Managing Projects with openSE

Part 2

Table of Content

4. Quality

Quality

At a glance

Quality Planning

Quality Assurance

"I say what I will do

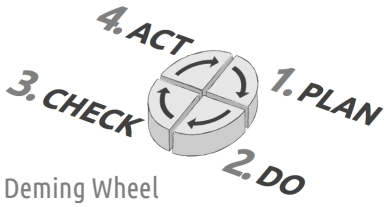
Someone checks that it is appropriate

I do what I have said

I provide evidence of compliance"

Quality Control

"I also identify defects in the processes and seize the opportunity to improve them"



Deming Wheel

Quality Planning

At a glance, in a complex system development project context

- Defining which **standards** are applicable
- Defining which "**tools**" to use (incl. document **templates** and **forms**)
- Assigning **roles**, i.e. setting up a **project organization**
- Defining key managerial **processes**:
  - For releasing **documents** (incl. verification and validation)
  - For managing the **configuration** (i.e. the baselines)
  - For handling **issues** and **nonconforming outputs**
  - For planning, scheduling, costing, hiring project participants, managing risks, reporting the progress, buying supplies and services…
- More broadly, for **decision making**

ISO 9001:2015 § 8.7

Project Quality Assurance Framework

(Management) (System)

Quality Control

At a glance, in a complex system development project context

- Implementing straightforwardly the Project QA Framework provisions:
  - Proceeding systematically to the **verifications** and **validations** as they have been planned
  - Insuring the **traceability** of the tasks (how they were performed) and of the task's outputs/deliverables (specifications vs. actuals) by means of records
  - Releasing **change requests** when a baseline shall be modified
  - Releasing **non conformity** reports when an output or a deliverable is not as expected…

the **QA trade-off**

Resources to dedicate to QA | Value created by QA

4.1 Quality Planning

Applicable Standards

- Standards related to the SE / NPD **project management**
  e.g.: ISO 21500:2012 or ANSI PMBoK 5th ed. or openSE
- Standards related to the NPD **engineering processes**
  incl. PLM, CAD systems, geometrical tolerencing, etc.
- Standards related to the **product/system** to develop itself
  in the fields of materials, of communication, of energy, of interfaces, of software, of reliability, of availability, of maintenability, of safety, etc.
- Standards related to the **manufacturing and assembly processes**
  incl. supply chain, plant engineering, etc.

4.1.1/3.2 Project Management Plan

Project Management Plan

- The "**entry point**" to project information
- The aim of the PMP is twofold:
  - Ensuring that the project participants agree upon and share a common framework for organizing their project
  - Giving the project board the assurance that the project expectations are well understood and that everything is done to ensure the operational suc- cess of the project
- A few possible approaches depending on the project participants maturity level w.r.t. project management processes

See openSE brochure #1000 "Setting up a Project Management System"

Project Management Plan

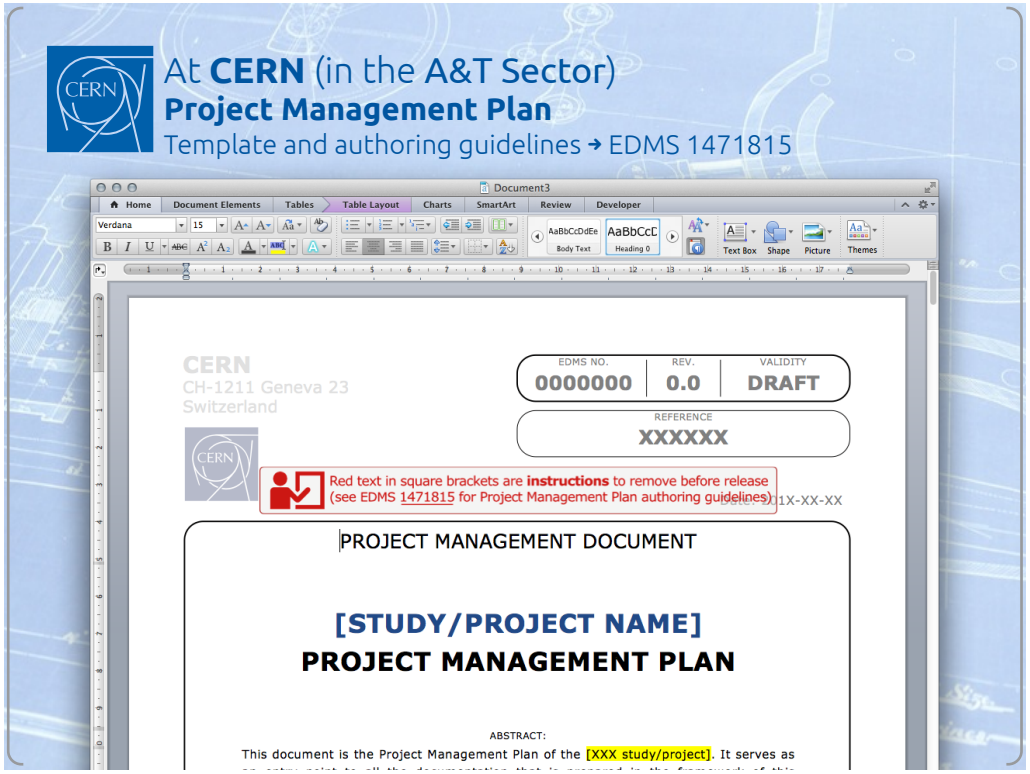
Typical Table of Contents
Simple Approach

