-CC adoption. In this scenario it makes sense to integrate TOPE and EGS-CC allowing a smoother transition to EGS-CC while demonstrating the flexibility of EGS-CC to support multiple scenarios relying on tools and environments not native to EGS-CC.

In collaboration with ESA, GMV developed adapters between EGS-CC and TOPE that would allow the migration of the existing MIB databases to EGS-CC and to run existing TOPE scripts having EGS-CC as the underlying system allowing an easier and smother transition from SCOS-EGSE to EGS-CC. These adapters were deployed with success with a development version of EGS-CC in the Avionics Test Bench (ATB) at ESTEC. This deployment has been one of the earliest deployments of EGS-CC showing the feasibility of such approach and making available a solution for the migration to EGS-CC without having to rewrite an existing TOPE code base.

OVERVIEW

Test procedure, preparation and execution, or **TOPE**, is essentially an extension of the popular scripting language TCL providing dedicated AIV commands for interacting with the EGSE (e.g. send command, acquire parameter). These AIV commands can be classified based on the pattern of system interaction as follows:

- **Synchronous interaction**: fetch (fetch parameter), syslog (add entry to system log), all patch database commands.
- These commands invoke the corresponding **CORBA calls on the EXIF**.
- **Asynchronous interaction**: Register for update of a given data element. While the registration itself is still synchronous, the subsequent updates will be sent to the test sequence asynchronously, where they will be mapped to the TCL language user level as variable updates.
- This pattern is used by the **subscribe commands** for TM packets and TM parameters.
- **Combination of synchronous interaction with a follow-up asynchronous progress notification**: tcsend (send command to S/C or SCOE), callasync (start detached child sequence).
- **Local commands**: TOPE comes with a number of additional "helper" commands that are essential for writing meaningful test sequences, even though they do not directly interact with the EGSE. These comprise waiting for time interval and/or event, logging, data access, and conversion functions.

TOPE IN ATB-RTB

TOPE is currently used in ESTEC's Avionics Test Bench (ATB) in the configuration Real-Time Bench (RTB) and this activity is being done in the scope of the migration of the ATB-RTB from SCOS-2000 to EGS-CC.

In the ATB-RTB context TOPE is used in the subsystem TSEQ, which is mainly responsible for the automated test sequence execution.

TSEQ components and interaction with EGSE can be described as follows:

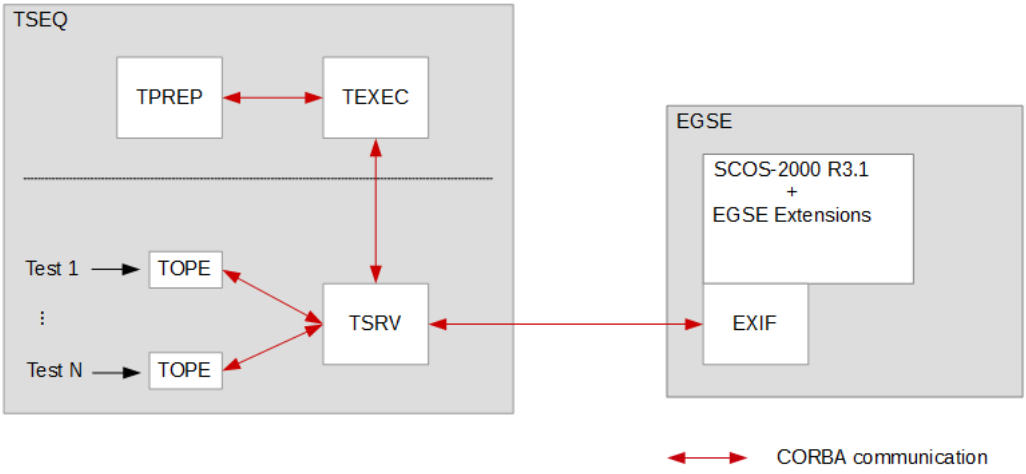

Fig. 1. TOPE in ATB-RTB

Where,

- **TOPE**: Is Test Sequence Language interpreter based on Tcl. Each test sequence is executed by its own instance of TOPE.
- **TSVR (TOPE Server)**: Is the server providing the coordination and synchronization services between the several TOPE instances running in parallel.
- **TEXEC (TOPE Execution Tools)**: Is the GUI for monitoring and control of running TOPE instances, log file viewer, and a graphical debugger.
- **TPREP (TOPE Preparation Tools)**: Is the editor and consistency checker that aids the user with creating syntactically and semantically correct Test Sequences.
- **EXIF**: Is the CORBA-based external interface of the SCOS-2000 kernel, of which TOPE is a client.

