

# Using A3 Architecture Overviews as an educational tool

## *Educating new artists in Systems Architecting*

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# The Authors



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# Our story today

1. Educating System Architects
2. The A3 Architecture Overview
3. Case Study @ Master Next Level Engineering
4. Discussion & Future Work

# 1

# Educating System Architects

# Systems Engineering & Architecting

*“...the systems engineer resembles an architect, ... Like architecture, systems engineering is in some ways an art as well as a branch of engineering. Thus, aesthetic criteria are appropriate for it also. For example, such essentially aesthetic ideas as balance, proportion, proper relation of means to ends, and economy of means are all relevant in a systems-engineering discussion. Many of these ideas develop best through experience. They are among the reasons why an exact definition of systems engineering is so elusive.”*

Source: SEBOK. (2023). *SEBOK - A Brief History on Systems Engineering*. [https://sebokwiki.org/wiki/Brief\\_History\\_of\\_Systems\\_Engineering](https://sebokwiki.org/wiki/Brief_History_of_Systems_Engineering)

# Systems Engineering & Architecting

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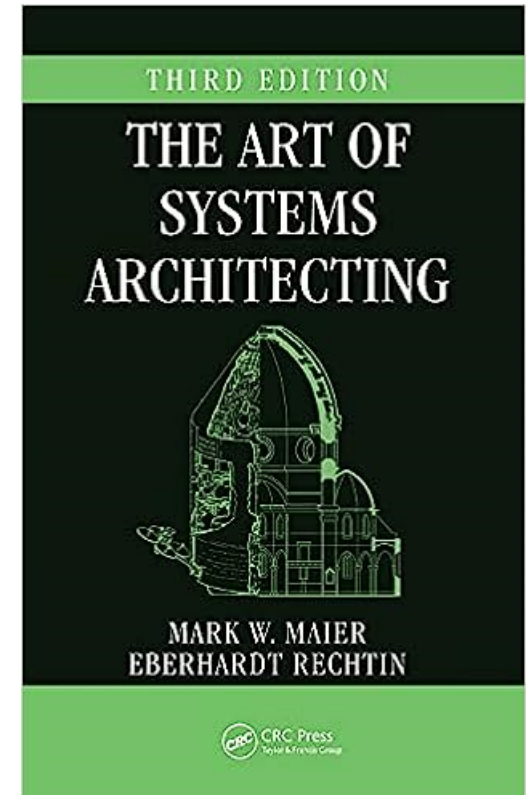
# System Architect – who do you picture?



Source: [This Photo](#) by Unknown Author is licensed under [CC BY-SA-NC](#)

# System Architect – Experienced Authority?

- Maier and Rechtin – heuristics
  - Experienced based application of common-sense guidelines
- Examples:
  - Simplify. Simplify. Simplify
  - Don't make an architecture too smart for its own good
  - Don't assume that the original statement of the problem is necessarily the best, or even the right, one



Source: Maier, M. W., & Rechtin, E. (2009). The Art of Systems Architecting (3rd ed.). CRC Press.

# Heuristics

- What are some of your favorite heuristics?
- (Steven) The largest part of the insight obtained through a modelling effort is through the process and not through the outcomes

# System Architecting Competencies Focus

Question in the paper:

- How to familiarize students with systems engineering and architecting? And which competencies to focus on?

What are your suggestions?

Our focused competences:

- be able to capture the essence of a system
- be able to visualize the essence of a system

