

# Managing Scientific Projects

## Part 1 on Project Quality Management

### References

The following resources were used to prepare the two parts of this course:

**Cochran, C.** (2008) *ISO 9001 in Plain English*. Chico, CA: Paton Professional. 178 p. ISBN 1932828206

**Kossiakoff, A.; Sweet, W.N.** (2002) *Systems engineering principles and practice*. Chichester: John Wiley & Sons (Wiley Series in Systems Engineering, no. 27). 448 p. ISBN 9780471234432

**ISO Std. 9001:2008.** *Quality Management Systems – Requirements*. ISO, Geneva, Switzerland. 27 p.

**ISO Std. 21500:2012.** *Guidance on Project Management*. ISO, Geneva, Switzerland. 44 p.

**PMI Standard Committee** (2008) *A Guide to the Project Management Body of Knowledge*. 4th ed. Newton Square, PA: Project Management Institute. 459 p. ISBN 1933890517

See also: [www.pmi.org](http://www.pmi.org).

**Sage, A. P.; Rouse, W. B.** (Eds.) (2009) *Handbook of Systems Engineering and Management*. 2nd ed. Hoboken, NJ: John Wiley & Sons. 1476 p. ISBN 0470083530

**Ulrich, K. T.; Eppinger, S. D.** (2011) *Product Design and Development*. 5th ed. New-York: McGraw-Hill/Irwin. 384 p. ISBN 9780071086950

**Wysocki, R. K.** (2007) *Effective Project Management. Traditional, Adaptive, Extreme*. 4th ed. Indianapolis, IN: John Wiley & Sons. 615 p. ISBN 0470042613

## 01 -- Introduction to the Concept of Quality

### Quality

Two meanings:

1. "Quality" means those features of products which **meet customer needs** and thereby provide customer satisfaction;
2. "Quality" means **freedom from deficiencies**.



<http://www.qualitygurus.com>

Joseph M. Juran

The difficulty in defining quality is to translate future needs of the user into measurable characteristics, so that a product can be designed and turned out to give satisfaction at a **price** that the user will pay.



<http://www.qualitygurus.com>

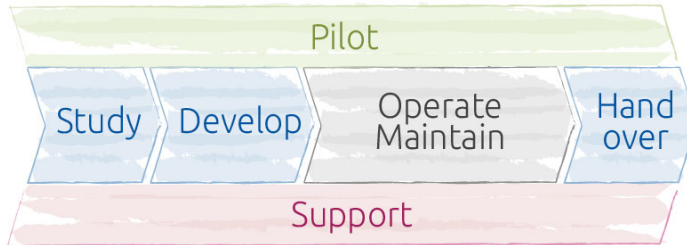
W. Edwards Deming



**Efficiency vs. Effectiveness**



## E.g. Quality at CERN



Quality of our **facilities** and **equipment**  
Quality of our managerial and operational **processes**

**Freedom of deficiencies**  
**Stakeholder satisfaction**  
**Effectiveness**

## Quality *at a glance*

### Quality Management



**Quality  
Planning**



**Quality  
Assurance**



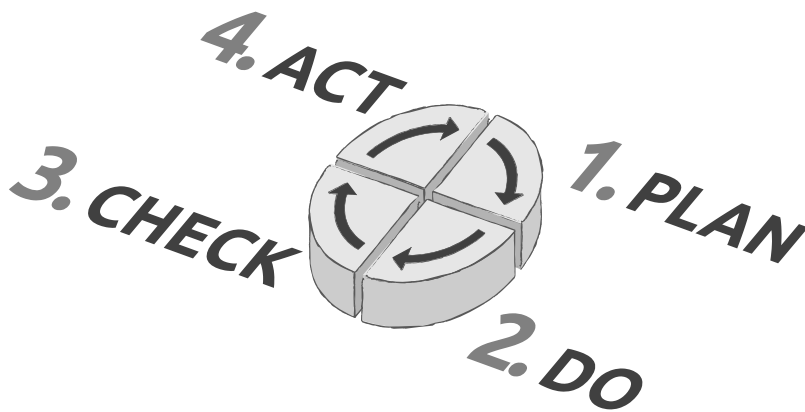
**Quality  
Control**

## Quality

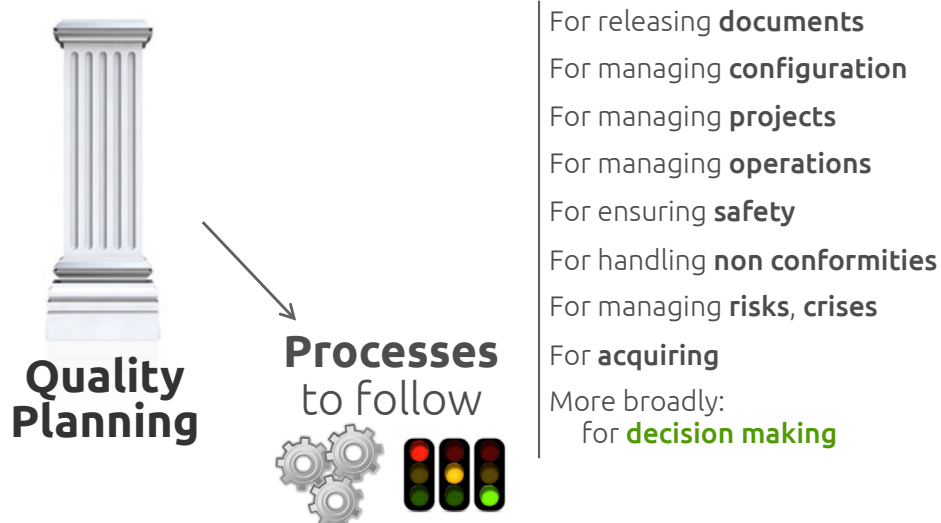
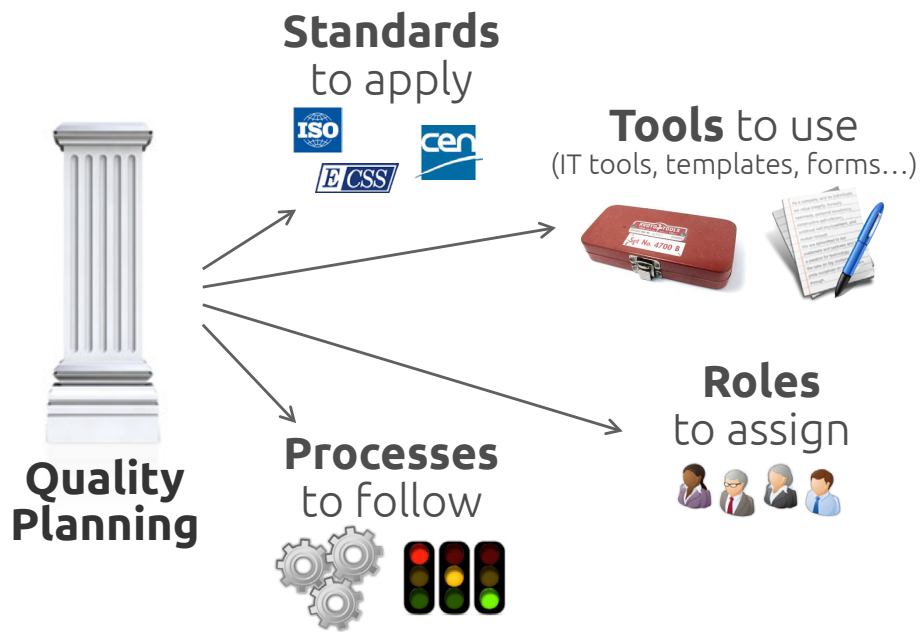
At a glance

