A new platform for innovating system design: the Concurrent Design & Data Facility (CD^2F)

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Outline – message: *Join us on the Concurrent Design & Data Facility (CD²F)!*

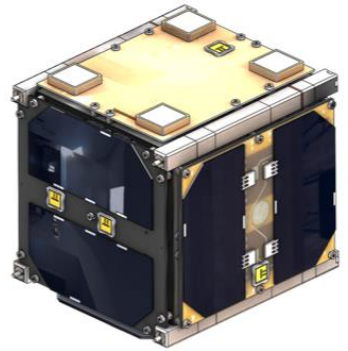
1- Introduction: Systems Engineering at EPFL, Space Center

2 - Concurrent Design & Data Facility (CD²F)

- 1-slide summary

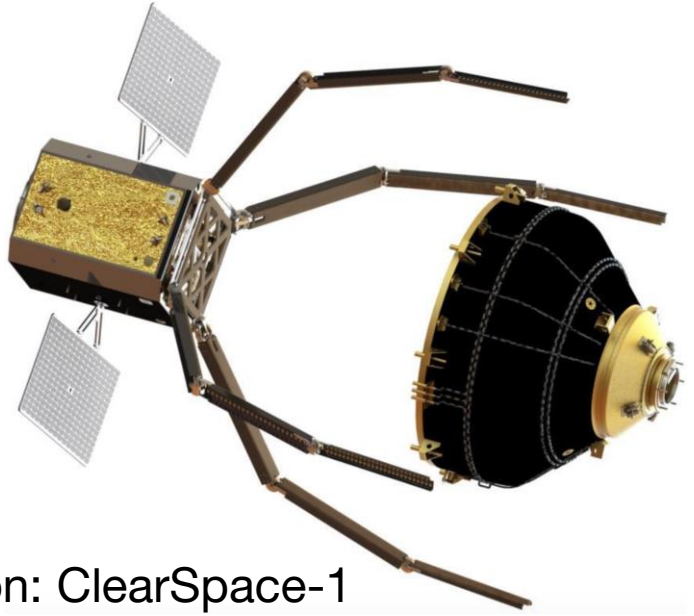
- Background
  - Concurrent Engineering & Systems Engineering
  - Design Research & Systems Engineering
- Facility design
- Research plan
- Next steps: how can you join?

SE activities at EPFL



- **One of first Concurrent Design Facilities at a University**
  - **Now being made Next-Generation**
- Minor in Systems Engineering
  - ~25 Master's students/year
- ~2-4 professors related to discipline
  - famous MIT Prof. Olivier de Weck associated
- EPFL's Space Center is a Systems home
  - Designed Switzerland's first satellite (SwissCube)
  - EPFL Rocket Team etc.

Sustainable Space Logistics: *a systems and SoS view of space*



Awarded ESA mission: ClearSpace-1 active debris removal (to spin-off *ClearSpace* – **86M€ mission**)

