Abstract
There are different schools in Systems Engineering (SE), such as the conventional SE in the military and Aerospace domain, agile SE, and Lean Product Development. These different schools have very different approaches towards architecting. In this paper we try to combine the best of these different schools: Lean Architecting. The core idea is to document architecture knowledge in digestable chunks, where several views are visualized at once in a coherent way.
3 schools in Systems Engineering

case: MRI scanner

Engineering, Designing, Architecting

design handbook

Darwin project: A3 architecting

conclusion: Lean Architecting
3 (of many) Schools of Systems Engineering

"conventional"
Systems Engineering
control by
process and artifacts
defense and aerospace

"agile"
Systems Engineering
EVO, XP, SCRUM, ...
early and continuous feedback
IT

LEAN product development
avoid waste
automotive, Toyota

Lean Architecting, the Way of the Future?
Lean Architecting, the Way of the Future?
Lean Architecting, the Way of the Future?
Lean Architecting, the Way of the Future?
Differentiation or Complementing

3 fighting religions?

"conventional"
Systems Engineering

"agile"
Systems Engineering

LEAN product development

or 3 sets of complementary principles?

+ control
+ feedback
+ avoid waste
3 schools in Systems Engineering

**case: MRI scanner**

Engineering, Designing, Architecting

design handbook

Darwin project: A3 architecting

**conclusion: Lean Architecting**
Case: Magnetic Resonance Imaging (MRI)
MRI Basic Principles

- Determine region and contrast of interest
- Convert needs in sequence
- Generate static field $B_0$, $G_x$, $G_y$, $G_z$, $B_1$
- Receive RF
- Reconstruct images
- View images

- Magnet, e.g. 3T
- Hydrogen resonance
- Gradient coil, e.g. 10 mT/m
- Gradient field $G_x$, $G_y$, $G_z$
- To encode spatial information
- RF transmit coil, e.g. 15 kW, 180 MHz
- RF field $B_1$
- To excite spins
- RF receive coils
- Receive RF signal to get data
How much knowledge has been accumulated (implicitly)?
3 schools in Systems Engineering

case: MRI scanner

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Level of Abstraction Single System

- static system definition (monodisciplinary)
- multidisciplinary design
- system requirements
- number of details
Capturing all information that is required for: logistics, manufacturing, legislation, maintenance, life cycle support,
from needs and requirements to design: 
decomposition, interface definition, allocation, 
concept selection, technology choices 

Design 

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LAWFdesign
Example from Automotive

- vehicle owners and drivers
- garage, dealer
- Scania, DAF
  - vehicle manufacturer
  - KA
    - automotive component supplier
    - part supplier
    - material or subpart supplier
      - gear shift, clutch, stabilizer rod
      - O-ring, rod, aluminium
      - truck, car

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KAWvalueChain
Architecting: realization and design choices in context

some context details are essential

some technical details are essential

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The Design Handbook Idea

Toyota:
+ let experts capture their expertise
+ in such way that fits their mental model
+ compact and digestable:
  ➡️ A3 format
+ the collection of A3's is a design handbook
+ practical, low overhead
Example of Capturing Design Knowledge

Knowledge Based Design – Case Study

Rollers/belts vs. chains/slides were tested. Both were equal performance – rollers/belts had less friction and therefore required a smaller less expensive drive motor.

source: Ron Marsiglio
3 schools in Systems Engineering

Engineering, Designing, Architecting

case: MRI scanner

design handbook

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conclusion: Lean Architecting
High Level Problem Statement

Installed Base Business
- costly
- high effort
- diversity and # of configurations

Life Cycle Management
- costly
- high effort

Development efficiency
- costly
- high effort
- too late

Innovation rate
- too low
- too late

see next slides
Darwin Project Goal

Specific methods, techniques, and patterns to improve the evolvability of product families within industrial constraints and while maintaining other qualities:

- scientifically sound, suitable for PhD
- based on modeling and Reference Architectures
- faster to market, less effort, more predictable
- market response to anticipated and unexpected changes
- very relevant for MR, also relevant for others (partially) validated
- diverse products, installed base diversity
- people, process, project duration, and cost
- patient throughput, system responsiveness, image quality, safety, reliability
- more predictable

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2006: Reconstruct Physical Architecture Overview

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LAWFphysicalArchitecture
Modeling workshops:

time-boxed
multi-view
usage and life cycle context
determine key drivers
measure and quantify
A3 Example Architecture Overview

Legend

- Functional View
- Visual aid
- Quantification of key parameters
- Physical View
- Constraints Choices

**A3 Architecture Overviews** Focusing architectural knowledge to support evolution of complex systems
by: Daniel Borches and Maarten Bonnema, INCOSE 2010
3 schools in Systems Engineering

case: MRI scanner

Engineering, Designing, Architecting

design handbook

Darwin project: A3 architecting

conclusion: Lean Architecting
multiple related views

one topic per A3

capture "hot" topics

digestable (size limitation)

quantifications

practical

close to stakeholder experience

source: PhD thesis Daniel Borches http://doc.utwente.nl/75284/
Colofon

This presentation is based on:
+ the master project of Simen Aaserud (HiBu SE, Kongsberg Automotive)
+ Darwin research project (ESI Eindhoven, Philips Healthcare),
  especially the research of Daniel Borches (TU Twente)