RangeDB the product to meet the challenges of nowadays System Database

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A spacecraft reference database plays a major role in S/C engineering, verification and operation process. The overall trend of integrated model-based engineering, also (and in particular) in avionics, are requesting for new technical solutions, to meet the challenges of today and tomorrow. The technical challenges cover the tool performance, fidelity, but also the costs, for development, maintenance and operation. Airbus DS decided to go for a new development, called RangeDB, realizing a solution, on technologies, matured and validated in internal R&D but also TRP. The development of RangeDB was finalized end of 2014, the deployment in the different programs is ongoing. With RangeDB Airbus DS is quite well prepared to provide efficient solutions to the programs.

EVOLVING SCOPE OF SRDB

The Spacecraft Reference Database (SRDB) use case is a well-established for managing spacecraft data, of a mission mainly in phase C/D. The SRDB provides the interfaces between various different processes, performed concurrently, from engineering to AIT, from equipment supplier to prime and from prime to operation. In terms of managed data, historically, the primary focus is spacecraft TM/TC data.

However the project demand in terms of scope, functionality and I/F to be provided has drastically changed in the past decade. The main reason is the deployment of many different modelling tools, DB and simulators in the project. Each tool has a particular demand of data which has to be satisfied, in the right version, correct format and the excepted maturity of the data. Especially for the “heavy-weight” processes, in phase C/D, the SRDB is the natural place for avionics related data, but also for system level data in general. With this trend the actual scope of an SRDB is gradually evolving from TM/TC avionics, or system level data. In that the SRDB, eventually grows into the scope, which many people always assumed, since the name does not indicate proper de-scoping.

The changes for this increasing demand, is quite heterogeneous. Mainly driven, by the typical pressure on process evolution, provide an answer to quite challenging, complex missing, in less time, with increased quality. This trend obviously is facilitated by the overall trend for “modelling and simulation”. The changed context can be described as of the following:

- Increased scope: A classical SRDB focuses mainly on TM/TC data. In the light of the changed context of an SRDB today, this is not sufficient anymore. It is a clear demand of the user to assemble and consolidate all avionics related data on the same framework. This comprises classic SRDB scope, but also data for electrical engineering, S/W engineering and AOC engineering. The glue to connect the data consistently is a shared product structure
- Increasing scope: While the scope is already increased significantly to the original SRDB scope, the trend of growing is ongoing. Currently there is a discussion which goes in a direction of integration of “all avionics data”. And in this the overall trend of MBSE, digital engineering or industry 4.0 is not far.

- New interfaces: Along with the increased scope, there is also the need to support additional interfaces. The range of tools involved in the process is quite significant. It involves Databases/ modelling tools, capturing the descriptive models, simulation or analysis tools for the executable models. The origin of the tools is also quite heterogeneous, from different tool vendors, up to self-written in house tools. For an efficient process, the tools have to be fed with the appropriate formats.
- Agility of processes: The trend of increasing use of computer based models, i.e. simulation models used in the verification process, have significant impact on the process. The process becomes "more agile" requires to support deliveries on a frequent basis. This put quite some constraints on usability and performance of a nowadays SRDB, with respect to the currently available systems
- EGS-CC: The decision to have a joint development of core components of future MCS and CCS also impacts the SRDB. One of the main reasons for EGS-CC is to improve the exchange and sharing of data. A conceptual data model is considered the main mean, to achieve "semantic integration". Where the expectation of semantics are expressed in formal conceptual data model, which used for the EGS-CC development and shared between all parties. Since the SRDB is to deliver data to the CCS and also to the operation centre, the SRDB has to support this I/F.
- Model management features: The model management features are in the heart of a SRDB, since they actually perform the "connecting" elements between the different processes, with the associated roles and access rights. The features e.g. allow to smoothly digesting the delivered data, track the origin, assuring the correctness and completeness of data, care for the proper versioning of data. One of the challenges for the model management features is to answer quite demanding needs, in terms of fidelity and reliability, but at the same time preserve the usability and care for easy access, since many users are non S/W experts.

