Requirements Analysis and Modeling Process (RAMP) for the Development of Complex Systems

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Abstract: Requirement Analysis and Modeling Process (RAMP) is a new project born recently in France from a joint initiative between 3 major industrial companies belonging to different domains (Aerospace, Automotive, Energy), 2 SMEs (Service consulting, Tool supplier) and 3 Research Lab & Universities in order to improve the efficiency and quality of requirements expressed in natural language during the development of complex systems.
Starting from a common view of the problem from industrial partners and the state of art in Requirement Engineering and Modelling, this project intends to deliver short & mid term solutions based on existing tool as well as promising research tracks in this field though a singular partnership organisation under the umbrella of AFIS (French Chapter of INCOSE).

Introduction

Trends observed in the aerospace business highlight that the market is asking for more complex and innovative products and services in a shorter time while keeping cost under control [Murman2000]. Our observation is that the development of complex products is also more and more challenging, in other domains than aerospace such as automotive industry, energy, bio-medical …

We are therefore convinced that Requirements Engineering is a key success factor for current and future development of complex products, as highlighted in [GAO2004] [SGI2001] that shows that poor or lack of requirements is one of the main causes to project failures.

This issue has raised new needs for improving Requirements quality of complex development products, especially in terms of tools to assist engineers in their specification authoring activities.

This paper describes how a recent joint initiative undertaken in France between major industrial companies, universities / research lab and SME (Small Medium Enterprise) is born from a common vision of the problem.
This initiative has created RAMP (Requirement Analysis and Modelling Process) project from common needs expressed by 3 industrial companies (EADS, EDF, RENAULT), research studies done in Requirements Engineering (University of Paris 1, ENSTA, INRIA) and solutions proposed by SME (ADN, CORTIM).
The first part of this paper deals with the stated problem and description of needs from each industrial partners. Then an overview of the State of the Art and research activities is depicted in order to clearly state from which existing studies and prototype this project is starting from.
The selected tool LEXIOR which is used as basis for the project is then presented.
The last part of the paper present RAMP project in term of objectives and organisation.
A singular feature of RAMP is that it is the very first example of co-financed shared project fully supported by AFIS, the French Chapter of INCOSE.

Situation of the problems - Industrial needs

1 – Aerospace Domain

EADS is a global leader in aerospace, defence and related services. In 2008, EADS generated revenues of € 43.3 billion and employed a workforce of about 118,000. The Group includes Airbus as the leading manufacturer of commercial aircraft, with Airbus Military covering tanker, transport and mission aircraft, Eurocopter as the world's largest helicopter supplier and EADS Astrium, the European leader in space programmes from Ariane to Galileo. Its Defence & Security Division is a provider of comprehensive systems solutions and makes EADS the major partner in the Eurofighter consortium as well as a stakeholder in the missile systems provider MBDA.

Faced with the challenge to produce increasingly complex, world-class systems while reducing development cost and time to the market, EADS has put strong emphasis on a Lean concept in different phases of the development cycle (Manufacturing, Engineering, Supply Chain) and more recently in Systems Engineering.
For that purpose, a research dedicated project was recently launched under the basic principles of Lean Enablers for Systems Engineering (LEfSE) [INCOSE2009]
The goal is to propose advanced Systems Engineering approaches in order to support the different EADS Business Units in the development of their respective products (Aircraft, launcher, satellite, defence systems, etc.) in accordance with Lean Principles.

Among the multiple enablers, which are described in the LEfSE, the key objectives of this project are:

- to set-up up **an advanced approach for Requirements Development and Management** with the goal to ensure full coverage of Customers and Stakeholders needs for **the whole product life cycle and its related services** while mastering the **volume of requirements**.

- use the benefits of Modelling & Simulation to **enable earlier validation of design through a MBSE approach** (Model Based Systems Engineering) and therefore improve significantly the left part of V where most of activities shall be done.

Figure 1 here after depicts the present and future situation, showing where most of the effort is to be done, i.e., the left part of V cycle by re-enforcement of Requirements Engineering and MBSE.

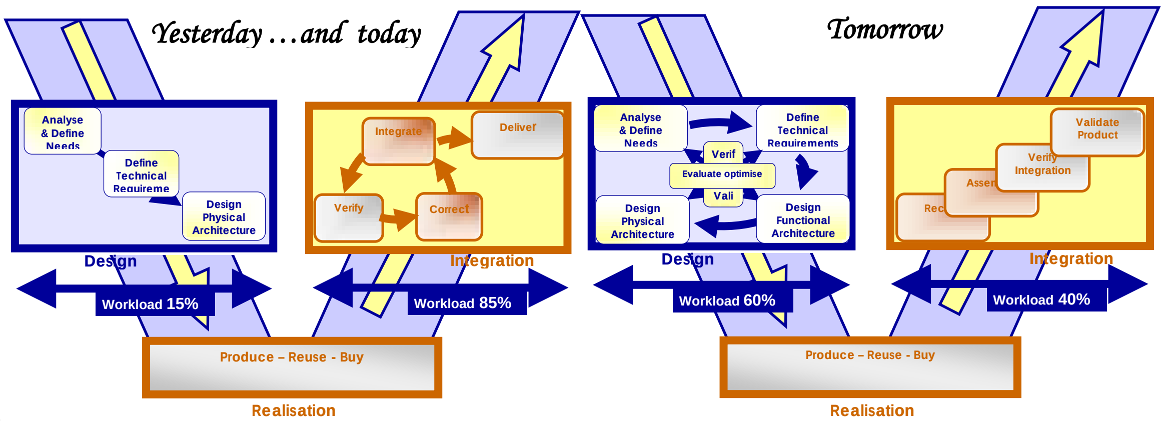

Figure 1: Evolution of the development cycle

In order to achieve this objective, EADS has captured and formalised short to long term challenges faced by their different Business Units in Systems Engineering. Among the captured challenges, 2 major topics were addressed which are Requirement Engineering and MBSE.

The major challenges which have been identified by EADS and subject to be treated by RAMP project are:

- To have the right requirements:
  - what the stakeholders really want (to bring value for customers in Lean approach)
  - only what is needed (to kill wastes in Lean approach)
- To have the requirements right (SMART[1])
- To master the volume and complexity of requirements
- To optimize the way to document the requirements
- To improve requirements verification through comparison between requirements and models

[1] *SMART: Specific, Measurable, Attainable, Realisable, Traceable*

Although an increasing number of initiatives are launched to introduce model-based approaches to requirements development, requirements are still mainly expressed textually in Natural Language.

Therefore, requirements engineering faces challenges to investigate opportunities to significantly improve the quality of textual requirements. There are different approaches to investigate such opportunities to improve requirements quality, which corresponds to the following R&D topics:

1. **Requirements Quality Monitoring**:
Requirements are considered as they are and investigations are focused on defining Process/Methods/Tools (PMT) to detect and highlight defective requirements. This approach is focused on individual requirements and quality is measured following the development of the requirements under investigation.

2. **Requirements Authoring and Structuring Support**:
A second level of improvement is to provide PMT to built requirements right from the start by guiding the analyst through a controlled language for instance. This approach is focused on both individual requirements and sets of requirements. This is a more advanced but more constraining approach that requires long-term investigation and experimentation.

3. **Management of Requirements Documentation**:
Requirements should not be considered as monolithic items but as dynamic and interdependent views evolving along the product lifecycle. Therefore, the way requirements are documented, associated and allocated to design documents has an influence on the performance of processes.

