



***Knowledge-Based  
Systems applying  
Artificial Intelligence***

*Elena Gallego. Consulting Director at TRC.*

“

- ◆ *It is the idea of **knowledge digitalization** one of the challenges that organizations need to pursue in order to **build better systems** or **deliver better services**, in less time, with less money and more efficiency.*



*Knowledge Based System: Infers and Uses a Knowledge Base to solve complex problems*

**Product Oriented**

**Services Oriented**





## *Knowledge Organization*

### **Product Oriented**

- ◇ Product Breakdown Structures
- ◇ Architectures
- ◇ Thesaurus
- ◇ Patterns
- ◇ Controlled Vocabulary

### **Services Oriented**

- ◇ Unstructured data
- ◇ Unknown inputs of information
- ◇ Thesaurus
- ◇ Patterns
- ◇ Controlled Vocabulary



*Different Knowledge Base **Applications using Artificial Intelligence***

**Services**

**Procurement**

**Predictive Maintenance**


The right  
assets

The right  
strategy

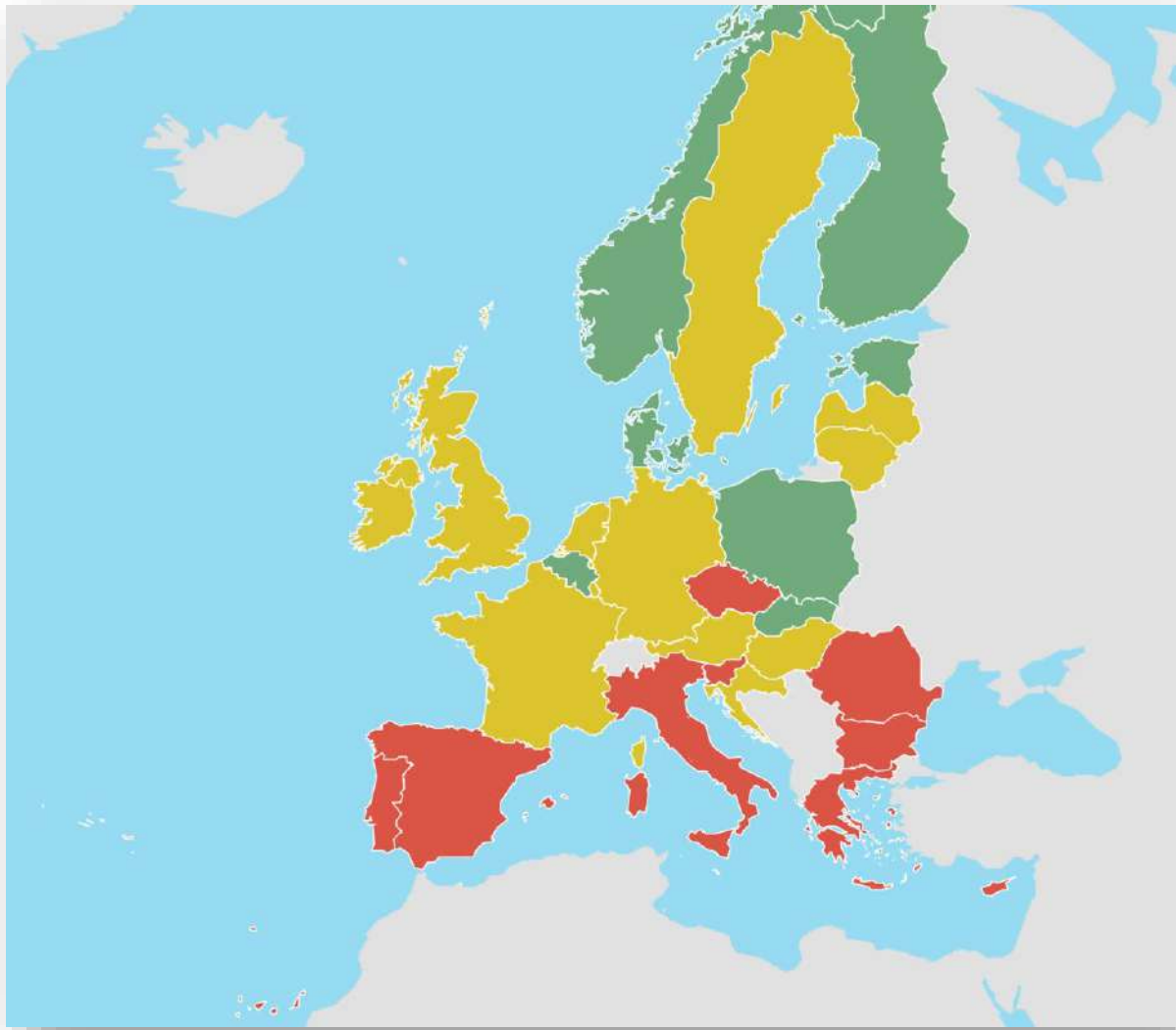
The right  
algorithm

**Products**

**Product Line**



*Procurement  
Knowledge Base*



[1] Single bidder	≤10%	> 20%
[2] No calls for bids	≤ 5%	≥ 10%
[3] Publication rate	>5%	< 2,5%
[4] Cooperative procurement	≥ 10%	< 10%
[5] Award criteria	≤ 80%	> 80
[6] Decision speed	≤ 120 days	> 120 days
[7] SME contractors	> 60%	< 45%
[8] SME bids	> 80%	< 60%
[9] Procedures divided into lots	> 40%	< 25%
[10] Missing calls for bids	≤3%	> 3%
[11] Missing seller registration numbers	≤3%	> 3%
[12] Missing buyer registration numbers	≤3%	> 3%