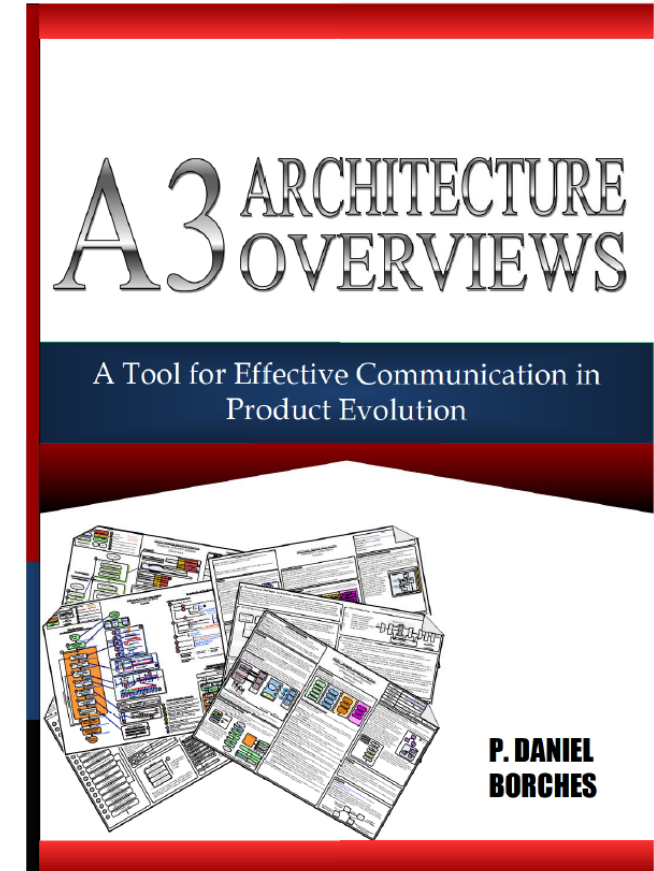
# 2

## The A3 Architecture Overview

# A3 Architecture Overviews

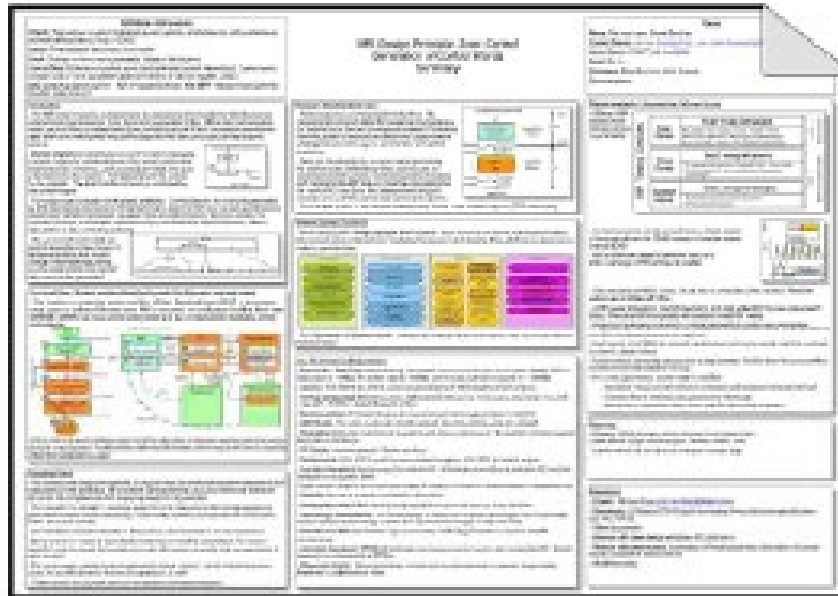
- Developed as tool to cope with product evolution challenges
- Inspiration from Toyota A3 reports
- Focuses on support of multidisciplinary communication
- Focuses on externalization of knowledge (Nonaka)

|      |                    | To                     |                        |
|------|--------------------|------------------------|------------------------|
|      |                    | Tacit knowledge        | Explicit knowledge     |
| From | Tacit knowledge    | <b>Socialization</b>   | <b>Externalization</b> |
|      | Explicit knowledge | <b>Internalization</b> | <b>Combination</b>     |

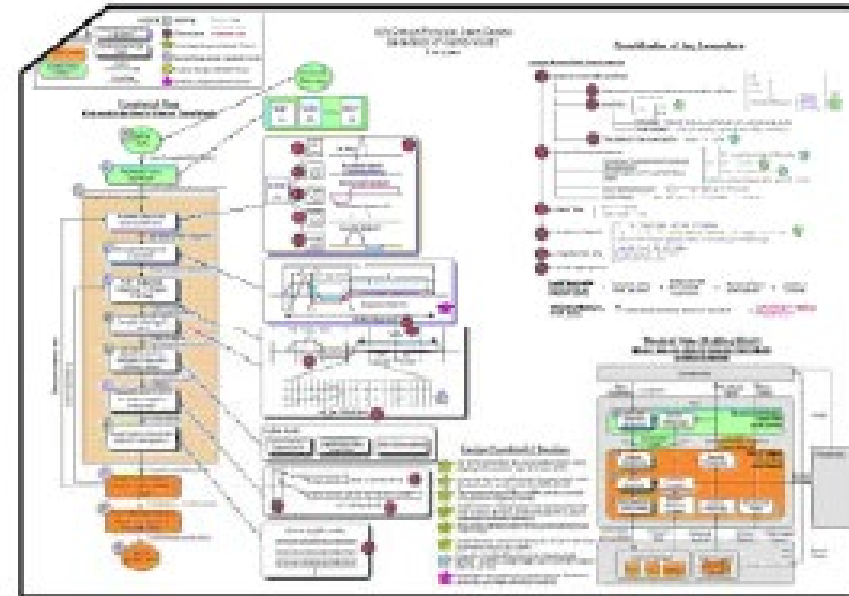


Source: Borches, P. D. (2010). A3 Architecture overviews. PhD Thesis. Department of Engineering Technology, University of Twente & Nonaka, I., & Takeuchi, H. (1995). The Knowledge-Creating Company. Oxford University Press .

# What is in an A3AO?



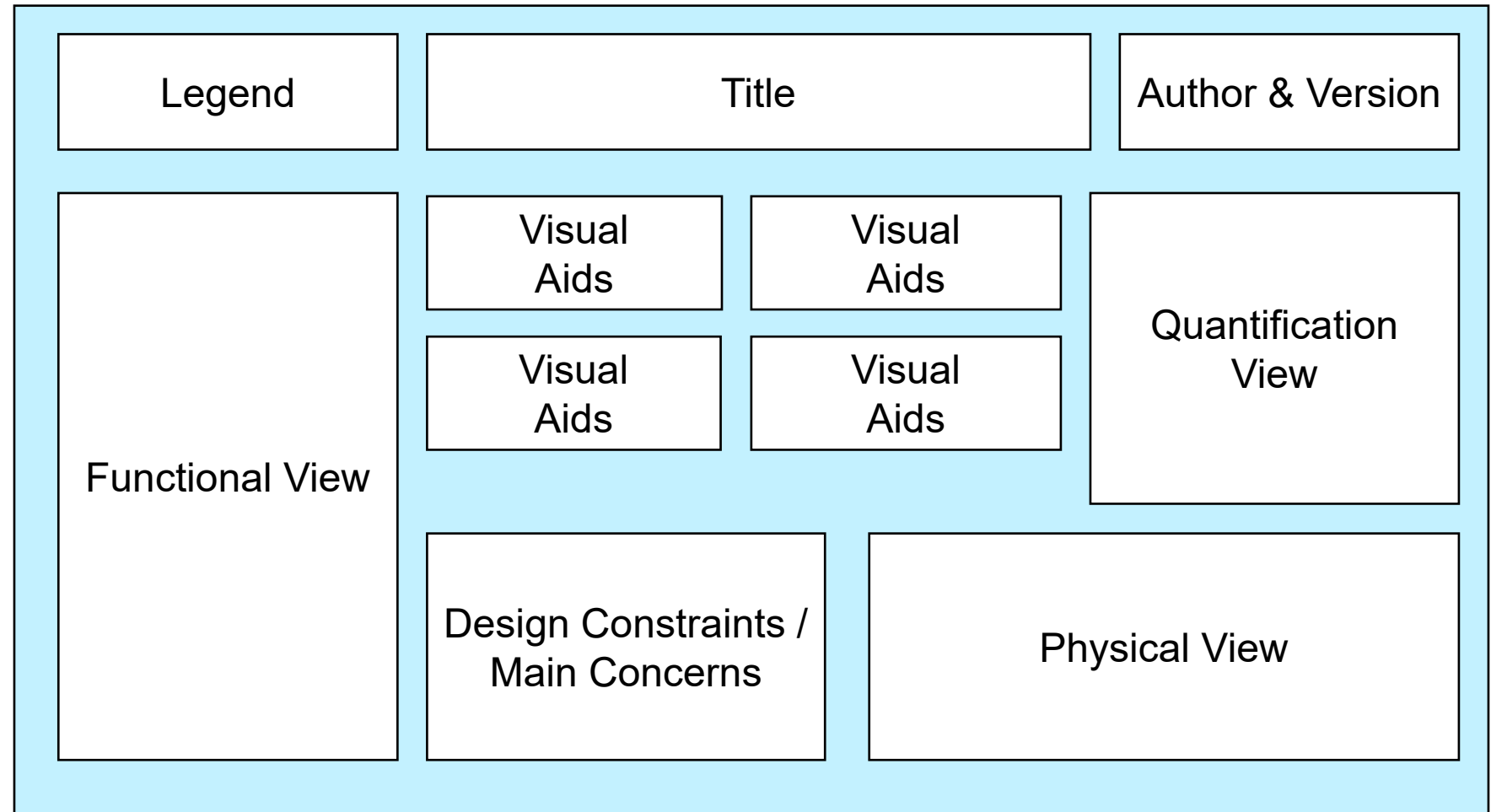
**Text/Summary Side**  
 Introduction  
 Rationale  
 References  
 Supporting Information