1. **Project Overview** PMP Scope + Reformulation of the Project Roadmap
2. **Project Organization** Project Board, Project Team, roles, OBS
3. **Project Management Processes**
   - 3.1 **Scope Management** WBS, Work Packages, Work Units, Activities
   - 3.2 **Time Management** Master and Coordination Schedules
   - 3.3 **Resource and Cost Management** Manpower, budgeting, EVM
   - 3.4 **Quality Management** Document management, V&V, configuration management, issue and non conformity handling
   - 3.5 **Communication Management** Meetings, reporting periodicity
   - 3.6 **Risk Management** Project Risk Register, Project Continuity Plans
   - 3.7 **Procurement and Contribution Management** Ordering, contracting
- A **Applicable Standards**

Project Management Plan

Editorial Process

- **Authoring:** Project Manager + a few Key Project Participants
- **Verification:** Some other Key Project Participants + some Project Management Experts (e.g. members of the PMO)
- **Validation:** **Project Manager**



Other Project Management Documents

Requirements Engineering related documents

- (Project) **Requirements Register**
- (Project) **Product Breakdown Structure**

Planning and Scheduling related documents

- Project **Master Schedule**
- Project **Work Breakdown Structure**
- Project **Coordination Schedule**
- Project **RACI Matrix**

Costing related documents

- Project **Cost Estimate**
- Project **Budget**

Risk Management related documents

- Project **Risk Register**

- Then, Project **Progress Reports**

4.2 Quality Assurance

Key Quality Assurance Processes

- Managing **documents**
  i.e. authoring, versioning, circulating (verification and validation), releasing and archiving project documents, but also 3D mock-ups and 2D drawings
- Managing the **configuration** and handling **issues** and **nonconformiting outputs** i.e. managing baselines, managing change requests and orders, ensuring traceability
- Conducting **quality audits** and **reviews**

4.2.1 Document Management System

Project Document Register

Unique ID	Document title	Ver.	Date	Authored by	Verified by	Validated by
100	Project Roadmap					
		0.1	2014-01-13	Alberte		
		0.2	2014-01-20	—	Ursule, Yvone	
		1.0	2014-01-22	—	—	Xavier, Zélie
101	Project Management Plan					
		0.1	2014-02-05	Alberte, Barnabé		
102	Project Work Breakdown Structure					
103	Project Cost Estimate					
104	Project Budget					
105	Project Master Schedule					
		0.1	2014-02-07	Alberte, Cyprien		
106	Project Coordination Schedule					
107	Project RACI Matrix					
108	Project Risk Register					

At **CERN** (in the A&T Sector)
Project Document Registers

- **EDMS** → 100% engineering and PM documents
- **EDMS/CDD** → 2D drawings
- **CATIA/SmarTeam** → 3D models
- **CDS** → Scientific publications (reports, notes)
- **Indico** → Presentations
- **SharePoint** or **Drupal** → General project information
- **DFS** → Nothing! Very bad practice
- **CFU/CDS** → Released procurement documents

No project-wide document register!

Project Document Template

Unique ID	Version	Status	Date
101	0.3	DRAFT	2014-02-22

the whatever project

PROJECT MANAGEMENT PLAN

Authored by:	Verified by:	To be validated by:
Alberte Barnabé	Cyprien Denise	Ernest

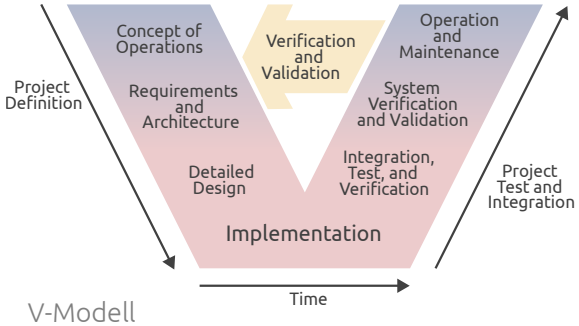
This document is uncontrolled when printed.
Check the Project Document Register to verify
that this is the correct version before use

Verification vs. Validation

Check vs. Approval

From Software Engineering but also widely applied to document lifecycle

Concept introduced by **Barry W. Boehm** (1981)



V-Modell

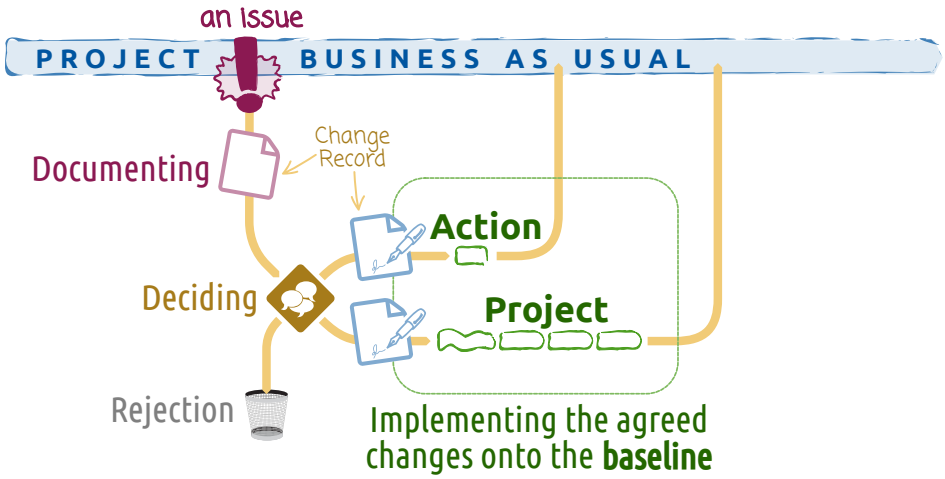
Verification:
Are we building the product right?
Are we solving the equation right?