4. **Requirements Repository Monitoring and Analysis**:
This topic deals with RE process quality and does not address the quality of requirements as such as opposed to the 3 previous approaches. As a matter of fact, it is important for program managers to benefit from an overview on the requirements repository and more specifically on requirements volume and status evolutions in order to identify process deficiencies as early as possible. Alternatives to traditional reporting techniques are investigated as part of this approach.

5. **Requirements Reuse and Discovery**:
This last topic is very challenging from a research viewpoint and deals with the ability of organisations to reuse requirements from one development programme to the next, but also to discover requirements from data collected from customers during various marketing and design events in the preliminary design phase, as well as from in-service experience at later stages of the product life cycle.

2 – Automotive Industry domain

A group with industrial and commercial presence in 118 countries, Renault designs, develops, manufactures and sells innovative, safe and environmentally-friendly vehicles worldwide. In 2008, total turnover was around € 38 billions, for some 2,4 million produced vehicles. More than 124 000 employees contribute to a strategy of profitable growth based on three key factors: competitiveness, innovation and international expansion. Renault is Europe's leading brand, the only vehicle manufacturer to have eight cars with the maximum five-star Euro NCAP security rating, and the winner of the Formula 1 World Championship for Constructors and Drivers. The Group is accelerating its international development with the new Logan and pursuing the Alliance with Nissan. Renault aims at offering sustainable mobility for all. Considering that optimizing existing solutions will not be sufficient, part of the strategy relies in the mass marketing of electric vehicles.

Some key characteristics of automotive industry are:
- High volumes and huge diversity of products (ranges, options, local regulations, …),
- Very competitive market for consumer goods with high technical content offered to “non professional” users,
- Heavy investments in a worldwide manufacturing system,

- Majority of parts specified/purchased to suppliers.

These characteristics historically induced organizational and engineering aspects at Renault such as:

⇒ "Matrix" organization, allowing both efficient re-use and segment-targeted projects management,
⇒ Dedicated organization to manage Customer requirements on both specification & validation sides,
⇒ Key perimeters (engine control System, …) developed in "white-box" approach with full mastery of related on-board software,
⇒ Merged management of product development and plant adaptation,
⇒ Standard/optimized organization & process for parts development and interface with Tier1 companies.

Even if these aspects have proved efficient, the following trends call for an improvement in our Systems Engineering (SE) practice":

- **Many ongoing "breakthroughs" in product content**: Electric & Hybrid Vehicles, Advanced Driver Assistance Systems (ADAS), Telematics do not only bring new technologies or components, such as traction electric motors, radars, multimedia devices. They also push new architectures (e.g. brake by wire …), new use-cases (e.g. charge of an Electric Vehicle…), new technical perimeters (e.g. mixed on-board & off-board for guidance coupling with telematic services…). This single trend brings both growing complexity and partial obsolescence of previous architectures.

- **Emergence of automotive safety standards**: Considering the growth of new on-board functions including electronics whose failure can lead to hazardous car behavior, the automotive industry is currently building ISO26262 standard, based on the existing IEC 61508 which is a generic international standard for functional safety of Electric / Electronic systems. Reference [Chale2009] presents this future standard and its associated impacts, which include a strict application of a SE process.

- **Ever-increasing quest for engineering efficiency:** Standardization of Engineering « objects » (parts, but also specifications, validation plans, architectures …) is a key criterion for efficiency, allowing to concentrate on new features and to maximize re-use. Previous organization was good at standardizing two extreme objects, Customer requirements and parts, but less adapted to objects lying in the "in-between area", for which description, models and development processes were only partial and ad-hoc.

Those trends led recently to a major evolution in Renault engineering division: first, a list of systems was built, covering main classical functionalities (braking, air-conditioning…) and including innovative ones, as a relevant intermediate level to improve consistency between the whole vehicle and its elementary parts. Second, as it is a recognized way to manage complex perimeters, it was decided to deploy on those perimeters a standard SE process, in line with AFIS / INCOSE references, merged with some automotive specificities, for instance the management of re-usable system references [Chale2010]. As a result, standard SE data model, process and template documents were elaborated, and a CAE tools roadmap was built for improved efficiency and quality.

At the heart of this evolution is Requirements engineering, which operates at different levels (Vehicle, Systems, Parts). Indeed, even if SE processes, methods & tools were formerly partially used in some teams, the "scaling-up" induced by the deployment of SE brings along tremendous demands in terms of training, coaching, documents inspections… Requirements contained in System Technical Requirements (STR) and System Design documents are mostly written in natural language and must be reviewed, individually (for instance, for syntactic and semantic correctness), globally (for instance, for consistency of a set of requirements), and in their relationships with other objects described in system files (for instance, for coverage reports).

The RAMP project described in this paper aims at mechanizing some of these activities and so directly supports the ongoing SE deployment at Renault. The project will help reduce the workload for of system engineers and architects involved in System requirement authoring and, most particularly, that of "rare" engineers participating in documents reviews allowing them to concentrate on the added-value aspects of inspections.

3 – Energy domain

The EDF group is a leading player in the energy industry, present in all areas of the electricity value chain, from generation to trading, along with network management and the natural gas chain. In 2008, EDF group's consolidated sales totaled € 64.3 billion and EDF group had 160,913 employees worldwide. The group has a sound business model, evenly balanced between regulated and deregulated activities. It is the leader in the French and British electricity markets and has solid positions in Germany and Italy. The Group has a portfolio of 38.1 million customers in Europe and the world's premier nuclear generation fleet.

One of EDF group core businesses is power generation, in which EDF is the owner and the operator, but also is involved in the industrial architecture definition of its power plants (fossil-fired, hydro, renewable and nuclear power plants). Moreover, EDF has a key role in proving the correct functioning of its power generation plants to the safety authorities, whose requirements can be different depending from a country to another one. In a nuclear power plant, instrumentation and control systems make up the "nervous system" of the plant process. Their implementation is mostly based on components off the shelf. With an outlook to extend our nuclear power plants' lifetime till 60 years, long-lasting maintenance of the functionalities implemented by these systems is decisive in order to insure the nuclear reactors safety and performances criteria in the long term.

The durability of the technical skills in EDF group, but also among its suppliers, and the preparation of even partial retrofit projects of process control systems require capitalization of knowledge by keeping for a long time our whole set of requirements complete, with their allocations to the design architecture and components to justify the design choices and to evaluate the impact of evolutions. To do that, EDF Research and Development maintains a strategic and technical survey in Requirements Engineering in order to verify that the referential is formalized in a complete and non ambiguous manner as regards the functional needs definition and the system different functioning modes (included its degraded modes) and that the referential will be kept up in spite of the generations renewal.

EDF utility has first to collect the requirements of both its operating (the end user) and engineering teams, then to verify the consistency and completeness of this set, to communicate with its suppliers, and finally to verify that suppliers' solutions including products and services fulfill this whole specification, for instance by means of platform and site validation. Meanwhile the requirements traceability should be carried out: for instance, the links between requirements and design choices, or between requirements and validation tests.

The requirements to be satisfied belong to several categories such as availability, safety, time performance, environmental qualification, etc. So they come from different actors within EDF and have to be understood by different suppliers. The requirements are mainly described with natural language but some functional requirements can be also expressed with diagrams.

The requirements can concern either the initial design or a modernization of a power plant. Even if the process does not change throughout the power plant long lifetime, modernizations can be necessary due to aging or obsolescence of instrumentation and control components, evolution of standards, needs of new functionalities, etc. So in a modernization project, some requirements can have changed since the initial design, but other requirements remain the same.

