Systems Engineering and Project Management Process Modeling in the Aeronautics Context: Case Study of SMEs

S. Lemoussu, J. C. Chaudemar, R. A. Vingerhoeds

***Abstract*—**The aeronautics sector is currently living an unprecedented growth largely due to innovative projects. In several cases, such innovative developments are being carried out by Small and Medium sized-Enterprises (SMEs). For instance, in Europe, a handful of SMEs are leading projects like airships, large civil drones, or flying cars. These SMEs have all limited resources, must make strategic decisions, take considerable financial risks and in the same time must take into account the constraints of safety, cost, time and performance as any commercial organization in this industry. Moreover, today, no international regulations fully exist for the development and certification of this kind of projects. The absence of such a precise and sufficiently detailed regulatory framework requires a very close contact with regulatory instances. But, SMEs do not always have sufficient resources and internal knowledge to handle this complexity and to discuss these issues. This poses additional challenges for those SMEs that have system integration responsibilities and that must provide all the necessary means of compliance to demonstrate their ability to design, produce, and operate airships with the expected level of safety and reliability. The final objective of our research is thus to provide a methodological framework supporting SMEs in their development taking into account recent innovation and institutional rules of the sector. We aim to provide a contribution to the problematic by developing a specific Model-Based Systems Engineering (MBSE) approach. Airspace regulation, aeronautics standards and international norms on systems engineering are taken on board to be formalized in a set of models. This paper presents the on-going research project combining Systems Engineering and Project Management process modeling and taking into account the metamodeling problematic.

***Keywords*—**Aeronautics, certification, process modeling, project management, SME, systems engineering.

I. Introduction

THE aerospace sector is facing nowadays a highly growth of innovative projects each addressing specific areas so to reduce weight, noise, and emissions, or to increase autonomy, capacity and flexibility. The global trend is indeed to find new concepts to make the air travels safer, greener, and more efficient. Safer as the traffic demand is expected to double in the next twenty years (IATA source). In that context, airspace congestion and conflict resolution will become a great challenge for the next decades. Greener as the sustainable development is a necessity now everywhere. The International Civil Aviation Organization (ICAO) has imposed recently new requirements which will force a large number of countries to commit on CO_2 emissions reduction. Also, many companies are on the way to do research on electric aircraft, hybrid engines, and basically on any new concepts to be more independent regarding the fossils fuels. With these kinds of projects, they expect to be more competitive in the future, and to be one step ahead in the innovation race.

Nowadays, airships are being studied again as a real alternative to passenger and cargo transportation. They should enable to reduce drastically fuel consumption, associated pollution and noise emission. Several projects are running in Europe, often generating new markets and raising a lot of hopes. But, the introduction of this kind of project in the airspace brings along a lot of challenges for them too. It implies a different view on air travel and safety and conflict resolution will be definitely impacted.

Many of these projects are carried out by newcomers, often SMEs. SMEs are of strategic importance for the economy of the States. In Europe, they represent indeed 99.8% of the total number of companies and employ 66.8% of the total number of European employees [1]. Many Small Business Acts are signed on different levels (States, Region, Federation levels) to simplify the environment (regulation and policy), remove some barriers to their development and facilitate the access to certain markets.

A major issue in the aeronautics sector is that, companies have a lot of rules to take into account and SMEs have to face the same constraints; even more if they have integration responsibilities. They need to provide all the necessary means of compliance to demonstrate to the civil aviation administrations (EASA in Europe, FAA in North America) their ability to design, produce, and operate their system with the expected level of safety and reliability. A lot of norms and standards exist, sometimes not well-known to the SMEs. Just as any commercial organization, SMEs have to face the usual constraints of safety, cost, time, and performance. The main difference is that they have to perform all these activities with much less resources than large companies. At the same time, it is important for them to remain agile enough to stay competitive and adaptive to the market. This challenging situation needs consideration. Airships are not the only new innovative flying projects. The same story holds for many innovative aircrafts as large civil drones or tethered aerostats.

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In this paper, we propose an MBSE approach, to better support the SMEs with a clearly identified integrator role and with responsibility towards the certification authorities. The idea is to formalize in models not only information coming from aeronautics regulation and certification expectations, but also any existing standards, norms and recommended practice in the aeronautics sector. After presenting background on aeronautics standards, systems engineering and quality management, and business process modeling, our global modeling approach will be presented. Finally, the paper will introduce the further research roadmap that this modeling will enable to conduct.

