



Information Technology for European Advancement

Task 1.8 Requirements Management method: Analysis Report (D1.8.1)

Version 01 - Public
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Software Development Process for Real-Time Embedded Software Systems (DESS)

ITEA COMPETENCES involved:

- 1) Complex Systems Engineering**
 - 2) Communications**
 - 3) Distributed Information and services**
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| | |
|--|-----------|
| 1. INTRODUCTION | 1 |
| 1.1 Purpose | 1 |
| 1.2 Scope of the ITEA DESS Requirements Management method | 1 |
| 1.3 Glossary | 1 |
| 1.4 References | 2 |
| 2. BASIC NOTIONS | 2 |
| 2.1 Requirements Management definition | 2 |
| 2.2 Organisational relations | 2 |
| 2.3 Distributed requirements management | 2 |
| 2.4 Documents and phases | 3 |
| 2.5 Information model | 3 |
| 2.6 <i>Traceability</i> and change management | 5 |
| 3. PROCESS IN REQUIREMENTS MANAGEMENT | 6 |
| 3.1 Requirements management activities | 6 |
| 3.1.1 Overview | 6 |
| 3.1.2 Pre-development activities | 7 |
| 3.1.3 Project management activities | 7 |
| 3.1.4 Capturing and derivation | 7 |
| 3.1.5 Defining and tracing the attributes of a requirement | 7 |
| 3.1.6 Validation and Verification of Requirements | 7 |
| 3.1.7 Test link management | 8 |
| 3.1.8 Change management | 8 |
| 3.1.9 Generation of intermediate reports and deliverables | 8 |
| 3.2 Process Requirements | 8 |
| 3.2.1 Compliancy | 8 |
| 3.2.2 Traceability requirements derived from the several standards | 8 |
| <i>CMM Model Requirements</i> | 8 |
| <i>DOD2167A Requirements</i> | 8 |
| <i>Requirements of the DO178</i> | 8 |
| 3.2.3 Requirements on the method | 9 |
| 4. PRINCIPLES | 10 |
| 4.1 Structuring requirements | 10 |
| 4.2 Views and access rights | 10 |
| 4.3 Traceability | 10 |
| 5. TOOLS | 11 |
| 5.1 Requirements on Tooling | 11 |
| 5.2 Attribute aspects of Requirements | 11 |
| 5.3 Standards compliance w.r.t. Requirements | 12 |
| 6. PROBLEMS WITH CURRENT PRACTICES | 12 |
| 7. EXPECTATIONS | 12 |
| APPENDIX 1 Some interesting RM tool-sites | 14 |

1. INTRODUCTION.

1.1 Purpose

The goal of DESS is to define an innovative object-oriented, component-based software development methodology for embedded real-time systems, to create supporting environments by integrating state-of-the-art tools and to prove the appropriateness of the methodology by implementing several validation test cases. DESS is the acronym for *Software Development Process for Real-Time Embedded Software Systems*.

This document summarises the topics related to the Requirements Management method and tooling.

This document reflects the latest insights in Requirements Management that result from the contributions of the ITEA DESS partners. It serves as input for the definition of the ITEA DESS Requirements Management method defined and tooling.

In the Requirements Management method defined, all Requirements Management related activities will be addressed like configuration management, quality assurance etc., without going into detail. It is not the intention to give a full description of the Software Creation process, because is process is owned, tailored by an specific organisation.

1.2 Scope of the ITEA DESS Requirements Management method

Requirements management is part of all phases of the entire system life cycle, ranging from market analysis and top-level customer requirements to system maintenance and en-of-product-life.

In system and software development different requirements engineering methodologies are used. But the necessary requirements management activities are nearly identical. Therefore we see no limitations of requirements management to specific application domains.

Requirements Management is important for product development. The product is a result of one Commercial Requirements Specification. A product is build with one or more hardware- and software- sub-systems (hybrid subsystems) working closely together. Although the ITEA DESS focuses on *Real-time Embedded **Software** Systems.*, the scope of the ITEA DESS Requirements Management method is at the *system level*.

The method defined will not only be applicable to large products, but should be customisable depending on the type of product and type of project.