So the set of requirements should be as correct, unambiguous and coherent as possible because it has to be understood by many different actors and to be capitalized during decades.

Different models are used in EDF. Their simulations are dedicated to safety evaluation, functions optimization, operators training, etc. But the links between these models and some textual requirements can be strengthened to make the requirements more accurate and better validated.

The use of RAMP project approach can help EDF to achieve the challenging goal of improving the correctness, coherence and completeness of the high volume of requirements expressed in natural language in the existing specification documents.

As conclusion, EDF needs in requirements engineering consist in:

- Reusing existing requirements.
- Expressing new requirements.
- Validating the coherence and the completeness of all the requirements from operating, maintenance, engineering teams.
- Communicating clearly with the suppliers.
- Updating the set of requirements with their evolutions and their impact on design and validation.

State of the Art – Research activities

There is probably no other language as expressive as natural language, which may be the reason why requirements specifications are mostly specified using natural language. One good thing about natural language is that everybody is familiar with it. This can in fact be even critical, for instance when end users, who are not comfortable with formal notations, are involved in the discovery, specification, or validation of requirements [Goldin1997].

The downside with natural language is that it is sometimes of poor quality. The consequence for requirements engineering is important. Empirical studies provide evidence that the difficulties and communication breakdowns experienced during requirements engineering activities are largely due to the use of natural language [Robinson1999]. As their impact can be sensed in the rest of the systems lifecycle, identifying the defects of the natural language requirements specifications is a crucial issue.

Unfortunately, identifying the defects of a requirements specification is a cumbersome and error prone activity. It was for example shown that in practice the detection of synonyms in requirements specifications mostly relies on human analyst's domain knowledge

[Kiyavitskaya2008]. On the other hand, Cheng and Atlee's [Cheng2007] detailed state of the art of requirements engineering shows that there is no sufficient tool support for most of the complex and time consuming tasks achieved manually during requirements engineering. Not only automating parts of these tasks can speed up the processing times of requirements but also it can decrease error rates. Many prototype tools exploiting linguistic theories to support requirements engineering tasks in a more or less systematic way have already been developed. For instance general purpose linguistic tools that were proposed to support ambiguity detection [Wilson1997] [Fabbrini2001] [Mich2002] [Garigliano1998] proved successful in other domains such as message understanding [Sundheim1996]. It is therefore very likely that the approaches behind these linguistic based requirements engineering tools are ready for industrialization.

The purpose of this section is to review approaches available to handle requirements specified in natural language. One particular criterion for selecting tools and research proposals was that they are supported by a tool. The rest of the section is divided into two parts. The first part deals with defects in natural language requirements specification, which as the previous section showed it, is a common critical concern for the 3 industrials involved in the RAMP project. The second part is an outlook on another important issue: the relationship between natural language requirements specifications and specifications formalized otherwise, e.g. by conceptual models or formal specifications.

Handling defects in natural language requirements specifications

There can be numerous kinds of defects in natural language requirements: ambiguity, incompleteness, inconsistency. Linguistic tools such as QuARS [Fabbrini2001], ARM [Wilson1997], KANT [Mitamura1999], LOLITA [Garigliano1998], NLOOPS [Mich2002] showed they could play a crucial role in the detection and measurement of various kinds of defects such as vagueness, subjectivity, optionality, or weakness of the requirements specification.

LOLITA is a general purpose natural language analysis tool that was used by Mich and Gaglioarno to calculate indices of ambiguity of natural language requirements specifications [Mich2000]. For a given word, an ambiguity index is calculated as a function of the number of meanings and of the number of syntactic roles that the word plays in the text.

QuARS (Quality Analyzer of Requirement Specification) is based on a quality model of natural language requirements specifications. The quality model specifies lexical, syntactic, structural, and semantic defects that appear in requirements specifications. Various linguistic analysis techniques are exploited to implement the detection of potential defects as defined in the quality model. Once QuARS has identified a defect in a requirements specification, it is up to the user to decide whether to modify it or not. The collection of quality metrics proposed by QuARS was recently extended with new defect indicators [Berry2006].

ARM (Automated Requirement Measurement) [Wilson1997] was developed by NASA to guide the analysis of natural language requirements specifications. Like QuARS, ARM is based on a quality model and highlights potential defects once they are detected.

Other approaches were proposed to deal with defects in natural language requirements specifications: for example using requirements specification patterns [Denger2003], or similarity analysis and reformulation [Boyd2007]. Another example is the ReqSimile tool that uses statistical analysis to cluster requirements then identify duplicates and eliminate them from a requirements document [NattOchDag2005]. While they can be used to handle defect in natural language requirements specifications once they are written, other approaches were developed to minimize the number of defects beforehand This is for example the case of the KANT system [Mitamura1999] that introduces various kinds of restrictions on the “natural” language that can be used in requirements specifications: constrained lexicon, constrained grammar, acceptable noun compounding, and domain model to constrain the semantics. Similarly, an unambiguous sub-set of natural language that can be used in a requirements specification was defined in [Fuchs1996].

While the aforementioned tools are research prototypes issued by research laboratories, other tools such as Requirements Assistant or Doors RQA can be quoted on the industrial side.

Requirements Assistant is a requirements engineering tool that was developed by Sunny Hills Consulting, Netherlands. Packaged in a web application in the latest release (called RAWeb), it enables to parse and analyze requirements in preformatted textual format. RAWeb is able to identify missing requirements on topics that should have been addressed in the original specifications. Detailed reports on quality are available for each requirement while overall metrics and figures are consolidated at the specification level with regard to specific quality criteria (testability, completeness, consistency, readability, accuracy).

DOORS Requirements Quality Analyzer (RQA) was developed by The Reuse company in Spain. This tool, that is fully connected to DOORS repository, provides two different ways to handle the quality of natural language requirements specifications: one by guiding requirements authoring and the other one dedicated to requirements review. DOORS RQA relies on linguistic techniques to analyze various requirements quality aspects such as: ambiguous, subjective, implicit, or speculative sentences. It is also able to provide more general information such as volatility or number of dependences regarding requirements contained in the repository.

LEXIOR has been developed by CORTIM five years ago for the European Space Agency, and aims at assisting the review of specification documents stored in various format such as DOORS, Word or PDF. Based on an English lexical analyzer, it parses every requirements and assesses best practice rules to detect potential defects at requirement level. It contributes also to assess the consistency of the document. The tool, through its web interface, offers a large panel of statistics, graphs and reports.

Relating natural language requirements with more formal specifications

Nuseibeh and Easterbrook’s [Nuseibeh2000] road map of future requirements engineering research quotes the development of new techniques to bridge the gap between natural language and formal specifications as one important research issue for the future. As market surveys [Mich2004] shows it, bridging the gap between natural language and more formal specifications, e.g. to accelerate the production of models, or to integrate requirements engineering tools with other systems engineering tools. Many tool supported approaches where proposed since NIAM [Nijssen1989] seminal ideas to integrate natural language processing with conceptual modeling: AMADEUS [Kersten1986], SECSI [Bouzeghoub1985], OICSI [Proix1990], CREWS-L’Ecritoire [BenAchour1999] [BenAchour1997], CIRCE [Ambriola2006], OsmOSE [Kla2004], OORA [Belkhouche 93], or NL-OOPS [Mich2002], just to name a few. These approaches are mostly based on three elements: a linguistic model, natural language parsing rules, and transformation rules.

