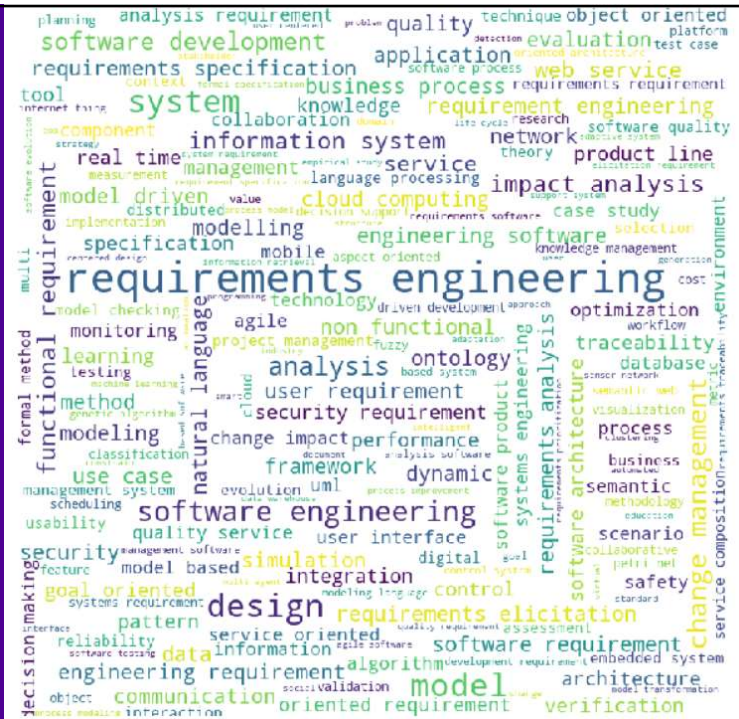# Requirements Engineering

Requirements and elements of value

Zheying Zhang
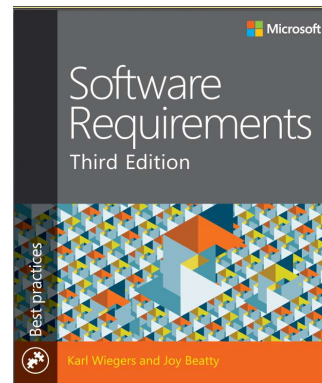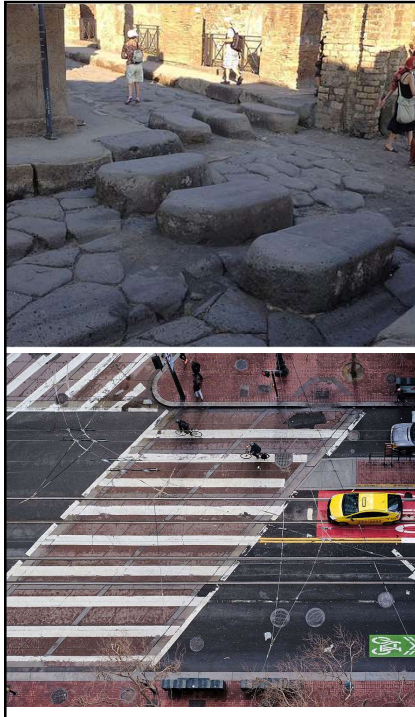

Outline

- **What are requirements?**
- Elements of value
- Requirements engineering

Textbook: (Wiegers and Beatty, 2013) Chapters 1-3

1

Example 1: Goals of traffic control

- Traffic control (goal: moving smoothly and safely)
  - Drivers stop at red lights
  - Drivers drive at green lights
  - Pedestrians and cars can not be in the intersection at the same time
- Smart traffic control (goal: efficient transportation)
  - The system shall adjust the traffic light timing according to real-time traffic conditions.
  - The system shall prioritize public transportation over private vehicles.
  - …

Tampereen yliopisto
Tampere University

Example 2 User story cards

http://www.agilemodeling.com/artifacts/userStory.htm

Front of Card

Copyright 2005-2009 Scott W. Ambler

As a student I want to purchase a parking pass so that I can drive to school.