1.3 Glossary

| | |
|--------|---------------------------------------|
| CRS | Commercial Requirements Specification |
| FRS | Functional Requirements Specification |
| HSI | Hardware-Software interface |
| HW-HLD | Hardware High-level design |
| RM | Requirements Management |
| SAD | Software Architectural Design |
| SRS | Software Requirements Specification |

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| | |
|---------|--|
| SW-ATS | Software Acceptance test specification |
| SW-HLD | Software High-level design |
| SW-ITS | Software Integration test specificatin |
| SW-UTS | Software Unit test specification |
| SYS-ATS | System Acceptance test specification |
| SYS-ITS | System Integration test specificatin |

1.4 References

- [1] IEEE Standard 830-1984, *Recommended Practice for Software Requirements Specification*, Institute of Electrical and Electronics Engineers, 1984.
- [2] IEEE Standard 610.12-1990, *IEEE Standard Glossary of Software Engineering Terminology*, Institute of Electrical and Electronics Engineers, 1990.

2. BASIC NOTIONS

2.1 Requirements Management definition

The term requirements management in our context is used in the following sense:

Requirements management regards the *structuring and administration of information*, which is processed during the acquisition, derivation, analysis, co-ordination, base-lining, updating, tracing, validating and verification of requirements over *the entire product lifecycle*.

2.2 Organisational relations

Important are the organisational relations between the responsible employees at the different specification levels of the requirements. The spectrum extends from working groups within an organisational unit through different departments of a group to a customer-supplier-relationship. Employees of higher specification level fulfil the role of the external stakeholder for the next specification level.

2.3 Distributed requirements management

Several physically distributed teams are often working together on a single project. The distribution of the requirements database and its consistent management have to be supported.

Different views with respect to roles and process activities must be provided, where only a subset of the existing information is presented to the user. E.g. a project manager is interested in other information details than a V&V expert, a requirements specification document is a particular representation of a view on the existing information related to requirements.

Regarding process and security aspects the access to particular information must be prohibited for some users. E.g. V&V staff should have only read access to requirements; cost information is exclusively readable for project managers.

A necessary prerequisite for definitions of distinct views and access rights are defined roles and user profiles. Requirements management tools usually support several forms of views and fine-grained definition of access rights.

2.4 Documents and phases

During the product development the system level documents and the software level documents are created, possibly using different processes.

The requirements management activity is done at every process or phase of the product development. The documents are owned/controlled by each process area. The traceability is done from CRS, FRS, SSD, to SRS and source code.