## *Procurement Knowledge Base Objectives*

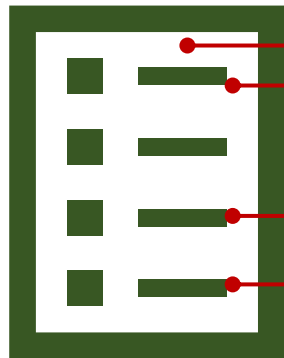
- ◆ **Automatic Analysis** of the Evaluation Criteria
  - ◆ Traceability between user and business needs and evaluation results
- ◆ Ensure **complete documentation** development process
  - ◆ Guarantee stakeholder priorities are covered at different documentation levels
- ◆ **Life-cycle cost analysis** among involved areas
  - ◆ Completeness and Consistency at all levels
- ◆ **Support the development of** requirements and models
  - ◆ Patterns guidance at all levels





## Procurement Knowledge Base

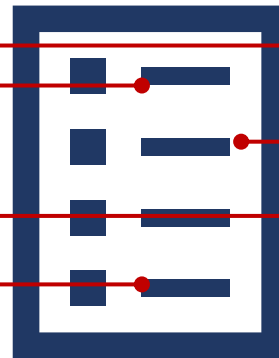
### Technical Specification



ISO 29148

- ✓ Correctness
- ✓ Completeness
- ✓ Consistency

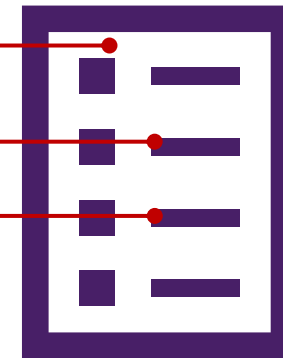
### Statement of Work



ISO 15288 | MIL-Hdbk-245

- ✓ Correctness
- ✓ Completeness
- ✓ Consistency

### Logistics Support



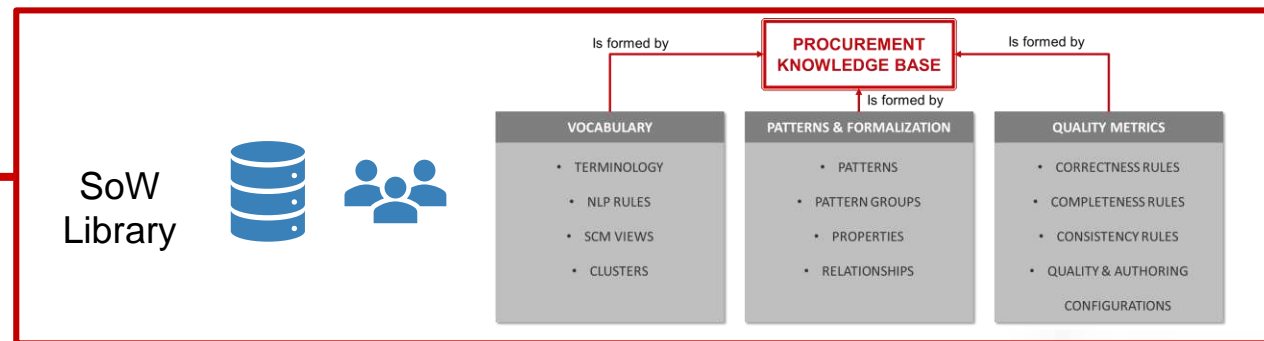
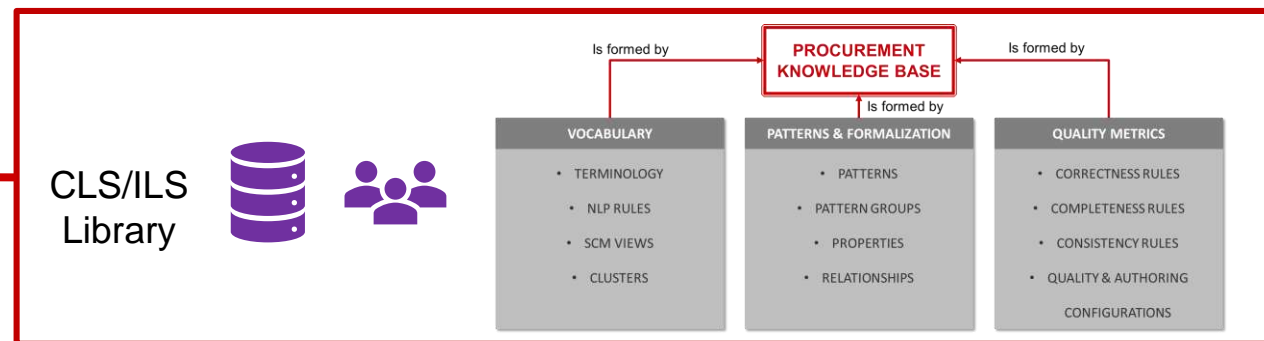
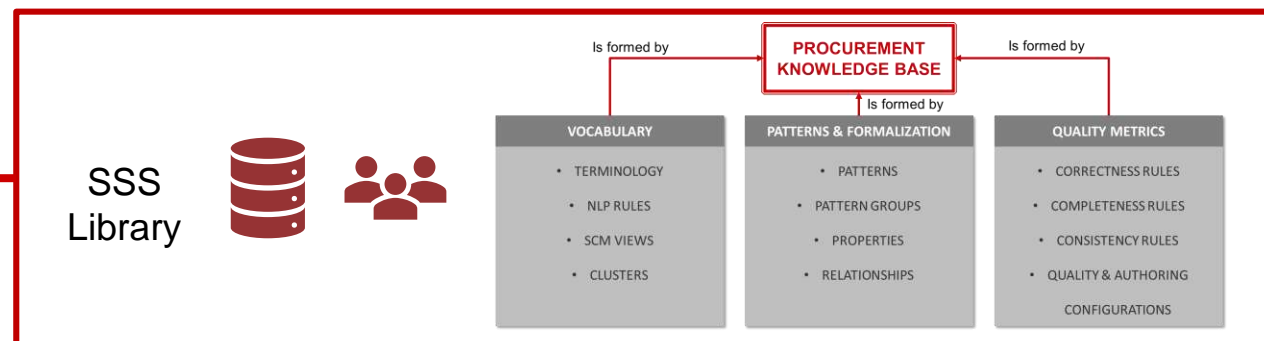
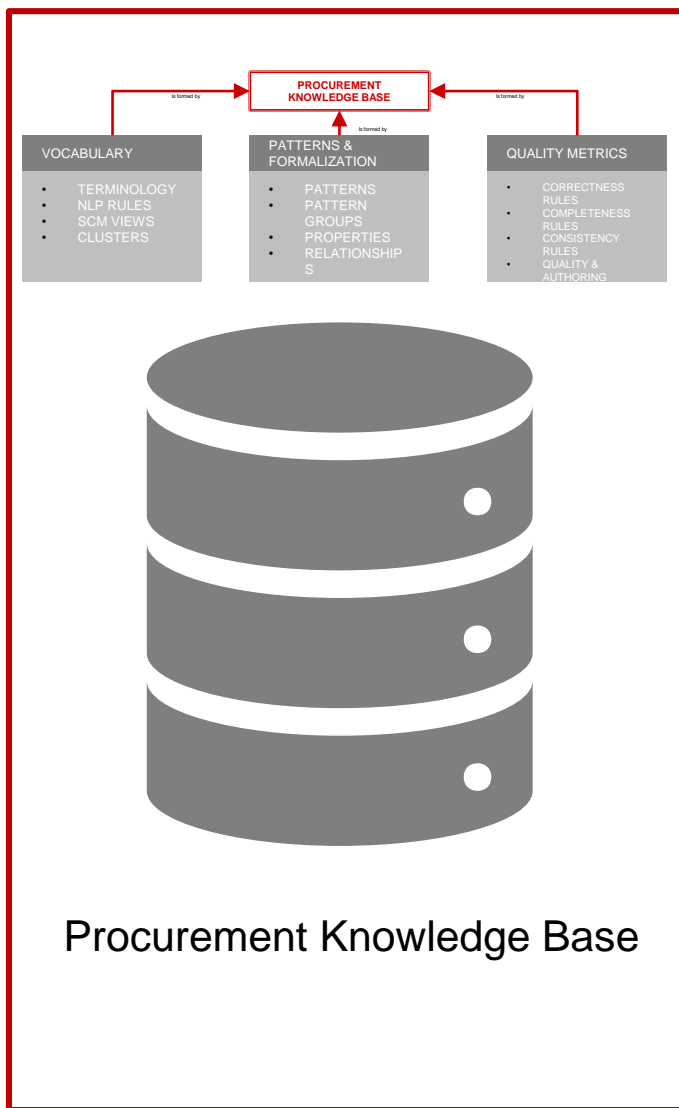
ASD SX 000i  
JSP886 | Def Stan 00-600