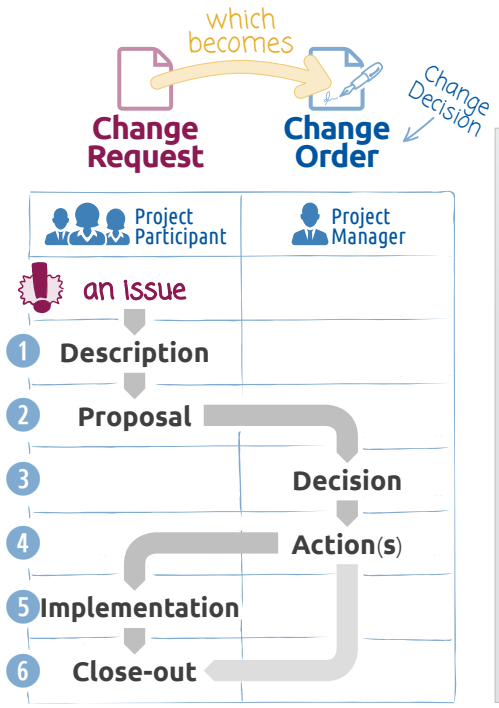
Validation:
Are we building the right product?
Are we solving the right equation?

4.2.2 Issue Management System

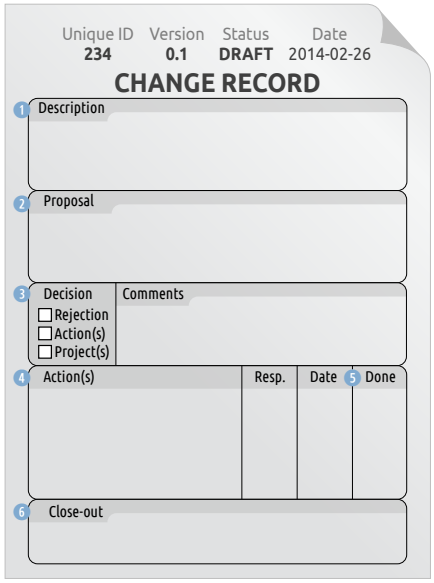
Managing Issues

Change Records (**CR**) featuring requests and orders





Change Record



Requirements Engineering

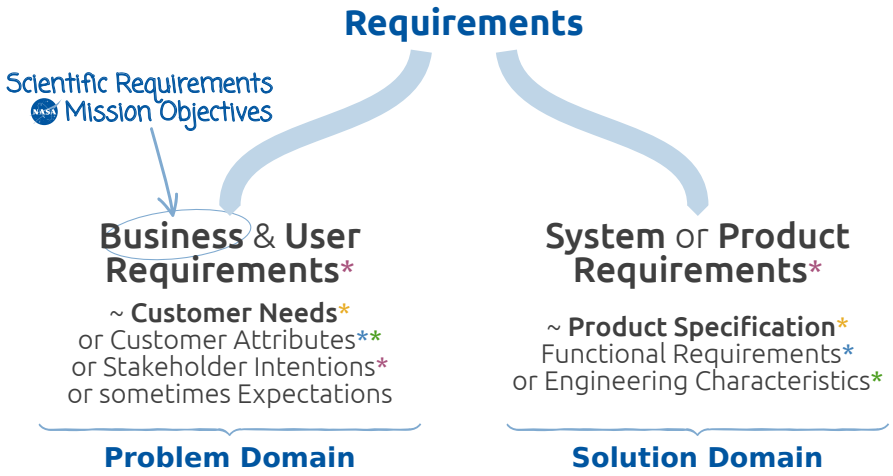
Requirement(s) Engineering

The process of documenting, analyzing, tracing, prioritizing and agreeing on requirements and then controlling change and communicating to relevant stakeholders

en.Wikipedia.org

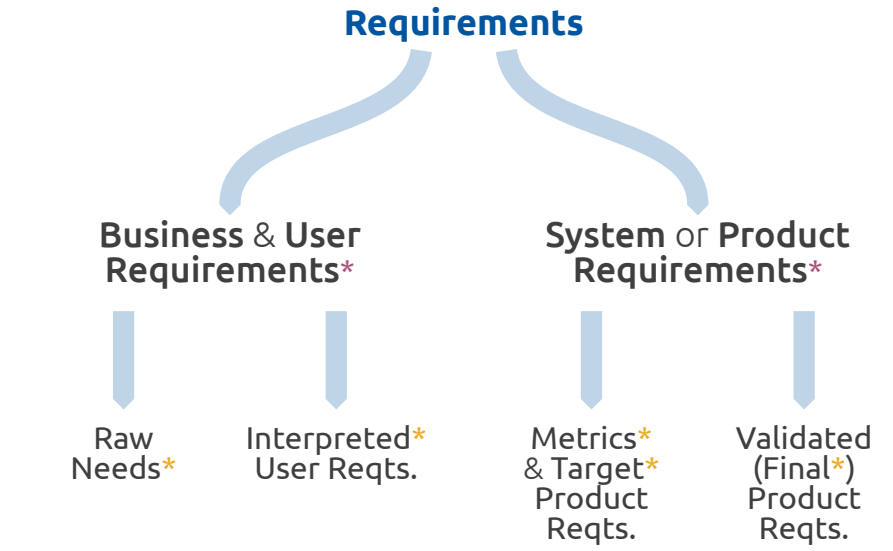
- Procurement and Purchasing → **technical specification** writting
- Quality Management → **QFD** (Quality Function Deployment) and the ***House of Quality*** ← 60's-70's in Japan
- New Product Development → gathering **customers needs** and translating them into **specifications** or specification items ← 80's
- Software Engineering → capturing **users requirements**
- Systems Engineering → identifying **users** vs. **functional** vs. **non-functional requirements** ← 90's, ca. 2005