While lexico-syntactic linguistic models allow to handle a surface level, semantic based models allow to reason on a deeper level of natural language. Parsing rules can be based on various approaches: statistical, based on a grammar, or based on general heuristics. They can produce tagged texts or structured derivation trees that are used as the input of transformations.

Tools such as AMADEUS, SECSI, or OICSI are based on a syntactic grammar of natural language subsets. The main problem of these approaches is the inherent constraint put by the restricted linguistic model on the specification of so-called “natural language” requirements specification. Not only this puts a limit on the transformations made possible, but also it is an obstacle to parsing when the analyzed requirements specification has defects. Being restricted to a subset of natural language it is unlikely that these tools have the level of pervasiveness and easiness of use expected in an industrial requirements engineering tool.

Semantic-based approaches such as [Kla2004], [BenAchour1999], [Belkhouche1993], or [Mich2002] also allow to specify requirements in a less restricted form of natural language. These models are based on semantics cases theory [Fillmore1968] according to which the meaning of simple sentences can be defined through the meaning of their main verb and of the connected ‘cases’. Since cases independent from the syntax level of language, a larger sample of natural language can be parsed and richer rules can be used to support transformation to the target formalism. The semantics level can also be tackled using ontologies.
The Ontology-driven Requirements Engineering Methodology (OntoREM) is an ontology-driven approach to requirements engineering, which was developed and tested in a series of applications in different domains of the aerospace industry with the objective to assess the extent to which this approach has the potential to develop better quality requirements in less time and at less cost compared to traditional requirements engineering processes. OntoREM is subject to a joint research project between Airbus and the University of West England and is a major initiative in this domain with the goal to improve knowledge transfer from one aircraft development programme to the next and contribute to improve requirements quality while reducing development time and costs [Kossmann09].

Bridging the gap between natural language requirements specifications and conceptual models can also be achieved the other way round. This is illustrated by the GeNLangUML (Generating Natural Language from UML) system that generates English specifications from UML class diagrams [Meziane2008]. The generated text can be used for validation by stakeholders of checked for consistency with other requirements.

Complementarily, several approaches propose requirements authoring guidelines [Salinesi2004]. It was demonstrated that such guidelines are effective to avoid many defects and improve the pervasiveness of parsing and transformation functions. However, their efficiency tends to diminish as soon as the authors have more experience in requirements authoring [BenAchour1999b].

Common errors affecting requirements quality

To support the analysis of a requirement documents, it is worth to investigate errors types and information. This is independent of the nature of the analysis that could be performed manually or computer aided. Such approach is generally called error abstraction process. Considering all possible errors, the objective is to define and document a Generic Errors Taxonomy (GET). While analyzing a requirement document, the challenges is then to identify potential errors in requirements documents with regards to the taxonomy of generic errors.
There were several attempts in the past to identify such a GET and most of them have already been reviewed by previous EADS IW projects and initiatives.

Meyer proposes a general list of errors observed in NL specification [Meyer1985] . This list is provided has to keep in mind that this list, also referred as the *"seven sins of the specifier"* and provided below, mainly relies on the author software development experience.

- **Noise:** The presence in the text of an element that does not carry information relevant to any feature of the problem[2].
- **Silence:** the existence of feature of the problem that is not covered by any element of the text.
- **Over-specification:** the presence in the text of an element that corresponds not to a feature of the problem but to features of a possible solution.
- **Contradiction:** the presence in the text of two or more elements that define a feature of the system in an incompatible way.
- **Ambiguity:** the presence in the text of an element that makes it possible to interpret a feature of the problem in at least two different ways.
- **Forward reference:** the presence in the text of an element that use features of the problem not defined until later in the text.
- **Wishful thinking:** the presence in the text of an element that defines a feature of the problem in such a way that a candidate solution cannot realistically be validated with respect to this feature

[2] *Redundancy and Remorse are variants of Noise*

At this point, it is interesting to notice that one of the errors mentioned above, silence, is particularly difficult to detect even through inspection. As a matter of fact, how is it possible to demonstrate the absence of a feature?
Hooks in [Hooks1993], discuss a similar list with more SE considerations. According to Hooks the common problems observed when writing requirements are:

- Making bad assumptions;
- Writing implementation instead of requirements;
- Describing operations instead of writing requirements;
- Using incorrect terms ;
- Using incorrect sentences structure of bad grammar
- Missing requirements
- Over-specifying

All the potential errors can produce some effects which can severely damage the performances of the company if not controlled through a proper quality system. They are depicted here below :

- **Over-specification:** leading to increased costs (also decreased reliability due to increase in complexity)
- **Under-specification:** leading to customer dissatisfaction
- **Mis-specification:** leading to re-design and/or modifications

From these different but consistent views on errors, it is possible to build a Generic Errors Taxonomy (Figure 2) in order to refine the "documentation errors" branch from the taxonomy proposed by [Walia2009]. GET provides a categorization of errors according to the three classes of effects discussed previously, i.e. Over-Specification, Under-Specification and Mis-Specification
The GET taxonomy enables the definition of an error abstraction process for both manual and assisted inspections.

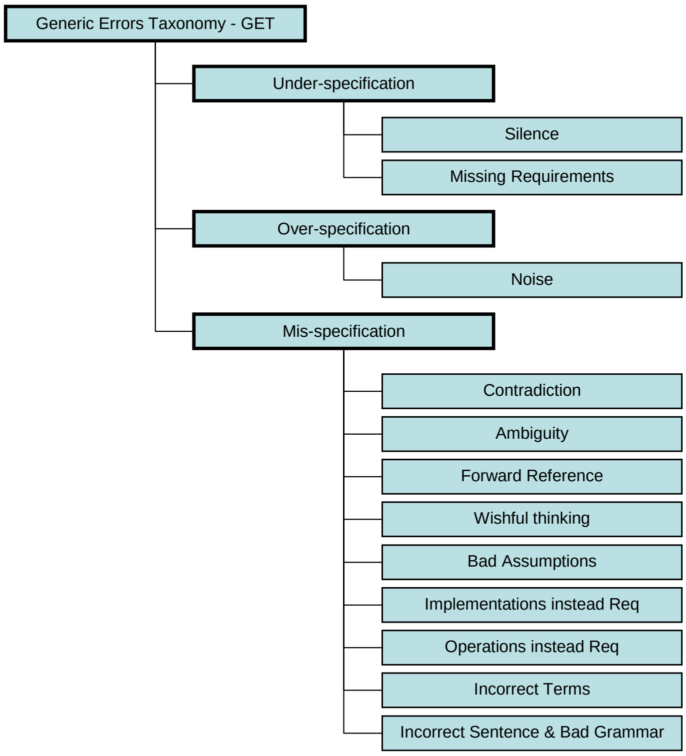

Figure 2: Generic Errors Taxonomy – GET

Potential solutions – Existing Tool

CORTIM has developed a prototype tool that helps reduce the overheads generated by requirements handling for complex systems development. Figure 3 presents a global vision of a Requirements Engineering (RE) tool that could improve the requirements development lifecycle for both legacy and new requirements processing:

- Legacy requirements processing handles those requirements that have already been written and are available in existing documents. Such documents are likely to have been written according to various standards, requiring format, structure and content checking to ensure consistency and adhesion to a common set of RE best practices. Content reports, containing statistical data or requirements inconsistencies are produced and the resultant “checked” requirements stored into the common requirements repository.