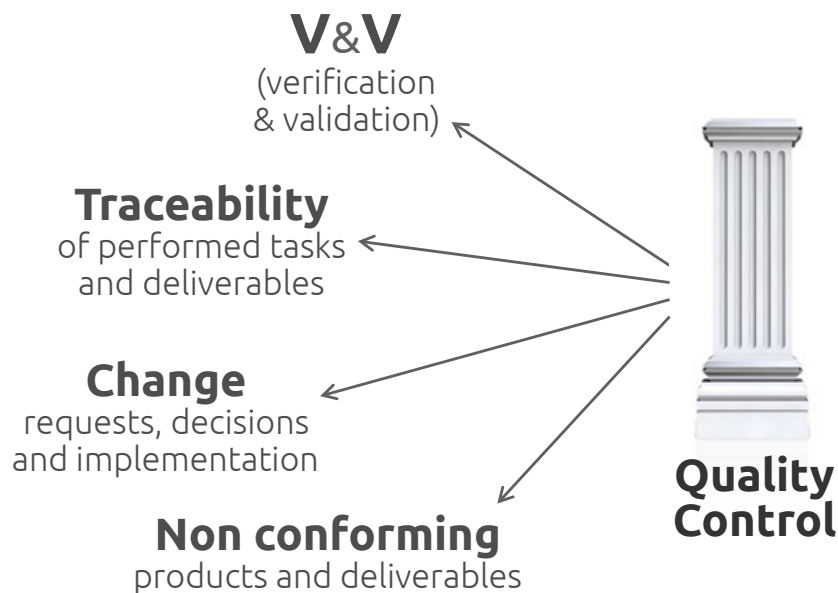
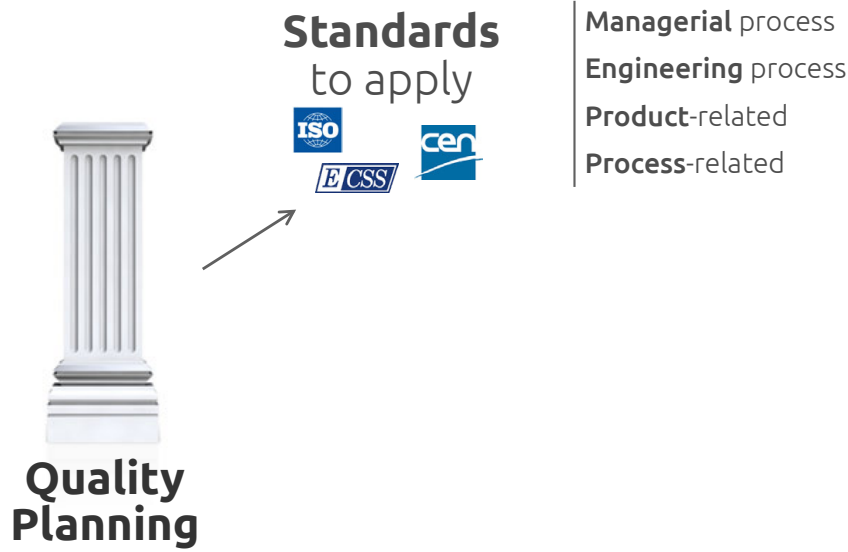


## Deming Wheel



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



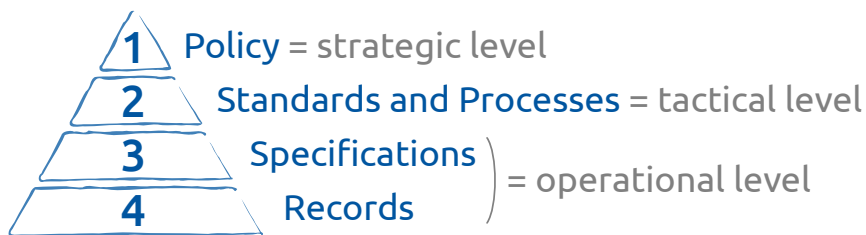


## ISO 9001:2008

At a glance

➔ Six **documented processes** are required to meet the ISO 9001:2008 :

- ➔ 4.2.3 Control of documents
- ➔ 4.2.4 Control of records
- ➔ 8.2.2 Internal audit
- ➔ 8.3 Control of non conforming products
- ➔ 8.5.2 Corrective actions
- ➔ 8.5.3 Preventive actions



## The QA Trade-off

Resources  
to dedicate  
to QA

Value  
created by  
QA



## Quality Planning

At a glance, in a NPD 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 ensuring **project deliverables** comply with **customer needs**
  - ➔ For managing the **configuration** (i.e. the baselines)
  - ➔ For handling **issues** and **non conformities**
  - ➔ For planning, scheduling, costing, hiring project participants, managing risks, reporting the progress, buying supplies and services...
- ➔ More broadly, for **decision making**



## Quality Control

At a glance, in a NPD project context

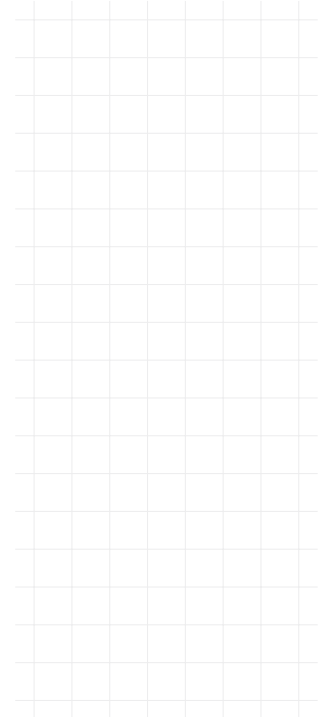
- ➔ Implementing straightforwardly the Project QA Framework provisions:
  - ➔ Proceeding systematically to the **verifications** and **validations** as they have been planned
  - ➔ Insuring the **traceability** of the tasks (how they were performed) and of the task's deliverables (specifications vs.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



## 02 -- Quality Planning

### Applicable Standards

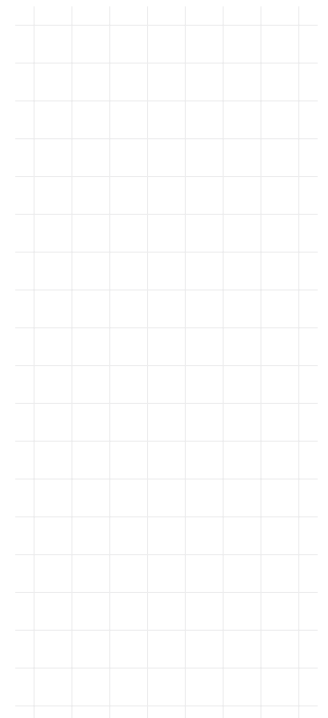
- Standards related to the NPD **project management**  
e.g.: ISO 21500:2012 or ANSI PMBOK 5<sup>th</sup> ed.
- Standards related to the NPD **engineering processes**  
incl. PLM, CAD systems, geometrical tolerancing, etc.
- Standards related to the **product** to develop itself  
in the fields of materials, of communication, of energy, of interfaces,  
of software, of reliability, of availability, of maintainability, of safety, etc.
- Standards related to the **manufacturing and assembly processes**  
incl. supply chain, plant engineering, etc.
- Internal standards related to **coding** (items, assets, docts., functions, etc.)  
and **tagging** (label plates, barcodes, etc.)



## 03 -- 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 **expectations**  
i.e. ensuring that the project deliverables comply customer needs
- Managing the **configuration** and handling **issues** and **non conformities**  
i.e. managing baselines, managing change requests and orders
- Conducting **quality audits**



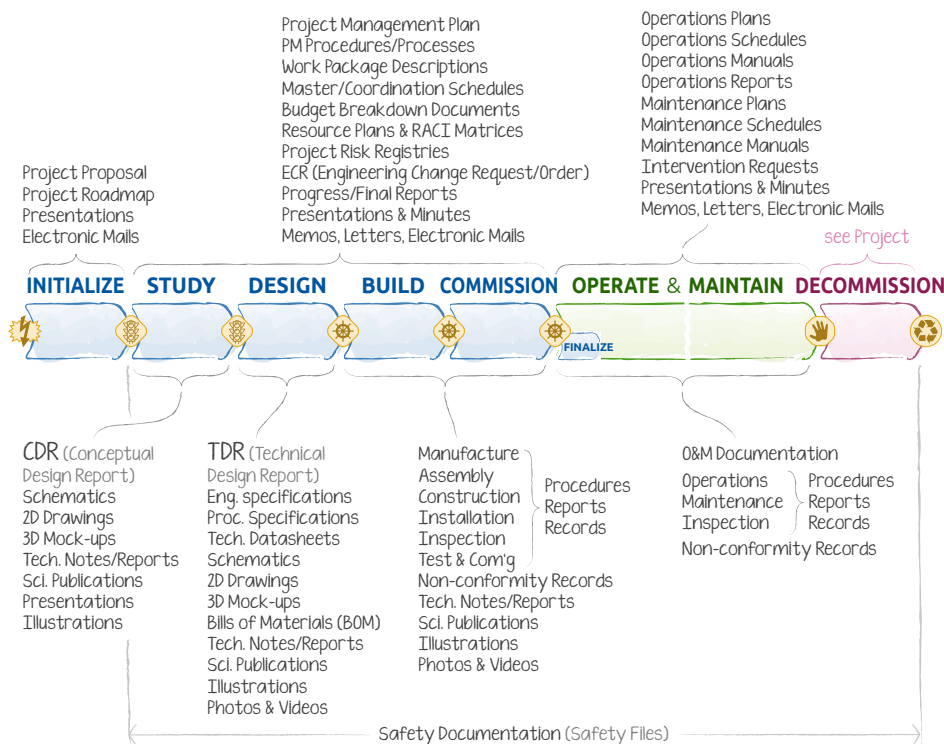


## 04 -- Handling Documents

### Handling Documents

- ➔ Agreeing upon a **typology** of documents
- ➔ Providing document **templates** and **authoring**
- ➔ **Identifying** documents (coding conventions) and **versioning**
- ➔ **Circulating** documents for **verification** then **validation**
- ➔ **Archiving** and **retrieving**

### 04.1 - Typology of Documents



## Key Documents

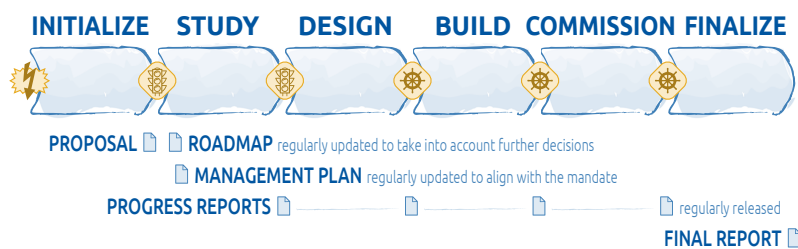
In a "Lean Project Management" perspective



8 documents!

