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# *Introduction to Systems Engineering*

*Abd-El-Kader SAHRAOUI (kader@laas.fr)*

*Industrial Dept Toulouse University: [www.iut-blagnac.fr](http://www.iut-blagnac.fr)*

*and Laboratoire d'Analyse et d'Architecture des Systems*

*LAAS du CNRS, Toulouse France : [www.laas.fr](http://www.laas.fr)*

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# SE : An Introduction

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- Systems Engineering I
  - Systems Engineering II
  - Systems Engineering Standards : EIA 632
  - Requirements management I
  - Requirements managements II : Traceability
  - Verification and Validation (V&V)
  - Case studies
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# Seminar goals

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- 1. Grasp the importance of SE
  - 2. Knowledge about the context and SE Framework
  - 3. Stimulus for further SE Knowledge acquisition
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What is the systems engineering : **produce an impression** or *create a rabbit*

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*Systems engineering is also an art without magic*

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# System Engineering: Definition (IncoSE)

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Systems Engineering is an **interdisciplinary** approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the **complete problem**:

- Operations
  - Performance
  - Test
  - Manufacturing
  - Cost & Schedule
  - Training & Support
  - Disposal
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# System Engineering: Definition (IncoSE)

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Systems Engineering integrates

- All the disciplines and
- specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation.

Systems Engineering considers both

- The **business** and
  - The **technical needs** of all customers with the goal of providing a quality product that **meets the user needs**.
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## A simple example : A pen

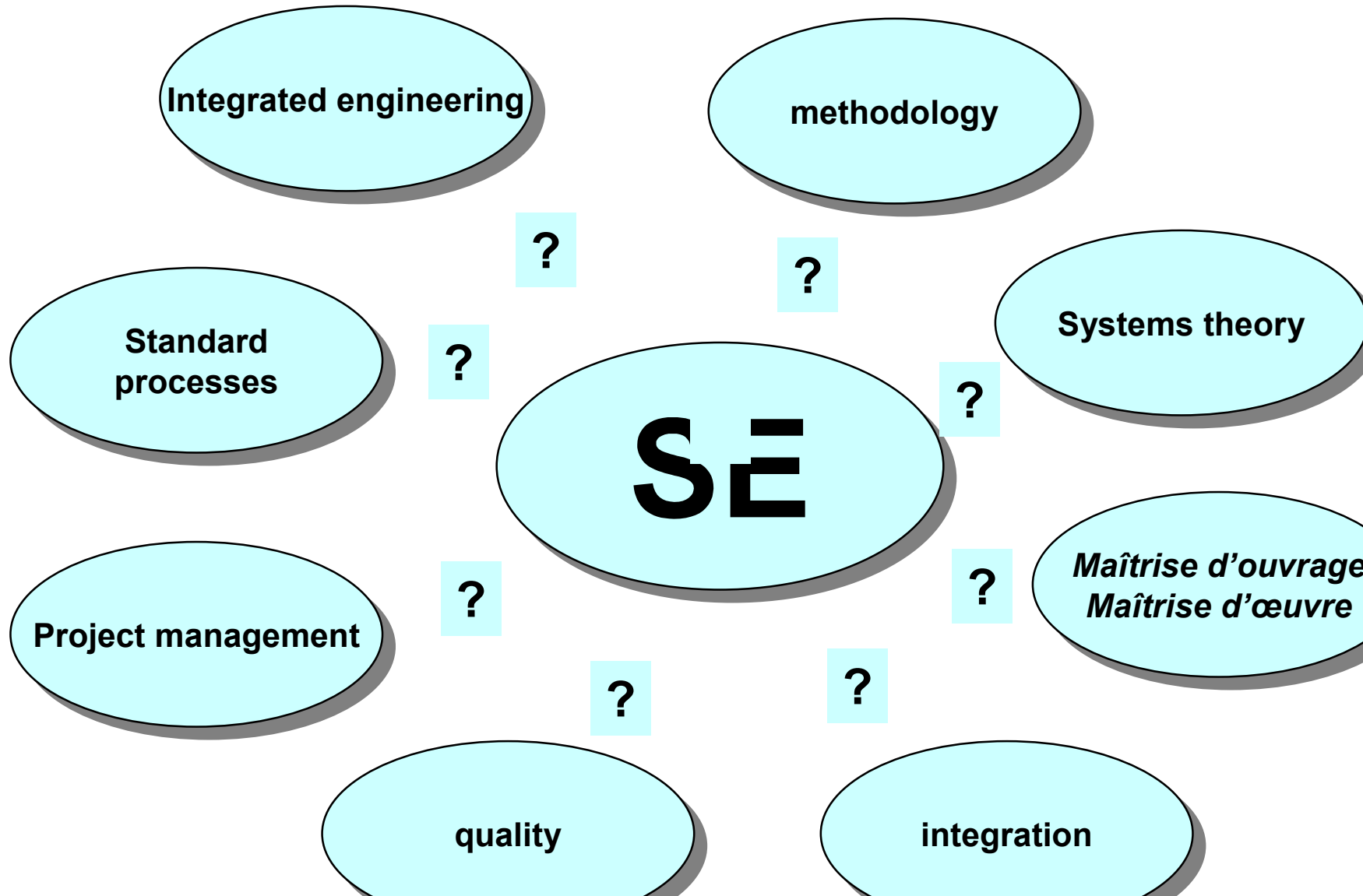
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We need : why a new pen