Currently the TSEQ interacts with the SCOS-2000 via the EXIF. The EXIF is an extension module of SCOS-2000 which provides a CORBA-based interface, allowing the acquiring of telemetry, the sending of command, raising events or alarm, and retrieve historical data.

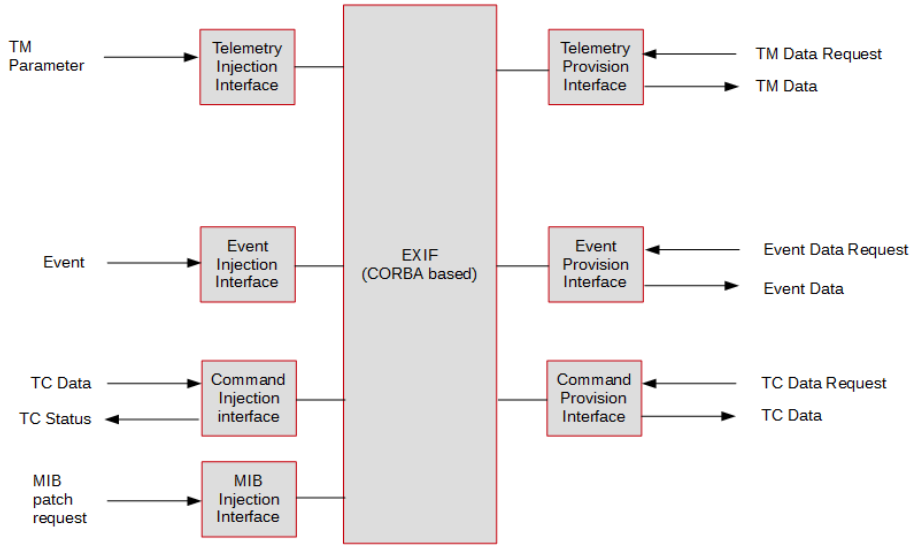

Fig. 2. External Interface Services

The services presented on the left side of EXIF are used by external interfaces to inject events, parameters or commands into SCOS-2000, while the services on the right side of EXIF provide telemetry, telemetry packets, events or command history data to the external applications that request the service.

Internally EXIF is composed of several CORBA servers for each of the services as depicted below.

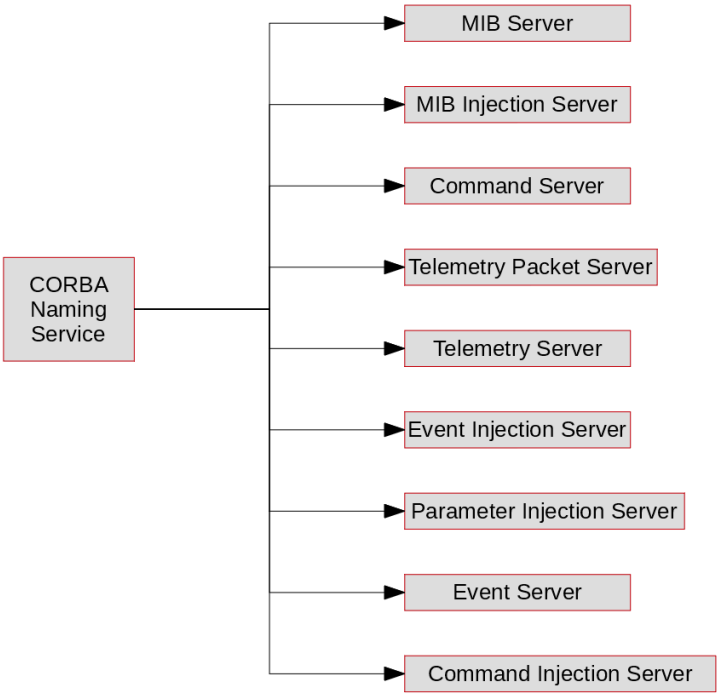

Fig. 3. EXIF Internal Servers

The CORBA naming service is the entry point for the CORBA clients, in this case the TSRV.

