Understanding the relation between systems engineering and software engineering

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Presenter: Richard Doornbos

ESI

Powered by industry, academia and TNO

ESI at a glance

Mission: Embedding cutting-edge methodologies into the Dutch high-tech systems industry in order to cope with the ever-increasing complexity of their products.

SYNOPSIS

- Foundation ESI started in 2002
- ESI acquired by TNO per January 2013
- ~60 staff members many with extensive industrial experience
- 8 Part-time professors
- Working at industry locations
- From embedded systems innovation to embedding innovation

FOCUS

Managing complexity of high-tech systems

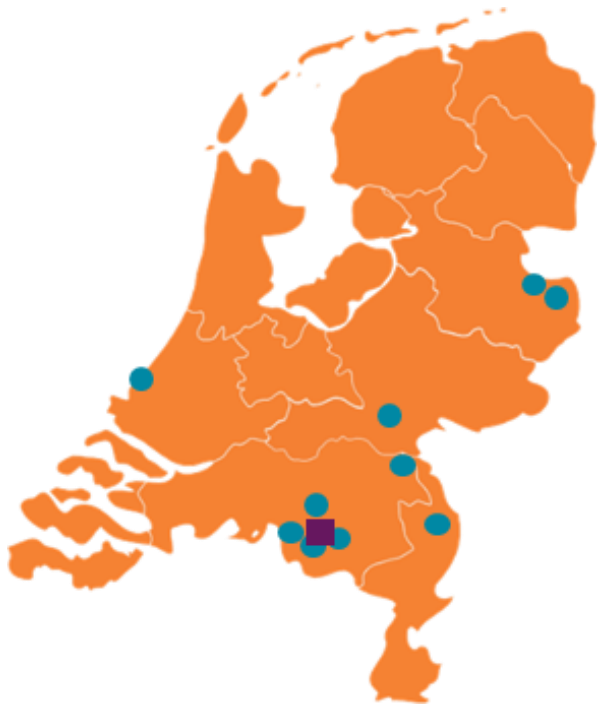
through

- system architecting
- system reasoning and
- model-driven engineering

delivering

- methodologies validated in cutting-edge industrial practice

THE NETHERLANDS



ESI's research program is driven by industry

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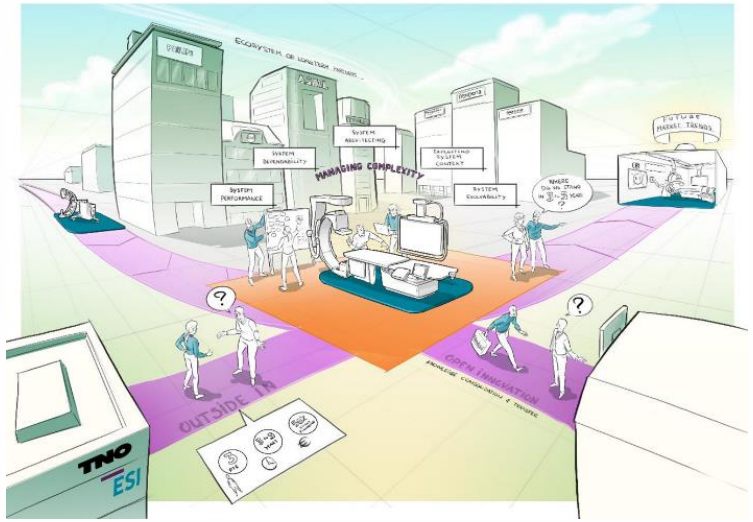


Industry drivers

ESI program lines

- System Performance
- System Dependability
- System Evolvability
- Exploiting System Context
- System Architecting

Knowledge development

ESI expertises

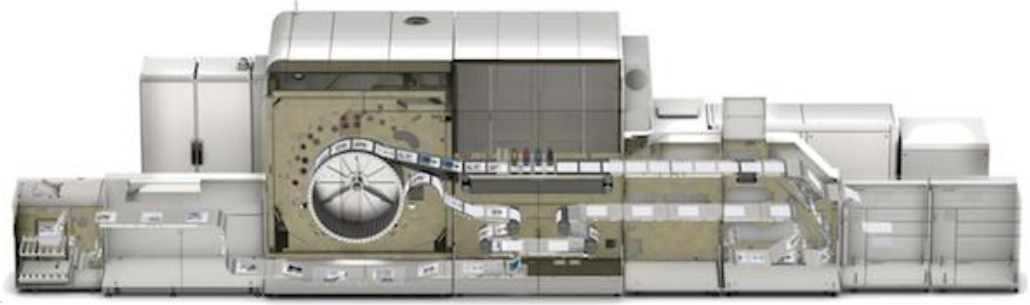
- System-Performance Engineering
- Software Legacy and Rejuvenation
- System and Software Testing
- Intelligent Diagnostics
- Software Behavior
- Adaptive Systems and Machine Reasoning
- System Architecting Systematics

