



**GEA Tianjin / 中国民航大学中欧航空工程师学院**

## **CS41: REQUIREMENTS DEVELOPMENT**

**THALES**

**AIRBUS**



**eurocopter**  
an EADS Company

**SAFRAN**

# Agenda

- Stakeholder Requirements Definition
- Requirements analysis



## Contexte



**Customer**

### *Problem space*



Operational  
needs &  
requirements

Industrial  
constraints



**Supplier**

### *Solution Space*

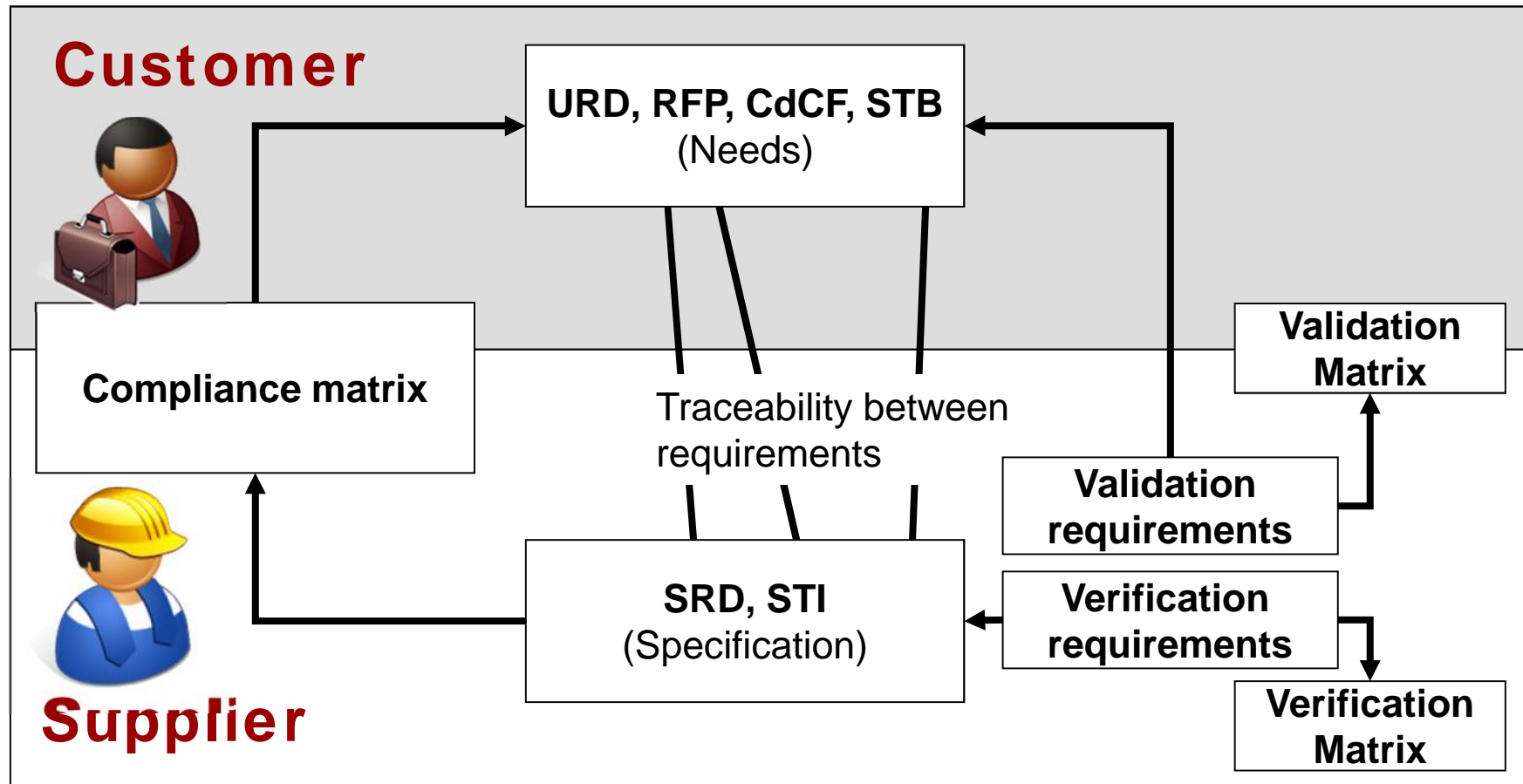
Technical  
requirements

Architectures

Existing components

**Sub contractors**

## Documents cascade



URD :User Requirements Document  
RFP : Request For Proposal

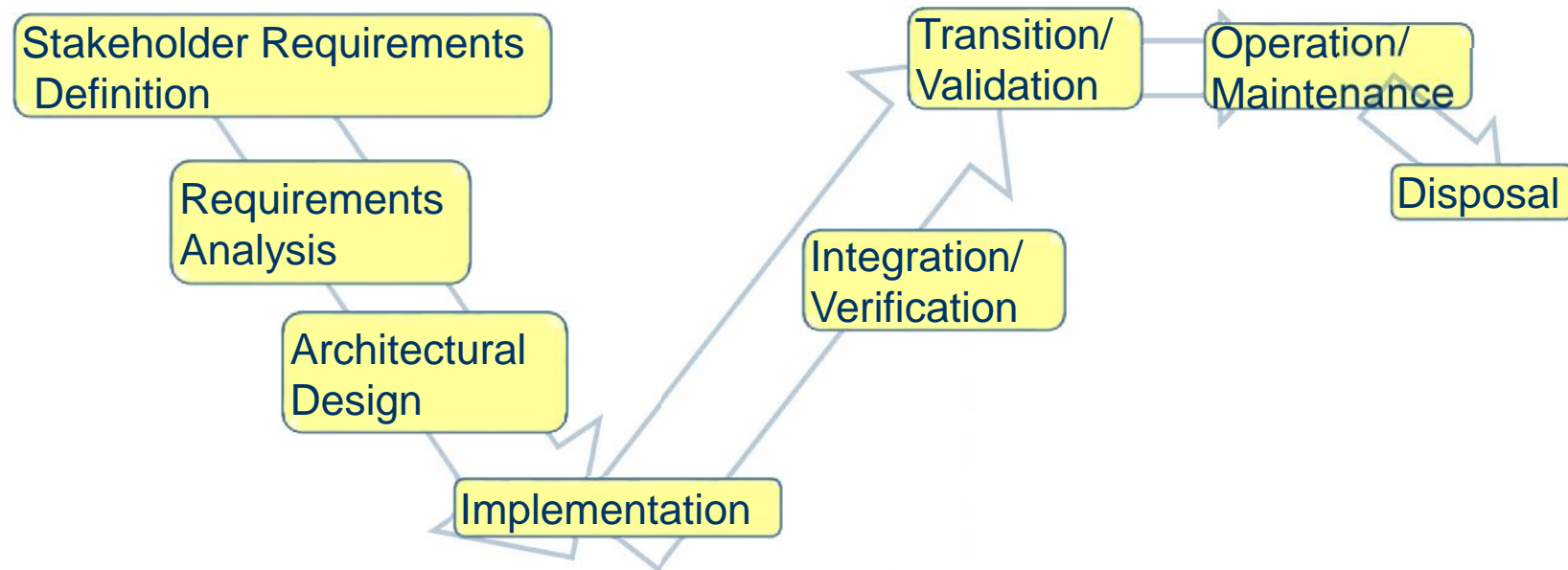
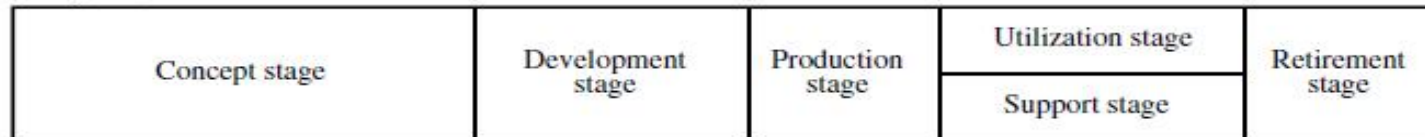
CdCF :Cahier des Charges Fonctionnel  
STB : Spécification Technique du Besoin

SRD : System Requirements Document  
STI : Spécification Technique Industrielle



## Processus and life-cycle

Generic life cycle (ISO/IEC/IEEE 15288:2015)



ISO 15288 On a V-Cycle

# Stakeholder requirement definition

Requirement analysis  
Architecture design  
Implementation  
Integration / Verification  
Transition (to use) / Validation  
Operational and maintenance  
Disposal

The purpose is to define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment.

SE Technical Processes (ISO-15288)



## What is a Stakeholder?

### ➤ Stakeholder

- individual or organization having a right, share, claim, or interest in a system or in its possession of characteristics that meet their needs and expectations

→ A stakeholder can influence the definition and the development of a system

Examples:

- Customer
- User, operator
- Suppliers
- Resellers
- Regulation organisms
- State



## What is a need ?

- A need comes from a lack, a dissatisfaction, a new **expectation**
- The need is **valid** when the following questions could be answered:
  - Why this need (rationale)?
  - What should make this need change or disappear?
  - What is the risk the need changes or disappears?