- ✓ Correctness
- ✓ Completeness
- ✓ Consistency

Completeness  
Consistency



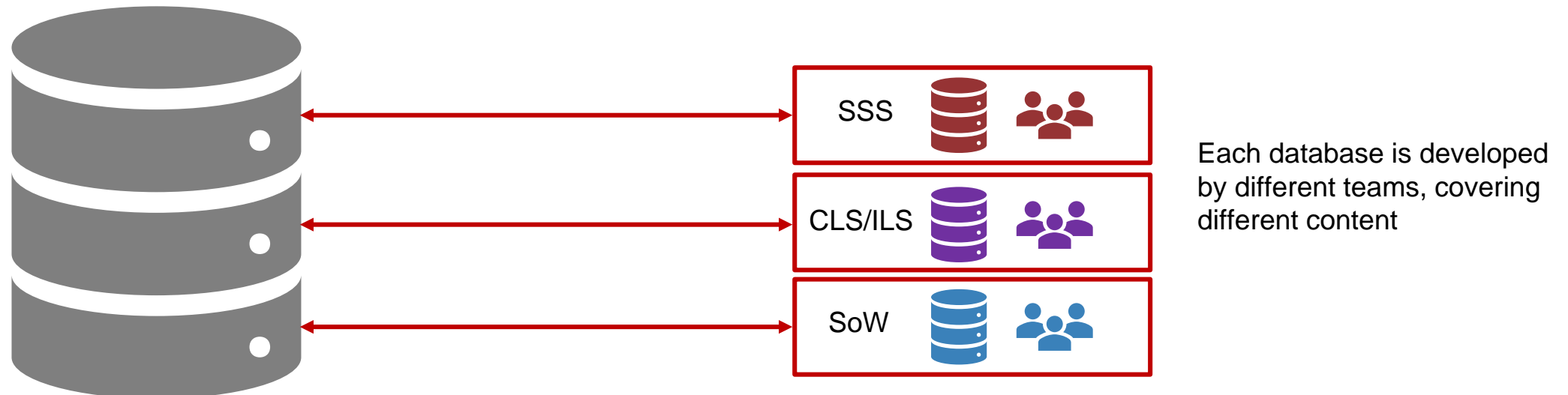
## Procurement Knowledge Base Organization

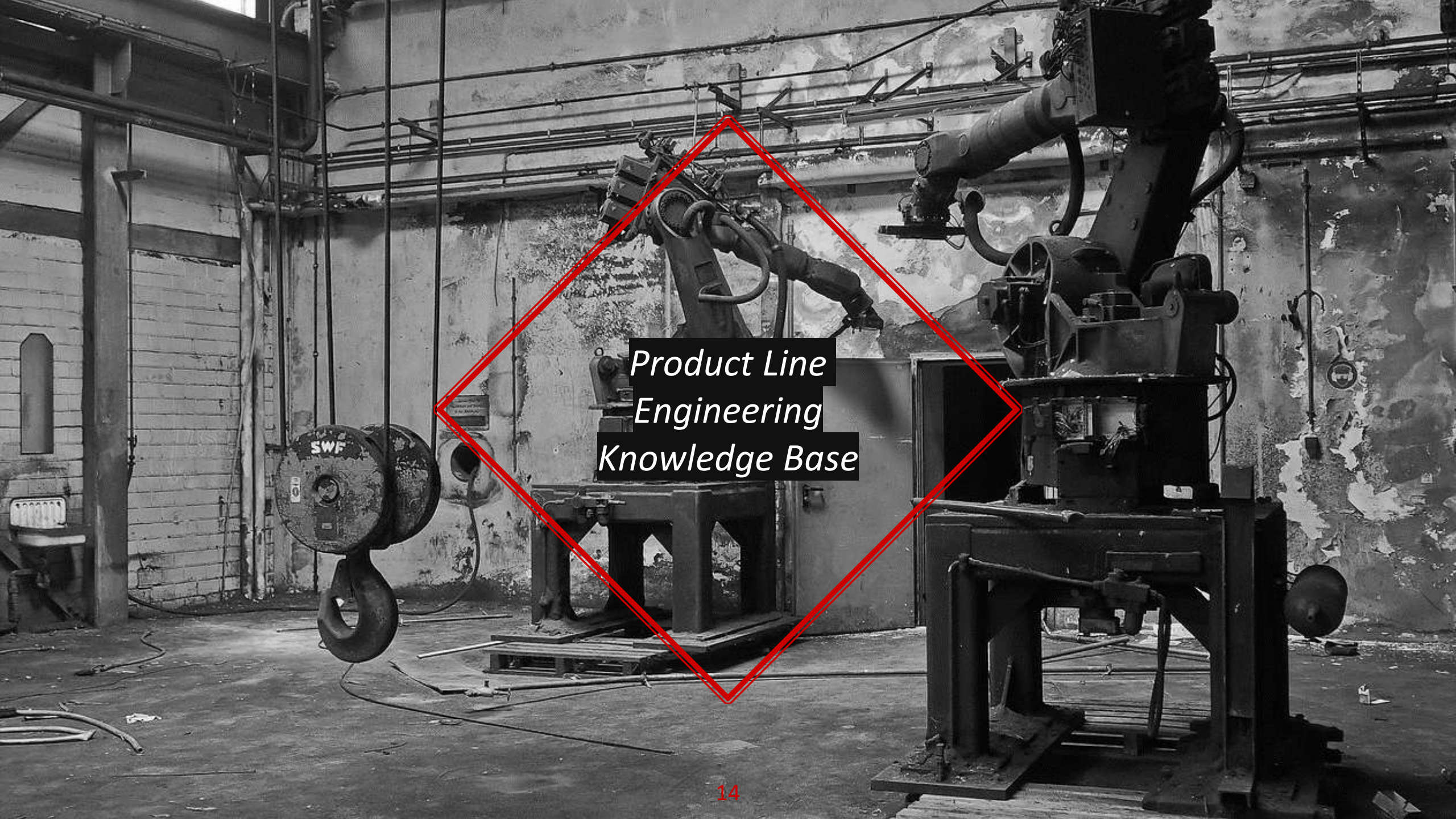




## Procurement Knowledge Base Organization

- ◆ The Procurement Knowledge Base has sub-Knowledge Bases to cover the three main sort of documents for each of the knowledge work products.