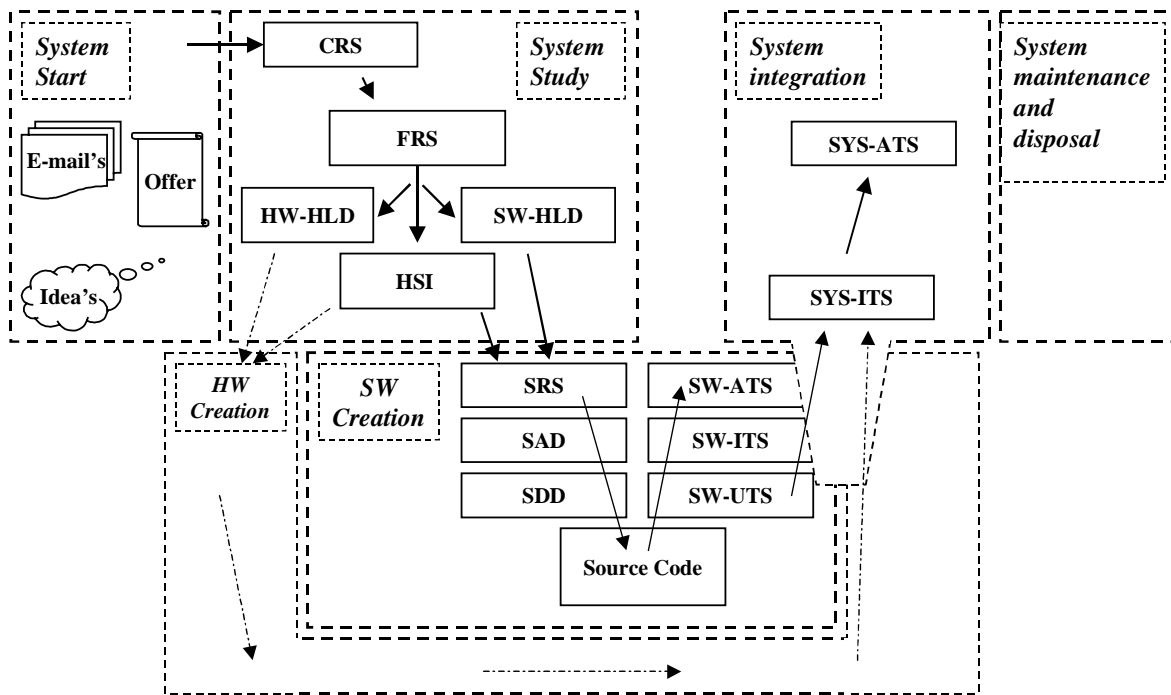


Figure 1 Documents and phases

2.5 Information model

An information model describes the relations between entities. Information models for Requirements Management are requirements attribute information model, a component information model and a document information model.

An example of a document information model is given in Figure 2. The definition of the document information model is part of the requirements management plan.

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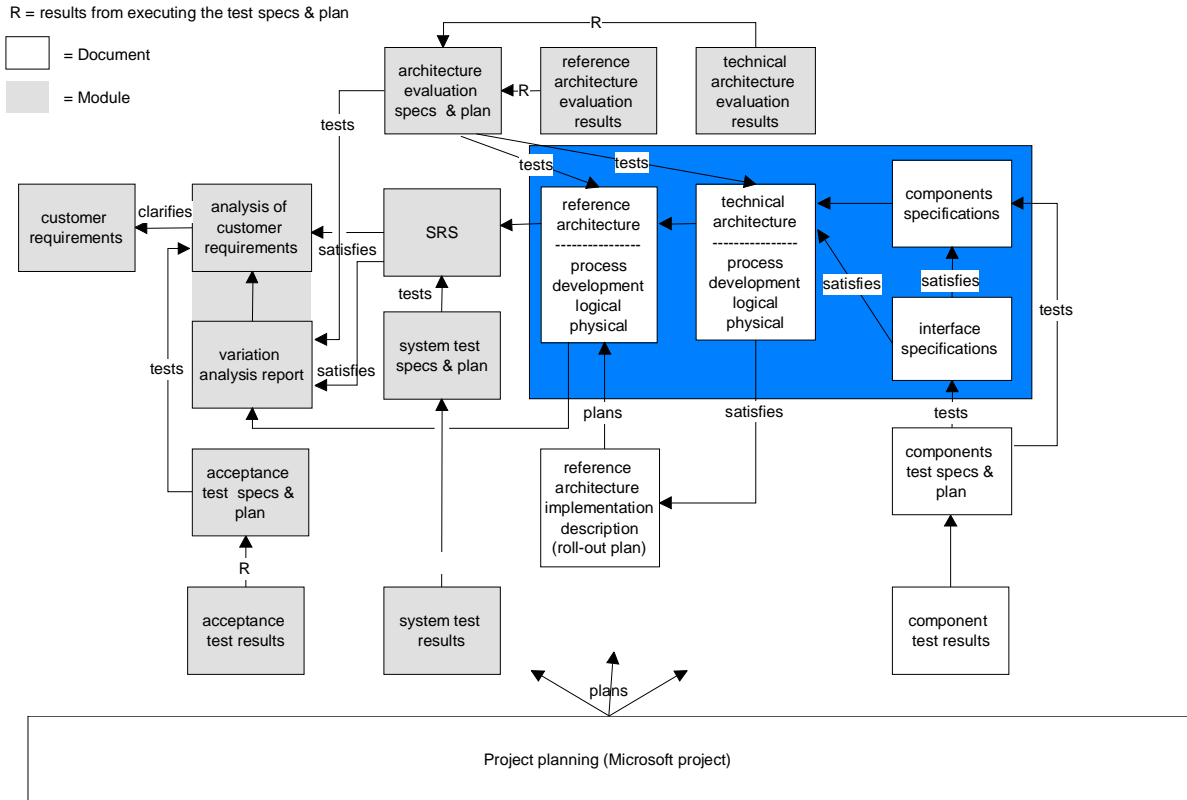


Figure 2 Example of a Document Information model

In addition to the model the information related to the several views are defined, for example:

Analysis of customer requirements and variation analysis report:

This module contains the analysis, clarification and elaboration of the customer requirements. The requirements will consist of a stable part and of a variable part. Part of the analysis consists of analysing the variations. It is the improvement of the CRS in case the customer does not maintain the document. The customer formally approves it.