Typology of Requirements



- *ISO/IEC/IEEE 29148:2011 Requirements Engineering
- *Karl Ulrich, Steve Eppinger (2011) Product Design and Development. McGraw-Hill/Irwin
- *Nam-pyo Suh (1990) Principles of Design. Oxford University Press
- *John Hauser, Don Clausing (1988) The House of Quality. HBR

Typology of Requirements



- *ISO/IEC/IEEE 29148:2011 Requirements Engineering
- *Karl Ulrich, Steve Eppinger (2011) Product Design and Development. McGraw-Hill/Irwin

Triggers to Requirements Engineering

Innovation Type

or

Incremental innovation

existing products incl. competitors' ones are used to elicit user requirements

Radical innovation

prototypes and mock-ups are used to elicit user requirements
+
Delphi panels

Innovation Type

or

Market -pull

~ incremental innovation

Techno -push

~ radical innovation

Basic Types of Requirements

Requirements

Functional Requirements

What the product shall **do**

i.e. Function of **FFF**

e.g. to hold two parts together

Mixed Requirements

quite often Fit of **FFF**

e.g. pan head parallel to part surfaces

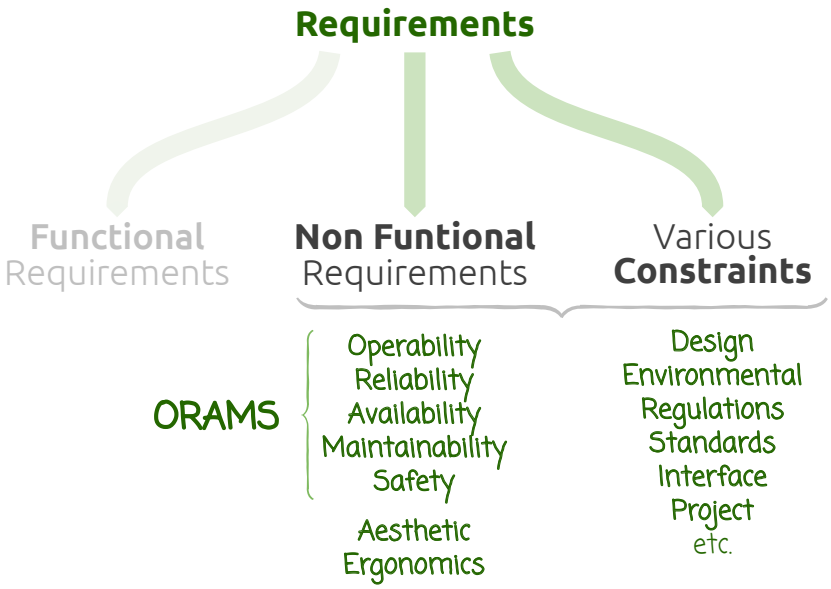
Non Fonctional Requirements

How the product shall **be**

i.e. Form of **FFF**

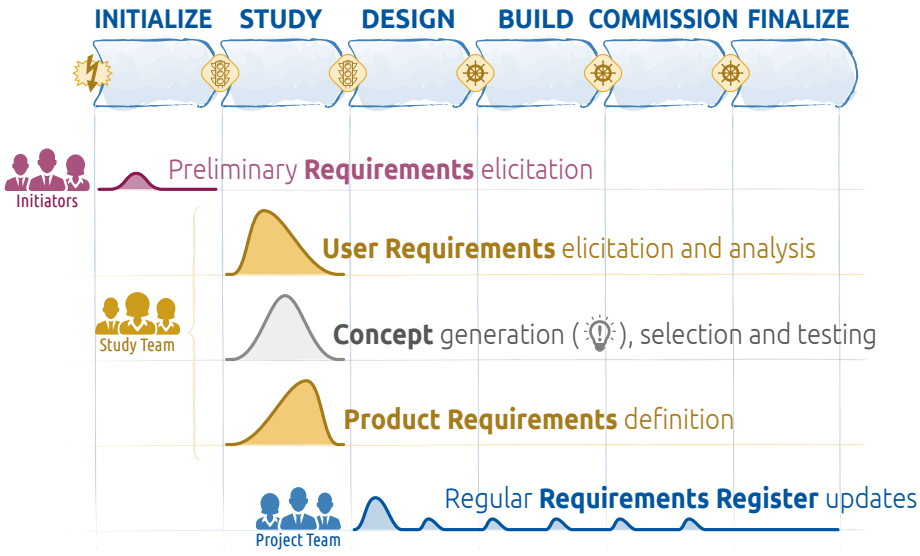
e.g. screw, pan head, M5 x 0.8, 20 mm, 316 SS + washer + bolt

Basic Types of Requirements



Requirements Engineering

When and which effort?



