APPLICATION OF DIGITAL EXCHANGES BETWEEN PROJECT PARTNERS IN THE FRAME OF ENVISION PROJECT

Gérald Garcia (1), Ana Rugina(2), Michaël Pateau(1), François Caullier (1)

(1) Thales Alenia Space, Cannes (FR), firstname.lastname@thalesaleniaspace.com
(2) European Space Agency (ESA), Noordwijk (NL), firstname.lastname@esa.int

ABSTRACT

Digital transformation of engineering is on-going both at customer and supplier sides. This transformation targets end-to-end digital continuity across all the life cycle of the projects. This transformation will be fruitful at the condition that it applies also to the extended enterprise including both customers on one side and external partners on the other side. This paper presents the work performed during an ESA study coupled to the EnVision phase A (the selected M5 mission to Venus), aiming to apply MBSE to digitalise relations between project stakeholders. During this study we relied on the application of ontologies and knowledge graph to extract engineering data coming from heterogeneous sources and the digitally distribute the relevant data to the project stakeholders. This paper presents the result of this work and open perspectives.

1. PROBLEM STATEMENT

During studies like the one in support of EnVision phase A, there is a lot of information exchanged between stakeholders. This information is traditionally exchanged based on documents (Word documents, slide decks, …) and very few of them are exchanged through digital formats (orbit ephemeris for example are traditionally exchanged using data files).

Relying on documents with no formal links between them (e.g., traceability links) implies a lot of drawbacks and pain points. The objective of this study is to demonstrate that they may be solved if we rely on digital exchanges (i.e., based on structured data).

The first family of drawbacks are on the review capability of the customer on these exchanges as described in [1]. There are two kinds of reviewers of engineering data: the customer project team and the independent reviewers. Customer project team has a regular and frequent interaction with the supplier team. The interaction relies on information that is regularly updated and also further processed at customer side. This case can be accommodated with "raw" exchanges that may be agreed between stakeholders sharing implicitly or explicitly the semantic and the interpretation of this data (for example a modelling convention in Capella). This is not true anymore for external reviewers that cannot adapt to each reviewed project habits and conventions. This last family of reviewers needs a clear and explicit delivery of the information in which they are immediately productive. There is a need of both type of exchanges: frequent ones that may be direct extracts of models and others that need to be post-processed in order to be easily understandable by external reviewers.

Customer project team has to recreate information from documents that the supplier team may already have in digital form. For example, to compare technical budgets from different projects, the ESA project team needs to extract and copy information from documents into their own format. The reverse is also true, the industrial team has to extract (mostly manually) information from the delivered specifications to feed their internal model even if this specification has been generated from a model on customer side.

The delivery of information in a document reduces the precision and capacity of automated processing of this information. It may be reduced by the fact that a document form is not sufficiently expressive, due to copy/paste human errors or because the formalised information in documents has to be synthesised (for time and budget reasons but also most of the time because the same output is used to perform co-engineering, review and also data delivery). This leads to inconsistencies and problems of understanding. For example delivering the mission and attitude profile from the system team to perform sub-system (i.e. thermal) analysis proved to be prone to misunderstanding and let to designing a subsystem for a different sizing case. The sub-system responsible had to reconstruct the assumptions based on implicit and informal information (for example slide decks explaining the different spacecraft attitudes).

During studies, the engineering data changes frequently (for example a mass budget and the constraints on the launched mass). Following these evolutions is important for all the stakeholders in order to understand the on-going changes but also to assess the state of the project (for example does the launched mass start to converge). In some cases, the data history is as interesting as the data it-self. On top of that, the interaction frequency between the different kind of reviewers is different: ESA project team needs to have access to historical information and differences from last progress meeting or key point while external reviewers need the historical information from previous major review to the current one. This kind of tailored historical view is not possible in document based exchanges.
Another drawback of a document-based approach is the

fact that it is very easy to create inconsistency: it is sufficient that one sub-system designer uses a deprecated data point or misunderstands slightly the assumptions made at system level. The system knowledge and design are always a step ahead the documents. In a digital exchange, the system knowledge is captured in single and semantically clear way and the same data is propagated to all parties.

2. LINK WITH OSMOSE AND ONGOING WORK ON ONTOLOGIES

Even in an "ideal" world where all the stakeholders would use the same tool suites or physical data exchange formats, the problem of digital exchanges of data would not be solved. This has been demonstrated many times, despite exchanges formats in UML like XMI or for requirements like ReqIF (but the same apply also for ECSS 10-25 on CDF exchange formats), there are a lot of difficulties to exchange data due to the missing alignment on the semantic level. The reality is even worse, as each stakeholder has selected different methodologies and different tooling.

The MB4SE community, under the ESA umbrella, has acknowledged this fact and decided to invest into the development of a space engineering ontology called Osmose focussing on the semantic of the exchanges that occur between project partners. This initiative is supported by different studies focussing on the definition of this exchanges (SaSYF lead by GMV) and Osmose development studies. The goal of Osmose is to agree on an ontology expressed in ORM.