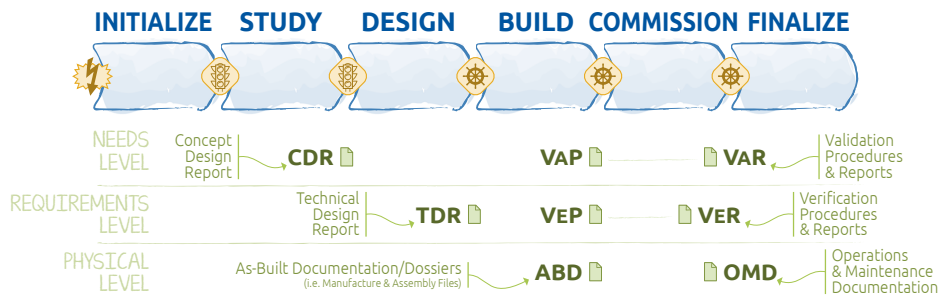
## Key Results

Project Management Documents



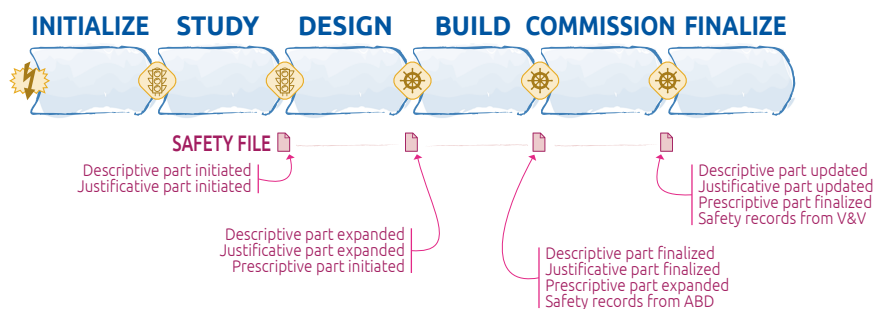
## Key Results

### Technical Documents



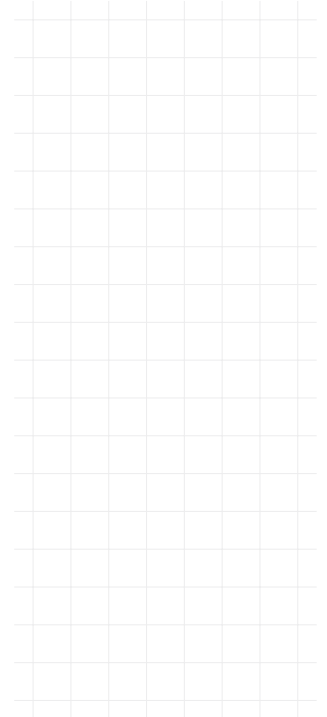
## Key Results

### Safety Documents



## Project Management Documents

- ➔ Project **Requirements Register**
- ➔ Project **Work Breakdown Structure**
- ➔ Project **Master Schedule**
- ➔ Project **Coordination Schedule**
- ➔ Project **RACI Matrix**
- ➔ Project **Cost Estimate**
- ➔ Project **Budget**
- ➔ Then, Project **Progress Reports**
- ➔ Project **Risk Register**
- ➔ Then, Project **Contingency/Continuity Plans**




## 04.2 - Document Templates

### Project Document Template



Unique ID	Version	Status	Date
101	0.2	DRAFT	2014-02-22

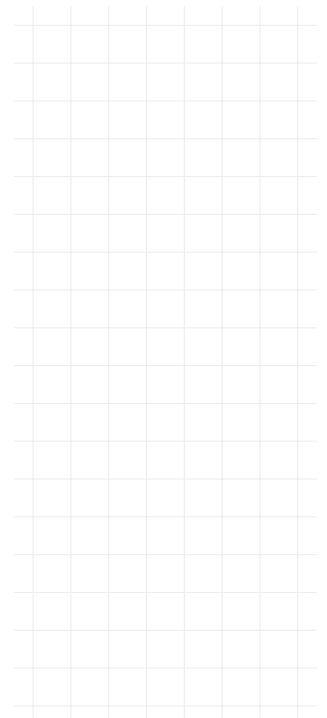
**the whatever project**



**DOCUMENT TITLE**

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

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



## 04.3 - Project Proposal/Roadmap

### Project Roadmap



It is a document that summarizes the direction to be followed by the project team for the whole duration of the project

Other names for this document:

- ➔ (Project) Charter
- ➔ (Project) Mandate
- ➔ (Project) Mission Statement
- ➔ (Project) Brief



### Project Proposal

Typical Table of Contents



- ① **Executive Summary** To the attention of the Project Board
- ① **Initial Situation** Problem statement, rationale, current situation
- ② **Project Objectives**
- ③ **Possible Solutions**
- ④ **A priori Preferred Solution**
  - ④-1 Description of the preferred solution
  - ④-2 Stakeholders and “approached Project Board” membership
  - ④-3 Phasing, project organization, masterplan
  - ④-4 Required resources
  - ④-5 Outcomes and benefits of the project
- ⑤ **Preliminary Risk Register**

## Project Proposal

Editorial Process



- ➔ **Authoring:** Project Initiators
- ➔ **Verification:** Some experts in the field  
The foreseen Project Manager  
A few possible Key Project Participants
- ➔ **Validation:** ∅

## Project Roadmap

Typical Table of Contents



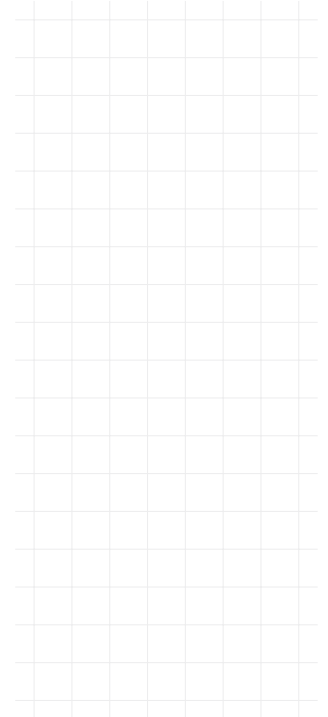
- ① **Executive Summary**
- ① **Initial Situation**
- ② **Project Objectives**
- ③ **Possible Solutions**
- ④ ***A priori* Preferred Solution**
- ⑤ **Preliminary Risk Register**
- ⑥ **Decisions**
  - ⑥.1 Decisions w.r.t. the **STUDY** phase
    - ⑥.1.1 Validation of the PB membership and project organization
    - ⑥.1.2 Decision w.r.t. the preferred solution
    - ⑥.1.3 Decision w.r.t. budgets and masterplan
  - ⑥.2 Decisions w.r.t. the **DESIGN** phase
  - ⋮

## Project Roadmap

Editorial Process



- ➔ **Authoring:** Project Initiators
- ➔ **Verification:** Some experts in the field  
The foreseen Project Manager  
A few possible Key Project Participants
- ➔ **Validation:** **Project Board**



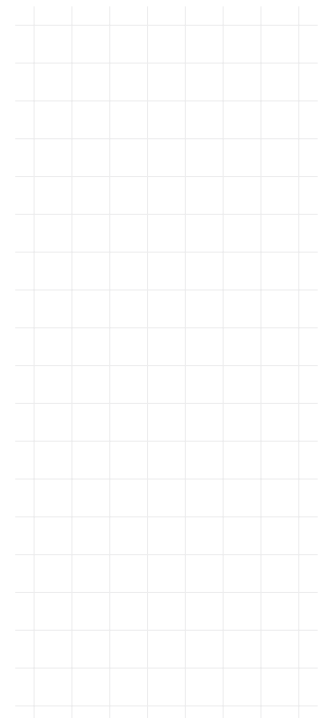
## 04.4 - Project Management Plan

### 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 success 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

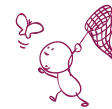
Typical Table of Contents  
Simple Approach



- ① **Project Overview** 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
- Ⓐ **Applicable Standards**