*Product Line  
Engineering  
Knowledge Base*



*The European automotive sector differed greatly in the level of variety they offered to customers, although variety had little relation to unitary sales.*

	Bodies	Power trains	Total number of variations	European units sales in 2002
<i>Mercedes E-Class</i>	<b>30</b>	<b>15</b>	<b>3,347,807,348,000,000,000,000,000</b>	<b>157,584</b>
<i>BMW 3-Series</i>	<b>10</b>	<b>20</b>	<b>64,081,043,660,000,000</b>	<b>350,723</b>
<i>Peugeot 206</i>	<b>5</b>	<b>24</b>	<b>1,739</b>	<b>596,531</b>

Source: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.469.2061&rep=rep1&type=pdf>



## *Product Line Knowledge Base Objectives*

- ◆ **Extraction** of requirements from the product-line assets
  - ◆ Automatic allocation of assets from the solution space to requirements document
- ◆ **Identification of the variant features** in the requirements
  - ◆ Patterns and Thesaurus to cover commonality and variability
- ◆ **Coverage** of the specific system features
  - ◆ Knowledge interfaces with Product Lifecycle Management software tools



The Product Line Knowledge Base is formed by all types of Knowledge

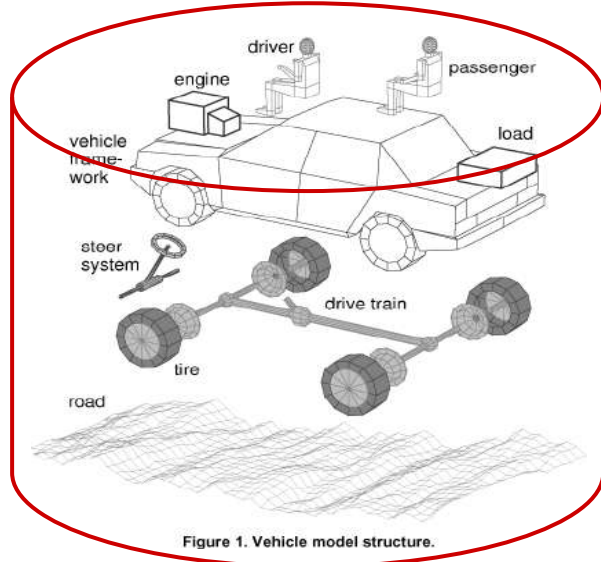
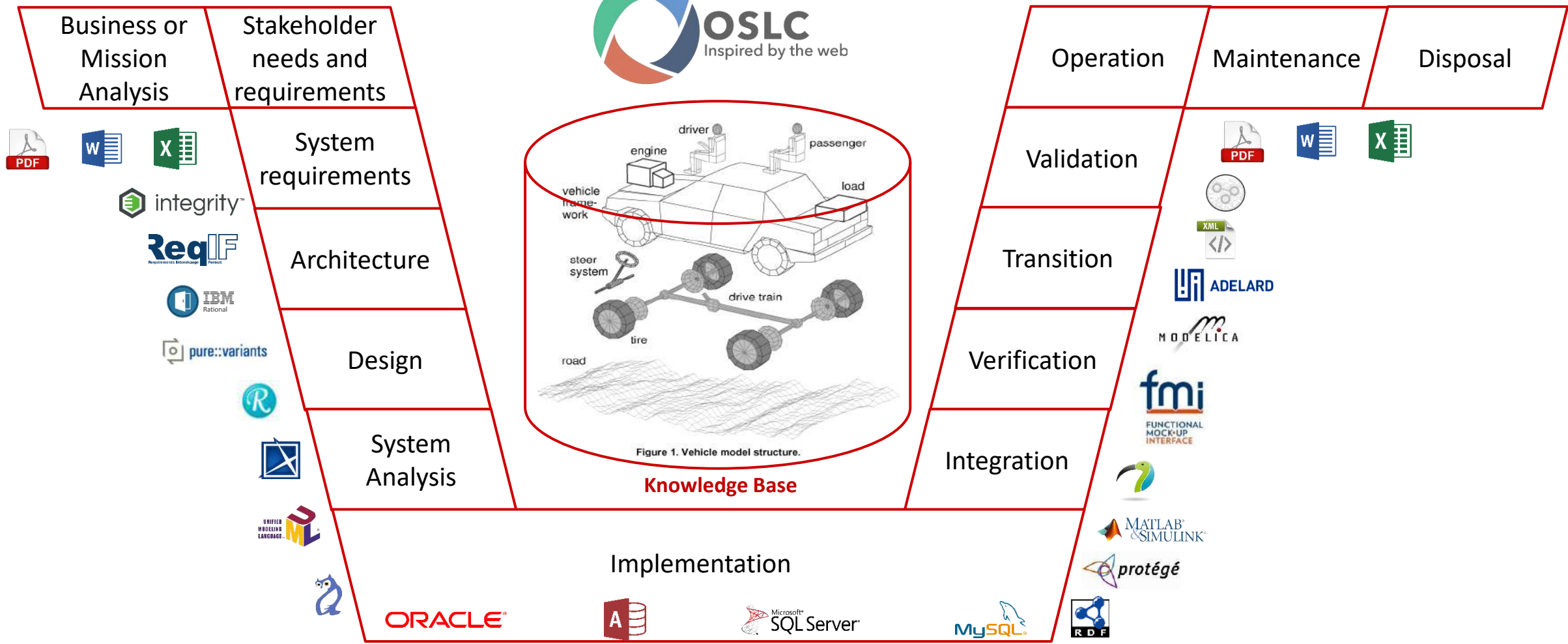


