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
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
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Case: Magnetic Resonance Imaging (MRI)
MRI Basic Principles

- **Human use**: Convert needs in sequence
- **SW HW magnet**, e.g. 3T
- **Static field** $B_0$, Hydrogen resonance
- **Gradient coil**, e.g. 10 mT/m
- **Gradient field** $G_x, G_y, G_z$ to encode spatial information
- **Receive RF**
- **Reconstruct images**
- **View images**
- **Generate** $B_0, G_x, G_y, G_z, B_1$
- **RF field** $B_1$ to excite spins
- **RF transmit coil** e.g. 15 kW, 180 MHz
- **RF receive coils**
- **Receive RF signal** to get data
How much knowledge has been accumulated (implicitly)?
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Lean Architecting, the Way of the Future?

Gerrit Muller

September 6, 2020

RAPpyramid
Capturing all information that is required for: logistics, manufacturing, legislation, maintenance, life cycle support,
Design

from needs and requirements to design: decomposition, interface definition, allocation, concept selection, technology choices

anticipating engineering needs and constraints
Example from Automotive

- Vehicle owners and drivers
- Garage, dealer
- Vehicle manufacturer
  - Scania
  - DAF
  - KA
  - Truck
  - Car
- Automotive component supplier
  - Gear shift
  - Clutch
  - Stabilizer rod
  - O-ring
  - Rod
- Part supplier
  - Material or subpart supplier
  - Aluminium
Architecting: realization and design choices in context

some context details are essential

some technical details are essential

Lean Architecting, the Way of the Future?

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LAWFdiabolo
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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
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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

based on modeling and Reference Architectures

faster to market
less effort
more predictable

market response to anticipated and unexpected changes

to improve the evolvability

of product families

within industrial constraints

and while maintaining other qualities

people, process, project duration, and cost

very relevant for MR
also relevant for others
(partially) validated

diverse products
installed base diversity

patient throughput
system responsiveness
image quality
safety
reliability

scientifically sound
suitable for PhD

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DERAprojectGoal
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

Constraints Choices

Physical View

Quantification of key parameters

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3 schools in Systems Engineering

Engineering, Designing, Architecting

case: MRI scanner
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/
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)