From Requirements Quality
to Requirements Authoring
By José Fuentes
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Introduction to The REUSE Company

- The REUSE Company, a spinoff company started in 1999
- Experts in:
  - Requirements Engineering,
  - Systems Engineering,
  - and mainly Reuse and Quality around Requirements and Systems Engineering
- Solutions and services related to these topics
- Creators of RQA and RQS
Requirements Quality
Requirements quality: Successful projects

Chaos Report, 2004

- Succeeded: 29%
- Failed: 18%
- Challenged: 53%
Requirements quality: Successful projects
Requirements Quality: source of defects

<table>
<thead>
<tr>
<th>Project Success Factors</th>
<th>% of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. User Involvement</td>
<td>15.9%</td>
</tr>
<tr>
<td>2. Executive Management Support</td>
<td>13.9%</td>
</tr>
<tr>
<td>3. Clear Statement of Requirements</td>
<td>13.0%</td>
</tr>
<tr>
<td>4. Proper Planning</td>
<td>9.6%</td>
</tr>
<tr>
<td>5. Realistic Expectations</td>
<td>8.2%</td>
</tr>
<tr>
<td>6. Smaller Project Milestones</td>
<td>7.7%</td>
</tr>
<tr>
<td>7. Competent Staff</td>
<td>7.2%</td>
</tr>
<tr>
<td>8. Ownership</td>
<td>5.3%</td>
</tr>
<tr>
<td>9. Clear Vision &amp; Objectives</td>
<td>2.9%</td>
</tr>
<tr>
<td>10. Hard-Working, Focused Staff</td>
<td>2.4%</td>
</tr>
<tr>
<td>Other</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

(Source: CHAOS Report, 2004)

+40% directly related with requirements definition and management
Requirements Quality: source of defects

Study in the scope of **RAMP project** (Requirements Analysis and Modeling Process) in partnership with Airbus Group, RENAULT, EDF, ADN, CORTIM, ENSTA, IRIT, PARIS 1 UNIVERSITY

(end 2010 over 22 industrials in several domains worldwide: interviews and questionnaires)

### Most common requirements defects

<table>
<thead>
<tr>
<th>Requirement Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements not good enough for tests and fabrication</td>
<td>1</td>
</tr>
<tr>
<td>Requirements not traced</td>
<td>1</td>
</tr>
<tr>
<td>Derived requirements not justified</td>
<td>1</td>
</tr>
<tr>
<td>Semantic contradictions</td>
<td>1</td>
</tr>
<tr>
<td>Use of synonyms or words with multiple meanings</td>
<td>1</td>
</tr>
<tr>
<td>Not identified as requirements</td>
<td>1</td>
</tr>
<tr>
<td>Lack of input data (vague needs, non mastered scenarios...)</td>
<td>2</td>
</tr>
<tr>
<td>Confusion between validation of needs and verification of the product</td>
<td>2</td>
</tr>
<tr>
<td>Too much details</td>
<td>4</td>
</tr>
<tr>
<td>Not understandable (complex sentences)</td>
<td>4</td>
</tr>
<tr>
<td>Littérature</td>
<td>6</td>
</tr>
<tr>
<td>Not verifiable</td>
<td>7</td>
</tr>
<tr>
<td>Not precise enough</td>
<td>7</td>
</tr>
<tr>
<td>Several requirements in a single requirement</td>
<td>9</td>
</tr>
<tr>
<td>Not consistency</td>
<td>9</td>
</tr>
<tr>
<td>Not complete</td>
<td>10</td>
</tr>
<tr>
<td>Ambiguity</td>
<td>10</td>
</tr>
<tr>
<td>Requirements expressed as solutions</td>
<td>14</td>
</tr>
</tbody>
</table>
Requirements Quality characteristics

- **IEEE Std. 830:**
  - Correct
  - Unambiguous
  - Complete
  - Consistent
  - Ranked
  - Verifiable
  - Modifiable
  - Traceable