II. Safety and Aeronautics Standards

Safety is the main stake of the aeronautics industry. Here any stakeholder is concerned by safety and safety improvement. As proof, accident rate and number of fatal injuries have been drastically decreasing since the 1950's and nowadays they are at their lowest level. Linked to this problematic, certification process is another stake for this industry. First, the stake is commercial as the certificate of airworthiness is the only way to market a flying product. Then, it is a societal issue as the certification has to ensure the safety of any passenger onboard, any people on ground and any infrastructure. Leading by ICAO recommendations, the states have created several regional institutions to manage locally the safety requirements and deliver the certificates of airworthiness. European Aviation Safety Agency (EASA) in Europe and Federal Aviation Administration (FAA) in United States are the major actors to monitor the safety level on the planet.

Marketing any aircraft in the northern hemisphere requires a certification from at least one of these administrations. It means that the enterprises have to demonstrate that they have put in place a real Design Assurance System (DAS) which implies a great control and monitor of the development of the systems.

Traditionally, in aeronautics sector, this target is achieved by being compliant with a list of well-known guides which are:

- EUROCAE ED-79/SAE ARP4754A [2]
- SAE ARP4761 [3]
- EUROCAE ED-12/RTCA DO-178C [4]
- EUROCAE ED-80/RTCA DO-254 [5]

These guides all represent a consensus for the aviation community and can be considered as best practices in this industry. Moreover, they are recognized by both EASA and FAA. They are applicable at different levels of the aircraft development, and thus, they are highly interdependent. ARP4754A is the reference for the system top level, whereas DO-178C is the reference for Software parts and DO-254 for Hardware parts. They implicitly assume that a system is composed of critical software parts and critical hardware parts only. The decomposition and the relationship between Systems, Hardware and Software parts are represented in Fig. 1. The Safety Assessment Process, the core process implied in the systems developments, is described in the ARP4761.

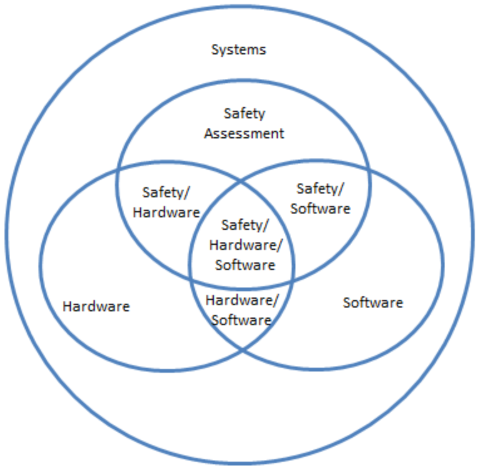

Fig. 1 Relationships between Systems, Safety Assessment, hardware and Software processes (based on [5])

TABLE I
Recommended Processes by Aeronautics Reference

Source	Recommended processes (RP)	Number of RP
ARP4754A	Development Planning Aircraft and System Development Safety Assessment Requirements Management Requirements Validation Implementation Verification Configuration Management Process Assurance Modification Management Certification	10
DO-178C	Software Planning Software Development Verification (the heart of the standard) Software Configuration management Software Quality Assurance Certification Liaison	6
DO-254	Planning Requirements Capture Conceptual Design Detailed Design Implementation Production Transition Validation Verification Configuration Management Process Assurance Certification Liaison	11

From these recommended guides, a list of necessary and required processes may be extracted and implemented in the enterprise architecture (see Table I). The problem is that, if a company decides to deploy these four documents, even with the best will in the world, it will not be sufficient to be fully compliant with the regulation. The Part-21 from EASA for instance, essence of the EASA rules, is more than the aggregation of these four documents. Even if they are the reference and actually the only current documentations which enable to be compliant with the regulation and to understand the Quality Assurance expectations of EASA, they are not sufficient.

For SMEs, it is quite difficult to understand that they have to read, understand, and digest the Part-21, and these four documents to build their enterprise architecture. The main idea of this research is thus to provide to the incomers in the aviation industry, and to the SMEs especially, a centralized methodology with the necessary and sufficient information to help them to be compliant with the regulation. The main stake is so to compile a lot of rules with the assurance that the data are complete, correct, consistent and intelligible. In that sense, the proposition needs to be fully sharable and updatable by the aviation community: academic and industrial too.

III. Systems Engineering Approach

The main objective of this research is to find leverage to support these new innovative projects allowing them to penetrate the aeronautics market. The chosen approach is the Systems Engineering approach, well-known in the large enterprises from aerospace industry.

