Complex Systems

Breakthrough Innovations Through People
The H-SEIF project booklet

Complex Systems: Breakthrough Innovations through People

The H-SEIF Research Project
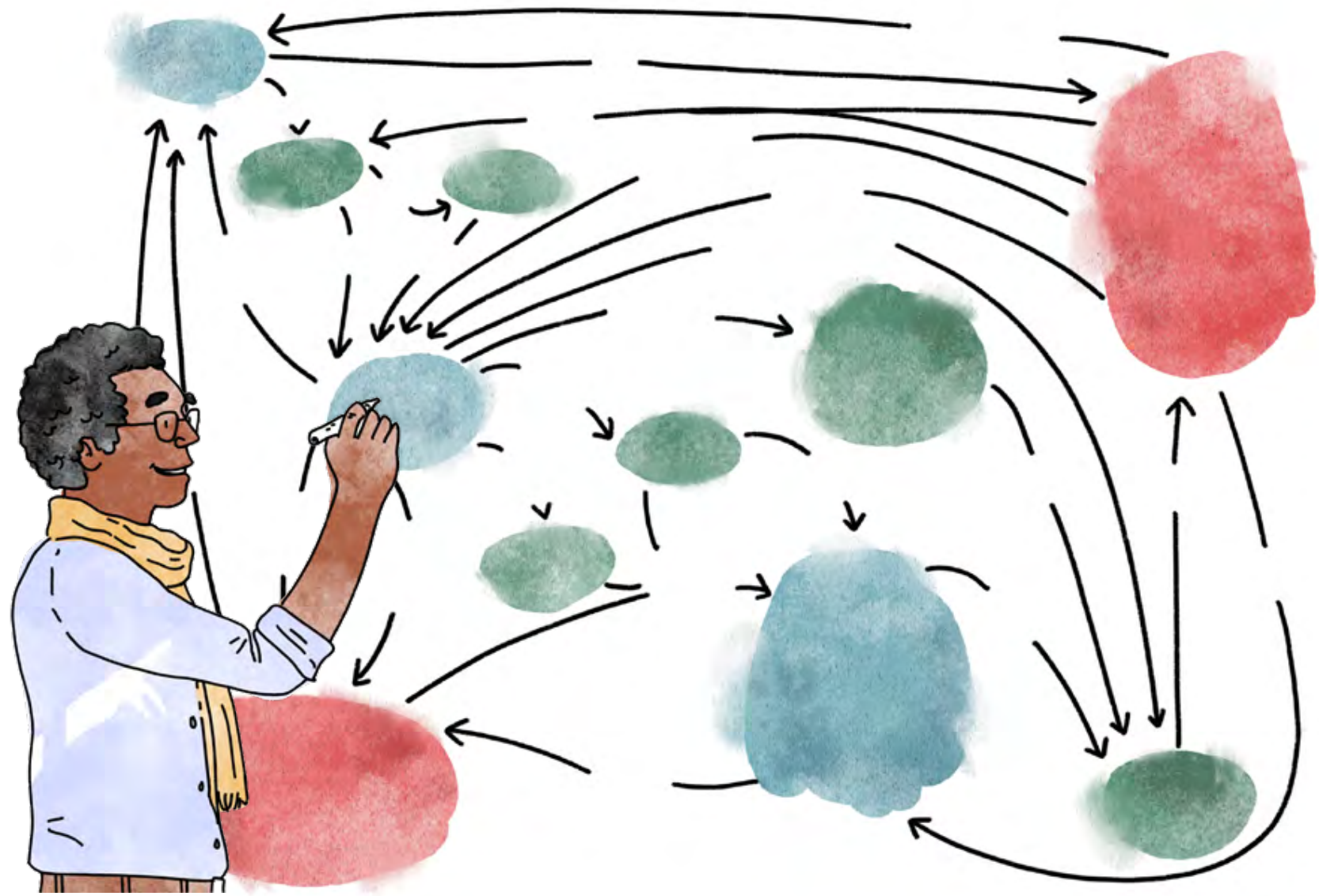
Editor's remarks

Through 2017 - 2020, the H-SEIF project has engaged many people across organisational and disciplinary silos. This booklet presents a summarised version of their work.

Palak Dudani is a designer researcher at the Institute of Design (AHO) and the creator and editor of this booklet. She has been responsible for simplifying the existing H-SEIF research, and writing and editing the content, along with overall direction, design and production of this booklet.

Andreas Wettre (AHO) is the leader and manager of this booklet project and has been responsible for the supervision, communication and coordination with the H-SEIF project partners.

As important contributors to our process, we thank **On Board Innovations** for supporting us with wonderful illustrations and visualisations.

Marianne Kjørstad finished her PhD in Systems Engineering at USN focusing on the H-SEIF project and has contributed significantly to the booklet's background literature. We would also like to thank **Gerrit Muller, Birger Sevaldson, Frode Bergan, José Pinto, Malin Guntveit, Halvor Røed** and **Nina Sjøkvist** for generous feedback - with a special thanks to the project leaders **Lasse Bjørkhaug** and **Kristin Falk** for their support!

Palak Dudani and Andreas Wettre
Oslo School of Architecture and Design (AHO)

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Development & Contributions

What's next

Introduction

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What is this book about?
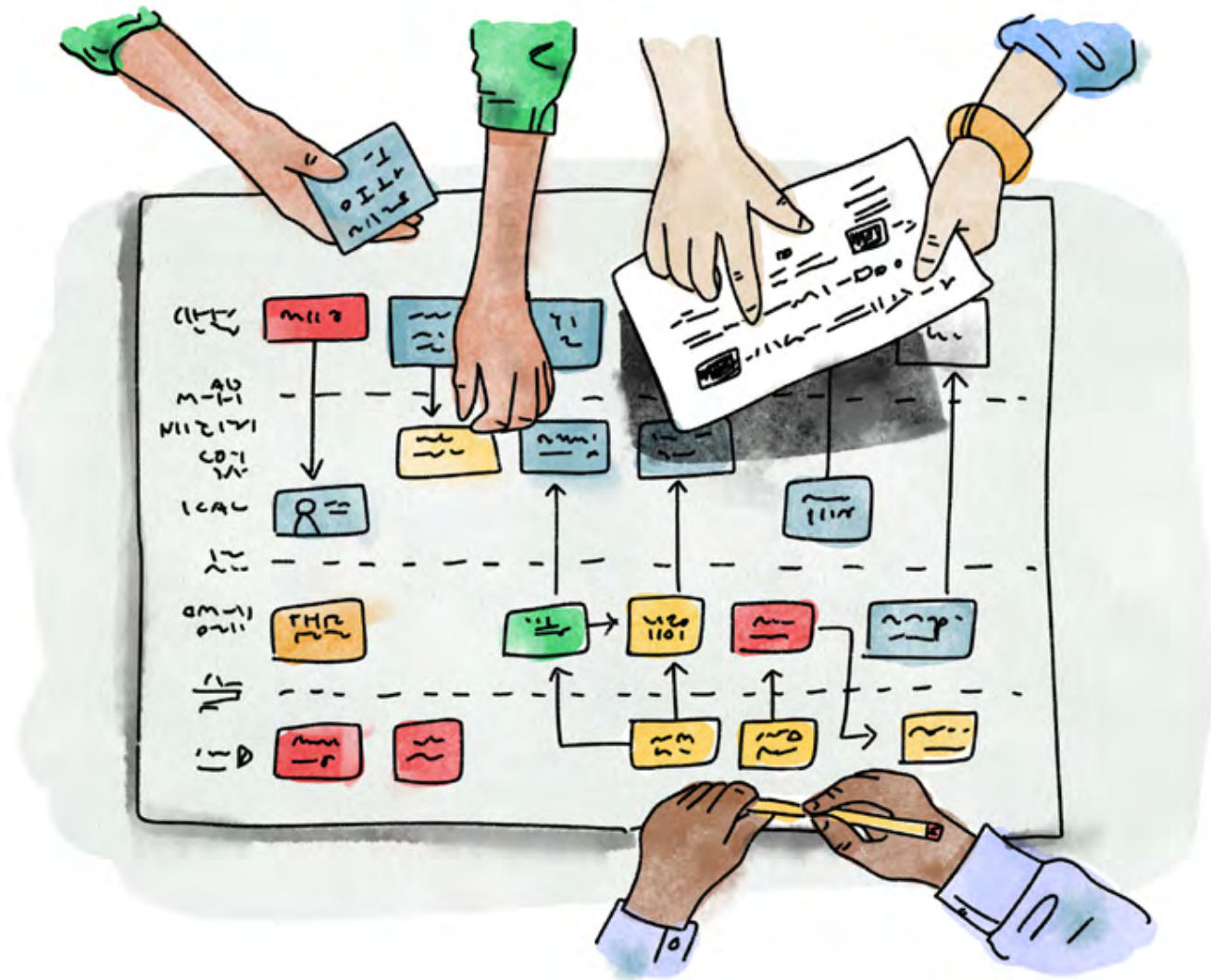
The H-SEIF project 'Technology with Empathy' was a three year (2017-2020) research collaboration project between industry and academia funded by Oslofjordfondet and in-kind by partners. This book is written to inspire systems engineering practitioners and create curiosity about new ways of working to take the step towards significant innovations.

We are a network of industry and academic partners sharing an interest and engagement in systems engineering. Our main goal was to create a framework for developing innovations using methods and tools combining design thinking and systems thinking. We found our current way of working as rigid and slow moving, leading us towards incremental innovations rather than significant "wow" innovations. On this journey, we explored a toolbox consisting of methods, tools and frameworks that enabled us to move faster and learn more rapidly through exploration, early validation, and knowledge sharing.

We try in this book to share our learnings using the toolbox and inspire you and your team to apply a new way of working on your journey towards significant innovations.

Enjoy reading!
Kongsberg, June 2020

Technology with Empathy
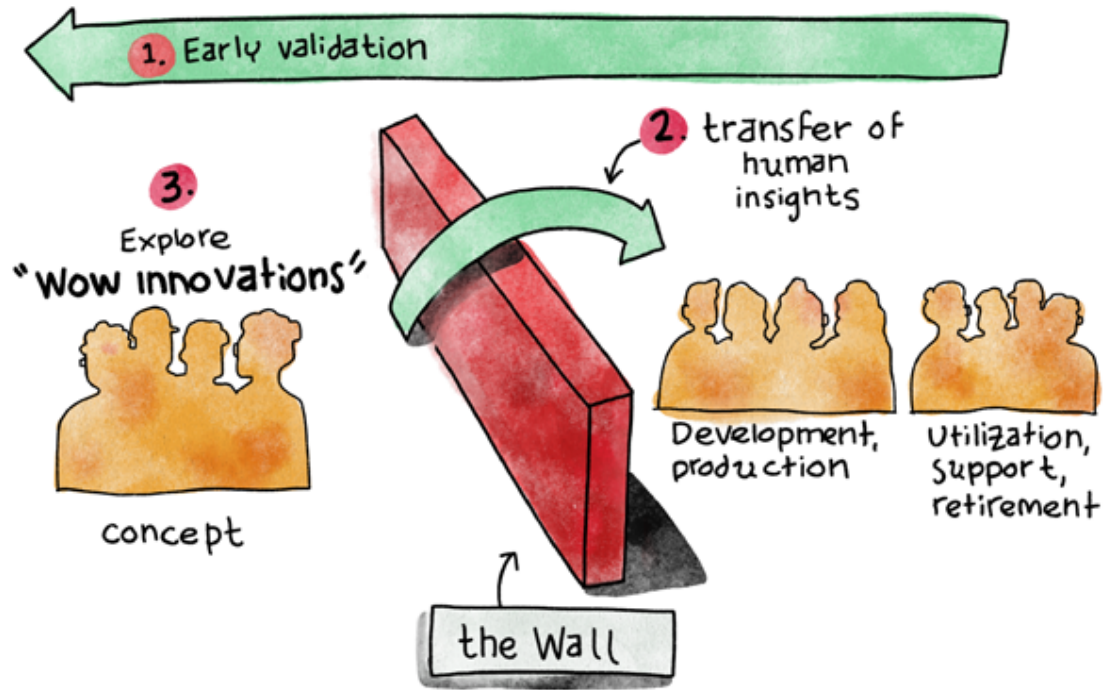
The H–SEIF Project

Context and Goal

Today's large-scale, highly complex socio-technical systems converge, depend on each other and interact in ways that were not imagined just a few years back.

As scale, scope and complexity increases, there is an emerging need for a systematic "framework" to manage all this while developing a culture that fosters "innovations" applicable for humans. That is a Human-Systems Engineering Innovation Framework (H-SEIF).

Problems Today

This project is about innovation, and the core problems it tackled include:

1. Missed opportunities and cost overruns in development projects due to the lack of cost-efficient early validation.

2. The realized systems lack user-friendliness. It is challenging to transfer (human) insight from initial design and through engineering. The "hard core" requirements win over softer, human aspects.

3. Disruptive products take market shares and teams often fail to explore new technologies during incremental development. Products end up lacking the "wow" factor and lose their competitive edge.

1. Early validation

2. transfer of human insights

3. Explore "Wow innovations"

concept

Development, production

Utilization, support, retirement

the Wall

Areas for Innovation

Systems Engineering

Business

Technology
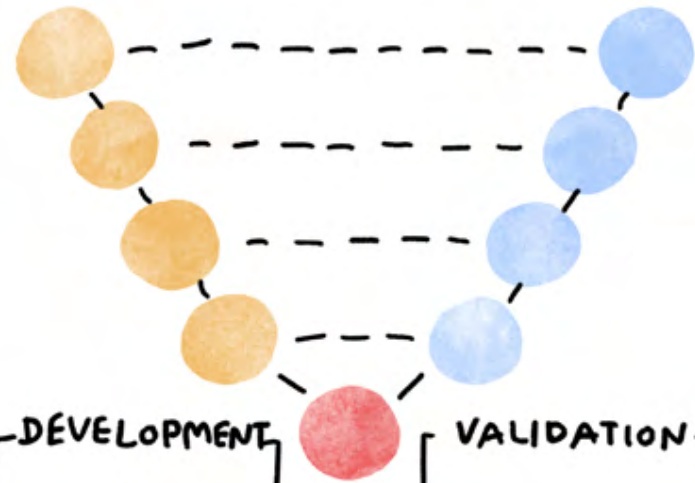
Human Values

DEVELOPMENT

VALIDATION

Design Thinking

APPLY → OBSERVE

+

DEVELOP ← ANALYSE

Breakthrough | Radical

Incremental | Disruptive
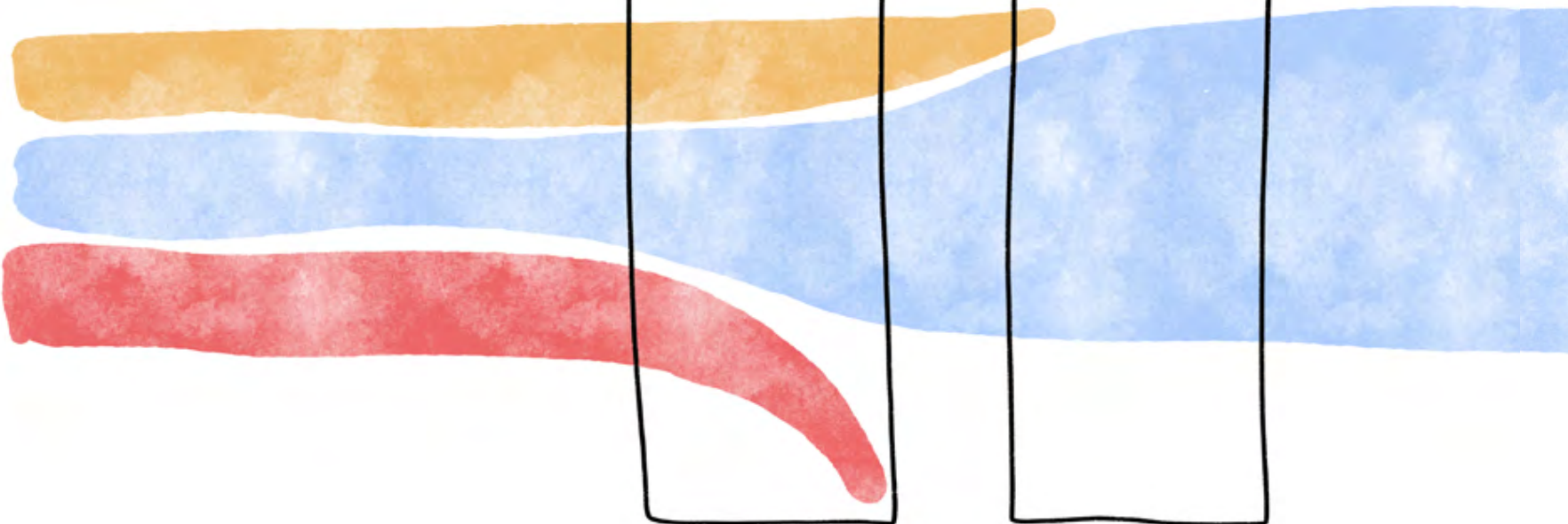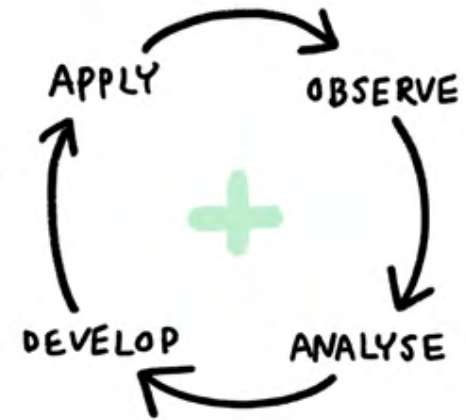
H-SEIF

Partnerships

The partners within the H-SEIF project have conducted research through a collaborative research project including four Norwegian high tech companies and two academic partners.

