SRDB Translator: A Tool to Transfer Data from S2K to ECHO Databases

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INTRODUCTION

Motivation

During the last several years, in the frame of spacecraft environment a great number of independent central checkout and mission control system software products have been developed and used.
Each one of these systems has specific hardware and software architecture and uses its own data model to define the behavior of the spacecraft unit, in terms of telemetry and telecommand data, parameters and so on.
Very often, this data model is heavily affected by the rules by which these entities are used by the on-line system and by the chosen implementation technology.
This leads to a heterogeneous and sometimes non-compatible physical representation of the same logical data.

Mission projects involving different legacy frameworks through the process phases, from test equipment to EGSE to AIT/AIV activities to mission control, require dedicated program implementations to convert data from one representation into another, with increasing project costs.

Nowadays, SCOS-2000, the generic mission control system software of ESA, has become a standard in ESA missions, for mission control canters and in most cases also for the EGSE. For this reason, the Satellite Reference Database (SRDB), holding all spacecraft data definitions, is almost always based on the SCOS-2000 run-time database.

Contribution

The SRDB Translator tool enhances the features of the TAS-I central checkout system (ECHO), offering a powerful Database Manager suite allowing to populate the legacy database by importing data directly from a SRDB compliant with SCOS-2000 Mission Information Base (MIB) static data structure.

The main benefit is the possibility to build-up the test database at the ground segment side starting directly from the source SRDB and to maintain consistency among them whenever a new SRDB release is delivered.

With this tool, the SRDB can be used as input of the workflow process from unit test equipment to EGSE, leading to a final validated equipment and database. In this way, the same database in used in all ground test phases. An example of a typical workflow process is sketched in Fig. 1.

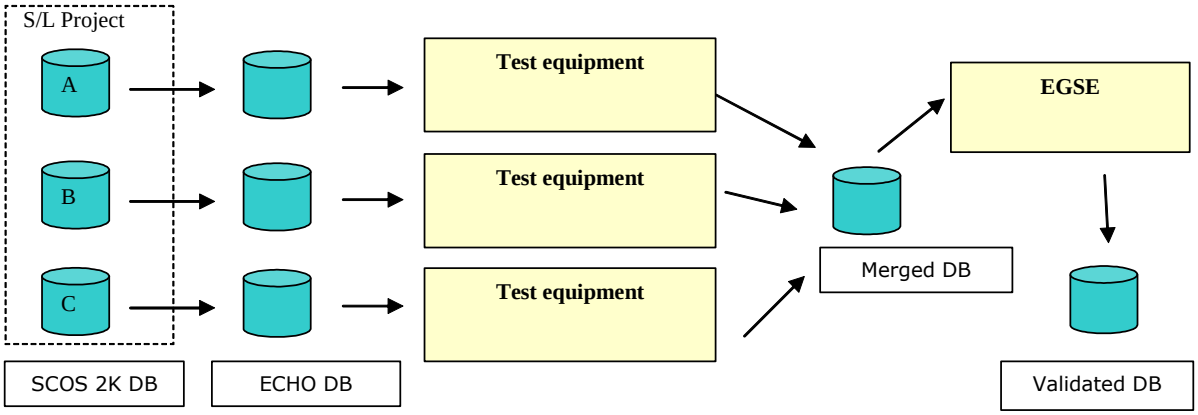

Fig. 1. Example of workflow process

CRITICAL ISSUE

The Databases

Input SRDB is compliant to SCOS-2000 tables' format, describing the following main entities:
- Monitoring data (parameters, textual and numerical calibration, parameter checks)
- Telemetry packets (identification, fixed and variable packets definition)
- Display and reports
- Command packets (headers, command and command sequences definition)
- Commanding data (verification, textual and numerical de-calibration, range checks)

Destination DB is the database maintaining the operational data necessary to support the monitoring and control of the elements under test during on-line activities of ECHO software. Its main entities are very similar to SCOS-2000 ones:
- Ground and on-board parameters (definition, textual and numerical calibration/de-calibration, limit sets, fixed checks)
- Telemetry packets (identification, fixed and variable packets definition)
- Telecommand packets (identification and packets definition, verification rules, pre-transmission checks)

Both databases are based on ECSS Packet Utilisation Standard for TM and TC packets definition [1].

Analysis

Databases Comparison
As first step, a detailed comparison of the structure of the two databases was performed, to identify the similarities and the differences between them.
The focus is centered on logical entities, instead of single source tables, as the same logical entity can be described and split into different table structures. A 1-to-1 mapping from one source table to one destination table is almost inapplicable.