Concurrent Design & Data Facility (CD^2F) for System Design

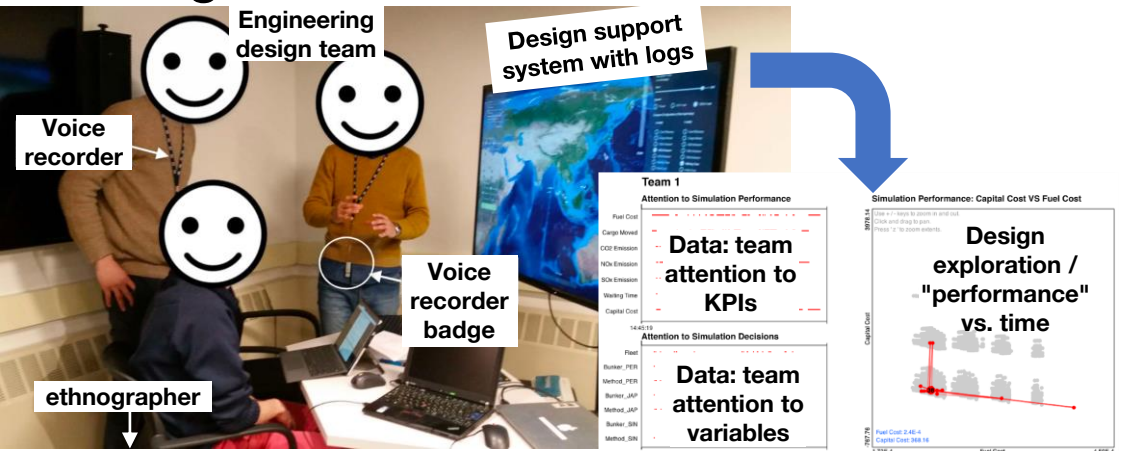
CDF: design platform in space sector

+

Design Observatory: re

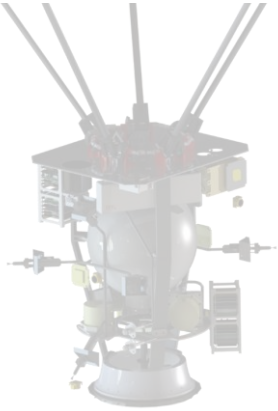
in Design Research

Huge synergies: CDF ripe for improvement via testing,
DO ripe for realistic data
Understanding opens applications to other sectors!



Outputs:

- Conceptual designs – missions, subsystems… considering
- Data on design processes, tools, their effectiveness
- Huge need, for e.g. *Design for sustainability*

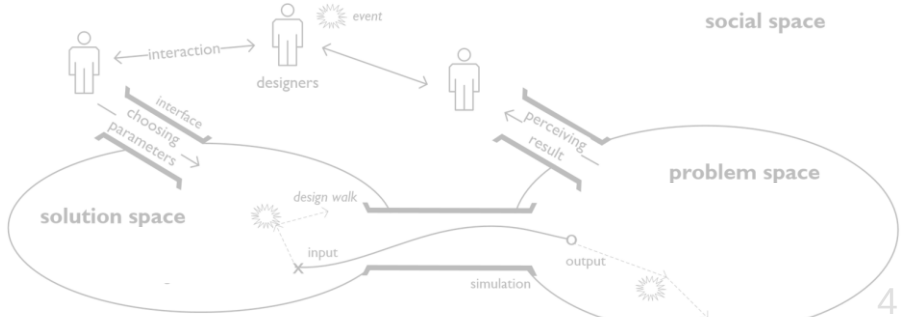


Benefits:

- 4x faster (ESA)
- 2x cheaper
- *Platform* for pooling engineering capability in EPFL/Swiss ystem

amental advances:
stand *how to design*

- Constantly improve CDF



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Background: **Concurrent Engineering & Systems Engineering**

- From early 1990s, associated to **Toyota** best practices, NASA
- Concern: away from "over-the-wall" silo'd engineering, accelerate early design
  - *Too many iterations, slow development, design not balanced for lifecycle - or doesn't reflect needs*
- Collocated team simultaneously, rapidly, holistically designs concept, transparently
- Often has dedicated facility, toolset, process
  - Ex

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Systems Engineering
(for comparison)

To enable the realization of successful systems	"why"	***To*** enable the realization of successful systems
By high-quality, fast, holistic conceptual design	"what"	***By*** considering them in a holistic, interdisciplinary way up-front
Using a dedicated facility & workshops with all stakeholders up-front	"how"	***Using*** Systems Thinking and Engineering