**Model Side**  
 The essence  
 Discussion tool  
 “Side in use / on the wall”  
 Oftentimes the only side

# A3AO Model Side Elements

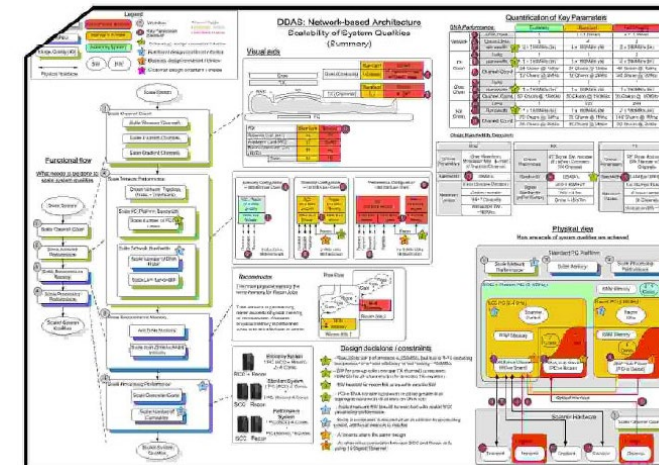
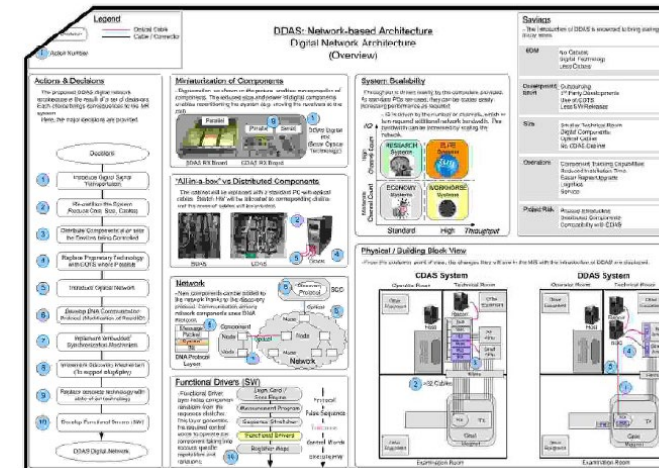
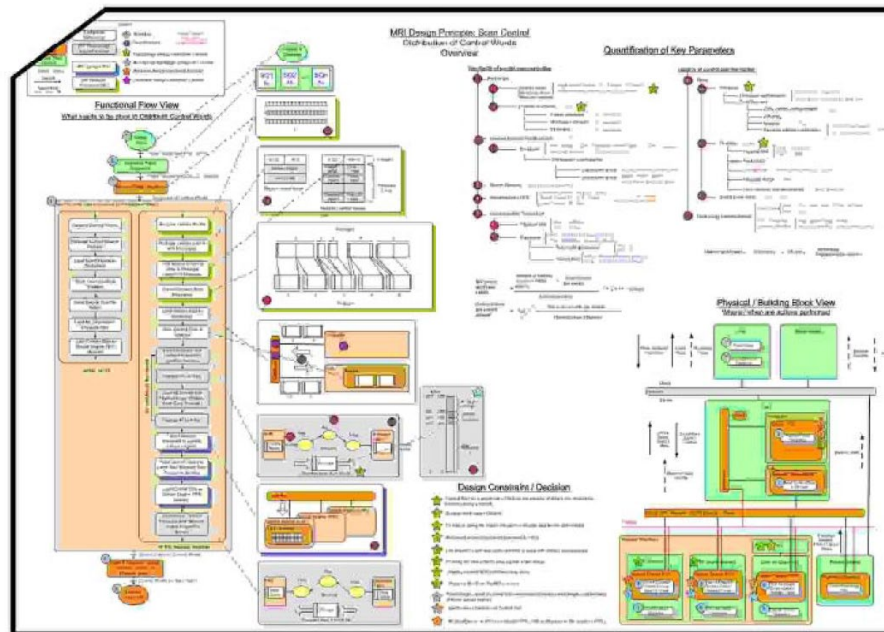
- This is the original structure
- Other structures certainly possible (and welcome)
- Combine views (and viewpoints!)