A. Systems Engineering Standards

The Systems Engineering, as we know now it today, has his roots in the middle of the 20th century, when some strategic States projects were pushed forward. Henceforth defense, space and aeronautics have been the main contributors of the discipline, whereas each sector developed its own norms in adequacy with its specificities, now numerous standards exist in Systems Engineering field. This paper and our research concentrate their interest on aeronautics field. Three well-known standards are so compared, like did the authors from [6]–[9]:

- ISO/IEC/IEEE 15288 [10]
- IEEE 1220 [11]
- ANSI/EIA 632 [12]

What we found is that the main differences between these norms are the detail of the activities and the perimeter of the norms. It seems difficult to argue if the one better is than another as far there are all different (See Fig. 2). It is better to consider them as complementary.

For SMEs, this may generate confusion. At the first sight, no Systems Engineering standard is simply available to answer the problematic. It requires an intensive research to identify the adequate Systems Engineering approach. One difference with the large enterprises, they have to embrace all the knowledge quicker than their elders as they did not participate to the elaboration of the texts. The Systems Engineering Standards are not adapted to them mainly because they are not made by them.

B. ISO/IEC TR 29110

Most of the international norms in Systems Engineering have been elaborated by and for large enterprises. The small organizations who would try to be compliant with them fail most of the time due to lack of knowledge or lack of resources. They are sometimes even not convinced that Systems Engineering is a must for their projects.

To address the case of SMEs case, the recent standard called "ISO/IEC TR 29110 Systems and Software Engineering" aims to provide a lightweight standard for SMEs who develops Software or Systems. This norm classifies SMEs target according the size of the projects they are supposed to manage. Four categories are characterized by four "Profiles" (see Table II): "Entry Profile", "Basic Profile", "Intermediate Profile" and "Advanced Profile".

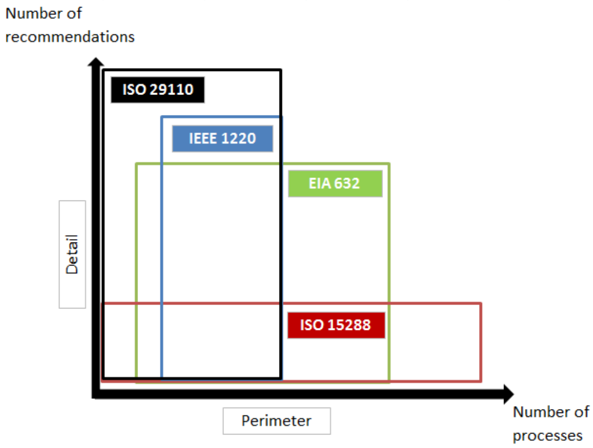

Fig. 2 A Systems Engineering Standards comparison (based on [13])

TABLE II
ISO/IEC TR 29110 Profiles Description

Profile	Target
Entry	Start-up SMEs (less than three years of operation) or SMEs working on small project (less than six person-months).
Basic	SMEs developing a single application by a single work team (external or internal contract).
Intermediate	SMEs involved in the development of more than one project in parallel with more than one work team.
Advanced	SMEs aiming to sustain and grow as an independent competitive system and/or software development business.

The norm is published publicly without any fee on the ISO website. Practical documentation called "Deployment Package" or DP, composed of guides, examples and templates are also available fully free. The DPs provide help for eight processes but unfortunately only for the two first profiles "Entry" and "Basic" (see Table III). The DPs for the two other Profiles "Intermediate" and "Advanced" should be available in 2018. This Systems Engineering standard is quite different from the ISO/IEC/IEEE 15288, the IEEE 1220, and the ANSI/EIA 632 and the scope is again different (See Fig. 2). ISO 29110 is more practical, furnished with a lot of guides and examples, fully free, and moreover enables the firms to be certified. Numerous papers exist providing the positive reasons to be certified [14]–[17]. Most of them distinguish the internal positive effects and external positive effects. Even if the firms claim that they wish to improve their internal processes, their products, they generally, first of all, want to improve their image regarding the market [14]. It means that the motivation may have diverse origins and can be also classified as internal or external. One wish of ISO 29110 is to answer to this basic need: to improve internal and external processes. Unfortunately, despite a great potential, ISO/IEC 29110 presents two main weaknesses regarding our problematic. First ISO/IEC 29110 applies for non-critical systems development projects. Safety and security requirements are not treated as specific requirements. Also the "Intermediate" and "Advanced" profiles are not available neither for Software nor Systems part. Finally, even if their publication is expected during 2018, as the norm does not tackle the regulation issue or even address the safety assessment, we think that it could not constitute a full answer to support the new SMEs on the aeronautics market.