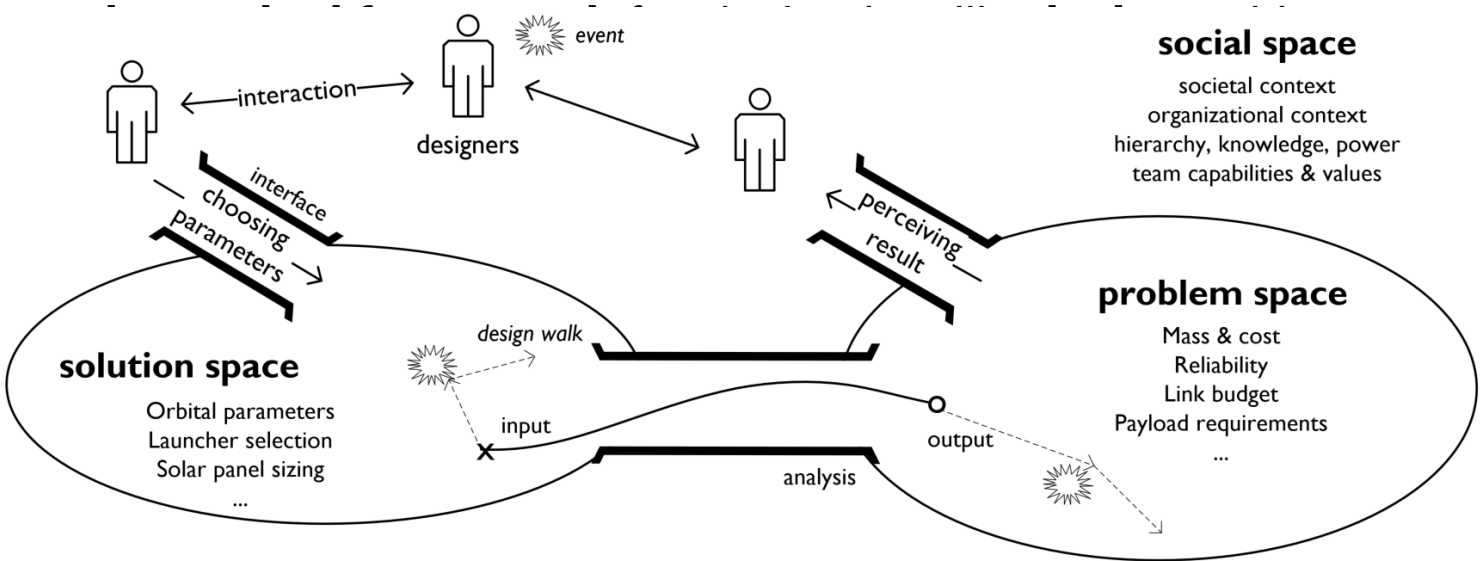
Background: **Design Research**

- **Design:** "*those activities that actually generate and **develop** a **product from** a **need**, product **idea** or technology to the **full documentation needed** to realise the product and to fulfil the perceived needs of the user and other stakeholders*."
  - Huge overlap with Systems Engineering! Especially early-phase design & needs
- Concern: **Design** as a human activity **is decisive** in creating **value** & innovation, yet **poorly understood**
  - The UK's "design economy" is 7% of all economic activity; we are entering the "Synthetic Age" – most of the world is designed
- **Lack of understanding** limits progres
  design researchers "yet to grapple wit

Empirical evidence *for* ***"design quality"?***

…for ***"design process performance"?***

➢ Actually profound questions!