- Its primary function
  - The stakeholders : writers, designers, salesman, ...
  - Cost constraints and related data (market)
  - Accumulated knowledge (the writing have been with for centuries ..)
  - More detailed requirements
  - related discipline
    - Chemistry (Ink)
    - Mechanics/metallurgy, manufacturing
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# System Engineering and System integration

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# Integration

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**Technical system**

**Control system**

**systeme  
d'organisation**

**Information  
System**

**Sub-system  
technology**

**Sub-system  
human**

**Sub-system  
Information**

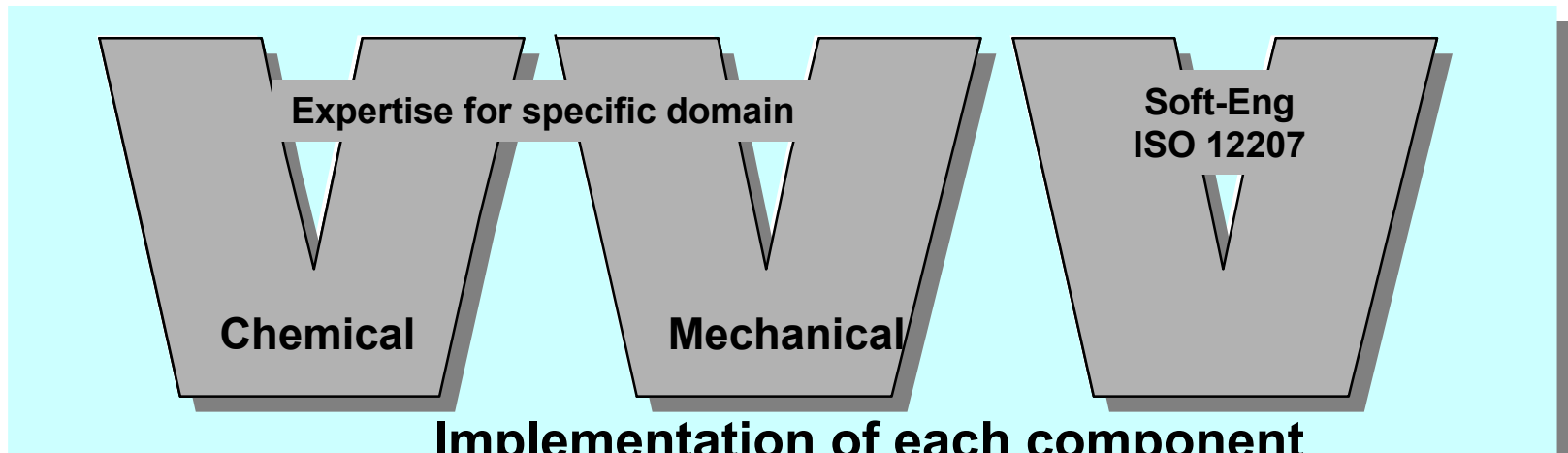
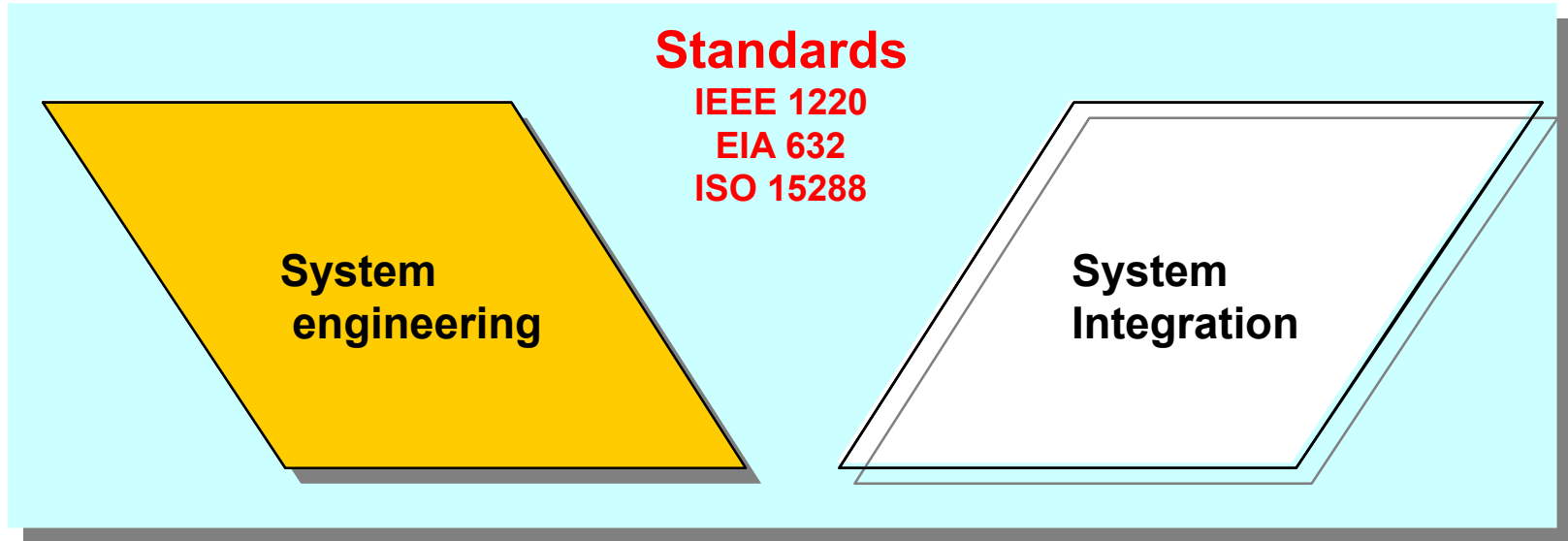
**Technological  
System**

**Logistic**

**Information and  
Decision System**

# Integration versus specific domains

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# The SE context

## External Environment

- LAWS & REGULATIONS
- LEGAL LIABILITIES
- SOCIAL RESPONSIBILITIES
- TECHNOLOGY BASE
- LABOR POOL
- COMPETING PRODUCTS
- STANDARDS & SPECIFICATIONS
- PUBLIC CULTURE

## Enterprise Environment

- POLICIES & PROCEDURES
- STANDARDS & SPECIFICATIONS
- GUIDELINES
- DOMAIN TECHNOLOGIES
- LOCAL CULTURE

## Project Environment

- DIRECTIVES & PROCEDURES
- PLANS
- TOOLS
- PROJECT REVIEWS
- METRICS

### Project Support

- Project Management
- Agreement Support

### Process Groups for Engineering Systems

- Acquisition & Supply
- Technical Management
- System Design
- Product Realization
- Technical Evaluation

## Enterprise Support

- Investment Decisions
- External Agreements
- Infrastructure Support
- Resource Management
- Process Management
- Production
- Field Support