ESI Research Program

High Tech industry

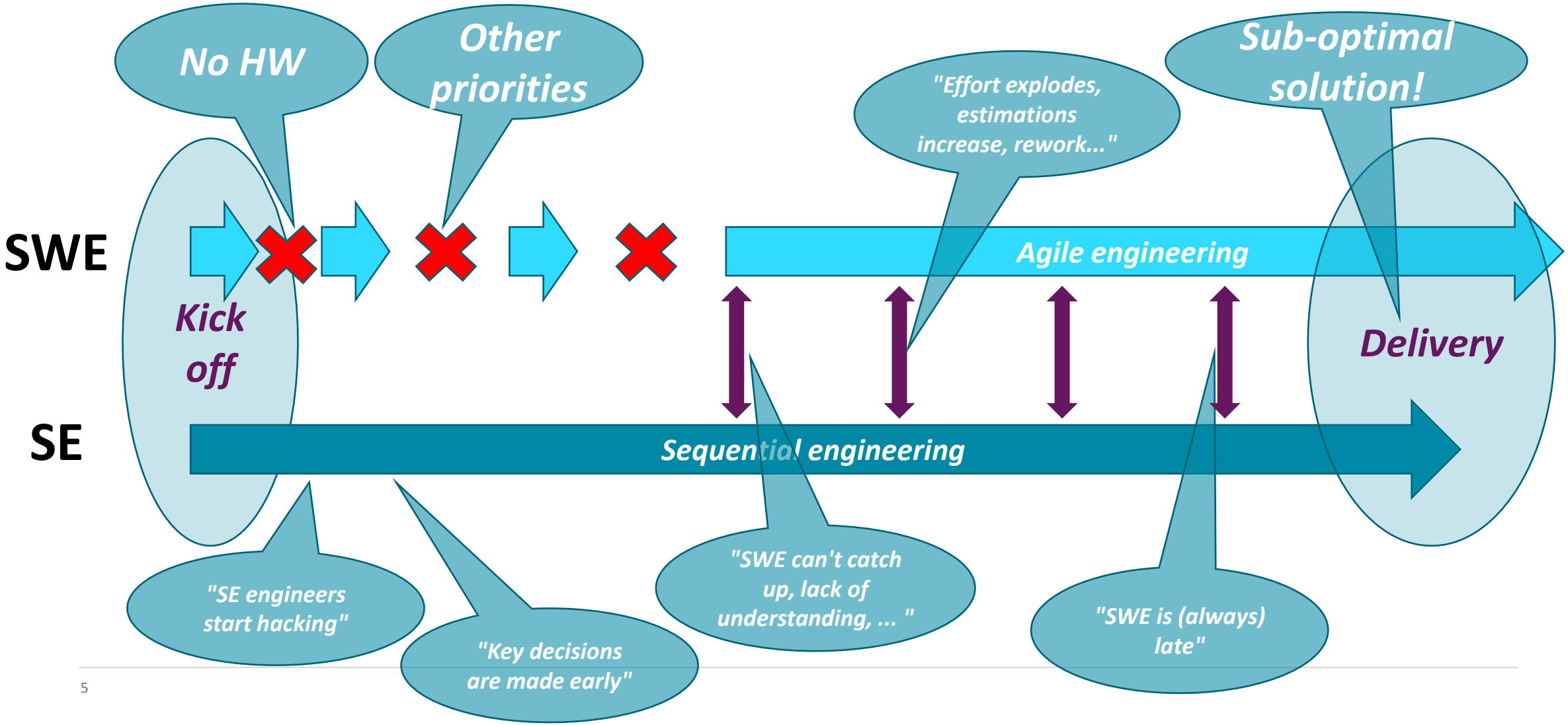
Complex systems

Systems & Software engineering...