The industrial organisations provide innovation services and full-scale systems for the global ocean space, such as service vessels, expedition vessels, subsea systems, and off grid renewable energy systems. The academic partners specialise within disciplines such as systems engineering and systems oriented design.

In this section, we will briefly summarize the different partner organisations and their roles within the H-SEIF project.

Ulstein

Ulstein Group is a family-owned company comprising several marine enterprises within ship design & solutions, shipbuilding, global sales and shipping. Ulstein's vision is to create tomorrow's solutions for sustainable marine operations.

In recent years, they've had a strong focus on strengthening their expertise in systems engineering. They are renowned for their innovative ship solutions and have used the H-SEIF project to explore entering into new markets.

Semcon

Semcon is an international product development company with more than 2,200 employees representing a wide range of expertise. Going from idea to production, it performs product development projects for its customers.

For Semcon, the development process is a competitive advantage and the H-SEIF project is expected to increase the customer value in their projects.

TechnipFMC

TechnipFMC is a global leader in subsea, onshore/offshore, and surface projects with 40 years of experience supplying reliable subsea systems. They operate in a rough environments and make use of their systems engineering expertise. They are now also going into new energy systems.

The company has used the H-SEIF project to a systemic innovation for offshore hydrogen production.

Kongsberg Innovation

Kongsberg Innovation AS (KI) is a frontrunner in Norway for development and industrializing innovative technology-based businesses. It aims at attracting the best technology based start-ups and entrepreneurs to the Kongsberg region. And support SME projects with innovation support.

H-SEIF provides tools to speed up the innovation process, improve their value creation and offer opportunities to realize projects from both start-ups and the industrial companies in a more efficient way.

University of South-Eastern Norway (USN)

The University of South-Eastern Norway (USN) is internationally recognized within Systems Engineering (SE) of complex systems. The SE program received the 2019 DIKU prize for quality in higher education for excellence in connecting academia and industry.

Oslo School of Architecture and Design (AHO)

The Oslo School of Architecture and Design (AHO) is internationally recognized as a major contributor to the creator of the design field 'Systems Oriented Design'. Its well suited for handling complexity, more so for development of 'gigamapping' tool.
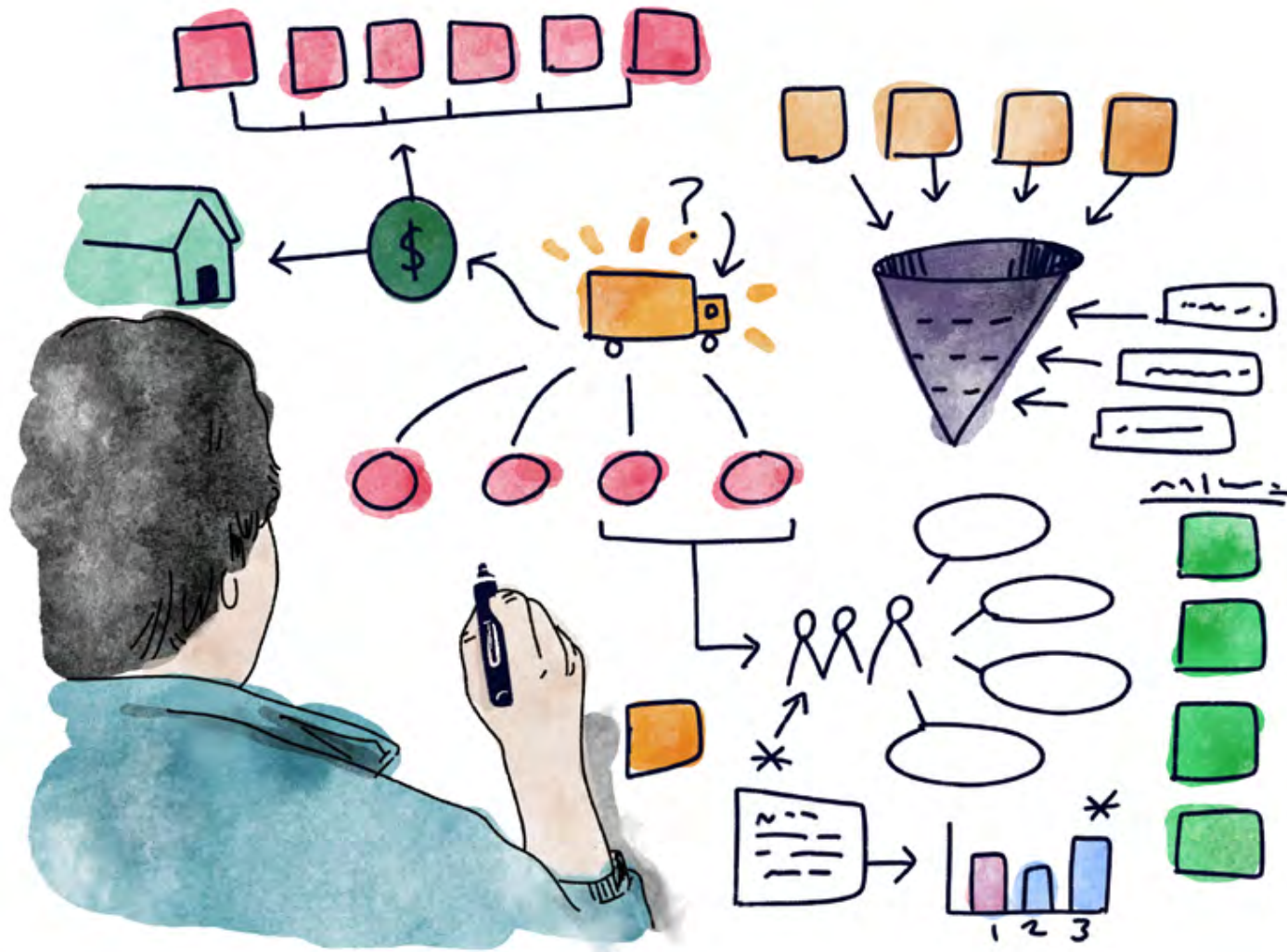
Bridging Theoretical Fields

In order to address the complex and multi-layered problems within industrial processes of the present, there was a need to connect the theories from a more human-centric design thinking point of view, with the theories of systems engineering.

Looking at engineering and design together, H-SEIF connected and coupled a series of individually advanced and highly interesting methodologies and perspectives, and applied these in an industrial setting.
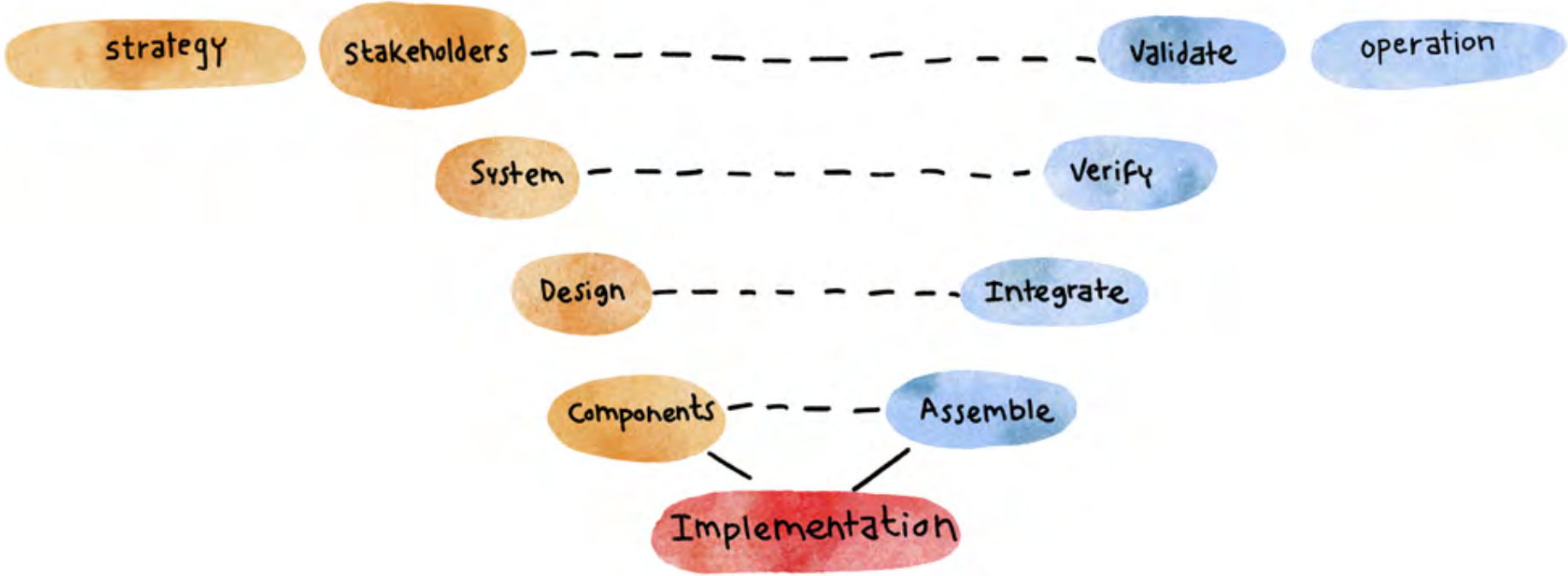
By bridging these fields, the H-SEIF project wanted to stimulate the innovative team to include aspects of both technology, value creation and Human Centric Design simultaneously.

This is new as a systematic study, and has produced process innovations for very complex innovation projects.

Systems Engineering

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Systems Engineering (SE) is defined as 'a trans-disciplinary and integrative approach to enable the successful realization, use and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods.' We use the terms "engineering" and "engineered" in their widest sense: "the action of working artfully to bring something about". "Engineered systems" may be composed of any or all of people, products, services, information, processes, and natural elements.

Systems engineers are at the heart of creating successful new systems. They are responsible for the system concept, architecture, and design. They analyse and manage complexity and risk. They decide how to measure whether the deployed system actually works as intended. They are responsible for a myriad of other facets of system creation.

strategy

Stakeholders - - - - - - - - - - Validate   operation

System - - - - - - - - Verify

Design - - - - - - Integrate

Components - - - - Assemble

Implementation
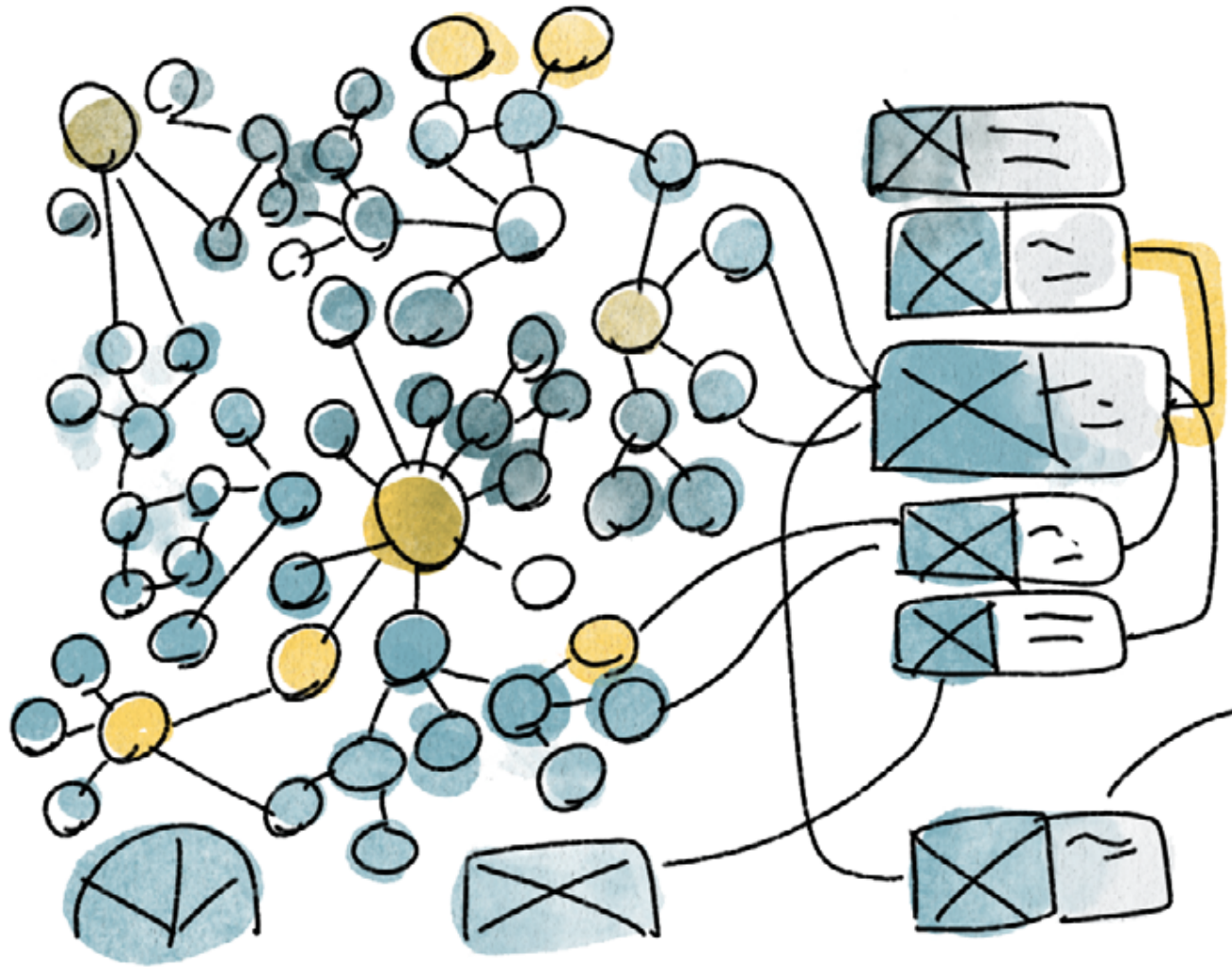
Systems engineering is the discipline that makes their success possible – their tools, techniques, methods, knowledge, standards, principles, and concepts. The launch of successful systems can invariably be traced to innovative and effective systems engineering.

A core idea in systems engineering is to understand the stakeholder needs, define the required functionality and investigate the complete problem throughout its product-life cycle - and do this early on in the development cycle. Traditionally, SE has been developed within Large to Very Large companies in slow moving domains focusing on risk reduction.

H-SEIF looked at innovative teams in start-ups, SMEs and large companies for their specific needs for system approach, especially in terms of responsiveness, adaptability, and agility.

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GLOBAL

MACRO

MESO

MICRO

Forced relations?
Tying relations

Modified concept

ZIP

GIGAMAP

Synergies?

Boundary Critique

IMP

Immersion incubation illumination

Orchestration

Four perspectives

Back Checking

Expert network

CREATION

Selection of concepts

Description

VALIDATION

Stake holders

4H-model

Concept Probing

CONOPS

Narrative

Storyboarding and comix

Design

——

Design occupies an important role within engineering organisations. Here we mention two specialisations within the larger discipline of design that were central parts of H-SEIF project.