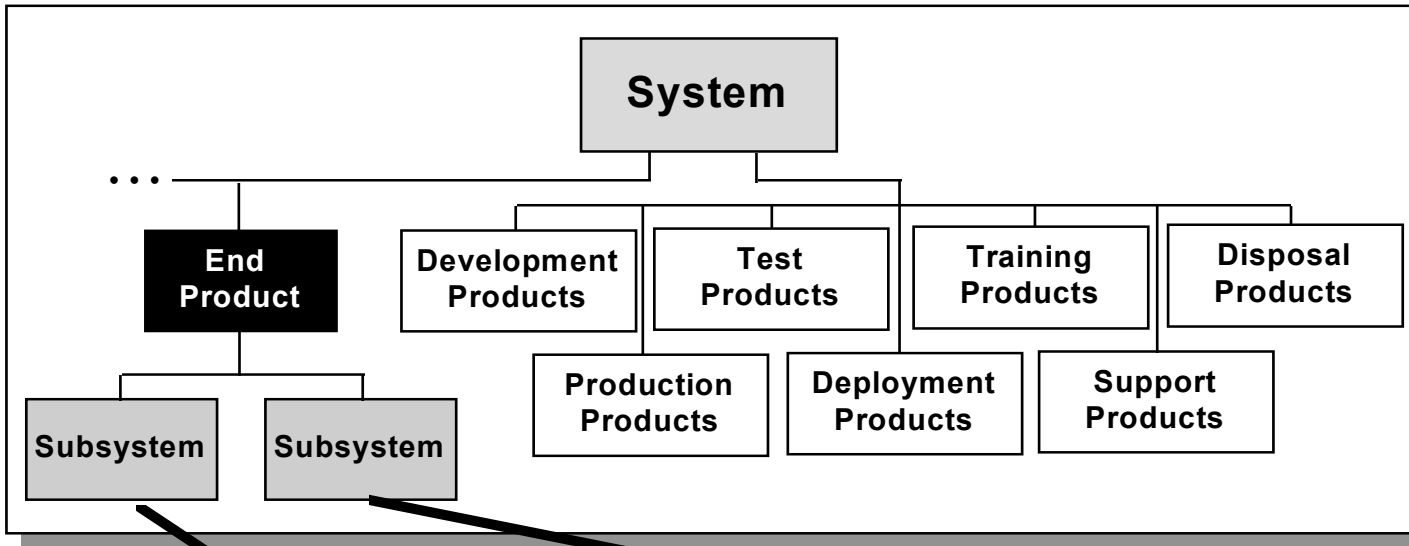
Project A

Project B

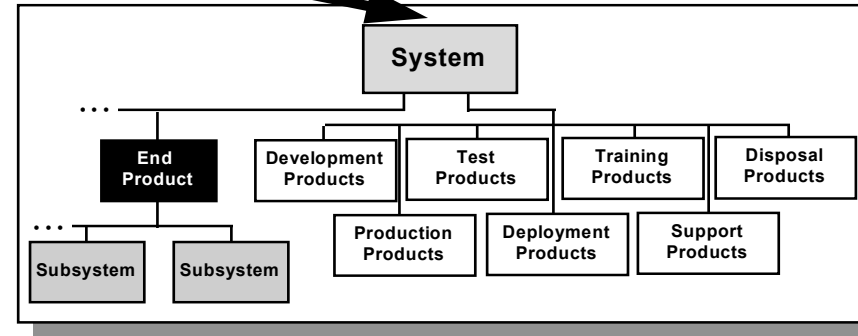
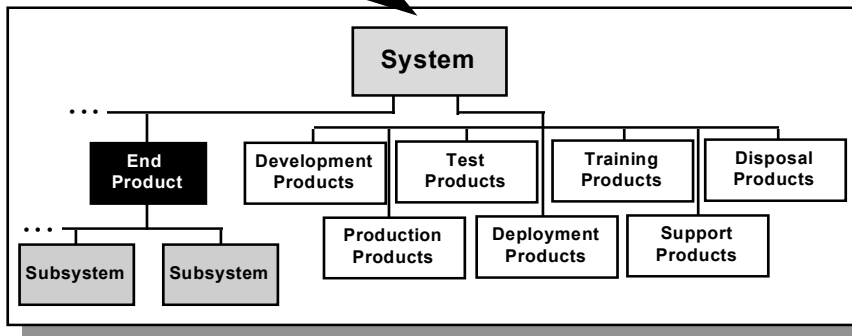
Project C