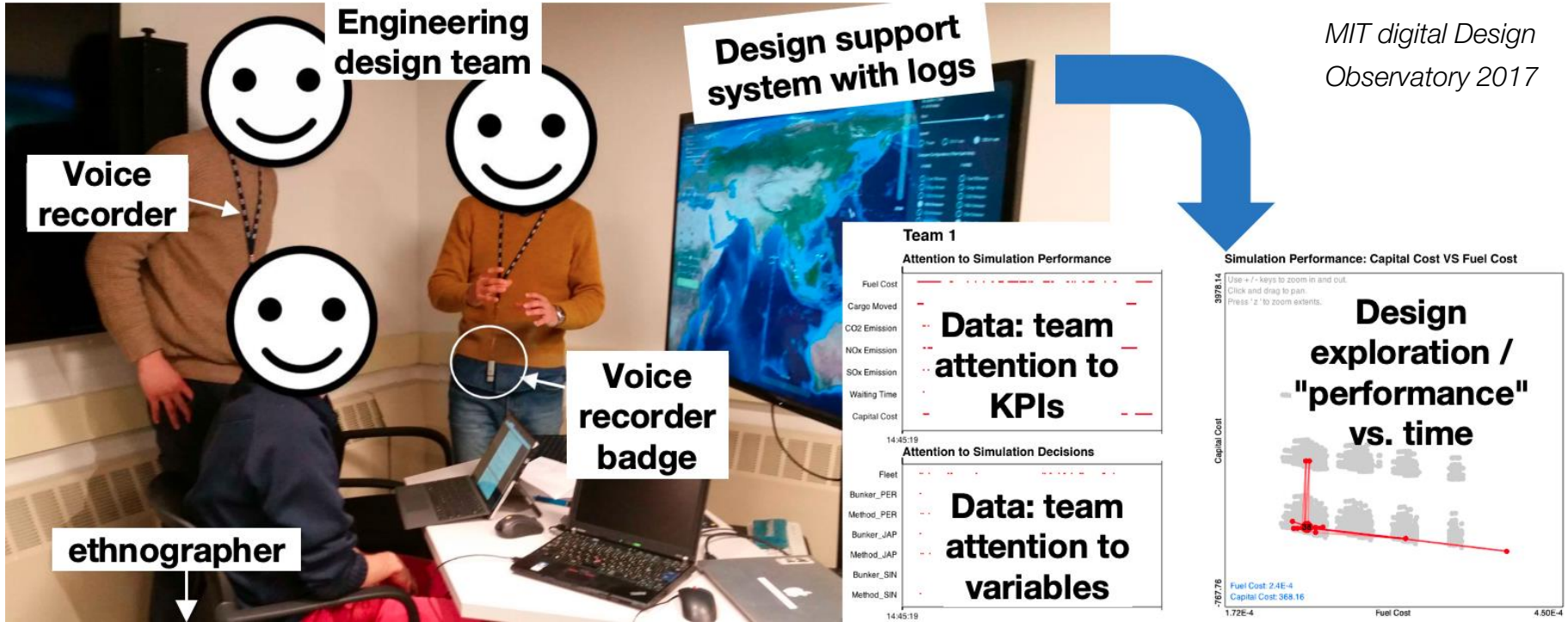


A digital Design Observatory?

- A **Design Observatory** is a concept invented at Stanford (2002), to bring **empirical evidence** on design:
- "*an integrated environment to observe, analyse, and intervene into design activity*"
  - basically: ethnographers studying engineers at work
- Recently developed: "*digital* Design Observatory" utilizing ubiquitous sensors, "Big Data" techniques
  - BUT – they do "design experiments" – expensive! Schedule experts, etc.