Considering the existing systems in operation the decision was taken at Airbus DS to develop a new product, which can be used to configure the SRDB system. The system to be developed is to provide a "state of the art" solution, which forms the basis for a SRDB today, and also be prepared to answer the evolving needs in the future. Based on an internal assessment of the situation, the careful trade of COTS solutions – or to go for an in-house developed solution, the K/O for "RangeDB" was given in 01/2011.

MEETING THE CHALLENGES

The likely trend of increasing the scope of a SRDB, with all the associated features, was not a surprise. Rather this development was expected from the programs, in the overall transition towards model driven system engineering. In order to prepare for the future ESA started in the frame of ECSS a working group on "engineering database". The objective was to define approaches for improving the situation on project databases, which were perceived arriving too late in the programme, too expensive and not flexible enough. The working group delivered a technical memorandum ECSS-E-TM-10-23, with a aiming to reduce cost for database development/maintenance, improved quality of data and architectural concepts for the deployment architecture. The key elements in that was an approach for the federation of databases, with shared data management functionalities. For improving the semantics of the data, and also enabling model-driven S/W engineering for the database, the need for a conceptual data model driven by the process needs was stressed.

Activities have been initiated in order to validate the concepts introduced in ECSS-E-TM-10-23, but also to select the appropriate technologies. In that it was clearly identified that the emerging Eclipse Modeling Framework (EMF), was identified as very appropriate technological basis. It comes with a rich set of functionalities, covering the full scope of data management, but also addressing deployment aspects in the same way as state of the art model driven S/W engineering. The most notably activity in this frame was the TRP activity Virtual Spacecraft Design.

Having in mind the changing context of an nowadays SRDB, considering the opportunities/options provided by current mainstream technologies, the key concepts for the RangeDB can be summarized as of the following:

- **A conceptual data model which explicitly specifies all data managed in a SRDB**. The initial effort on the ECSS-E-TM-10-23, was quite appreciated, since i.e. the product structure model provided, formed an excellent starting point for the development. In the frame of the development the close connection of the CDM of RangeDB to the CDM of EGS-CC formed a major constraint in the development. The goal was to be as closed as possible, in order to minimize the risk of integration errors, or the loss of information in the transfer.
- **A powerful, robust data management kernel**. The core architecture has been adopted from the Eclipse Modelling Framework, in order to benefit of the various individual functions EMF comes along. The functionality provided by EMF, is quite comprehensive and powerful, however the tailoring of the functionality according to the actual needs was a major effort in the overall

development. The tailoring did include the completion of missing functionality, but also the tuning and performance optimization. For the data management framework a key constraint was to keep the independence of the CDM, in order to enable future change of the CDM, or scope enhancements.

- **A deployment architecture which can be tailored according to projects constraints**. In the heart there is a server, offering configuration control and data management functions. Clients can connect to the server either as “rich client”, where all data needed to perform a certain operation, are locally cached, or a thin client, where all data is managed on the server only. For rich clients, it is also possible to manage the data “offline” to the server.
- **A MMI framework, to ease the tailoring according to user needs**, without being a big burden in the overall agile development approach. This tailoring allows comprises the process depending presentation of data, i.e. allowing a cost efficient entry and retrieval of data – with a continuous effort to minimize the “mouse clicks”.
- **A crucial element for the economic success of RangeDB is the limitation of maintenance effort.** With strongly relying on the Eclipse Modelling Framework, in that utilizing model driven S/W engineering, a significant part of the S/W can be automatically generated.