# System layering

Layer N Building Block



Layer N+1 Building Blocks



# Elicitation and ... *Acquisition* ...

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- Elicitation versus acquisition
- Main issues about elicitation : ethno and sociological



*Requirement elicitation is a team effort*

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# Requirements management

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- What do we manage
- Managing to objective
- Traceability
- Requirements prioritisation
- Problems with metrics

*Manage your Requirements*

*=> Manage your time*



# Requirement expression

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- Maturity levels for expression
- Standard languages and methods
- Dedicated methods
- Others



*Intended message and perceived message :  
That's all about semantics !!*

*Pragmatics and Syntactic issues have a role*

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# Requirements exchange

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- The exchange process
- The rationale behind

*Exchange is a must : Easiness of requirement validation statement*

*Where do you come from ?*

*Do you mean which country or which University I come from ?*

*No I mean which place have you been before !!*

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# Requirement validation

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- Importance of Validation
- V&V Techniques
- Case studies

*Eureka, It Works !!*

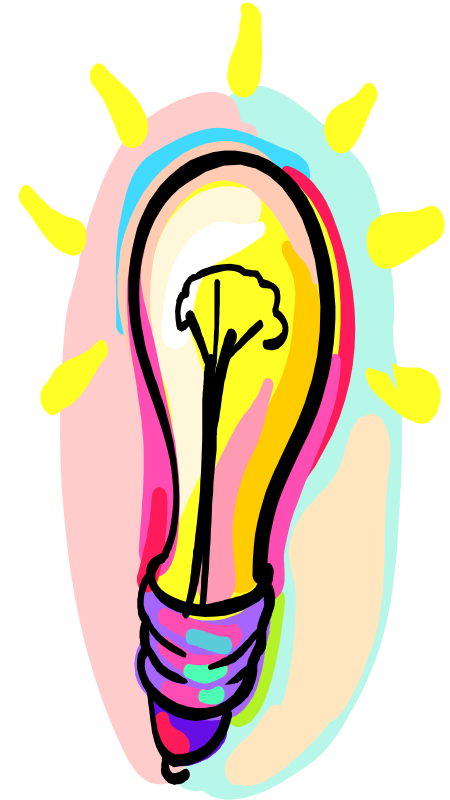
*It means it **corresponds to***

*What You requested ,*

*What You required*

*What You needed*

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# Standards

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- IEEE-1220
- INCOSE/EIA-632
- ISO 15288
- Specific : aeronautic . ARP and space ECSS-E10