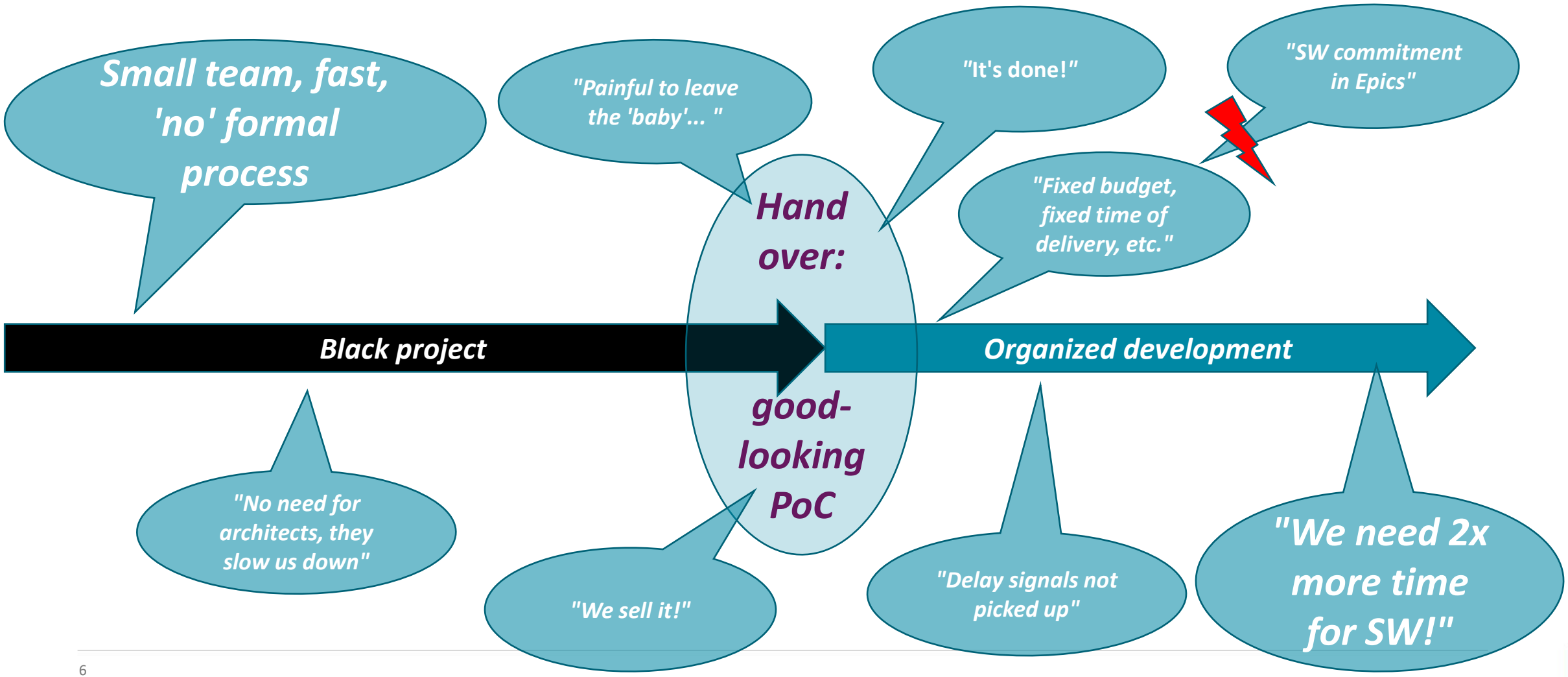


One example we heard...

Do you recognize this?



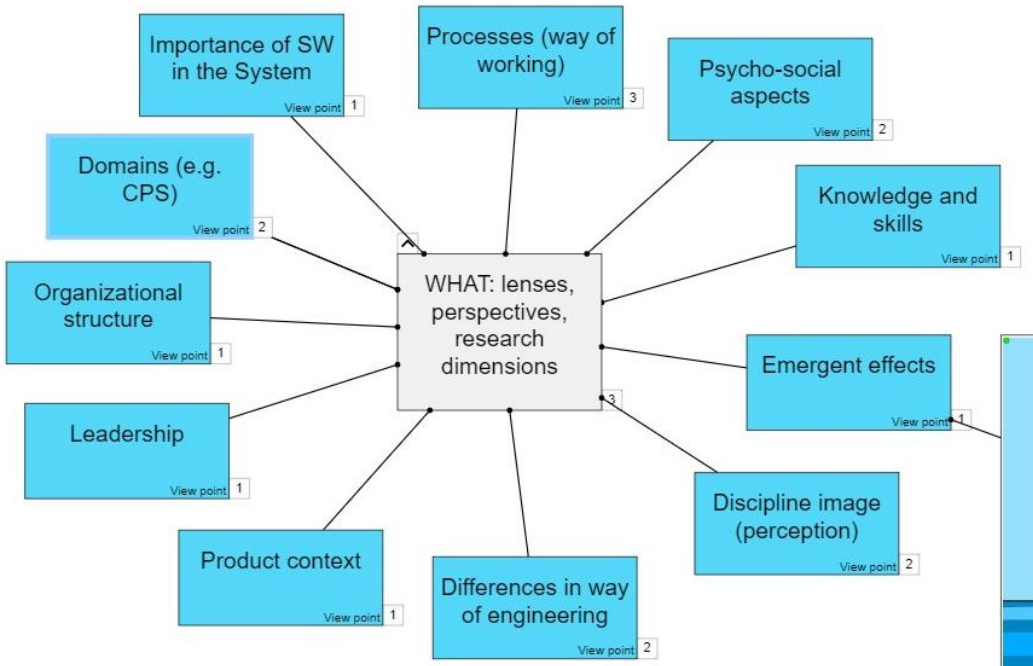
Another example...