# A3AO Main Characteristics

- **A3 format**
  - Limits information content & forces abstraction
  - Allows enough information to get a good overview
- **Informal & Free Format**
  - No specific formalisms or syntax
  - No specific procedures described
- **Living Document**
  - Snapshot of relevant knowledge at a particular point in time
  - System Engineer is Owner
- **Communication Support Tool**
  - Main intent is a reference tool for design discussions
  - Can also be used for self learning

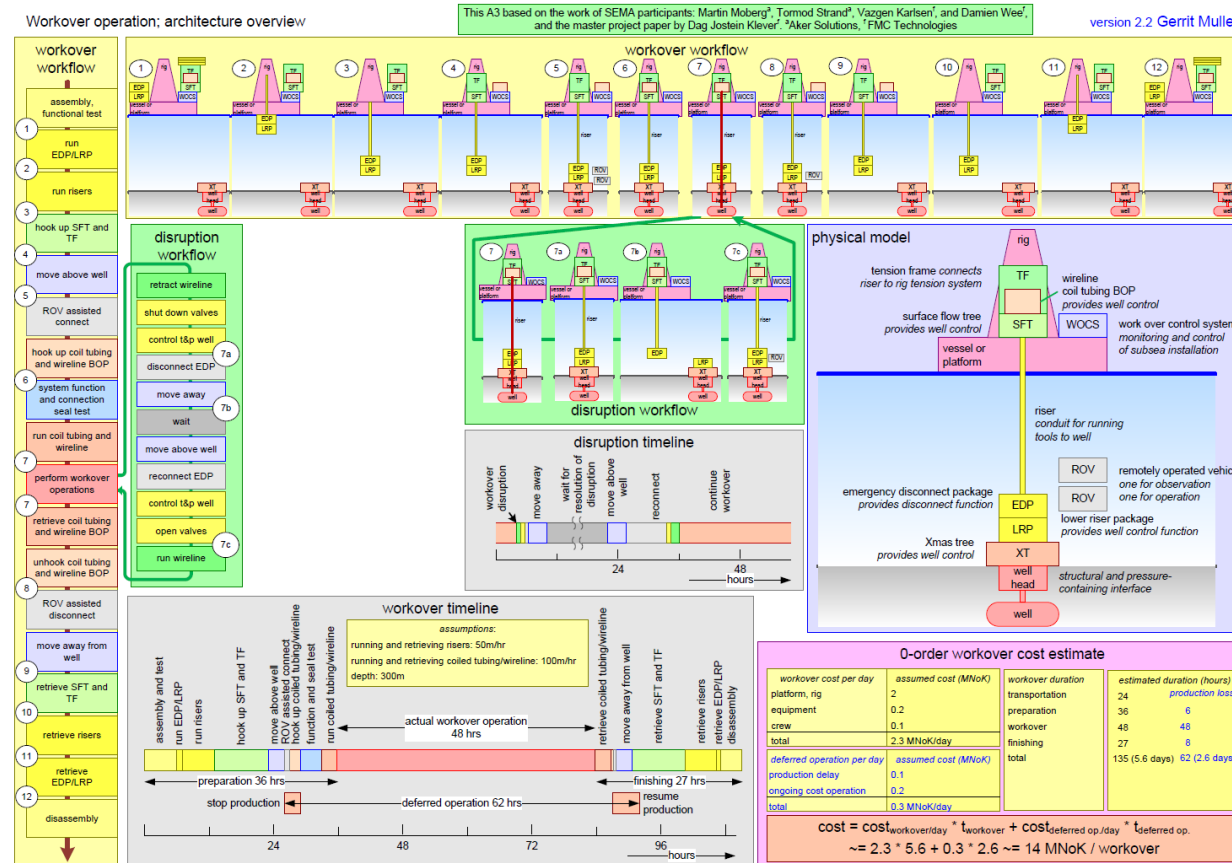
# A3AO Examples



## MRI @ Philips Healthcare

Source: Borches, P. D. (2010). A3 Architecture overviews. In *Department of Engineering Technology: PhD Thesis*. University of Twente.