Figure 1. Vehicle model structure.

**Knowledge Base**



“

◆ *The goal of this process is to automatically generate the right set of **patterns to formalize the features** of the products and the different semantics and values from the natural language to SRL and later use the formalization of the different products to **generate the variability model** based on the captured features.*

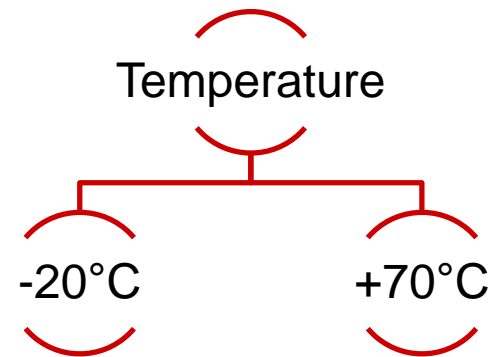
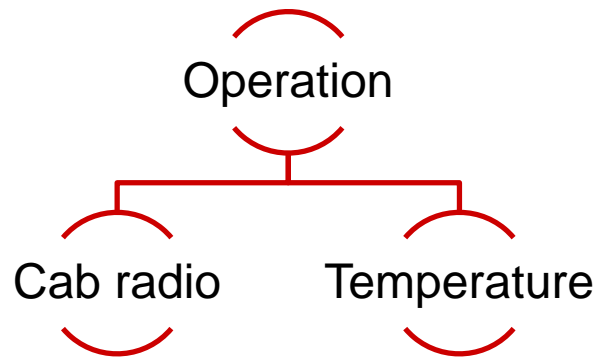





*A simple example of a pattern matching, and relationships generation*

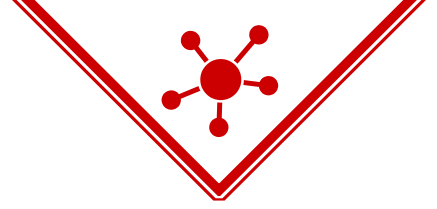
When switched on, the **Cab radio** shall **operate** within a **temperature** range of **-20°C** to **+70°C**

When [**TRIGGER**] and [**PRECONDITION**], the [**ACTOR**] shall [**ACTION**] [**OBJECT**]



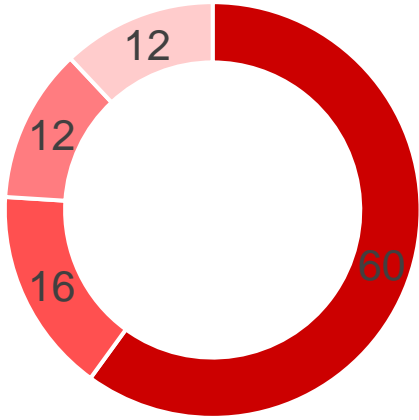


*Predictive  
Maintenance  
Knowledge Base*



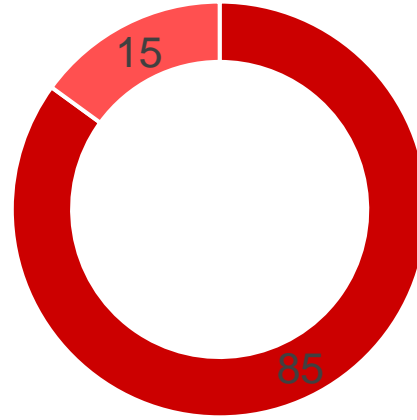
## The Cost of Operations & Maintenance

■ Wind Turbines ■ Rest of the Wind Farm

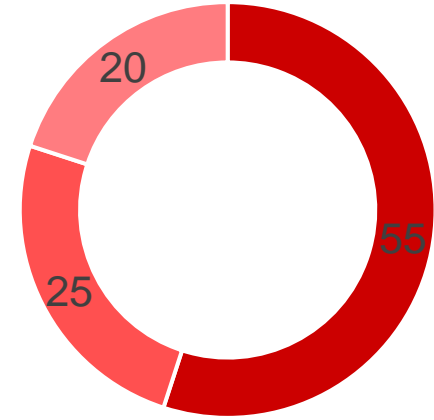


■ O&M ■ Tax ■ Management ■ Insurance

**Exploitation Costs**



**O&M Costs**



■ Spare parts ■ Personnel ■ Consumables

**Wind turbine Costs**

“

- ◆ *Combination of a **predictive** and **preventive maintenance** with an efficient corrective action can save up to 70% wind turbine operational costs.*



