IC1404 - Multi-Paradigm Modelling for Cyber-Physical Systems (MPM4CPS)

Training School: processes

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Blowout preventer failed
- $400 Million
- Environmental damage

Software error (Operating system configuration)
- Repaired

Copper vs aluminium wiring
Tool version problems
- $2 billion revenue loss

Interface failure: metric vs. imperial units
- $321 Million
Many Stakeholders

- Requirements Engineering
- Geometric Design
- Management
- Electronic Design
- Software Design
- Physical Design
Number of Components
Heterogeneity
Tackle by **Multi-Paradigm Modelling (MPM): explicit Modelling of all concerns/parts/... at the most appropriate level(s) of abstraction, using the most appropriate formalism(s)**

... but don’t forget **processes**!
Example Process

Physical View

Abstract View

Arrival

[Boarding]

Queue

Cashier

Departure

[Departure]

[Boarding]

Queue

Cashier

[Departure]
“The Software Engineering process is the total set of Software Engineering activities needed to transform requirements into software.”

Watts S. Humphrey. Software Engineering Institute, CMU. (portal.acm.org/citation.cfm?id=75122)
## Capability Maturity Model

### Processes!

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Characteristics</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ad Hoc</td>
<td>Almost no repeatable processes, Reactive management</td>
<td>Based on practitioner’s abilities</td>
<td>Risk</td>
</tr>
<tr>
<td>Repeatable</td>
<td>Processes are dependent on individuals</td>
<td>Independent learning, Process-focused</td>
<td></td>
</tr>
<tr>
<td>Defined</td>
<td>Standard processes are defined and institutionalized</td>
<td>Tools &amp; templates, Central repositories, Training &amp; job aids</td>
<td></td>
</tr>
<tr>
<td>Managed</td>
<td>Standard processes have metrics</td>
<td>Problem prevention, Process updates, Resource accountability</td>
<td></td>
</tr>
<tr>
<td>Optimized</td>
<td>Feedback loops are in place to update standards</td>
<td>Synergy, evaluation and organization management</td>
<td>Opportunity &amp; Quality</td>
</tr>
</tbody>
</table>

From: http://performanceexpress.org/
System Engineering Process

A logical **sequence of activities and decisions** that **transforms** an **operational need into a description** of system performance parameters and a preferred system configuration.

*MIL-STD-499A, Engineering Management, 1 May 1974*

An interdisciplinary, collaborative approach that derives, evolves, and verifies a life-cycle balanced system solution which satisfies customer expectations and meets public acceptability.

*IEEE P1220, Standard for Application and Management of the Systems Engineering Process, [Final Draft], 26 September 1994*
Processes!
Waterfall Process

Mechanical Engineering

In Reality?

With Prototyping
Iterative vs. Incremental Development

INCREMENTAL DEVELOPMENT

ITERATIVE DEVELOPMENT

1. Determine objectives
2. Identify and resolve risks
4. Plan the next iteration
3. Development and Test

(Rational) Unified Process
Types of Process Modelling

- Descriptive
- Prescriptive
- Proscriptive
Describing Processes

Functional:
- Functional dependencies
- Data-flow
- Produce – Consume
- ...
Languages!

- UML Activities
- Business Process Modelling Notation (BPMN)
- Event Process Chains
- Petri-nets
- Role Activity Diagram
- FTG+PM
- Etc.
UML Activities

- Receive Order
- Fill Order
- Send Invoice
- Overnight Delivery
- Regular Delivery
- Receive Payment
- Close Order
- Choose Menu Item
- Chosen Menu Items
- Confirm Order
FTG+PM: Typing
Power Window Example

Reactive!
Real-time!
Distributed!
Embedded!
Heterogeneous!
Process Modelling for MPM


Sadaf Mustafiz, Joachim Denil, Levi Lucio, and Hans Vangheluwe; "The FTG+PM Framework for Multi-Paradigm Modelling: An Automotive Case Study"; Accepted @ MPM2012 of Models2012, 2012
Safety Analysis
Safety Analysis Models
Hybrid Models and Trace
Deployment Process
Deployment
Deployment

SWC
CmdUp

SWC
CmdDown

SWC
CmdStop

SWC
ControlDrv

SWC
UpDrv

SWC
DownDrv

DrvDoor
MPC5567

BodyLogic
MPC5567

PsgDoor
MPC5567

Body
CAN
Analysis
Design-Space Exploration
Design-Space Exploration

Joachim Denil, Antonio Cicchetti, Matthias Biehl, Paul De Meulenaere, Romina Eramo and Serge Demeyer; Automatic Deployment Space Exploration Using Refinement Transformations; Accepted @ MPM Workshop of Models 2011
Formalism: Activity-Diagrams


Sadaf Mustafiz, Joachim Denil, Levi Lucio, and Hans Vangheluwe; "The FTG+PM Framework for Multi-Paradigm Modelling: An Automotive Case Study"; Accepted @ MPM2012 of Models2012, 2012
simulate to get performance metrics
reason about consistency and time-to-market!

- Generate alternative processes
- Add consistency management activities

István Dávid, Joachim Denil, Klaas Gadeyne, Hans Vangheluwe: Engineering Process Transformation to Manage (In)consistency. COMMitMDE@MoDELS 2016: 7-16
Follow the process: dashboard

Lúcio, Levi, et al. "Process-Aware Model-Driven Development Environments.", FlexMDE@MoDELS, 2018
Properties

P: Property

Process

Architectural decomposition

(*)

System integration

architecture: Design

Design