*Standard are guideline for common understanding and Good Practice*



# Case Studies

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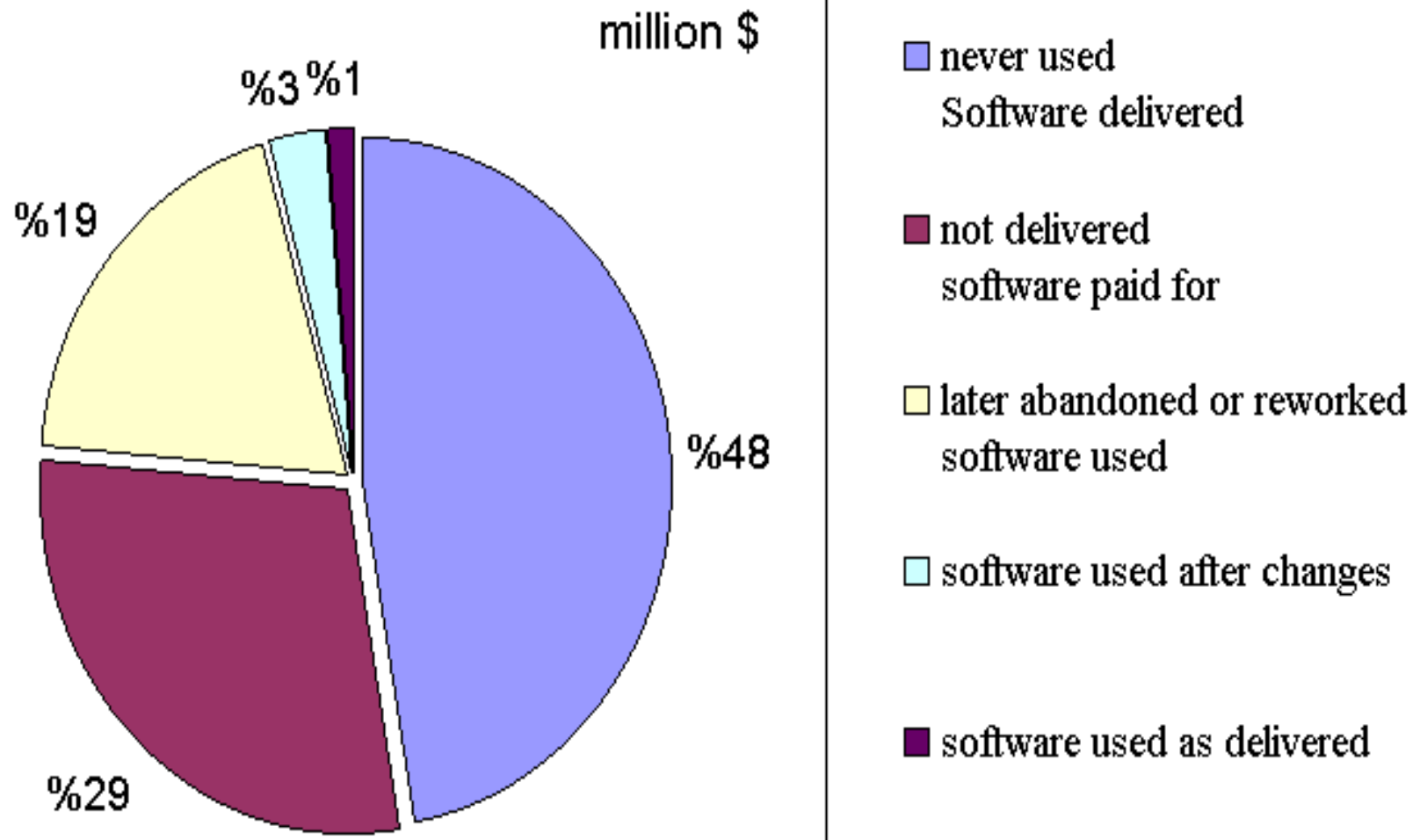
- Requirements expression case with Statemate (Lab)
- Traceability issues with RTM (Lab)