TABLE III
AVAILABLE DEPLOYMENT PACKAGES IN ISO/IEC 29110

Id	Entry Profile	Basic Profile
1	Requirements Engineering	Requirements Analysis
2	Interface Management	Constructing and Unit testing
3	Configuration Management	Version Control
4	Project Management	Project Management
5	Functional and Physical Architecture	Functional and Physical Architecture
6	Integration	Integration and tests
7	Product Deployment	Product Delivery
8	Self-Assessment	Self-Assessment

IV. QUALITY MANAGEMENT APPROACH

The origins of Process Thinking date to the 18th century with the Adam Smith theories on division of labor, but the concept of process has been widely spread thanks to the emergence of quality standards, and particularly when the ISO 9000 suite has been published for the first time in 1987. The main idea of this norm is that the business processes are reproducible and can be so formalized. It is then possible to describe all the activities, all the necessary steps for the process orchestration.

According to the ISO 9000 norm, the introductive and explicative norm to the suite, a process is "any activity or a set of activities that uses resources to transform inputs into outputs".

More precisely we can say that a process is set of human tasks and automatic steps following a planned scenario which provide a predictable result (service launch, product production, customer request satisfaction, etc.).

Business processes are generally classified in three categories:

- Realization, or Engineering processes,
- Support, or Enabling processes,
- Management, or Project Management processes.

This classification shows how it is important to identify all the processes and alerts on the fact that the three types of processes are interdependent and may sometimes generate confusion in the organizations. It is then important to identify the relative activities as detailed as possible.

A. ISO 9001 and EN 9100

Regarding Quality Management, the ISO 9001 [18] is the norm the most popular and probably the most widespread in the world. Indeed in 2016, more than 1,6 million of companies have been certified [19]. The implementation of a Quality System is a long way on which the SMEs can find a lot of barriers. On the other hand, as ISO/IEC 29110, ISO 9001 may only be considered as the first step for our targets of enterprise as this one too does not address the specificity of the aeronautics sector. Moreover, the link between the norm ISO 9001 and the effect on innovation is not very clear. Some studies lead to the result that the effect may be positive [20], [21] and some others at contrary that the effect could be negative [22]-[24]. Indeed, incremental improvement, compliance necessity may prevent from creativity and in-fine from innovation. Radical changes would be too risky with respect to this norm. Some SMEs could even be encouraged not to follow these rules because implicitly innovation needs disobedience to current rules [25]. However there are not so many debates, nor research regarding the impact of performance after implementing this norm. It is so difficult to have a clear idea about this norm.

More interesting, based on ISO 9001:2015, the latest version of EN 9100 [26] has been published in 2016. The EN 9100 is the equivalent of the ISO 9001 but dedicated to aerospace and defense sector. It imposes some additional requirements where the risk management process is the core activity. Special requirements, critical items, key characteristics are essentially coming from the risk analysis are expected to impact and lead the planning and development activities. EN 9100 is more acceptable to our targets of enterprise. But again, it cannot be the only source of information to be compliant with the full regulation.

The existing Quality standards' analysis leads to two observations. First, the existing quality standards cannot provide the complete solution to the problematic. The context in aviation industry is extremely constrained and governed by the regulation. Even if they may constitute a step towards certification, they never could constitute the final objective.

B. Maturity Models

Maturity models appeared in the 1990's in the same moment where the concepts of process improvement emerge. As Systems Engineering standards their objective is to provide good practices without imposing how to implement them [6].

Just after the emergence of the CMM (Capability Maturity Model), proposed by the Software Engineering Institute (SEI) in 1990, the SECAM (Systems Engineering Capability Assessment Model) is launched by an INCOSE Working group [27] in parallel with the SE-CMM from SEI. In 1998, the SECM (EIA-731) enables to merge the two initiatives SECAM and SE-CMM [28]. Finally in 2011, SEI decided to integrate available models in the now famous CMMI, becoming from that date the dominant model. Recently some other norms were proposed [29] but the CMMI still remains the reference model [30].

SMEs could beneficiate of an adequate maturity model which would be a tool used for a ramp-up strategy. Unfortunately, the CMMI may often be considered as too complex to deploy and too expensive. No maturity model is then available for the SMEs.

V. BUSINESS PROCESS MANAGEMENT/MODELING

Business Process Management and Business Process

Modeling share the same acronym; however, there should be no confusion between them as one is a sub-activity of the other. Business process management (BPM) provides governance framework for business environment to improve agility and operational performance. It is a systematic approach to improve any organization's business processes. BPM is not a technology and it is not related to diagram creation or systems architecture [31]. Business Process Modeling is one manner to treat BPM. It is a technique to represent the processes in order to improve them. The activity is generally deployed in two phases called “AS IS” and “TO BE”. The first one corresponds to the representation of the processes as they are experienced in the company, whereas the second would be the representation of a target organization recommended for the company.