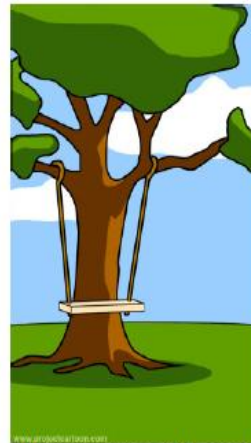


## How Projects Really Work (version 1.5)

Create your own cartoon at [www.projectcartoon.com](http://www.projectcartoon.com)



How the customer explained it



How the project leader understood it



How the analyst designed it



How the programmer wrote it



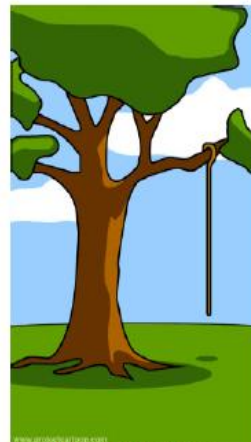
What the beta testers received



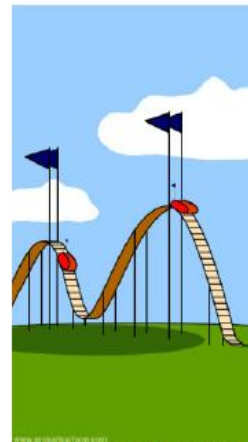
How the business consultant described it



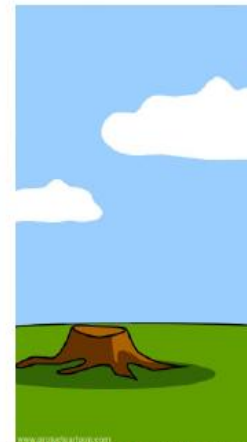
How the project was documented



What operations installed



How the customer was billed



How it was supported



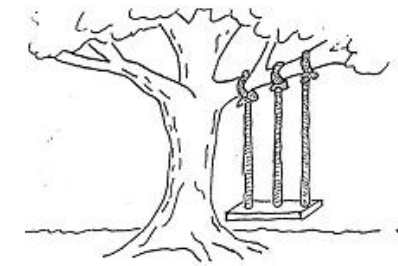
What marketing advertised



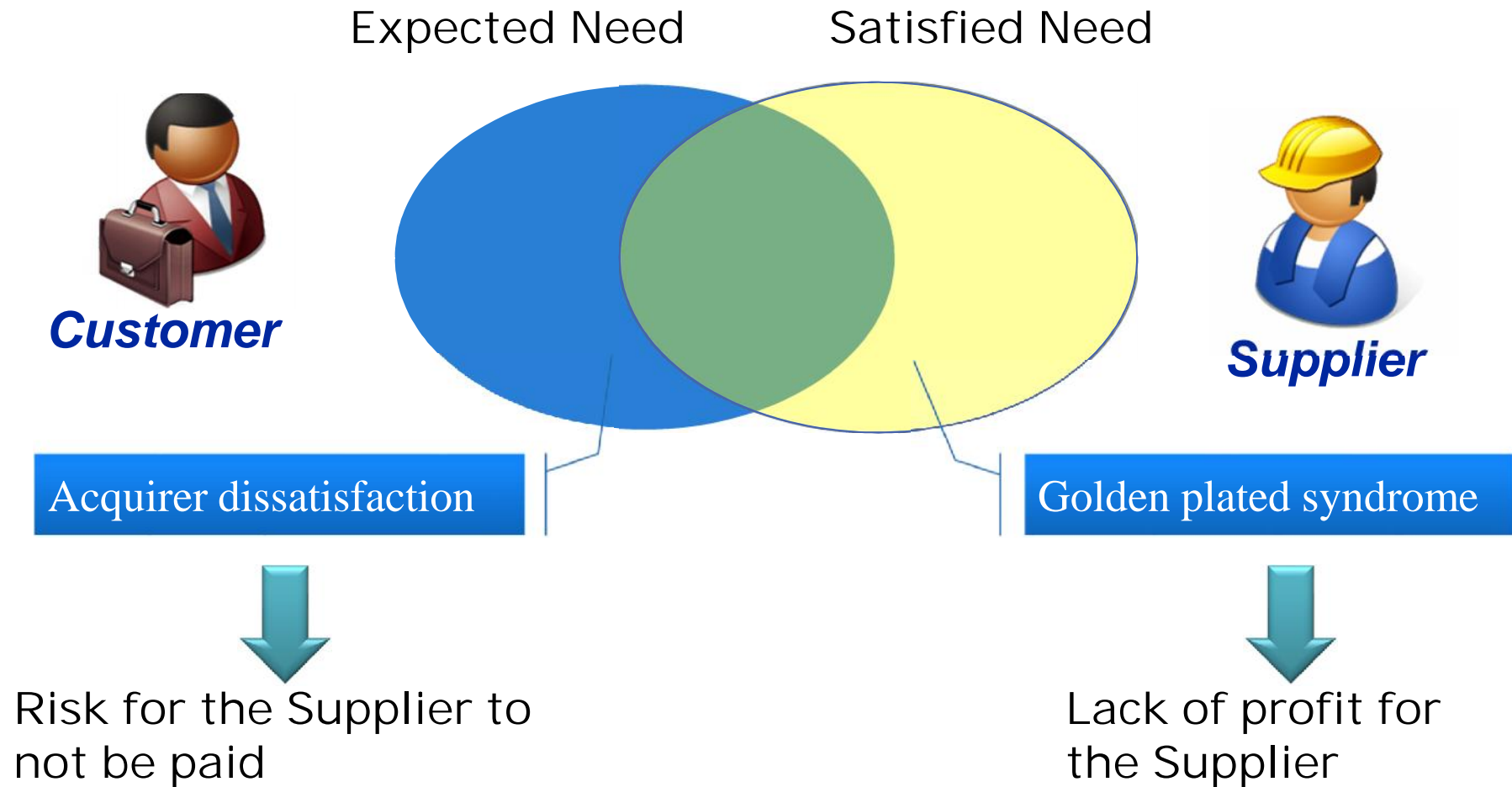
What the customer really needed



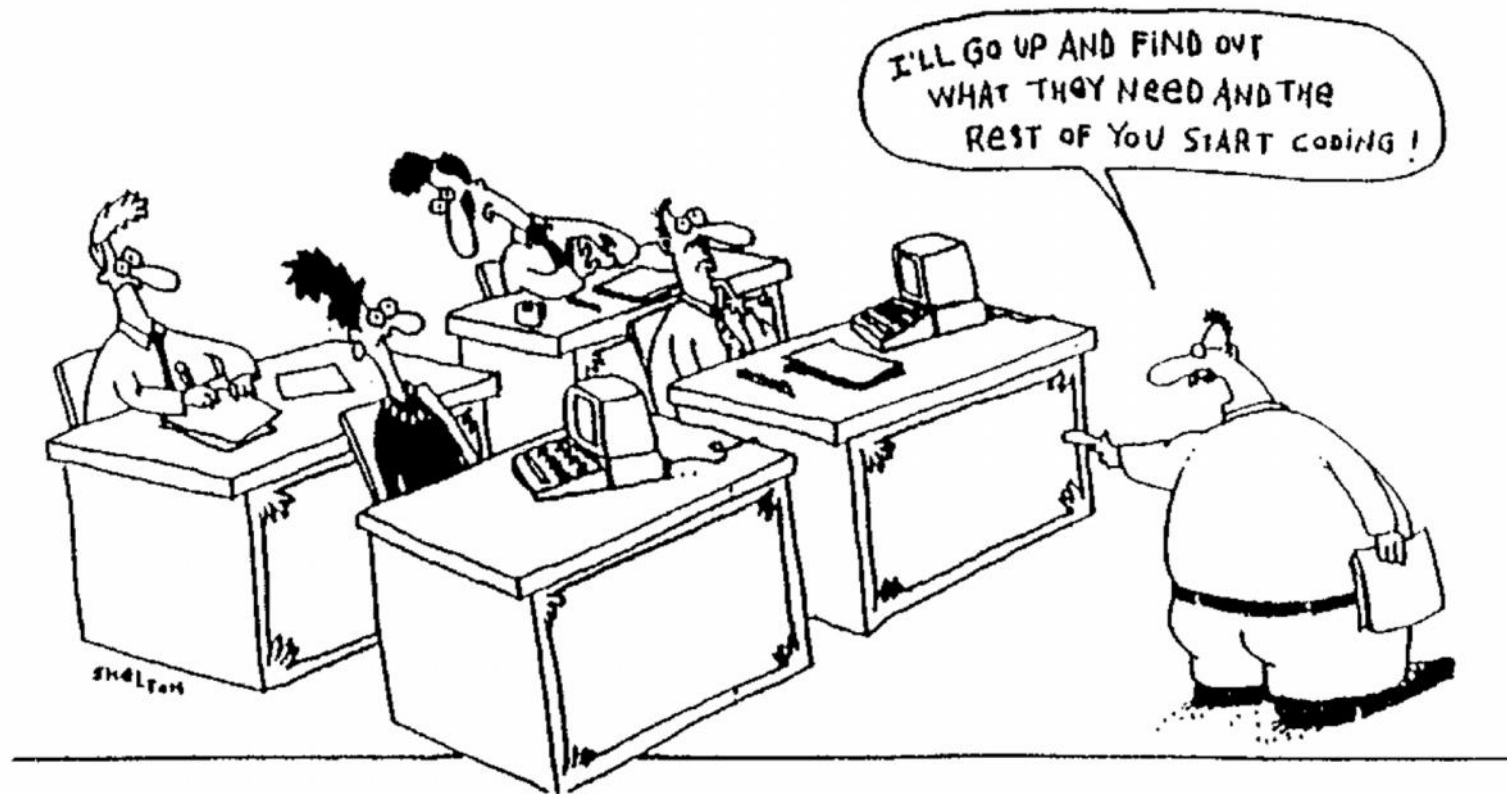
Government	Percentage
Current government	85%
Previous government	15%



## Main objective to implement the expected need



## Needs elicitation





## Customer Needs Elicitation - Difficulties

- Although the customer understands better than anybody else the need that he is trying to satisfy, the customer cannot always express his needs clearly and completely in terms understandable to the supplier.
  - ➔ In short, needs have to be clarified.
- Needs have to be clarified ... By
  - Analysis
  - Negotiation with stakeholders
  - Requirements formalization
- Typical difficulties:
  - Customer can have unrealisable needs
  - Customer can have changing needs
  - Customer can have contradictory needs
  - Customer do not know their needs
  - Customer have unclear needs



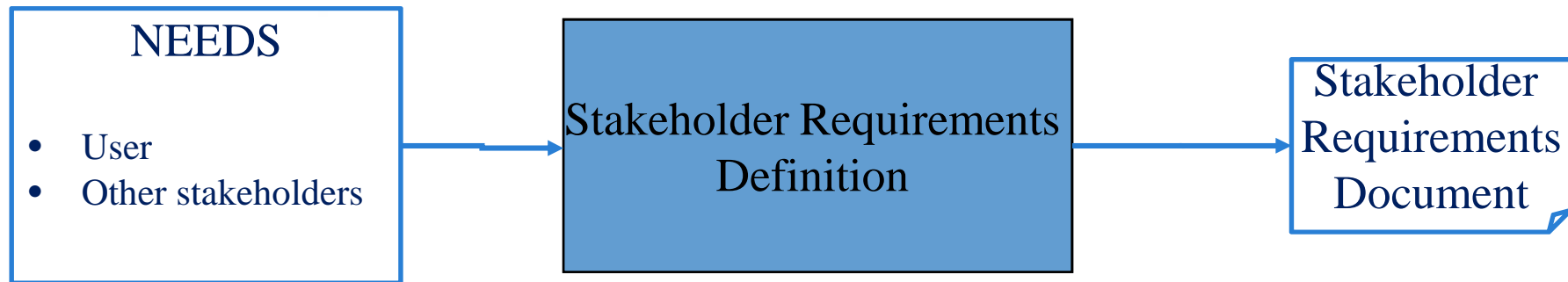
## How to elicit needs ?