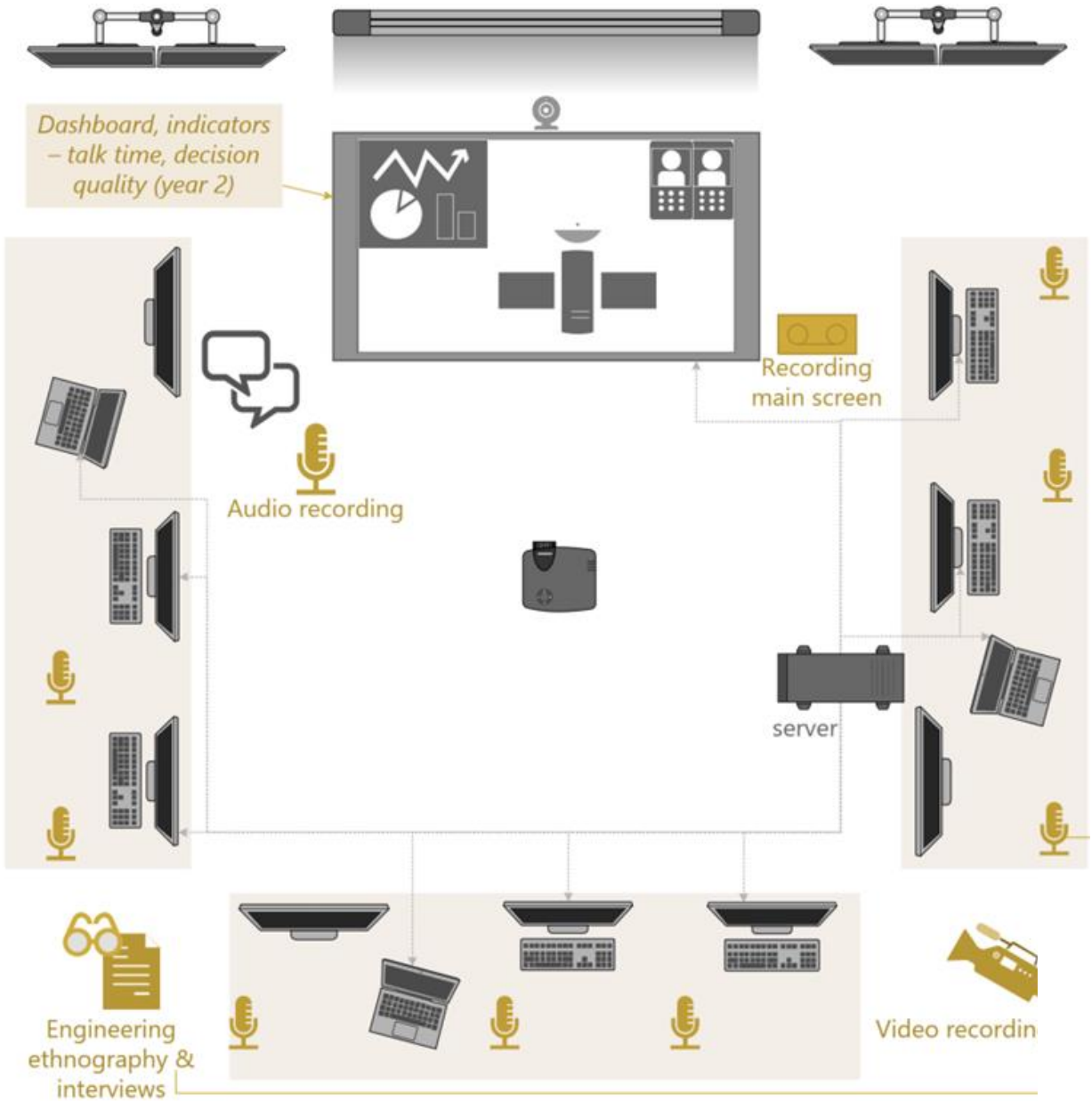
Rich data on "CE in action": a first step to major advances in its practice

Brings realistic data on design processes: more persuasive then experiments



MIT digital Design Observatory 2017

Facility design



Facility design: some key decisions

- Key design decisions identified, implicitly based on sensitivity & connectedness
- *Some tentatively decided – others remain open*

(DSS: Design Support System)

Key Decision	Option 1	Option 2	Option 3
D1: Data capture method	Comprehensive	DSS-based	manual/external
D2: Data analysis	Fully automatic (real-time?)	Semi-automatic	manual
D3: CDF + DO integration	Full (seamless)	Partial	Limited
D4: Data scope	Ethnography/social variables	Technical variables	Both: comprehensive