A. *Business Process Management Origin*

The BPM is a quite young discipline. The origin could be dated as process concept emergence in the 18th century, but it seems to be more appropriate to link it with the emergence of computer sciences and technologies. In the 1960’s, the first software is available on the market. In the 1970’s, the information systems put information in the core of the firm thank to the development of the data bases. In the 1990’s, the Enterprise Resource Plannings (ERPs) enable to automate a set of tasks and give birth to what we called the Work Flow Management. It is probably more realistic to lay out the early stages of BPM with the Work Flow Management and the Work Flow Management Systems (WFMS). These tools enabled for the first time to model the processes.

The Business Process Management Systems (BPMS) arrived just after around the 2000’s (see Fig. 3). BPMS are becoming more powerful than WFMS where there are embracing all the activities of Business Process Management from modeling and analysis to simulation and enactment.

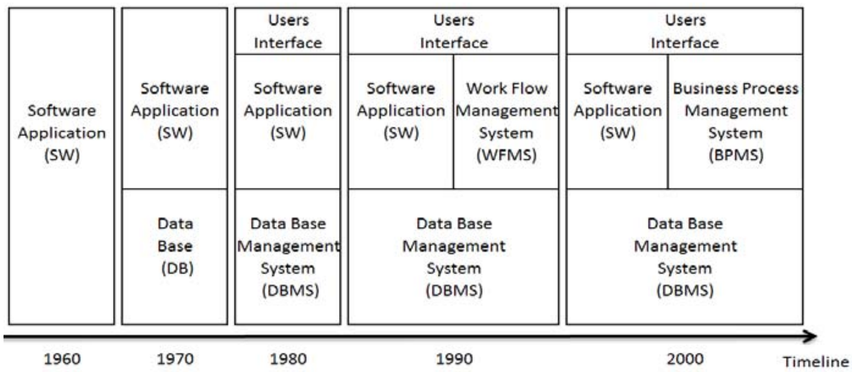

Fig. 3 Historical view of Information Systems (based on [32])

B. *Business Process Modeling*

BPM enables to identify the necessary processes answering to the enterprise strategy. Unlike Systems, the processes are not physical objects. From the design to the execution, they remain an abstract concept. It is then more difficult to describe them, represent them, and verify them. In the organizations, when the processes are documented, we may only find a textual description of the goals. At best in the company, a graphical representation of the internal processes exists. For few examples, they are modeled with an available standard language supported by a modeling tool. It is actually the best way to identify the potential inconsistencies, the hidden errors, the bottlenecks, everything that weakens the management of the processes. But, in many cases, this kind of model does not exist, especially in SMEs who do not have the time and the knowledge.

As for the systems, the graphical representation of the processes enables to improve the communication on the process model and participates to the share of the assumptions. The language used for the representation enables to share the syntax and to avoid misunderstanding in the communication. Additionally, more the language will be formalized more we will be able to declare rules and then compliance and validation techniques. Also, there are different ways to model the processes. The methodology may be different according point of view that we chose. Several orientations to describe the processes may be identified [33]:

- Activities oriented,
- Flux oriented,
- States oriented,
- Decision oriented,
- Strategy oriented.

No unique kind of model enables to represent the full vision of the enterprise. Modeling and a fortiori Business process Modeling requires making choices.

In any case, the process modeling enables several activities for the enterprise:

- The processes management and control,
- The documentation of the enterprise activities,
- The analyze and the re-engineering of the processes,
- The conformity analyze of the executed activities,
- The performance estimation thanks to simulation,
- The Business risk management,
- The Enterprise Architecture framework,
- The Workflow management.

The typical error in modeling is to provide a vision too ideal compared to reality. Also, unfortunately everything cannot be modelled. Often the abstraction level does not suit at the end to the enterprise problematic and all necessary modifications to change the abstraction level for a model become very expensive. Moreover, using process modeling approach, several limitations may reduce the modeling results.

First, the choice of the modeling language may prevent from verification and validation methodology. The chosen modeling language should enable to build some verification tests to validate the conformance. In that sense, the chosen modeling language should be enough formal to be able to validate some minimum characteristics of the models.

Secondly, the modeling language should be able to support a certain kind of enactment. Otherwise, the possibility to transform the model has to be identified early to enable this kind of orientation.

Thirdly, the modeling proposition should be generic enough to be adaptable to many kind of situations and not too much restrictive.