### Comparison of a few techniques

Technique	Good for	Kind of data	Plus	Minus
Questionnaires	Answering specific questions	Quantitative and qualitative data	Can reach many people with low resource	The design is crucial. Response rate may be low. Responses may not be what you want
Interviews	Exploring issues	Some quantitative but mostly qualitative data	Interviewer can guide interviewee. Encourages contact between developers and users	Time consuming. Artificial environment may intimidate interviewee
Focus groups and workshops	Collecting multiple viewpoints	Some quantitative but mostly qualitative data	Highlights areas of consensus and conflict. Encourages contact between developers and users	Possibility of dominant characters
Naturalistic observation	Understanding context of user activity	Qualitative	Observing actual work gives insight that other techniques cannot give	Very time consuming. Huge amounts of data
Studying documentation	Learning about procedures, regulations, and standards	Quantitative	No time commitment from users required	Day-to-day work will differ from documented procedures

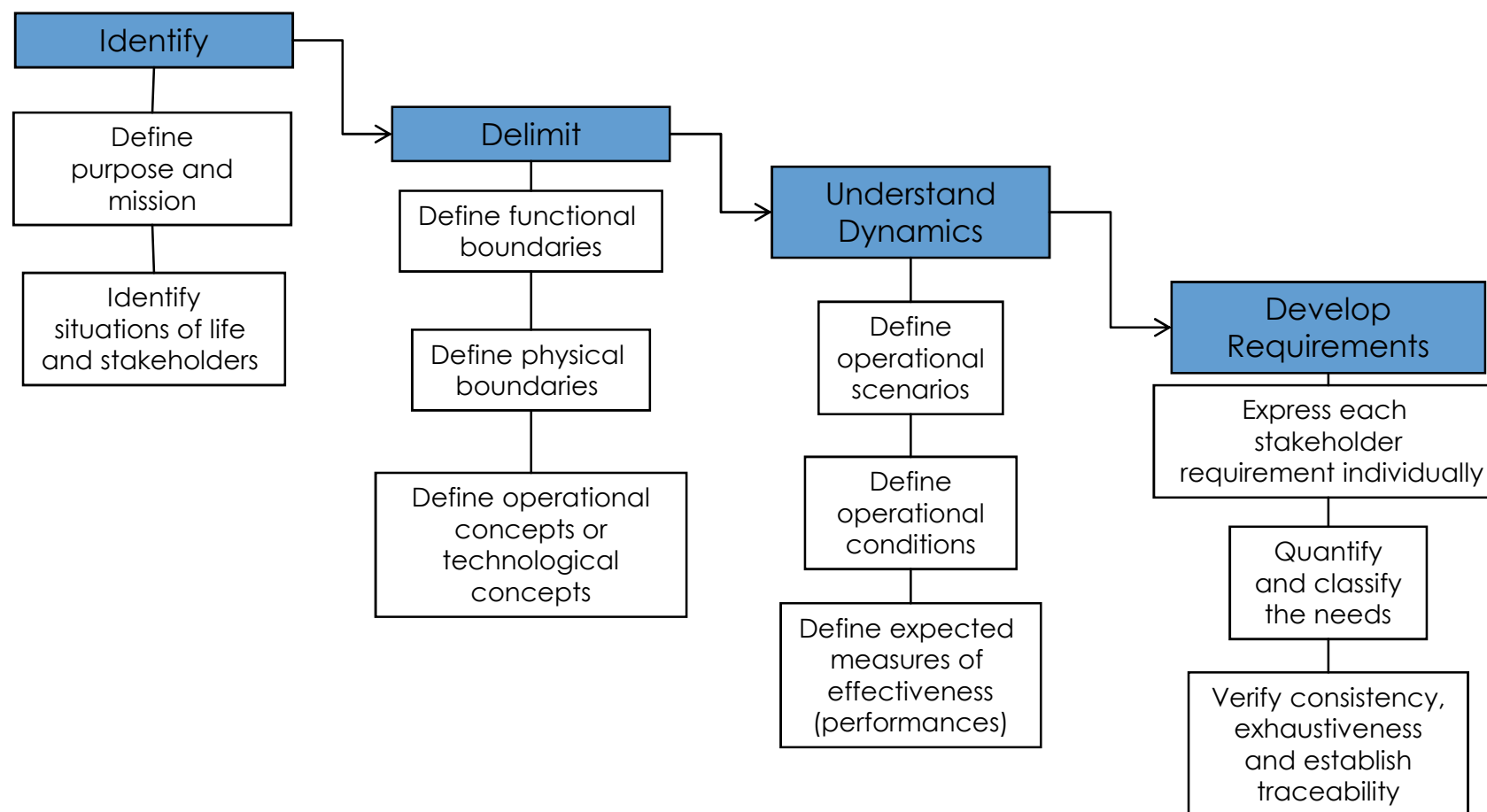
Source: Preece, Rogers, and Sharp "Interaction Design: Beyond human-computer interaction", p214

## Stakeholder Requirements Definition Process



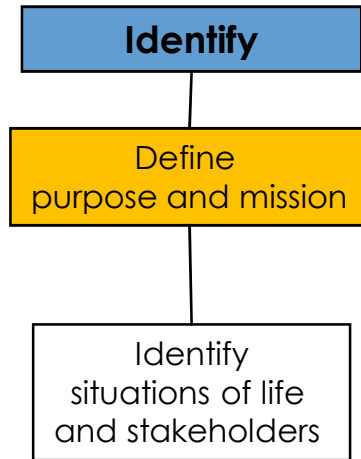
The purpose is to define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment.

## Activities of the Stakeholder Requirements Definition Process



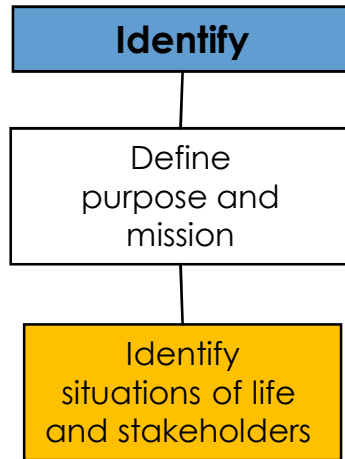


## Purpose and mission



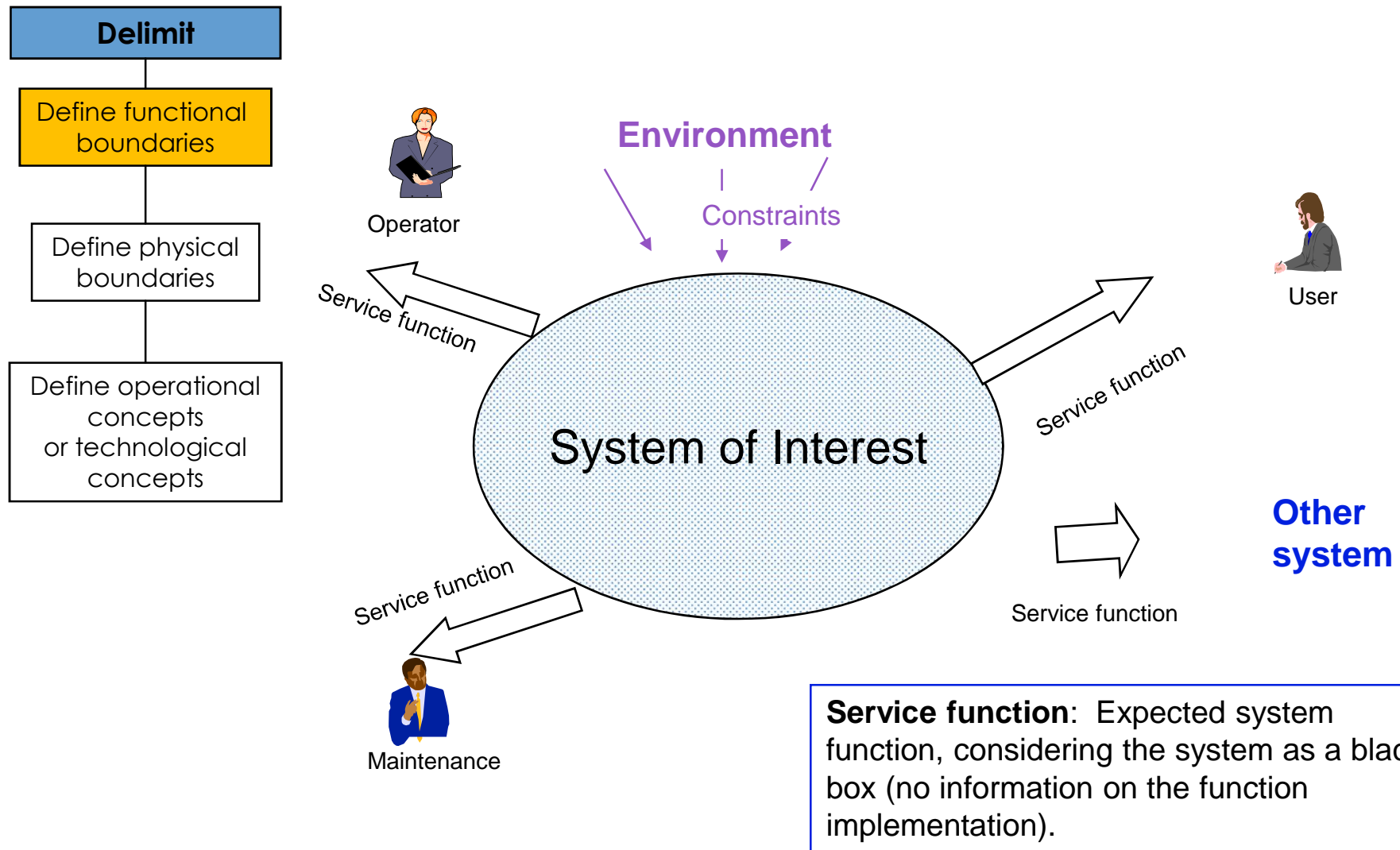
- Identify the purpose of the system
  - Why does the system exist ? What for ?
- Identify the mission of the system
  - What does it do ?
- Define the objectives of the system
  - What level of performance/efficiency ?