Systems Oriented Design (SOD)
SOD is about understanding, interacting with, and designing complex systems. It's a skill-based methodology that helps creating an overarching perspective, binding together different domains and fields. It helps to find significant innovations through the holistic understanding of the whole system.
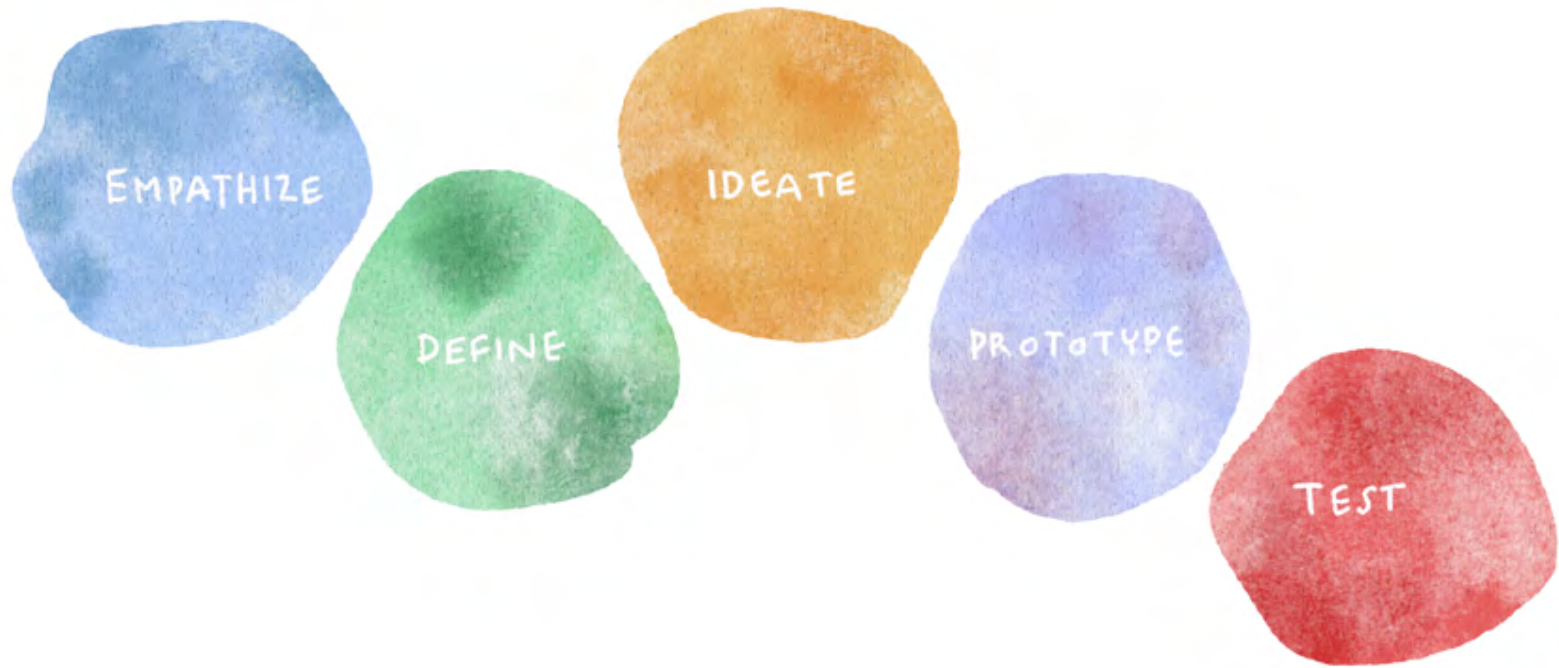
Within organisations, collaborators often need to understand and agree upon the complexity they are dealing with. Techniques such as gigamapping allows bridging silos in order to utilize the diversity and build shared understandings and common goals.

Design Thinking

Design Thinking is a methodology from the design professions that was conceptualised for engineers to be more creative. It's a human centric methodology which was quickly adopted by the Silicon Valley, and is now in use in a world of innovation consultants.

The design profession is developing new techniques to deal with systems innovations.

This approach has not been tried before in a systematic study, and will potentially produce process innovations for very complex innovation projects.

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EMPATHIZE

DEFINE

IDEATE

PROTOTYPE

TEST

Research → Education

Cross system/project
Cross company
Cross domain

Industry as laboratory
PhDs in industry,
Industry goal and needs

Reflective Practice
Case-based education
Industry as classroom
Industry in the
classroom

Industry Practice
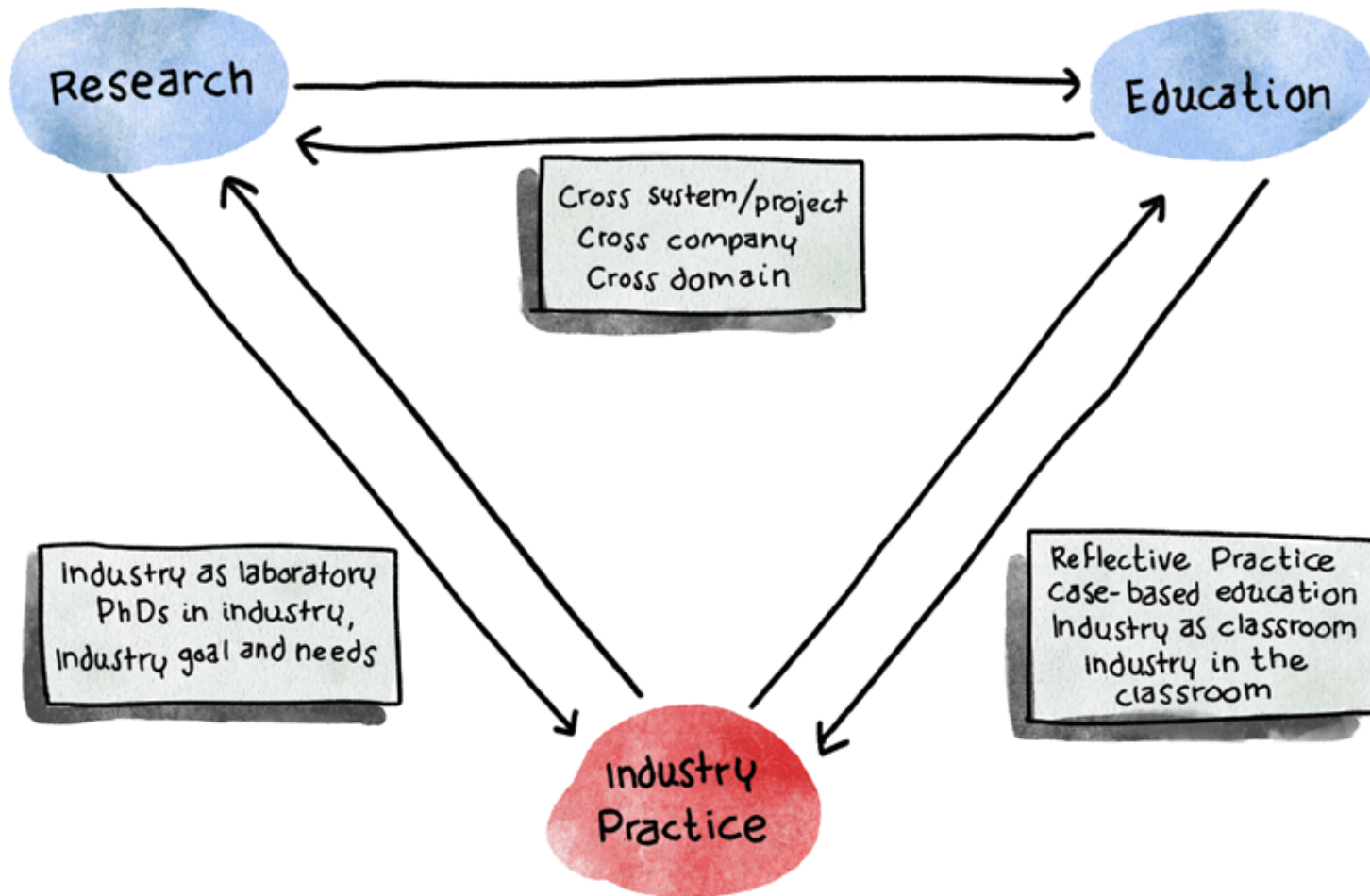
Outcomes

The H-SEIF project incorporated more than ten industrial cases. During this project, eight master's students, one Ph.D. student and associated academic staff used industry as 'laboratory' set-up.

This approach was used to explore and further develop visual collaborative methods and tools such as Architecture Overviews, Co-creation workshops, Gigamapping, while also supporting exploration of new tools such as IKA or Interactive Knowledge Architecture.

Outputs include publishing of more than ten scientific papers, one book chapter, and organisation of six cross-industry workshops. The project was also covered by Teknisk Ukeblad, bringing it to a broader audience.

The partner companies implemented some of the new tools and ways of working during product engineering processes. Other tools were only tried out in the companies, while a third group of ideas were less mature and only explored to inspire new thinking and reflections.
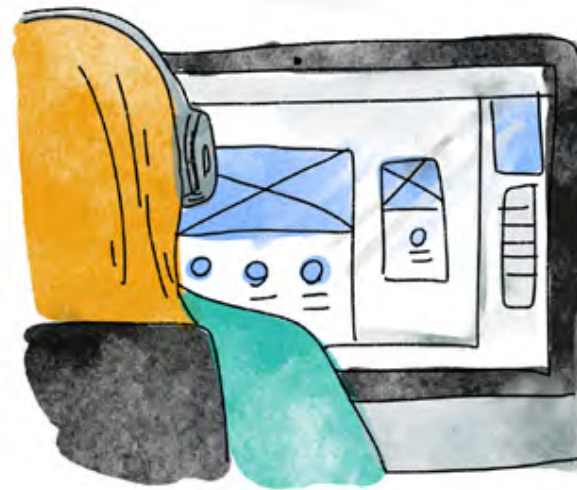
Development
& Contributions

Tools, Methods and Processes

Norwegian high-tech industries face rapidly changing market needs. The organisations strive for further reducing risk and cost in the innovation process while customers demand new systems that are attractive to use.

System Engineering provides tools and methods for managing complexity, however the industry needs to further increase the effectiveness of this set of tools.

It's important to mention that for the purposes of this overview, we have not created a sharp distinction between our references to tools, methods and processes.

This is because we find that some tools might be a 'tool' within one disciplinary context and a 'method' or a 'framework' within another disciplinary contexts.
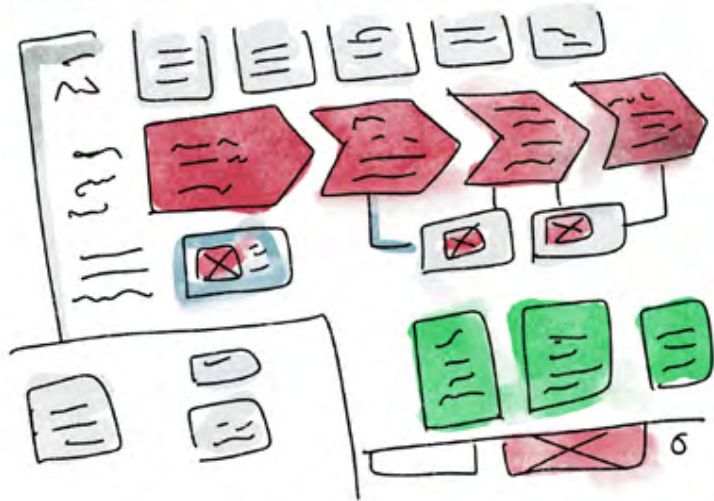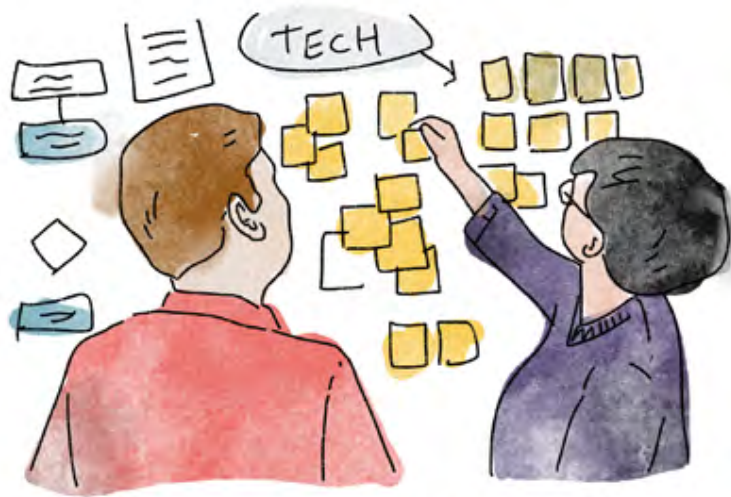
Early validation of design concepts

Transfer of insight

Systemigram

IKA

Illustrative-ConOps

Co-Creation sess

Visual canvas

Gigamapping

Early concept exploration

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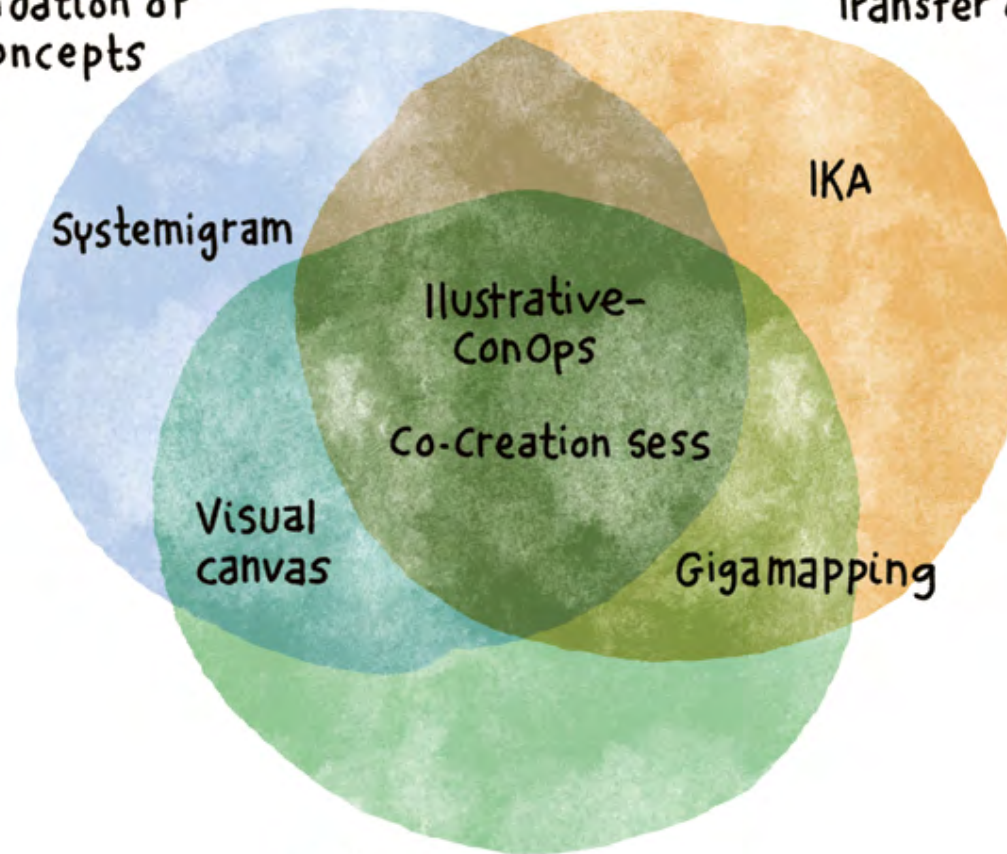
" The objective of the H–SEIF project is to develop the System Engineering toolbox to create concrete, tangible improvements for Norwegian companies and industries."

What can you expect

In this section, we'll talk about the following tool/method in brief:
1. Gigamapping
2. Interactive Knowledge Architecture (IKA)
3. Illustrative Con Ops
4. Visual Canvas
5. Co-sessions

While some tools/methods have been tested, others were explored less rigorously. We remind our readers that this booklet aims to provide inspiration and generate curiosity and therefore, the discussion on relevance and use of the tools will not include an 'instruction manual' of any kind. The sections will conclude with some additional resources if you'd like to learn more about the tools/ methods.

We hope that this will make you curious & inspire you to try out them out in your workplace.

ULSTEIN FIELD STRATEGY

MARKET (Identify strategic vessel segments, customers, shipyards)

ULSTEIN

DIVERSE

Ski? P

V: KAN

Equipment packages Integration

LOGISTIKK

ESTETISK DESIGN

FAST RADICAL CHANGES

Erfaring ment verft-samarbeid

Kontakt (Ulstein project funding) Potential customers (Ship owners, shipyards, investors, etc)

Problem definition

communication

TYPE
Design from Ulstein
Open feder (design + build)
FEED
QUALIFICATION

LEAD

PRODUKT:
TJENESTE: AB

PROBLEM:

SELLING POINTS

Speculation (mindre kontrakt)

tender
tech.

KUNDE REDERI

Behov

BYR PROSJEKT

50 MRD oppdrag

Kundens kunde / operatør

BRUKERE

MILJØORGANISASJO

VIDUAL.

Gigamapping

——

When teams want to build shared understanding among its members, it becomes essential for them to communicate at the same level, to discuss views and perspectives that can be questioned, and create shared knowledge that can be understood by others.

Gigamapping has emerged as an effective tool to create alignment between different stakeholders and to increase awareness of the differences, creating value that goes beyond gathering data and information.

Gigamapping is one of the central techniques used within systems oriented design, which allows for working with complex problems by building shared understandings and sense making between participants.