As a <type of user>, I want <activity> so that <goal>.

Slide 5

Example 3 A use case specification for a Cafeteria ordering system
(Wiegers and Beatty, 2013 p. 581-582)

Tampereen yliopisto / Tampere University

ID and Name:	UC-1: Order a Meal		
Created By:	Prithvi Raj	Date Created:	October 4, 2013
Primary Actor:	Patron	Secondary Actors:	Cafeteria Inventory System
Description:	A Patron accesses the Cafeteria Ordering System from either the corporate intranet or external Internet, views the menu for a specific date, selects food items, and places an order for a meal to be picked up in the cafeteria or delivered to a specified location within a specified 15-minute time window.		
Trigger:	A Patron indicates that he wants to order a meal.		
Preconditions:	PRE-1. Patron is logged into COS. PRE-2. Patron is registered for meal payments by payroll deduction.		
Postconditions:	POST-1. Meal order is stored in COS with a status of "Accepted." POST-2. Inventory of available food items is updated to reflect items in this order. POST-3. Remaining delivery capacity for the requested time window is updated.		
Normal Flow:	**1.0 Order a Single Meal** 1. Patron asks to view menu for a specific date. (see 1.0.E1, 1.0.E2) 2. COS displays menu of available food items and the daily special. 3. Patron selects one or more food items from menu. (see 1.1) 4. Patron indicates that meal order is complete. (see 1.2) 5. COS displays ordered menu items, individual prices, and total price, including taxes and delivery charge. 6. Patron either confirms meal order (continue normal flow) or requests to modify meal order (return to step 2). 7. COS displays available delivery times for the delivery date. 8. Patron selects a delivery time and specifies the delivery location. 9. Patron specifies payment method.		

nd Communication Sciences, Tampere University

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Slide 6

E x a m p l e 4

INTERNATIONAL ORGANISATION FOR STANDARDISATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO/IEC JTC1/SC29/WG11
CODING OF MOVING PICTURES AND AUDIO

ISO/IEC JTC1/SC29/WG11 **N18127**
January 2019, Marrakech, MA

Source	Requirements
Status	Approved
Title	Requirements for MPEG-I Phase 2
Editor	Eric Yip, Rob Koenen

1 Introduction

This document contains the draft requirements for MPEG-I Phase 2.

"The specification" shall mean any specification which may be targeted for MPEG-I Phase 2, as well as any supporting standards that may require updating, such as those specifying certain types of metadata.

2 Definitions

This Section contains definitions for terms that are not defined in specifications related to MPEG-I Phase 1 and 1b.

Media Types	Types of media (visual and audio) including at least: 2D video, spherical video, point clouds and various audio media data.
6DoF scene	A scene in which a user is able to move around freely with 6 degrees of freedom.
Viewpoint	The point from which the user observes (views and hears) the scene; it usually corresponds to a camera position. Slight head motion does not imply a different Viewpoint
Audio Object	Audio Signal and associated metadata as used in ISO/IEC 23008-3.
Audio Channel	Audio Signal and associated metadata as used in ISO/IEC 23008-3.
HOA	Audio Signal and associated metadata as used in ISO/IEC 23008-3.
Earcon	Audio Signal and associated metadata as used in ISO/IEC 23008-3:2019/AMD 1.
Audio Element	One or more audio signals and associated metadata. Audio Elements are audio objects, channels or HOA signals with associated MPEG-I 6DoF metadata and MPEG-H 3D Audio

3.3 Requirements on Audio Renderer

6. The specification shall support metadata describing the audio scene.
7. The specification shall support metadata for controlling and restricting the audio scene.
   Note: This may already be fulfilled by MPEG-H 3D Audio.
8. The specification shall support control (e.g., via metadata or interface) of the audio rendering parameters (e.g., consumption space, player capabilities, etc.).