## Situation of life and Stakeholders



- Situations of life are the various phases leading a system from its birth to its death
- Stakeholders will be found by identifying
  - External actors
    - Persons or organisations (operators who will operate or maintain the system, users who will exploit it)
    - Other systems interacting with or constraining the System of Interest
  - External constraints
    - Norms, regulations, laws, ...
    - the operational environment (physical, climate, ...)

## Functional context



## “Functional Analysis”

used here as a means to find expected “functional” features of the system

[SEHDBK]

The objective of Functional Analysis/Allocation is to create a functional architecture for which system products and processes can be designed and to provide the foundation for defining the system architecture through the allocation of functions and sub-functions (...)



## Functional Analysis: General purpose

### ■ Function

- **Action** of something expressed exclusively in term of **purposes**.

### ■ Functional Analysis

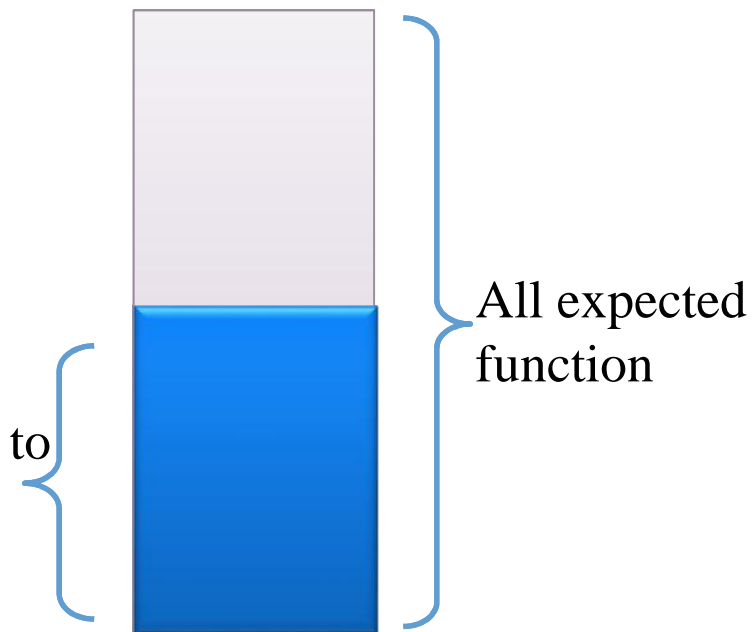
- An **approach** which consists to seek, order, characterize, hierarchies and/or weight up the functions.
- This approach is supported by several **methods and tools**, some tools being computer aided.



## Why is functional analysis useful?

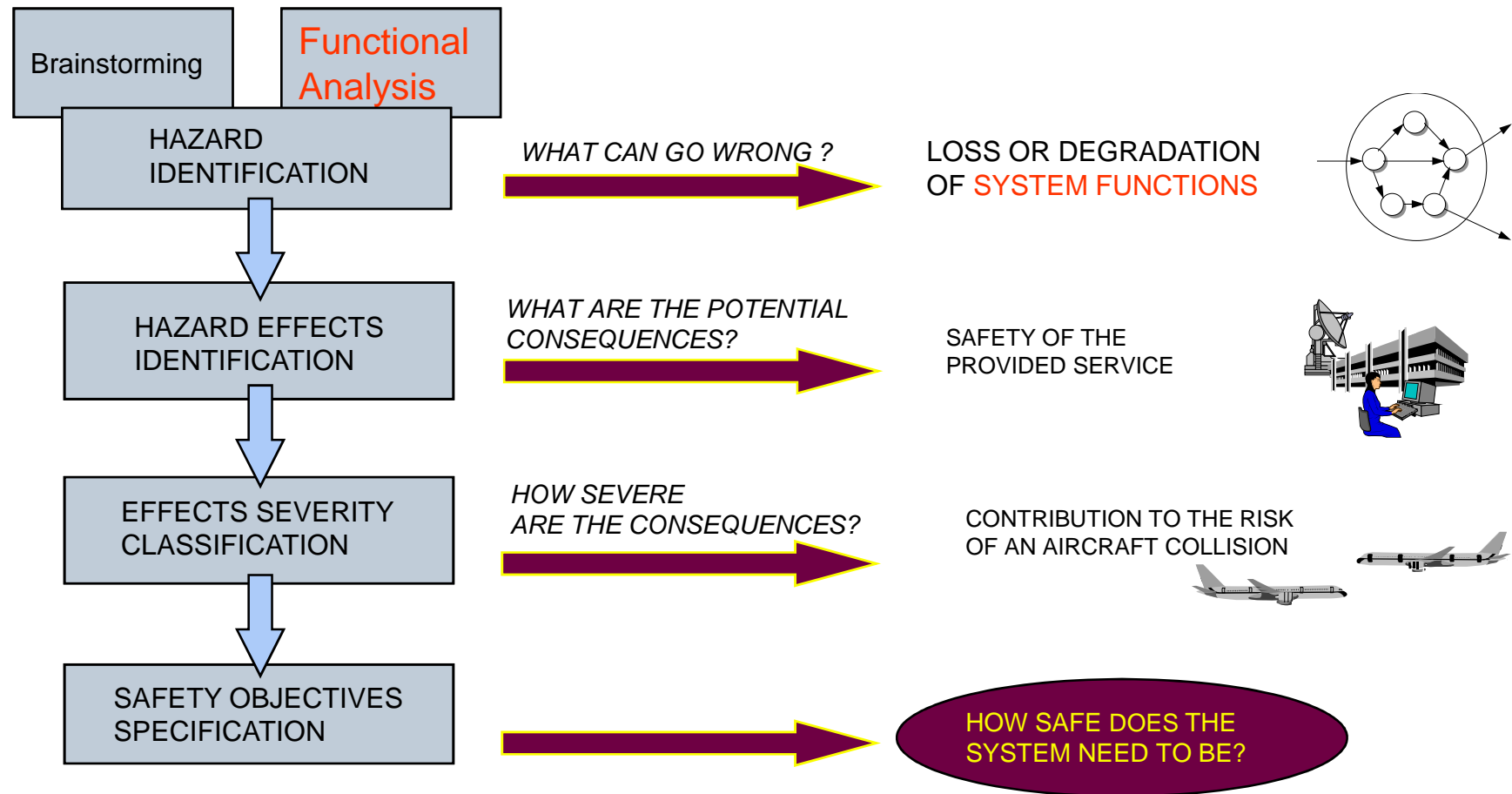
- Statistically, it has been proven that
  - Unsatisfied functions are mainly due to a **lack of functional identification** and **not to a bad implementation** of an identified need .
  - Bad implementation is generally due to a **poor Functional Analysis**.

**Instinctive capture** of functions conducts to identify only 50% - 60% of the required functions



## Functional Analysis as pre requisite for Hazards and Risk Analysis (safety)

Example: Functional Hazard Assessment (FHA) used by DGAC (French Aviation Authority) for ESARR (Eurocontrol Safety Regulatory Requirement) implementation



## External Functional Analysis - The Octopus method - © APTE

### Method:

1. Identify, for one or more situations of the **life profile**, the “**External Environment of Use**” (EEU) of the system.
2. Express functions connecting the EEU and the system:
  - “**Principal Functions**” (PF):
    - Such a function exists when there is a relation between two or more EEU.
    - Reminder: These functions express the reasons for which the product exists.
  - “**Function**” of Constraints (FC):
    - Such a function exists when there is a relation between a EEU and the system.
    - Reminder: The system was not created for these functions, but the fact of existing imposes certain functions to it (constraints) .





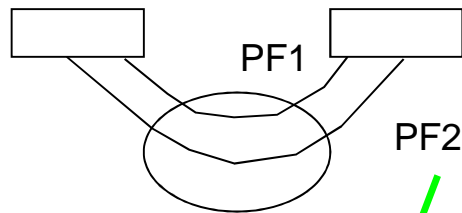
## EFA - The Octopus method - Rules 1/2

### Rules of expression:

- The functions must be expressed with a **verb in the infinitive form**.
- The functions must be expressed with a verb which **does not prejudge a solution**, nor even of a technical principle.
- The expression of a function of a product **must include the elements concerned of the EEU** and **never include the name of the system**.
- The expression of a function **shall not be negative**.
- The expression of a function **shall not employ the passive form**.



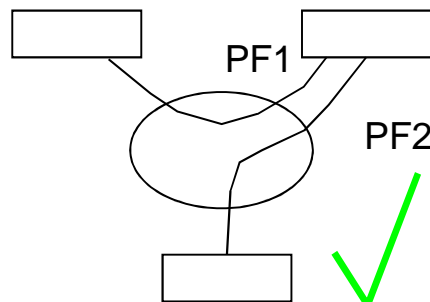
## EFA - The Octopus method - Rules 2/2



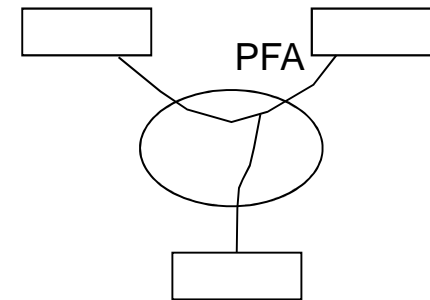
PF1  $\neq$  PF2



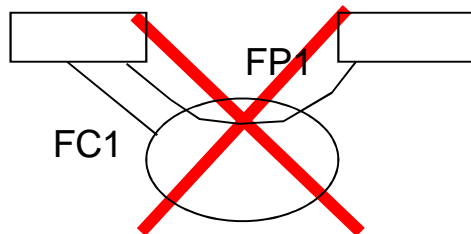
2 different principal functions may be identified from a same couple of EEU.



Aim PF1 = Aim PF2



PFA = Aim PF1 + Aim PF2  
(including names of the 3 EEU)



FC1

A FC can be generated only by one element of the EEU which is not concerned with a FP...

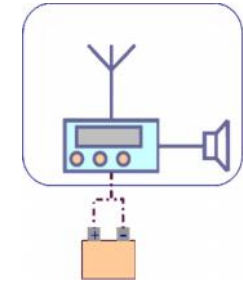
**Except:** EEU = Human being  
EEU expressed by an overall

name.