C. Process Modeling Tools

Process Modeling requires first a language and then a software application to support the language. There are numerous solutions on the market to model business process. Most of them are not freeware and require a contact with a business unit. We oriented first on the selection of freeware tools or with a limited free student release. We limited first our study to BPMN solutions too.

The tool evaluation methodology represented in Fig. 4 led to identify five eligible modeling tools which we studied and compared:

- Adonis
- Aris Architect
- Bizagi
- Modelio
- Bonita

The result of this study is summarized in Table IV. From this result, the ideal picture of the perfect tool has been identified. We determine six main capabilities which are:

- Modeling
- Analysis
- Simulation
- Verification
- Publishing
- Execution

As no tool is offering all these capabilities, the challenge was then to select the adequate tool with the optimal functionalities. We decided that it is essential that the chosen tool enables verification capacities either natively or by additional programming. Also, the tool should propose some capability of simulation to be able to evaluate the processes performance.

Adonis tool has finally been chosen for one feature we did not identify initially: its capacity to compare two different models. It has been used then to represent in BPMN some activities expected by the EASA regulation (see Fig 5 as an example). The first produced diagrams lead to several remarks. First, the experience of the tool shows that the results report from the comparison of two different models could be useable but with difficulty as a lot of differences emerged when we compared even two similar models. How manage too many differences when the two models in comparison will propose two opposite vision of the enterprise? Additionally, the capacity of verification is very important for our research and Adonis proposes only to control the model according pre-determined criteria. The tool does not enable to create some additional criteria (unlike Bizagi).

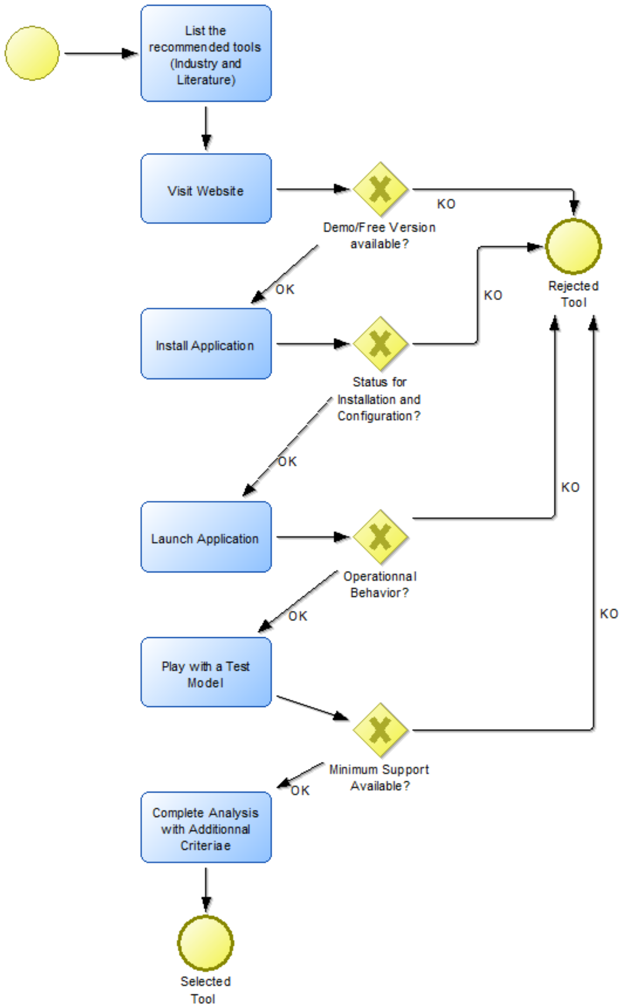

Fig. 4 BPMN diagram for the BPMN tool evaluation methodology

Finally we are convinced that Adonis does not propose sufficient capacities regarding the execution of the processes. The tool enables only step by step execution; it means unfriendly and inefficient way for execution. More generally we faced some difficulties with the BPMN limitations which definitely lacks of formal properties and prevents from a sufficient validation of the approach. We assume that additional research has to be led on process modeling languages and process modeling tools.

To go further we think that process metamodeling is another area of research which could answer in part to this problematic.

D.Process Metamodeling

Metamodeling is an engineering activity which may support the modeling activity.

The metamodel has then two main properties. First, it can be considered as a real language with its own syntax and its own rules. Secondly, it is a reference to control and verify the models of interest.

When one is modeling, it may be recommended to provide the meta-model. To define a meta-model, three approaches exist:

- Create a new metamodel from scratch,
- Modify an existing metamodel (add, delete, modify the available elements and the constraints they may have in relation)
- Specialize an existing metamodel by creating a new profile (new elements, new constraints) and without deleting any existing elements and existing constraints.

