A new paradigm for early systems engineering

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Problem Statement 1

We need a better/faster/easier way of capturing information upstream of design including:

- Capturing Ideas (Innovation)
- Goals & Goal Conflict Resolution
- Feature, Product & Product Line Definition
- Hazard & Thread Identification & Mitigation
- Distinction between Use Cases and Business Processes
Problem Statement 2

We need intrinsic End-to-End Tracing
Problem Statement 3

We Need Semiotic Clarity

Principle of Semiotic Clarity: There should be a 1:1 correspondence between semantic constructs and graphical symbols*

The Unified Requirements Modeling Language (URML)

- Has an abstract syntax
- and a concrete syntax
- and semantics\(^1,2\)
- Partial Integration with UML/SysML

The Unified Requirements Modeling Language permits a unified, holistic, design-free view of systems.
Capture of System and Process Behaviour

Physician orders test for patient
Clerk/Nurse enters order into HIS
Laboratory receives test order in LIS
Phlebotomist draws blood sample

Sample preparation
Sample delivered to testing area
Sample accessioning
Sample receipt in lab

Use Cases

Different Symbols for Different Concepts!
Early Sketching of Product Lines and Variability

### Product Map

<table>
<thead>
<tr>
<th>Source: Chevrolet Malibu Cars</th>
<th>Target: Model</th>
</tr>
</thead>
</table>

#### Product Map

<table>
<thead>
<tr>
<th>Feature</th>
<th>LT</th>
<th>LT 1</th>
<th>LT 2</th>
<th>LT 3</th>
<th>LTZ</th>
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<tbody>
<tr>
<td>4 Wheel Independent Suspension</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>6 spd Automatic Transmission</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
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<tr>
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<tr>
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<tr>
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#### Features

- Steering Power Assist
- Ecotec Engine with Variable Timing
- 4 Wheel Independent Suspension
- Chrome Exhaust Tip
- Chrome Exhaust Tip
- 6 spd Automatic Transmission w/manual control
- Ecotec 4 Cyl Engine
- Ecotec 6 Cyl Engine
- Chrome
- requires

#### Composite Structure

- Malibu Drive Train
- 4 Wheel Independent Suspension
- Exhaust Tip
- 6 spd Automatic Transmission w/manual control
- Malibu Feature Set

#### Products

- LS
- LT
- 2LT
- 3LT
- LTZ
Early Capture of Hazards & Threats

- Mix hazards, threats & requirements
- Special symbols for mitigations
- Early identification of potential issues.

Hazard Analysis

- Equivalent of assay results across platforms
- Monitor instrument for processing errors, inventory needs, and sample exceptions
- Put STAT sample into STAT testing area
- Perform STAT sample
- Instrument or sample troubleshooting
- Handle exceptions unrelated to instrument malfunction
- Most commonly ordered tests in one system

Threat Modeling

- Property Asset
- Threat
- Financial Asset
- Identity Asset

The system shall encrypt customer information.
The building shall have a security fence.
The system shall not permit the transfer of funds without biometric identification.

Unique symbols for common hazard types.
Identification of Conflicts
Summary & Conclusions

- The URML is a work in progress
- It still needs construction heuristics
- An as-yet unexplored area is the relationship of URML concepts to SysML design concepts
- It has been tested on several internal Siemens projects with a few “gotchas”, but basically – It Works!
- This coming year, our research team is focusing on completing the meta-model, defining construction and relationship semantics, and Beta testing.
Questions?