The use of a requirements modeling language for industrial applications

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Outline of the talk

- Introduction to Corporate Technology
- Four stories of *industrial experience* in requirements engineering or why we need the Unified Requirements Modeling Language (URML)
- Overview of the URML
- *Early feedback* regarding use of the URML on **REAL** projects
- A demonstration (Time Permitting)
- Questions & answers
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Siemens is organized in 4 Sectors: "Industry", "Energy", "Healthcare" and "Infrastructure & Cities"

Siemens: Facts and Figures

<table>
<thead>
<tr>
<th>Siemens Sectors</th>
<th>Key figures FY 2011</th>
</tr>
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<tbody>
<tr>
<td><strong>Industry</strong></td>
<td>• Sales: ~€ 74 bn</td>
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<tr>
<td>Divisions:</td>
<td>• Locations: in 190 countries</td>
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<tr>
<td>• Industry Automation</td>
<td>• Employees: ~402,000</td>
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<tr>
<td>• Drive Technologies</td>
<td>• R&amp;D expenses: ~€ 4 bn</td>
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<tr>
<td>• Customer Services</td>
<td>• R&amp;D engineers: ~28,600</td>
</tr>
<tr>
<td>~€ 20 bn 1)</td>
<td>• Inventions: ~8,600</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>• Active patents: ~53,300</td>
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<tr>
<td>Divisions:</td>
<td></td>
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<tr>
<td>• Fossil Power Generation</td>
<td></td>
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<tr>
<td>• Wind Power</td>
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<tr>
<td>• Solar &amp; Hydro</td>
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<td>• Oil &amp; Gas</td>
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<td>• Energy Service</td>
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<tr>
<td>• Power Transmission</td>
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<tr>
<td>~€ 25 bn 1)</td>
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<td><strong>Healthcare</strong></td>
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<td>Divisions:</td>
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<tr>
<td>• Imaging &amp; Therapy Systems</td>
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<td>• Clinical Products</td>
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<tr>
<td>• Diagnostics</td>
<td></td>
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<tr>
<td>• Customer Solutions</td>
<td></td>
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<tr>
<td>~€ 12 bn 1)</td>
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<tr>
<td><strong>Infrastructure &amp; Cities</strong></td>
<td></td>
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<tr>
<td>Divisions:</td>
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<tr>
<td>• Rail Systems</td>
<td></td>
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<tr>
<td>• Mobility &amp; Logistics</td>
<td></td>
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<tr>
<td>• Low and Medium Voltage</td>
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<tr>
<td>• Smart Grid</td>
<td></td>
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<tr>
<td>• Building Technologies</td>
<td></td>
</tr>
<tr>
<td>• Osram 2)</td>
<td></td>
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<tr>
<td>~€ 17 bn 1)</td>
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</table>

1) Sales in FY 2011 estimated for the new organizational setup with 4 Sectors
2) Not included in sales figure; Siemens announced its intention to publicly list Osram

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Corporate Technology has 3 missions

We develop Siemens' technology and innovation strategy on corporate level. We ensure seamless technology and innovation processes between Corporate and Business Unit levels.

We deliver services for the businesses as a strategic partner and integral part of their value chain.

We regularly develop high-impact technologies and innovations for Siemens with a clear focus on results. The business responsibility for implementing innovations lies with the Business Units.

We actively manage our technology and innovation portfolio. We systematically leverage external competence networks to provide the best know-how for Siemens.

The source of our excellence are our people. We attract and develop creative talents for Siemens. We foster talent exchange with the Business Units.

We foster a culture of innovativeness and high performance and our visibility to all internal and external stakeholders.

We take a focused approach (e.g., in regional setup, technology focus) to achieve high performance.

We primarily serve internal Siemens customers with a global mindset and setup.

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Corporate Technology: Mission, roles and basic principles

3 missions
- Secure the company’s technology & innovation base
- Secure the company’s technology & innovation future
- Support Siemens as an integrated technology company

6 roles
- Business creation
- Technology integration
- Applied research
- Corp. standards & guidance
- Technology & innovation mgmt.
- Services (production, R&D, IP)

Corporate Technology: Mission, roles and basic principles

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CT Research and Technology Center: ~1,650 experts in 13 technology fields

CT Research and Technology Center (RTC)

- Materials development & processing
- Analytics
  - HQ: Munich
  - RGs: 8
- Electronic design & manufacturing processes
  - Assembly & test
  - HQ: Munich
  - RGs: 8
- Sensor devices & system integration
  - Inspection & test
  - HQ: Erlangen
  - RGs: 9
- Power electronics & management
  - Mechatronic systems
  - Mechanical assembly
  - HQ: Erlangen
  - RGs: 9
- Energy conversion & storage
  - Environmental technologies
  - Oil & gas
  - HQ: Erlangen
  - RGs: 9

