On the Effect of Using SysML Requirement Diagrams to Comprehend Requirements: Results from Two Controlled Experiments

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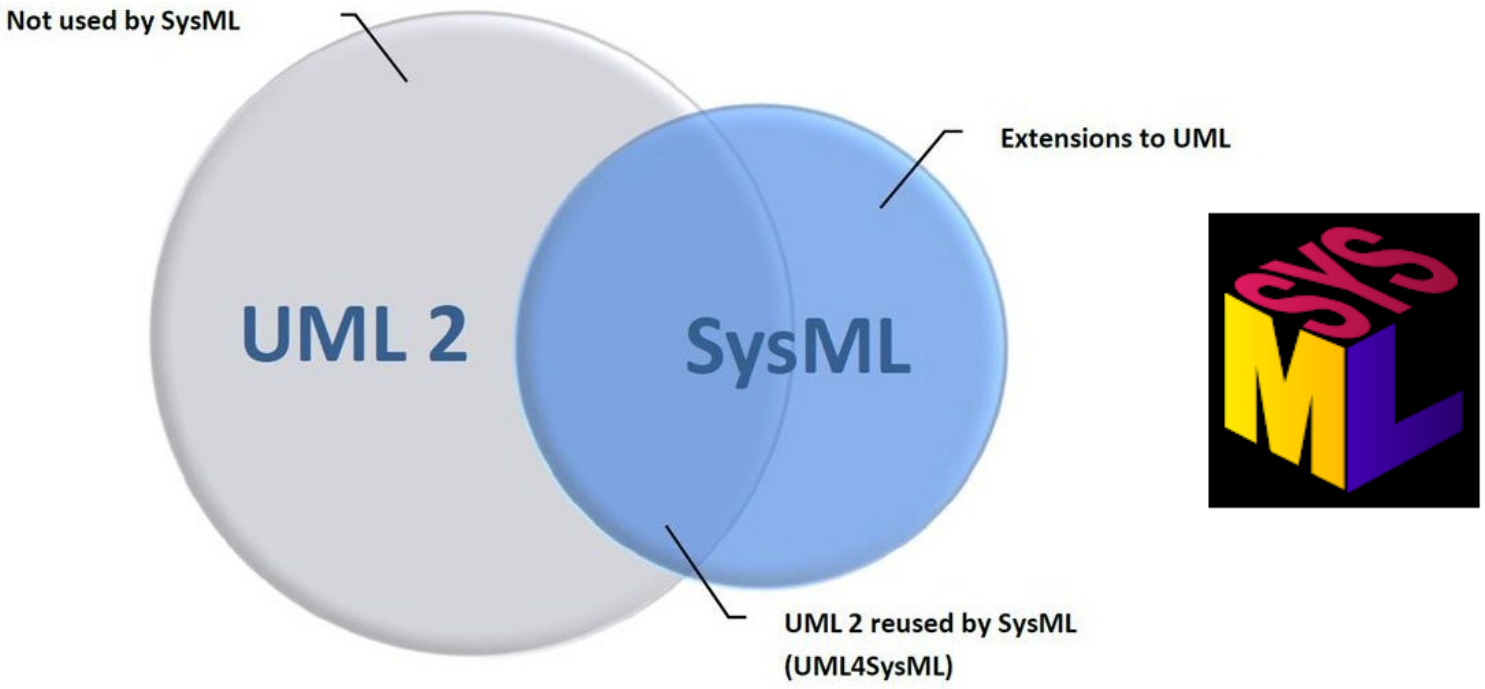
Results at a glance

Using requirements diagrams from SysML increases comprehension and does not change the time

SysML vs. UML



SysML reuses a subset of the UML2 (UML4SysML), and defines its own extensions. Therefore SysML includes nine diagrams instead of the thirteen diagrams from the UML 2.0, making it a smaller language that is easier to learn and apply.