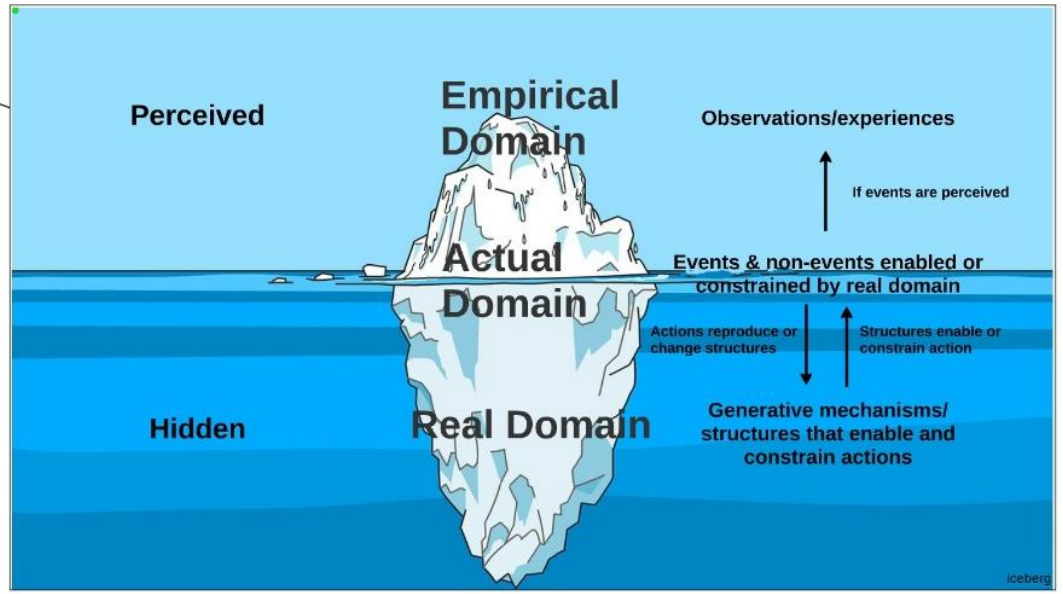
We are dealing with a complex sociotechnical system

Many things to look at: system, organization, processes, people

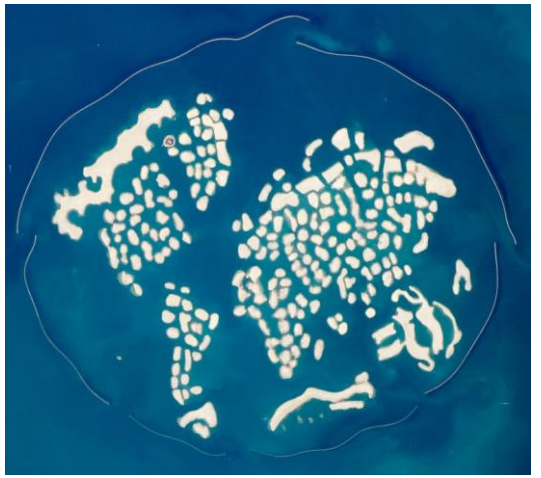
- symptoms, causes, effects, relations, opinions, inconsistencies, etc.



How important are these problems?
What are the costs, the effects?
How to investigate?



ESI's Archipel project



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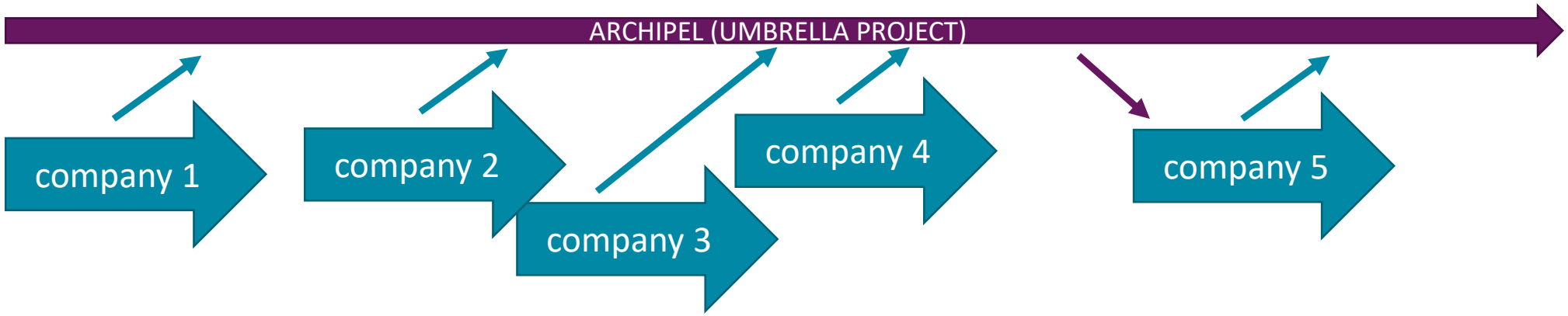
Goals and research questions