- **ESA PSS-05:**
  - Pretty much the same characteristics

- **SMART:**
  - Specific
  - Measurable
  - Aligned
  - Realistic
  - Time-limited

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth"
Requirements Quality characteristics

- Good characteristics to check but…
- Can we measure how correct, how complete, how consistent, how measurable… a specification is??
- Are those characteristics SMART?
  - Are they specific?
  - Easy to measure? From a objective point of view?
  - Is it realistic to ask for those characteristics?
Requirements Quality Metrics

- Different initiatives to use a set of easy-to-measure metrics/rules instead of the former fuzzy characteristics:
  - ARM (Automated Requirement Measurement) by NASA

<table>
<thead>
<tr>
<th>Categories of Quality Indicators</th>
<th>Quality Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Continuances</td>
<td>X</td>
</tr>
<tr>
<td>3. Directives</td>
<td>X</td>
</tr>
<tr>
<td>4. Options</td>
<td>X</td>
</tr>
<tr>
<td>5. Weak Phrases</td>
<td>X</td>
</tr>
<tr>
<td>6. Size</td>
<td>X</td>
</tr>
<tr>
<td>7. Text Structure</td>
<td>X</td>
</tr>
<tr>
<td>8. Spec. Depth</td>
<td>X</td>
</tr>
<tr>
<td>9. Readability</td>
<td>X</td>
</tr>
</tbody>
</table>
Requirements Quality Metrics

- Different initiatives to use a set of easy-to-measure metrics/rules instead of the former characteristics:
  - Artemis EU Projects:

    - Classifying a number of different measurable rules into three main clusters:
      - Correctness: mainly for individual requirements
      - Consistency: mainly for whole specifications, but also with SysML models
      - Completeness: mainly for whole specifications, but also with SysML models
Requirements Quality Metrics

- Different initiatives to use a set of easy-to-measure metrics/rules instead of the former characteristics:
  - INCOSE Guide for Writing Requirements
  - Matching among characteristics and easy-to-measure rules
Requirements Quality Metrics

- Different initiatives to use a set of easy-to-measure metrics/rules instead of the former characteristics:
  - Génova et al.

Measurable indicators and related desirable properties:

- \( x \) = direct influence; \( \cdot \) = indirect influence
Requirements Quality Metrics: a “perfect”… bad requirement

Whatever the context, the system should be able to switch-off as quickly as possible, to restart without inducing any perturbation and at the same time to inform the operator in a friendly and understandable manner…

Not so SMART requirement (Specific, Measurable, Aligned, Realistic, Time-limited)
Ambiguous (What System ?)
Several unclear requirements (switch-off, restart, inform)
No use of shall
Not measurable (quickly, same time,..)
Not testable (friendly, understandable,..)
...

→ Need to perform a Requirement Quality Analysis against all the set of the system Requirements to improve the requirement quality before any delivery
Requirements Engineering Process

- It’s good to automate the verification process but…
- … it’s even better to provide such a help to requirements authors
Requirements Authoring
Requirements Authoring

- Experiences shown that about **25% of system Requirements are critical and can grammatically be improved**
  - No Shall: 8 to 10%
  - Forbidden words: 10 to 15%
  - Subject, multiple objects, design: 15%
  - Incorrect grammar: 50%, ...

- Requirements **error costs are high**
  - Fixing requirements after delivery may cost up to **100 times more** than fixing in the requirements definition stage

- Training, best practices and **verifying requirements by reviews** can help to get SMART requirements:
  - But the process is **costly and time consuming**

- Introducing quality analysis during the **authoring** activity:
  - Reduce the number of iterations between System Engineers and sub-contractors and improve the verification activities
Requirements Authoring

Classical figures for software engineering…
… But clearly too short in case of safety-critical systems
Requirements Authoring

- Authors of the specifications can be empowered by (1 of 4):
  - Checking a number of correctness issues on-the-fly
  - Using a consistent vocabulary through the use of a domain ontology

Diagram:
- Terminology layer
- Thesaurus layer
- Patterns layer
- Formalization layer
- Inference layer
Requirements Authoring

