

Towards a method for creating Reference Architectures

- a journey together with Thermo Fisher Scientific -

Richard Doornbos

Senior Research Fellow, ESI

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Transmission Electron Microscopy Systems

Complicated
physics

World record
performance

Web of
dependencies

RASEI
RESEARCH AND SCIENTIFIC ENERGY PARTNERS
University of Colorado
ThermoFisher
SCIENTIFIC

X-FEC
Monochromator
Accelerator
3 Lens
Condenser
Probe
Corrector
Objective
Lens
4 Lens
Projector
System

CETA Camera
FEI STEM Detectors

4 On-Axis STEM Detectors

- + Fischione HAADF detector
- + FEI ADF, 4 Quadrant ADF (for DPC imaging), and BF Si SSDs
- + Imaging a large range of elements from low to high Z in single STEM image
- + Imaging Electromagnetic Fields

Highlights:

Cross-sectional atomic resolution STEM image of Bi_2Te_3 sheet at 200 kV.

Atomic resolution chemical maps of SrTiO_3 . Raw EDX data are shown in the first column for comparison.

Isosurface visualization of an electron tomographic reconstruction of GaMnAs nanowire.

CU Boulder, SEEL Building, Room 165
Email: sadegh.yazdi@colorado.edu



Many applications

Complex
applications

Getting connected
and integrated

A reference architecture for electron microscopes?

- approach at Thermo Fisher Scientific -

Some characteristics:

- multi-site and multi-culture (risk of having silos in the organization)
- multi-disciplinary development groups (growing importance of software)
- highly complex systems and applications (fast innovations)
- many product types with high commonality (increase in diversity)
- diversity of system components and interfaces (complex manufacturing process)
- limited architectural documentation

So what are the needs of the company?

- alignment in the organization: a shared baseline of why, what, how
- guidance for future developments
- improved effectiveness and efficiency, reduce cost/time

→ applying a Reference Architecture

→ ESI to develop a method

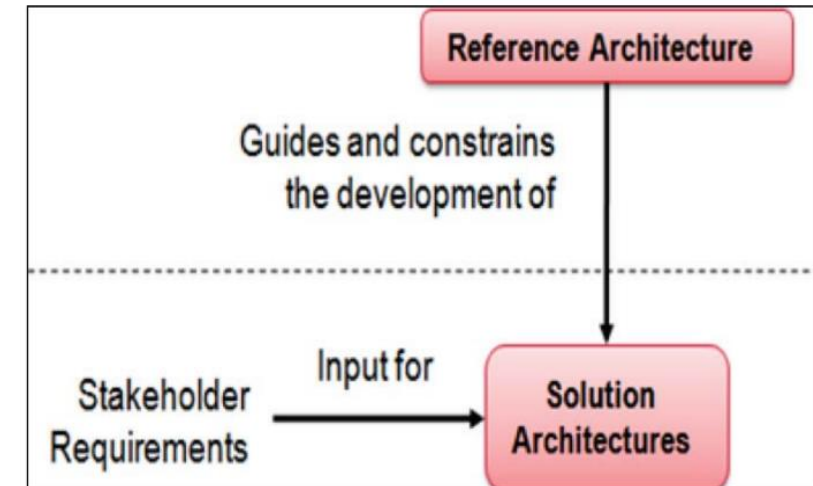
3 product lines
17 product types

What is a Reference Architecture?

"...capture the essence of existing architectures, and the vision of future needs and evolution to provide guidance to assist in developing new system architectures."

Purposes

- provide guidance for future developments
- incorporates the vision and strategy for the future
- a shared baseline of why, what and how



➔ Control Complexity, Common Understanding, Mitigate Risks, Knowledge Management

What is covered by a Reference Architecture?

It depends in general on ...

- business mission, vision, and strategy
- specific domain and application
 - determines standards, legislation, domain constraints, and mandatory frameworks, ...

But also different abstraction levels are possible!

- top-level overviews showing commonalities in product portfolio, or guidelines for function allocation
- extract architectural patterns, or detailed interface descriptions

In practice: you start by addressing particular challenges

- e.g. configuration management issues, doing more with the same resources, reasoning about customer values, ...