9. The specification shall support random-access in time (e.g. every 0.5 seconds) and space (e.g. jump within a sub-scene or to a new sub-scene).
10. The specification shall support metadata for enabling transition effects on audio rendering during user jumps between two different listener positions in the audio scene (e.g., fade-out fade-in).
11. The specification shall support metadata for enabling audio zooming (e.g., adjustment of prominence, dialog enhancement, simulation of depth-of-field effect, etc.).
    Note: This may already be fulfilled by MPEG-H 3D Audio.
12. The specification shall support 3D spatial extent for audio objects, supported by metadata.
13. The specification shall support rendering of the radiation pattern of audio objects and channels, supported by metadata.
14. The specification shall support occlusion of audio elements, supported by metadata.
15. The specification shall support locally captured audio (e.g., user's own voice, side tone) in the audio scene.
16. The specification shall support accurate 3D spatial localization of audio objects (sound sources). Differences in location are with respect to what is perceivable.

3.4 Interfaces and extensions

17. The specification shall support input interfaces for changing the audio scene.
    Note: MPEG-H 3D Audio already provides interfaces enabling basic functionality that could be enhanced for MPEG-I Audio.

Available at: https://mpeg.chiariglione.org/standards/mpeg-i/omnidirectional-media-format/requirements-mpeg-i-phase-2

6

3

Example 5 a first-order logic specification in a train control system

∀ tr1, tr2

Following (tr2, tr1) → Dist (tr2, tr1) > WCS-Dist (tr2)

- The atomic predicate *Following (tr2, tr1)* is true if and only if the pair (tr2, tr1) is a member of the binary relation *Following* over trains, defined as the set of pairs of trains in which the 1st train in the pair directly follows the 2nd
- Function *Dist* returns the exact distance between two given trains
- Function WCS-Dist returns the worst-case distance needed for the train to stop in an emergency

- Let's rephrase the expression: The distance between two successive trains should be kept sufficient to avoid collisions if the 1st train stops suddenly.
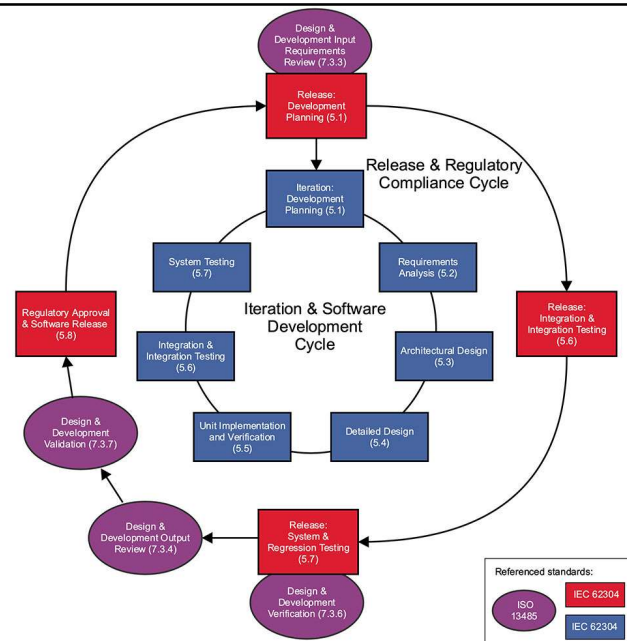

Example 6
Medical software development model

IEC 62304: medical device software – software life cycle processes

ISO 13485: Medical devices — Quality management systems — Requirements for regulatory purposes

Source: Juha Vedenpää (2020) Is it possible to develop medical software with agile methods – is RegOps the next step? Available at: https://www.solita.fi/en/blogs/is-it-possible-to-develop-software-with-agile-methods/

- Requirements are expresses on the different abstraction levels, from goals to services, features, functions,….

- Rules and conventions are a kind of requirements. There are also regulartory requirements for the software development process.

- There are different ways of presenting requirements, e.g. pictures, text, form, index card, maths, etc.