This Osmose work is a corner stone to be able to exchange data and the direct application of this concept to the EnVision mission is described in the following chapter.

3. KNOWLEDGE GRAPH AND TOOLING ARCHITECTURE

The proposed architecture is relying on ontologies (for the moment specific one, but the alignment with first preliminary deliveries of Osmose is on-going) and knowledge graph. A knowledge graph is a graph that interconnects engineering data wherever they originate from (any engineering tooling or discipline). This graph is structured by the ontologies. Knowing the ontologies is sufficient for understanding how the information is stored in the graph and how to access or query it.

This knowledge graph is the central and unique repository of data that will support reasoning on data and exchanges. Instead of addressing each engineering domain, activities and tooling, the proposed architecture first centralises and connects all the information before exchanging it. It also permits to define the content of the exchanges, not at authoring tool level but at ontology level. As the objective of Osmose is to be widely adopted by the space community, it will permit to define the exchanges without taking care about the different implementation and tooling choices in each entity.

As the data history management is a key capability of the solution, the knowledge graph is capable to track versioning of data (at a granularity expressed on the ontology) and services accessing to the graph can access transparently to the information and its history or to the information as it was at a given point in time.

4. DYNAMIC AND SIMULATION RESULTS

Most of the time the ontologies (and it is the case for Osmose) contain "static" definition of the system, i.e. design of the system in a point in time and do not address the link between this design and simulation (or in flight data). This raises a number of issues in particular to exchange simulation scenarios. Indeed a scenario exchange encompasses both dynamic data (for system mode at a given time of a particular scenario) with "by design" data (for example the spacecraft consumption for that mode from the power budget). The ontology has been extended to take into account these dynamic data (for example a spacecraft has a certain number of modes from design and has only one current mode for a given scenario and a given time). This permit to query in a unified manner information coming from design and from simulation.

5. RECONSCILIATING DATA AND DOCUMENT DURING REVIEWS

In a previous CNES and Thales Alenia Space study ([1]) we demonstrate that only 50% of the content of a typical data-package is worthwhile to be digitalised, and in many cases this is not a whole document but only some parts (for example a design justification document may be composed of digital analysis results but also narrative parts that explain the justification of the design). This implies that in a foreseeable future, the data packages will be composed of a digital part but also of documents or plain text with figures.

This implies that the knowledge graph must also be capable to link digital data with document content. This requires smart textual content processing (relying on natural language processing AI) and also UI capabilities to create a seamless experience between documents and digital data connecting the two world. A user is capable to go through a document and in the same unified review engineering environment "jump" to a digital content following a navigation link. The reverse being also true, a user navigating the digital data should be given the possibility to jump to document content when relevant.

6. USER ACCESS TO ENGINEERING DATA

The most natural access to this data for the end user is though a web application. This allows to be used without any installation requirements and with limited network interconnection problems. The objective being to "replace" documents delivered during review, it has to have nearly the same retention capabilities (meaning that we are still capable to open review data packages of spacecraft launch 20 years ago). This is difficult to achieve for an online web site (due to the final cost of maintaining the infrastructure in operation and in security for such a long time).

In the future, if we need to deliver more advanced experience that web sites (for example AR/VR or delivering huge quantity of data), we will need a common IT infrastructure or at least common platforms between customer and industrial teams to deliver this kind of contents, this is certainly an important topic to tackle.

7. CONCRETE RESULTS

This R&D study was phased with the real project, to answer in real-time the concrete needs for digitalization identified in this project during phase A. This was a very interesting way to test on the field the proposal of digitalisation and evaluate impacts on the team work (for example constraints like configuration management on team models to be able to automatically extract information to the knowledge graph). Starting from end of 2020, we delivered digital content (each time enriched following the minimum viable product approach) at the same time than the real project progress meeting. The digital content consisted in: (1) system engineering budgets with history, change log and trend charts; (2) a mission performance report allowing to navigate between the mission performance requirements and the data package items that demonstrate or contribute to the fulfilment of these requirements.

8. WAYS FORWARD AND CONCLUSION

This paper focuses on the work performed by Thales Alenia Space in a parallel contract to the EnVision phase A ESA study, to deploy digital engineering and MBSE. The resulting prototype is promising and Thales Alenia Space already plans to deploy this kind of approach in some of the on-going projects to move from a document centric approach to a data centric approach.
The adoption of a knowledge graph approach permits to adopt quickly ontologies like Osmose and it is seen as a corner stone of the future engineering environment (including extended enterprise in the case presented in this paper).

There are many challenges still in front of us. Demonstrating the adoption of Osmose for communication between partners where IT platform and interconnection will have to be shared. Once we have a knowledge graph, we have a huge quantity of connected data and that is exactly the right playground for AI algorithms and data analytics. These will allow getting significant value from this data through processing and increased automation of our engineering process, and through the implementation of engineering assistants, the extraction of KPIs to follow engineering process and more.

9. REFERENCES

[1] Digital transformation of exchanges between a customer and a supplier. G. Garcia, R. Soumagne, R. De Ferluc. SECESA 2020.