Source of information: Customer requirements and discussions with the customer serve as input for this module.

2.6 *Traceability* and change management.

Term "traceability" covers the following aspects:

1. The traceability establishes links between the various elements of a product. It is insured by coherent requirements and hierarchies the documentation.
2. The traceability is used for remembering and restoring at any time, the history, the state, the location, the definition (requirements), the evolutions of a product and the functions which it carries out.
3. The traceability is required for the evaluation of the factors of maintainability, correctness, testability, and therefore contribute to the quality of a product.
4. The traceability is obtained by the strict and precise marking of the various elements of the product and by the systematic recording of their related events. Through the "traceability" it is the coherence of all the production which is aimed.

System requirements have to be traced in order to show that all the commercial requirements are met and that no unnecessary system requirements have been created.

Traceability and change management are often identified as main issues within more general presentations of requirements management. Examples for definitions of traceability can be found in IEEE standard 830-1998.

The relevant standards related to requirements management include requirements on the traceability of requirements and the execution of changes.

A common solution in order to guarantee these requirements is the filing of additional information within requirements attributes or independent elements. This additional information forms the set of parameters for the marketing- and technical managers, architects and engineers.

3. PROCESS IN REQUIREMENTS MANAGEMENT

3.1 Requirements management activities

3.1.1 Overview

In the following, is briefly described what is considered as the important activities of a tool-supported requirements management process. Figure 3 shows a rough assignment of requirements management process activities to process phases. We refrain from imposing a strict ordering of these activities as this may vary in different project contexts.