# Why SE: A Bad Experience with Software

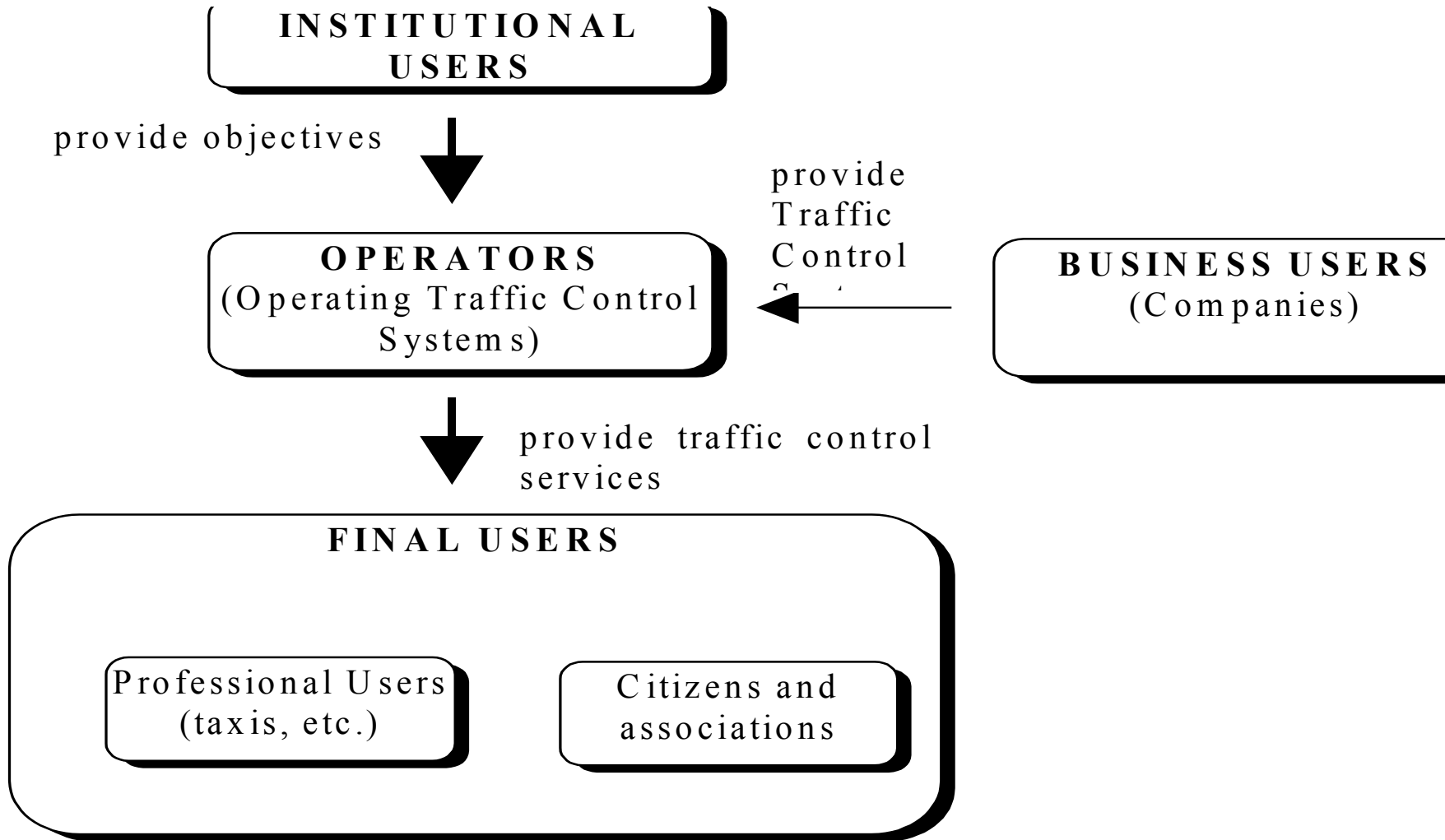
(source NASA)

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# Experiences with transport<sup>(4)</sup>

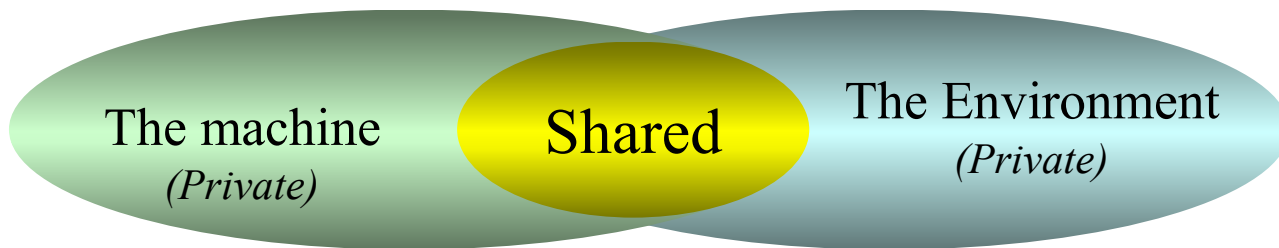
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# Main Orientations (2) : The Jackson View

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- A View based on environment and context
  - A machine (system) to be developed
  - Machine interacts with environment
  - User needs make abstraction on system internal
  - The environment exist; the machine to be developed
  - Shared phenomen :