- New requirements processing uses a more interactive editing means. The requirements repository provides a rich source of requirements information that can be fully or partially reused for developing new ones. An interactive editing wizard could provide document templates, repository searching mechanisms and an automated means of checking using the same rules as those for processing the legacy requirements processing.

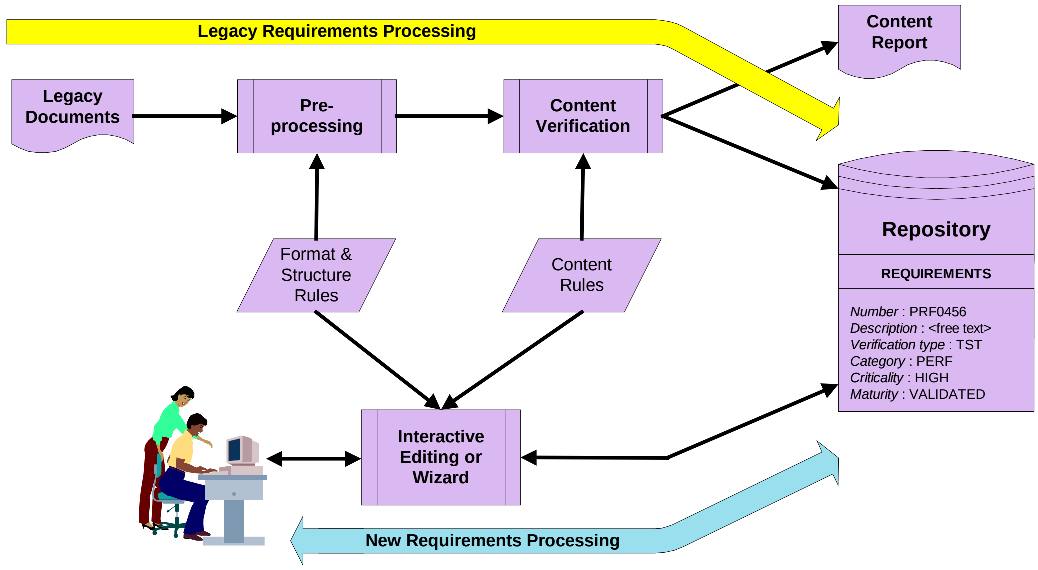

Figure 3 - Global Vision for Requirements Engineering Tool

This global vision is characterised by two key elements:

- Requirement Best Practices: Format, Structure and Content rules capturing Best Practices for requirements specifications in the specific domain of embedded systems for space applications,
- Checker/Wizard: Lexical analysis and parsing for pre-processing, content verification and interactive writing/editing according to a set of predefined best practices.

Requirement Best Practices

Requirements are at the heart of the embedded systems development process. They form a contract between the system requester and the industrial developer committed to delivering the end product. Requirements Engineering enables the establishment of a common and unambiguous understanding via agreed methods, rules and processes. Some rules already exist in the form of guidelines and standards for developing requirement documents for space applications. Indeed, the critical nature of space applications readily lends itself to the implementation of clearly structured document formats, writing styles and precise specification rules. The expression of a requirement needs to be as explicit as possible, which means that a reduced language syntax and domain-based vocabulary can be used.

As identified in Figure 3 above, these elements can be captured in the form of:

- format and structure rules for document parts that are concerned with presentation aspects of a documents (e.g. chapter titles & document structure)
- content rules that are concerned with the requirements structure and semantics details. The content rules are tightly linked with the type of equipment being specified or the type of requirement (e.g. a performance requirement can be recognised via a fixed structure, must contain certain keywords and a measure of time).

These rules establish the model or patterns with which the requirement documents will be compared or validated. The concept depicted in Figure 3 shows that format and content rules can be used to generate content reports. An example of this type of application could be to “check” an equipment specification during a formal contractor review process. A global document “Format Content Report” could be generated by the tooling and submitted to the contractor as a set of Review Item Dispositions (RIDs), thus enabling the reviewer to offload such a time-consuming step to automated tools. The reviewer’s job could concentrate on verifying other value-added aspects not checked by the tooling, such as determining whether the system is really “fit-for-intended-purpose”. It was this scenario that was put to the test in the frame of the LEXIOR project.

A “**Requirements Best Practices**” workshop was held with selected members of the European Space Agency, the ECSS-E10 Systems Engineering Working Group, and the International Council on Systems Engineering (INCOSE). The following table provides the list of best practices, agreed during the workshop, that would be validated with the aid of the LEXIOR Specification Verification Tool prototype. Note that during this study, the rules that were defined were limited to General Rules only. However, many other types of rules could be investigated in a future study such as performance and interface requirements rules.

Rule Identifier	Rule Description	Explanatory Comments
RG1	A clear distinction shall be made between requirements and statements included only for information or guidance.	A requirement is recognised by the verbal form “shall”. *The bus controller shall respond within 3 seconds.*
RG2	Requirements relevant to different aspects shall be presented as separate clauses or sub clauses.	This should be split into two clauses: *The bus controller shall respond within 3 seconds and it shall poll for incoming ground commands.*
RG3	The subject of the « shall » verb shall be defined in the document.	The bus controller is the defined subject: *In the event of a fatal exception, the bus controller shall provide a visual signal to the front panel.*
RG4	Requirements shall be allocated a unique identifier.	*BC-0233, Functional. In the event of a fatal exception, the bus controller shall provide a visual signal to the front panel.*
RG5	Requirements should be allocated a requirement type.	*BC-0233, Functional. In the event of a fatal exception, the bus controller shall provide a visual signal to the front panel.*
RG6	Use of existing references and data dictionaries should be made (use of common reference).	MIL-1553B should be an agreed reference: *The bus controller protocol shall conform to the standard MIL-1553B.*
RG7	Use of recognised forbidden words must be rejected.	Vaguely should be rejected: *The bus controller protocol shall vaguely conform to the standard MIL-1553B.*
RG8	Requirements should be expressed in a correct grammatical form to avoid risks of misinterpretation.	Without the word “within”, this sentence would be grammatically incorrect: *The GPS absolute position fix shall be obtained within 180 seconds.*

Table 1 – Requirements Best Practice Rules Selected for LEXIOR Validation

Checker/Wizard

The purpose of a lexical analyser is to take a stream of input characters (e.g. a Legacy document or new requirements) and decode them into higher-level information items (or tokens) that a domain-based rule checker can understand. A domain-based rule checker then analyses the requirements according to the specific best practice rules. A lexical analyser and associated domain-based rules checker was used to analyse existing or new embedded systems requirements and identify any basic construction errors. There are a number of lexical analysis tools, parsers and associated methods available on the market today. Some are commercially available and others used for non-profit making research purposes. The lexical analyser selected for the purposes of this study is the Link Grammar Parser from Carnegie Mellon University.