Building a generic information structure

A minimum set of views, to keep it light weight

Need for system understanding

→ functional views

Need for describing modules and interfaces

→ system decompositions

Need the link to concrete realizations

Innovative: the explicit link to customer values

Business values and processes determine system structures



Customer Value

Business Value

Customer
Workflows

Business Processes

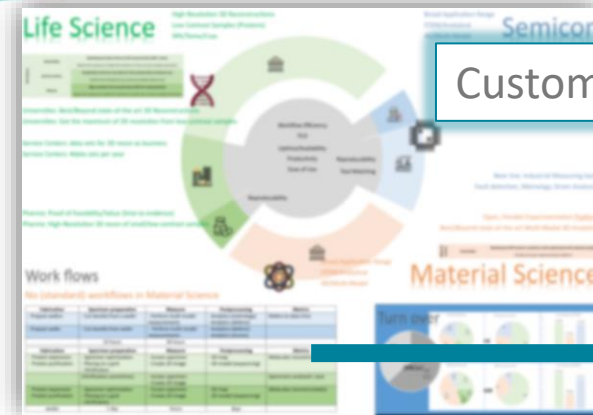
System Workflows

System Functions

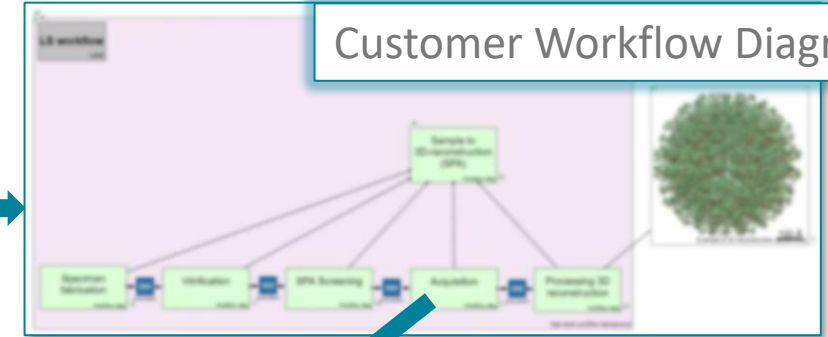
System Decomposition

System Configurations &
(Component) Realizations

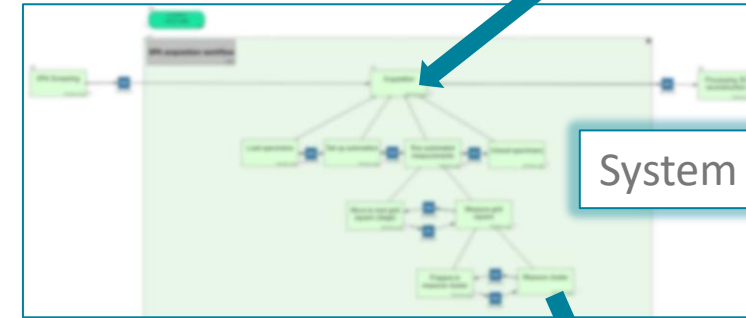
Customer Value Overview



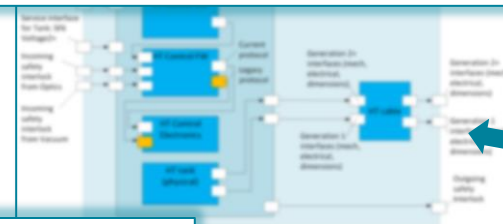
Customer Workflow Diagrams



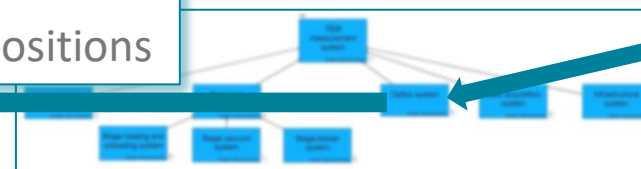
System Workflow Diagrams



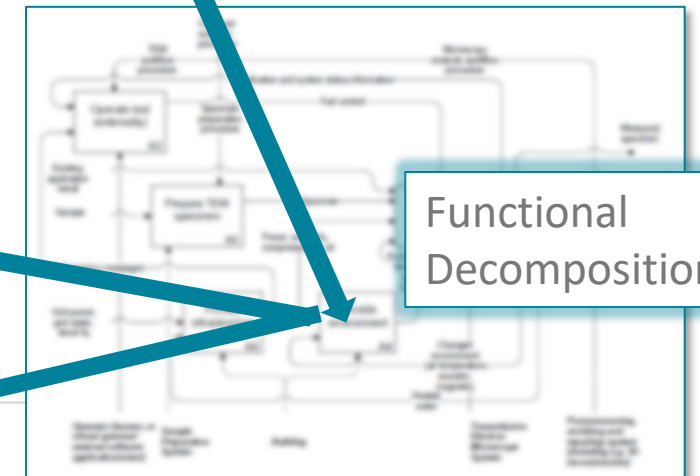
System Interaction Diagrams



System Decompositions



Functional Decompositions