SysML vs. UML

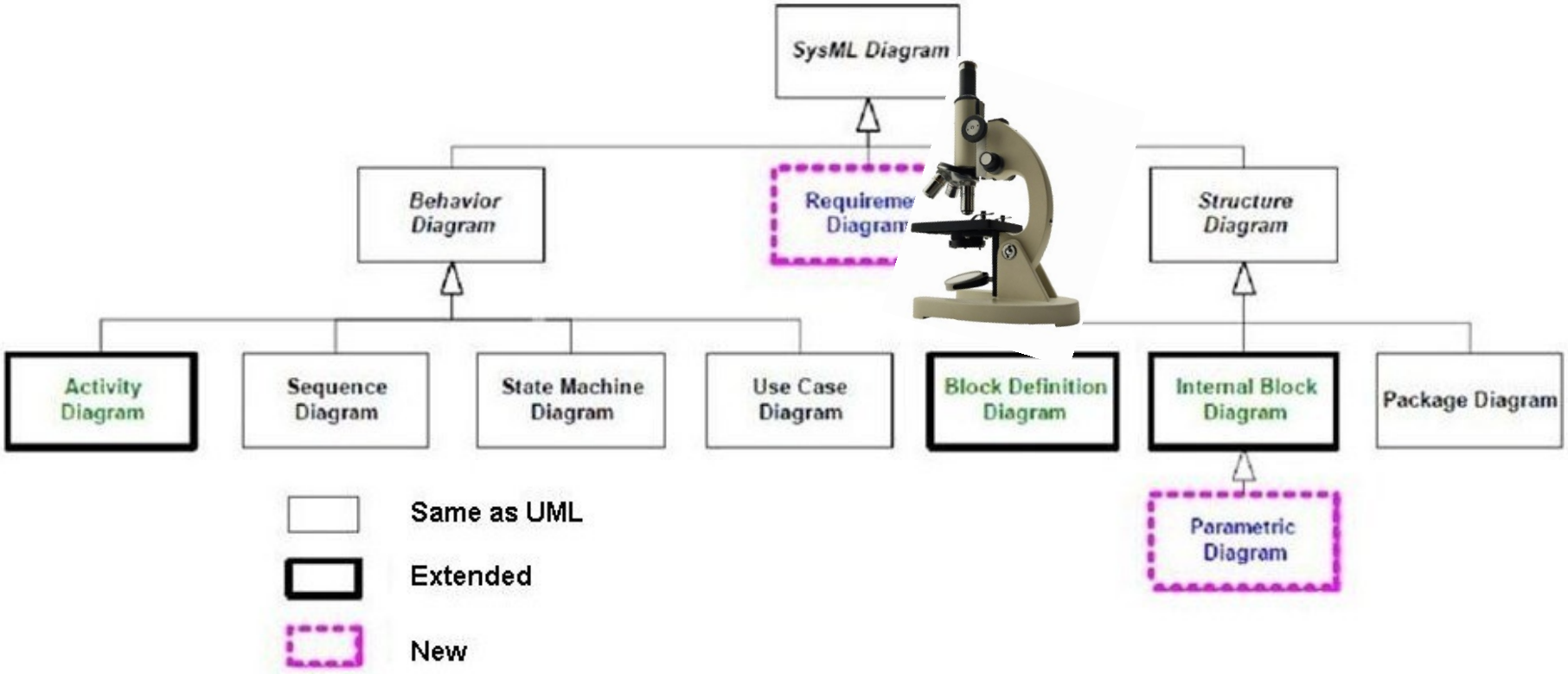
- Extensions and / or changes with respect to the UML:

- **Reuse and Extension of the UML:**
  SysML reuses the UML and makes changes without altering the language, the moreextended with new diagrams;

- **Package:**
  the package is the basic unit of partitioning in the specification, i.e. packages share model elements into logical groups;