Requirements Engineering

A nine-step process → **incremental** innovations / **market-pull** products

1. Identifying the **stakeholders** (end users, key users, customers, etc.)
2. Elicitating the **user* requirements** (~ needs gathering*)
3. Searching for **solutions** (~ concept generation*)
4. Translating the **user requirements** into **target product requirements** (~ target specifications setting*)
5. Benchmarking the **solutions** (~ concept selection and testing*)
6. Setting the **final product requirements** (~ final specifications setting*)
7. Developing the **solution**, the product, the service or the facility (i.e. going through the **DESIGN** and **BUILD** phases)
8. Verifying the product w.r.t. the **product requirements**
9. Validating the end product w.r.t. the **user requirements**

*User requirements include business/scientific requirements

*Karl Ulrich, Steve Eppinger (2011) Product Design and Development. McGraw-Hill/Irwin

Requirements Engineering

A nine-step process → **radical** innovations / **techno-push** products

1. Searching for **solutions** (~ concept generation*)
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User Requirements

1. Identifying the **stakeholders** (end users, key users, customers, etc.)
2. Elicitating the **user requirements**
   - 2.1 Gathering **raw needs**

When and why do you (or will you) **use** this product?
Walk us through a **typical usage** of it
What do you **like** (👍) about the (existing) product?
What do you **dislike** (👎) about the (existing) product?
What issues do/will you consider when acquiring it?
What **improvements** would you make to it?

   - 2.2 Translating raw data into **interpreted user requirements**
   - 2.3 Organizing the IUR's into a list → prelim. **Requirements Register***

*Stakeholder Requirements Specification (StRS) or preliminary Systems Requirements Specification (SyRS)

User Requirements

2.1 Gathering **raw needs**

cordless screwdriver
incremental innovation
market-pull

I need to drive screws fast, faster than by hand.
I sometimes do duct work; use sheet metal screws.
A lot of electrical; switch covers, outlets,
fans, kitchen appliances.
I like the pistol grip; it feels the best.
I like the magnetized tip.
I don't like it when the tip slips off the screw.
I would like to be able to lock it so I can use it with a dead battery.
Can't drive screws into hard wood.
Sometimes I strip tough screws.
An attachment to allow me to reach down skinny holes.
A point so I can scrape paint off of screws.
Would be nice if it could punch a pilot hole.

User Requirements

2.2 Translating raw data into **interpreted user requirements**

- Raw needs → *"in any vernacular spoken by the users"*
- Requirements → in a formal language*, a.k.a. *"shall-statements"* or "**deontic statements**"
  (this applies to all types of requirements)
  - "**Shall**" indicates **mandatory** or **binding** requirements strictly to be followed in order to conform and from which no deviation is permitted
    ("shall" equals "is required to")
  - "**Should**" indicates that among several possibilities one is **recommended** as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required
    ("should" equals "is recommended that")

*ISO/IEC/IEEE 29148:2011 Requirements Engineering → § 5.2.4 Requirements Constructs

User Requirements

2.2 Translating raw data into **interpreted user requirements**

- "**May**" is used to indicate a course of **action permissible**, of **allowance** or **suggestion**
  ("may" equals "is permited to")
- "**Can**" is used for statements of **possibility** and **capability**, whether material, physical, or causal
  ("can" equals "is able to")
- "shall" or "should" or "may" or "can"
  - Mandatory
  - Desirable
  - Optional
  - Possible — future enhancement
- ~~"must"~~
  "It is best to avoid using the term 'must' due to potential misunderstanding as a requirement"*
- "**Will**" is used for **statement of fact**, **futurity**, or **declaration of purpose**

*ISO/IEC/IEEE 29148:2011 Requirements Engineering → p. 10

User Requirements

2.2 Translating raw data into **interpreted user requirements**

- "**Is/are**" are used for **non requirement statements**
  "Is/are-statements" aim at providing information in the StRS or SyRS
  → "**epistemic statements**" (opposite to "**deontic statements**")
- The **active voice** shall be preferred to the passive voice
  (passive voices promotes ambiguity and leads to needlessly complex sentences)
- **Positive** "shall-statements" shall be preferred to negative ones
  (such as "the system shall not do this")
- One shall be carefull to possible multiple meanings

  "Flying aircraft may be hazardous"
  ('flying' may act as a noun, an adjective or a verb!)

User Requirements

2.2 Translating raw data into **interpreted user requirements**

cordless screwdriver
incremental innovation
market-pull

The CSD **shall** drive screws faster than by hand
The CSD **shall** drive sheet metal screws into metal duct work
The CSD **can** be used for screws on electrical devices
The CSD **shall** be comfortable to grip
The CSD tip **shall** retain the screw before it is driven
The CSD tip **shall** remain aligned with the screw head without slipping
The user **can** apply torque manually to the CSD to drive a screw
The CSD **can** drive screws into hard wood
The CSD **shall** not strip screw heads
The CSD **can** access screws at the end of deep, narrow holes
The CSD **shall** allow the user to work with screws that were painted over
The CSD **can** be used to create a pilot hole

User Requirements

2.3 Organizing the IUR's into a list → prelim. **requirements register**

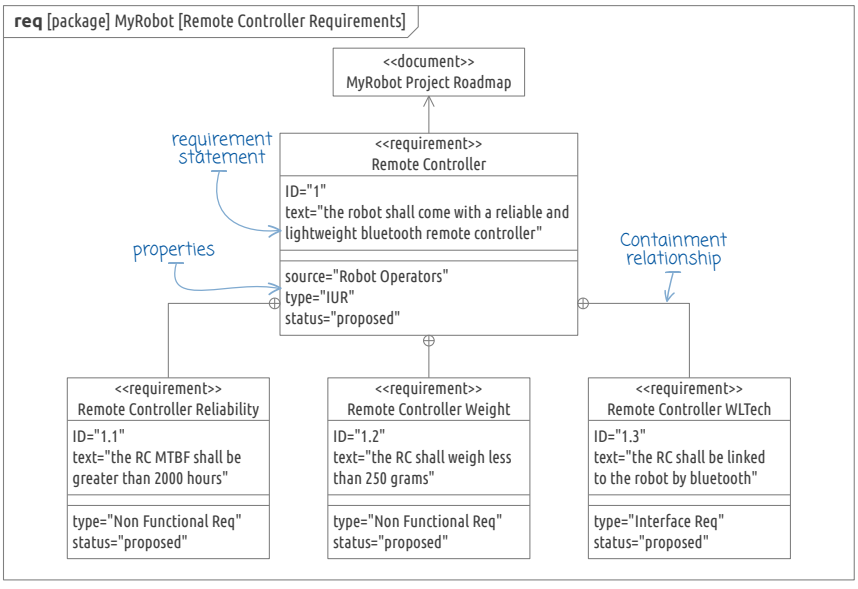
- Merging all interpreted user requirements in a list
- From a few dozens to several hundred IUR's
- Eliminating redundant “shall-statements”
- Flagging them: **M**andatory, **D**esirable, **O**ptional, **P**ossible
- Grouping them according to the similarities of the needs they express