## *Predictive Maintenance Knowledge Base Objectives*

- ◆ **Automatic failures diagnosis** through condition monitoring
  - ◆ Reasoning engine to identify deviations in data
- ◆ Representation of **legacy data**
  - ◆ Knowledge interface with the data
- ◆ **Predictive techniques** to identify behavioural patterns
  - ◆ Definition of patterns that capture data variations



11,399€	100	1173,378	100	70,506€	100	56,101	100	1,98005	100
11,399€	100	1068,718	100	69,933€	100	56,415	100	1,53884	100
11,399€	100	1014,819	100	69,361€	100	56,729	100	1,09763	100
11,399€	100	1089,433	100	68,788€	100	57,043	100	0,65641	100
11,399€	100	171,4513	100	65,169€	100	57,358	100	31,7183	100
11,399€	100	1188,124	100	66,349€	100	57,588	100	9,99519	100
11,399€	100	968,9018	100	68,400€	100	57,599	100	4,89087	100
11,399€	100	211,3709	100	64,167€	100	57,599	100	38,1913	100
11,399€	100	822,6924	100	64,326€	100	57,599	100	8,76880	100
11,399€	100	855,4813	100	65,252€	100	57,599	100	7,60702	100

# *Data Mining*

## **Knowledge Base**

Infer data structures

## **Data**

Information containers


## **Information**

Set of patterns



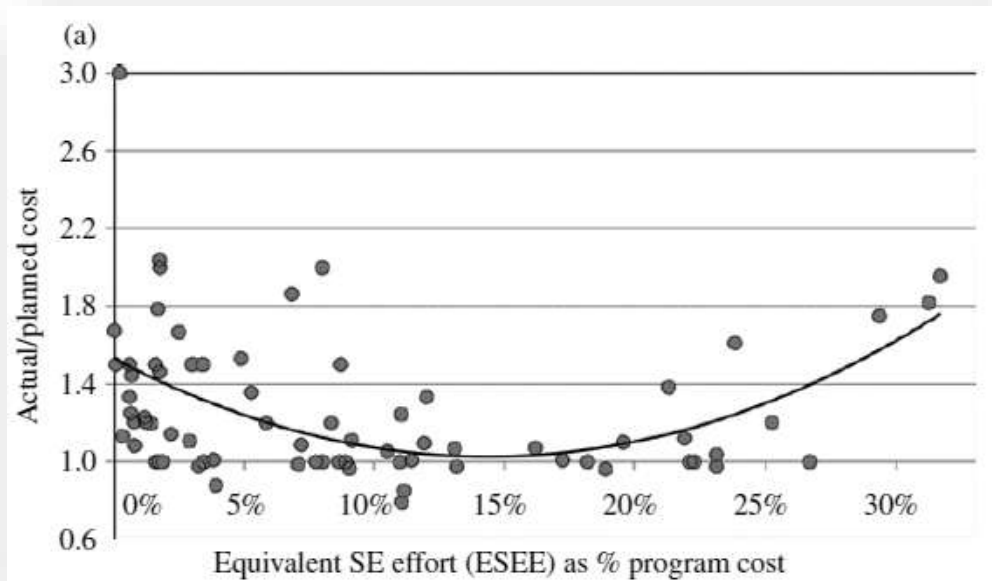
# 93.77%

Knowledge Based systems can infer the status of a wind turbine from its measurements and predict its behaviour in 93.77% of the cases



*Efficient application  
of Knowledge-  
Based Engineering*





Systems Engineering Handbook. INCOSE-TP-2003-002-2015

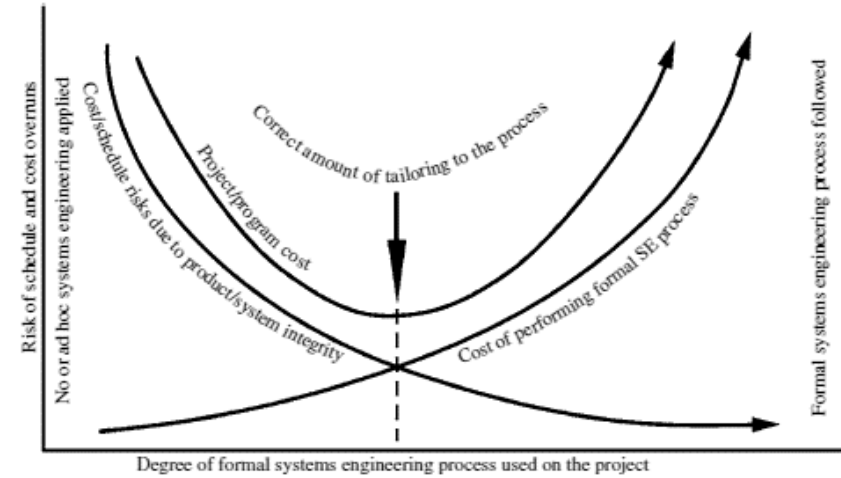
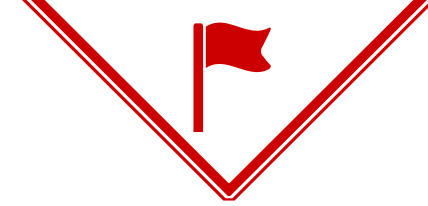