## Project Management Plan

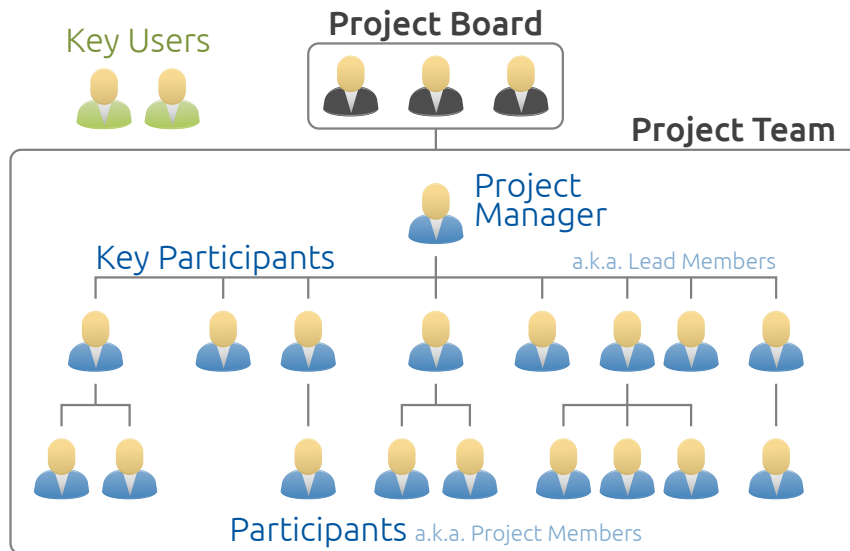
Editorial Process  
Simple Approach



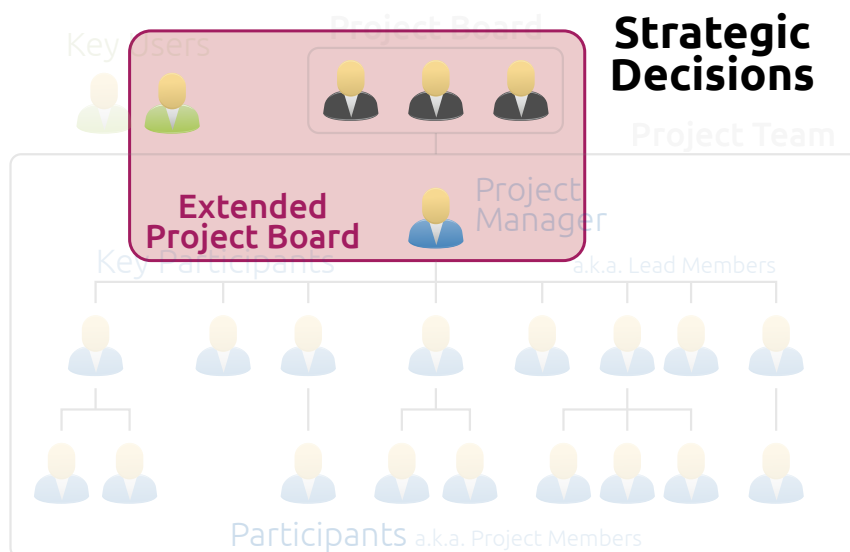
- ➔ **Authoring:** Project Manager + a few Key Project Participants
- ➔ **Verification:** Some other Key Project Participants + some Project Management Experts (e.g. members of the PMO)
- ➔ **Validation:** **Project Manager**



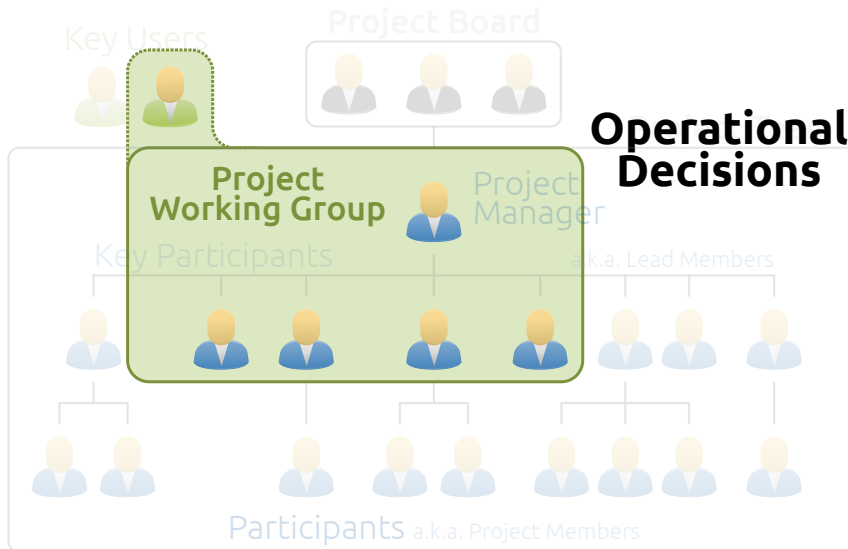
## Roles



## Roles



## Roles



## Roles



### *Project Board (PB)*



Strategic/Steering Board/Committee  
Project Owner, Product/Systems Owner  
Comité de projet (CoP), — de pilotage (COPIL)  
Donneur d'ordre, Maître d'ouvrage (MOU)  
Projektausschuss, comitato di progetto

- ➔ Ensure the **strategic management** of the projet
- ➔ Is ultimately responsible w.r.t. successfull completion
- ➔ Guarantee the acquisition and availability of resources
- ➔ Validate transitions between phases
- ➔ In case if conflicts, arbitrate

## Roles



### Project Manager (**PM**)

*Project Leader (PL), Project Coordinator, Coordinator  
Chef de projet (CP), Maître d'œuvre (MŒU)  
Projektleiter (PL), capoprogetto (CP)*

- ➔ Ensure the **operational management** of the projet
- ➔ Is responsible for the organisation of the project and for its coordination

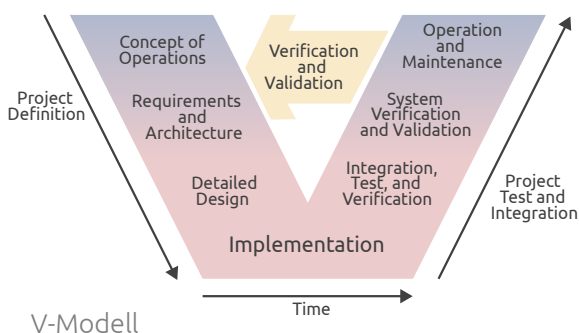
## 04.5 - Document Identification and Circulation

### Verification vs. Validation

Check vs. Approval

From Software Engineering but also widely applied to document lifecycle

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



### Verification:

*Are we building  
the product right?*

*Are we solving  
the equation right?*

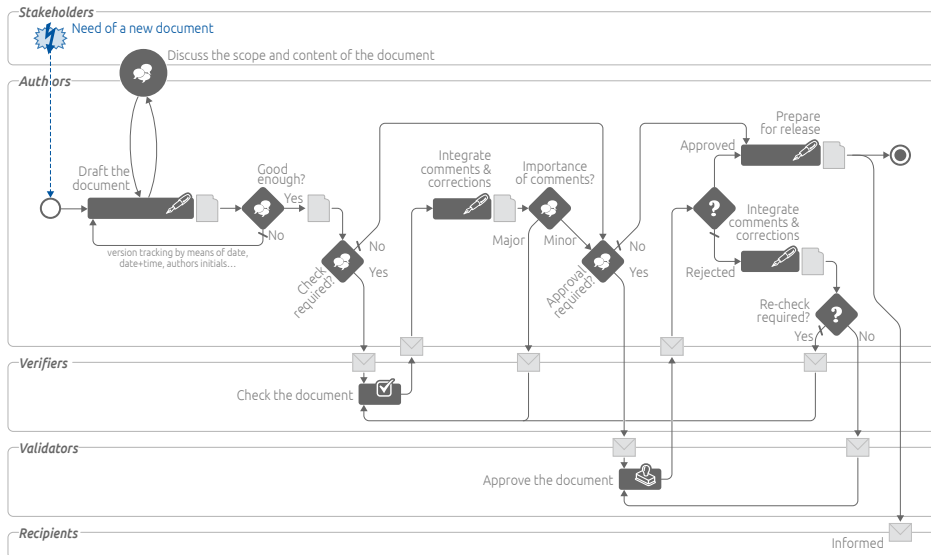
### Validation:

*Are we building  
the right product?*

*Are we solving  
the right equation?*

## Document Lifecycle

Document authoring, circulating and versioning



To have some means to refer to a given version of a given document without ambiguity.

Document ID  
Version ID

**1234 v. 5**  
Lorem ipsum dolor sit amet, consectetur adipiscing elit. Curabitur est purus, facilisis a pharetra ut, mattis sit amet lacus. Nullam vitae nisi urna, quis pellentesque nisl. Nullam sed velit dui. Cras at elit ut quam vestibulum fermentum in vitae libero.