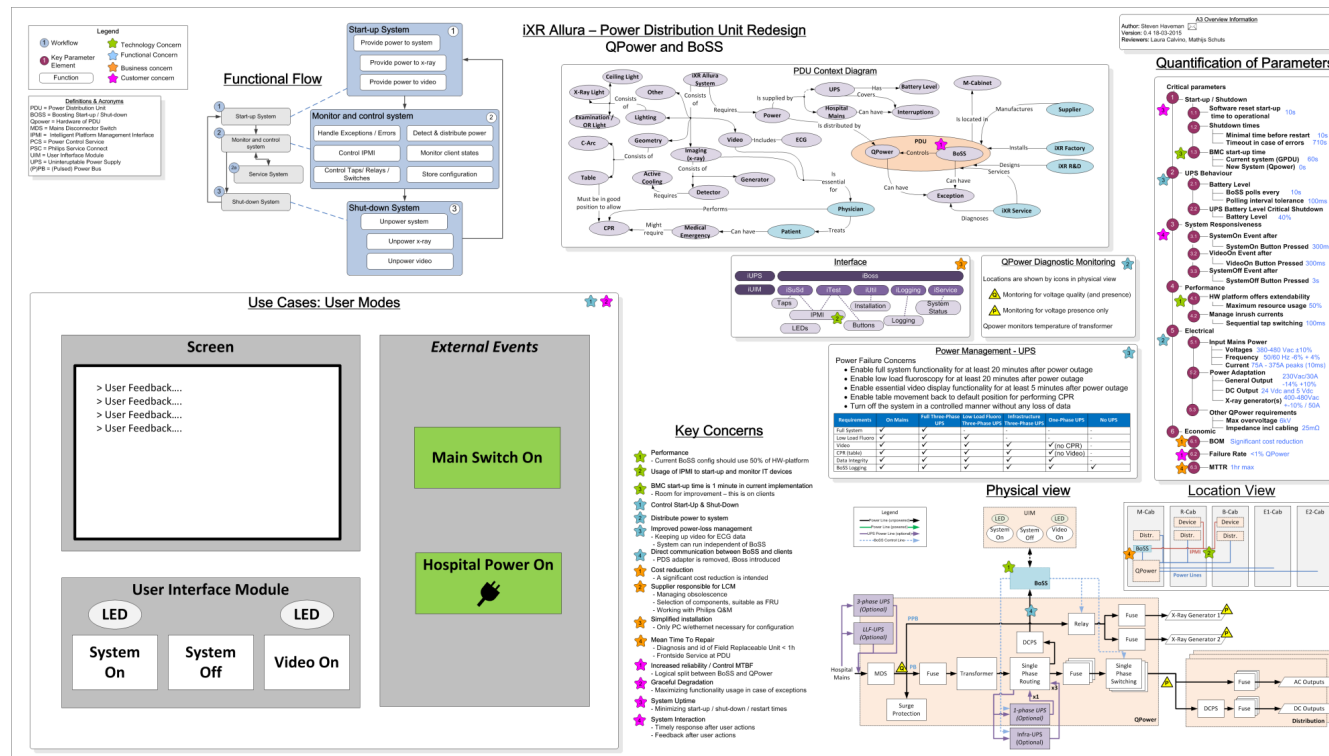
# A3AO Examples



Source: <https://www.gaudisite.nl/SSMEoverviewA3.pdf>

## Operational view of subsea installations for Oil Drilling

# A3AO Examples



## Philips iXR – Simulation with A3AO as interface

Source: Haveman, S. P. (2015). COMBOS: Communicating behavior of systems - Incorporating simulations in conceptual system design. In *Department of Engineering Technology: PhD Thesis*. University of Twente.

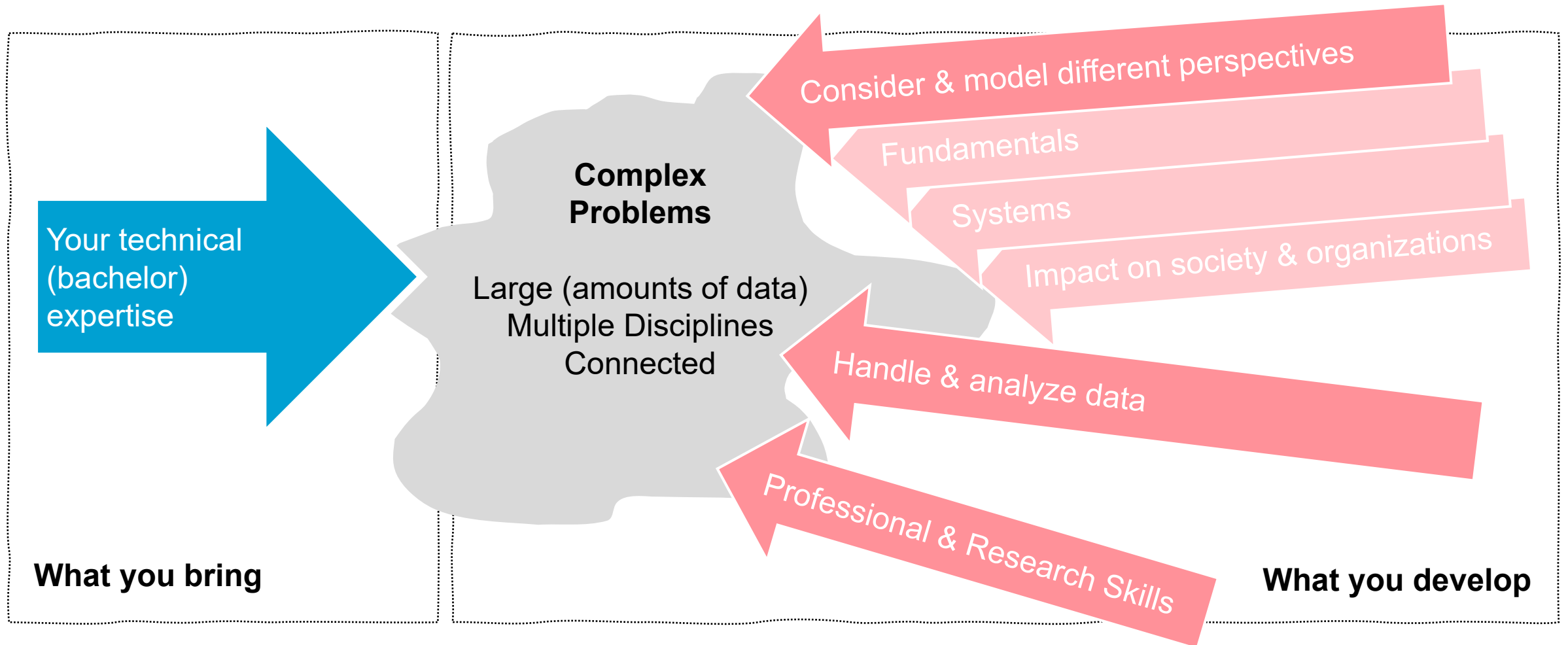
# A3AOs as an educational tool?