For each piece of data associated to an entity in the SRDB, three cases may occur:
1. Information is present in both databases, even if organized in a different manner.
2. Information is present only in the SRDB database.
3. Information is present only in the ECHO database.

Case 1
Data can be imported into ECHO tables. Some transformation may be required, to be compliant with the different organization of the database tables or with the different data representation.

Case 2
Three sub-cases are foreseen:
- The data is mandatory for SRDB and the EGSE shall take care of it. ECHO SW shall be modified to be able to handle the new data and ECHO database tables shall be extended to hold it.
- The data is mandatory for SRDB but not meaningful for ECHO checkout activities. Data can be ignored.
- The data is optional for SRDB. Data can be ignored.

Case 3
Two sub-cases are foreseen:
- The data is mandatory for ECHO. Data shall be supplied somehow to ECHO DB, even if not held by input SRDB.
- The data is optional for ECHO. Data can be ignored.

Examples

TC Verification Checks
Both databases allow associating telecommands to verification checks based on the check of telemetry parameter values against specified criteria. Information recorded in the databases is anyway conditioned by on-line SW implementation rules, causing many limits on data transfer.
Main data conversion rules and constraints are summarized in Table 1.

Numerical Calibration
Both databases allow associating a numerical monitoring parameter to one or more calibration curve definitions, used to convert the parameter raw value into its engineering corresponding one.
Data conversion and constraints are summarized in Table 2.

Table 1. Verification parameter checks conversion rules

Data	SCOS-2000	ECHO	Action
verification checks and telecommands	Two different DB entities, with a correlation table	Verification checks as a TC detail table	Data will be duplicated for each linked TC command
stage in the command execution profile	Any applicable	Not applicable. All checks are associated to TC uplink	Verification stage is not imported.
Verification window	Two values: Start time and duration interval, in secs	Max elapsed time from TC packet emission, in msec	Verification window is calculated as (start time + interval) * 1000 This constraint imposes a rule to source data.
Expected value and tolerance	Raw or engineering	Engineering only	Verification checks expressed as raw values are discarded. This constraint imposes a rule to source data.
Effect on actual TC verification	Controlled by a flag	Not applicable	ECHO on-line SW does not affect the TC verification status depending on the result of the check, but only the monitoring parameter status.

Table 2. Numerical calibration conversion rules

Data	SCOS-2000	ECHO	Action
Numerical curve identifier	Char(10)	Int 1..9999	A mapping algorithm between S2k and ECHO shall be identified The original identifier is added to textual description of the curve, as a reference for the operators
Radix of unsigned integer raw values	Decimal, octal, hex	Decimal only	Hex and octal values are translated to decimal before import
Point by point curve. Number of points	No constraints	Min 2 points Max 1000	Curves with less than 2 points are not imported. Points over 1000 are discarded
Polynomial curve. Boundaries	No info	mandatory	ECHO modified to relax the constraint. No default was possible
Logarithmic curve.		Not handled	ECHO on-line SW modified to handle the same logarithmic formula
Number of different curves associated to a single parameter	No limits	4	Limit extended to 99. Remaining associations not imported.

SRDB TRANSLATOR

The SRDB Translator is the tool dedicated to the handling of the SCOS-2000 database and the extraction of data applicable to the ECHO system.

Context Environment

The ECHO system is a Thales Alenia Space Italia EGSE framework dedicated to the overall control of manual, semi-automatic and fully automatic testing of satellites and electronic units.

Among ECHO components, Database Manager (MTGP) is the one which allows defining and maintaining of the test database.
The main goals are:

- define the test database through a Graphical User Interface
- perform a consistency check on the defined test database
- generate files with a copy of the defined entities used during the test execution phase, in order to access a frozen and configured image of the Test Database. This set of files is commonly called Real Time DataBase (RTDB).