MONITORING AND CONTROL MODEL

A central concept of EGS-CC is the Monitoring and Control Model (MCM). The MCM is a model of the space system which is monitored and controlled for test (in an EGSE system) or for operational purposes (in an MCS).

The MCM enables the capture of all relevant information related to the Space System in a structured way which reflects the functional decomposition of the space system itself. Actors in different engineering, product assurance or management domains have their "domain-specific views" of the space system. For the purpose of the EGS-CC, the domain-specific views of interest are related to the Monitoring and Control of both the Space Segment (e.g. a satellite or launcher) and Ground Segment (i.e. the overall infrastructure required during Development, Assembly, Integration and Testing and for Operations) for the AIT or operational contexts.

The MCM concept ensures a clean separation between the M&C abstract view and generic processing and the specific processing related to the data units exchanged with the controlled systems. This approach allows the application of the same M&C kernel to different types of controlled systems, such as spacecraft, EGSE systems, ground station equipment, etc. This means that the M&C system can control not only the target system (e.g. a spacecraft), but also all other contributing ground systems (e.g. EGSE supporting equipment, and the EGS-CC itself), with which the exchanged data are not necessarily based on TM/TC packets.

The MCM contains a hierarchy of Monitoring and Control Elements (MCE). MCEs typically correspond to the elements of the space system decomposed from the M&C perspective, providing the operator with the desired level of abstraction. The space system knowledge is categorized into activities, events, parameters and nested M&C Elements.

INTEGRATING TOPE WITH EGS-CC

TAL stands for TOPE Adaptation Layer. TAL was developed in the scope of the ERFEC (EGSE reference facility in EGS-CC context) activity as one of the components for the integration of EGS-CC in ATB-RTB. It is a software adaptation layer that replaces the SCOS-2000 extension module EXIF and acts as an adapter of EGS-CC as depicted in the following picture:

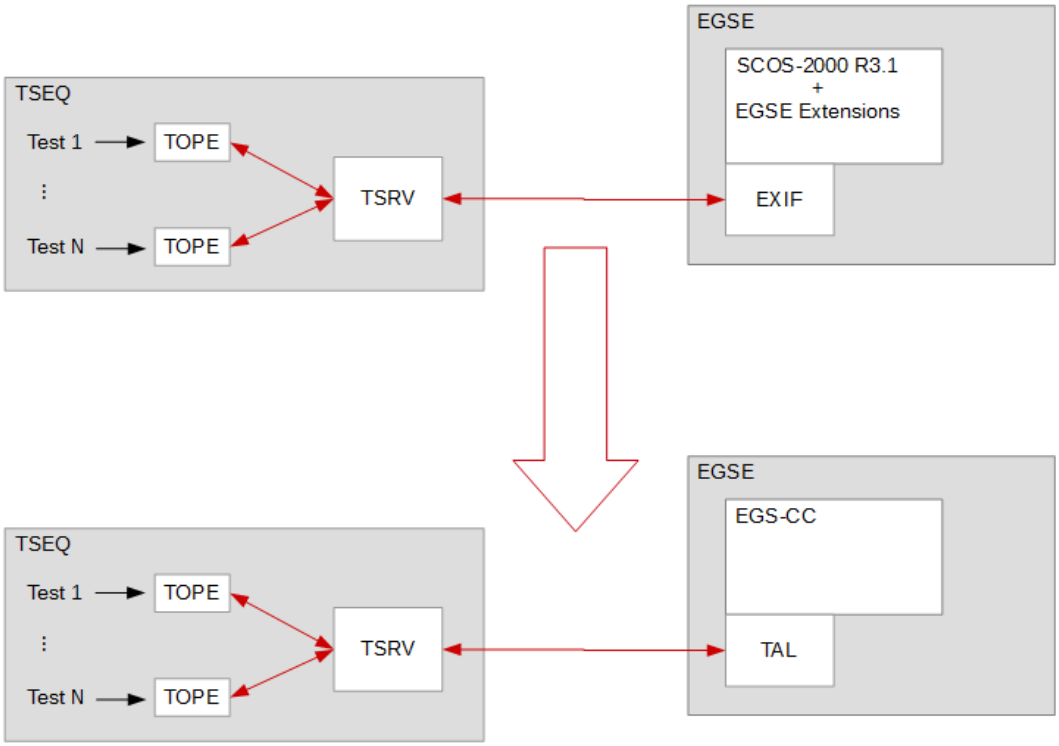

Fig. 4. External Interface Services

The TOPE Adaptation Layer provides a bridge between the existing TSEQ platform and EGS-CC without any modification in TSEQ, it does so providing the same interfaces as SCOS-2000. As presented in [1], the current