- **A3AOs currently mainly used in**
  - Industry & Research
  - With respect to education, applications in thesis or occasionally in course work, and not yet as assessment
- **Suitability?**
  - Template poses hard limitations
    - Strict selection of information necessary
  - Visual style
    - Supports communication and alternative uses
  - Utilize alongside real-life project
    - Ability to work with stakeholders
  - Easy to learn, hard to master
    - Provides suitable entry point with ample room for development
  - Functional view / modelling
    - In our experience - a new way of thinking for most students

# 3

## Case Study: Master Next Level Engineering

# Master Next Level Engineering



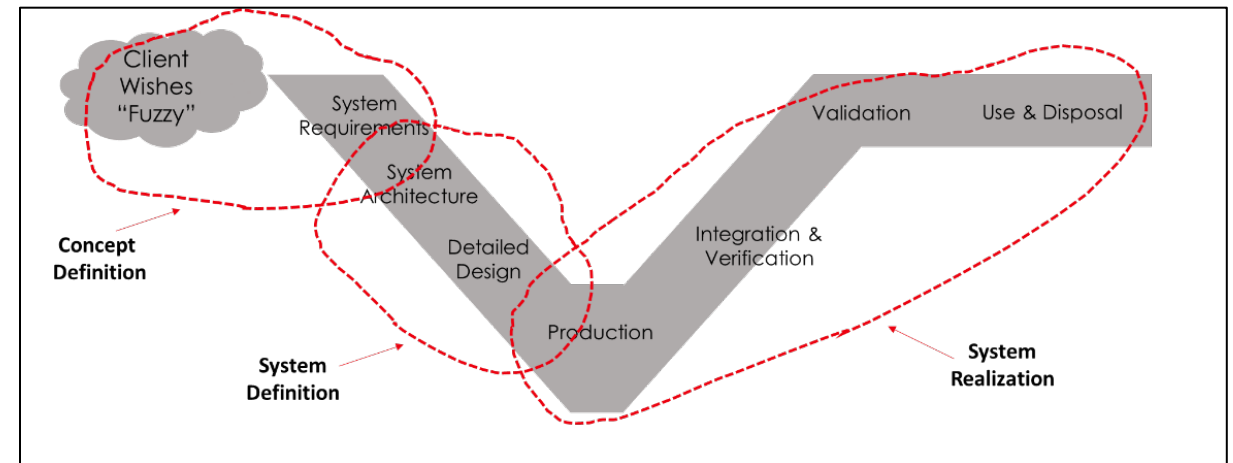
# Systems Engineering Course

- Related learning outcome of the Systems Engineering Course to the application of A3AOs
- The student has hands-on experience with Systems Engineering

| Block                  | Generic modules                      | Specific modules                          | Project                                  | Learning Team  |
|------------------------|--------------------------------------|-------------------------------------------|------------------------------------------|----------------|
| <b>A</b><br>Sept – nov | Professional Skills<br>(5 EC)        | Systems Engineering<br>(5 EC)             | Interdisciplinary<br>Projects<br>(10 EC) | Learning teams |
| <b>B</b><br>Nov – jan  | Engineering Fundamentals<br>(5 EC)   | Complex Systems & Organizations<br>(5 EC) |                                          |                |
| <b>C</b><br>Febr – apr | Applied Science & Research<br>(5 EC) | Data Science<br>(5 EC)                    | Thesis Preparation<br>(5 EC)             |                |
| <b>D</b><br>Apr - jun  | Thesis<br>(15 EC)                    |                                           |                                          | Thesis teams   |