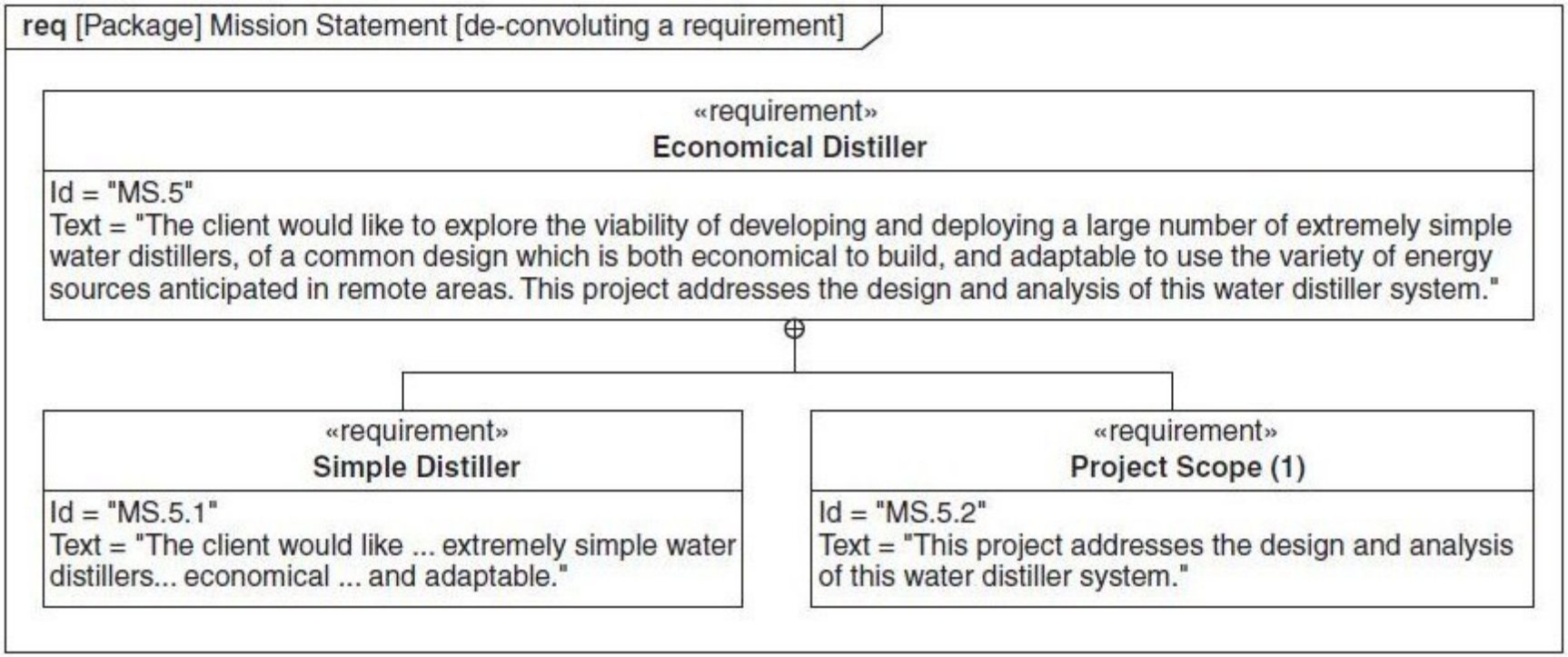
- **Stratification:**
  each package is treated as an extension to the UML model layer;

Structure of SysML

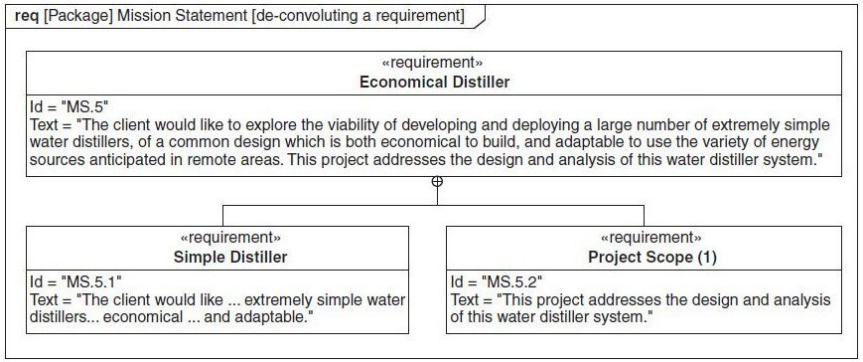


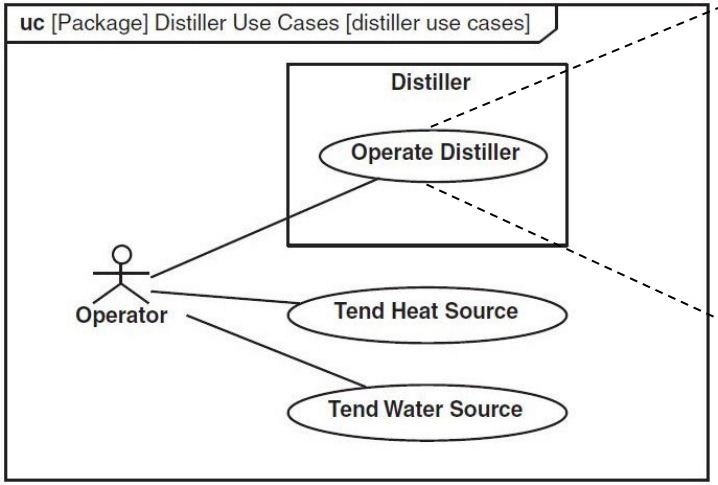
SysML is defined on a modular basis. We can distinguish between elements of the *Structural Model* (**Structure**) used to describe the structure of the system, elements of the *Behavioral Model* (**Behavior**) used to describe the functions of the system, and other model elements that relate to both (structural and behavioral).