Verification&Validation

CS 41- p 32

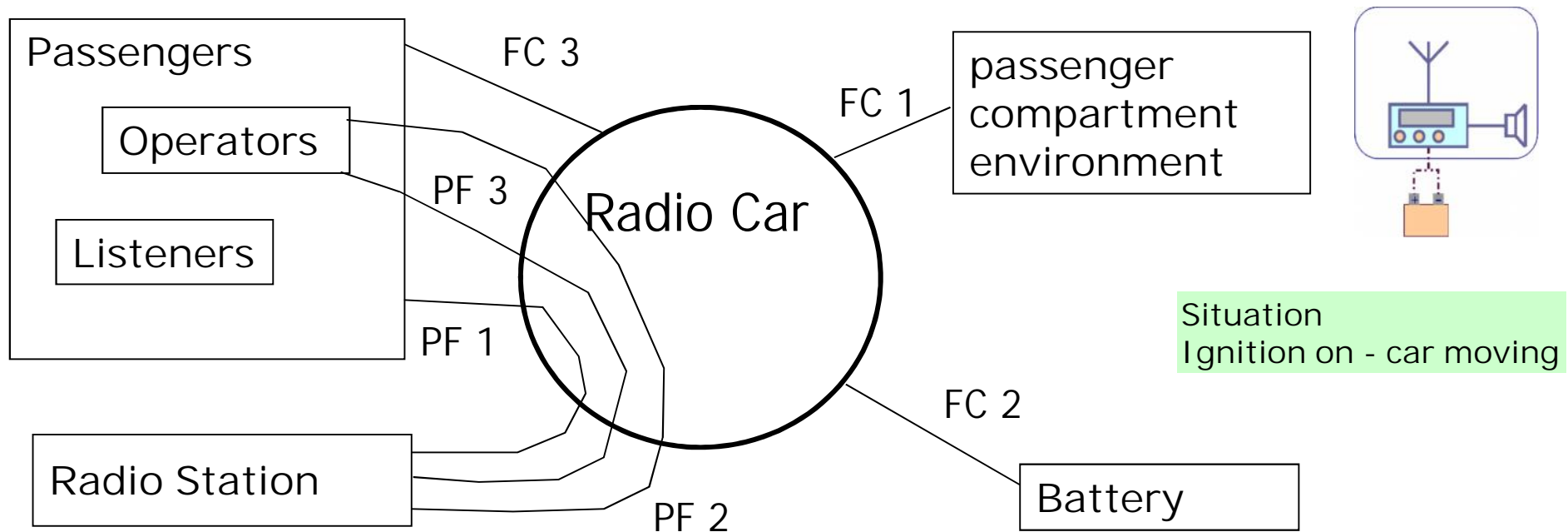
## EFA - The Octopus method - Exercise



Situation: Ignition on

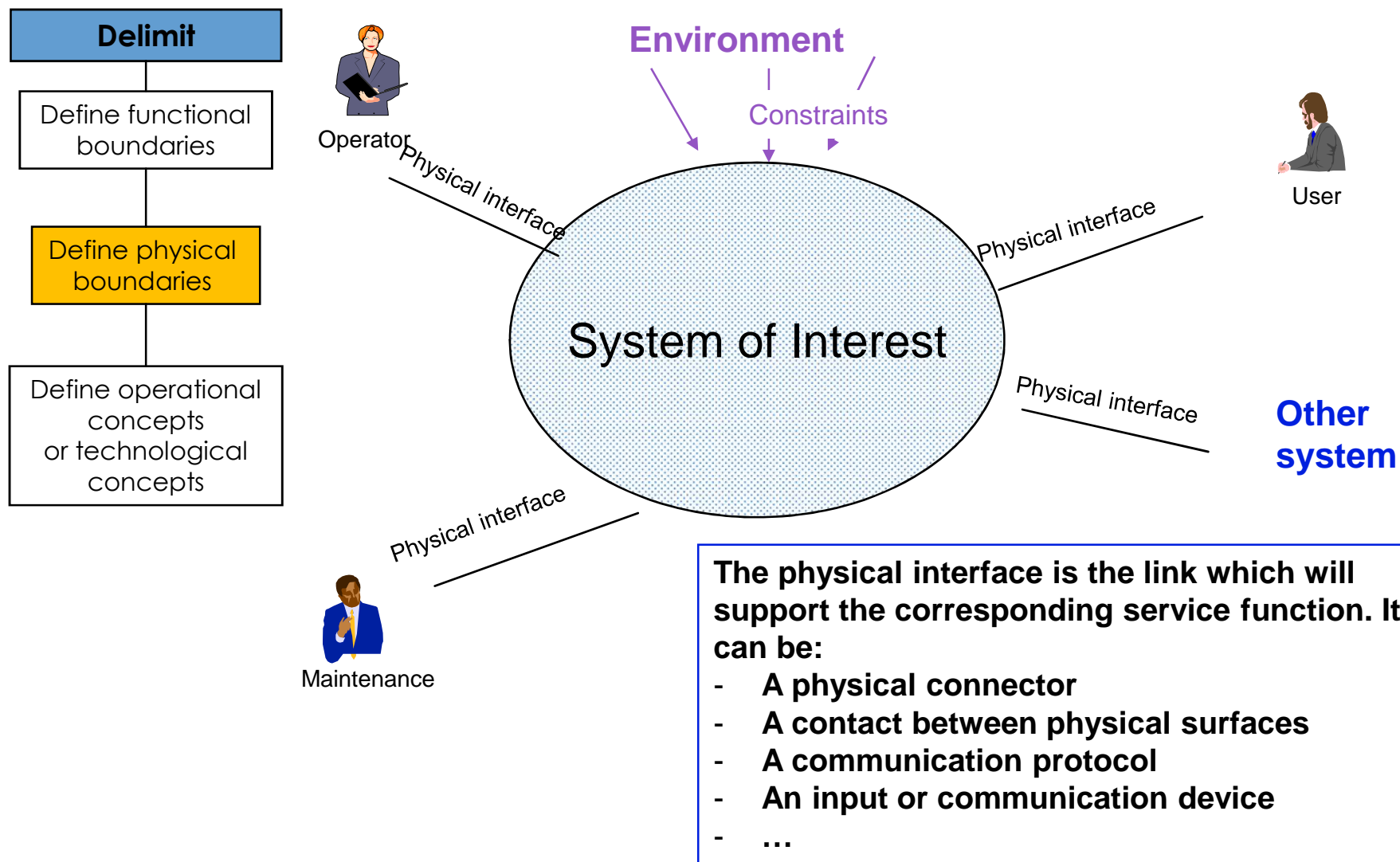
1. Identify the *External Environment of Use* (EEU) entities
2. Identify the couplings, and the corresponding *Principal Functions* and *Functions of Constraint*
3. Express each function with the proper sentence describing the coupling

## EFA - The Octopus method - Exercise

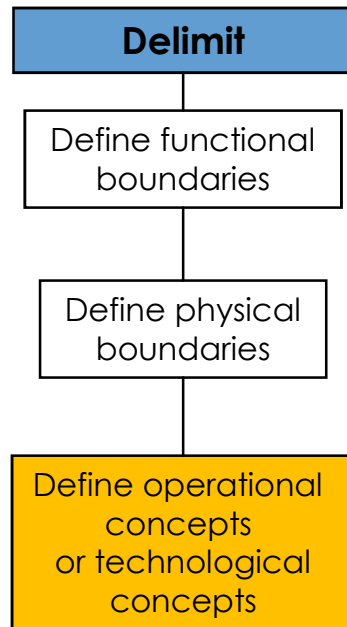


- PF 1: Allow the passengers to listen to a selected radio station.
- PF 2: Allow the operators to select a radio station to be listened.
- PF 3: Allow the operators to control the sound restitution of the selected radio station.
- FC 1: Resist to the passenger compartment environment.
- FC 2: Use the vehicle battery as an only source of energy.
- FC 3: Looks pretty for passengers.

## Physical context

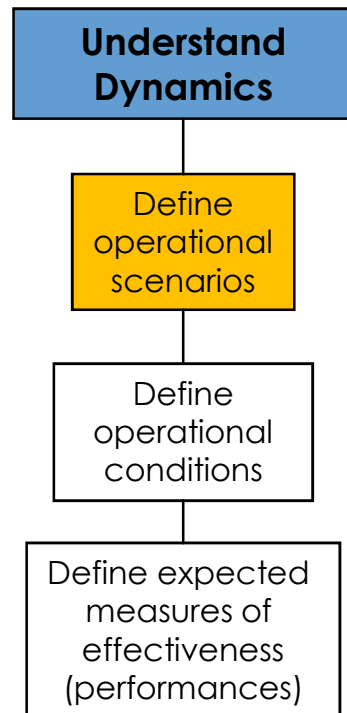


## Operational/technological concepts



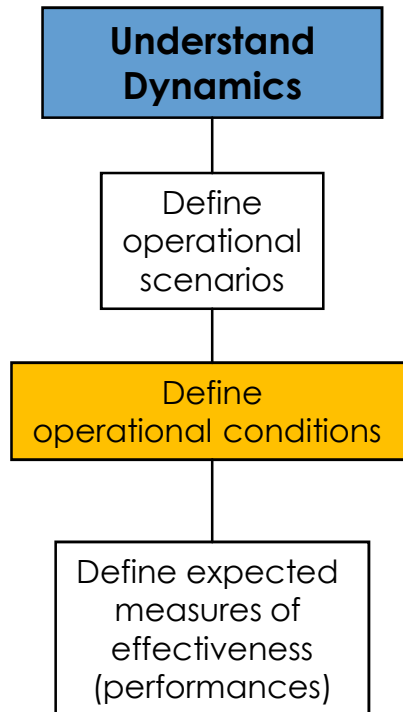
- "Operational concepts" correspond to strategy of operation / utilization:
  - basic options of how will the system be used in operation / in service.
- Example:
  - a completely automated system,
  - or a system which let human to decide on operation tasks and to make decisions.
- "Technological concepts" are technological options for the global usage of the system.
- Example:
  - a solution based on "electronic" or "pneumatic" technology

## Operational scenarios



- Operational scenarios describe how the system will be operated under various conditions.
  - It is usually defined as a sequence of actions and interactions between the System of Interest and the other actors.
- It shall be representative of a typical usage of the system
  - Nominal scenario, corresponding to a system working properly, fulfilling its service functions
  - Incident management scenarios would include normal monitoring, the sequence of events following an incident, and response to failure.