- There are different kinds of information associated with requirements, e.g. priority, estimation of effort

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Requirements

Requirements are *specifications* of the *services* that the system should provide, the *constraints* on the system and the *background information* that is necessary to developing the system (Zave 1997)

Zave, P. Classification of Research Efforts in Requirements Engineering, ACM Computing Surveys, 29(4), 1997

Outline

- What are requirements?
- **Elements of value**
  - The amount and nature of value in a particular product or service always lie in the eye of the beholder
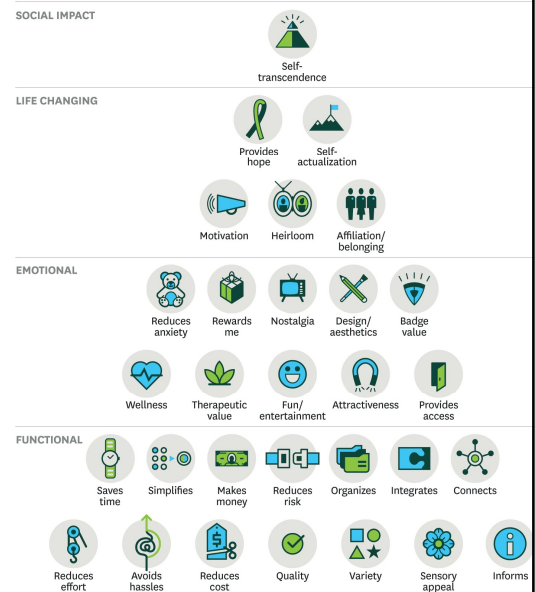- Requirements engineering

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The Elements of Value

- The amount and nature of value in a particular product or service always lie in the eye of the beholder
- 4 kinds of needs in the elements of value pyramid, i.e. functional, emotional, life changing, and social impact
  - The model ranges from the physiological and safety needs to self-actualization and self-transcendence
  - people cannot attain the needs at the top until they have met the ones below

E. Almquist, J. Senior, and N. Bloch (2016) The Elements of Value. Harvard Business Review. Sept. 2016

The Elements of Value Pyramid

Products and services deliver fundamental elements of value that address four kinds of needs: functional, emotional, life changing, and social impact. In general, the more elements provided, the greater customers' loyalty and the higher the company's sustained revenue growth.

SOCIAL IMPACT
- Self-transcendence

LIFE CHANGING
- Provides hope
- Self-actualization
- Motivation
- Heirloom
- Affiliation/belonging

EMOTIONAL
- Reduces anxiety
- Rewards me
- Nostalgia
- Design/aesthetics
- Badge value
- Wellness
- Therapeutic value
- Fun/entertainment
- Attractiveness
- Provides access

FUNCTIONAL
- Saves time
- Simplifies
- Makes money
- Reduces risk
- Organizes
- Integrates
- Connects
- Reduces effort
- Avoids hassles
- Reduces cost
- Quality
- Variety
- Sensory appeal
- Informs

SOURCE © 2015 BAIN & COMPANY INC.
FROM "THE ELEMENTS OF VALUE," SEPTEMBER 2016
© HBR.ORG

Functional

FUNCTIONAL — Saves time, Simplifies, Makes money, Reduces risk, Organizes, Integrates, Connects, Reduces effort, Avoids hassles, Reduces cost, Quality, Variety, Sensory appeal, Informs
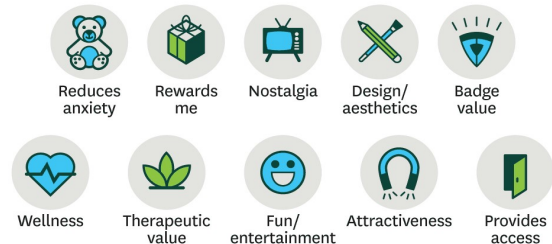
- **Functional elements** are based on a *product attribute that provides the customer with functional utility.*

- *E.g.* Sisu
  - Study plan, signup for courses, study calendar, completed studies - integrates, informs, variety …
- Nysse Mobile – app for public transport in Tampere
  - Buy one-time, day or season tickets – saves time, simplify, reduce effort
  - Travel guide – informs, reduces effort, avoids hassles, variety

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Emotional

Reduces anxiety, Rewards me, Nostalgia, Design/aesthetics, Badge value, Wellness, Therapeutic value, Fun/entertainment, Attractiveness, Provides access

- **Emotional elements** provide customers with *a positive feeling when they purchase or use a particular product.* They add richness and depth to the experience of owning and using the product.