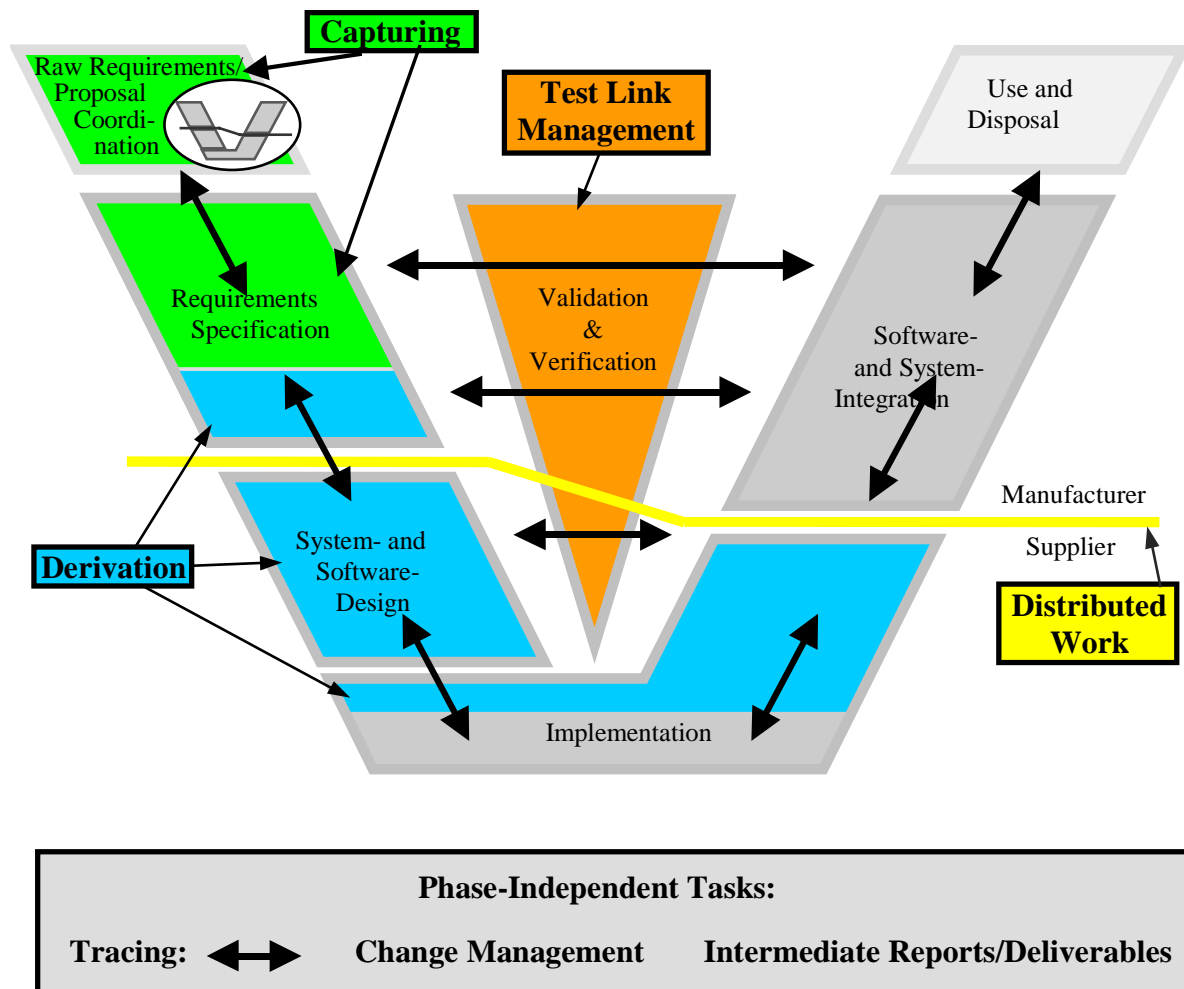


Figure 3 Requirements Management process activities

The validation and Verification applies to all development phases and deliverables.

3.1.2 Pre-development activities

In these activities, by means of market analyses or customer discussions, one or more documents are developed, possibly including contracts, which describe the top-level requirements of the system to be built.

3.1.3 Project management activities.

The development project manager makes an agreement with the customer in which the process of the requirements gathering and approval and change management is done. The project management plan will contain the requirements management activities, the approach in terms of the collection of metrics, (senior management) reporting and effort etc.

3.1.4 Capturing and derivation

In this activity, the requirements are imported from the initial documents or other sources into a database of a requirements management tool. Of course, capturing can in principle take place already during initial customer discussions.

New requirements are possibly derived from existing ones according to (system) design decisions being taken. This may include the refinement of a single requirement, the splitting of a single requirement into several ones, or the merging of several requirements into a single one.

3.1.5 Defining and tracing the attributes of a requirement.

A number of group of attributes are recognised:

- The general attributes: Classification, Category, Type, Priority, Status, the Standards, Creation date, and Modification date. The attribute Status can be split into: Correct, Consistent, Feasible, etc.
- V&V related attributes: test stages required (Acceptance test, Unit test, Integration test), complexity, Verifiable, Level of testing to be applied. This attribute defines the kind of tests which are to be defined: integration tests and acceptance tests.
- Project Management related attributes: Costs, Risk, time, etc.

3.1.6 Validation and Verification of Requirements.

In the course of the product development a the lower level specifications (including architecture design.

1. Validation: “Do we build the right product?” Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Basically, this is checking whether the requirements are valid.
2. Verification: “Do we build the product right?” Confirmation by examination and provision of objective evidence that specified requirements has been fulfilled. Basically, this is checking whether the requirements are satisfied by the deliverables.

The term V & V are used to express activities like (formal) inspections, simulations.

3.1.7 Test link management

In this activity, the links between requirements and test specifications are managed. In general, each requirement must have at least one test case or test procedure associated with it.

3.1.8 Change management

This activity includes all activities concerning the change of requirements.

3.1.9 Generation of intermediate reports and deliverables

Typically, in the course of a project, various reviews take place. According to the nature and the purpose of the review, the requirements database should be analysed and all necessary information about the current project's status should be extracted and presented as a written document. This should be done automatically, e.g. by developing or using some customised scripts for automatic report generation.

3.2 Process Requirements

3.2.1 Compliancy

The requirements management process description is compliant with the Capability Maturity Model. The process will be adjusted when new (worldwide-accepted standard) shows-up like CMMI (Integrated) etc.

3.2.2 Traceability requirements derived from the several standards

CMM Model Requirements

The documentation of traceability between assigned requirements and software requirements, design, code and tests data, is managed and checked.