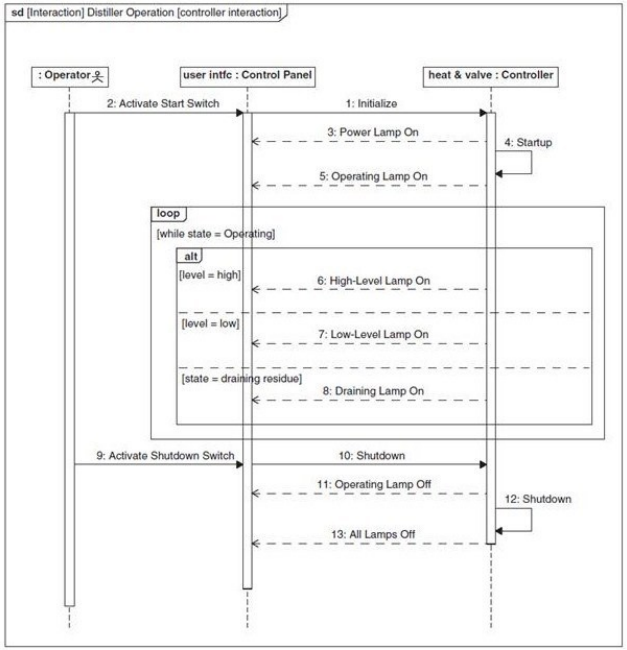
Example of a requirement diagram



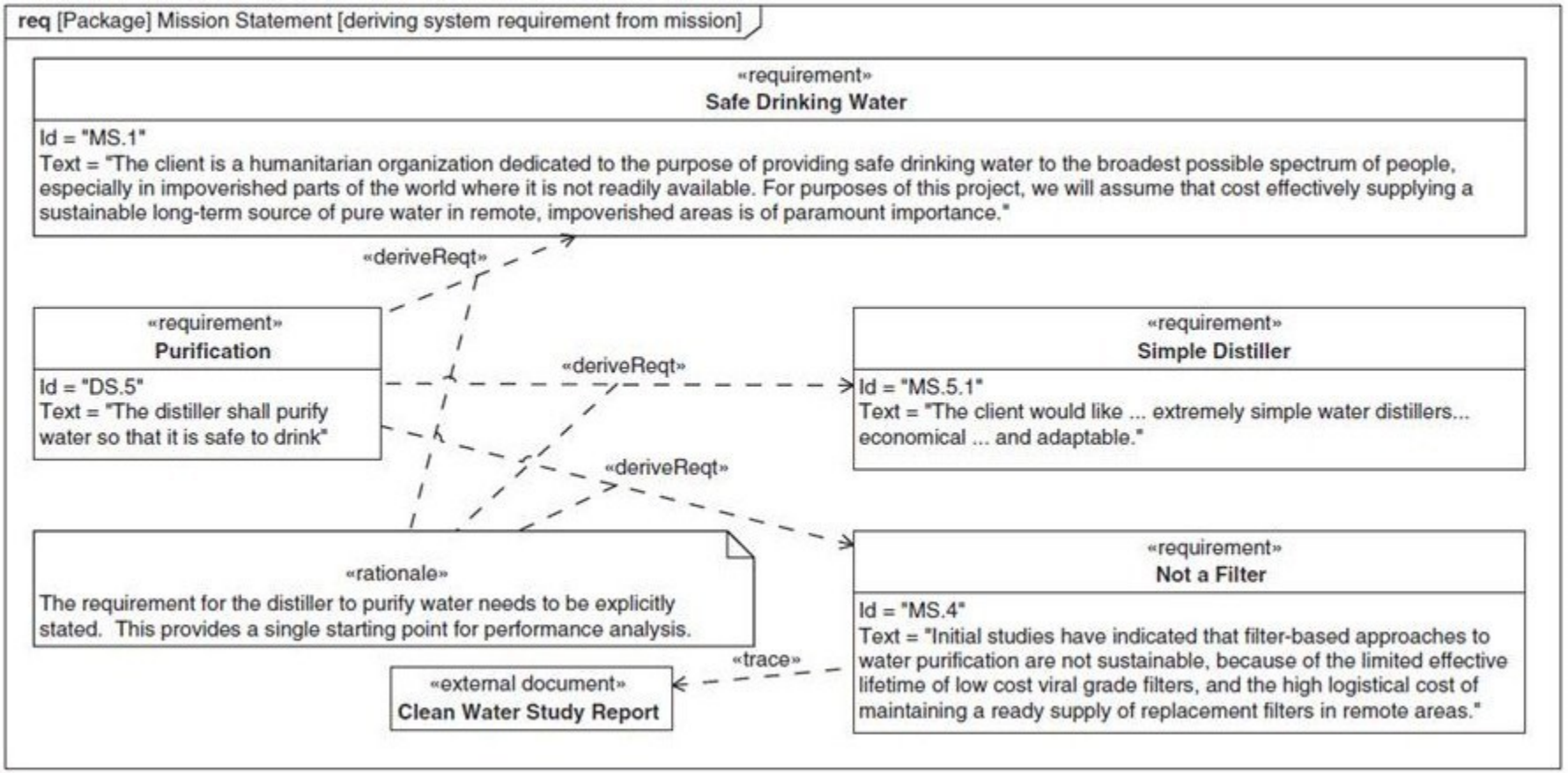
Requirements diagram and Use Cases







Example of a requirement diagram



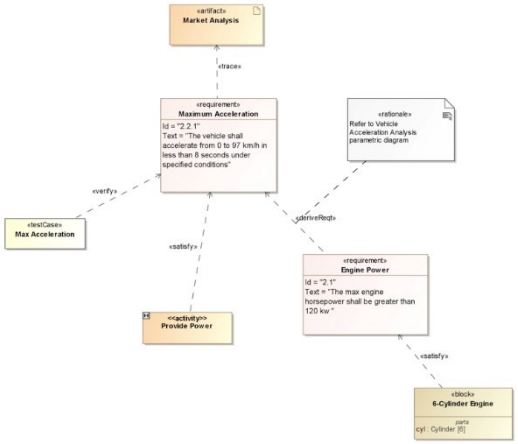
Experiment design – hypotheses

- Goal
  - Analyze **SysML requirement diagrams**
  - for the purpose of **evaluating requirements comprehensibility**
  - with respect to correctness of **comprehension** and **time** to accomplish a comprehension task
  - from the point of view of the **requirements analyst and the developer**
  - in the context of students in Computer Science/Software Engineering.

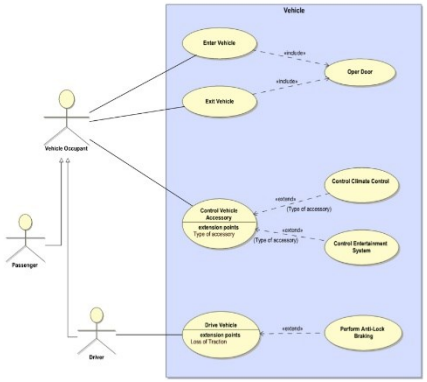
- Hypotheses
  - Hn0: *The mean value of the comprehension for the RD factor is the same as the mean value of the comprehension variable for the NORD factor*.
  - Hn1: *The mean value of the comprehension for the RD factor is the same as the mean value of the comprehension variable for the NORD factor*.

RD: SysML document with requirement diagram
NORD: UML document with Use case diagram

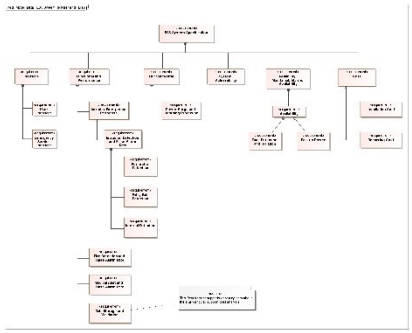
Experiment objects



Class diagram



Use case diagram



Requirements diagram

- **Intruder Emergency Response**
  → *Intrusion Detection and False Alarm Rate:* ESS must provide intrusion detection and the frequency of false alarms. It must ensure the detection of intrusions in the perimeter (Perimeter Detection), interior (Internal Detection) and entry-exit (Entry-Exit Detection) area of the place where the system is present/installed.
- **Fire Detection and False Alarm Rate**
  ESS must ensure fire detection and must take note of false alarms (frequency).