Developed by Prof. Birger Sevaldson at Oslo School of Architecture and Design (AHO), gigamapping involves mapping contents across multiple layers and scales, utilizing descriptive and generative thinking, drawing from a designerly way of dealing with complexities.

A Workshop Guide

Gigamapping within Organisation

Looking at organisational complexity, one can hardly trust a process purely based on a rational analytical approach, singling out particular problems that could be addressed with some actions to create an expected result. We need to think of the construction of knowledge in a more organic way, where shared understanding is something we gain when interacting with others and working together to try to understand the complexity.

Gigamapping is about both sense-making of the complexity and creating shared understanding between people. It's important to openly seek out different perspectives and engage in exploration.

Workshop at Ulstein

So, how can you work with gigamapping within your team? In this section, we'll take you through a workshop case study, its goal being teaching gigamapping technique within one day that help participants bridge inter-departmental silos.

Introduction and Gigamapping

The facilitators recede as the groups start gigamapping, keeping interference minimal. When faced with difficulty, facilitators probe with questions, helping participants express their thoughts on paper even if they have mixed feelings about it. This balancing act allows us to interfere when hard arguments break in but also make space for free expression.

ZIP Analysis and Discussion

ZIP analysis is a method for generating output from gigamapping, a process which engages participants in sharing and deliberating, creating common ground and building consensus across team members.

Team Communication

Our assumptions are usually based on where we are coming from, heavily influenced by what "silo" we belong to. Gigamapping also opens up discussion around diversity and how understanding the task and relational conflicts within teams is crucial for their success.

Recommendations

When to use it and what to expect

Gigamap is a visual tool, best suited for exploration and in this way, it enables creativity. It works well for any part of the design process and is an excellent tool for grasping complex systems and sharing knowledge through interactive sessions. It also supports on-boarding a new member on an existing project and can serve a reference tool for keeping track of the project. This also helps team members stay on the same page and communicate effectively.

Main benefits that the participants replied after gigamap were a better understanding of complex problems and stakeholders. They also reported that gigamap enabled communication and ensured that all participants were on the same page.

Some concerns included whether agreed upon actions would be followed-up, and how can it be ensured that gigamap gets used as part of their daily team work.

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"Different phases of the process have different requirements, including goals, timelines, and people involved. Gigamap allows us to get an outside perspective on different aspects of the process."

Publications

Bridging Silos: A New Workshop Method for Training Silo Busting

This paper presents a preliminary report on the results from a series of workshops on silo bridging held in the frame of the Human Systems Engineering Framework (H-SEIF) research project in 2018-2019.

Access it here:
https://systemic-design.net/rsd-symposia/rsd8-2019/social-system-labs-and-methodology/

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Gigamapping, a dynamic tool
Gigamapping is part of the Systems Oriented Design (SOD) framework.

Access it here:
https://www.systemsorienteddesign.net/

———

"Gigamapping is an opportunity to gather several perspectives from various experts, discuss issues on how different stakeholders perceive it and build a common understanding."

"How do you map and understand stakeholders here, which will lead to a product or result in the operation? In this case, I think gigamapping has to be a perfect way of populating these issues and visualizing what they are."
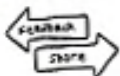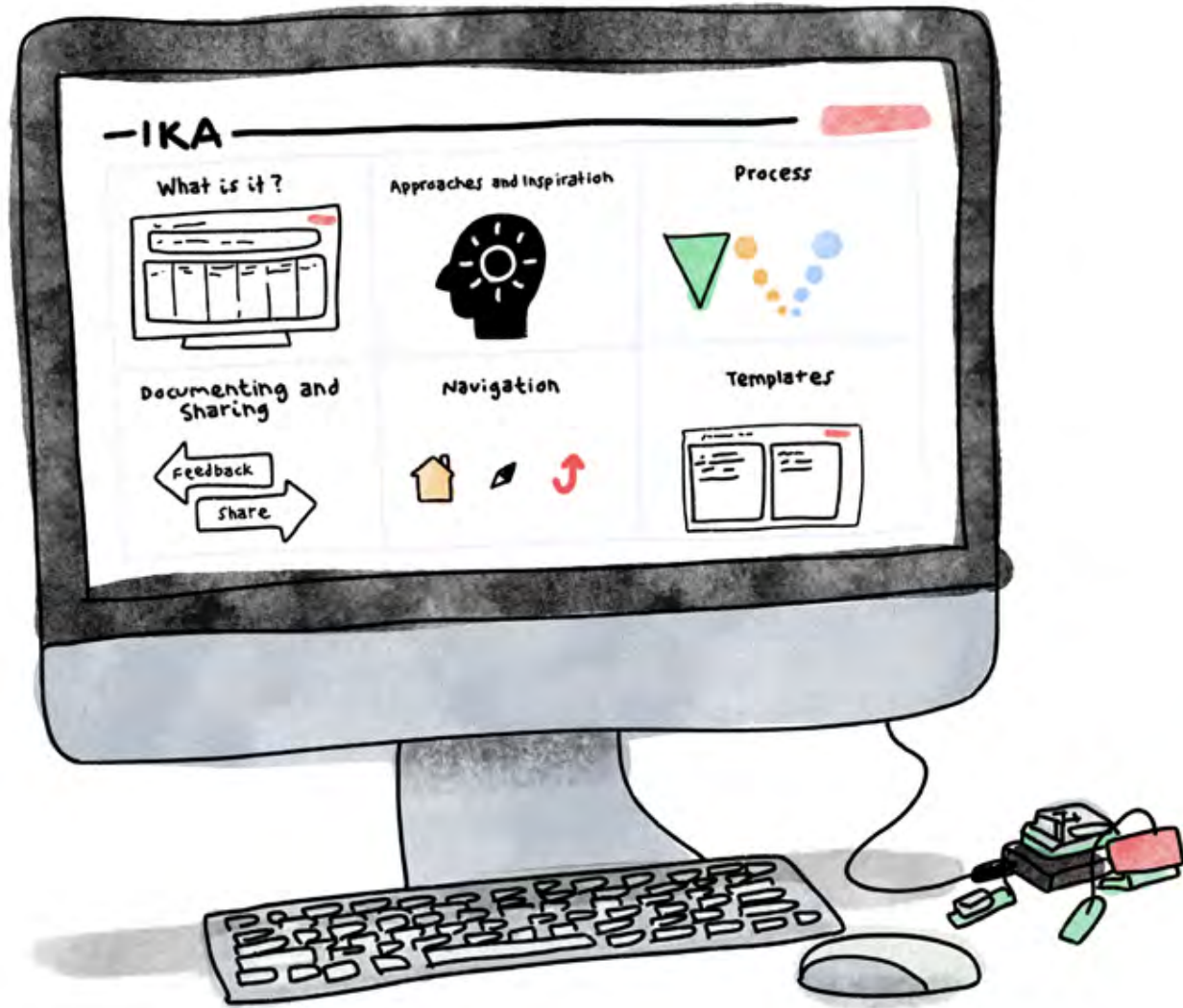
Interactive Knowledge Architecture (IKA)

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Sharing knowledge through architecture is a key element in successful development projects. However, companies often fail with effective knowledge transfer due to poor communication of the problem domain between project stakeholders.

Communicating knowledge with a variety of stakeholders across several sectors is no easy task. Soft factors such as organizational boundaries, personal skills, mindset, and relations further complicate this interaction.

Inspired by design thinking and informal methods in systems architecting, IKA uses visualizations and interactive links to provide a usable and desirable interface for all users, including but not limited to the systems engineers.

IKA was developed by engineers at Semcon. It uses a variety of analyses structured in an interactive architecture within Power Point with an aim to share the knowledge more effectively within projects by making it easily accessible for the organization as well as the customer.

A Guide

IKA within Organisations

The Interactive Knowledge Architecture (IKA) is used as a tool to create a common ground of knowledge between the main project stakeholders including project leaders, team members, and customers among others.

As a common documentation structure for the whole team, engineers irrespective of specialisations can set-up and work with this tool. However, it is the systems engineers who are the owners of the architecture of IKA.

Implementing IKA in Project Execution

The IKA aims to provide the engineering team with the ability to navigate between the content with minimal effort. The architecture is built by placing the slides in a hierarchical structure where each new level is decomposed from the one above.

Introduction to setting up IKA for your project

The IKA is an iterative tool which is in the process of development from the moment your project starts and till its finished.

In order to set-up the tool, the System Engineers have to go through the cycle of 'exploring and understanding the project', building knowledge architecture around the project, sharing that with the team, collecting feedback and then repeating the cycle. This is the overall process and it starts with building your project framework and IKA gives you the templates to get started.

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Templates

semcon

Stakeholder Tools

A3's

— General A3

System Analysis

Project Tools

Step One: Building the IKA framework

IKA is built on a hierarchical framework based on the SE process. When establishing a new IKA, start by building your framework as a place holder for your content.

This template supports Systems Engineers so they can get started with the IKA tool by documenting the key aspects of the product development project.

Step Two: Developing accessible knowledge base

While working on the project, this template allows the System Engineers to make sure they've collected information on all aspects of the project and documented them for easy access. The navigational structure is built with the home page as a top level. Each category links to a more detailed level in the framework.

Home Page

CREATED | **UPDATED**

Need Statement

Show the properties of the IKA

| BACKGROUND INFORMATION | PROBLEM DOMAIN | REQUIREMENTS & DRIVERS | CONCEPT STUDY |
| WEEKLY STATUS | WEEKLY HIGHLIGHTS | WORK SESSIONS | PROJECT RECOMMENDATIONS |
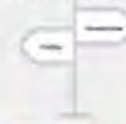
Build Your Architecture Framework — semcon

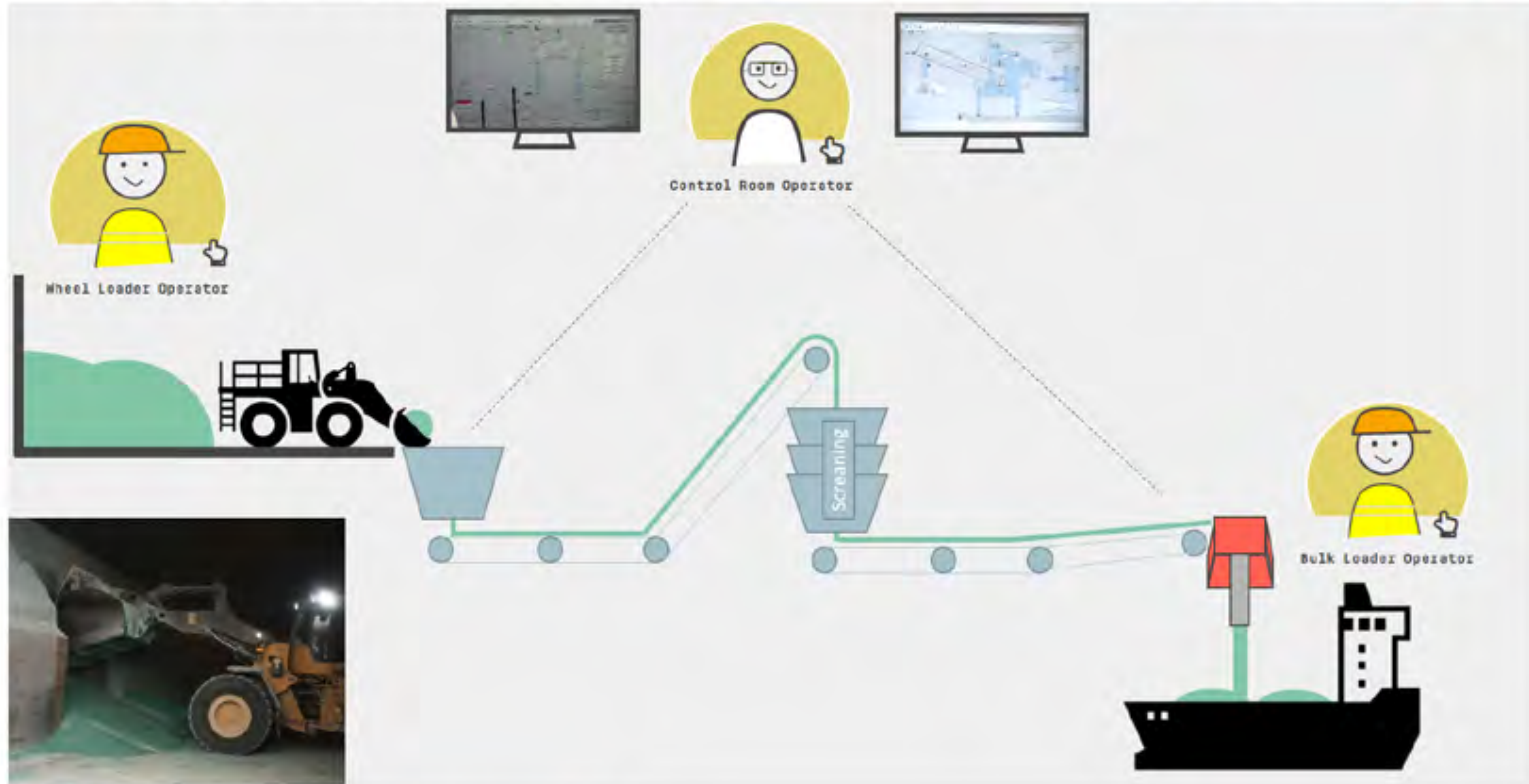| PROBLEM DOMAIN | STAKEHOLDER OVERVIEW | CONCEPTS | PROJECT MANAGEMENT |

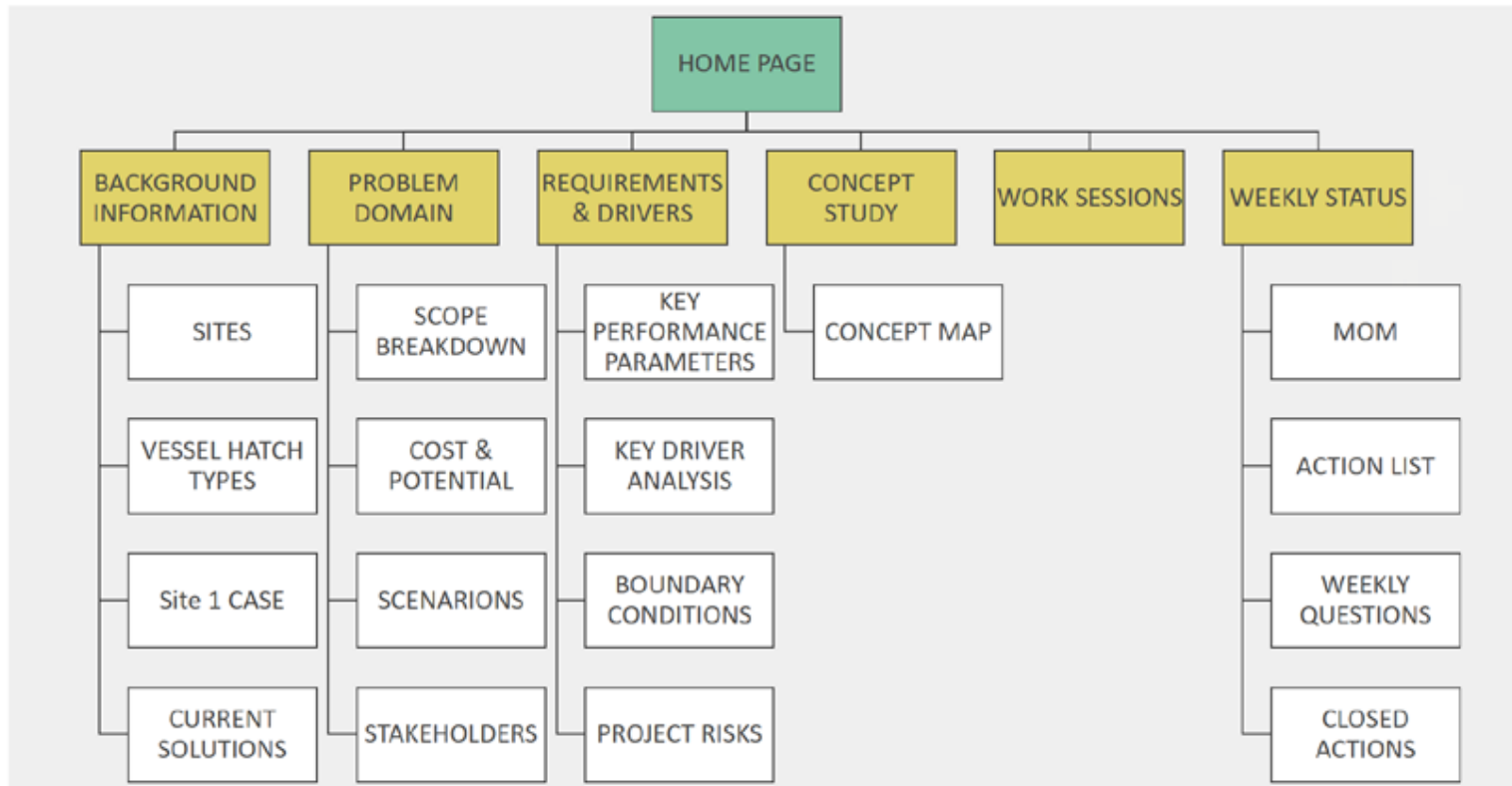**Step Three: Documentation and
Analysis within IKA**

The IKA toolbox provides a large set of templates
for performing different project analyses. These
are usually placed in the lower levels of the
framework.