interaction between TSEQ and SCOS-2000 is made through a set of CORBA servers, divided by the type of task that it is performed, i.e., there is a server to handle the commands and another server to handle telemetry.

In the core of each CORBA server resides its IDL specification. This specification defines the data structures supported by the servers and the operations performed by the server. In our particular case, the TOPE Adaptation Layer implements CORBA servers compliant with the IDL files already defined in the TSEQ/SCOS-2000 context.

TAL receives the TOPE test sequence from TOPE and injects it into EGS-CC. The same way, it will receive, from the EGS-CC, the result of the execution of the commands translated to TOPE format and sends it to the TOPE.

TAL acts as consumer of the components: M&C Access API, M&C Definition Management, Messaging and System Configuration consuming the services depicted in the following diagram.

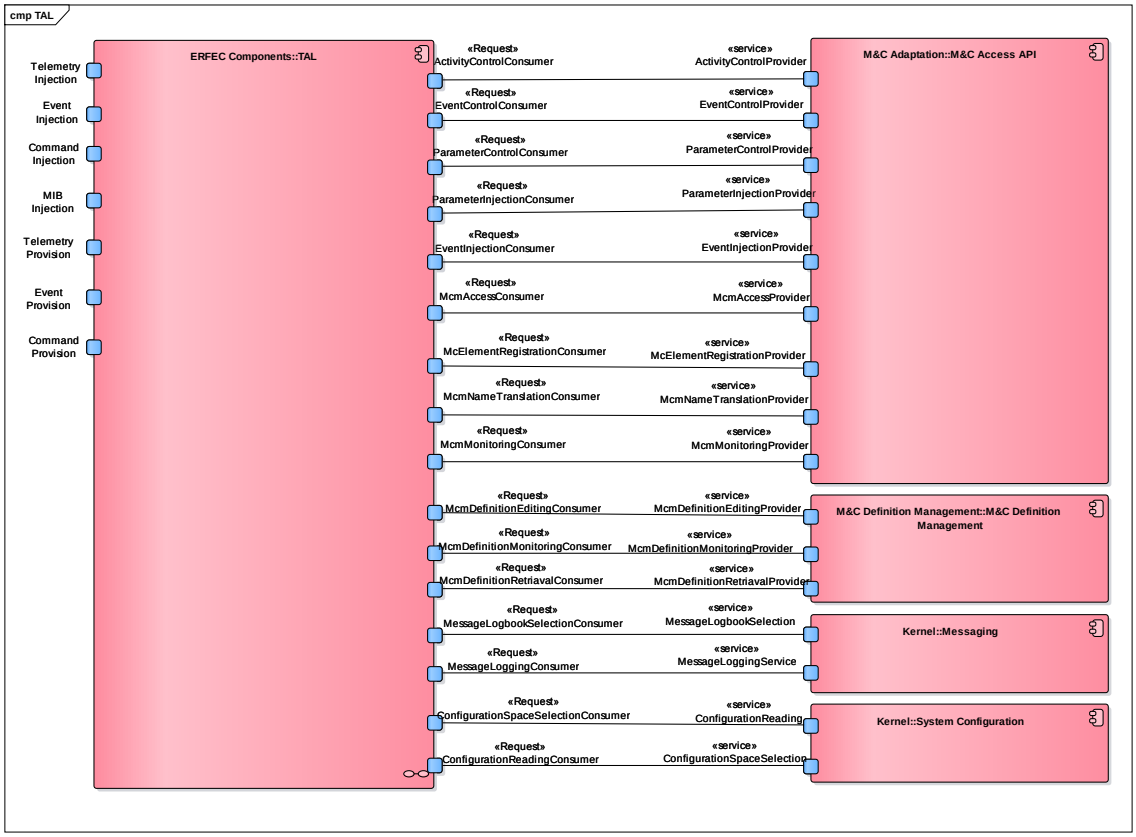

Fig. 5. TAL Architecture

The TAL component interacts directly with the MCM using EGS-CC M&C and Kernel Services and establishes a CORBA interface mimicking the existing interface between TOPE and SCOS-2000 EGSE Reference Facility that accepts the telecommands coming from TOPE and sends back the telemetry. The telecommands are passed to the EGS-CC and later to their destination SCOEs by the MCM and the telemetry coming from the SCOEs is collected through the MCM and passed back to TOPE.