Doct. ID → Should not be problem

Legal people approach:

First release:

DRAFT  
DRAFT *n*  
1234

First revision:

1234/DRAFT  
1234/DRAFT 2  
1234/DRAFT *n*  
1234/Rev.

Next revisions:

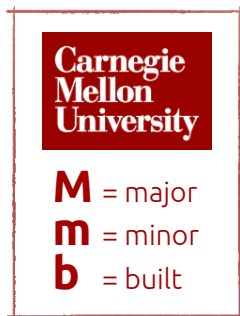
1234/Rev./DRAFT  
1234/Rev./DRAFT 2  
1234/Rev./DRAFT *n*  
1234/Rev.2 ... *n*

One-digit/letter approach:

1234 – A DRAFT  
1234 – B DRAFT  
1234 – C

1234 – D DRAFT  
1234 – E DRAFT  
1234 – F DRAFT  
1234 – G

1234 – H DRAFT  
1234 – J DRAFT  
1234 – K DRAFT  
1234 – L ... Z, AA



Doct. ID → Should not be a problem

## CM M.m

approach:

First release:

1234 v. 0.1 DRAFT

1234 v. 0.2 DRAFT

1234 v. 1.0 RELEASED

First revision:

1234 v. 1.1 DRAFT

1234 v. 1.2 DRAFT

1234 v. 1.3 DRAFT

# 1234 v. 2.0 RELEASED

Next revision:

1234 v. 2.1 DRAFT

1234 v. 2.2 DRAFT

1234 v. 2.3 DRAFT

1234 v. 3.0 RELEASED

## CM M.m.b

approach:

1234 v. 0.0.1 DRAFT

1234 v. 0.0.2 DRAFT

1234 v. 0.1 DRAFT

1234 v. 0.2 DRAFT

1234 v. 1.0 RELEASED

1234 v. 1.0.1 DRAFT

1234 v. 1.0.2 DRAFT

1234 v. 1.1 DRAFT

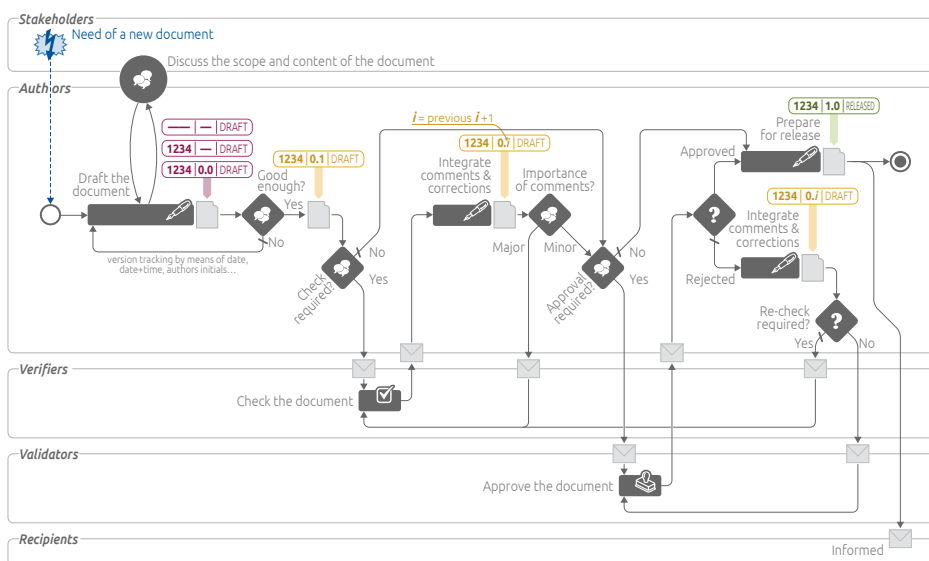
1234 v. 1.2 DRAFT

1234 v. 1.3 DRAFT

1234 v. 2.0 RELEASED

## Document Lifecycle

Document authoring, circulating and versioning



## 04.6 - Document Archival and Retrieval

### Two Families of Documents

Documents of personal interest

vs.

Documents of general interest

**Engineering** docts.  
**Safety** docts. + **O&M** docts.  
**Scientific publications**

### The “5 Roles”

- **Author**

*auteur*

- **Proofreader**

*correcteur*

- **Editor**

*resp. de collection*

- **Publisher**

*éditeur*

- **Librarian**

*bibliothécaire*

#### **Authors**

“Prepared by”

#### **Checkers**

“Checked by” (~ “Verified by”)

#### **Approvers**

“Approved by” (~ “Validated by”)

#### **Releaser**

“Released by” (the *Appro Leader*)

#### **e-Librarian / Cataloguist**

“Cataloged by”

## 04.7 - Document Management System

### Project Document Register

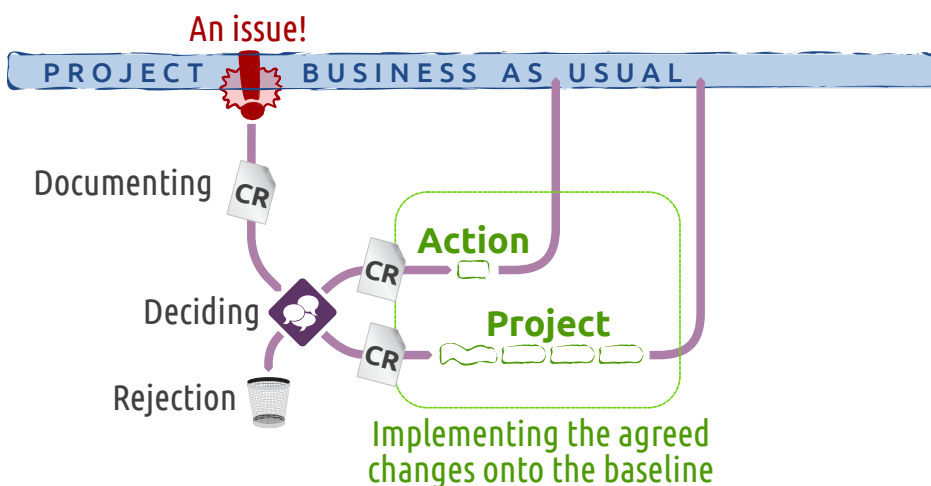


Unique ID	Document title				
	Ver.	Date	Authored by	Verified by	Validated by
100	Project Roadmap		Alberte	Ursule, Yvone —	Xavier, Zélie
	⊗ 0.1	2014-01-13			
	⊗ 0.2	2014-01-20			
	⊗ 1.0	2014-01-22			
101	Project Management Plan		Alberte, Barnabé		
	⊗ 0.1	2014-02-05			
102	Project Work Breakdown Structure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

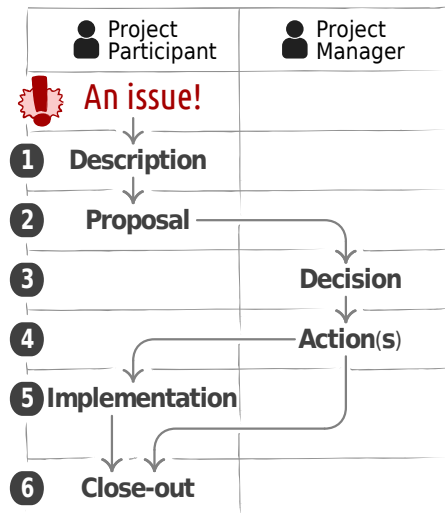
## 05 -- Handling Issues

### Managing Issues

Change Records (CR) featuring requests and orders



## Change Record



Unique ID	Version	Status	Date
234	0.1	DRAFT	2014-02-26

### CHANGE RECORD

- Description
- Proposal
- Decision
 

Decision	Comments
<input type="checkbox"/> Rejection <input type="checkbox"/> Action(s) <input type="checkbox"/> Projects	
- Action(s)
 

Action(s)	Resp.	Date	5 Done
- Close-out

## 06 -- Handling Requirements

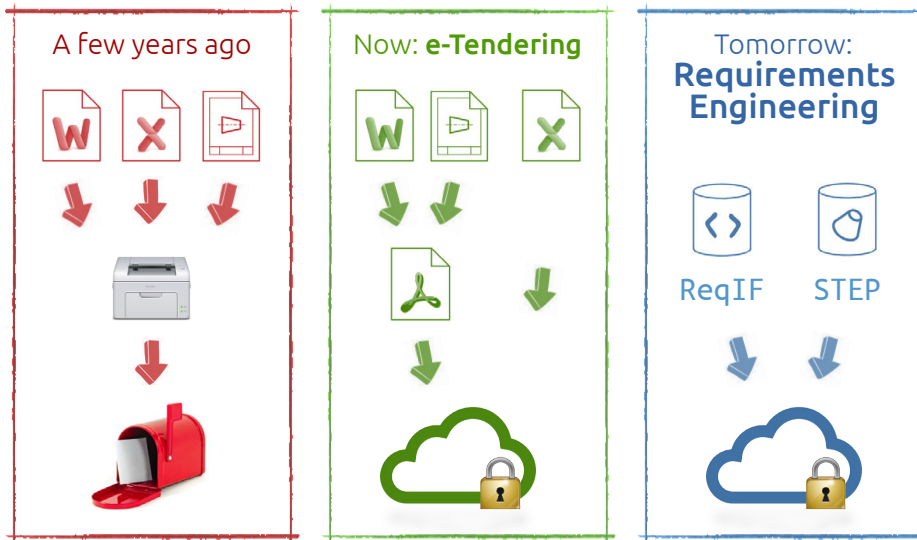
### Requirement Engineering / Management