Bulk Loading Operation

Wheel Loader Operator

Control Room Operator

Screening

Bulk Loader Operator

Document Overview

HOME PAGE

- **BACKGROUND INFORMATION**
  - SITES
  - VESSEL HATCH TYPES
  - Site 1 CASE
  - CURRENT SOLUTIONS
- **PROBLEM DOMAIN**
  - SCOPE BREAKDOWN
  - COST & POTENTIAL
  - SCENARIOS
  - STAKEHOLDERS
- **REQUIREMENTS & DRIVERS**
  - KEY PERFORMANCE PARAMETERS
  - KEY DRIVER ANALYSIS
  - BOUNDARY CONDITIONS
  - PROJECT RISKS
- **CONCEPT STUDY**
  - CONCEPT MAP
- **WORK SESSIONS**
- **WEEKLY STATUS**
  - MOM
  - ACTION LIST
  - WEEKLY QUESTIONS
  - CLOSED ACTIONS

Document Overview

PLAN   TEAM

Clickable links: Go to Home Page: Go to Document Map: Go up one level:

Step Four:
Setting up the Navigation within IKA

Navigation is designed to help users understand where they are, where they have been, and where they can go next.

The user can navigate through the levels of detail in a linear order, going back and forth between levels using the navigation bar. We based the architecture on a tree structure to give the stakeholders a logical overview.

However, the hyperlink feature gives the possibility to provide alternative paths between views. It is possible to navigate to any page/ external link or document using hyperlinks. However, the page's position within the architecture gives the content its context and adds value. The user can also navigate to any part of the document with two clicks when using the document map.

Recommendations

When to use it and what to expect

From product development to market research, IKA can be used for a wide variety of engineering projects. It's best used for inter-team communication in the early concept phase development. It's main benefit is its usage as a communication format for the systems engineers, helping them be specific and simplify concepts. The navigation links also gave a rapid knowledge transfer for new team members.

The value of IKA depends on its design and it does not replace any of the other documents in the project. It's important to be aware that IKA layout might depend heavily on internal quality check and since IKA requires maintenance, system engineers might perceive using IKA as part of their processes as added work.
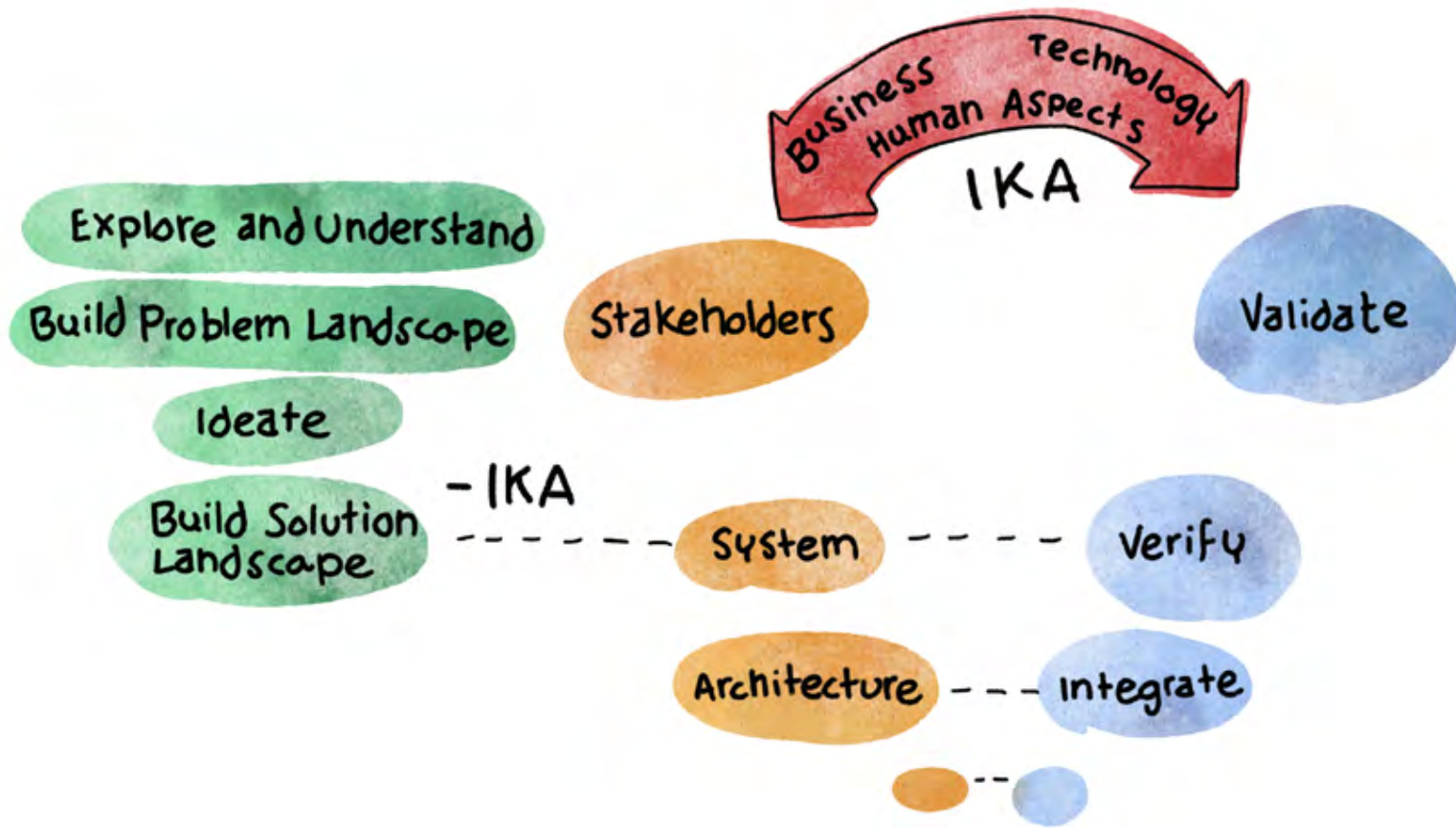
In this section, we'll highlight some of the feedback and learnings from the engineers who had the chance to use the IKA tool.

Standardisation of Knowledge

The architecture played a significant role in building a common understanding between the engineers. The engineers state they did not need any introduction on how to perform the analysis using the IKA, as the software is well known and the templates are self-explanatory.

Powerful tool for Project Execution

The engineers perceive the IKA to be a powerful tool for status and meeting activities during project execution. Since it was easy to navigate through the performed work, the meetings ended up being more effective than earlier. The engineers felt it was easier to get a good overview of project status and plan further work. Overall, the team perceived the IKA to support increased cooperation and felt they were working towards a common goal.

Explore and Understand

Build Problem Landscape

Ideate

Build Solution Landscape

– IKA

Stakeholders

System

Architecture

IKA
Business
Human Aspects
Technology

Validate

Verify

Integrate

60

"(During project work) IKA made it easier to know where to look and where to go. "

Effective communication

With the use of IKA in the project, the engineers agree that the standardization of the knowledge presentation supports more effective communication.

Efficiency and Consistency

The standardization of analysis templates also provides a more efficient creation process as well as it ensures consistency between the team members.

Publications

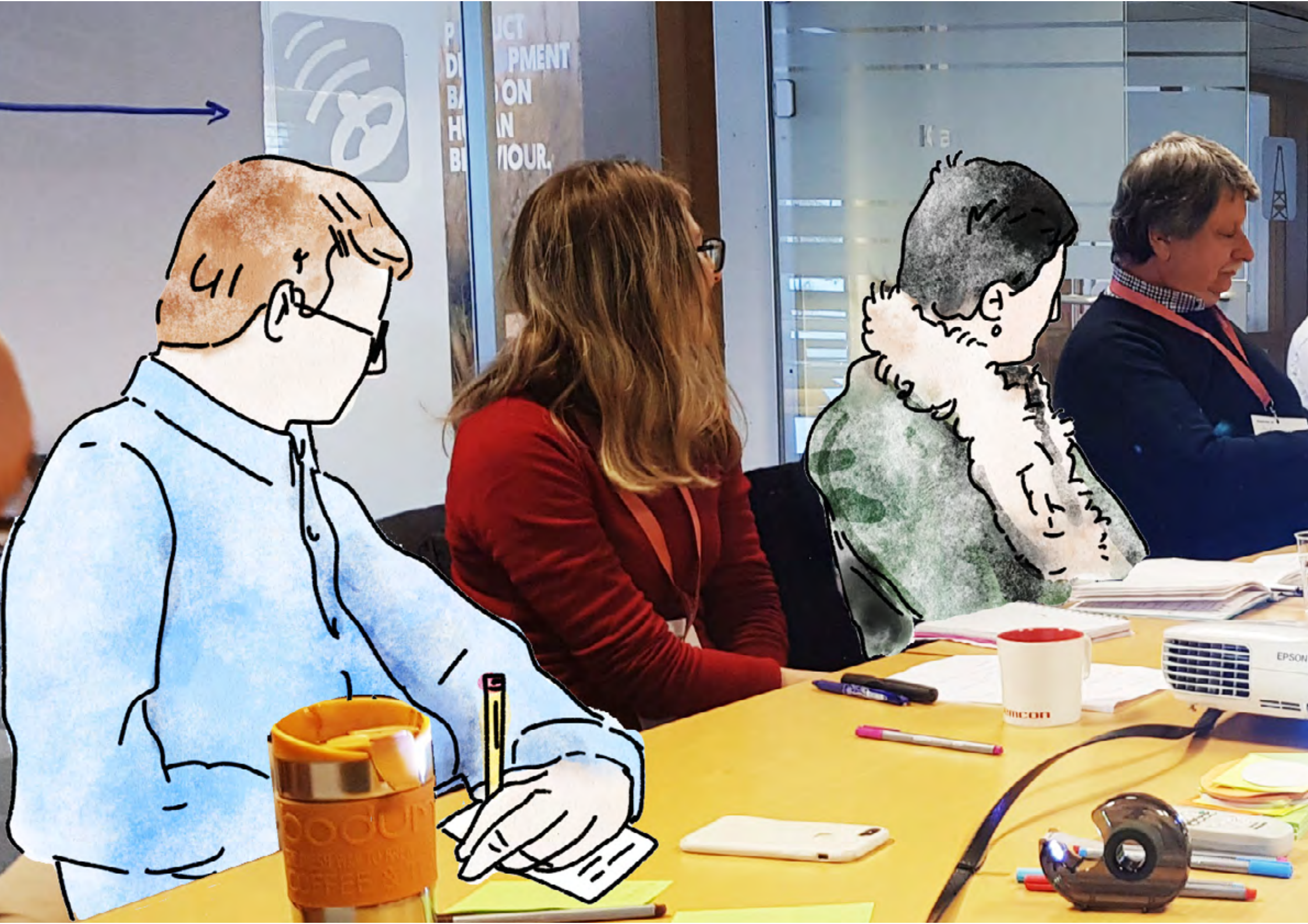**An action research report on IKA and its testing results on in-house teams.**

Reference:
H. R. Jensen, G. Muller, and A. Balfour, "Interactive Knowledge Architecture: An intuitive tool for effective knowledge sharing,"
Published in INCOSE Int. Symp., 2019.

This paper investigates the effect of Design Thinking techniques for capturing and communicating human values in the early phase of Systems Engineering.

Reference: N. M. Sjøkvist and M. Kjørstad, "Eliciting Human Values by Applying Design Thinking Techniques in Systems Engineering," INCOSE Int. Symp., vol. 29, no. 1, pp. 478–499, 2019.
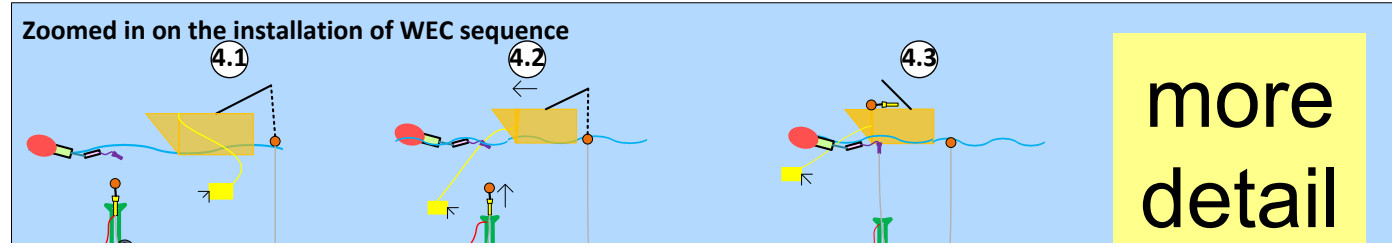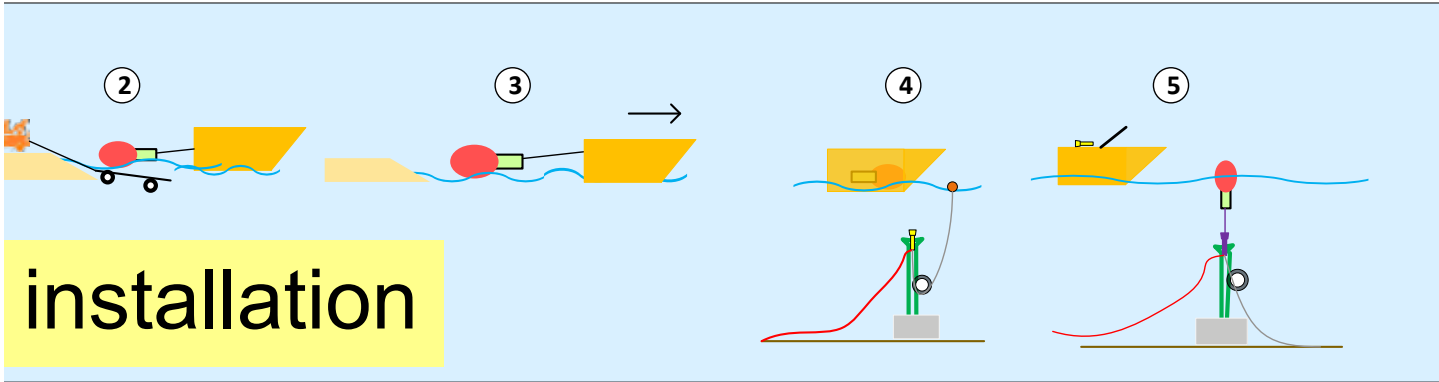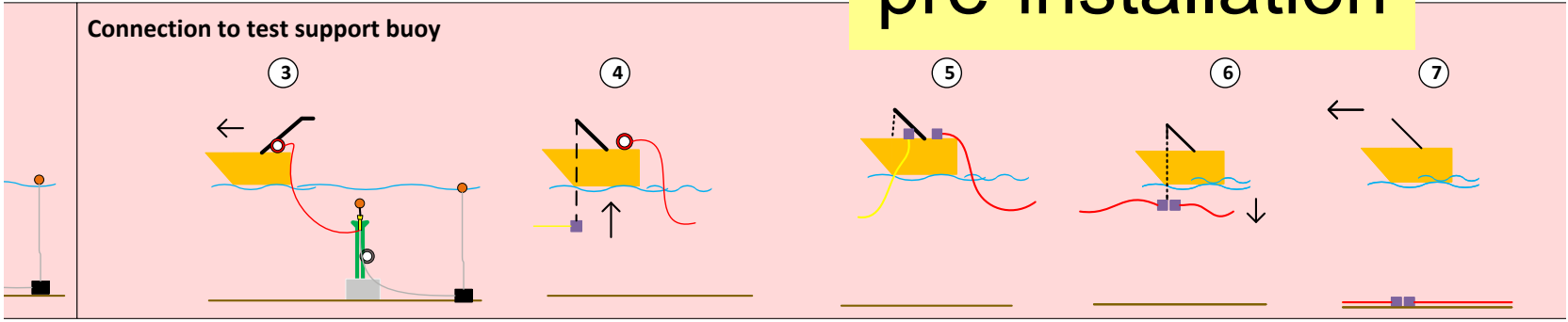
This paper looks at how the use of IKA as an interactive tool can facilitate collaboration, knowledge sharing and enhance the understanding of customer needs in conceptual phase at a global shipbuilding company.