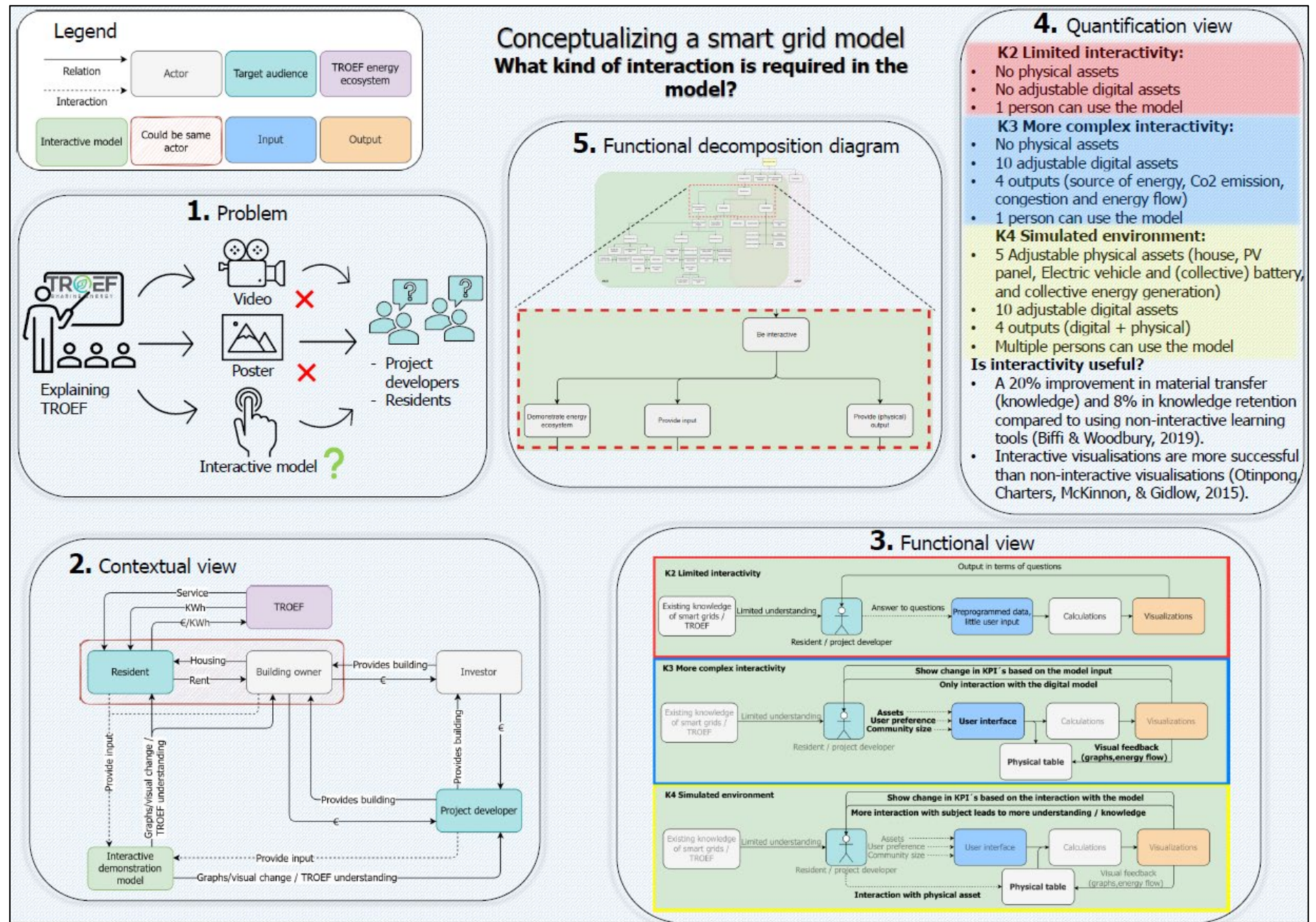
# Assignment

- Create three posters, which together give a good overview of your Interdisciplinary Project, with the following scope:
- (1) Concept Definition, (2) System Definition, (3) System Realization
  - Include appropriate views in each poster, at least functional, quantification and physical (or contextual)
  - Additionally, the poster should support the project team to defend a trade-off that was made with relevant stakeholders
- Assessment: oral exam in “meeting room style setting” – printed A3AO in middle of table



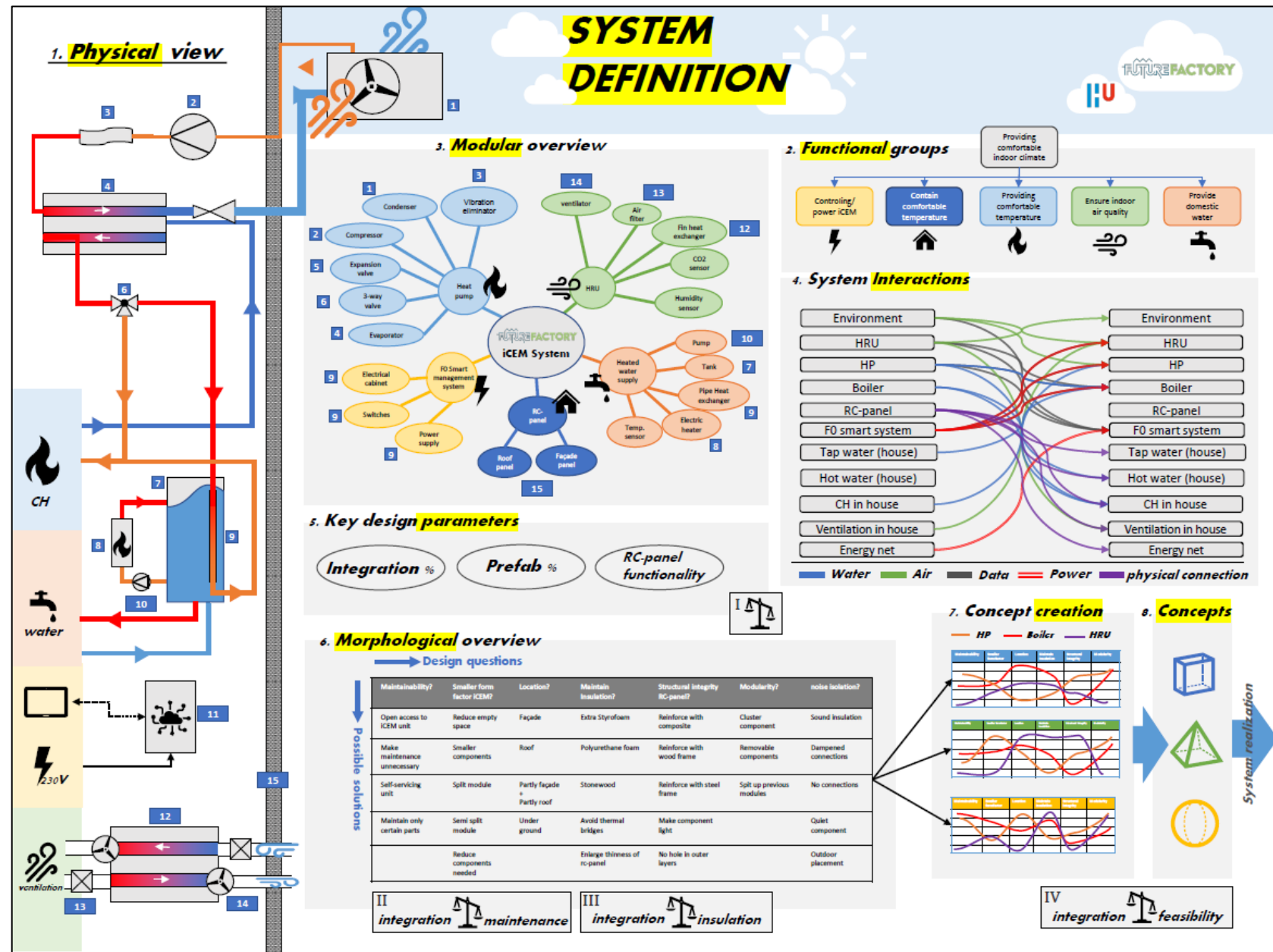
# Results

- Concept Definition Poster
- **Top:** All views included and linked
- **Tip:** Relevant details missing which showed after discussion