Very few process-oriented metamodels exist. Two are identified in our research:

- SPEM 2.0 (an extension of the UML metamodel)
- BPMN/BPDM 1.0 (Business Process Definition Metamodel)

TABLE IV
COMPARATIVE ANALYSIS OF MODELING TOOLS

Tool	Capabilities	Strengths and Weaknesses	Free-Ware?	Open Source?
Adonis	Modeling Analyze Simulation Verification Publishing Execution	-Small verification capacities (according pre-defined criteria only), -Small simulation capacities (Step by step only), -Comparison between two models, -User request on linked database, -Export/Import in ADL, XML, XPDL, BPMN and pictures format, -Numerous settings, -Support UML and BPMN, -Intuitive interface.	Y	N
Aris Architect	Modeling Analyze Simulation Verification Execution	-Verification capacities, -Simulation capacities, -User help and Forum support, -Support UML, EPC and BPMN, -Basic training needed.	N	N
Bizagi	Modeling Analyze Simulation Verification Execution	-Extended Verification capacities, -Extended Simulation capacities, -Export in XPDL, Visio and pictures format, -Support BPMN only, -Intuitive interface.	Y	N
Modelio	Modeling Analyze Verification Publishing Execution	-Extended Verification capacities, -Support BPMN,UML, SysML, Java, -Intuitive interface.	Y	Y
Bonita	Modeling Analyze Verification Publishing	-Verification capacities, -Comparison between two models, -Small simulation capacities (Step by step only), -Request on database, -Export in BPMN, XSD and pictures format, -Support UML and BPMN, -Basic training needed.	Y	Y

SPEM 2.0 is a UML metamodel. It means that this proposition is compliant with the meta-metamodel provided by OMG. BPMN/BPDM 1.0 is also a proposition done by OMG but it is not a UML profile. These two metamodels are quite old now. BPDM/BPMN 1.0 and SPEM 2.0 have both been published in 2008.

Based on SPEM 2.0, SysPem has been built to propose a whole consistent metamodel to answer to the problem of the potential lack of consistency between the different modeled processes and to answer to the specific systems engineering approach, whereas SPEM has been initially developed for Software engineering purpose [13]. Also, eSPEM has been developed to support lack of SPEM enactment and propose a solution for automated enactment of development processes [34]. Using the behavior modeling concepts from UML, the authors propose an extension of SPEM metamodel.

VI. OUR MODELING APPROACH

The MBSE is a successful approach to support system requirement, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. Models are used to represent the systems and enable to better master the design and the verification for complex systems which have to be compliant with a lot of requirements sometimes contradictory. This approach is widespread and largely approved in aeronautics industry. Models generally describe, additionally to nominal scenarios, any contingencies: alternative scenarios, emergency situations, exceptions, etc. Our research aims to use this approach to propose a solid, reproducible and verifiable methodology on BPM.

The main input for this research will be the EASA Regulation which is known as the Part-21. It may be set as a list of requirements which do not follow any expected rules of the requirements engineering discipline: clarity, unicity, non-ambiguity, testability, etc. The content is an aggregated text in English which force the interpretation and lead obviously to some misunderstandings. We propose then a modeling approach to make more formal the content of this text. This approach is composed of a-four-layer original architecture considering:

- a “Metamodel”,
- a “Business” model,
- a “Project” model,
- a set of instantiations to the “Project” model.

Moreover, the modeling approach will be led in two stages:

- a top-down stage
- a bottom-up stage

The top-down stage will begin with the “Metamodel” definition. The “Metamodel” layer could be supported by a specialized SPEM model or a BPMN/BPDM model according the necessities. This “Metamodel” will be the support to build the “business model” a formal construction of the regulation requirements from EASA administration, base of the certification work for any European manufacturer or equipment supplier of the aeronautics industry. This “Business” model will be completed by DO178C, DO254, ARP 4754A; ARP4761, and most probably by ISO 15288 and EN9100 to propose a good picture of the aeronautics context. All the expected Systems Engineering and Project Management processes will be thus represented in a set of consistent models. Then, applying some decision-making rules and optimization mechanisms on the “Business” model, another model dedicated to SMEs context, called “Project” model, will be supplied. In a sense, this model will be definitely simpler than the “Business” model but should provide more details for some activities.