Reference: R. B. Vanebo and M. Kjørstad, "An Interactive Tool for Collaboration and Knowledge Sharing of Customer Needs in the Conceptual Phase (in press)," INCOSE Int. Symp., 2020.

Connection to test support buoy

③ ④ ⑤ ⑥ ⑦

pre-installation

installation

② ③ ④ ⑤

Zoomed in on the installation of WEC sequence

4.1 4.2 4.3

more detail

The installation A3 as in use at CorPower Ocean. Source: Emilie Aune, Henrik Lind & Gerrit Muller (2016)

Illustrative ConOps

——

A systems engineer uses ConOps in the early phase of innovation to describe the current "as-is" state of the organization's operations. Then the future state "to-be" will inspire the visions, desires, and expectations for a new system.

Usually, the creation of a ConOps occurs in the development of a new system or product, upgrade on existing systems or product, or to create a strategy involving the whole life cycle of systems or product.

ConOps presents the technology as a black box and focuses instead on the people and interaction with other systems. This is to enable the engineers and users to think and discuss from a perspective on how a system interacts with users or other systems. By early involvement of the end-user, companies can avoid making costly design mistakes that reduce the usability of the system.

Case Study: Sub‑Sea Project

ConOps within Organisations

Illustrative-ConOps should visualize the systems in an easy-to understand manner.

This can be related to storytelling because of the illustrations. Customers and users of systems can use storytelling to inform their needs in the design process and inspire new possibilities. A user-focused ConOps will create a collective understanding.

A Case Study

The subsea and offshore systems provider, TechnipFMC were going into a new domain namely offshore renewable energy system. Their new system, Deep Purple, combines offshore wind and hydrogen energy to provide a stable and climate-friendly energy source for consumers.

At the early stages of the project they considered different maintenance concepts.
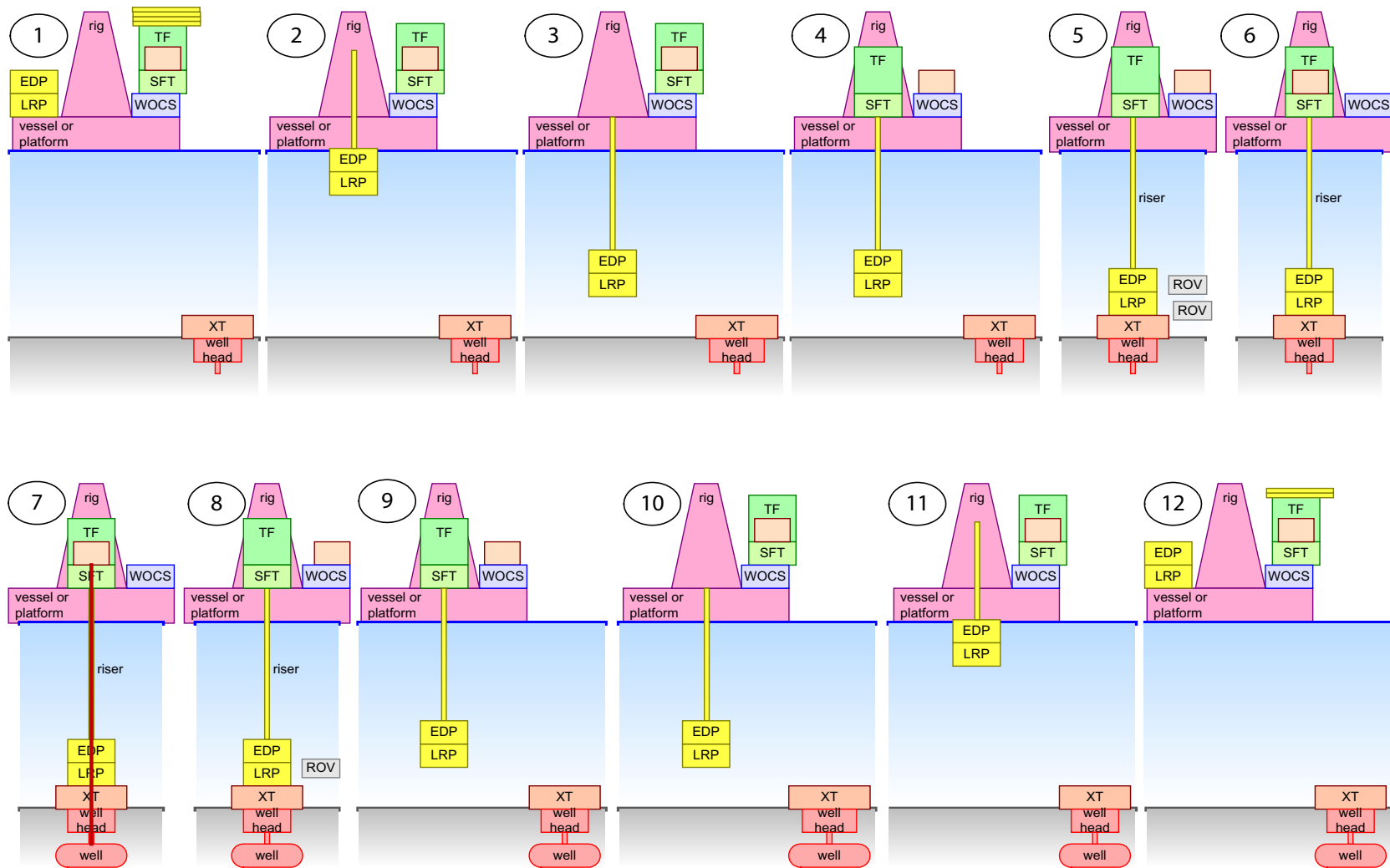
Example of an illustrative con-op showing the work-over work flow for a sub-sea context. Source: Gerrit Muller
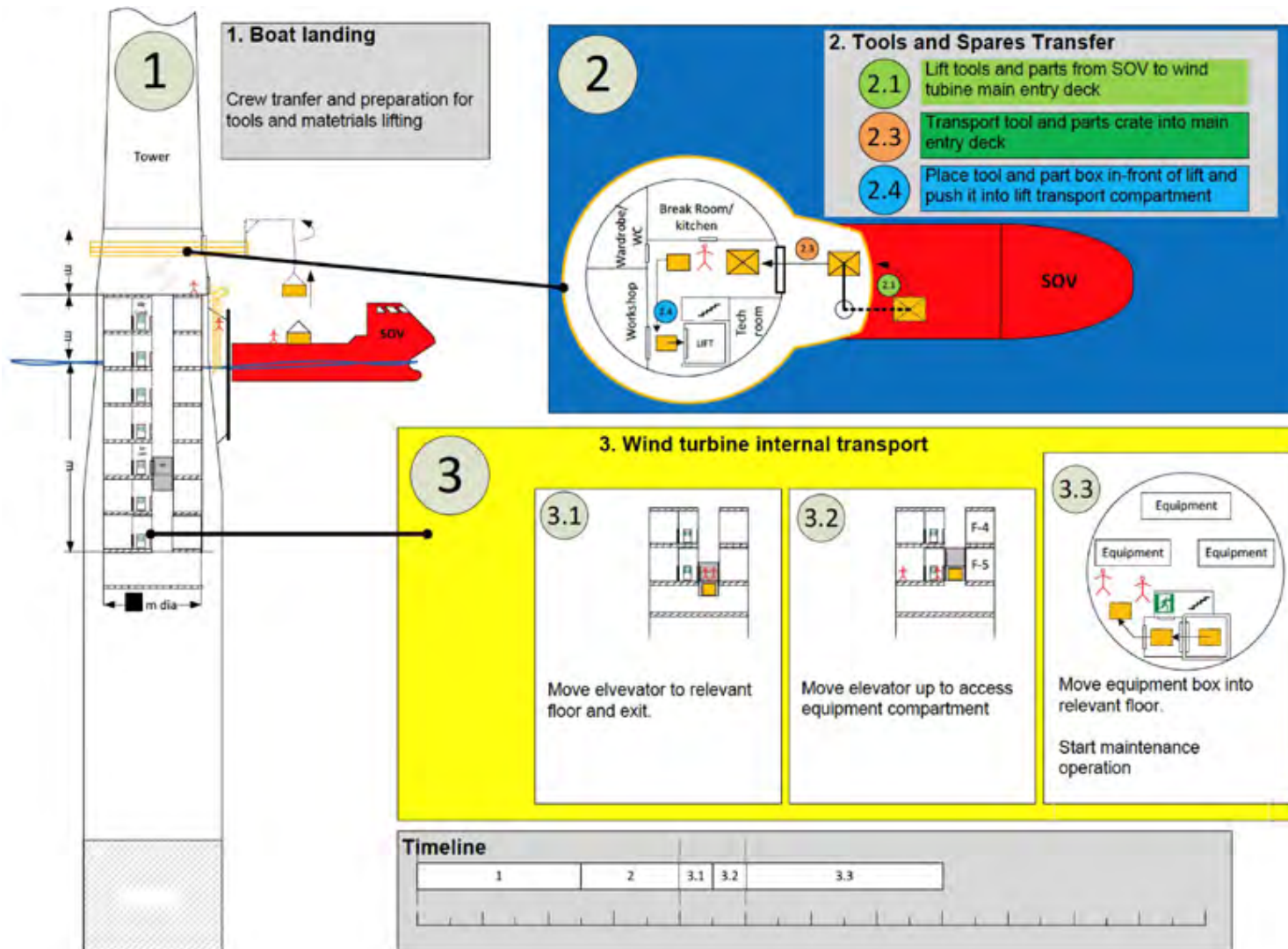
Deep Purple Project: Illustrative CONOPS used in the interview process. (Source: See Publications, first paper)

Challenges

Engineering teams seem to be focusing on technology and cost, while user's desirability often gets lost in the engineering process. The Deep Purple project team was therefore looking to perform activities that could involve the end-users early in the design phase.

A challenge arose as there was no Deep Purple systems realized, and thus no current users. As a substitute for Deep Purple-user, the project interviewed subsea personnel working in oil and gas.

Working with ConOps

Showing the illustrative ConOps to the offshore personnel as we talked, had a positive effect on the information we were able to gather from them.

The interviewees had no experience with Deep Purple, but the illustrations made them comment on things they could relate to such as accessibility offshore, claustrophobia and how to effectively move around during an offshore maintenance operation.

Recommendations

When to use it and what to expect

Using an illustrative ConOps helped the interviewees to reflect on the questions asked and create an understanding of the system.

Illustrative ConOps is well suited to gain insight in what potential users of a new system needs, and their problems. Overall, including human values in the early phase of an innovation project are hugely supported through the use of illustrative ConOps.

1. Focus on the operation

Discussing operational aspects at the startof a large project is essential for success of the resulting system. Illustrating the operations in a simple drawings improves communication. ConOps can facilitate feedback from operational and other non-technical persons, and force the technical persons to focus on the operations and not only technology.

72

2. Validation and Rapid Learning

Illustrative ConOps has been identified to be effective for early validation of user needs, offering a good approach to fail early and to learn rapidly. Stakeholder involvement supports faster development by knowledge sharing.

3. Scenario Making

The focus on human values enabled systems engineers to elicit new stakeholder requirements. Designing visual representations of operational scenarios forces the systems engineers to focus on users, and helps other stakeholders to give feedback on to the system.

Publications

This paper investigates how to better understand end users' human values at an early phase of system design in an innovative new-energy project with the focus on the use of ConOps.

Reference: R. T. Aarsheim, K. Falk, and S. Kjenner, "Electing User Needs Related to Human Values through Illustrative ConOps - a new energy case study (in press)," INCOSE Int. Symp., 2020.

This paper explores the use of an illustrative Concept of Operation and Pugh matrix as tools when evaluating concepts in the subsea domain.

Reference: Solli, H., & Muller, G. (2016). Evaluation of illustrative ConOps and Decision Matrix as tools in concept selection. INCOSE International Symposium, 26, 2361–2375. https://doi.org/10.1002/j.2334-5837.2016.00300.x
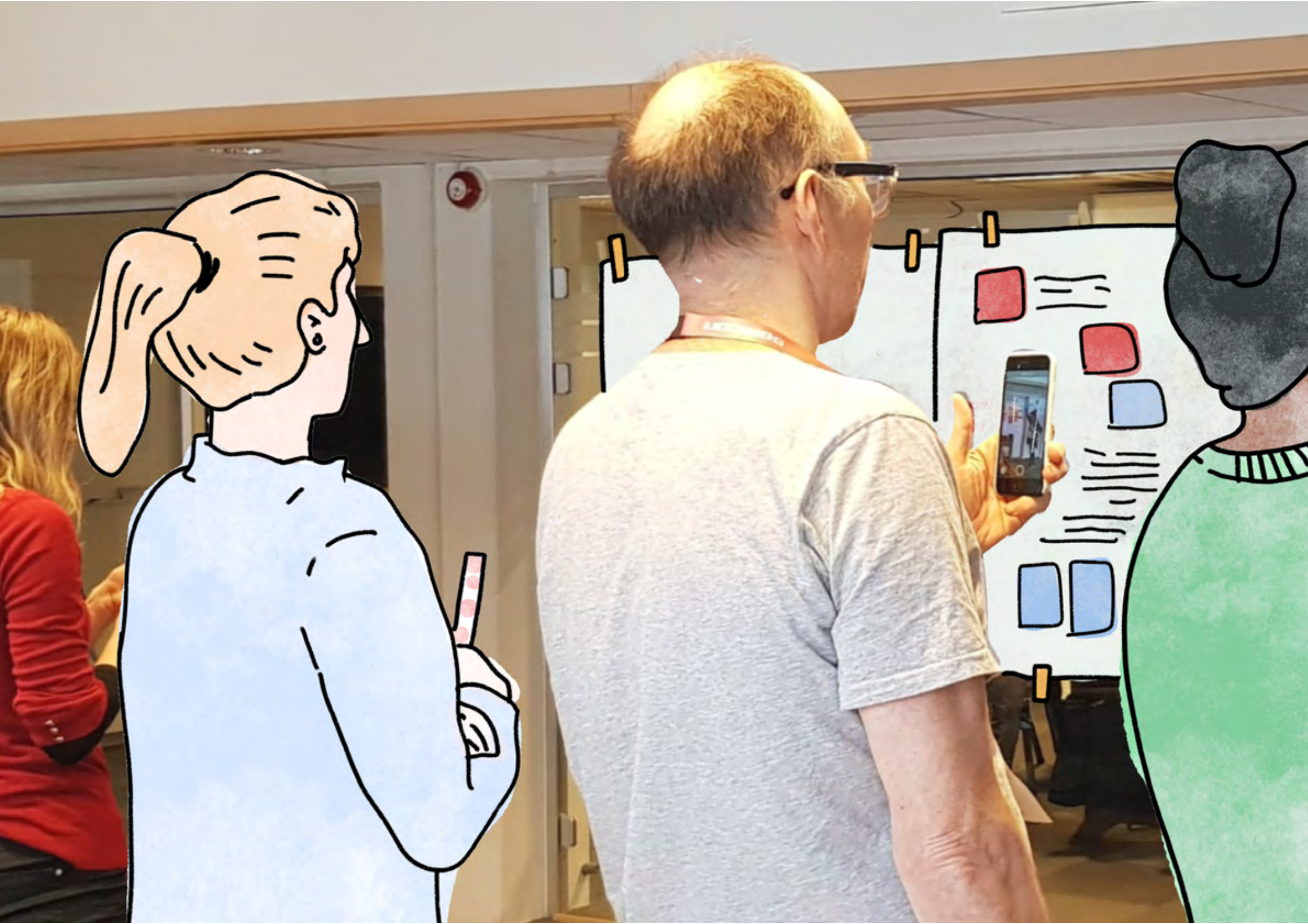
AUTHOR	DOC. NR	ISSUE	PROJ. & TASK	DATE
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👤 PROFILE

Who is the Stakeholder? Is it an Active or Passive one? Primary or secondary? Internal or external? Say more.

♻ ROLES AND RESPOSIBILITIES

Describe the responsibilities and roles of the Stakeholder.

MAIN INTERESTS

❤ DESIRABILITY

- What are the emotional, cultural and social wishes of the Stakeholder? What shall the stakeholder be proud of?

💰 VIABILITY

- What revenues and benefits is the Stakeholder looking for? More turnover? Lower costs? More intangible assets (brand awareness, customer loyalty, patents)?

🎯 CAPABILITY

- What is the stakeholder's functional goal? What functions, tasks and performance the stakeholder needs to improve life?

Visual Canvas

———

Systems developers need a method that captures emotional needs from the users and customers, and communicates those needs to other project members, bridging the gap between the human values and the engineering tasks of a project.

Typically, the emotional needs of humans are often not included in the stakeholder requirements provided by technical-oriented customers. Inspired by design thinking, visual canvases are designed to elevate human values and perception, enabling design of systems that are desirable, feasible, and viable - where desirability includes user experience and user interaction.