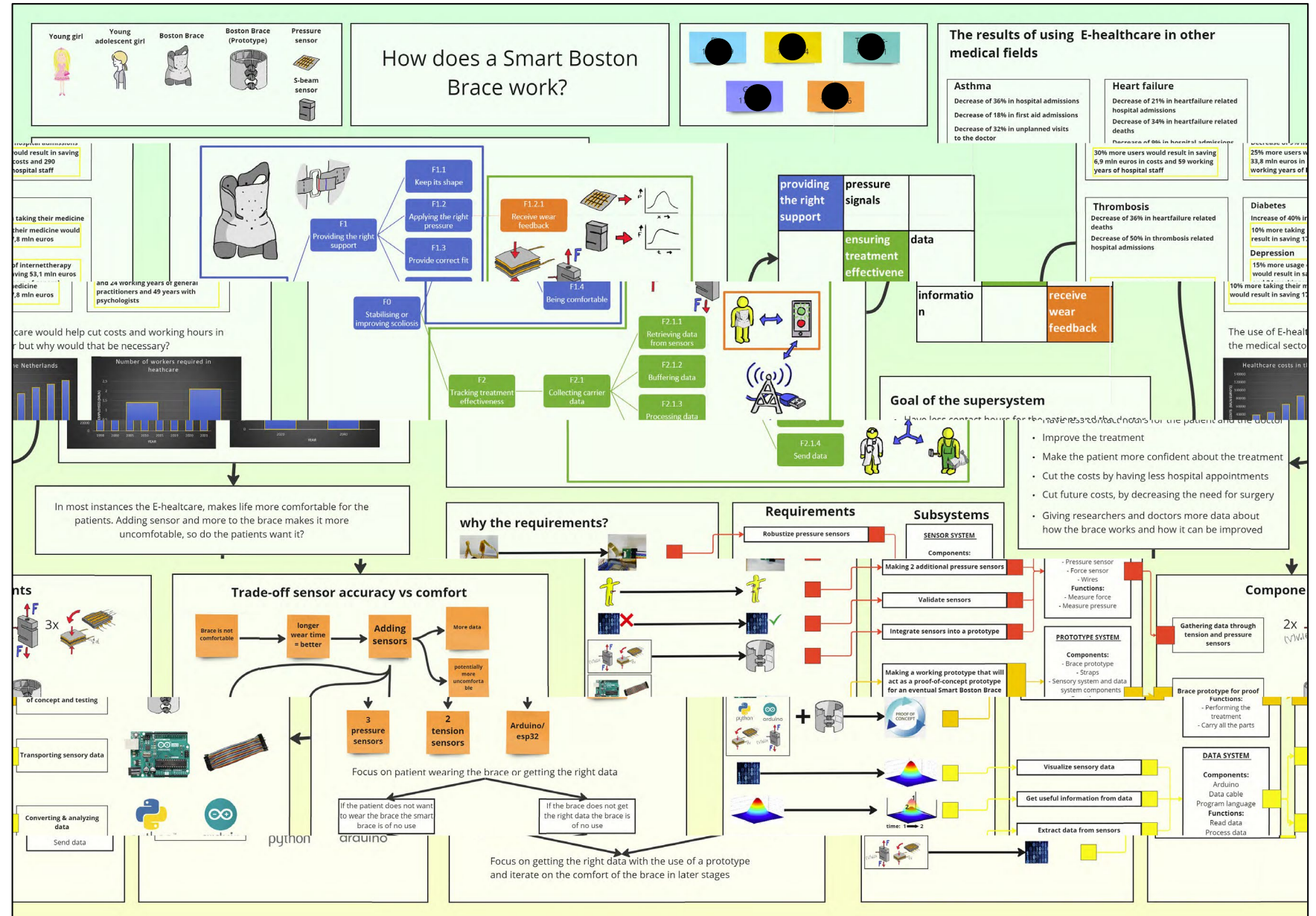
# Results

- System Definition Poster
- **Top:** Nice balance between visual attractiveness and SE visual style
- **Tip:** (Too) broad scope



# Results

- System Definition Poster
- **Top:** Focus on storyline and visually supported
- **Tip:** Lacks some SE-style language, and again too broad



# 4

## Discussion & Future Work

# Evaluation

- Student feedback
  - “I thought the example poster was very ugly. If I would encounter this at a company, I could not take this company seriously”
    - (Beauty is in the eye of the beholder -> also a heuristic)
  - “The posters were a lot of work for information that was already known”
  - Not all students may work on posters in group work
- Educator perspective
  - Perceived approach as beneficial – A3AO allowed discussions on capturing and communicating essence of a system
  - Timing was less fortunate – the most worthwhile discussions occurred at the assessment instead of throughout the course

# Discussion

- Crucial point of feedback: “The posters were a lot of work for information that was already known”
  - Why?
    - Students did not yet know everything, and at least did not know which parts of the information that they knew was relevant enough for the A3AO?
    - Our engineering students struggle with the visual style of the A3AO?
    - The benefits of creating an A3AO are missing or not made visible well enough?
      - Do the students see the process around creating the A3AO properly?
      - Were the cases too simplistic? (The combination of information does not reveal new insights or information was not fragmented enough when starting)
    - Or... something else?

# Future work

- Build up further experience with A3AOs in education through additional years of application
- Address student concerns by earlier and more consistent application
  - Single A3AO, right from the start, also present evolution in portfolio
- Work towards a typology of application of A3AOs since they are multi-purpose, which is both an opportunity and a threat

Thank you for your  
attention!

Any questions?