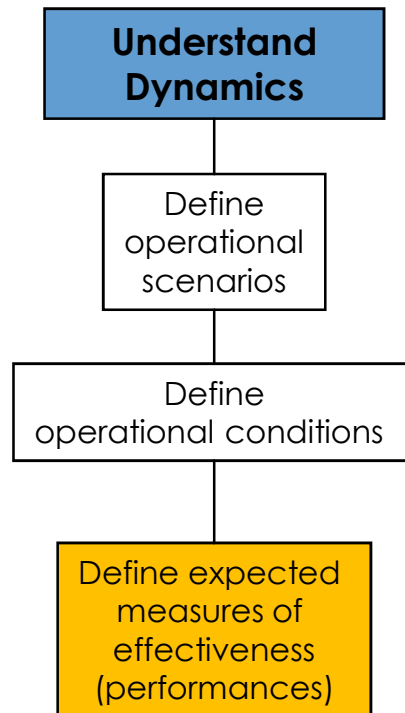
## Operational conditions



- Operational conditions describe the situation under which the system is operated
  - It can correspond to environmental conditions (weather, heat, humidity, dust, vibrations, ..)



## Performance/effectiveness



➤ Performance or effectiveness correspond to a quantitative objective set for the operation of the system.

- Examples:

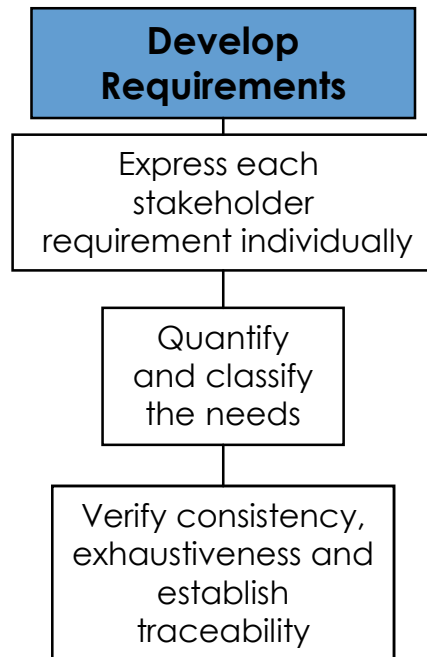
- Produce 12000 cars/year.
- Support a bandwidth of 20 MB

➤ Efficiency correspond to the measure of the ratio of the performance achieved with respect to the resources consumed

- Example: drive 100 km for 4,5 l of fuel

# Requirements classification

Classification is an organisation of requirements in order to facilitate the review and the usage of a requirement set. A typical classification can be:



- ☐ Expected services
- ☐ Expected effectiveness
- ☐ Operational modes
- ☐ Operational scenarios
- ☐ Interfaces or interactions
- ☐ Physical connections
- ☐ Human factors
- ☐ Dependability
- ☐ Security (of information)
- ☐ Operational environment
- ☐ Means
- ☐ Transport, storage
- ☐ Constraints

## How many stakeholder requirements ?



# Requirement analysis

Stakeholder requirement definition

Architecture design

Implementation

Integration / Verification

Transition (to use) / Validation

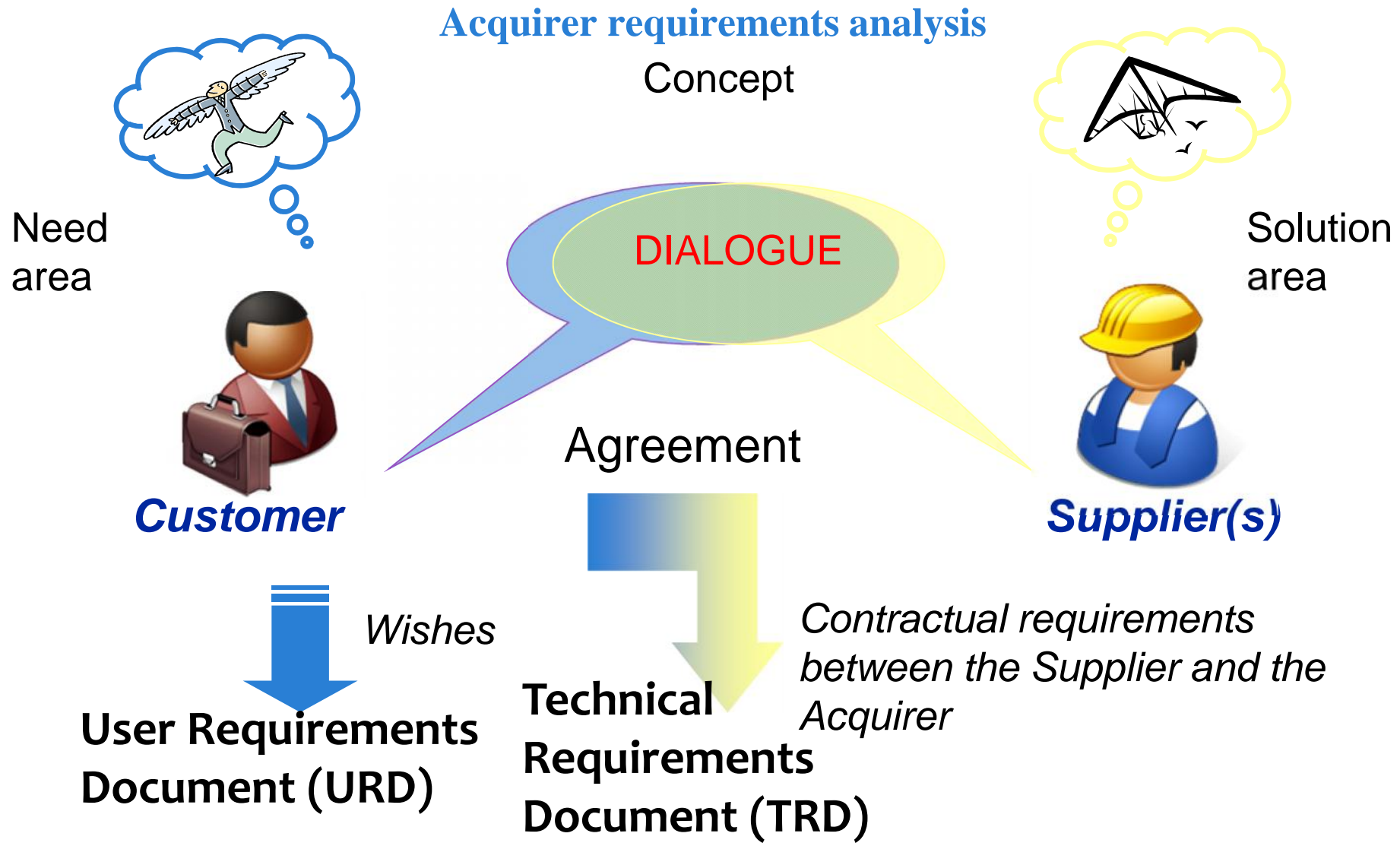
Operational and maintenance

Disposal

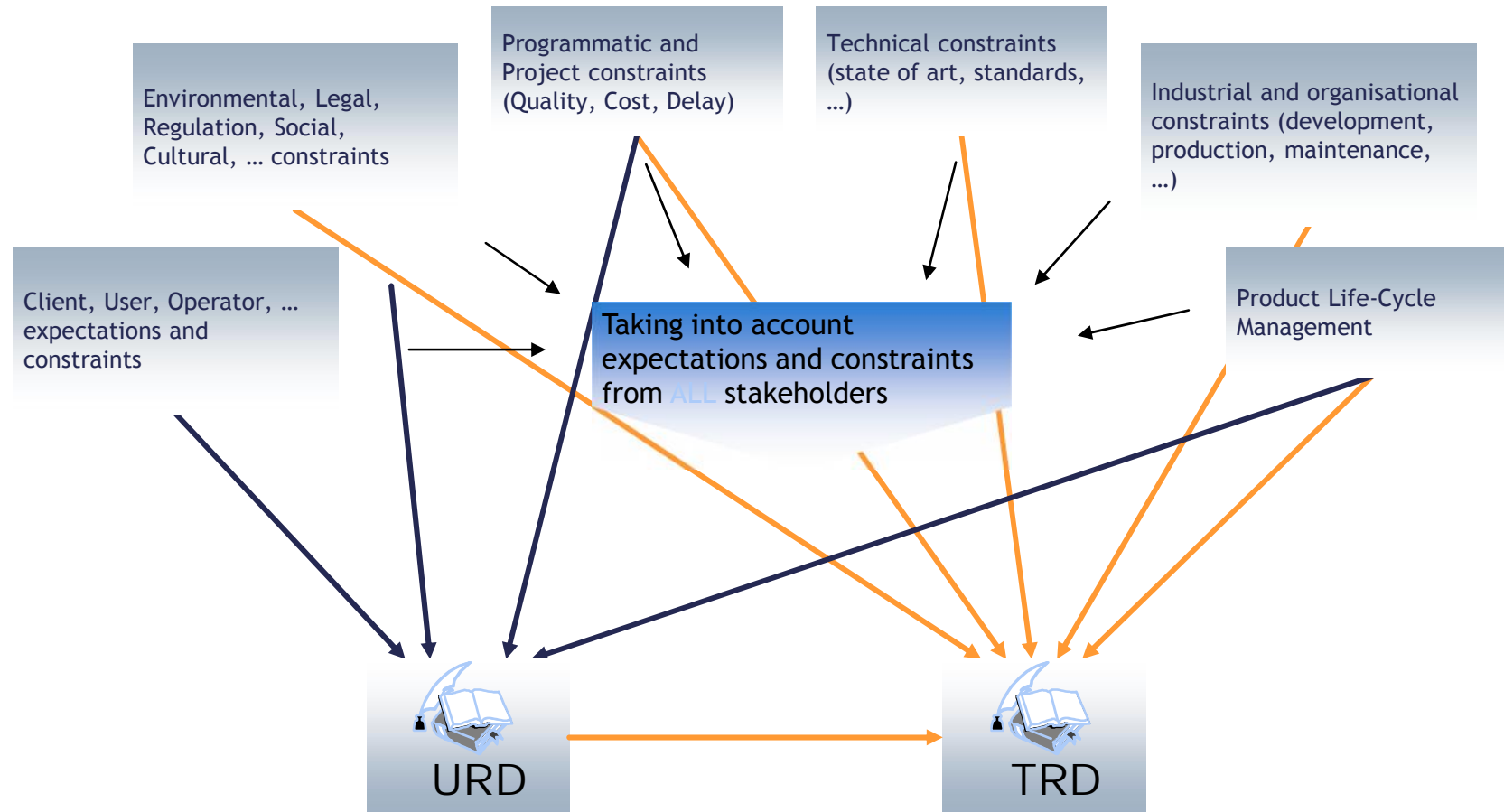
The purpose is to transform the stakeholder, requirement-driven view of desired services into a technical view of a required product that could deliver those services.