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

- Software Engineering → capturing **users requirements**
- New Product Development → gathering **customers needs** and translating them into (product) **specifications** or specification items
- Systems Engineering → identifying **users** vs. **functional** vs. **non-functional requirements**
- Quality Management → **QFD** (Quality Function Deployment) and the **House of Quality**
- Procurement and Purchasing → **technical specification** writing





High/good quality products/services

**AIRFRANCE**

Low/affordable cost products/services

**BLACKLIST AIRWAYS**

Competitive advantage ➡ They can choose their customers

Well organized ➡ They prefer well organized customers

Have adopted or adopting requirements engineering tools

## 06.1 - Gathering Needs and Defining Requirements

### Identifying Needs



- 1 Identifying **needs**
- 2 Setting **target requirements**
- 3 Generating, selecting and testing **concepts**
- 4 Setting **final requirements**

### Identifying customer needs in 4 steps

#### Step 1: *Gather raw data from customers.*

What to ask to elicit customer needs...

- ➔ When and why do you use this type of product?
- ➔ Walk us through a typical usage of the product.
- ➔ What do you like about the existing products?
- ➔ What do you dislike about the existing products?
- ➔ What issues do you consider when purchasing the product?
- ➔ What improvements would you make to the product?

## Identifying customer needs in 4 steps

**Step 1: Gather raw data from customers.**

To be efficient, use the *Customer needs data gathering* template!



## Customer needs gathering data sheet

Interviewee :		NPD Project :	QA matters :
		Interviewer(s) :	
		Currently uses :	
Willing to do follow up?		Type of user :	
Question	Customer statement	Interpreted need	
When and why do you <b>use</b> this type of product? Walk us through a <b>typical usage</b> of the product. What do you <b>like</b> about the existing product? What do you <b>dislike</b> about the existing product? What issues do you consider when <b>purchasing</b> the product? What <b>improvements</b> would you make to the product?			

## Customer needs gathering data sheet

Interviewee : Ignatius Reilly Constantinople Street New-Orleans 314 159 2742		NPD Project : cordless screwdriver	QA matters : # 06-137
Willing to do follow up? yes		Interviewer(s) : Robichaux & Mancuso	v. 1.0
		Currently uses : Triton PDA100 18V	2006-11-22
		Type of user : Handy person (frequent user)	

Question	Customer statement	Interpreted need
X When and why do you use this type of product?	I need to drive screws fast, faster than by hand.	
X Walk us through a typical usage of the product.	I sometimes do duct work; use sheet metal screws.	
X What do you like about the existing product?	A lot of electrical; switch covers, outlets, fans, kitchen appliances.	
X What do you like about the existing product?	I like the pistol grip; it feels the best.	
X What do you like about the existing product?	I like the magnetized tip.	
X What do you like about the existing product?	I don't like it when the tip slips off the screw.	
X What do you like about the existing product?	I would like to be able to lock it so I can use it with a dead battery.	
X What do you like about the existing product?	Can't drive screws into hard wood.	
X What do you like about the existing product?	Sometimes I strip tough screws.	
X What do you like about the existing product?	An attachment to allow me to reach down skinny holes.	
X What do you like about the existing product?	A point so I can scrape paint off of screws.	
X What do you like about the existing product?	Would be nice if it could punch a pilot hole.	

## Identifying customer needs in 4 steps

### Step 1: Gather raw data from customers.

Hints for effective data gathering...

- ➡ Go with the flow  
(don't worry about answering all the questions  
if you're getting great data from one question)
- ➡ Use visual stimuli / props  
(existing products, related products, early prototypes)
- ➡ Have customer demonstrate product use  
(this invariably reveals new information)
- ➡ Be alert for surprises and expression of latent needs  
(if something surprising comes up... ask follow-up questions).

## Identifying customer needs in 4 steps

### Step 2: Interpret raw data in term of customer needs.

#### Customer needs gathering data sheet

Interviewee :		NPD Project :	QA matters :
Willing to do follow up?		Interviewer(s) :	
		Currently uses :	
		Type of user :	
Question	Customer statement	Interpreted need	
When and why do you use this type of product? Walk us through a typical usage of the product. What do you like about the existing product? What do you dislike about the existing product? What issues do you consider when purchasing the product? What improvements would you make to the product?	Customer statement	Interpreted need	

#### Customer needs gathering data sheet

Interviewee : Ignatius Reilly Constantinople Street New-Orleans 314 159 2742		NPD Project : cordless screwdriver	QA matters : # 06-137 v. 1.0 2006-11-22
Willing to do follow up? yes		Interviewer(s) : Robichaux & Mancuso	
		Currently uses : Triton PDA100 18V	
		Type of user : Handy person (frequent user)	
Question	Customer statement	Interpreted need	
X	I need to drive screws fast, faster than by hand.	The SD drives screws faster than by hand.	
X	I sometimes do duct work; use sheet metal screws.	The SD drives sheet metal screws into metal duct work.	
X	A lot of electrical; switch covers, outlets, fans, kitchen appliances.	The SD can be used for screws on electrical devices.	
X	I like the pistol grip; it feels the best.	The SD is comfortable to grip.	
X	I like the magnetized tip.	The SD tip retains the screw before it is driven.	
X	I don't like it when the tip slips off the screw.	The SD tip remains aligned with the screw head without slipping.	
X	I would like to be able to lock it so I can use it with a dead battery.	The user can apply torque manually to the SD to drive a screw. (!)	
X	Can't drive screws into hard wood.	The SD can drive screws into hard wood.	
X	Sometimes I strip tough screws.	The SD does not strip screw heads.	
X	An attachment to allow me to reach down skinny holes.	The SD can access screws at the end of deep, narrow holes.	
X	A point so I can scrape paint off of screws.	The SD allows the user to work with screws that have been painted over.	
X	Would be nice if it could punch a pilot hole.	The SD can be used to create a pilot hole. (!)	

## Identifying customer needs in 4 steps

### Step 2: Interpret raw data in term of customer needs.

	Customer statement	Need statement <b>RIGHT</b>	Need statement <b>WRONG</b>
<b>What not how</b>	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery is protected from accidental shorting.	The screwdriver battery contacts are covered by a plastic sliding door.
<b>Specificity</b>	"I drop my screwdriver all the time."	The screwdriver operates normally after repeated dropping.	The screwdriver is rugged.
<b>Positive not negative</b>	"It doesn't matter if it's raining; I still need to work outside on Saturdays."	The screwdriver operates normally in the rain.	The screwdriver is not disabled by the rain.
<b>An attribute of the product</b>	"I'd like to charge my battery from my cigarette lighter."	The screwdriver battery can be charged from an automobile cigarette lighter.	An automobile cigarette lighter adapter can charge the screwdriver battery.
<b>Avoid must and should</b>	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	The screwdriver provides an indication of the energy level of the battery.	The screwdriver should provide an indication of the energy level of the battery.

## Identifying customer needs in 4 steps

### Step 3: Organize the needs into a hierarchy.

The result should be **50 to 300 need statements**.

These should be distilled into **primary needs & secondary needs**.

- ➔ Write each statement on separate card
- ➔ Eliminate redundant statements
- ➔ Group cards according to the similarity of the needs they express
- ➔ For each group choose label (general statement).

## Identifying customer needs in 4 steps

### Step 3: Organize the need into a hierarchy.



#### **SD provides plenty of power to drive screws.**

- \* The SD maintains power for several hours of heavy use.
- \*\* The SD can drive screws into hardwood.
- The SD drives sheet metal screws into metal ductwork.
- \*\*\* The SD drives screws faster than by hand.

#### **The SD makes it easy to start a screw.**

- \* The SD retains the screw before it is driven.
- \*! The SD can be used to create a pilot hole.

#### **The SD works with a variety of screws.**

- \*\* The SD can turn Phillips, Torx, socket, and hex head screws.
- \*\* The SD can turn many sizes of screws.

#### **The SD can access most screws.**

- The SD can be maneuvered in tight areas.
- \*\* The SD can access screws at the end of deep, narrow holes.

#### **The SD turns screws that are in poor condition.**

- The SD can be used to remove grease and dirt from screws.
- The SD allows the user to work with painted screws.