- **Understand the relation between SE and SWE**
- **We want to develop a *reasoning framework* to quickly diagnose a new situation**
- **Find and evaluate possible interventions**



ESI's partners ask for analysis and interventions

Still a lot to be learned: diverse and company-dependent problems

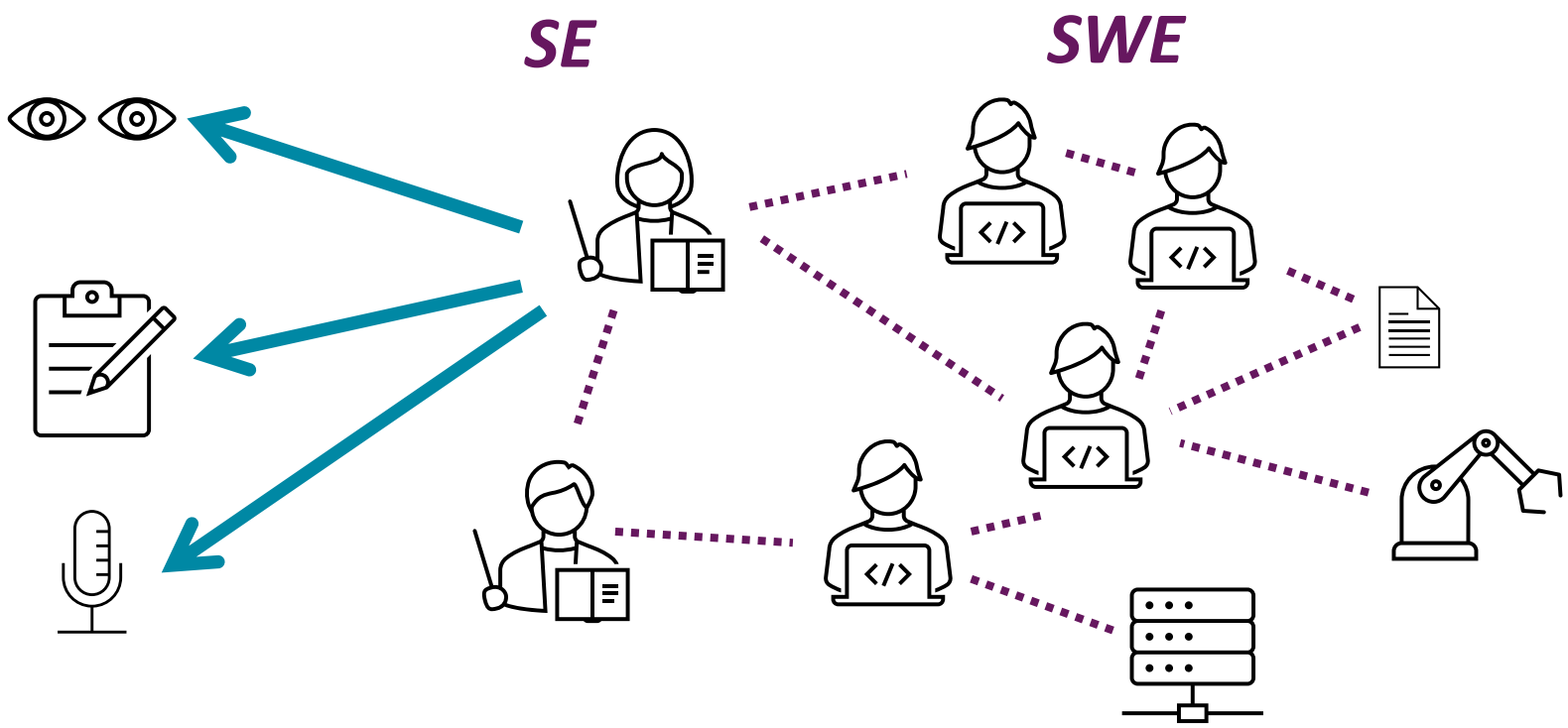
Approach

As an external team we:

1) analyze cases

2) understand

3) experiment / improve



Methods, formalisms, tools

analysis

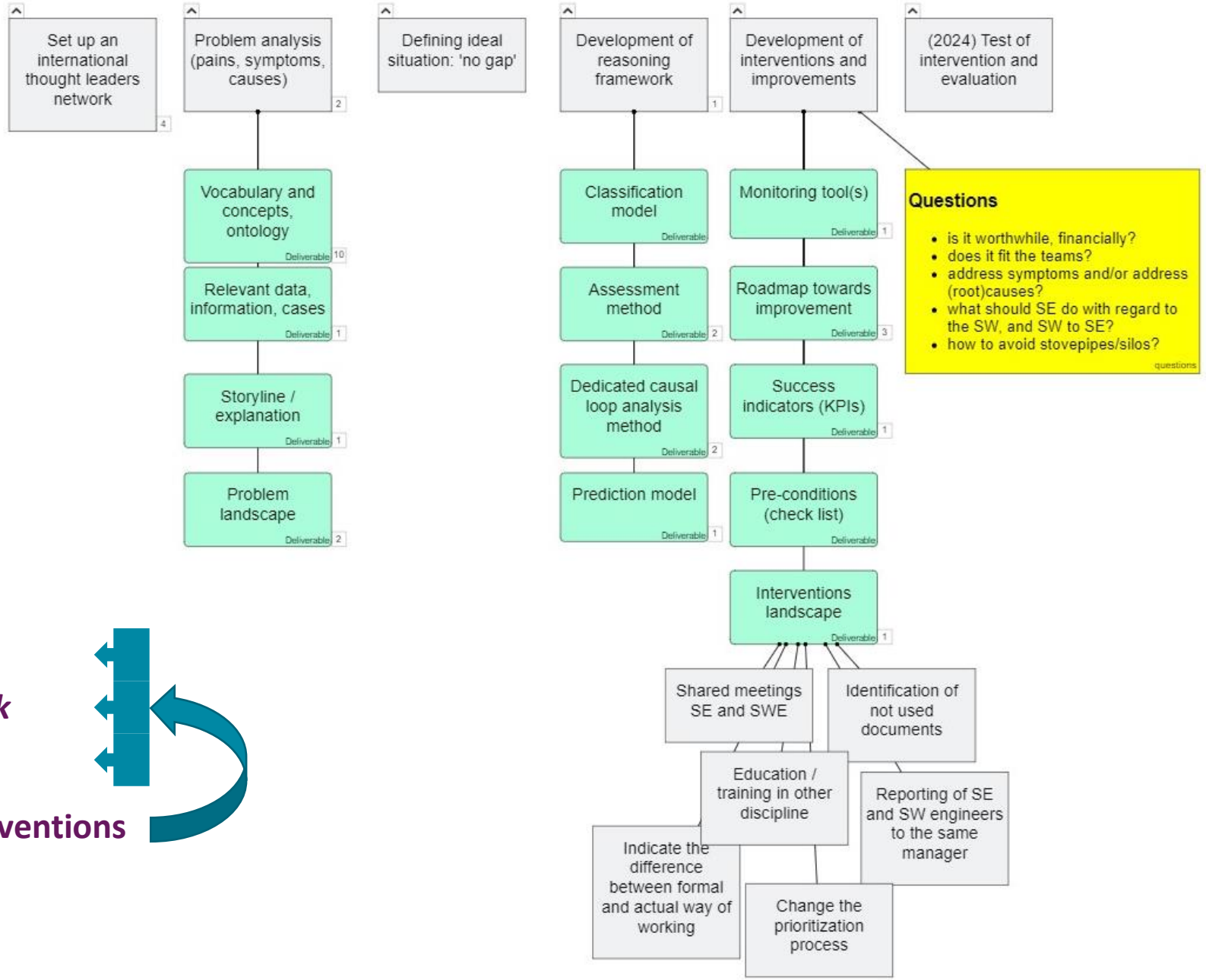
Proposed methods

- ***exploratory workshops*** **and** ***interviews*** **➔** ***rich information*** **about their processes and interactions**
- ***grounded theory***[1] **➔** ***recurring concepts*** **and their interrelationships**
- ***system dynamics*** **to understand underlying processes and how they influence each other**
- **different** ***lenses*** **(perspectives) on the subject**

Research challenges foreseen:
- bias (each interaction is an intervention)
- many domains to cover by the research team
- methods from social sciences (discomfort for empirical thinkers)
- company's domain knowledge is required
- keep attention (not their responsibility?)
- ...

1) Patricia Yancey Martin & Barry A. Turner, "Grounded Theory and Organizational Research," The Journal of Applied Behavioral Science, vol. 22, no. 2 (1986), 141.