  ⚠ UR's (and IUR's) can be contradictory! → "the product shall be red" "the product shall be blue"

- Requirements breakdown into more focused requirements

User Requirements

2.3 Organizing the IUR's into a list → **requirements diagram**



The CSD shall provide plenty of power to drive screws
The CSD shall maintain power for several hours of heavy use
The CSD can drive screws into hardwood
The CSD shall drive sheet metal screws into metal ductwork
The CSD shall drive screws faster than by hand
The CSD shall make it easy to start a screw
The CSD shall retain the screw before it is driven
The CSD can be used to create a pilot hole
The CSD shall work with a variety of screws
The CSD can turn Phillips, Torx, socket, and hex head screws
The CSD can turn many sizes of screws
The CSD can access most screws
The CSD can be maneuvered in tight areas
The CSD can access screws at the end of deep, narrow holes
The CSD should turn screws that are in poor condition
The CSD can be used to remove grease and dirt from screws
The CSD shall allow the user to work with painted screws
The CSD shall feel good in the user's hand
The CSD shall be comfortable when the user pushes on it
The CSD shall be comfortable when the user resists twisting
The CSD shall be balanced in the user's hand
The CSD shall be equally easy to use in right or left hands
The CSD weight should be just right
The CSD shall be warm to touch in cold weather
The CSD shall remain comfortable when left in the sun
The CSD shall be easy to control while turning screws
The user can easily push on the CSD
The user can easily resist the CSD twisting
The CSD can be locked on.
The CSD speed can be controlled by the user while turning a screw
The CSD shall remain aligned with the screw head without slipping
The user can easily see where the screw is

The CSD shall not strip screw heads
The CSD shall be easily reversible
The CSD shall be easy to set up and use
The CSD shall be easy to turn on
The CSD shall prevent inadvertent switching off
The user can set the maximum torque of the CSD
The CSD shall provide ready access to bits or accessories
The CSD power shall be convenient
The CSD can be attached to the user for temporary storage
The CSD shall be easy to recharge.
The CSD can be used while recharging
The CSD shall recharge quickly
The CSD batteries shall be ready to use when new
The user can apply torque manually to the CSD to drive a screw
The CSD last a long time
The CSD tip shall survive heavy use
The CSD can be hammered
The CSD can be dropped from a ladder without damage
The CSD shall be easy to store
The CSD shall fit in a toolbox easily
The CSD can be charged while in storage
The CSD shall resist corrosion when left outside or in damp places
The CSD shall maintain its charge after long periods of storage
The CSD shall maintain its charge when wet
The CSD shall prevent damage to the work
The CSD shall prevent damage to the screw head
The CSD shall prevent scratching of finished surfaces
The CSD shall have a pleasant sound when in use
The CSD shall look like a professional quality tool
The CSD shall be safe
The CSD can be used on electrical devices
The CSD shall not cut the user's hands

Product Requirements

- User requirements are expressed in the language of the user
- Too much space is left for subjective interpretation
- The achievement of product requirements shall be measurable
- Product requirements are expressed in engineer's language

4 Translating the **user requirements** into **target product requirements** (~ target specifications setting)

- 4.1 Based on the IUR's, preparing a list of **metrics** → one to one mapping (House of Quality, QFD)
- 4.2 Collecting **competitive benchmarking** information
- 4.3 Setting ideal and marginally acceptable **target values**
- 4.4 Translate target values into **target product requirement** statements → "formal shall-statements"

4.1 Preparing a list of **metrics**

mountain bike suspension fork

ID	IUR	Imp.
1	The suspension shall reduce vibration to the hands	3
2	The suspension shall allow easy traversal of slow, difficult terrain	2
3	The suspension shall enable high-speed descents on bumpy trails	5
4	The suspension shall allow sensitivity adjustment	3
5	The suspension shall preserve the steering characteristics of the bike	4
6	The suspension shall remain rigid during hard cornering	4
7	The suspension shall be lightweight	4
8	The suspension shall provide stiff mounting points for the brakes	2
9	The suspension shall fit a wide variety of bikes, wheels, and tires	5
10	The suspension shall be easy to install	1
11	The suspension shall work with fenders	1
12	The suspension shall instill pride	5
13	The suspension shall be affordable for an amateur enthusiast	5
14	The suspension shall be not contaminated by water	5
15	The suspension shall be not contaminated by grunge	5
16	The suspension can be easily accessed for maintenance	3
17	The suspension shall allow easy replacement of worn parts	1
18	The suspension can be maintained with readily available tools	3
19	The suspension shall last a long time	5
20	The suspension shall be safe in a crash	5