#### **The SD feels good in the user's hand.**

- \*\*\* The SD is comfortable when the user pushes on it.
- \*\*\* The SD is comfortable when the user resists twisting.
- \* The SD is balanced in the user's hand.
- ! The SD is equally easy to use in right or left hands.

The SD weight is just right.

The SD is warm to touch in cold weather.

The SD remains comfortable when left in the sun.

#### **The SD is easy to control while turning screws.**

- \*\*\* The user can easily push on the SD.
- \*\*\* The user can easily resist the SD twisting.
- The SD can be locked on.
- \*! The SD speed can be controlled by the user while turning a screw.
- \* The SD remains aligned with the screw head without slipping.
- \*\* The user can easily see where the screw is.
- \* The SD does not strip screw heads.
- \* The SD is easily reversible.

## Identifying customer needs in 4 steps

### Step 3: Organize the need into a hierarchy.



#### **The SD is easy to set up and use.**

- \* The SD is easy to turn on.
- \* The SD prevents inadvertent switching off.
- \* The user can set the maximum torque of the SD.
- \*! The SD provides ready access to bits or accessories.
- \* The SD can be attached to the user for temporary storage.

#### **The SD power is convenient.**

- \* The SD is easy to recharge.
- The SD can be used while recharging.
- \*\*\* The SD recharges quickly.
- The SD batteries are ready to use when new.
- \*! The user can apply torque manually to the SD to drive a screw.

#### **The SD lasts a long time.**

- \*\* The SD tip survives heavy use.
- The SD can be hammered.
- \* The SD can be dropped from a ladder without damage.

#### **The SD is easy to store.**

- \* The SD fits in a toolbox easily.
- \*\* The SD can be charged while in storage.
- The SD resists corrosion when left outside or in damp places.
- \*! The SD maintains its charge after long periods of storage.
- The SD maintains its charge when wet.

#### **The SD prevents damage to the work.**

- \* The SD prevents damage to the screw head.
- The SD prevents scratching of finished surfaces.

#### **The SD has a pleasant sound when in use.**

#### **The SD looks like a professional quality tool.**

#### **The SD is safe.**

- The SD can be used on electrical devices.
- \*\*\* The SD does not cut the user's hands.

## Identifying customer needs in 4 steps

**Step 4:** *Establish the relative importance of the needs.*

### Customer needs survey form

NPD Project : <i>cordless screwdriver</i>	Reviewer : <i>Ignatius Reilly Constantinople Street New-Orleans 314 159 2742</i>	QA matters : <i># 06-258 2006-11-22</i>
<p>For each of the following features, please indicate on a scale of 1 to 5 how important the feature is to you. Please use the following scale :</p> <p>1. Feature is undesirable. I would not consider a product with this feature. 2. Feature is not important, but I would not mind having it. 3. Feature would be nice to have, but is not necessary. 4. Feature is highly desirable, but I would consider a product without it. 5. Feature is critical. I would not consider a product without this feature. Also indicate by checking the box if you feel that the feature is unique, exciting and or unexpected.</p>		
Importance of the feature	Interpreted need	
<div style="display: flex; justify-content: space-between;"> <span>LOW</span> <span>HIGH</span> </div> <div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px; margin-right: 5px;"> <div style="display: flex; justify-content: space-between;"> <span>2</span> <span>3</span> <span>4</span> <span>5</span> </div> <div style="text-align: center;"> <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">5</span> </div> </div> <input type="checkbox"/> </div>	The SD drives screws faster than by hand.	
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px; margin-right: 5px;"> <div style="display: flex; justify-content: space-between;"> <span>2</span> <span>3</span> <span>4</span> </div> <div style="text-align: center;"> <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">3</span> </div> </div> <input type="checkbox"/> </div>	The SD drives sheet metal screws into metal duct work.	
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px; margin-right: 5px;"> <div style="display: flex; justify-content: space-between;"> <span>2</span> <span>3</span> <span>4</span> </div> <div style="text-align: center;"> <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">2</span> </div> </div> <input type="checkbox"/> </div>	The SD can be used for screws on electrical devices.	
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px; margin-right: 5px;"> <div style="display: flex; justify-content: space-between;"> <span>2</span> <span>3</span> <span>4</span> </div> <div style="text-align: center;"> <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">4</span> </div> </div> <input type="checkbox"/> </div>	The SD is comfortable to grip.	
<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 2px; margin-right: 5px;"> <div style="display: flex; justify-content: space-between;"> <span>2</span> <span>3</span> <span>4</span> </div> <div style="text-align: center;"> <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">5</span> </div> </div> <input type="checkbox"/> </div>	The SD tip retains the screw before it is driven. a	

## Setting Requirements



- 1 Identifying **needs**
- 2 Setting **target requirements**
- 3 Generating, selecting and testing **concepts**
- 4 Setting **final requirements**



## Product Specification

The issue:

Customer needs are generally expressed in the language of the customers, i.e. it leaves too much space for subjective interpretation.

Customer needs → *mountain bike suspension fork.*

No.	Need	Imp.
1	The suspension reduces vibration to the hands.	3
2	The suspension allows easy traversal of slow, difficult terrain.	2
3	The suspension enables high-speed descents on bumpy trails.	5
4	The suspension allows sensitivity adjustment.	3
5	The suspension preserves the steering characteristics of the bike.	4
6	The suspension remains rigid during hard cornering.	4
7	The suspension is lightweight.	4
8	The suspension provides stiff mounting points for the brakes.	2
9	The suspension fits a wide variety of bikes, wheels, and tires.	5
10	The suspension is easy to install.	1
11	The suspension works with fenders.	1
12	The suspension instills pride.	5
13	The suspension is affordable for an amateur enthusiast.	5
14	The suspension is not contaminated by water.	5
15	The suspension is not contaminated by grunge.	5
16	The suspension can be easily accessed for maintenance.	3
17	The suspension allows easy replacement of worn parts.	1
18	The suspension can be maintained with readily available tools.	3
19	The suspension lasts a long time.	5
20	The suspension is safe in a crash.	5



## Product Specification

For this very reason, product development teams usually expressed these customer needs statements in term of specification, which spell out in precise and measurable detail what customers expect from the product.

The product specifications do not address the **how** the product will satisfy the customer needs, but the **what** it has to do.

### Target specifications vs. final specifications

## Target product specification

1. Prepare a list of **metrics**
2. Collect **competitive benchmarking** information
3. Set ideal and marginally acceptable **target values**.

## Target product specification

### Step 1: Prepare a list of metrics.

An efficient approach consists to contemplate each need in turn and (to try) to consider what precise and measurable characteristic of the product can be used.

The ideal case is a one to one mapping between needs and metrics. In practice this is not always the case. A needs-metrics matrix can represent visually the relationship between needs and matrix. This matrix is part of the so-called *House of quality* used in QFD.

### Metrics → mountain bike suspension fork.

Metric No.	Need No.	Metric	Imp.	Units
1	1, 3	Attenuation from dropout to handlebar at 10Hz	3	dB
2	2, 6	Spring preload	3	N
3	1, 3	Maximum value from the Monster	5	g
4	1, 3	Minimum descent time on test track	5	s
5	4	Damping coefficient adjustment range	3	N-s/m
6	5	Maximum travel (26-in. wheel)	3	mm
7	5	Rake offset	3	mm
8	6	Lateral stiffness at the tip	3	kN/m
9	7	Total mass	4	kg
10	8	Lateral stiffness at brake pivots	2	kN/m
11	9	Headset sizes	5	in.
12	9	Steertube length	5	mm
13	9	Wheel sizes	5	List



## Metrics → mountain bike suspension fork.

Metric No.	Need No.	Metric	Imp.	Units
14	9	Maximum tire width	5	in.
15	10	Time to assemble to frame	1	s
16	11	Fender compatibility	1	List
17	12	Instils pride	5	Subj.
18	13	Unit manufacturing cost	5	US\$
19	14	Time in spray chamber without water entry	5	s
20	15	Cycles in mud chamber without contamination	5	k-cycles
21	16, 17	Time to disassemble/assemble for maintenance	3	s
22	17, 18	Special tools required for maintenance	3	List
23	19	UV test duration to degrade rubber parts	5	hr
24	19	Monster cycles to failure	5	cycles
25	20	Japan Industrial Standards test	5	binary
26	20	Bending strength (frontal loading)	5	kN



## Needs-metrics matrix

### 20 needs

### 26 metrics

Needs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
The suspension reduces vibration to the hands.	●																			
The suspension allows easy traversal of slow, difficult terrain.	●	●																		
The suspension enables high-speed descents on bumpy trails.	●	●	●																	
The suspension allows sensitivity adjustment.			●																	
The suspension preserves the steering characteristics of the bike.			●	●																
The suspension remains rigid during hard cornering.			●																	
The suspension is lightweight.				●																
The suspension provides stiff mounting points for the brakes.					●															
The suspension fits a wide variety of bikes, wheels, and tires.						●														
The suspension is easy to install.							●													
The suspension works with fenders.								●												
The suspension instils pride.									●											
The suspension is affordable for an amateur enthusiast.										●										
The suspension is not contaminated by water.											●									
The suspension is not contaminated by grunge.												●								
The suspension can be easily accessed for maintenance.													●							
The suspension allows easy replacement of worn parts.														●						
The suspension can be maintained with readily available tools.															●					
The suspension lasts a long time.																	●			
The suspension is safe in a crash.																		●		

## Target product specification

Guidelines to be considered when constructing the **list of metrics**:

- ➔ Metrics should be **complete**: at least a metric per identified customer need
- ➔ Metrics should be **dependant variables**, answering preferably the **what** question and not the **how** question: e.g. specifying a light material for a weight is non dependant while giving a weight metrics in kilograms for instance is dependant
- ➔ Metrics should be **practical**, i.e. measurable with usual measurement means
- ➔ Some metrics cannot be translated into quantifiable metrics, i.e. colour, aesthetic consideration... → specify "**Subj.**" as a unit!
- ➔ Metrics may also include **popular comparison criteria**.

