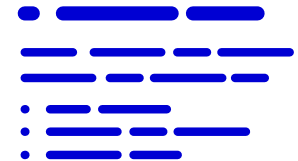
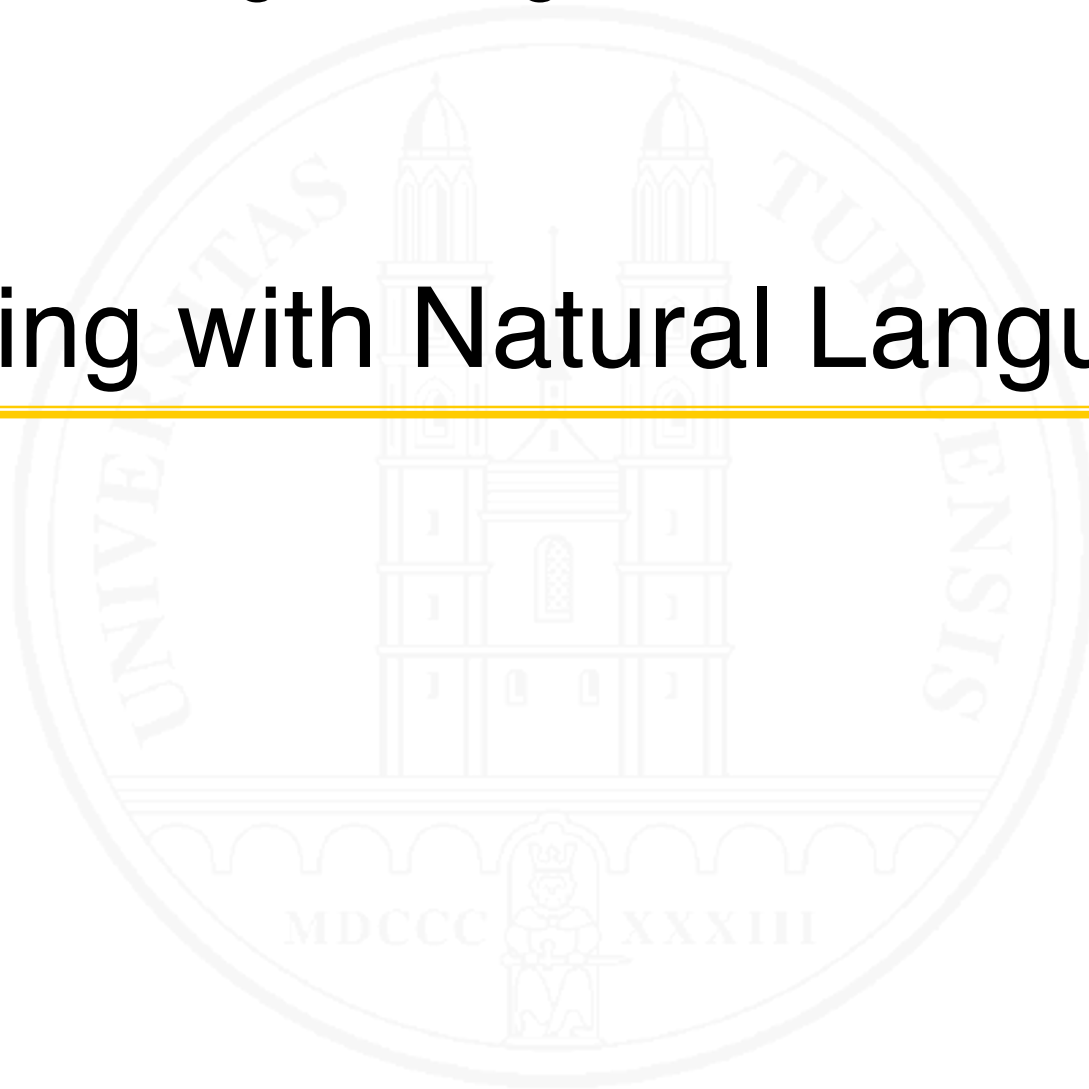