Study Results – "Real World" Specification Examples

In order to validate our approach, the prototype Specification Verification Tool developed in the frame of the LEXIOR project was used to verify several operational specifications submitted in the PDF document format. They were analysed and a set of Review Items Disposition Sheets were produced automatically in the PDF document format. The correction of the errors reported by the tool improved the requirements specifications analysed. This usage concept is depicted in the diagrams below:

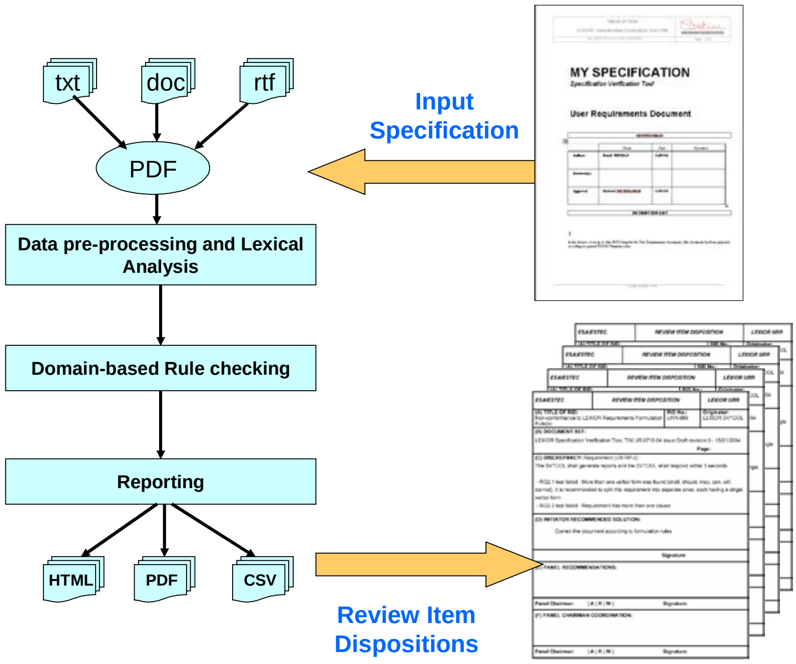

Figure 4 – LEXIOR Prototype Specification Verification Tool Process

The Prototype Specification Verification tool has been used on real-world requirements documents, such as System Specification, On-Board Software Specification and also Ground tool Specification.

These documents contained up to 4000 requirements and were successfully processed overnight by the tool. The ratio of "well formulated" requirements varies in the range of 75% of the total amount of requirements, even for documents having passed several manual reviews. The tool automatically generates RIDs, and it appears reasonable to submit at least the top 50 critical RIDs during the Requirements Review.

Overall presentation of RAMP Project

The RAMP project includes a research platform

The project RAMP, Requirements Analysis and Modeling Process consists in a research platform. This project is hosted under the umbrella of the new AFIS organization.

Partnership:

The partners involved in the project are various and complementary:

- Various by the domains of application.
  EADS in Aeronautics, Space, Defence and Security.
  EDF in Energy
  RENAULT in Automotive
  ADN in Life Sciences
- Complementary by the skills and competences
  Industries - EADS, EDF, and RENAULT: by their commonalities and specificities in engineering complex systems in their domain.
  Laboratories - University Paris 1 Sorbonne, ENSTA, INRIA: by their research on the state of the art in requirements, modeling, ontology, and natural language.
  Small enterprises (consulting companies) – ADN and CORTIM: by their knowledge of the state of the art in requirements good practices, models and tools.

Research platform:

The project has for objective to strengthen the quality of requirements baselines to improve the management of complex systems. This quality is obtained via assistance to the writing and the analysis of requirements. The evacuation of requirements form issues allows the actors to focus on the real substance of requirements.
The point of departure of the project is the syntactic analysis of the quality of the requirements written in natural language, taken individually. This analysis is made via an existing prototype LEXIOR, developed by the company CORTIM.
The end point of the project is the quality of a set of requirements, within a RAMP tooled platform research:

- The automatic identification of redundancies or similar textual requirements
- The extraction of data allowing the formalization of requirements and their environment via the analysis of scenarios
- The creation, exploitation and re-use of business know-how by the use of ontologies and other models.

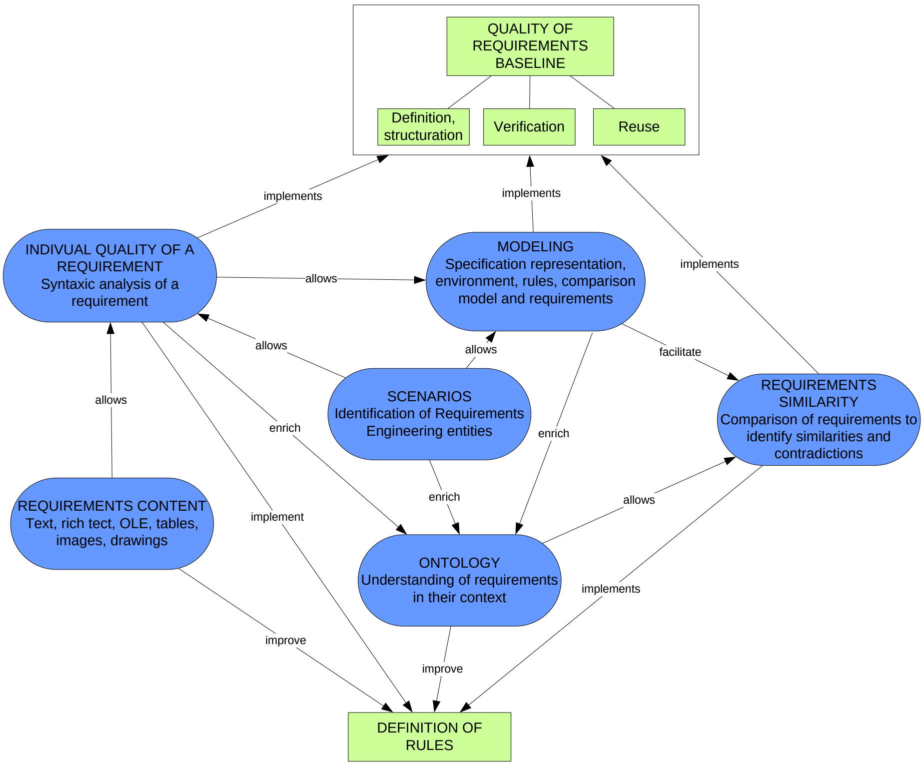

Figure 5 - RAMP Platform

Individual quality of a requirement: a requirement has to be MUST (Measurable, Useful, Simple, Traceable) or SMART (Specific, Measurable, Attainable, Realizable, Traceable). The assistance to the diagnosis of requirements with regard to writing rules helps in obtaining quality requirements

Ontologies: the ontologies allow the capitalization of the Business know-how. The assistance to the identification and the characterization of the nature of a requirement in a Business context allows making sure of the appropriate re-use of the requirements in their context. It is also an entry for the analysis of the similarity of requirements.

Similarity of requirements: the evaluation of the degree of similarity of requirements allows defining the possible redundancy and the contradictions of requirements.

Scenarios: the scenarios are often written by operational and contain multiple information. Their analysis allows identifying the involved entities the Requirements Engineering process: requirements, functions, conditions, interfaces, systems…

Modeling: writing requirements is complex and may require other forms of representation more adapted than the textual expression. Diagrams, models can be used in complement or by comparison with textual requirements in the goal of exhaustiveness and consistency.

Requirements content: various forms of requirements expression are to be taken into account: text, drawings, and graphs. Considering these various forms is necessary to take into account this diversity.

RAMP project in AFIS Technical Committees

The project is driven by the “Global Processes” Technical Committee of the new AFIS organization.

Within AFIS, a Technical Committee is composed of experts of the domain (from 5 to 40, variable according to domains). A Technical Committee replaces the Working Groups of the previous AFIS organization. The goal of a TC is develop value added deliverables for AFIS members, in a quite short duration. A TC is based in a project mode.

In its field of expertise a Technical Committee (TC) propose to the Board of directors (CA) a list of projects.
After selection of the projects by the CA, the TCs pilot the realization of the project and confirm the results.