- E.g.
  - Facebook: "on this day" - nostalg
  - Snapchat: lenses, filters, bitmoji – fun/entertainment, attractiveness
  - Nysse mobile
    - buy tickets before getting up the bus – reduces anxiety
    - Timetables, routes – provides access

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Life changing

Provides hope
Self-actualization
Motivation
Heirloom
Affiliation/belonging

- **Life changing elements** provide an opportunity for *someone to communicate his or her self-image.*
- Inwardly focused, focusing on the act of using the product, primarily addressing consumers' personal needs, such as providing hope, self-actualization, affiliation and belonging or motivation
- E.g.
  - Spotify – find music playlists: for runners that detects their tempo and finds music to match it - motivation
  - Home workout – record training progress & customize workout reminder: personalized training plans to provide hopes, self-actualization

---

Social impact

Self-transcendence

- Social impact elements convey the sense of doing good for others
- Helping other people or society more broadly
- E.g.
  - Nysse: the public transport - reduce carbon emissions, protect environment
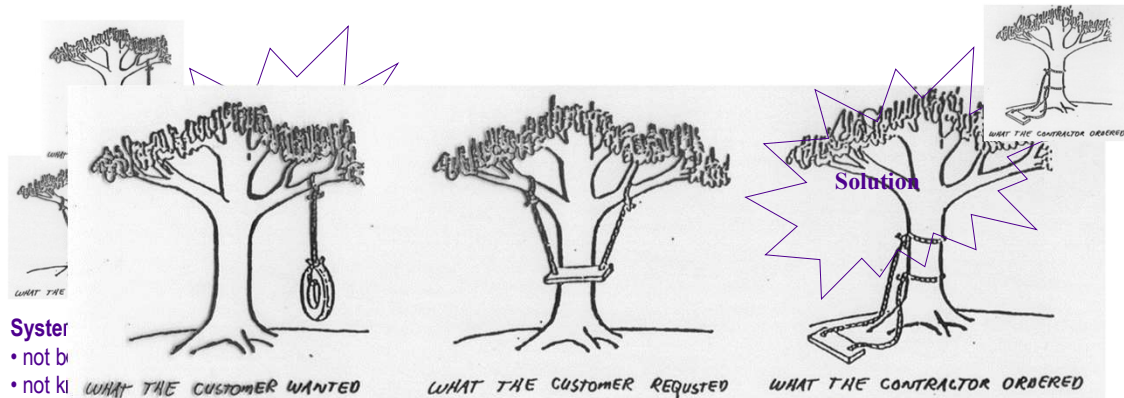
Patterns of value

- Some elements do matter more than others
  - Products and services must attain a certain minimum level - *quality*
  - the critical elements depend on the industry domain
    - food and beverages -> *sensory appeal (*appealing in taste and smell*)*
    - Netflix -> *variety,*

- Putting the elements to work
  - Understand the elements critical to business
  - Implement critical elements before attempting to add new ones
  - Refine product designs to deliver more elements, e.g. save time, reduce cost
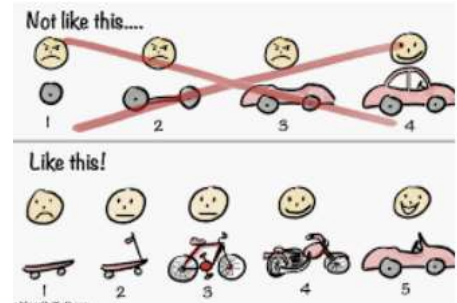
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Outline