Requirements specification

Experiment operation

	Trial #1	Trial #2
Group A	RD, Automobile	NORD, Surveillance
Group B	NORD, Automobile	RD, Surveillance
Group C	RD, Surveillance	NORD, Automobile
Group D	NORD, Surveillance	RD, Automobile

The experiment was done at *University of Basilicata* (24) and *Chalmers | University of Gothenburg* (63 students)

Data collection: Example question

7. The maximum acceleration of a car is strongly connected to (one or more answers may be correct) ☐ Engine power ☐ Car noise ☐ The number of the cylinders of the engine ☐ The space for the occupants inside the car ☐ The maximum speed				
How much do you trust your answer?				
☐ Unsure	☐ Not sure enough	☐ Sure Enough	☐ Sure	☐ Very Sure
How do you assess the question?				
☐ Very difficult	☐ Difficult	☐ On average	☐ Simple	☐ Very simple
What is the "main" source of information used to answer the question?				
☐ Previous Knowledge	☐ Requirements List	☐ Internet	☐ Use Cases	☐ Use Case Diagram	☐ Requirement Diagrams

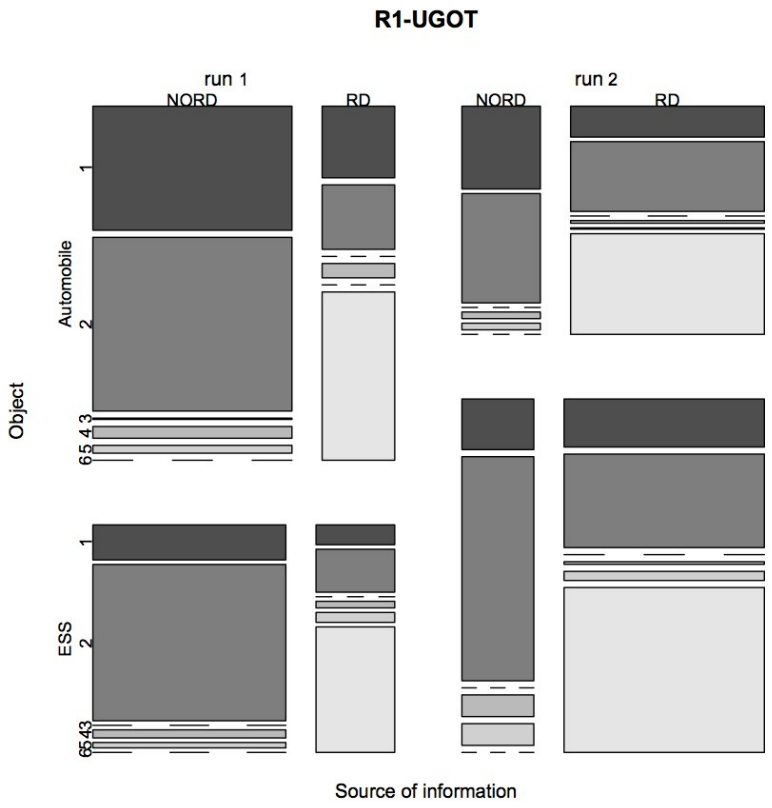
- Pre-experiment questionnaire
- Comprehension test
- Post-experiment questionnaire

Results (hypothesis testing)

Experiment	Dependent Variable	#obs for RD	#obs for NORD	p-value	Statistical Power	β-value
E-UBAS	Comprehension	24	24	YES (< 0.001)	0.949	0.051
	Completion time	24	24	NO (0.556)	0.068	0.932
R1-UGOT	Comprehension	63	63	YES (< 0.001)	0.881	0.119
	Completion time	59	56	NO (0.805)	0.064	0.936

- The effect on comprehension is significant
  - Size of the effect: 24% and 32% improvement in comprehension

Results (information source)



- What is the main source of information used to answer the question?
  - 1. Previous Knowledge
  - 2. Requirements List
  - 3. Internet
  - 4. Use Cases
  - 5. Use Case Diagram
  - 6. Requirement Diagrams

- Requirements diagrams seem to be useful (and used)

Conclusions

- Summary
  - Using requirements diagrams increases comprehension and does not affect speed
- Practical implications
  - Lower number of defects
  - Higher design costs (additional effort to create requirements)
  - Modelled requirements are more expressive