4.1 Preparing a list of **metrics**

mountain bike suspension fork

ID	Metric	Imp.	Unit
1, 3	Attenuation from dropout to handlebar at 10Hz	3	dB
2, 6	Spring preload	3	N
1, 3	Maximum value from the Monster	5	g
1, 3	Minimum descent time on test track	5	s
4	Damping coefficient adjustment range	3	N-s/m
5	Maximum travel (26-in. wheel)	3	mm
5	Rake offset	3	mm
6	Lateral stiffness at the tip	3	kN/m
7	Total mass	4	kg
8	Lateral stiffness at brake pivots	2	kN/m
9	Headset sizes	5	in.
9	Steertube length	5	mm
9	Wheel sizes	5	List

4.1 Preparing a list of **metrics**

mountain bike suspension fork

ID	Metric	Imp.	Unit
9	Maximum tire width	5	in.
10	Time to assemble to frame	1	s
11	Fender compatibility	1	List
12	Instils pride	5	Subj.
13	Unit manufacturing cost	5	US$
14	Time in spray chamber without water entry	5	s
15	Cycles in mud chamber without contamination	5	k-cycles
16, 17	Time to disassemble/assemble for maintenance	3	s
17, 18	Special tools required for maintenance	3	List
19	UV test duration to degrade rubber parts	5	hr
19	Monster cycles to failure	5	cycles
20	Japan Industrial Standards test	5	binary
20	Bending strength (frontal loading)	5	kN

4.1 Preparing a list of **metrics**

IUR's × Metrics Matrix

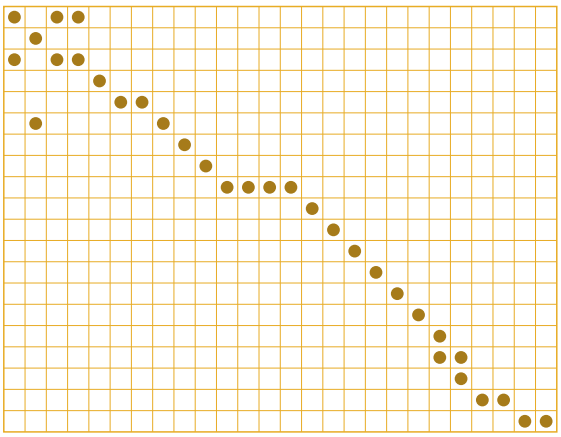
mountain bike suspension fork

20 IUR's

The suspension shall reduce vibration to the hands
The suspension shall allow easy traversal of slow, difficult terrain
The suspension shall enable high-speed descents on bumpy trails
The suspension shall allow sensitivity adjustment
The suspension shall preserve the steering characteristics of the bike
The suspension shall remain rigid during hard cornering
The suspension shall be lightweight
The suspension shall provide stiff mounting points for the brakes
The suspension shall fit a wide variety of bikes, wheels, and tires
The suspension shall be easy to install
The suspension shall work with fenders
The suspension shall instill pride
The suspension shall be affordable for an amateur enthusiast
The suspension shall be not contaminated by water
The suspension shall be not contaminated by grunge
The suspension can be easily accessed for maintenance
The suspension shall allow easy replacement of worn parts
The suspension can be maintained with readily available tools
The suspension shall last a long time
The suspension shall be safe in a crash

28 Metrics

Attenuation from dropout to handlebar at 10Hz
Spring preload
Maximum value from the Monster
Minimum descent time on test track
Damping coefficient adjustment range
Maximum travel (26-in. wheel)
Rake offset
Lateral stiffness at the tip
Total mass
Lateral stiffness at brake pivots
Headset sizes
Steertube length
Wheel sizes
Maximum tire width
Time to assemble to frame
Fender compatibility
Instils pride
Unit manufacturing cost
Time in spray chamber without water entry
Cycles in mud chamber without contamination
Time to disassemble/assemble for maintenance
Special tools required for maintenance
UV test duration to degrade rubber parts
Monster cycles to failure
Japan Industrial Standards test
Bending strength (frontal loading)



Product Requirements

4.1 Based on the IUR's, preparing a list of **metrics**

- Metrics should be **complete** → one metric per IUR
- Metrics should be **quantifiable**
- Metrics should be **pratical** → measurable with usual measurement means
- A few metrics can be non quantificable (identified as '**Subj.**' in the list)
- Metrics may also include **popular comparison criteria**

Product Requirements

4.2 Collecting **competitive benchmarking** information

- 4.2.1 Identifying **benchmark products** → i.e. competitors' products, existing products offering similar features, prototypes
- 4.2.2 Mesuring the benchmark products w.r.t. metrics
- 4.2.3 Assessing the benchmark products w.r.t. IUR's

4.2.2 Mesuring the benchmark products w.r.t. metrics (1/2)

#	Metric	Imp.	Unit						
1	Attenuation from dropout to handlebar at 10Hz	3	dB	8	15	10	15	9	13
2	Spring preload	3	N	550	760	500	770	480	680
3	Maximum value from the Monster	5	g	3.6	3.2	3.7	3.3	3.7	3.4
4	Minimum descent time on test track	5	s	13	11.3	12.6	11.2	13.2	11.0
5	Damping coefficient adjustment range	3	N-s/m	0	0	0	200	0	0
6	Maximum travel (26-in. wheel)	3	mm	28	48	43	46	33	38
7	Rake offset	3	mm	41.5	39	38	38	43.2	39
8	Lateral stiffness at the tip	3	kN/m	59	110	85	84	65	130
9	Total mass	4	kg	1.409	1.385	1.409	1.364	1.222	1.100
10	Lateral stiffness at brake pivots	2	kN/m	295	550	425	425	325	650
11	Headset sizes	5	in.	1.000 1.125	1.000 1.125 1.250	1.000 1.125	1.000 1.125 1.250	1.000 1.125	N/A
12	Steertube length	5	mm	150 180 210 230 255	140 165 190 215	150 170 190 210	150 170 190 210 230	150 190 210 220	N/A
13	Wheel sizes	5	List	26 in.	26 in.	26 in.	26 in. 700 mm	26 in.	26 in.