Term of documentation does not mean necessarily a Word document as an example, but every registered item.

DOD2167A Requirements

The standard asks to trace the Software Requirements Specification(SRS and Interface Requirements Specification) software requirements with:

1. system requirements assigned to the software
2. tests
3. The Computer Software Component and Computer Software Unit, without any description of the way to achieve it

Requirements of the DO178

The directives of traceability are the following ones:

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1. The traceability between the specifications of the system and those of the software must be provided to verify the complete system specifications and to give a visibility of derived requirements.
2. The traceability between the low level requirements and the high level requirements has to be provided to verify derived requirements and choices on the architecture made during the software design, and to allow the check of all the high level requirements.
3. The traceability between source code and the low level requirements has to be provided to check the lack of not documented source code and the check of all the low level requirements.

3.2.3 Requirements on the method

A method for requirements management should be in principle combinable with a number of different requirements engineering notations and methods. It should also be noted that content-concerning aspects of requirements engineering are as a rule part of specific tasks during the product development phase, whereas requirements management extends over the entire product life cycle, and should also include the acquisition of raw requirements from customer talks or market analyses as well as the tracing of change requests during the product application time. As a whole, it can be said that both domains overlap though neither has to include the other.

The Requirement Management method should:

1. Describe the process (RM procedures and templates) and organisation of the requirements management activities.
2. Take into account the scope: product- to components-family (re-use of components). The method should be suitable for the Hardware/Software co-designed system / product development.
3. Be configurable for the several types of projects prototype development to high-quality component / product development, multi-site development support through the whole product development life cycle.
4. Describe the notation rules of the identification of the requirement.
5. Incorporate the Validation and Verification related activities. Identification of tests to be re-run, coverage etc..
6. Describe the traceability of the requirements from the customer's, architect's, project leader's (etc.) view up to and including the maintenance/service engineer's view of the product or components at the several levels of requirements
7. The structure and traceability of information in order to check the coherence, and perform analysis of impact of changes to relations/entities/data like resource constraints.
8. The value analysis of the choices of architecture from sorting multi-criteria (costs, efficiency, flexibility, risks, re-use...) as far as the requirements management aspects are concerned.
9. The management of the evolutions of all the elements associated to the product (requirements, documentation, architecture, tests, codes...).

4. PRINCIPLES

4.1 Structuring requirements

There is no formal language available for formulating requirements, except particular constraints. Requirements have to be numbered and delimited, such that they can be verified individually.

The process of formalizing software requirements (Requirements Engineering) has to be supported by the Requirements Management process.

The information model (see section 2.5) can describe the contents (requirements and requirements related information) which should be stored in a requirements management tool's database. It describes the parts of the process and the roles, which are relevant for requirements management, and their interdependencies and relations. This description should be tool-independent.

The methodological work on requirements management related activities will be defined with reference to the information model. The relationships between activities, roles, and assigned requirement information should also be established via the information model. The application area expert will continue to construct and edit individual requirements. But the proper filing of requirements, their traceability, their presentation, and in simple cases their analysis (often you need additional analysis tools) are related to the structure of the information model and not to the content of individual requirements. The methodological implementation of related activities requires a clear and comprehensible structuring of the information model.

4.2 Views and access rights

Different views with respect to roles and process activities must be provided, where only a subset of the existing information is presented to the user.

Regarding process and security aspects the access to particular information must be prohibited for some users.

A necessary prerequisite for a definition of distinct views and access rights are defined roles and user profiles. Requirements management tools usually support several forms of views and fine grained definition of access rights.

4.3 Traceability

Traceability can be established with different techniques:

- Predefined document structures that dictate the contents of the project documentation
- Explicit cross referencing (information tagging, numbering or indexing, traceability matrices,...)
- enhancement of the project documentation by restructuring it in terms of an underlying network or graph.

Traceability is to be supported by templates, procedures and tooling. A continuous and corrective control (in-process control) is required to discover and handle problems as soon as possible.