The data management are the core means needed in order to provide the functionality for the process. The data management features, can be described along the basic use cases of the tool:

- Input / Output: In order to answer the particular needs of the S/W systems to be integrated, RangeDB allows having a dedicated internal IO format of the targeted system. This dedicated format, allows a mapping and subsequent transformation of data – in both directions. The key element in this however, is that consistency on the IO format level are enabled. With this directly on the target format the checks can be performed, and with that allow an immediate identification of the flaws in the data. And with that deliveries to the RangeDB can be rejected, while deliveries from RangeDB can be consolidated prior to the delivery.
- Version control: An efficient underlying configuration control is needed, in order to track the evolving data. The configuration items on RangeDB levels are system elements and data sets. System elements are key items of the system, and are represented with an own artefact in the version control system. Pending on the processes, system elements can be further decomposed into aspects. The data sets are a collection of system elements.
- Data organisation: The process applied drives the needs for the data organization. Basically for each process, dedicated artefacts are needed, in order to have a clear traceability of the data evolution. To ease and simply the management of data, in RangeDB data sets are introduced. Data sets are collections of system elements in a folder like structure. With this the actual configuration control status of the individual configuration items, forming the data set, are hidden in the data set, which has its own versioning. Between data sets version dependent links can be established. These links indicate that a particular data set, relies, depends on other data sets – in a particular version.
- Check for consistency: For assuring the consistency of data, the RangeDB infrastructure can be configured with consistency checks, as defined with the conceptual data model. The consistency checks are defined in OCL. In addition to that consistency checks can also be defined at runtime.
- Dealing with updates: The nature of complex engineering processes is that there is not only one single definition of data, with the subsequent use of it. Rather the process is characterized with an initial definition step, and subsequently many small steps, where data is further detailed and matured. In addition to that the data might be also changed due to changes applied to the baseline. For this the RangeDB is equipped with many different features, supporting this frequent update process. The features, comprise, e.g. the effective comparison of data, allowing the detailed view of the changes or history features for the visualization of the evolution of data.

Besides the technical, development oriented aspects a key attention was given for the close coordination with the user community. Right from the beginning a representative group of users, from different sites and organisation was closely involved in the development. After the common specification phase the users, work out individual validation cases, and followed the development. Thanks to state of the art technologies and i.e. agile development techniques a validation process has been established which started very early in the life-cycle, and continued with frequent deliveries along the development.

RANGEDB IS FINALIZED, DEPLOYMENT IS ONGOING, IMPROVEMENTS ON THE ROAMAP

The development of RangeDB is finalized. The estimated 3y development was followed by a 1y phase dedicated to intense validation close to the operational process. The development was finalized by 12/2014. With the development Airbus DS space system is quite well prepared to answer the needs of the SRDB today and tomorrow. The deployment progress of RangeDB is ongoing. RangeDB is the baseline for all new programs. With that, the deployment for more than 10 different programs is ongoing.

At the moment the main difference the most tangible difference is the fidelity and performance of the data management functions, as described above. Moreover the situation on interfaces to other tools is changing significantly. The notion of a shared integrated avionics data management is clearly shared by the stakeholders. This includes the tools needed for the flight S/W development, AOC analysis and electrical engineering.

However a discussion is starting to eventually share the data management functions, in order to have a shared approach for data management. The advantage for this is at least twofold. On one hand there is a clear advantage for a shared use on the infrastructure, since it would allow merging, and re-hosting functions, and in that reduction development costs. However there will be no decision to directly re-host all related tools, rather there will be a careful consideration of ROI on a case by case basis. One of the key enablers would be e.g. technology obsolescence, where RangeDB would be the default solution for any re-hosting or new development.

In addition to the potential savings on development and maintenance, there is also a saving possible on the user side. The harmonization of data management functions, in particular for the data organization and version control, would significantly ease the consistent management of data. And in that it is not impacting the investment and maintenance cost, but would have a direct impact application process, where the savings would materialize in each project.

The notion of a DB offering shared data management services supporting the avionics process from engineering into AIT, is well appreciated, by the user communities. Various enhancements in terms of scope are currently being discussed, prepared or are already under development.

With RangeDB a state of the art data management solution is provide to the programs, which meets the challenges of today, but also the expected evolving needs in the overall transition to integrated model-based engineering.