SE Technical Processes (ISO-15288)





## Taking into account ALL stakeholders



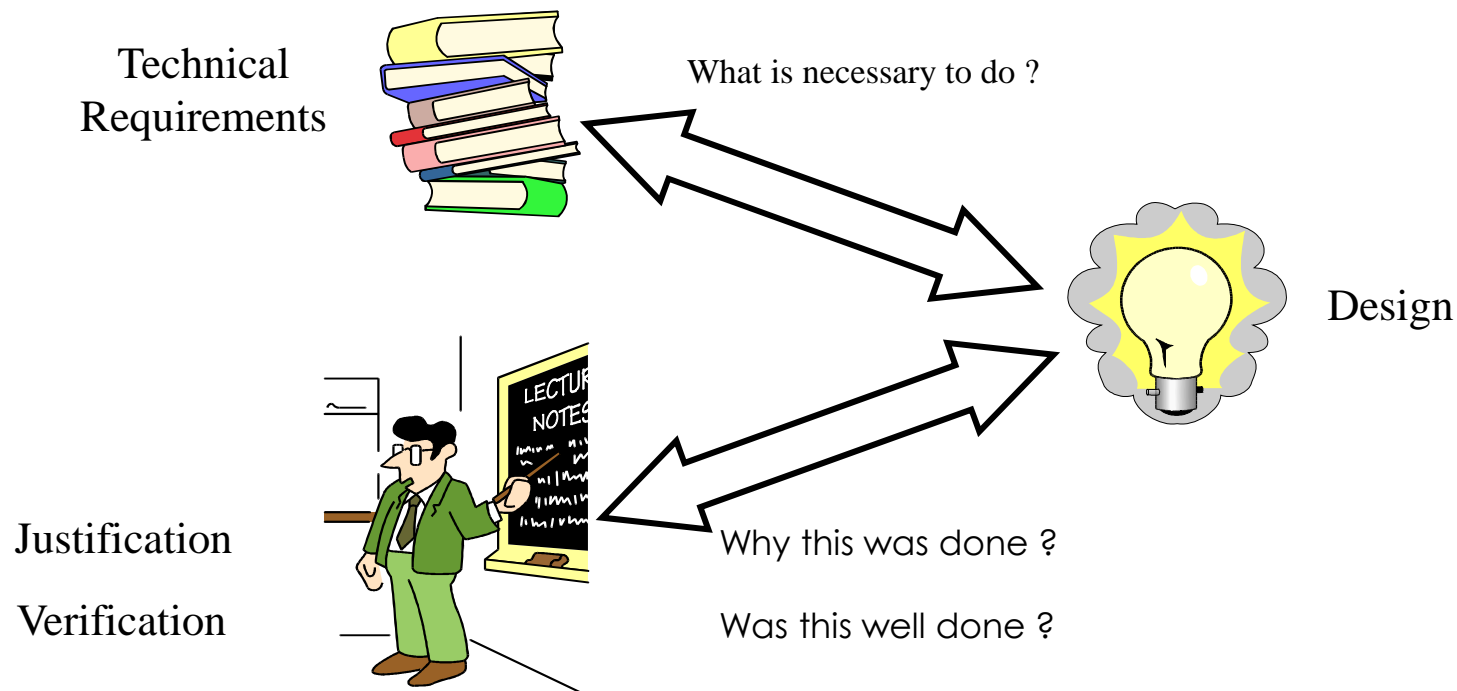
## Goal of the TRD

- Technical requirements describe the **needs** expressed by the Acquirer in **technical** terms applied to the **system**.
- The technical **requirements** shall be **good enough** to allow the Supplier to **define a solution** complying with the Acquirer need.
- The TRD shall also contain requirements issued from **solution choices** (resulting from trade-off cost/schedule/performance)
- The Supplier must have existing or potential feasible solutions responding to the TRD.
- **The TRD must NOT describe the foreseen solution. It is not a design document.**

## Roles of Technical Requirements

Technical Requirements play two roles :

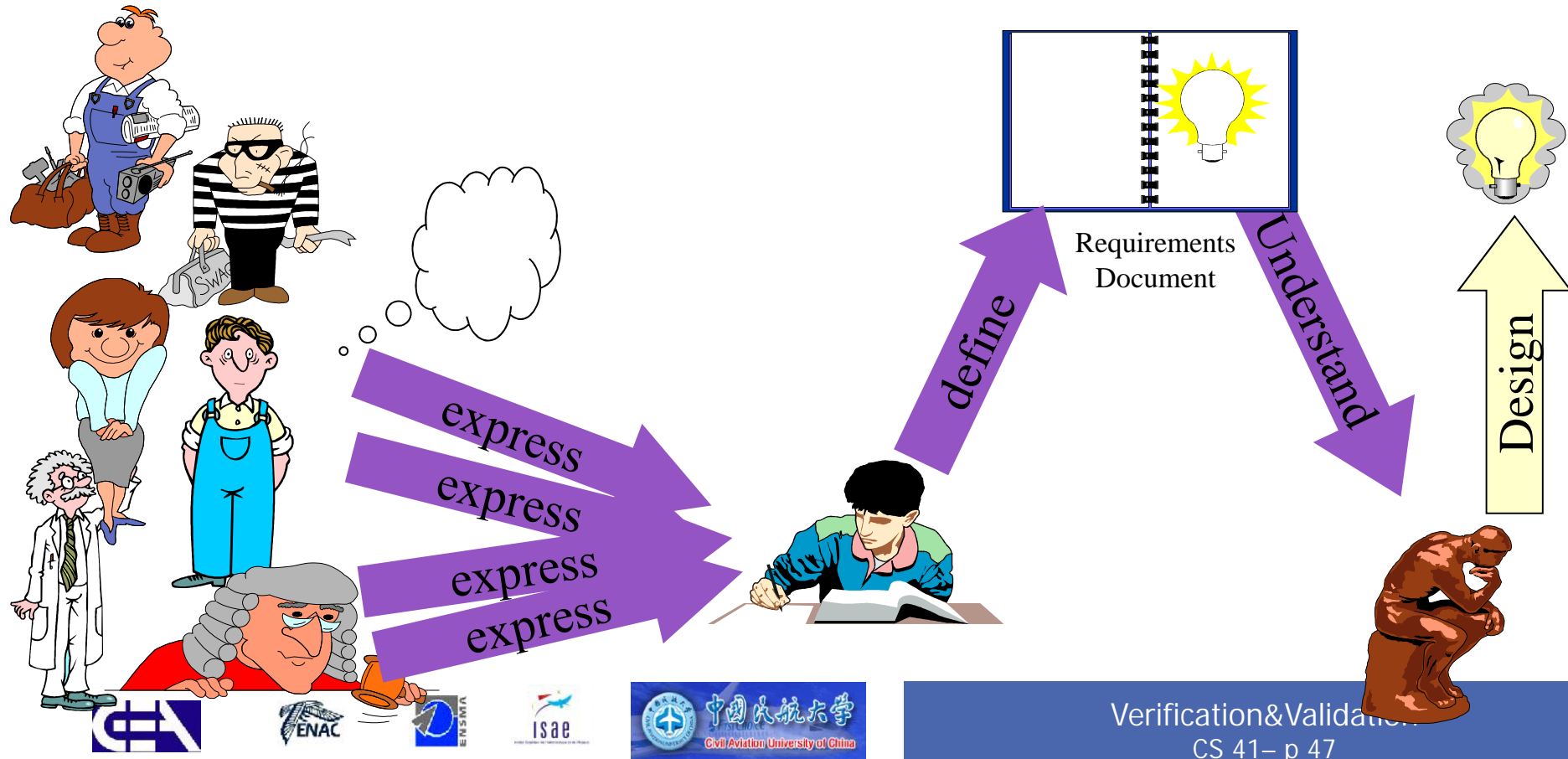
1. Prepare the inputs for design activities
2. Be used as reference for justification and verification