5. TOOLS

5.1 Requirements on Tooling

| Aspects |
|---|
| 1. Impact analysis, Value analysis. Related to resource constraints, test-runs, |
| 2. Automatic import, export of documents in the various formats. |
| 3. Production of metrics (nr. of requirements assigned, of changes, tests |
| 4. Tool import/support requirements : complete or part of components including requirements etc. |
| 5. Administration of projects, users and access rights. |
| 6. Software Design Flow related tool interface requirements* |
| 7. Reference requirements inheritance |
| 8. Up- and down stream traceability : From CRS, SRS,V&V, change Requests etc. to source code, graphical forms,(coverage),Candidate architectures, |
| 9. Multiple version of a document (historical information) |

Table 1 Aspects of RM tooling

*Matlab , MS Word (OFFICE 97), Interleaf, Framemaker, Rational Rose or Together, MESTRA, Rhapsody, Esterel Studio

| Tool | Related RM information |
|--------------------------|--|
| Configuration management | Component label Development history |
| Design tools | Graphical data etc. |
| Planning/tracking | Development costs Planning |
| Validation and testing | Realised quality (of a system, component, requirement) |
| Problem tracking | Problem reports / change requests Status of problem reports / change requests |
| E-mail | Any correspondence on the requirements |

Table 2 RM information related to tooling

5.2 Attribute aspects of Requirements.

| Aspects |
|--|
| 1. Status |
| 2. Importance (critical ones, priority...) |
| 3. Re-usability. |
| 4. Validation and testing method |

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| Aspects |
|--|
| 5. Requirements status (completeness...) |
| 6. Requirements priority |
| 7. Value (costs, efficiency, flexibility, risks, re-use ...) |
| 8. Quality |

Table 3 Attribute aspects of Requirements

5.3 Standards compliance w.r.t. Requirements.

| Standard(s) |
|---|
| 1. CMM |
| 2. DOD2167A |
| 3. ARP 4754 |
| 4. DO-178B |
| 5. PSS-05 or the Development Standard for IT-Systems of the Federal Republic of Germany (V-Model) |
| 6. IEEE 830-1984 |
| 7. IEEE 610.12-1990 |

Table 4 Standards with respect to requirements

6. PROBLEMS WITH CURRENT PRACTICES

An inventory of problems with current practices is described in a separate deliverable, see D1.1.1: RM problem description.

7. EXPECTATIONS

Expectations on current and future RM method and tooling are as follows.

| Expectations |
|--|
| 1. Support of V-model , spiral model. The ITEA DESS method implies process flow description and Requirements management covering the system life-cycle (HW/SW) |
| 2. Scope of requirements management: including marketing phase. |
| 3. Re-usability of components |
| 4. History and status reporting of components. |

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| Expectations |
|--|
| 5. Monitoring and control of activities like: Metrics related to the change requirements, ... |
| 6. Strong related to Validation and Testing, use of components, resource constraints. |
| 7. Multi-site development support and communication support (customer – development) |
| 8. Configuration Management and Change management. |
| 9. Requirements management related project planning and tracking. List of RM activities in project plan, CMM rm-kpa related. |
| 10. Method and tooling configurable for small to large sized projects. Variation in the degree of automation of requirements traceability. |
| 11. Analysis document for complex or unclear commercial requirements |
| 12. Documents Information model creation. |
| 13. Naming convention of Requirements in CRS etc. |
| 14. Traceability matrix. |
| 15. TOOL proposal: integration with the methods and tool chains used in the software design flow. |
| 16. Multiple user views and access rights |
| 17. Traceability level |
| 18. Multiple attributes per Requirements type |

Table 5 Expectations on current/future RM method and tools

APPENDIX 1 SOME INTERESTING RM TOOL-SITES

| Tool | site |
|---|--|
| RtM | http://www.chipware.com/index.php3 |
| Case study DOORS | http://www.computerweekly.co.uk/cwarchive/features/20000928/cwcontainer.asp?name=F2.html&ct=search http://www2.telelogic.com/doors/products/doors/interfaces.cfm |
| Published in CD-ROM Proceedings of the 8th Annual International Symposium of the International Council on Systems Engineering - Technical Committee Papers, 1998. | http://www.incose.org/rwg/98_paper_exec/index.html This document contains links to other possible Software Tools. |
| Caliber RM | http://www.tbi.com/products/caliber.html |
| RequisitePro | http://www.rational.com/products/whitepapers/index.jsp |

Table 6 RM tool sites