# Requirements Engineering I

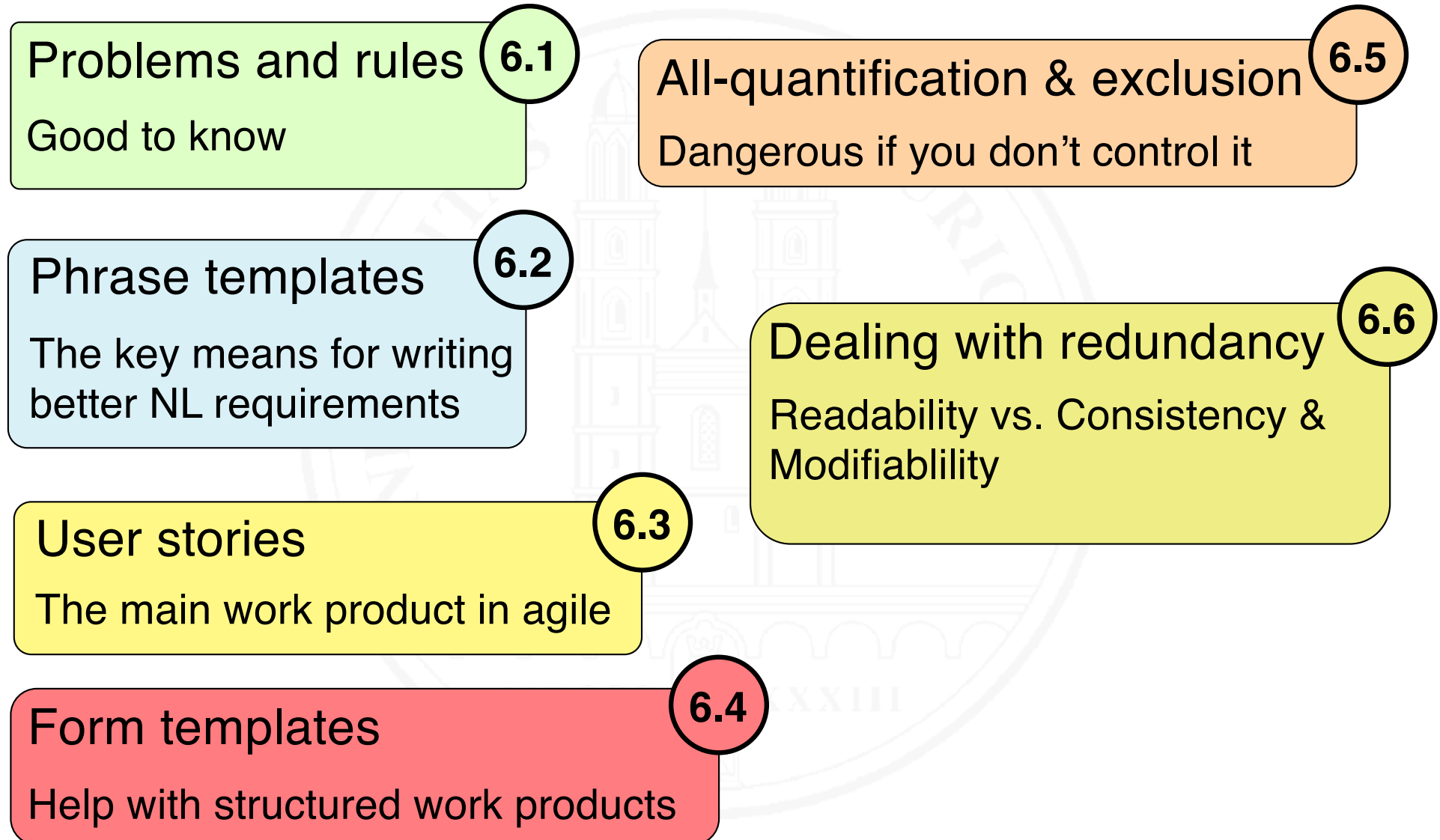
## Chapter 6

# Specifying with Natural Language

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# Chapter roadmap



# Natural language for expressing requirements

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The system shall ...

The oldest...

...and most widely used way

- taught at school
- extremely expressive

But not necessarily the best

- Ambiguous
- Imprecise
- Error-prone
- Verification primarily by careful reading



Michelangelo's Moses (San Pietro in Vincoli, Rome)  
Moses holds the Ten Commandments in his hand:  
written in natural language

## 6.1 NL requirements: problems and rules

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Read the subsequent requirements. Any findings?

“For every turnstile, the total number of turns shall be read and archived once per day.”

“The system shall produce lift usage statistics.”

“Never shall an unauthorized skier pass a turnstile.”

“By using RFID technology, ticket validation shall become faster.”

“In the sales transaction, the system shall record the buyer’s data and timestamp the sold access card.”