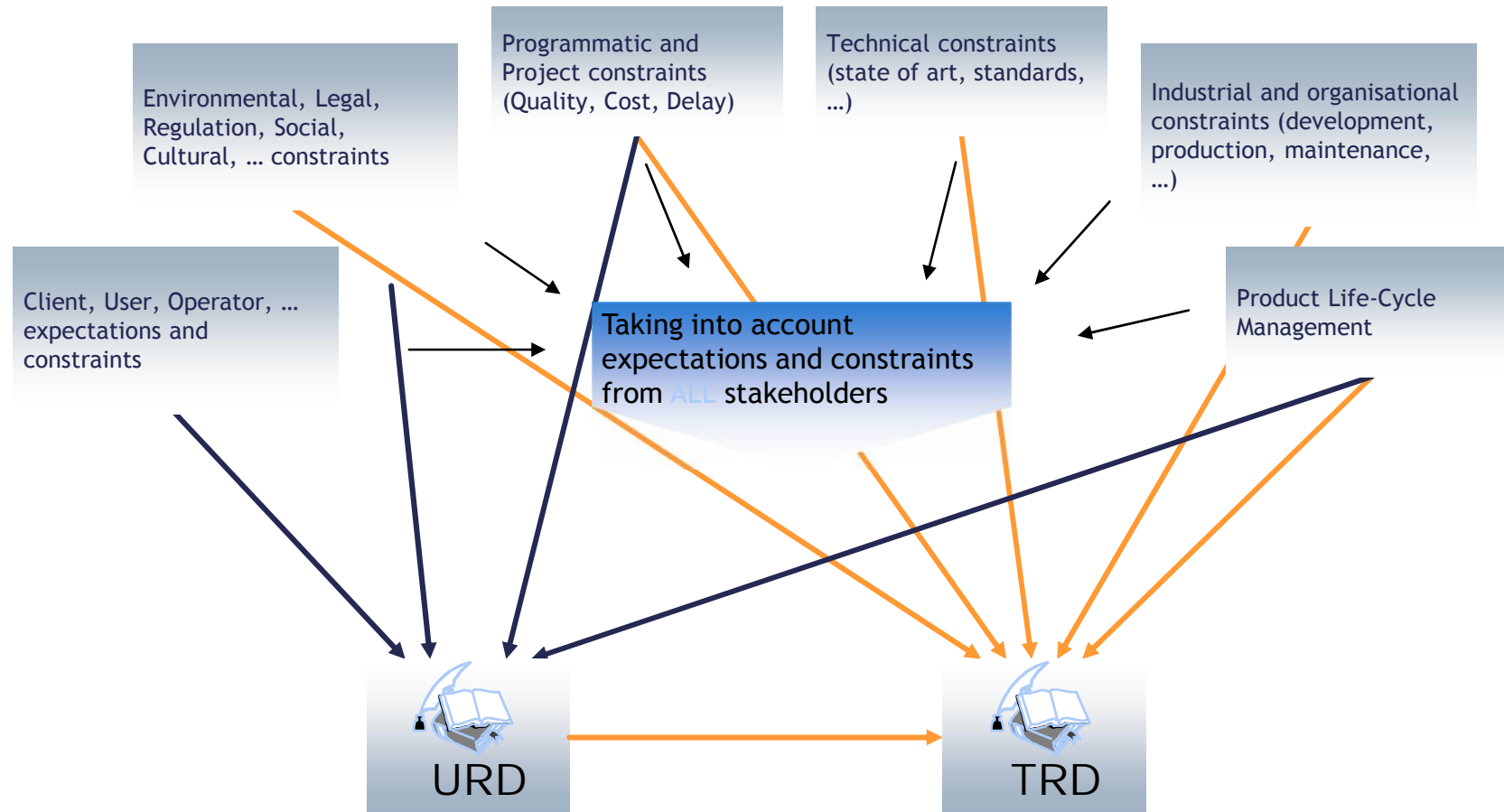


## Why express Technical Requirements ?

The role of Technical Requirements is to ensure the quality of the communication between the various technical communities who have to interact and to work for a common implementation.



## Taking into account ALL stakeholders



## Difference between Applicable and Reference documents

### ■ Applicable Document

- By contract required document and having imperatively to be applied.

**Tip =>** Each applicable document shall be referred by at least a requirement of the specification.

- Each applicable document shall be available and carefully read...
- Must be understood as “Document to be applied”...

### ■ Reference Document

- Document quoted in the specification and being able usefully to be consulted.

No any contractual value.

**Tip = >** Shall NOT be called by a requirement of the specification.



## Communication is difficult !

Entre

Ce que je pense

Ce que je veux dire

Ce que je crois dire

Ce que je dis

Ce que vous avez envie d'entendre

Ce que vous croyez entendre

Ce que vous entendez

Ce que vous avez envie de comprendre

Ce que vous croyez comprendre

Ce que vous comprenez

Il y a dix possibilités qu'on ait des difficultés à communiquer

Mais essayons quand même ...

*Nouvelle encyclopédie du savoir relatif et absolu*

*Bernard Werber*

Considering

What I am thinking

What I want to say

What I believe I am saying

What I am saying

What you want to hear

What you believe you are hearing

What you are hearing

What you would like to understand

What you believe you understand

What you understand

There are ten possibilities for communication mismatch

But let's try nevertheless ...



## Ease communication

### ➤ Use the same concepts

- Define common vocabulary, glossaries, acronyms, ontologies

At The  
Moment  
naturally



Asynchronous  
Transfer Mode  
commonly



www.shutterstock.com - 85254862

# ATM ?

26 (!) interpretations  
on wikipedia

Air Traffic  
Management  
of course



Automated  
Teller Machine  
without doubt

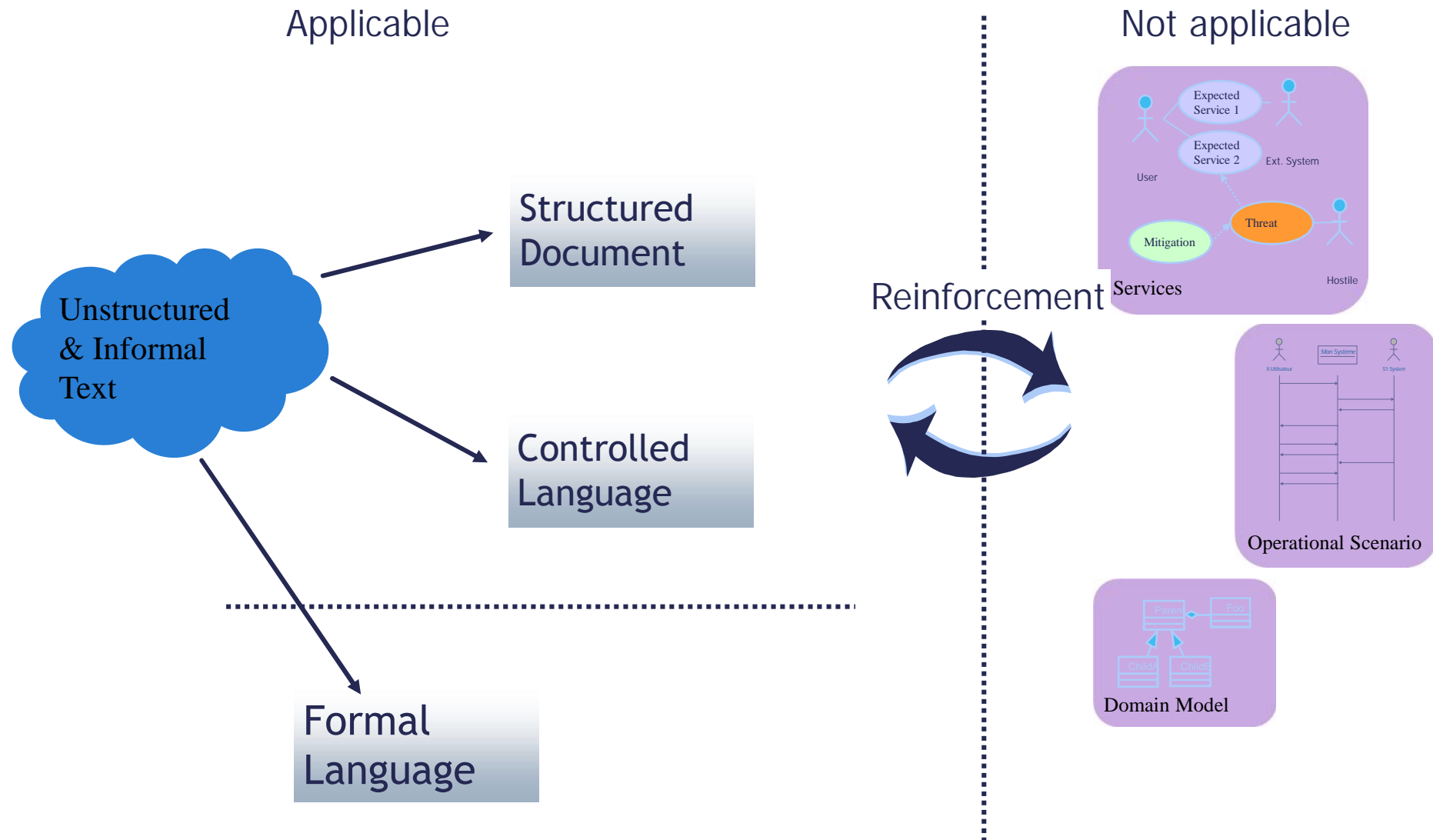


## Ease communication

- Use the same concepts
  - Define common vocabulary, glossaries, ontologies
  
- Use shared formalisms
  - The more diverse (multi-disciplinary) are the teams,  
the simpler must the formalisms be
  - Non ambiguous formalisms are a must
  
- Ensure the proper transmission of information
  - Identified, secured, perennial and accessible storage of information
  - Version and configuration management



## Requirement: writing form ?



## Anatomy of a Good Requirement

**Defines a subject**

***Shall or should* verb**

*“The system shall allow the Internet user to browse the book catalogue”*

**Defines a positive end result**

This requirement sentence identifies a specific subject and a positive end result

A requirement ...:

- ... is written in the present tense
- ... usually uses the keyword “shall”
- ... is expressed through a simple, complete sentence
- ... describes *what* must be done, rather than *how*



## Example

- *“The product shall ask for a password before data is accessed”*
  - C’est une **expression de solution**. Il faut remonter au besoin:
    - → *“The product shall authenticate the user prior to access of [named] data”*
- *“The product shall use a mouse”*
  - C’est une **solution**
    - **Eliminer le composant technologique**
      - “The product shall use a pointing device”*
    - **Mais on peut aussi remonter au besoin**
      - “The product shall allow the user to manipulate interface items”*

## Qualities of a requirement

- ☐ Feasible One or several technical solutions are foreseen
- ☐ Needed The requirement has a technical value
- ☐ Verifiable A verification mean and an objective can be identified
- ☐ Concise The sentence is short and easy to understand
- ☐ Complete The requirement contains all necessary information for understanding
- ☐ Not-ambiguous There is only one possible meaning
- ☐ Simple The words used are common or in a glossary
- ☐ Communicable All recipients can understand the requirement with their knowledge
- ☐ Single idea The requirement expresses only one idea
- ☐ Rationale The requirement has an origin and a reason to exist
- ☐ Correctly written The requirement complies with grammatical rules and imposed formalisms.



## Writing pitfalls

Pitfall	Danger signs
Escape clauses	if, but, when, except, unless, although, ...
Ambiguity	Or, etc, ...and so on
Vagueness	user-friendly, highly versatile, flexible, to the maximum extent, approximately, as much as possible, minimal impact
Multiple requirements	and, or, with, also, ... joining sentences
Speculation	usually, generally, often, normally, typically
Suggestion	may, might, should, ought, could, perhaps, probably
Wishful thinking	100%, all, always, never, fully, ...

## Requirement categories

Functional Requirements are services the system must render

Non-Functional Requirements are qualities the system must meet