Aiming for



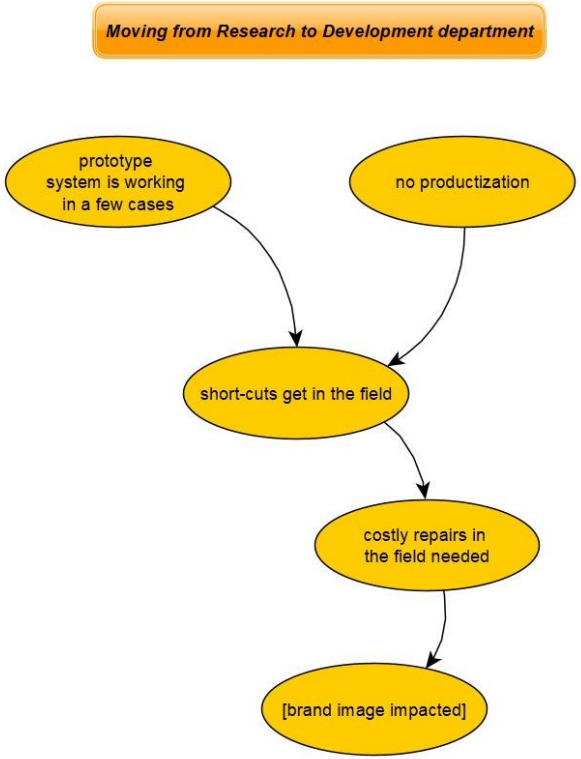
Generic deliverables

synthesis

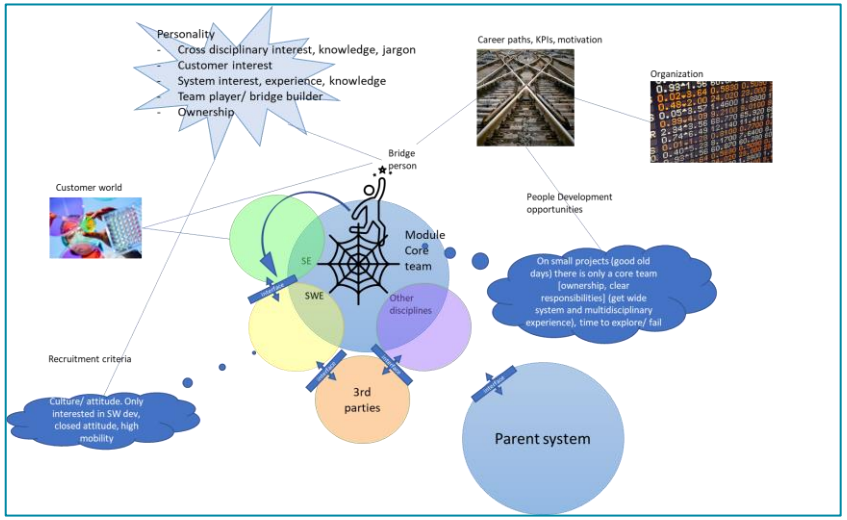
- **method for problem analysis**
- **concrete *reasoning framework***
- **identify *interventions***
- **implement and *evaluate* interventions**

Company 1: first interpretations of interviews

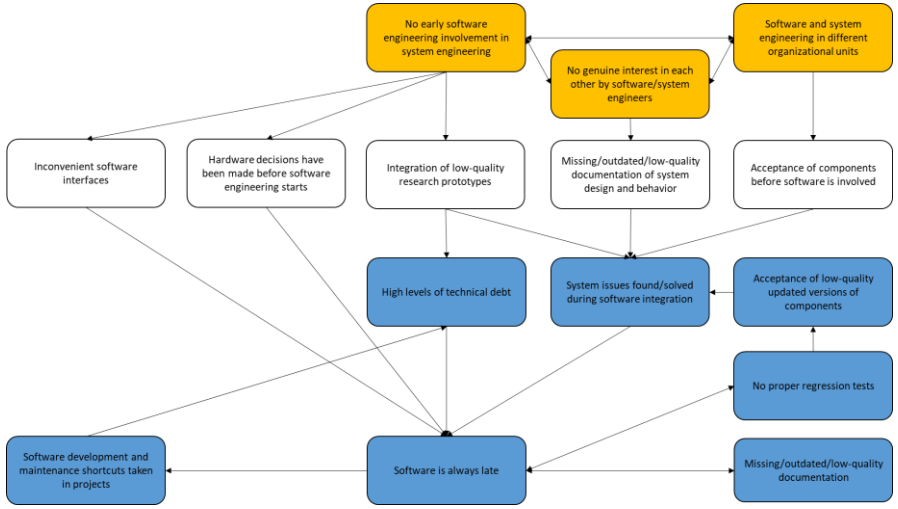
cause and effect diagrams



rich pictures



causal loops (system dynamics)



textual clustering

Way-of-working

* Project X:
--- Lot of new hardware + ….
--- Easy project because ….
----- Later on integrated in …
* Situation sketch
--- Y is formally 100% software architect, but ….
* Team with representatives of different disciplines + project management
--- Responsible from …