Different types of projects can be considered: Investigation Groups (IG), Project Groups (PG) or Co financed shared Projects (CP).
Investigation Groups (IG) are groups of volunteers that work on new subjects or subjects that need exchanges between members of one or several technical committees, before defining a project.
Project Groups (PG) are groups of volunteers (there are no major modifications of the composition of the group during a project) that work on generic deliverables.
Co financed Shared Projects (CP) concern projects where several AFIS members share the same needs and specific objectives and decide to share their efforts and resources. The results of the project are shared by the partners of the project. The intellectual property of the results is individually defined.

RAMP is a Co financed Shared Project.

The roadmap is to initialize the project within AFIS to consolidate the needs and the state of the art in modeling and ontology.

Conclusion

First “Chaos” report from Standish group reported in 1994 that lack of requirement engineering was the main cause of project failure. This issue is still a main concern in the industry, even if tremendous progress has been made in the past years on processes, good practices and use of dedicated tools.
Natural language is the most common way used to describe requirements. Some initiatives have been made to replace requirements in natural language by requirements with formal description or requirements with model. But these initiatives are most often limited to a specific discipline or domain.

The RAMP project intends in short term to help users to improve significantly the writing of requirements in natural language. In a medium term, it intends to bridge the gap between traditional requirements writing and model based approaches.

LEXIOR is a framework where new services will emerge and will be gradually integrated.

References

[Ambriola2006] V. Ambriola, V. Gervasi. Analysis of Natural Language Requirements with CIRCE. Automated Software Engineering, Springer Volume 13, Number 1. January 2006

[Belkouche1993] B. Belkouche, J. Kozma, Semantic Case Analysis of Informal Requirements. Proceedings of NGCT’93, 4th Workshop on the Next Generation of CASE Tools, (S. Brinkkemper, F. Harmsen, eds), Memoranda Informatica 93-32, Twente, The Netherlands, pp.163-182, 1993.

[BenAchour1997] C.Ben Achour. Linguistic Instruments for the Integration of Scenarios in Requirements Engineering. Proceedings of the 3rd International workshop on Requirements Engineering, Foundation forSoftware Quality. Barcelona, Spain, pp. 93-106, (ed. E. Dubois, A. Opdahl, K. Pohl), Presses Universitaires de Namur. June 1997.

[BenAchour1999] C. Ben Achour-Salinesi. Extraction des Besoins par Analyse de Scénarios Textuels. PhD dissertation. Université Paris 6 Pierre et Marie Curie. January 1999.

[BenAchour1999b] C. Ben Achour, C. Rolland, N.A.M. Maiden, C. Souveyet. Guiding Use Case Authoring : Results of an Empirical Study. Proceedings of RE'99, fourth IEEE International Symposium on Requirements Engineering, 7-11 June 1999, University of Limerick, Ireland.

[Berry2006] Berry, D.M., Bucchiarone, A., Gnesi, S., Lami, G., Trentanni, G.: A new quality model for natural language requirements specifications. In: Proceedings of the International Workshop on Requirements Engineering: Foundation of Software Quality (REFSQ). (2006)

[Bouzeghoub1985] M. Bouzeghoub, G. Gardarin, E. Metais, Database Design Tools : an Expert System Approach. Proceedings of the 11th Conference on Very Large Databases, pp.82-95, August 1985.

[Boyd2007] S. Boyd, D. Zowghi, and V. Gervasi. Optimal-constraint lexicons for requirements specifications. Proceedings of the 13th International Working Conference on Requirements Engineering: Foundation for Software Quality, Trondheim, Norway, June 2007.

[Chale2009] Chalé Góngora H G, Taofifenua O, Gaudré T: Conception de systèmes critiques automobiles – Etude de mise en oeuvre de la norme ISO26262. In Proceedings of 5ème Conférence Annuelle AFIS (Paris, France) (2009)

[Chale2010] Chalé Góngora H G, Taofifenua O, Gaudré T: A Process and Data Model for Automotive Safety-Critical Systems Design. Submitted to: INCOSE Interational Symposium (2010)

[Cheng2007] B. H. C. Cheng and J. M. Atlee, “Research Directions in Requirements Engineering,” in Proc. Future of Software Engineering FOSE ’07, 23–25 May 2007, pp. 285–303.

[Fabbrini2001] Fabbrini, F., Fusani, M., Gnesi, S., Lami, G.: The linguistic approach to the natural language requirements, quality: Benefits of the use of an automatic tool. In: Proceedings of the Twenty-Sixth Annual IEEE Computer Society - NASA GSFC Software Engineering Workshop. (2001) 97–105

[Fillmore1968] Charles Fillmore, The Case for Case. In Universals in Linguistic Theory.E. Bach, R. Harms (eds), Holt, Rinehart and Winston Publishing Company, pp.1-90, 1968.

[GAO2004] United States General Accounting Office, Defense Acquisition: Stronger Management practices are needed to improve DOD's software-intensive weapon acquisitions, 2004

[Garigliano1998] Garigliano, R., Urbanowicz, A., Nettleton, D.J.: Description of the LOLITA system as used in MUC-7. In: Proceedings of the Message Understanding Conference (MUC-7). (1998) http://acl.ldc.upenn.edu/muc7/.

[Goldin1997] L. Goldin and D. M. Berry, "AbstFinder, A Prototype Natural Language Text Abstraction Finder for Use in Requirements Elicitation," Automated Software Engg., vol. 4, no. 4, pp. 375–412, 1997.

[Hooks1993] Hooks I., Writing good Requirements, Proceedings of the Third International Symposium of the NCOSE - Volume 2, 1993.

[INCOSE2009] INCOSE Lean Systems Engineering WG, Lean Enablers for Systems Engineering, Version 1.0, 2009

[Kersten1986] M.L. Kersten, H. Weigand, F. Dignum, J. Proom, A Conceptual Modelling Expert System. Fifth International Conference on the Entity Relationship Approach, Dijon, 1986.

[Kla2004] R. Kla. OSMOSE: A Natural Language Based Object Oriented Approach with its CASE Tool. PHD dissertation. Univertsité Paris 1 Panthéon Sorbonne. June 2004.

[Kossmann09] M. Kossmann, M. Odeh, A. Gillies, S. Watts, Ontology-driven Requirements Engineering with Reference to the Aerospace Industry, ICADIWT '09, IEEE, London, UK, 2009.

[Meyer1985] Meyer B., On Formalism in Specification, IEEE Software, 6-26. Jan. 1985

[Meziane2008] F. Meziane, N. Athanasakis, S. Ananiadou. Generating Natural Language specifications from UML class diagrams. Requirements Engineering Journal 13:1–18. 2008

[Mich2000] Mich, L., Garigliano, R.: Ambiguity measures in requirement engineering. In Feng, Y., Notkin, D., Gaudel, M., eds.: Proceedings of International Conference on Software—Theory and Practice (ICS2000), Sixteenth IFIP World Computer Congress, Beijing, Publishing House of Electronics Industry (2000) 39–48

[Mich2002] Mich, L., Garigliano, R.: NL-OOPS: A requirements analysis tool based on natural language processing. In: Proceedings of Third International Conference on Data Mining. (2002) 321–330

[Mich2004] Mich, L., Franch, M., Inverardi, P.N.: Requirements analysis using linguistic tools: Results of an on-line survey. Requirements Engineering Journal 9 (2004) 40–56

[Mitamura1999] Mitamura, T.: Controlled language for multilingual machine translation. In: Proceedingsof Machine Translation Summit VII. (1999)

[Murman2000] Murman, E.M., Walton, M. and Rebentisch, E., Challenges in the Better, Faster, Cheaper Era of Aeronautical Design, Engineering and Manufacturing, The Aeronautical Journal, Oct 2000, pp 481-489.