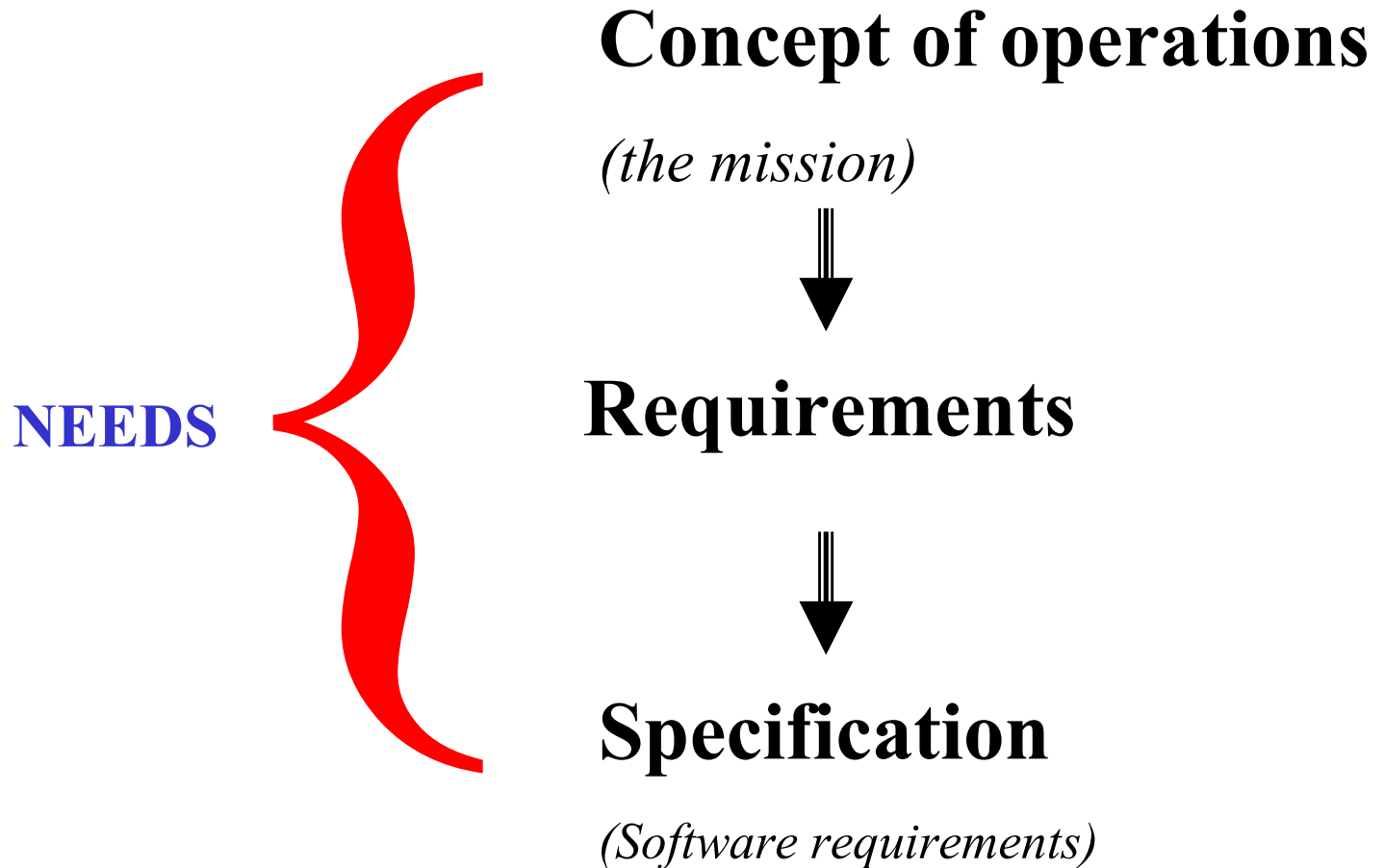
# Requirement and concept of operation (3)

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- *The concept of operations (ConOps) document is a bridge between the operational requirements (events occurring over time) and the technical requirements (static, hierarchical description). It is written in narrative prose that is in the user's language. It states priorities, it uses visual images and leads to software requirements.*
  - *IEEE Standard 1362, IEEE Guide for Concept of Operations Document, 1998.*
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# Needs, requirement and specification

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# Challenges in SE

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- **A System View : Global View**
  - **An interdisciplinary**
  - **Comparative methodologies**
  - **From In House to General approach**
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# Next lecture : Keypoints

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