# Some rules for specifying in natural language

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[Rupp et al. 2020]  
[Goetz&Rupp 2003]

- Use **active voice** and defined subjects
- Build phrases with **complete** verbal structure
- Use terms as defined in the **glossary**
- Define precise meanings for **auxiliary verbs** (shall, should, must, may,...) as well as for process verbs (for example, “produce”, “generate”, “create”)
- Check for nouns with **unspecific semantics** (“the data”, “the customer”, “the display”,...) and replace where appropriate
- When using adjectives in comparative form, specify a **reference point**: “better” → “better than”

# More rules

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- Scrutinize **all-quantifications**: “every”, “always”, “never”, etc. seldom hold without any exceptions
- Scrutinize **nominalizations** (“authentication”, “termination”...): they may conceal incomplete process specifications
- State **every requirement** in a **main clause**. Use subordinate clauses only for making the requirement more precise
- Attach a **unique identifier** to every requirement
- **Structure** natural language requirements by ordering them in **sections** and **sub-sections**
- Avoid **redundancy** where possible

## 6.2 Phrase templates

[Mavin et al. 2009]  
[Rupp et al. 2020]  
[ISO/IEC/IEEE 2018]

Use **templates** for creating **well-formed** natural language requirements

Typical template:

[<Condition>] <Subject> <Action> <Objects> [<Restriction>]

Example:

When a valid card is sensed, the system shall send  
the command 'unlock\_for\_a\_single\_turn' to the turnstile  
within 100 ms.

EARS (Easy Approach to Requirements Syntax) provides a set of templates:

- **Ubiquitous** requirements (no restrictions)  
“The control system shall prevent engine overspeed.”
- **Event-driven** requirements (WHEN)  
“When continuous ignition is commanded by the aircraft, the control system shall switch on continuous ignition.”
- **Unwanted** behavior (IF-THEN)  
“If the computed airspeed fault flag is set, then the control system shall use modeled airspeed.”



# EARS – 2

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- **State-driven** requirements (WHILE)  
“While the aircraft is in-flight, the control system shall maintain engine fuel flow above XX kg/s.”
- **Optional** features (WHERE)  
“Where the control system includes an overspeed protection function, the control system shall test the availability of the overspeed protection function prior to aircraft dispatch.”
- Complex requirements are expressed by **combining keywords**:  
“While the aircraft is on-ground, when reverse thrust is commanded, the control system shall enable deployment of the thrust reverser”.

## 6.3 User stories

[Cohn 2004]

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- A **single sentence** about a requirement
- Written from a **stakeholder's perspective**
- Optionally including the **expected benefit**
- Accompanied by **acceptance criteria** for requirement
- Acceptance criteria make the story more precise

Standard **template**:

As a **<role>** I want to **<my requirement>** so that **<benefit>**

# A sample user story

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As a skier, I want to pass the chairlift gate so that I get access without presenting, scanning or inserting a ticket at the gate.

Author: Dan Downhill

Date: 2013-09-20

ID: S-18

# Sample acceptance criteria

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## Acceptance criteria:

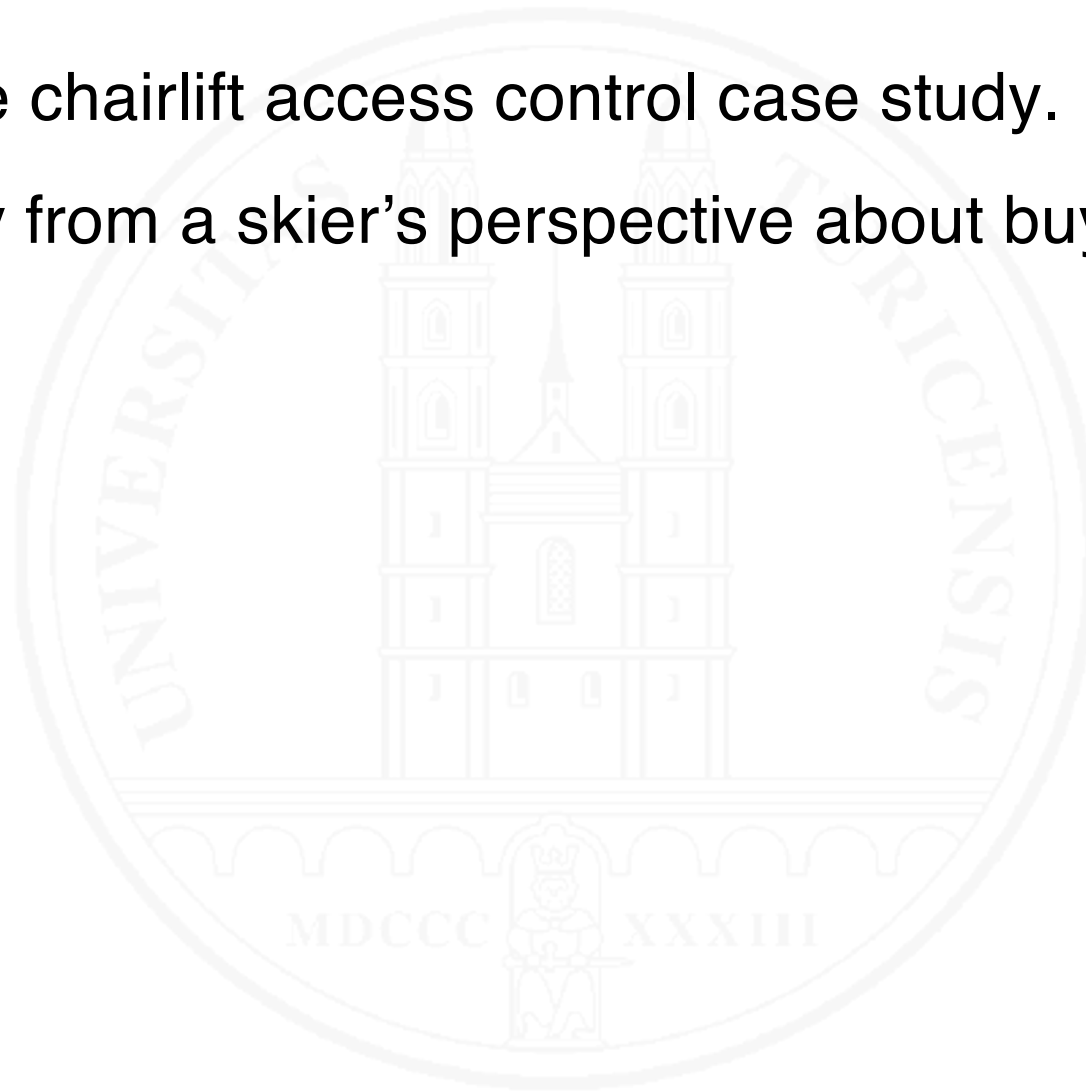
- Recognizes cards worn anywhere in a pocket on the left side of the body in the range of 50 cm to 150 cm above ground
- If card is valid: unlocks turnstile and flashes a green light for five seconds or until the turnstile is moved
- If card is invalid: doesn't unlock gate and flashes a red light for five seconds
- Time from card entering the sensor range until unlock and flash red or green is less than 1.5 s (avg) & 3 s (max)
- The same card is not accepted twice within an interval of 200 s

# Mini-Exercise: Writing a user story

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Consider the chairlift access control case study.

Write a story from a skier's perspective about buying a day card.



## 6.4 Form templates

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- Provide a **form** with predefined **fields** to be **filled in**.
- Examples:
  - Use case templates (see Chapter 7)
  - Quality requirements template

A form template for specifying measurable quality requirements [Glinz et al. 2024]

Template		Example
<b>ID</b>	<Number of requirement>	R137.2
<b>Goal</b>	<Qualitatively stated goal>	Confirm room reservations immediately
<b>Scale</b>	<Scale for measuring the requirement>	Elapsed time in seconds (ratio scale)
<b>Meter</b>	<Procedure for measuring the requirement>	Timestamping the moments when the user hits the “Reserve” button and when the app has displayed the confirmation. Measuring the time difference.
<b>Minimum</b>	<Minimum acceptable quality to be achieved>	Less than 5 s in at least 95% of all cases
<b>OK range</b>	<Value range that is OK and is aimed at>	Between 0.5 and 3 s in more than 98% of all cases
<b>Desired</b>	<Quality achieved in the best possible case>	Less than 0.5 s in 100% of all cases

## 6.5 All-quantification and exclusion

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- Specifications in natural language frequently use all-quantifying or excluding statements without much reflection:

“When operating the coffee vending machine, the user shall **always** be able to terminate the running transaction by pressing the cancel key.”

Also when the coffee is already being brewed or dispensed?

- ⇒ **Scrutinize all-quantifications** (“every”, “all”, “always”...) and **exclusions** (“never”, “nobody”, “either – or”,...) **for potential exceptions**
- ⇒ **Specify found exceptions** as requirements

## 6.6 Dealing with redundancy

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- Natural language is frequently (and deliberately) **redundant**
  - Secures **communication success** in case of some information loss
- In requirements specifications, redundancy is a **problem**
  - Requirements are specified **more than once**
  - In case of modifications, all redundant information must be **changed consistently**
- Make redundant statements only when needed **for abstraction purposes**
- Avoid **local redundancy**: “never ever” → “never”