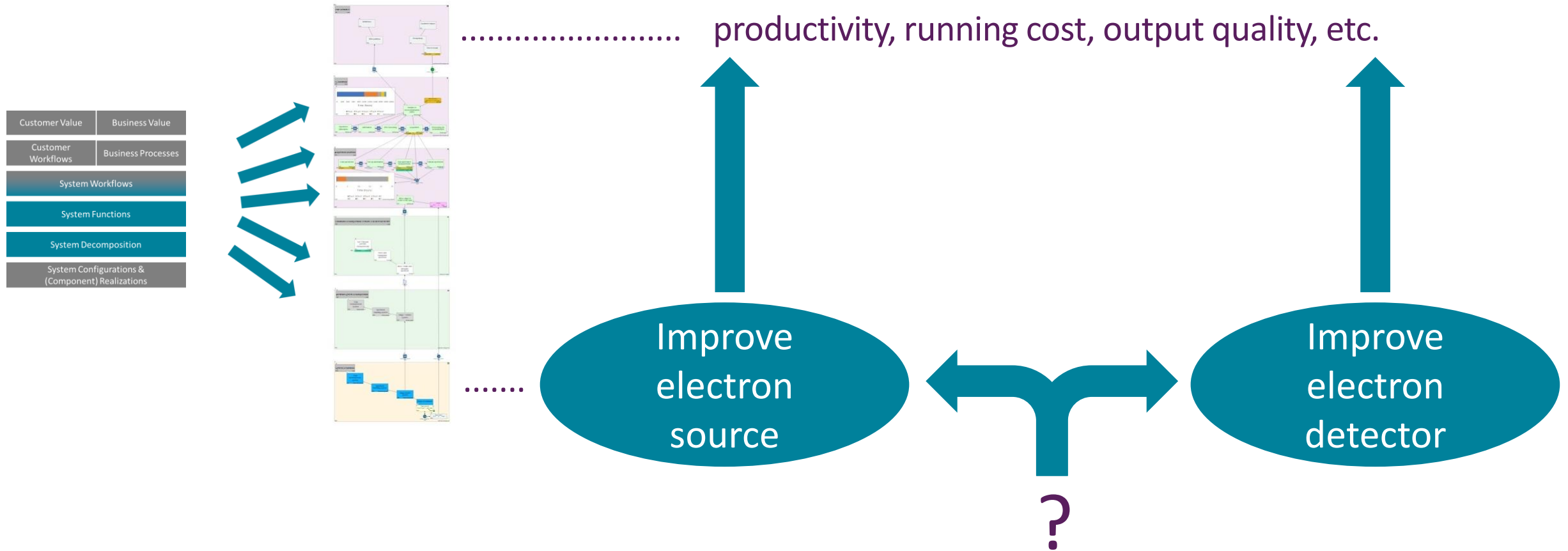


Realizations



Customer Value	Business Value
Customer Workflows	Business Processes
System Workflows	
System Functions	
System Decomposition	
System Configurations & (Component) Realizations	

Impact analysis: what if ...?



Benefits and challenges

Benefits: technical AND organizational

- systems thinking, ownership, multi-site cooperation
- explicit reuse reasoning, roadmapping and product proposals, special products, etc.
- central point of system knowledge, easier knowledge sharing

A few experiences at Thermo Fisher Scientific:

- faster CTQ flow down analysis: from 200 hours to 40 hours
- “Previously it took 4 hours to find the right information: open and read 25 Powerpoints to get the overview. Now it is only 5 clicks away to full access! And this holds for 200 people...”
- “I can talk to SW engineers, system engineers, application specialists, managers. They can all understand me. Brilliant!”

