

# Bridging the Gap between Natural Language Requirements and Formal Specifications

Verkehr  
Transportation



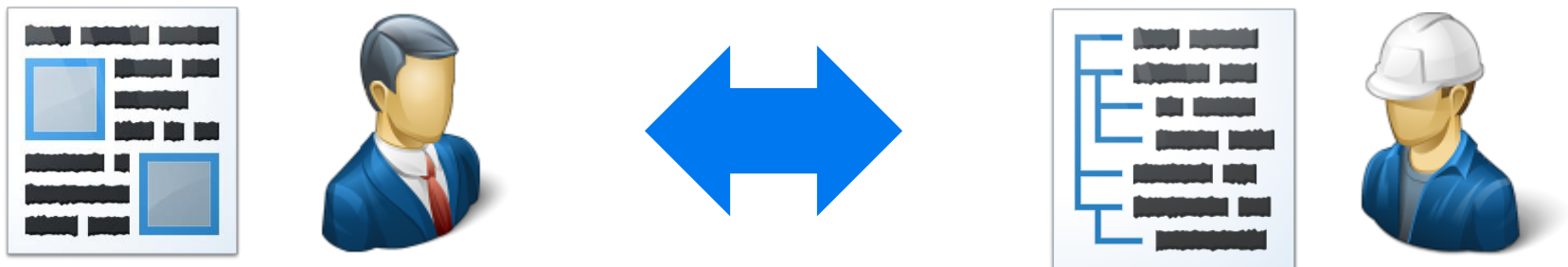
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Group „Safety & Security oriented Design Methods & Processes”

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RET --- Goetheburg

## Research Problem

**Problem: Need of a consistent set of (human) readable and (maschine)-testable requirements**

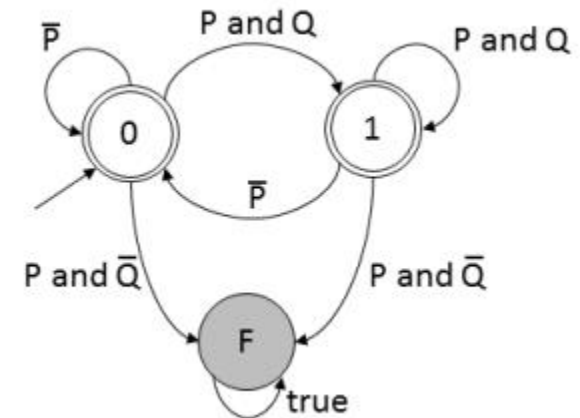


Research question:

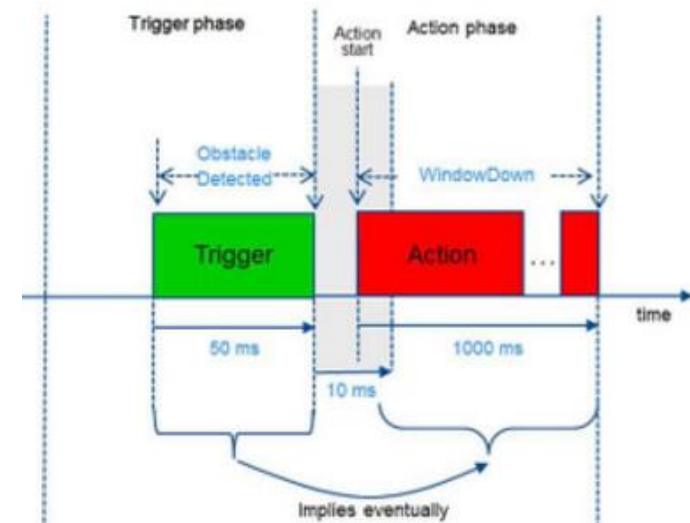
What are the right restrictions on writing natural language requirements, such that they are comprehensible for the system engineer, but facilitate the derivation of a formal specification?

## Formal Specification

- ▶ Functional Specification for causality, timing, ordering
- ▶ Organized as a „pattern catalog“
- ▶ Enabling Technology:
  - ▶ Test case generation
  - ▶ Runtime monitoring
  - ▶ Verification of safety goals



*“If an obstacle is detected at least for 50 ms, the window down signal has to be activated for minimum time frame of 1 sec. “.*



## Background: CRYSTAL Project

**CRITICAL SYSTEM  
ENGINEERING  
ACCELERATION**



Tool provider:



Academic Partner:

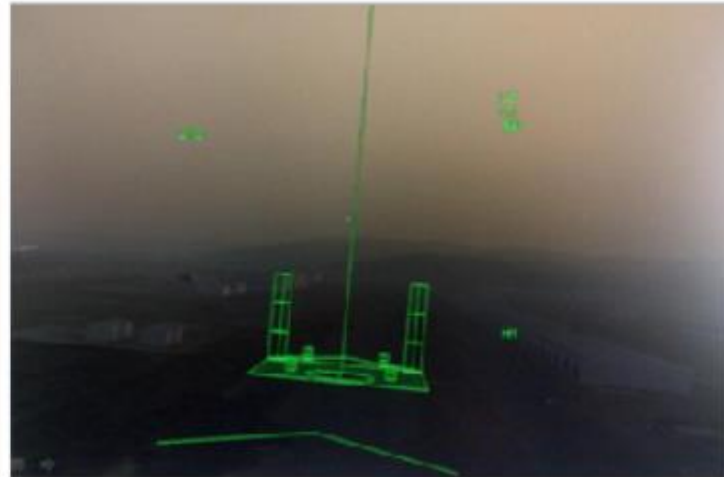


Use Case provider:



## Use Case

- Landing symbology function of the Situational Awareness suite Sferion
- Supports pilots in degraded visual environments
- Rich set of complex, functional requirements



## Tool chain



DOORS

Requirements repository



RQS

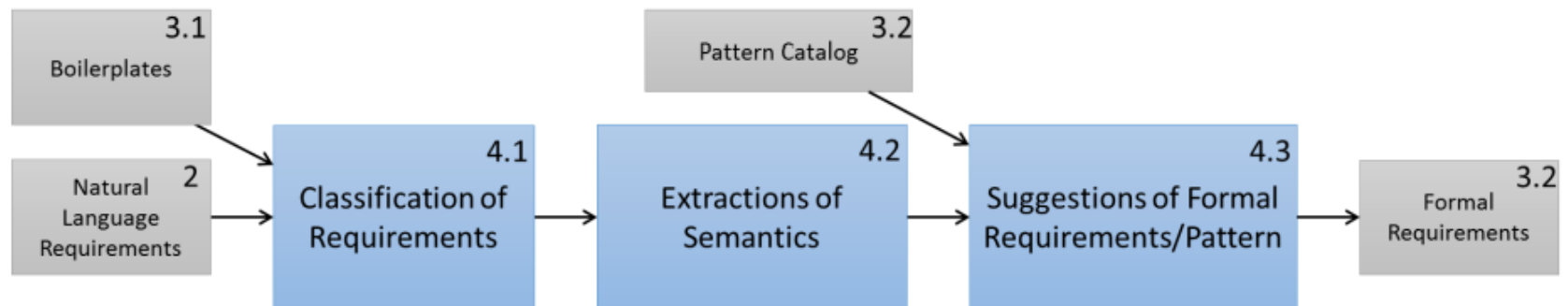
Write and analyze natural-  
Language requirements



Embedded Specifier

Manage formal  
requirements

## Formalization Process



## Identification of Relevant Requirements

### Requirement Boilerplates:

B1: WHEN <trigger> the <system> shall <action> if <assumption>.

B2: WHILE <state> the <system> shall <action> if <assumption>.

Custom metrics: Custom code to perform analysis on the enriched natural language requirements

Index text
Define pattern groups for indexing

Enter the paragraph to index:

WHEN the triggermarklanding symbol is received and there is an intersection between the LoS of the tracker of the HMSD and the ground surface and there is no sensor and database classified obstacle within the doghouse square with edge length of 40 m for the marked landing position the LS3D function shall set the marked landing position to valid if the landing symbology has been activated.

Index

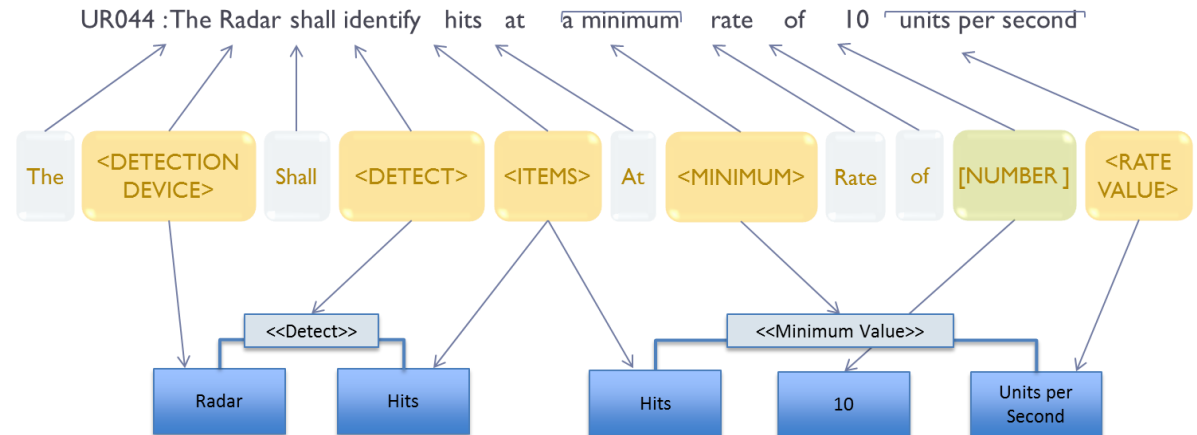
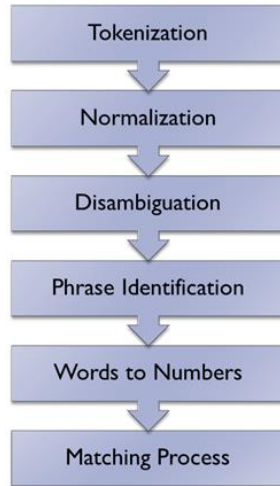
Indexing results:

Syntax Analysis
Formal representation model
Metaproperties
Log
Similar requirements tester

Id: 816; [B1]: Matches : "when the triggermarklanding symbol is received and there is an intersection between the los of the tracker of the hmsd and the ground surface and there is no sensor and



# Extracting Semantics from Boilerplates



Index text:

Enter the paragraph to index:

If the pin symbol is visualized and the distance H/C to landing position < 0.4 NM then the ls3d function shall visualize a slope indication in 20 ms.

Indexing results:

Syntax Analysis | Formal representation model | Metaproperties | Log | Similar requirements tester

Properties	Attribute type	Attribute name	Operation	Value type	Value
String	trigger	Equal	String	the pin symbol be visualized and the distance h / c to land position < 0.4 nm	
String	reaction	Equal	String	the ls3d function shall visualize a slope indication	
String	time	Equal	Term	20	

Index text:

Enter the paragraph to index:

whenever x then y.

Indexing results:

Syntax Analysis | Formal representation model

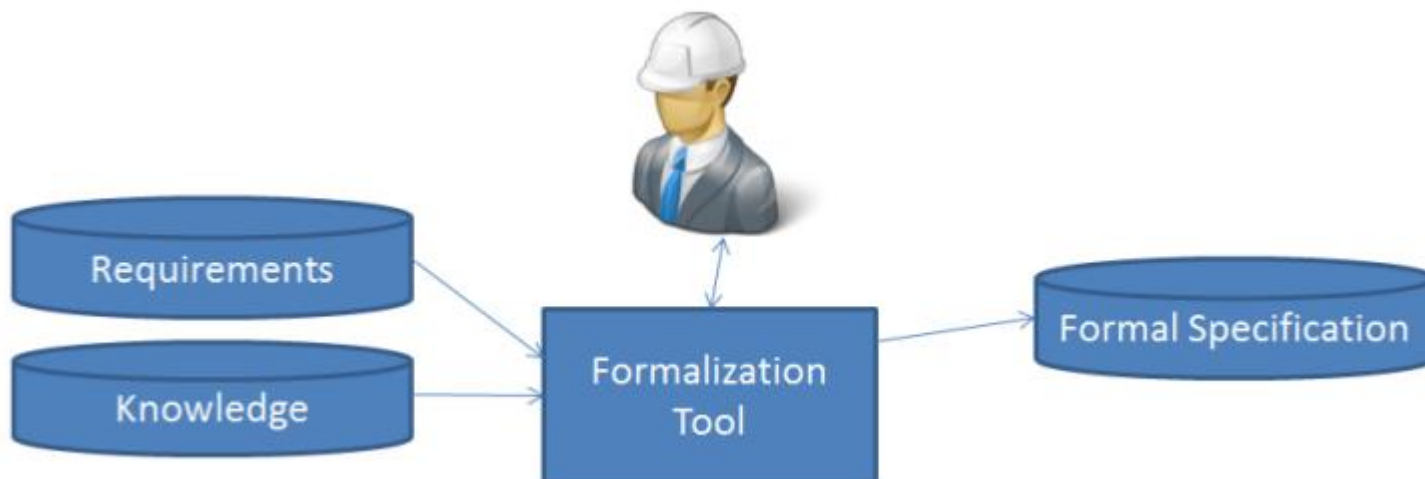
«TriggerReaction»: (X, Y)

X

Y

## Guided Formalization

- ▶ Knowledge base is being opened for access of external applications
- ▶ Hints for formal pattern can be generated based on matched Boilerplates or relationships
- ▶ Extracted Meta Properties can be translated into boolean expressions
- ▶ Common terms can be identified with model variables/macros



## ▶ Lessons learned

- ▶ Industrial Perspective
  - ▶ Enriched Natural language requirements enables further analysis: Styleguiding, Pattern Matching, Ontologies
  - ▶ Can be introduced step-by-step
  - ▶ Customization effort is an issue
  - ▶ Difficult to predict RoI for the more advanced Methods
- ▶ Academic Perspective
  - ▶ Use of commercial tools led to a better understanding of industrial needs
  - ▶ Lack of control of the tools made it harder to test “advanced methods”