[NattOchDag2005] J Natt Och Dag, B. Regnell, V. Gervasi, S. Brinkkemper. A Linguistic-Engineering Approach to Large-Scale Requirements Management. IEEE Software February 2005. Pp 32-35.

[Nijssen1989] G. Nijssen, T. Halpin. Conceptual Schema and Relational Database Design. Prentice Hall, Sydney. 1989

[Nuseibeh2000] B. Nuseibeh and S. Easterbrook, “Requirements engineering: a roadmap,” in ICSE ’00: Proceedings of the Conference on The Future of Software Engineering. New York, NY, USA: ACM Press, 2000, pp. 35–46.

[Proix1990] Christophe Proix. OICSI: an information system design tool: specification and realizattion. PhD Dissertation. Université Paris 6 Pierre et Marie Curie. 1990.

[Robinson1999] W. N. Robinson and S. D. Pawlowski, “Managing requirements inconsistency with development goal monitors,” vol. 25, no. 6, pp. 816–835, Nov.–Dec. 1999.

[Salinesi2004] Camille Salinesi. Authoring Use Cases. In "Scenarios & Use Cases, Stories through the System Life-Cycle" (ouvrage collectif) , Editors: Ian Alexander & Neil Maiden, John Wiley and Sons, ISBN 0470861940, Août 2004.

[SGI2001] Standish Group International, Extreme Chaos, 2001

[Sundheim1996] Sundheim, B.: Overview of the results of the MUC-6 evaluation. In: Proceedings of the 7th Message Understanding Conference (MUC-6), Vienna, Virginia, USA. May 1996

[Walia2009] G.S. Walia, J.C. Carver, A systematic literature review to identify and classify software requirement errors, Inform. Softw. Technol. (2009), doi:10.1016/j.infsof.2009.01.004

[Wilson1997] Wilson, W.M., Rosenberg, L.H., Hyatt, L.E.: Automated analysis of requirement specifications. In: Proceedings of the Nineteenth International Conference on Software Engineering (ICSE-97), New York, NY, USA, ACM Press (1997) 161–171

Biography

Jean-Claude Roussel is a Senior Expert at EADS Innovation Works (EADS Research Center) where he is charge of upstream research projects on Systems Engineering since March 2009.
He was before in charge of Systems Engineering within Airbus Central Entity at Toulouse where he has developed and deployed within all Airbus sites in Europe the Requirement Based Engineering (RBE) Policy, the Airbus Policy for Systems Engineering. He was previously in charge of Project Management and Configuration Management for all aircraft development since 92 (from A319 till A380).
From 88 till 92, he has been working for ESA Space Program (European Space Agency) where he was in charge of Configuration Management for the Hermes Space Vehicle.
He started his career at Airbus in 81 by developing PDM application and data exchange standard (SET) for CAD/CAM application, which initiated STEP project.
He is member of INCOSE since 2001 where he has taken active role in the Requirements WG (as co-chair) to extend it to European members. He was President of AFIS (French INCOSE Chapter) in 2007 and 2008, and got the Gold Circle Award of INCOSE.
He is graduated Engineer from Polytech Lille.

Gauthier Fanmuy serves as Technical Director and head of the Skill Center "Systems Engineering" at ADN (http://www.adneurope.com), a consulting company. He has a particular responsibility for the expansion strategy of ADN in the industry outside the life sciences field, the technical coordination of Skill Centers, the deployment of methods and tools related to transverse Systems Engineering and Project Management.
Within AFIS (http://www.afis.fr), he is the leader of the Technical Committee "Global Processes".
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He previously worked at PSA Peugeot-Citroen, where he was responsible for the implementation of Requirements Engineering on a project vehicle. He was also responsible for the deployment of System Engineering in a department in charge of vehicles engineering and testing.
Prior to this experience, he worked at Dassault Aviation on weapons systems Rafale, Mirage 2000-9, F1CR Mirage and Atlantic 2, where he served various responsibilities in the quality, development of tactical functions, integration of opto-electronic equipment, covering all activities of the lifecycle of a system.
He is an Engineer from the Ecole Centrale de Marseille.

Dr Camille Salinesi, Associate Professor at Université Paris 1 is the leader of a research team that works on various Requirements Engineering (RE) related topics such as: scenarios, modelling variability, matching requirements, priorization, configuration, or modeling and measuring alignement. He published more than 70 refereed papers in international conferences and scientific journals on these topics and showed multiple domains of applications such as ERPs, product lines, data warehouses, or Enterprise Architecture. Dr Salinesi was involved in fundamental research projects (FP4 NATURE, FP5 CREWS) and he managed se several collaborations and consultancy works for the industry (e.g. with France Télécom, SNCF, Renault, MédiaScience, and EDF). In 2005, he was Organizing Chair of the 13th IEEE International Conference on Requirements Engineering.

Alain Dauron is the head of Systems Engineering department in Research, Advanced Studies and Materials Engineering Division at Renault. He was formerly in charge of Powertrain Control Systems activities. He is a member of AFIS (French INCOSE Chapter) since 2007, participating to the Technical Committee "Global Process", particularly to Product Lines & Lean SE projects, and to the working group on Requirements Engineering.
He graduated Engineer from Ecole Polytechnique, and then obtained a PhD degree at Université de Paris IX Dauphine in the area of Automatic Control

Richard Szczepaniak is the founding chairman of CORTIM, consultancy company in Systems Engineering since 2001. CORTIM is specialized in requirements engineering and participates to AFIS RE working group and INCOSE RWG.
Richard has led several company-wide projects dedicated to requirements engineering process improvement, mainly using the DOORS tool. Outcomes of this kind of projects are best practices, tool customization and user training.
Before, he was Senior Expert in on-board data management for Astrium Space Company after having worked on automatic control, operational support for satellite deployment and software project management.
He is a graduated engineer from Ecole Nationale Supérieure de l'Aéronautique et de l'Espace in Toulouse. He contributed to set up the Systems Engineering training program in Supaéro.

Laurence Picci is a Research Engineer at "Simulation and information technologies for power generation systems" (STEP) Department of EDF R&D. Her R&D activities concern mainly the field of Instrumentation & Control: formal methods, system modeling in UML/SysML, FPGA-based, renovation, validation & verification and requirements and traceability approach. She graduated her engineering degree from the "Ecole Centrale de Lille".

Omar Hammami is a Professor with ENSTA ParisTech/DGA since 2000. Prior to that, from 1993 to 2000, he was Associate Professor in the University of Aizu , Japan and Head of the Performance Evaluation Laboratory. He received his Phd in Computer Science from University of Toulouse and has been an assistant professor with ENSEEIHT, Toulouse. Omar Hammami have been involved in numerous R&D projects at national and international levels, both civilian and military, in system level design, high performance embedded systems design methodologies, System on Chip Design Methodologies and Military Software Defined Radio (JTRS/SCA) . His current interest lies in Cognitive radio and Network science, Systems Engineering for Energy and Transports fields with strong research emphasis on automatic system engineering flow. He is currently involved in 2 R&D projects with French Competitiveness Cluster System@tic.