Visual canvases are artefacts that facilitate communication and support decision making. In this section we will highlight two canvases - Human Stakeholder Analysis Canvas and Use Case Scenario Canvas. Building on the momentum of the H-SEIF project, further development of visual canvases took place through projects within industry setting.
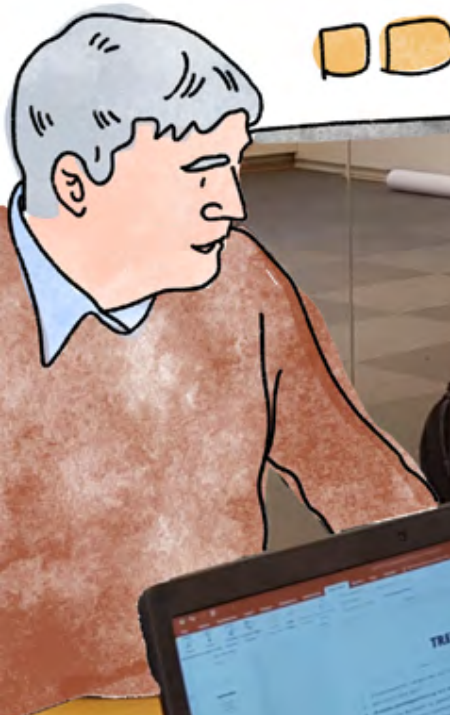
A Case Study

In this section, we'll show a case study of a system development project in Semcon, a medium sized innovation consultancy. We implemented two visual canvases in an early concept study for a customer in the construction industry. One of the canvases was used for conducting stakeholder mapping and stakeholder interviews. The second visual map was used to support concept generation by use case scenario mapping. The project team used the maps for documentation and communication towards customers and within the project team.

Project Background

The customer was an international supplier of construction machinery and equipment. Due to stricter regulations, the customer needed a system that improved the operational working environment by reducing emission from the construction machines during operation.

The challenge was to reduce the dust emissions without compromising the effectiveness of the machine or the operator.
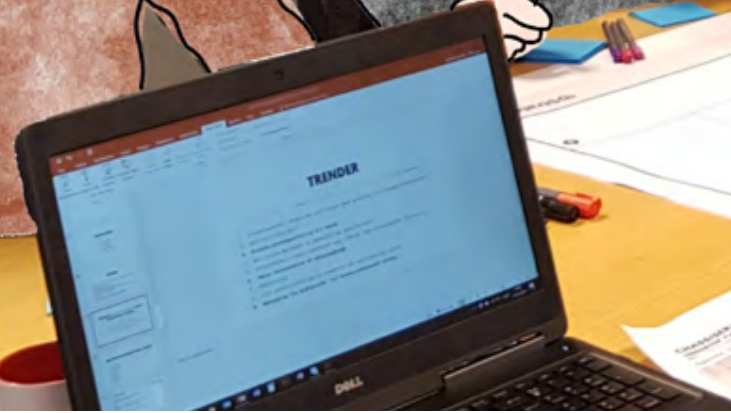
Step one: Identifying stakeholders

The project team conducted an initial research during the start-up phase. The customer explained the problem and presented the stakeholders and their needs. The information gave a starting point to the stakeholder map.

The stakeholder map evolved during the stakeholder analysis phase, as the team discovered new stakeholders and acquired new information. The project team used the stakeholder map as a tool in conversations within the team and with stakeholders which created the basis for the stakeholder interviews, use case scenarios, and concept of operations.

Step two: Observing and interviewing stakeholders

The project team performed three visits to different construction sites. They wanted to visit both small and large construction sites, as the customer explained that large construction companies have different needs than smaller companies. The team learned that regulations and controls are stricter in urban areas than in rural areas, due to neighbours and surrounding properties.

INTERVIEW DEL 1

#x NYE IDEER, ASPEKTER ETTER INTERVJUET.

ENGINEERING, OPERASJONSSENTRAL OVERVÅKNING

SVEIN

GOD TILGJENGELIGHET & SPACE i BÅT.

SPARE:
- 3 MNTH LEAD TIME

BEDRE PLANLEGGING

1. SIKKER TILSTAND i VINDMØLLA
   ||
   KLARGJØRE ARBEID, PROSEDYRER

2. LØFTE INN/UT

3. KLARGJØRE FOR OPPSTART.

TASK? BYTTE FILTER
×4 PER FC.

FORBEREDELSE   #2

KRAN FOR LØFT

OK CA. 30MIN

TRAPP/HEIS

PAIN POINT KREVENDE

KRONGLET TRANG

RISKS

LYS   AUTOMATISK SEKVENS

40× 4MW H₂

OK?

1 TIME
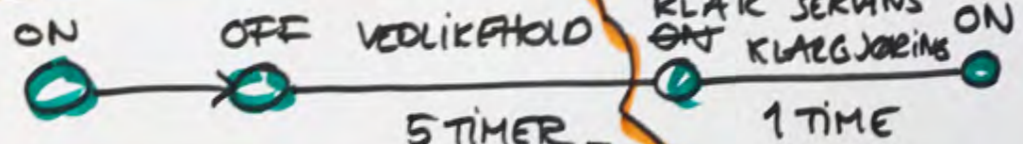
MIN 3, GÅR MED 2.

VEKT AV UTSTYR
STILAS, HØYT, BISTÅ HVERANDRE

H₂ SENSOR

SIKKERHET

NY TEKNOLOGI

ON   OFF   VEDLIKEHOLD   KLAR SEKVENS SÅ KLARGJØRING ON

5 TIMER   1 TIME

TRENING, FORBEREDELSE ONSHORE
GODT ARBEIDSMILJØ

FAST UTST SLIPPE Å FRETT & T

NYE IDEER, ASPEKTER ETTER INTERVJUET.

Human Stakeholder Analysis - Operator

semcon

Profile

Who is the stakeholder?
Is it a primary, secondary or external one?

The operator is performing the construction work from the cabin or outside, where he is exposed to emissions

Any additional tasks required from the operator will impact his productivity.

The operator is an active, primary stakeholder.

Role and responsibilities

What is the stakeholder role?
What are their responsibilities?

The operator is responsible for operating the construction machine and develop the construction area according to plan provided by the site manager

- Plan daily work
- Construction work
- Control machine w/ remote control or in cabin
- Daily maintenance

Operator

Interviews: "Joachim"   "Magnus"   "Erik"

Main Interests

Desirability

How will the system be perceived by the stakeholder?

- The operator expects to experience a robust and reliable system
- The system should be easy to operate with brief training.
- The operator wants to spend as much time as possible on the main operation, other tasks are considered inconvenient.

Viability

How will the system generate value (what value?) to the stakeholder?

- Productivity - effective production time
- Operational reliability - down time critical for economy

Capability

What are the interests related to the functions & performance of the system?

- The operator must be able to perform his tasks without being exposed to health hazardous emissions.
- The system needs to work without extra effort from the operator
- Safe working environment

Step three: Analysing the stakeholders

The engineer created Human Stakeholder
Analysis Canvas for each stakeholder, containing
a high level summary. The interviewers used the
canvas for notes during the interviews and for
further documentation after the interview.

The canvas allocated fields for the tasks and
responsibility of the stakeholder, in addition to
the pains and gains related to the daily work
interacting with the system. By documenting
the learnings from stakeholder interviews on
a canvas, the knowledge was available for
other members in the project team and to the
customer.

Step four: Defining key drivers and stakeholder requirements

The human stakeholder analysis, together with
the user scenarios and the CONOPS, formed
the foundation for the key drivers and the
stakeholder requirement specification. The
purpose with the key driver graph was to keep the
traceability between stakeholder requirements
and the stakeholder needs, and to create a basis
for discussions during concept development and
concept evaluation.

Step Five: Concept Generation and Selection

The project team generated concepts in internal brainstorming sessions and in workshops with the customer and other experts from the industry. The Use Case Scenario Canvas was used to further develop use cases and define system requirements for the selected solution.

In the workshops, the workshop facilitator presented the material from field visits and stakeholder analyses to provide context to the problem. The concepts were later evaluated in multiple iterations.

The engineers defined the criteria for evaluation based on the input from stakeholder analyses, key drivers, and stakeholder requirements, with the purpose of highlighting the human values in the selection of possible solutions.

Use Case Scenario Analysis

semcon

Short Description

What to achieve on this case?
What is the context and background for it?

Actors

Who are the primary actors (represent the use case goal)?
Who are the supporting actors (support the use case)?

Preconditions

What are de conditions that must be true for this use case to begin?

Guarantees

What are de conditions that must be true at the end of this use case?

Steps (actions)

What is the sequence of steps in which nothing goes wrong?

1.

2.

3.

4.

5.

Human Interaction

How shall the actor (user/operator) interact?

Experience

How shall it look, sound and feel? How shall the actor perceive the interactions?

Recommendations

When to use and what to expect

Direct contact with end-users is not always possible, known or prioritized in the early concept exploration phase. Visual canvases can be used to increase awareness of domains of interests, in this case - human values, through focusing on the user. Learning from the canvases can be used to identify needs and transform them into stakeholder and systems requirements. Here are some of the outcomes which can be achieved by using visual canvases:

1. Building mutual understanding

Complex problems can be hard to grasp and communicate with only words. Human Stakeholder Analysis Canvas contributes to a mutual understanding among the project participants where visual presentations helped the actors to see the whole picture and facilitate discussions. For instance, customers experienced that Human Stakeholder Analysis canvases were effective for communicating with managers and other external stakeholders.

2. Developing empathy for human needs

To design for people, the designer must gain empathy for who the people are, and what is important to them.

Project participants experience the stakeholder interviews and observation as effective activities for understanding the needs of stakeholders. Conducting multiple field visits facilitates a better understanding of the problem and its context.

3. Better learning and synthesis

The canvases provide a point of view of real persons related to the problem of interest. By documenting the stakeholder interviews and observations on Stakeholder Interview Canvases it was observed that the project participants were able to synthesize the learnings from field visits.

4. Use of multimedia process as an add on

In sessions with participants, the use of photos, videos, and visual descriptions has shown to be significantly better (compared to exclusively text based descriptions) for obtaining knowledge and mutual understanding of human values.

Using mapping techniques in the transition between empathize and define mode can help in achieving a mutual understanding of stakeholder needs.

Publications

This paper investigates development of the 'visual canvas tool' for the purposes of ensuring that systems engineers generate requirements related to human values.

Reference:
J. Pinto, K. Falk, and M. Kjørstad, "Inclusion of human values in the specification of systems : bridging design and systems engineering," INCOSE Int. Symp., vol. 29, no. 1, pp. 284–300, 2019.

This study explores the effect of Design Thinking techniques for capturing and communicating human values in the early phase of Systems Engineering using visual canvases.

Reference:
N. M. Sjøkvist and M. Kjørstad, "Eliciting Human Values by Applying Design Thinking Techniques in Systems Engineering," INCOSE Int. Symp., vol. 29, no. 1, pp. 478–499, 2019.

"Systems engineers are educated to ignore all subjective, fluffy requirements!"

Programme Manager

"I know I should take 'more' the human values into the specification, but it is just very easy not to..."

Systems architect

Co-Sessions

———

When developing a system or product, it's crucial to avoid expensive changes late in the development process. Validation of stakeholder needs, prior to project start, is necessary to ensure that the right idea is being developed.

Co-sessions as a tool was explored with the intention of providing better input for the "Elicit stakeholder" activity during early systems engineering processes.

Co-session is a tool for systems engineers that consists of a carefully chosen set of tools, a planned agenda and structured as a two day workshop.

The Design Thinking tool 'Co-creation session' was investigated within the SE context at Semcon by a systems engineering student to see how it could contribute as a tool to validate stakeholder needs during early development projects.

A Workshop Case Study

Co-sessions within industry set-up

Semcon develops products together with customers in a number of different domains. In this work they use co-creation sessions as an early phase workshop together with key stakeholders.

Co-sessions engage the customer in the design ideation, creative problem solving and decision making.

Workshop with Chassis Production Company

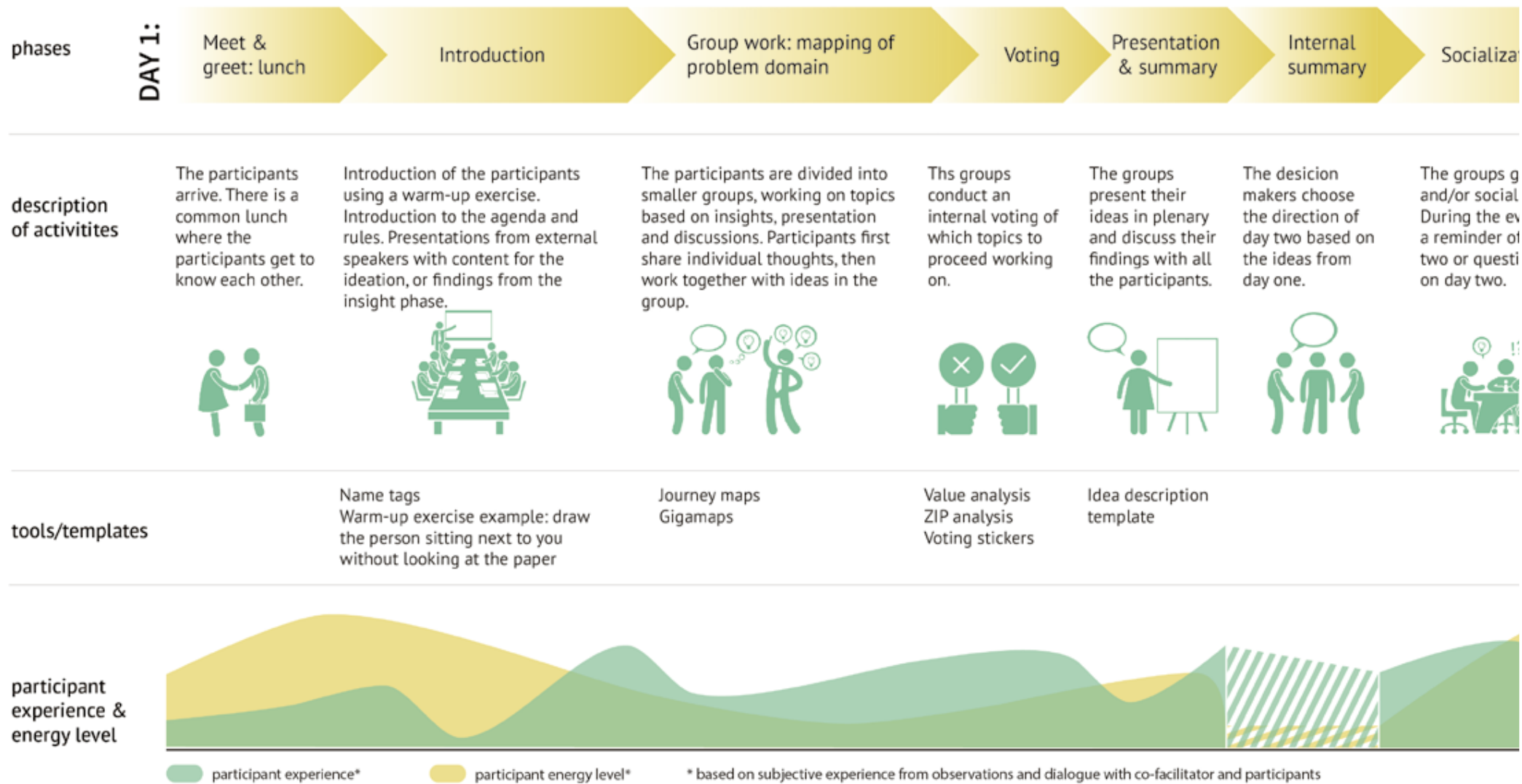One of Semcon's clients is a small production company ('customer') working with installations on chassis. Their users include car dealers, entrepreneurs and communes.

Their primary challenge was the need for developing a competitive advantage by moving towards digital and, creating more effective and robust processes.

EXAMPLE OF HOW TO RUN A TWO-DAY CO-SESSION

phases	DAY 1:	Meet & greet: lunch	Introduction	Group work: mapping of problem domain	Voting	Presentation & summary	Internal summary	Socializa
description of activitites		The participants arrive. There is a common lunch where the participants get to know each other.	Introduction of the participants using a warm-up exercise. Introduction to the agenda and rules. Presentations from external speakers with content for the ideation, or findings from the insight phase.	The participants are divided into smaller groups, working on topics based on insights, presentation and discussions. Participants first share individual thoughts, then work together with ideas in the group.	Ths groups conduct an internal voting of which topics to proceed working on.	The groups present their ideas in plenary and discuss their findings with all the participants.	The desicion makers choose the direction of day two based on the ideas from day one.	The groups g and/or social During the ev a reminder of two or questi on day two.
tools/templates			Name tags Warm-up exercise example: draw the person sitting next to you without looking at the paper	Journey maps Gigamaps	Value analysis ZIP analysis Voting stickers	Idea description template		

participant experience & energy level

participant experience*   participant energy level*   * based on subjective experience from observations and dialogue with co-facilitator and participants

| Socialization: dinner | DAY 2: | Introduction | Group work: sprints | Presentation & voting | Group work: concept work | Presentation & summary | Closing & socialization: lunch |

...e groups gather for dinner
...nd/or social activities.
...uring the evening, the group get
...reminder of the topics for day
...wo or questions to be answered
...n day two.