FIGURE 8.1 Tailoring requires balance between risk and process. INCOSE SEH original figure created by Michael Krueger, adapted from Ken Salter. Usage per the INCOSE Notices page. All other rights reserved.

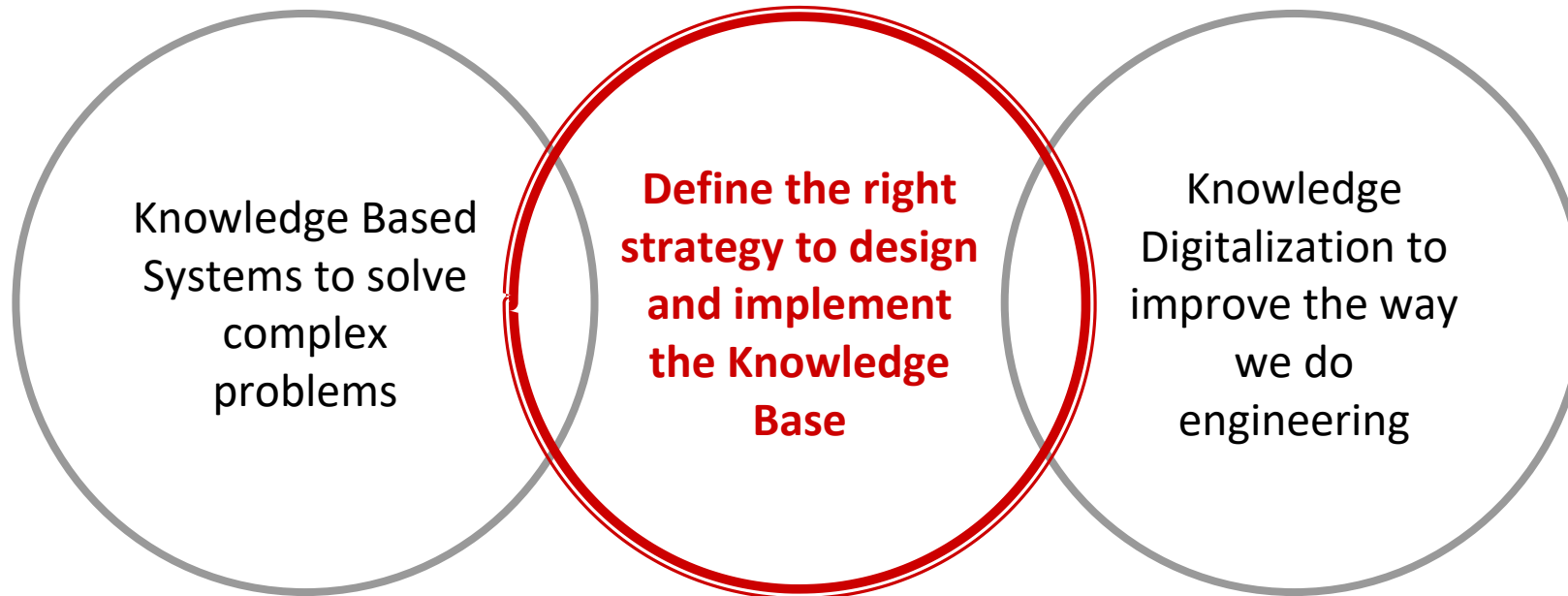
Systems Engineering Handbook. INCOSE-TP-2003-002-2015

# *Make it Simple*

Process automation and User's Support



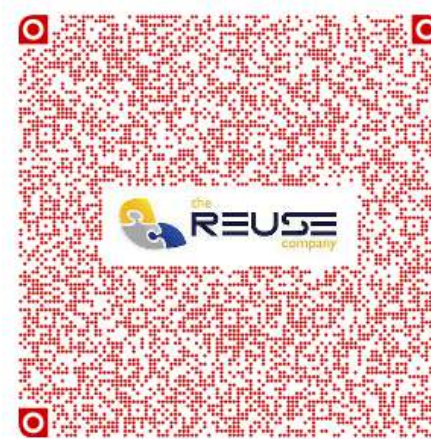
*And all this to conclude...*





*Thank you!*

Any questions?



You can reach me at [elena.gallego@reusecompany.com](mailto:elena.gallego@reusecompany.com)