## Target product specification

**Step 2: Collect competitive benchmarking information.**

Collecting competitive benchmarking information is a rather simple, tough, but rather simple! The investment is in general very valuable.

## Competitive benchmarking



1	Attenuation from dropout to handlebar at 10Hz	3	dB	8	15	10	15	9	13
2	Spring preload	3	N	550	760	500	710	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
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	85	65	130
9	Total mass	4	kg	1.409	1.385	1.409	1.364	1.222	1.100

## Competitive benchmarking



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	NA
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	NA
13	Wheel sizes	5	List	26 in.	26 in.	26 in.	26 in. 700 cm	26 in.	26 in.
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	Zefaf	None	None	None	None	All
17	Instils pride	5	Subj.	1	4	3	5	3	5

## Competitive benchmarking



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

## Competitive benchmarking



1	The suspension reduces vibration to the hands.	3	.	....	..	.....	..	...
2	The suspension allows easy traversal of slow, difficult terrain.	2	..	....	...	.....	...	.....
3	The suspension enables high-speed descents on bumpy trails.	5	.	.....	..	.....	..	...
4	The suspension allows sensitivity adjustment.	3	.	....	..	.....	..	...
5	The suspension preserves the steering characteristics of the bike.	4	....	..	.	..	.....	.....
6	The suspension remains rigid during hard cornering.	4	.	...	.	.....	.	.....
7	The suspension is lightweight.	4	.	...	.	...	....	.....
8	The suspension provides stiff mounting points for the brakes.	2	.	....	...	...	.....	..
9	The suspension fits a wide variety of bikes, wheels, and tires.	5	....	.....	...	.....	...	.
10	The suspension is easy to install.	1	....	.....	....	....	.....	.

## Competitive benchmarking



11	The suspension works with fenders.	1	...	.	.	.	.	.....
12	The suspension instills pride.	5	.	....	...	.....	...	.....
13	The suspension is affordable for an amateur enthusiast.	5	.....	.	...	.	...	..
14	The suspension is not contaminated by water.	5	.	...	....	.....	..	.....
15	The suspension is not contaminated by grunge.	5	.	...	.	....	..	.....
16	The suspension can be easily accessed for maintenance.	3	....	.....	....	.....	.....	.
17	The suspension allows easy replacement of worn parts.	1	....	.....	....	.....	.....	.
18	The suspension can be maintained with readily available tools.	3	.....	.....	.....	.....	..	.
19	The suspension lasts a long time.	5	.....	.....	.....	...	.....	.
20	The suspension is safe in a crash.	5	.....	.....	.....	.....	.....	.....

## Target product specification

### Step 3: Set ideal and marginally acceptable target values.

There are five ways to express a value of the metrics:

- ➔ **At least X**, i.e. a bound or the higher value the better
- ➔ **At most X**, i.e. a upper bound or the smaller value the better
- ➔ **Between X and Y**, i.e. a lower and upper bounds
- ➔ **Exactly X**, a particular value of a metric
- ➔ **Discrete values**.

The set of valued metrics of the target product specification is obtained after some iterations.



## Final product specification

1. Develop **technical models** of the product
2. Develop a **cost model** of the product
3. Refine the specification, make **trade-offs** if necessary
4. Flow down the specification.

More difficult because of some trade-offs: stringent specifications have a cost! Inverse relationships between two or more specifications, e.g. weight and strength.

## 06.2 - Requirements Engineering

### Requirements Engineering

**INCOSE Systems Engineering Handbook** - a guide for system life cycle processes and activities, version 3.2.1 January 2011, INCOSE-TP-2003-002-03.2.1 (374 pages)  
[www.incose.org](http://www.incose.org)



**ISO/IEC 15288:2008**, Systems and software engineering – System life cycle processes



**Guide to the Systems Engineering Body of Knowledge (SEBoK)**, version 1.2, 2013 (816 pages)  
[http://www.sebokwiki.org/pdf/SEBoKv1.2\\_full.pdf](http://www.sebokwiki.org/pdf/SEBoKv1.2_full.pdf)



**NASA Systems Engineering Handbook**, NASA/SP-2007-6105 Rev1, December 2007 (360 pages)  
[http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080008301\\_2008008500.pdf](http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080008301_2008008500.pdf)



**Space Engineering – Verification**, European Cooperation for Space Standardization ECSS-E-ST-10-02C, March 2009 (45 pages) [www.ecss.nl](http://www.ecss.nl)

**A Glossary of Requirements Engineering Terminology**, IREB, v1.5, May 2013 (116 pages)  
[www.ireb.org](http://www.ireb.org)



**Get It Right The First Time: Writing Better Requirements**, IBM Rational DOORS, 2011 (68 pages),  
[http://publib.boulder.ibm.com/infocenter/rsdp/v1r0m0/topic/com.ibm.help.download.doors.doc/pdf92/get\\_it\\_right\\_the\\_first\\_time.pdf](http://publib.boulder.ibm.com/infocenter/rsdp/v1r0m0/topic/com.ibm.help.download.doors.doc/pdf92/get_it_right_the_first_time.pdf)

## Requirements Engineering

The Systems Engineering approach

- ① Gathering **UR's** (user/stakeholders requirements), i.e. **needs**
- ② Searching for **solutions** that may satisfy the UR's
- ③ **Benchmarking** the solutions w.r.t. the UR's; elimination those that do not match UR's
- ④ Translating the UR's into **FR's** (functional requirements) and **¬FR's** (non-functional requirements)
- ⑤ **Verifying** and **validating** the portfolio of requirements prior UR's, FR's and ¬FR's become "released/planned"
- ⑥ **Implementing** the preferred solution, and by the way the requirements
- ⑦ **Qualifying** the requirement after they have been implemented

## Requirements Register

It is a structured list of requirements

- ➔ Rqt. **ID** and a short description
- ➔ So-called "**shall statement**"
- ➔ Category or **type**, e.g. UR, FR or ¬FR
- ➔ **Compliance** to solutions, and per solution:
  - ➔ Compliant (C)
  - ➔ Partially 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)




It is a structured list of requirements

- Rqt. ID and a short description
- So-called "**shall statement**"
- Category or **type**, e.g. UR, FR or -FR
- **Compliance** to solutions
- **Deviation** request(s) and decision(s)
- **Qualification** method:
  - **Tests** (T), destructive on samples or not destructive
  - **Analyses** (A)
  - **Inspections** (I)
  - **Reviews** (R), design reviews, etc.
- **Qualification** procedure(s), report(s) and status
- **Non conformance** report(s) and decision(s)
- Editorial quality control: comments, V&V, traceability, rqt. status

## Requirements Engineering

IBM Software  
Requirements management



**Highlights**

- Supports collaborative, intuitive and scalable management of requirement specifications
- Helps enable simpler creation of links and powerful traceability views across requirement specifications, designs and tests
- Provides automatic notification of changes that can impact related requirements, designs and tests
- Helps integrate requirements into the lifecycle as a core component of the IBM® Rational® solution for systems

### IBM Rational DOORS

*Requirements management for complex and embedded systems*

Effective requirements management practices have a positive impact on the success of systems and product development.

IBM Rational DOORS® software is designed to capture, trace, analyze and manage changes to requirements and helps you comply with industry standards.

**Intuitive, collaborative and scalable requirements management**

Successful management of requirements starts by documenting them in a way that's easy to interpret and navigate. In Rational DOORS, the hierarchical organization of requirements—in a familiar, document-style list—shows each individual requirement in context, while a convenient navigation tree reveals the structure of the information set. A tabular view of the requirements helps you view and assign additional information to them with an unlimited number of your own attributes. Rational DOORS is designed for managing small to large requirement documents,