Day two starts with a funny warm-up exercise.
Then the topics and agenda for the day are presented.

The groups constitute themselves into new groups and start working in fast sprints on three to six topics. The groups rotate, so everyone have worked on the topics and built on each others ideas.

The groups present their work in plenary, starting a common discussion before a voting session.

Based on the voting, each group get one idea they will develop further into a defined concept.

The concepts are presented and an action plan made. The two days are summarized by the participants and the customer.

The co-session closes with everyone sharing their thought of the two days.
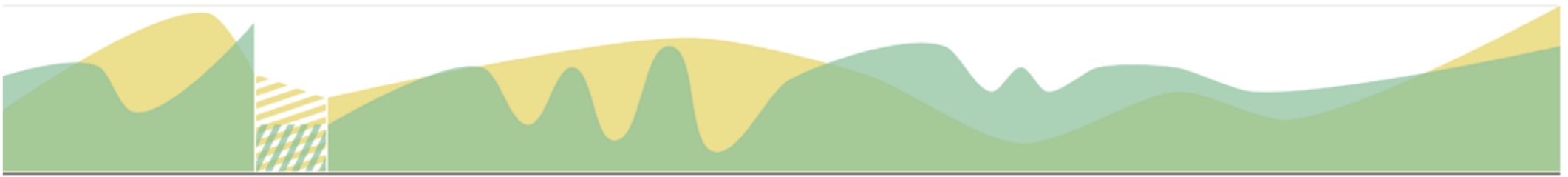A social lunch wrap-up the co-session before the participants return back home.

Warm-up exercise example: secret gift

Gigamaps
Concept descriptions
Business Model Canvas
Low fidelity prototypes

Voting stickers

Concept description
Action plans
Future forecast description

Innovation timeline with defined actions

Research and Field work

Before the workshop, project members undertook research to find data that helps to understand customer's reality. They conducted field visits and interviewed people working in manufacturing as well as management personnel to understand from their perspective.

Documentation in terms of process mapping, customer journeys, product life cycles and flow (work habits) were further supported by market and trend research. This provided material for strategy and analysis work.
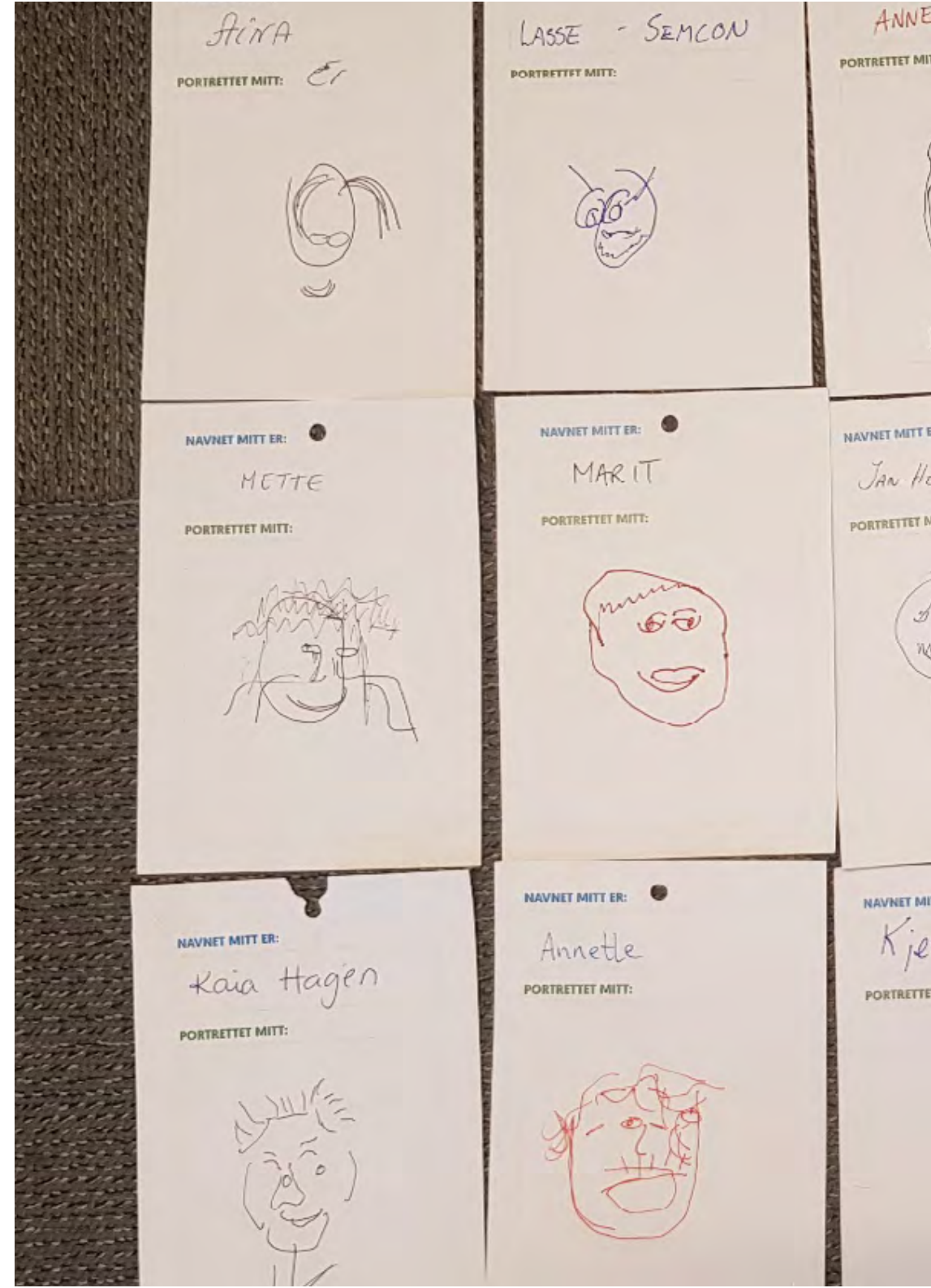
DAY ONE

Co-session usually includes people from different organisations, such as the customers and other relevant people such as external experts.

Step One: Introduction and Ice Breakers

It's important to create a positive environment and make space for free expression. The introduction of the participants begins with name tags and playful familiarising 'warm-up' exercises like drawing the person sitting next to you.

This is followed by agenda and rules, presentations from external speakers and a summary of findings from the insight phase which serves as content for the ideation.
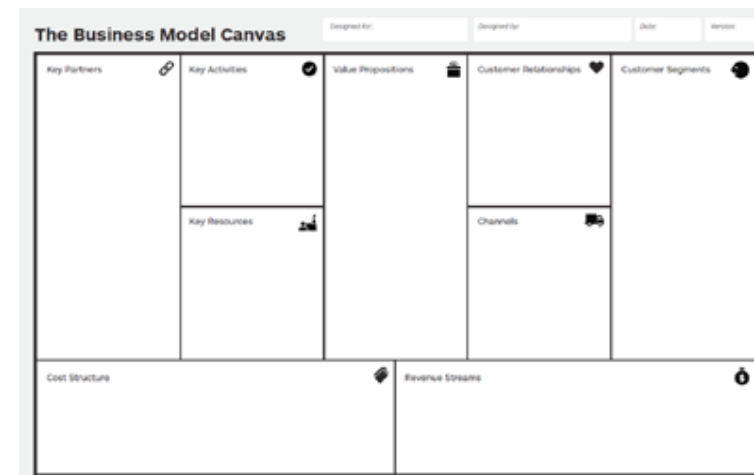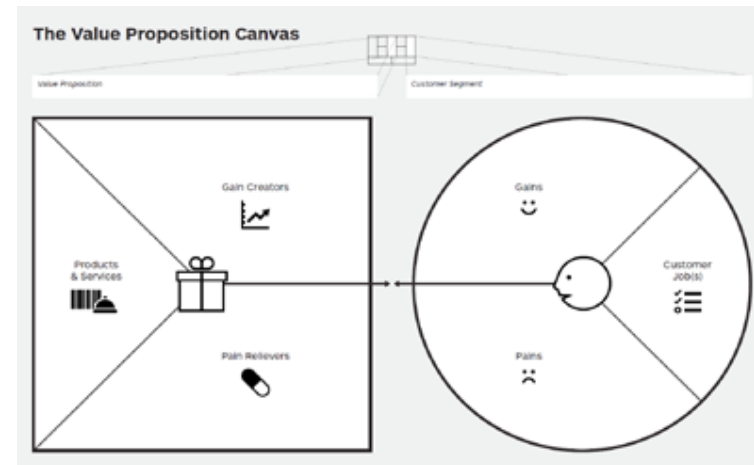
Step Two: Mapping of the problem domain

The group is divided into smaller groups working on topics based on the presentation and discussions. Participants share individual thoughts, then work together with ideas in the group.

Based on the customer profile, the groups use the value proposition canvas and business model canvas (by Osterwalder) and build a common understanding of how things are today. This includes building consensus on problem areas, challenges and opportunities. (Journey maps, Post-its and pens)

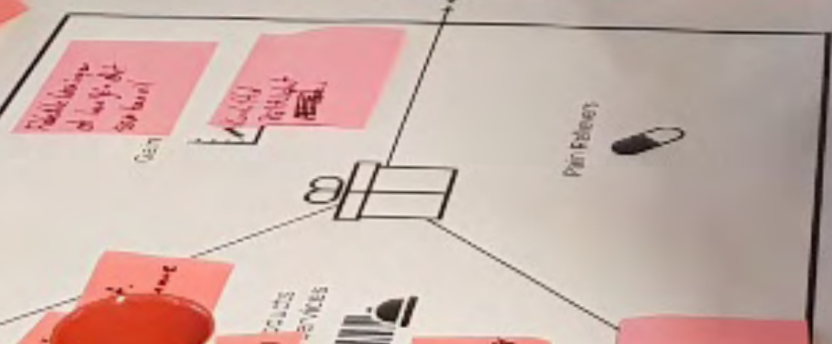**Step Three: Dinner and Discussion for next day**

The groups gather again to meet for dinner and/or social activities. During the night the group gets a reminder of the topics for day two.

DAY TWO

It starts with a funny warm-up exercise. Then the topics and agenda for the day are presented.

Step Five: Topics and Sprints

The groups constitute themselves into new groups and start working in fast sprints on three to six topics. The groups rotate, so everyone has worked on the topics and built on each others ideas. (Gigamaps, Post-its and pens)

Step Six : Voting and concept development

The groups present their work in plenary, starting a common discussion before the ideas are voted on. (Voting stickers) Based on the voting, each group get one idea they will develop further into a defined concept. (Concept description Action plan template Gigamap Post-its and pens)

Step Seven : Building the Solution Landscape

The two days are summarized by the participants, followed by a presentation of the final concepts. These concepts were further mapped as innovation time-lines or 'swim-lines' to create long term strategy that's based on results.

Step Eight: Collaborative Action Planning

This section also sets a foundation of decision making for people who will decide if this will become a project or not. By condensing and validating the next steps for the concept going forward, it ensures that the action plan is built by collaboration and consensus, making it much more likely to be picked up for execution post workshop.

ENGASJERT KUNDEREISE

- Lage plan for sosiale medier "Gratulerer med nytt kjøretøy"
- Ny nettside
- Skape relasjon med sluttkunde (filter) f.eks. Bring og Schenker
- Lage prosess for inkludering av sluttkunde i oppstartsmøte
- Lage service strategi
- Oppsøke 5 bilforhandlere i Ringerike
- Evaluere besøk
- Sende 5 tilbud med oppfølging
- Lande 2 avtaler (2 kraner x 2 mill)
- Få 1 ny kunde på kran

GODE PROSESSER

- Lage ny layout av verksted og lager
- **Skrive kontrakt om ny leieperiode på lokaler**
- Beslutte MPS/ERP system
- Godkjenning av endrings-meldings mal
- Nytt lagersystem
- Lage 1. utkast på prosessbeskrivelse
- Fjerne løftebukk
- **Opp...**
  lok...
- Flytte stillager

2019
Q2

SAMARBEID

- Avklare med HIAB selgere angående "felles"-kunder
- Nasjonal servicepartner via HIAB
- **Lande HIAB strategiavtale**
- Strategisk møte med HIAB

SMART & GRØNN PROFIL

Recommendations

Co-session is recommended to be used in the early phase of product development. By engaging the customer and the service-providing organisation early on, co-creation gives an opportunity to focus on customer's perspectives and share knowledge through interaction.
As a result we build mutual understanding of the customer needs. Engaging customers and exploring early phase concepts in collaboration makes it possible to fail early and learn fast, while enabling customer ownership of chosen concepts. This builds trust between the parties.

One of the areas of concern is pre-required skills. Co-sessions involves managing groups of people through many tasks, thus a good facilitator is one of the key skills required for an effective co-session.

Shorter co-sessions (co-sessions light) can also be applied within smaller teams to support more collaborative and creative ways of working than traditionally used by systems engineers. We have adapted this way of working and used it in rapid co-sessions within development teams.

1. Engaging key stakeholders for contributions

When a diverse group of stakeholders come together in an exclusive arena for dialogue, it creates a positive space for discussion and open mindedness.

2. Anchor and align stakeholder needs during co-creation sessions

By building a common problem and solution landscape using unconstrained formats, templates and canvases. Inclusive voting creates a consensus in the group that we are focusing on the right need.

Publications

This paper compares human-centered methods applied by the consultancy (in the context of early phase development) with theory from the body of knowledge within Design Thinking and Systems Engineering.

Reference:

M. Kjørstad, K. Falk, G. Muller, and J. Pinto, "Early Validation of User Needs in Concept Development: A Case Study in an Innovation-Oriented Consultancy," Int. Hum. Syst. Eng. Des. Conf., vol. 876, pp. 54–60, 2019.

This paper investigates the application of co-creation sessions as a method in the early phases of development projects.

Reference:

M. Guntveit, M. Kjørstad, and B. Sevaldson, "Early Validation of Stakeholder Needs by Applying Co-creation Sessions (in press)," INCOSE Int. Symp., 2020.

This paper investigates the use of co-creation sessions in a shorter and more iterative format for systems engineers not skilled in facilitation.

Reference:
Kjørstad, M., Muller, G., Falk, K. "A co-creative problem solving method for concept exploration and early validation in high-tech industry", in preparation for INCOSE Journal of Systems Engineering, 2020.

What's next

"The end of our journey..?"

We set out to create a new framework to develop significant innovations inspired by methods and tools from design thinking and systems thinking.

Through our journey we found our challenges and ways of working to be more similar than we first thought, even though we operate in different domains and our companies are of different sizes.

The H-SEIF project enabled us to discuss challenges and explore solutions across company boundaries. We have found the research collaboration project to provide valuable knowledge transfer and networking between our companies and academia where the companies have updated their ways of working.

Over these three years, we've had a core project team with one to four representatives from each partner, discussing challenges and solutions through six workshops and exploring six methods and tools in ten different cases at the companies.

We have graduated nine master students and (soon) one Ph.D. student through the Systems Engineering Master Program at USN. We have published twelve academic papers providing our learnings to the systems engineering community. Finally, we have inspired new ways of working within the companies using the H-SEIF toolbox.

The team is applying for funding for the H-SEIF Phase 2 and will focus on the theme of Big Data and Digitisation.

We hope that this booklet has inspired you and your team as well. Please contact us if you would like more information on the toolbox, or how to initiate a research collaboration project yourself.

Lasse Bjørkhaug
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Additional Resources

H-SEIF Project website
Centre for Design Research, Institute of Design
Oslo School of Architecture and Design (AHO)
https://designresearch.no/projects/h-seif/about

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Research papers by Doctoral Candidate Marianne Kjørstad (USN)

Kjørstad M, Falk K, Muller G. Exploring a co-creative problem solving toolbox in the context of Norwegian high-tech industry (in press). IEEE Syst J. 2020. doi:10.1109/JSYST.2020.3020155

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Kjørstad M, Mansouri M, Muller G, Kjenner S. Systems Thinking for Early Validation of User Needs in the Front End of Innovation; a Case Study in an Offshore SoS. In: 2019 14th Annual Conference System of Systems Engineering (SoSE). IEEE; 2019:382-387. doi:10.1109/SYSOSE.2019.8753865

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kind by partners. This book is written to inspire
systems engineering practitioners and create
curiosity about new ways of working to take the
step towards significant innovations.