Trends

Solution directions

Paradoxes / Inconsistencies

Feedback loops

Company 1: first aggregation

In 3-person team

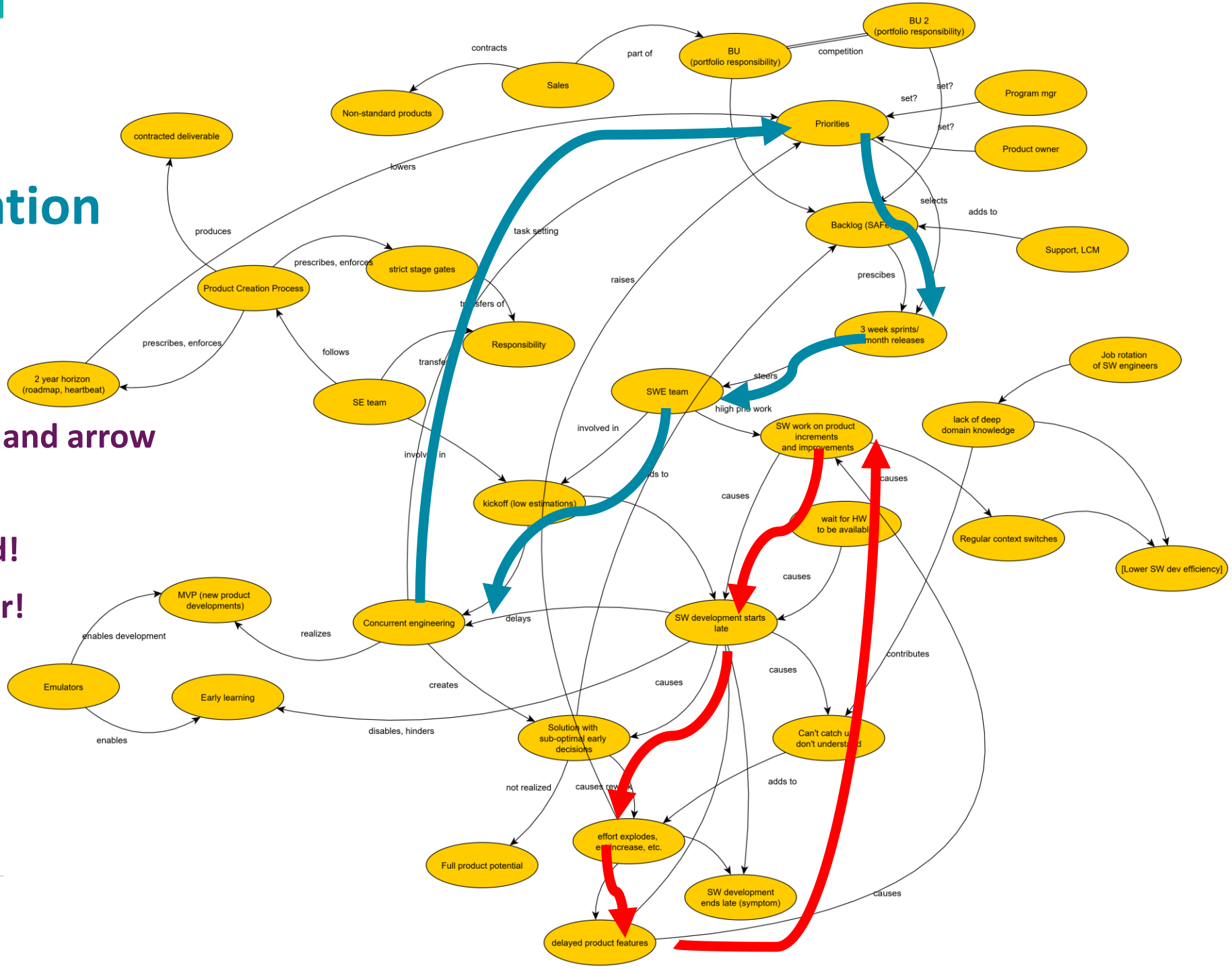
Free format

Meaning in bubble and arrow

Patterns recognized!

Causal loops appear!

Recognized in multiple cases



Company 1: results

Observations (a selection after 7 extensive interviews)

- Positive and negative
  - technical debt, delays, extra costs, damage of brand image, not repeatable results... *and still: successful products, enough work, growth*
- Engineering culture of isolated disciplines
  - SW engineers have preference for SW-only work; difficult to stimulate SW engineers to get experience with systems/products (motivation challenge)
  - SE engineers have little experience in SW
  - shortage of SW engineers leads to difficulty in getting and keeping them
- Development process
  - SE and SWE development processes are different: 'sequential' vs. 'agile'
  - not strictly followed, system engineers start hacking
  - SW development shifted in time
- No worries, no urgency at interviewees... (who is feeling the 'pain'?)
  - just waiting for someone else (higher up) to solve it?

Company 1: key factors (so far)

Different and not synchronized development processes

- **priority setting HW and SW by different 'committees'**
- **short-term business unit concerns vs. long-term new product features**

Job rotation of SW engineers

Shortage of SW engineers

Selling proof-of-concepts/prototypes as products

…

Do you see other key factors?
Is this only a Dutch problem, what about Norway?
Is this similar for Mech. Eng., El. Eng?

Summary

A complex dynamic socio-technical system with many connections: network of causes, effects

- A broad view is essential
- By doing this investigation we change the situation already

Careful planning of small interventions and evaluations required

More study required

- We've just started
- identifying common patterns requires investigations at multiple companies
- eventually publish generic results

Please join the conversation!

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