- What are requirements?
- Elements of value
- **Requirements engineering**

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Gap between users and developers

WHAT THE CUSTOMER WANTED

WHAT THE CUSTOMER REQUESTED

WHAT THE CONTRACTOR ORDERED

Solution

feasible, *necessary* and *sufficient*

System
• not be
• not kr
• change their minds once they see the possibilities more clearly, and
• often not appreciate the complexity inherent in software engineering, and the impact of changed requirements
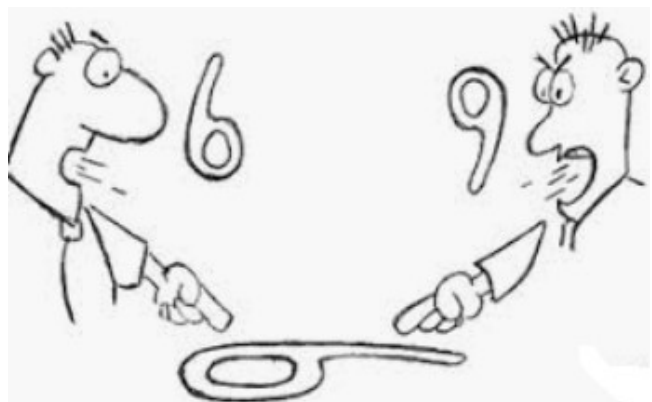
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Requirements engineering (RE)

• RE is a systematic process of developing requirements through an iterative cooperative process of analyzing the problem, documenting the resulting observations in a variety of representation formats, and checking the accuracy of the understanding gained. (Pohl, 1994)
  • A social process
  • A variety of representation formats
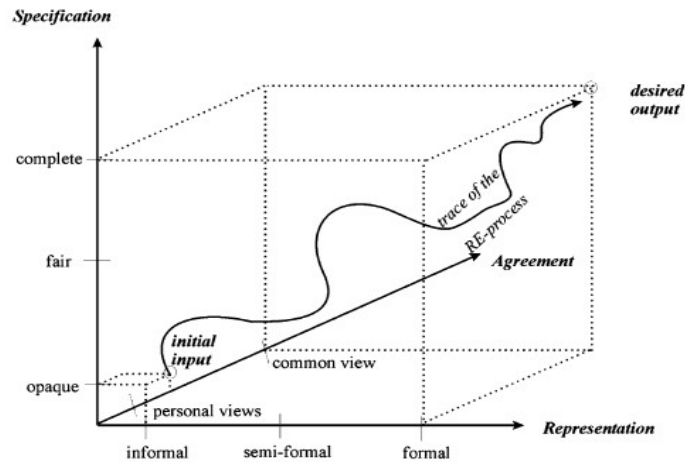 • Understanding and validating the requirements

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Slide 21

The three dimensions of RE

(Pohl 1994)

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Slide 22

Main goals sketched from the three-dimension framework

The *specification* dimension deals with the degree of requirements understanding at a given time.	• Develop a complete system specification out of an opaque system understanding
The *representation* dimension copes with the degree of formality of knowledge expression: informal (user-oriented) -> formal (system oriented)	• Provide integrated representations and support the transformation between them
The *agreement* dimension deals with the degree of agreement reached on a specification	• Accomplish a common agreement on the final specification allowing personal views

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Readings

M. Jackson (1997) The meaning of requirements, Annals of Software Engineering, v3, 1997.

K. Pohl. The three dimensions of requirements engineering: a framework and its applications , Information Systems, 19(3), p.243-258, April 1994.

E. Almquist, J. Senior, and N. Bloch (2016) The Elements of Value. Harvard Business Review. Sept. 2016

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Reminder ☺

- A1: element of value, answering by 19/9 and reviewing by 20/9
- Teaming up for a selected topic in Moodle
- Course cancellation in SISU, by Sept. 18

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