Authors of the specifications can be empowered by (2 of 4):

- Using patterns to “force” an agreed way of writing
- Providing all the expected data for the requirements, according to their types (e.g. performance information)
Requirements Authoring

- Authors of the specifications can be empowered by (3 of 4):
  - Identification of inconsistent information:
    - Duplicated requirements: by using a semantic search engine
    - Inconsistent content among requirements: e.g. inconsistent unit systems
    - Inconsistent content requirements vs. SysML: e.g. MTBF, weight of components…

Consistency
Requirements Authoring

- Authors of the specifications can be empowered by (4 of 4):
  - Semantic reuse of requirements among previous projects
RQS – Requirements Quality Suite
Requirements Quality Suite

- The Requirements Quality Suite (RQS) intends to tackle requirements quality management by offering a set of tools and processes.
- RQS defines, measures, manages and improves requirements quality.
- RQS models requirements quality using the CCC approach (Correctness, Consistency and Completeness).

**Requirements Quality Analyzer (RQA):**
- to setup, check and manage the quality of a requirements specification.

**Requirements Authoring Tool (RAT):**
- to assist authors in the process of creating requirements with the right level of quality.

**knowledgeMANAGER (kM):**
- to manage knowledge around a requirements specification:
  - the ontology it is based on
  - the structure of the requirements to be used in the project
  - the communication between authors and domain architects.
Requirements Quality Suite

Metrics

Correctness (individual metrics)

Consistency (semantic)
Consistency (inconsistent units)

Completeness (missing req.)
Completeness (missing links)
Requirements Quality Suite

- **Types of metrics:**
  - Automatic metrics
  - Parameterized metrics
  - *In-house coded* metrics
  - Manual metrics

- **Metric customization:**
  - Which metrics to use, metrics weight
  - Metrics limits/thresholds
  - How to parameterized some of the metrics: e.g. named links
  - Can include new *in-house coded* metrics
  - Manual metrics to support the further verification process

- **Customization according to:**
  - The maturity of every company or team
  - The type of requirements document: level of abstraction
Requirements Quality Suite

Example of correctness metrics:

- Requirements size/length
- Readability
- Conditional vs. imperative sentences
- Active vs. passive voice
- Ambiguous sentences
- Optional sentences
- Subjective sentences
- Implicit sentences
- Abuse of connectors
- Negations
- Speculative sentences
- Use of false friends
- Design terms
- Flow terms
- Number of domain nouns and verbs
- Acronyms
- Hierarchical levels
- Volatility
- Number of dependences
- Forbidden Words
- Standard Requirement (match pattern)...
Requirements Quality Suite

- Other features:
  - Connectors:

- Languages:
RAT : Requirements Authoring Tool

- Main features:
  - Assisting authors while they’re writing requirements
  - Following a agreed upon set of patterns

- Other (on the fly) features:
  - Quality assessment (correctness based on individual metrics) on the fly
  - Consistency analysis on the fly
  - Missing links on the fly
  - Inconsistent units analysis on the fly
RAT: Requirements Authoring Tool

- Author assistance on the fly (typing requirement)

- Pattern choice
- Ontology terms to keep fulfilling the selected patterns
- Valid paths to fulfill the selected patterns and pattern examples
RAT: Requirements Authoring Tool

- Author assistance on the fly (fulfilled patterns)
RAT : Requirements Authoring Tool

- Quality assessment on the fly

Whatever the context, the system should be able to switch-off as quickly as possible, to restart without inducing any perturbation and at the same time to inform the operator in a friendly and understandable manner.
RAT: Requirements Authoring Tool

- Semantically similar requirements on the fly

There's a requirement in the SKB very similar to the writing requirement.
RAT : Requirements Authoring Tool

- Inconsistent measurement units on the fly

There's a requirement in the SKB conflicting with the writing requirement:

`The plane must be able to fly at least 1600 kilometres without landing`

`The second rocket must be able to measure at least 20 inches`
Thank you for your attention!!

Questions??
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