- Software Architecture Development
  - HQ: Munich
  - RGs: 7
- IT platforms
  - SW / System integration
  - Middleware, cloud
  - Enterprise IT
  - HQ: Munich
  - RGs: 10
- IT security
  - Security architecture & lifecycle
  - CERT services
  - Access control
  - HQ: Munich
  - RGs: 8
- Business Analytics and Monitoring
  - Decision support
  - Knowledge discovery
  - Condition monitoring
  - HQ: Munich
  - RGs: 8
- Automation and Control
  - Control systems
  - Engineering
  - Simulation & Optimization
  - HQ: Princeton, US
  - RGs: 10
- Networks & Communication
  - Wireless & industrial networks
  - Internet of things
  - HQ: Munich
  - RGs: 6
- Systems Engineering
  - User Interface Design
  - PLM process support
  - Systems Engineering
  - HQ: Munich
  - RGs: 11

- Imaging & Visualization
  - Computer vision
  - Image processing & analytics
  - HQ: Princeton, US
  - RGs: 12
- Materials
  - Materials development & processing
  - Analytics
  - HQ: Berlin
  - RGs: 8
- Electronics
  - Electronic design & manufacturing processes
  - Assembly & test
  - HQ: Munich
  - RGs: 8
- Sensor Technology
  - Sensor devices & system integration
  - Inspection & test
  - HQ: Erlangen
  - RGs: 9
- Power and Actuators
  - Power electronics & management
  - Mechatronic systems
  - Mechanical assembly
  - HQ: Erlangen
  - RGs: 9
- Energy Conversion
  - Energy conversion & storage
  - Environmental technologies
  - Oil & gas
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- Overview of the URML
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- A demonstration (Time Permitting)
- Questions & answers
1. Oh, you have a *PRODUCT LINE*!
2. Why is this feature in the product? What are we really trying to accomplish??? And where are the requirements?
3. Hazard analysis (and threat modeling) early on
4. “I can’t tell the processes from the use cases”
What they got in a modeling session

XXX Product Line

<<include>>

<<include>>

<<include>>

Persist Time Series Data

Bidirectional XML Connector

Trend Predicted Data

XXX Embedded

XXX Enterprise

XXX Workgroup

Solutions

UC Details

Product

Features

Data Manipulation

Data Computations

Data Conditioning

Condition Checking
Analysis of Story 1

Customer Company

expresses

The customer wants to know whether he can profit from commonalities in existing products

result in

The system shall support feature modeling

The system shall support the modeling of product lines
What they needed

Products

Features

XXX Solutions
XXX Workgroup
XXX Enterprise
XXX Embedded

Data Manipulation
Data Computations
Condition Checking
Data Conditioning
Story two – stakeholder goals

What they had from the transcript of a meeting

Joe:
We need high market share
We need lower lifecycle costs than today

Mary:
We really need a competitive feature set
And it has to cost less than $150K per unit
And we need a reduction in complexity

John:
Yes, but we need packaged options and high reliability

Tom
Maybe we want a reduction in complexity compared to the current unit

Marketing Manager:
These are all great ideas. let’s go with them.

Engineering: Huh???
Analysis of Story 2

The customer wants to know how many of his goals can be addressed.

The system shall support goal modeling.

The customer wants to know which parts of the new product address which goals.

The system shall allow mapping goals to features.

The customer wants to talk about features of the new product.

The system shall support feature modeling.
What they needed!

Visualization of Goal Conflicts

Goal to feature realization
Analysis of Story 2 Where are the requirements?

Engineer

The system shall support modeling functional requirements

The engineer wants to distinguish between functional and quality requirements

results in

Engineers

The system shall support the modeling of quality requirements

results in

Analyst

The analyst wants to talk to customers and engineers and have a mapping between their mental models

results in

The system shall allow mapping of features to functional- and quality requirements

results in

Engineering Company
What the designers wanted to see

The stand shall move slowly and continuously to avoid discomfort to the patient.

Panning the table shall be supported

The stand base shall support swiveling.

It shall be possible to perform a height adjustment of the table

It shall be possible to repair the table without disassembling it

It shall be possible to rotate the table

Quality Requirement

Functional Requirement
Phlebotomy - ORDER OF DRAW
Blood collection tubes must be drawn in a specific order to avoid cross-contamination of additives between tubes. The recommended order of draw for plastic vacutainer tubes is:

First - blood culture bottle or tube (yellow or yellow-black top)

Second - coagulation tube (light blue top). If just a routine coagulation assay is the only test ordered, then a single light blue top tube may be drawn. If there is a concern regarding contamination by tissue fluids or thromboplastins, then one may draw a non-additive tube first, and then the light blue top tube.

Third - non-additive tube (red top)

Last draw - additive tubes in this order:

SST (red-gray or gold top). Contains a gel separator and clot activator.

Sodium heparin (dark green top)

PST (light green top). Contains lithium heparin anticoagulant and a gel separator.

EDTA (lavender top)

ACDA or ACDB (pale yellow top). Contains acid citrate dextrose.