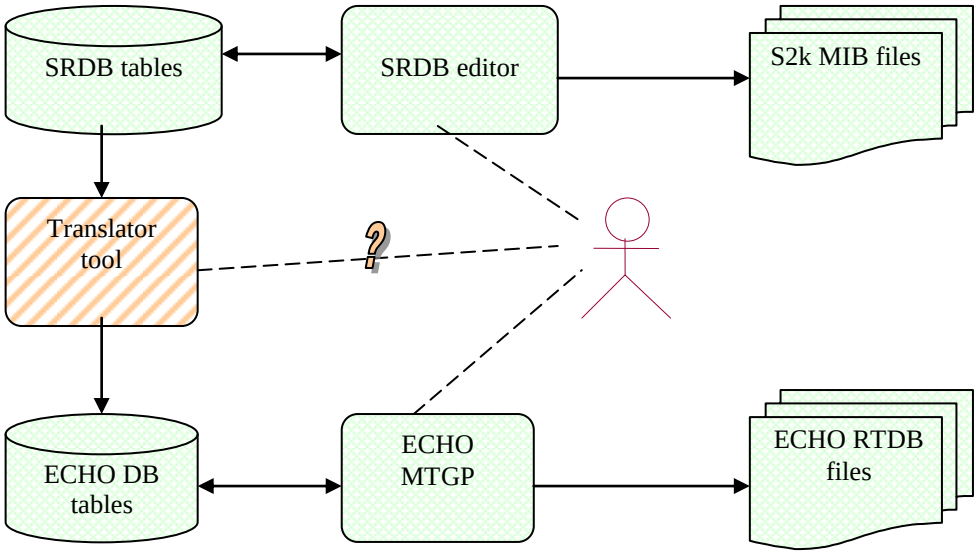

Fig. 2. SRDB Translator context environment

Requirements

The translator tool shall take into account the following requirements:
- ECHO DB shall be compliant with the content of input SRDB.
- ECHO DB shall be updated each time a new release of SRDB is delivered.
- ECHO DB shall maintain information locally defined for exclusive use of the EGSE, with no loss of data when an update is performed.

The tool shall be able to:
- Read data from input database
- Perform the transformation on data representation/organization
- Compute and /or acquire mandatory information not available into SRDB.
- Resolve potential conflicts on duplicated records or referential shortcomings with respect to EGSE local data.

All these steps shall be as automated as possible, to reduce operator interaction to a minimum.
The critical points with respect to the automation are the acquisition of the data mandatory for ECHO, but not available, and the potential conflicts between new and existing data.

Main Features

The SRDB translator is implemented as a utility of ECHO Database Manager application and uses MS SQL Server RDBMS.

With this tool the operator can import into an empty ECHO database data from a SCOS-2000 satellite reference database, performing the needed data conversion and tailoring.
ECHO database can then be merged with a locally defined ECHO database holding objects needed by the EGSE team. Moreover, all other ECHO Database Manager functionalities are available to the operator to review imported data, to define local objects and to perform consistency checks among local and imported data.

The current SRDB Translator SW version is compliant with SCOS-2000 ICD Issue 6.1, described in [2].

SW Architecture

The architectural model of the SRDB Translator tool consists of a single-user application that uses directly the business services of the ECHO Database Manager. Consequently, all operations of data insertion into ECHO tables maintain the same checks and behavior as those performed directly with the Database Manager interactive application.

The SRDB Translator extends the Echo database, adding new tables and stored procedures.

The Translator workflow, shown in Fig. 3, has two main steps:
- the first step imports SCOS-2000 data into Translator dedicated tables having the same format as original tables. These tables are used only as temporary data storage. All data of involved tables is loaded, without transformation, to speed-up the process.
- the second step transforms SCOS-2000 data just imported into Echo data, using dedicated stored procedures.

The user interacts with this SW module through a GUI, allowing selection of input SCOS-2000 database file and destination ECHO database. The whole content of input database is analyzed, no filtering on input data is possible. The user can select to perform the import directly, inserting the data into ECHO tables, or to export the converted data to a file, for later import using the Database Manager interactive tool.

At the end of the acquisition process, a log is produced, listing for all loaded data objects the positive or negative result of the transformation.
The content of each original loaded SRDB table can also be displayed or printed on file, to help operators in case of error detections.

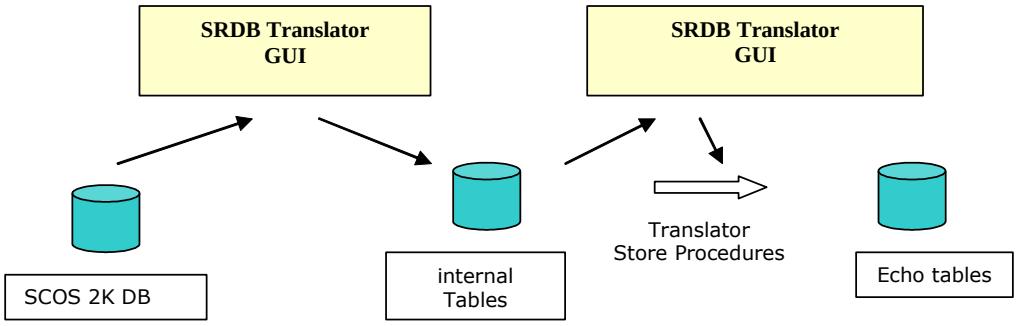

Fig. 3. SRDB Translator workflow

Applications

The first version of the SRDB Translator has been developed by TAS-I and Intecs in the frame of Galileo Giove-B project, with the objective to allow an easy import of the Satellite Reference Database into the EGSE system.
The Giove-B project was based on SCOS-2000 database, tailored according to the specific mission requirements, delivered to all database users as a single MS Access 2000 file.
The database has been validated during satellite AIV/T by TAS-I central checkout system, using ECHO legacy system and its native database.
The existence of two different databases led to the development of a tool which allowed maintaining consistency of the test database at EGSE side whenever a new Master SRDB release was delivered.