4.2.2 Mesuring the benchmark products w.r.t. metrics (2/2)

#	Metric	Imp.	Unit						
14	Maximum tire width	5	in.	1.5	1.75	1.5	1.75	1.5	1.5
15	Time to assemble to frame	1	s	35	35	45	45	35	85
16	Fender compatibility	1	List	Zefal	None	None	None	None	All
17	Instils pride	5	Subj.	1	4	3	5	3	5
18	Unit manufacturing cost	5	US$	65	105	85	115	80	100
19	Time in spray chamber without water entry	5	s	1300	2900	>3600	>3600	2300	>3600
20	Cycles in mud chamber without contamination	5	k-cycles	15	19	15	25	18	35
21	Time to disassemble/assemble for maintenance	3	s	160	245	215	245	200	425
22	Special tools required for maintenance	3	List	Hex.	Hex.	Hex.	Hex.	Long hex.	Hex, pin wrench
23	UV test duration to degrade rubber parts	5	hr	400+	250	400+	400+	400+	250
24	Monster cycles to failure	5	cycles	500k+	500k+	500k+	480k	500k+	330k
25	Japan Industrial Standards test	5	binary	Pass	Pass	Pass	Pass	Pass	Pass
26	Bending strength (frontal loading)	5	kN	5.5	8.9	7.5	7.5	6.2	10.2

4.2.3 Assessing the benchmark products w.r.t. IUR's

Interpreted User Requirements	Imp.						
The Susp. shall reduce vibration to the hands	3	•	••••	••	•••••	••	•••
The Susp. shall allow easy traversal of slow, difficult terrain	2	••	••••	•••	•••••	•••	•••••
The Susp. shall enable high-speed descents on bumpy trails	5	•	•••••	••	•••••	••	•••
The Susp. shall allow sensitivity adjustment	3	•	••••	••	•••••	••	•••
The Susp. shall preserve the steering characteristics of the bike	4	••••	••	•	••	•••••	•••••
The Susp. shall remain rigid during hard cornering	4	•	•••	•	•••••	•	•••••
The Susp. shall be lightweight	4	•	•••	•	•••	••••	•••••
The Susp. shall provide stiff mounting points for the brakes	2	•	••••	•••	•••	•••••	••
The Susp. shall fit a wide variety of bikes, wheels, and tires	5	••••	•••••	•••	•••••	•••	•
The Susp. shall be easy to install	1	••••	•••••	••••	••••	•••••	•
The Susp. shall work with fenders	1	•••	•	•	•	•	•••••
The Susp. shall instill pride	5	•	••••	•••	•••••	•••	•••••
The Susp. shall be affordable for an amateur enthusiast	5	•••••	•	•••	•	•••	••
The Susp. shall be not contaminated by water	5	•	•••	••••	••••	••	•••••
The Susp. shall be not contaminated by grunge	5	•	•••	•	••••	••	•••••
The Susp. can be easily accessed for maintenance	3	••••	•••••	••••	••••	•••••	•
The Susp. shall allow easy replacement of worn parts	1	••••	•••••	••••	••••	•••••	•
The Susp. can be maintained with readily available tools	3	•••••	•••••	•••••	•••••	••	•
The Susp. shall last a long time	5	•••••	•••••	•••••	•••	•••••	•
The Susp. shall be safe in a crash	5	•••••	•••••	•••••	•••••	•••••	•••••

Product Requirements

4.3 Setting ideal and marginally acceptable **target values**

- Five ways to express a value in the metrics:
  at least *X*, at most *X*, between *X* and *Y*, exactly *X*, discrete values

  Metric #1:
  Attenuation from drop out to handlebar at 10 Hz > 13 dB
  Metric #2:
  Spring preload > 700 N

4.4 Translate target values into **target product requirement** statements

- In the form of a formal *"shall-statement"*:
  "the product [shall | should | can | may] do, be, etc..."

  Product Reqt. #1:
  The fork shall have an attenuation from drop out to handlebar at 10 Hz that is at least 13 dB
  Product Reqt. #2:
  The fork should have a spring preload of at least 700 N

Requirements Register

It is a structured list of requirements

- Rqt. **ID** and a short description
- So-called "***shall-statement***"
- Category or **type**, e.g. raw need/IUR or PR and **subtype**
- **Compliance** to solutions, and for each solution:
  - Compliant (C)
  - Partialy compliant (PC)
  - Not compliant (¬C or NC)
  - Compliance not applicable (NA)
  - Compliance to be defined (TBD)
- **Deviation** request(s) and decision(s)

Requirements Register (cont'd)

- **Relationships** between requirements:
  - **Containement** Split of a composite reqt.
  - **Derivation** Reqt. of lower level in hierarchy
  - **Refinement**

- **Qualification** method:
  - **Tests** (T), destructive on samples or not destructive
  - **Analyses** (A), calculations, etc.
  - **Inspections** (I), incl. visual inspections
  - **Reviews** (R), design reviews, etc.

Verification for PRs
Validation for IURs

- **Qualification** procedure(s), report(s) and status
- **Nonconformance** report(s) and decision(s)
- Editorial quality control: comments, traceability information, requirement status (draft, V&V, etc.)

For reqt. statements