Oxalate/fluoride (light gray top)

NOTE: Tubes with additives must be thoroughly mixed. Erroneous test results may be obtained when the blood is not thoroughly mixed with the additive.
Analysis of Story 3

The domain experts of the customer company know best about potential hazards or threats.

Customer Company

The customer wants to do early hazards analysis during requirements elicitation.

The system shall support danger modeling.

The customer wants to see which functions of the new product are affected by dangers.

The system shall support mapping use cases to dangers.

The customer wants to talk about functions of the new product.

The system shall support use case modeling.
What the designers wanted to see

**Processes**

- Manual Identification and Order Entry
- Put sample in carrier and enter into system
- Monitor instrument for processing errors, inventory needs, and sample exceptions
- Put STAT sample into STAT testing area
- Instrument or sample troubleshooting
- Handle exceptions unrelated to instrument malfunction

**Hazards**

- Instrument malfunction in delivery of sample
- Instrument malfunction in delivery of reagents
- Instrument malfunction in sample carryover
- Instrument malfunction in reagent carryover
- Sample crosscontamination
- Reagent crosscontamination
- Reagent calibration
- Reagent stability

**Mitigating Requirements**

- Equivalency of assay results across platforms
- Constrains
- Requires

**Mitigating Procedures**

- STAT test menu
- «include»
- «extend»
- Most commonly ordered tests in one system
- «extend»

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Use Case vs. Process

**Autocaser to DU Transportation**

- **Move Containerized Mail To Loading Dock**
  - Shall move containers
  - Containerization to dock area
  - Truck Loading
    - Method to load trucks with containers
  - Truck goes to DU
    - Transportation Plan
      - Shall provide a transportation plan
  - Staging area
    - Shall buffer containerized mail
  - Area to unload trucks
    - Clerk
      - Provide an area to unload
  - Unload Truck at DU
    - Plant Supervisor
      - Shall provide a transportation plan
- **Move Containerized Mail Into Truck**
  - Mail Handler
    - Shall move containers
    - Shall buffer containerized mail
    - Staging area
  - Unload Truck at DU
    - Plant Supervisor
      - Shall provide a transportation plan
Use Case vs. Process

Activity Details

UC Details

Receive Letters in Trays

Cull Manual Mail

Receive Flats in Bundles

Receive Flats in Trays

Place Letters in Cartridges

Place Flats in Cartridges

<<include>>

<<include>>

<<include>>

<<include>>

<<include>>

<<include>>

Huh?
The customer wants to talk about existing business processes.

The customer wants to talk about functions of the new product.

The analyst wants to distinguish between business processes and use cases.

The system shall support the modeling of business processes.

The system shall support use case modeling.

Use different notation for use case and business process.
Maybe this?
Why not address all these requirements in one graphical language?
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Unified Requirements Modeling Language (URML)

✓ Abstract Syntax
✓ Incorporation of concepts
✓ Well-formedness rules (in progress)
✓ Concrete Syntax
✓ Icon-based
✓ Semantics
✓ Informal (as in the UML).
Abstract Syntax Meta-Model
Abstract Syntax Meta-Model
Abstract Syntax Meta-Model

- **Mitigation**
  - "protects..from..with"
  - "refines"
  - "res"

- **Procedural Mitigation**
  - 1

- **Requirement Mitigation**
  - 1

- **Stakeholder**
  - atomic : Boolean
  - preCondition : String
  - postCondition : ...

- **Goal**
  - weight: int
Abstract Syntax Meta-Model
Simplified Abstract Syntax Meta-Model

- «class» Process
  - Enablement
  - Detail
  - Trigger
  - Vulnerability
  - Mitigate
- «class» Feature
  - Detail
  - Realize
- «class» Goal
  - Expression
- «class» Danger
- «class» Requirement

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Focus of the URML

The Unified Requirements Modeling Language permits a unified, holistic view of systems
Variants of Hazard + Quality Requirement Icons

The visual notation has two kinds of overlays:
1) A type-specific overlay (e.g. Efficiency Quality Requirement)
2) Attribute-specific overlay (e.g. Requirement that is a regulatory requirement)
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Evaluation Results

✓ Positive Feedback
  – Goals, features, and requirements in the same tool
    • Design tradeoffs
  – Product Lines, Features, and requirements in the same tool
    • Product map with requirements traceability
  – Processes and dangers in the same tool
    • Process-related danger

✓ Issues
  – Bugs in meta-model in general (fixed now)
  – Clear guidelines missing for an interface between the URML and design-oriented languages (UML, SysML)
  – Implementation UML Profile-based (with deficiencies of the UML)

“For the first time I can see where there are so many issues with this step of the process!” – a comment by a medical practitioner on seeing the hazards associated with the process step.
Solves the tracing problem

Tracing can be difficult with multiple tools
1. It Works
2. So why isn’t everyone using it?
Questions?