A new enhanced version of the tool has been recently released in the frame of Sentinel-1 project, as part of the EGSE Central Checkout System which will support the integration and the test activities of the satellite.

The Sentinel-1 tool version is currently used also in the BEPI Colombo program, even if not specifically designed for this program, to import data from S2K databases used to test On Board Computer (OBC) and Solid State Mass Memory (SSMM).
Metrics on handled databases are reported in Table 3.

Limits

The current version of the SRDB Translator tool is affected by some limitations which condition its applicability.

The tool offers only a partial compatibility with SCOS-2000 DB. In some cases entities can be imported, with some restrictions, and the conversion constraints impose rules on how the source SRDB shall be populated to obtain a correct on-line handling of imported data.

Actual implementation of the first translation step, concerning the import of data into Translator temporary tables, impose a one-to-one mapping between each source table and its corresponding Translator one. If the original table does not contain one of the expected columns, the whole import process is aborted. This is the case, for example, of BEPI Colombo databases. Input databases are compliant with a previous SCOS-2000 ICD issue than that managed by SRDB translator tool, and need some adjustments to the original tables to add missed columns, before performing the import.

Table 3. BEPI Colombo DB metrics

Data	OBC	SSMM
Approximate number of records	10000	10000
Parameters	3745	1947
TM packets	521	1921
TM samples	2944	2540
TC packets	399	535
TC samples	427	1445

Furthermore, frequent releases of S2K database enhanced versions and their customization to meet mission specific data requirements add complexity to the data exchange process and force work with different input database structure in each new project. The analysis process shall be repeated to identify changes and the tool shall be upgraded to adapt to new source data. The upgrading can also affect other components of ECHO suite, with increasing project costs for design, development and validation of the new release.

CONCLUDING REMARKS

Benefits

The availability of this tool allows TAS-I to perform test activities at unit level using its legacy systems, with benefits in terms of efficiency. Moreover, the same systems and test data can be used at satellite level, reaching a vertical commonality in the test workflow.
The output to final client, either internal or external, is improved offering a validated unit together with the corresponding validated database.

TAS-I central checkout system offers an increased flexibility, adapting to different scenarios, depending on internal workflows and assets.
For example, in Sentinel-1 program, TAS-I is responsible for the validation at satellite level, and SCOS-2000 database is an imposed requirement. By using the tool, test activities can be performed using ECHO, avoiding expensive training of the AIV team on a different checkout.
In the frame of BEPI Colombo, instead, TAS-I is performing tests and data handling and mass memory levels, with no requirements regarding the unit databases. In any case, the SRDB Translator tool has allowed using available SCOS-2000 databases as input, reducing costs for internal database definition and population.

Future Enhancements

Tool Extensions
The main goal is to design a SW version of the tool that will be able to follow the evolutions of the SCOS standard ICD independently from the specific project using it. Project customizations should be handled by ad-hoc add-ons, to reduce the impact of SW modifications.

Nowadays, the tool performs the translation process from SCOS-2000 to ECHO DB only, while the final upgrading of the SCOS-2000 database with the changes applied to the data during the tests is performed by a different, separate process. A new enhancement will be the integration in the same tool of data transfer from ECHO to SCOS-2000 database, to obtain a complete import-export environment.

Virtualized Database
The experience and the knowledge acquired during the development and maintenance phase of the SRDB Translator tool outline the great benefits that can be gained by the design of a standard database interface, at least for the data concerning the satellite database.
This standard interface would allow an easier data exchange among different EGSE systems, reducing program costs both in SW development and AIT training and improving harmonization.

For example, even the only definition of an ad-hoc mark-up language based on XML could lead to the development of legacy import/export procedures, without the need to know details of other systems and totally independent from their evolution.
The mark-up language would also reduce the checks on data consistency, allowing defining detailed validation rules and constraints.

REFERENCES

[1] ECSS-E-70-41, "*Ground systems and operations – Telemetry and telecommand packet utilization*", Issue A, January 2003.
[2] EGOS-MCS-S2K-ICD-0001, "*Scos2000 database Import ICD*" , Version 6.1, February 2006.