Challenges:

- now focus on business values and future product development
- tooling

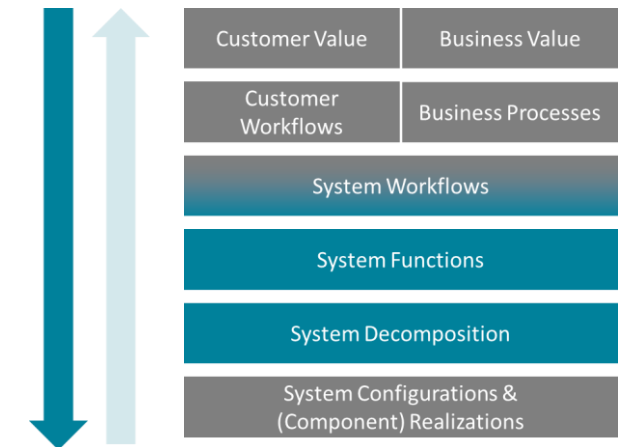
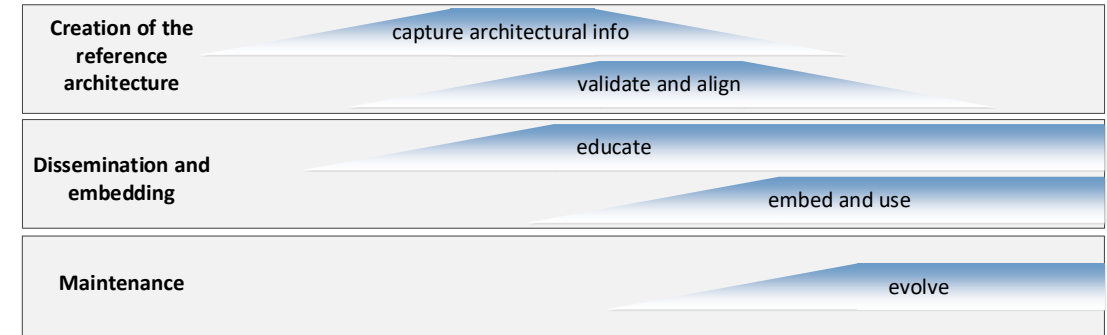
Generalizing the approach

White paper

- definitions, scope, purposes, state of the art
- structures to describe and techniques to create
- embedding

Further steps

- enhance value-driven aspect: from business value to RA
- how to evolve the reference architecture?
- validation of the method: ensure it works (metrics?)
- more on non-functionals and qualities
- linking to product platforms
- governance



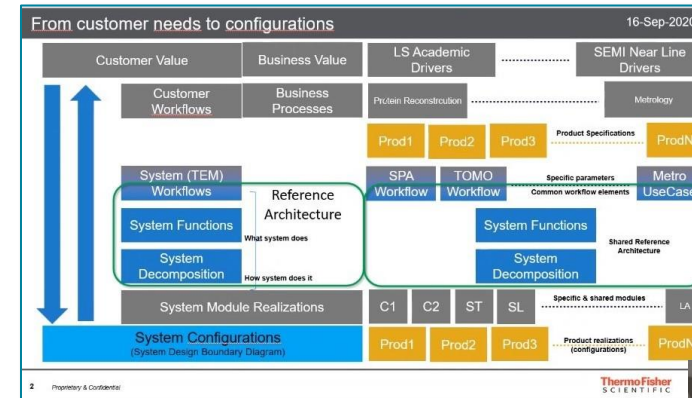
Summary

Impact at Thermo Fisher Scientific!

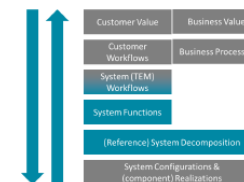
- embedding in processes, further systems thinking throughout organization, ownership, starting with MBSE tooling
- benefits recognized and support is strengthened (project continued)

Method development got a strong boost

- more info on the ESI website
- drop a mail to get the white paper



Reference Architecting
A methodology for distilling and documenting a reference architecture for complex high-tech systems



Thank you

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