Industry Needs for Academic Systems Knowledge

by Gerrit Muller
Buskerud University College / Buskerud University College

e-mail: gaudisite@gmail.com
www.gaudisite.nl

Abstract
Many complex systems are multi-disciplinary. The multi-disciplinarity is further complicating the design of these systems. Academic knowledge tends to be developed within disciplinary fields. We will discuss what systems needs are present in industry to stimulate academia to research these multi-disciplinary system needs.

This work has been carried out as part of the Darwin project at Philips Healthcare under the responsibility of the Embedded Systems Institute. This project is partially supported by the Netherlands Ministry of Economic Affairs under the BSIK program.

March 6, 2013
status: preliminary
draft
version: 0.2
Industry Needs for Academic Systems Knowledge

Introduction

Problem Statement

Systems Engineering

Scoping SE Research

SE Research Approach

Need

Research Questions

Conclusion
from Boderc: Tension or Opportunity?

needs
constraints

opportunities
unconventional techniques

unfreeze

focus

time first delivery
cost
accuracy
power

Industry Needs for Academic Systems Knowledge

Problem Statement

- problem statement
- Systems Engineering
- need
- conclusion
- scoping SE research
- SE research approach
- research questions

Industry

academia

introduction
Problem Statement: Organization Size and Specialization

512 employees
many disciplines
distributed over multiple sites/countries

How will these 512 individual experts develop
a single consistent well-functioning system?
Examples of Complex Systems

MRI scanner

wafer stepper

Cardio Vascular Xray

volume printer
Industry Needs for Academic Systems Knowledge

Gerrit Muller
Systems Engineering: responsible for customer key drivers and key performance parameters of system.
Example of SE job

daily meeting at 4 o'clock (natural pressure to make progress)
on invitation:
  system engineers
  project leaders
  relevant experts
result oriented

overlay budget wafer flatness transport
  stage concept
synchronization system adjustments
  lens specification productivity model
integration plan sensor concept
Scoping SE Research

Industry Needs for Academic Systems Knowledge

version: 0.2
March 6, 2013
INASKlogoAcademia

10  Gerrit Muller
Exponential Pyramid, from requirement to bolts and nuts

- **Requirements**
  - Number of details: $10^0$
  - System requirements
  - Design decisions
  - Parts, connections, lines of code

- **System**
  - Multi-disciplinary

- **Research Focus**
  - Mono-disciplinary

Industry Needs for Academic Systems Knowledge
11  Gerrit Muller
From Mono-Disciplinary to System

Evolvability, system, robustness, cost, performance, reliability, multi-objective design methods.

Process organization, people, well defined, but soft, rather soft, legend.

Mechanical Engineering, Electrical Engineering, Software Engineering.

process issues, multi-disciplinary design, mono-disciplinary design, ESI focus.
Industry Needs for Academic Systems Knowledge

13 Gerrit Muller
Research Methods

- **Mono-disciplinary**
- **Multi-disciplinary**
- **System**

Field research:
- Make implicit methods explicit

Borrow & Adapt approach:
- Adapt existing mono-disciplinary method

Delta-approach:
- Extend existing body of knowledge with well founded increments
Systems Engineering is a Young Field

observational research
- best practices
- heuristics
- classification
- ontology

theory development
- metrics
- formalisms
- techniques
- models
- methods

experimental research
- theory evaluation
- theory evolution
- fundamentals
- principles
- methodologies

fundamental research
- optimizations
- rigorous proofs
- first principle based

Industry Needs for Academic Systems Knowledge

version: 0.2
March 6, 2013
PENGresearchTypes
Goal-Means Inversion

- Academic perspective
- Industrial perspective
- Organizational and operation context
- User needs and system requirements
- Design and realization
- Case
- Connect
- SE body of Knowledge
- Reflection
- Depth
- Breadth

Industry Needs for Academic Systems Knowledge

version: 0.2
March 6, 2013
SETP stakeholders view

Gerrit Muller
Counter Intuitive Spending of Time/Effort

SE body of Knowledge

organizational and operation context
user needs and system requirements
design and realization
case
connect

10%
reflection
academic achievement

20%
context
facilitation
lubrication

+ 70%
blood, sweat, and tears
Industry Needs for Academic Systems Knowledge

Gerrit Muller

version: 0.2
March 6, 2013
INASKlogolIndustry
Designers in the Field (Industry)

**How many views are used during design?**

- "one"-dimensional
  - e.g. one of
- few dimensional
  - e.g. three of
- many dimensional
  - e.g. ~10 of
- too many
  - e.g. >20
- chaotic
  - e.g. >50

<table>
<thead>
<tr>
<th>object oriented</th>
<th>functional</th>
<th>behavioral</th>
<th>vibrations</th>
<th>interfaces</th>
<th>physical</th>
<th>work break down</th>
<th>planning</th>
<th>time</th>
<th>space</th>
<th>flow</th>
<th>cost</th>
<th>maintenance</th>
<th>life cycle</th>
<th>installation</th>
<th>manufacturing</th>
<th>performance</th>
<th>reliability</th>
<th>safety</th>
<th>security</th>
<th>business</th>
<th>process</th>
<th>organization</th>
<th>people</th>
<th>power</th>
<th>energy</th>
<th>cooling</th>
<th>efficiency</th>
<th>operations</th>
<th>exceptions</th>
<th>disposal</th>
<th>sustainability</th>
</tr>
</thead>
</table>

- et cetera, et cetera

- majority of designers
- better designers
- experienced architects
- analysis paralysis

Industry Needs for Academic Systems Knowledge

version: 0.2
March 6, 2013
INASKengineeringApproaches
productivity, overlay, imaging = f(context, ~10 main functions)

functions, e.g. align, position, level, focus, expose, load, unload, climate condition, ... = g(15 subsystems)

subsystems, e.g. wafer stage, reticle stage, lens, illuminator, laser, ... = h(1k+ of subsubsystems)

subsubsystems = i(10k..100k+ of hardware and software components)

components = j(1M+ statements, connections, sizes, materials, ...)

context: other systems, environment, fab-infrastructure, operators, IC-products, wafers, reticles, process, ...
Research Questions

Industry Needs for Academic Systems Knowledge

version: 0.2
March 6, 2013
INASKlogoAcademia
Example Research Questions

What makes good systems architects successful?

How to design in many dimensional space?

How to cope with heterogeneous dimensions?

How to distribute work over many designers?

What design methods prevent integration surprises?

What models support the multi-disciplinary design?

et cetera

et cetera
Industry Needs for Academic Systems Knowledge

Gerrit Muller

version: 0.2
March 6, 2013
INASKlogo
Industry and Systems Research

| industry = | systems research requires: |
| field (to be observed) | open/perceptive attitude |
| laboratory (to experiment) | critical attitude |
| customer (to benefit) | large dynamic range |

isn't that the meaning of academic?