Also TAL maintains a “MIB to MCM conversion” service, with the current MCM state that will provide the MIB to the TOPE and will also be used to convert the commands, parameters and event received from TOPE into the correspondent commands, parameters and events in the MCM, Requiring for this the use of the several necessary services, provided by EGS-CC:

- ActivityControl
- ParameterControl
- ParameterInjection
- EventInjection
- EventControl

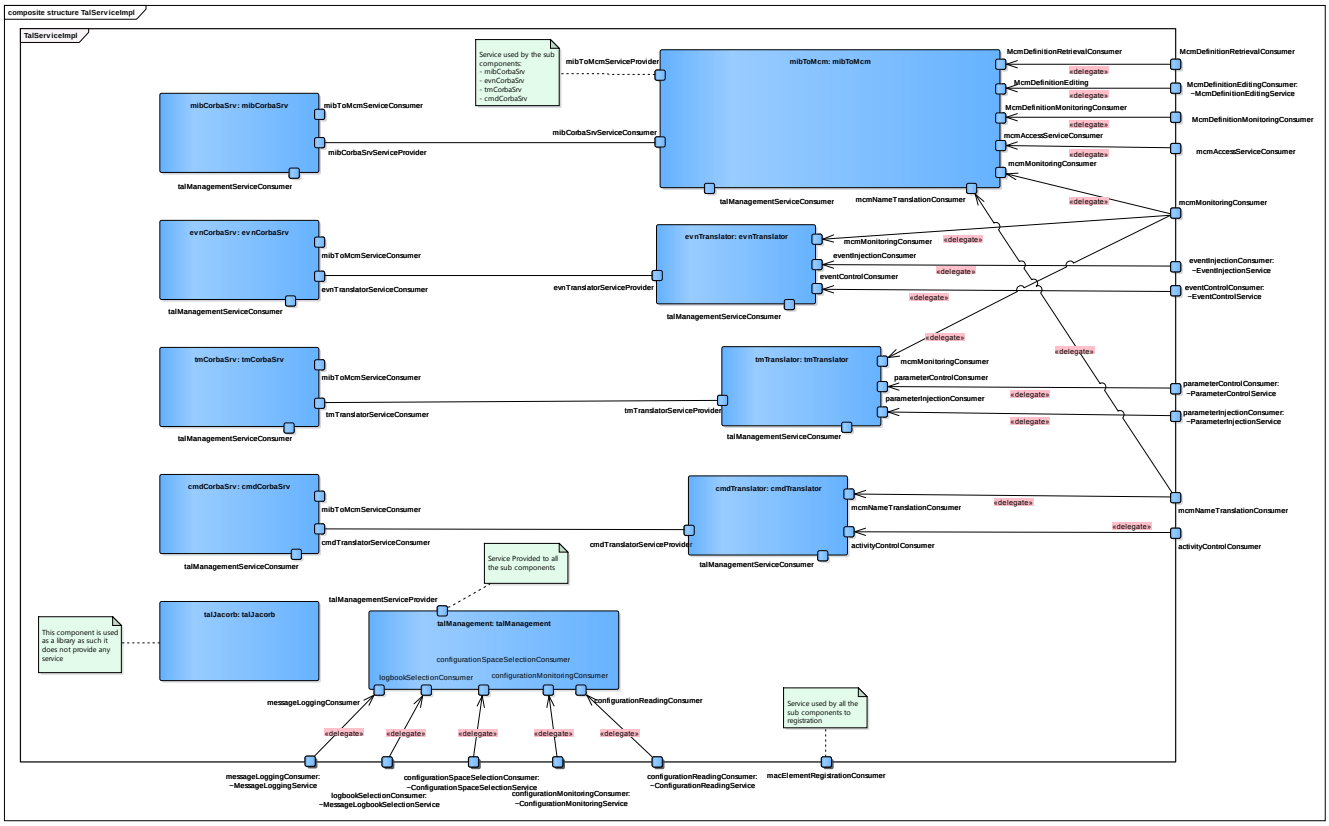

Fig. 6. TAL high level architecture

Besides the data provided to TSEQ via CORBA protocol, TSEQ test platform needs also the presence of the MIB definitions, to have the mission context. This task is performed by the TOPE Adaptation layer as follows:

- TAL receive through the EGS-CC configuration service the path to the MIB definitions (also referred as ASCII MIB files) and the path to the file used to map MIB definitions to MCM definitions.
- TAL loads all the MIB definitions
- TAL generates the EGS-CC CDM based on the MIB definitions that are loaded by EGS-CC into the MCM on startup.
- Upon CORBA request, TAL will extract from MCM the requested MCM Parameter, MCM Activity or MCM Event.
- Upon injection CORBA request, TAL will create a new instance of MCM Parameter, MCM Activity or MCM Event and inject it into MCM.

Please note that, although necessary, this approach conducts to some constrains:

- It is always necessary to provide the ASCII MIB files. In the case of the ATB the EagleEye mission, was used.
- New telecommand and telemetry defined in MCM definitions cannot be converted and stored in ASCII MIB definitions due to compatibility issues. In this case a message is produced and logged, warning the user that these new definitions will not be reflected in the ASCII MIB files.

DEVELOPING FOR EGS-CC

Being TAL an adaptor for EGS-CC it was made an effort to align TAL component design with the methodology, concepts and guidelines defined for EGS-CC [2].

The design was produced using standard UML 2 in Enterprise Architect and following the guidelines described in [3] to have the design developed in the context of the EGS-CC procedures producing a design aligned with the EGS-CC templates and concepts.

Being java the EGS-CC programing language Java, TAL is developed in Java. In particular it was used the JacORB library to implement the CORBA servers. This library has, not only the advantage of being in the same language of the

rest of the components but also can generate automatically all the Java classes representing the IDL specifications and the skeletons of the CORBA servers.

This way for developing of TAL it was used the EGS-CC Reference SDE also called "EGS-CC Integration and Validation SDE" that was used for requirements specification, test specification, TAL implementation and validation. This environment was used also for continuous integration (Jenkins, Nexus) and code quality checking (SonarQube).

The TAL final product is a set of bundles consuming and providing services as defined by the OSGi specifications to be executed as a single instance inside an EGS-CC system session: deployment outside a session is not foreseen. This component is deployed in the same execution environment of EGS-CC and will start automatically with the starting of the system session through the use of the EGS-CC user interface. For its validation and prove of concept the existing "egscc-test-application" deployed was used along with all the TAL bundles incorporated in it.

The EGS-CC Component Test Framework (CTF) was used to support TAL validation and was managed using the EGS-CC Test Management System. The Test Management System (TMS) is the tool used for the design and monitoring of the EGS-CC component validation tests against software requirements and system level validation tests against user requirements. TMS enables the definition of all the required test cases and help in generating the required documentation.

CONCLUSIONS

Such a solution allows the reuse of the existing code base in TOPE in EGS-CC allowing for considerable savings if a migration from SCOS-2000 to EGS-CC is required. This approach could be used long term or as part of a staged approach allowing the progressive migration of code instead of having to do a full migration in one go.

The TAL development was part of the ERFEC activity that was one of the earliest integrations using EGS-CC and established itself as a showcase for the expandability of EGS-CC at a very early stage of its development. The ERFEC activity and the TAL component in particular shows the expansion and abstraction capabilities of EGS-CC while achieving the objectives of the activity by allowing the interface with the MCM and the use of TOPE as an automation platform with EGS-CC. This was done using the EGS-CC Reference SDE also called "EGS-CC Integration and Validation SDE" validating not only EGS-CC as system but also as development environment.

REFERENCES

[1] TSEQ Technical Specification v1.2, GAL-REQ-SIA-CRE-A-0004, February 23rd 2007
[2] SSDD TAL, GMV-ERF-DD-01104 v2.1, July 28th 2017.
[3] EGS-CC Modelling and Documentation Guidelines v3.08, EGSCC-SYS-TN-1022, February 9th 2016.