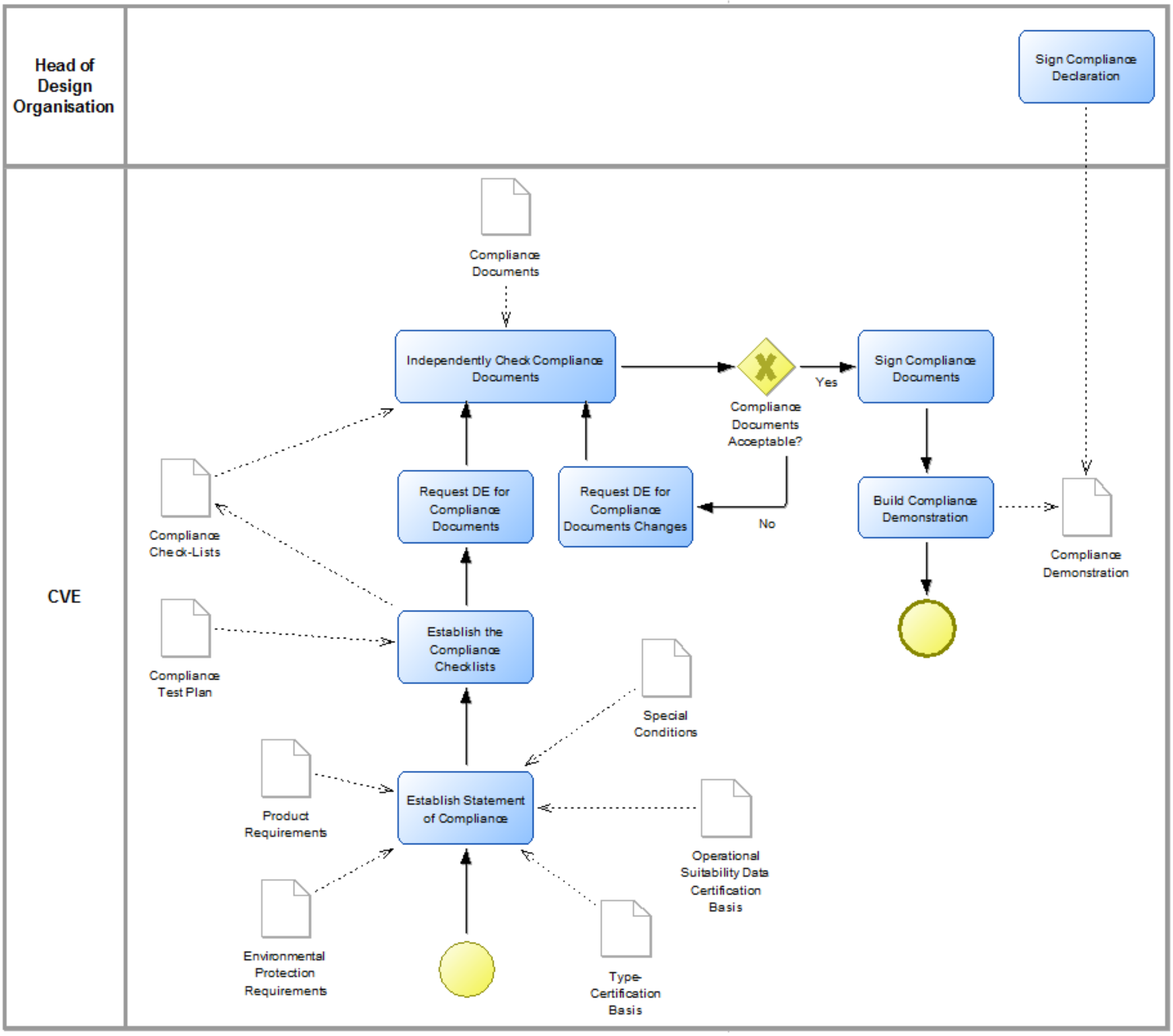

Fig. 5 BPMN diagram for the Independent Compliance Checking requested by Part-21

Finally, this last model will be confronted to real use cases coming from STAR ENGINEERING landscape supporting some innovative projects in their certification roadmap. The comparison between the "AS IS" models coming from SMEs and the "Project" model initially designed for them will enable to provide several instantiations which will lead to create probably new models more adequate to the specific context of each enterprise. Also, the bottom-up stage should be applied in parallel. Based on the information and knowledge coming from the SMEs, a model can be built and confronted to the ideal situation expected by the regulation.

The feedback from SMEs will be twofold: first, it will generate a status for all SMEs implied in this project. The cursor provided by the "Project" model could be seen as a target process model, a "TO BE" model. Secondly it will provide some feedback and criteria to evaluate the "Project" model and to identify some leverage to improve it.

Finally, we expect that our approach should contribute to answer to the double barriers:

- How formalize the regulation and the expected and informal requirements coming from diverse institutions and standards?
- How compare the built models to real life in SMEs?

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