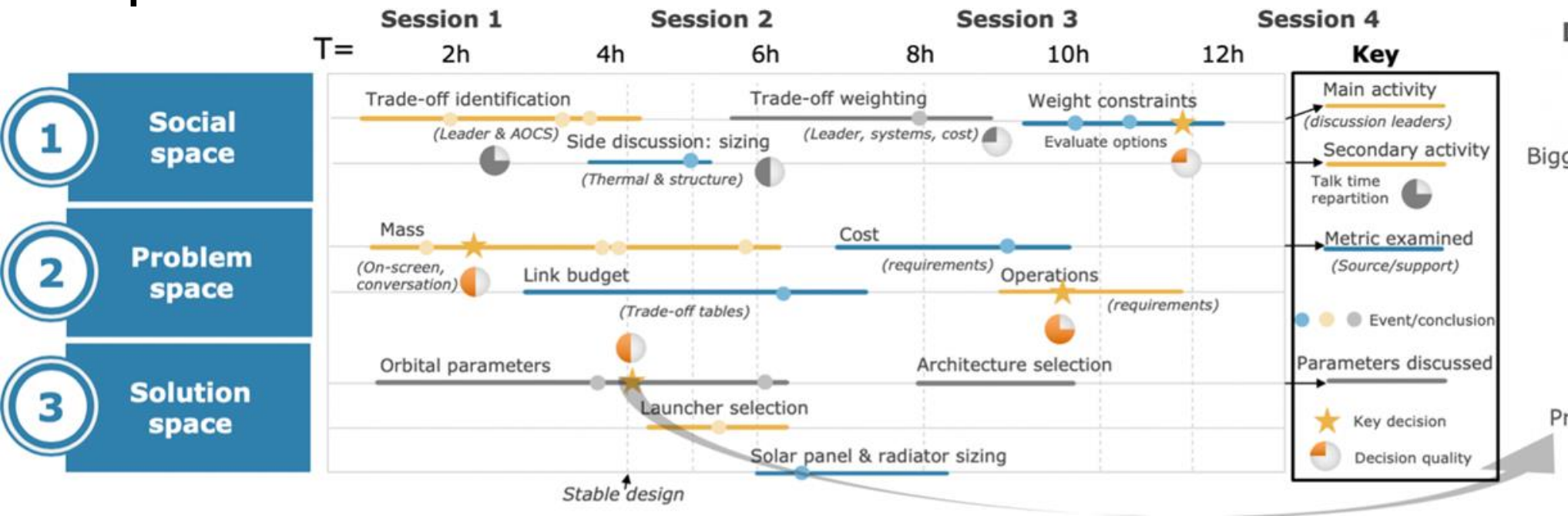
Take-aways:

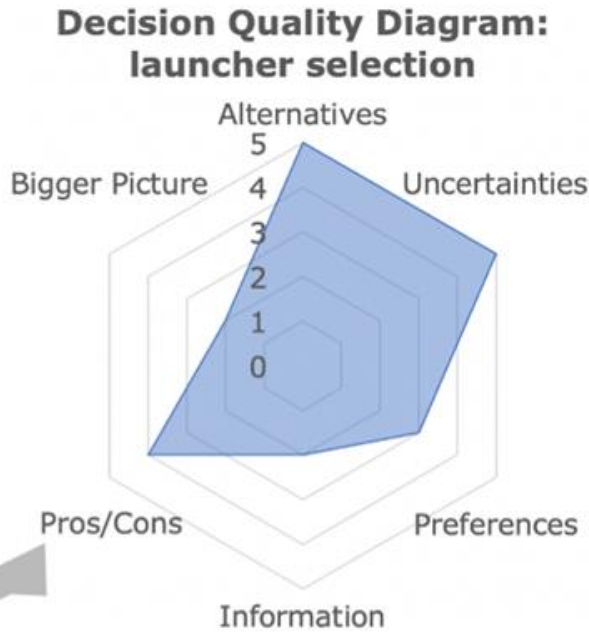
- Many key decisions & options to implement a combined Design Observatory and Support System
- Aiming for rather comprehensive sensors & data, "calibrated" by ethnography, focused on system-level
- Targeting space first, "professional-grade" designs

Research plan

Create facility	Exploratory studies	Test basic (local) metrics	Propose global metrics
Develop facility, process; Obtain operating funding	Iteratively test & improve Observatory setup	Rapidly test many local measures of design walk quality	Compose, assess key metrics; make dashboards

Example "fake data":





Conclusion: join us!

- Have defined a concept, initial design for a “next-generation CE facility”, addressing 2 problems:
  1. Too-slow, silo’d conceptual design – addressed via Concurrent Engineering;
  2. Lack of understanding and data on design processes, tools, training – addressed via Design Observation
- Our **goal**: to permit deep insight-driven advances of CE & other design/systems practice (G0)
  - The CD^{2}F should unobtrusively capture rich, abundant empirical data on design processes.
  - The CD^{2}F should perform best-practice Concurrent Engineering studies.
- **Current status**: have support from EPFL (equipment grant etc.), European Space Agency (in-kind + possibly their own CD^{2}F)
- **Looking for**:
  1. partners from SE community, (incl. individual experts)
  2. facility design inputs,
  3. users – needing conceptual design work

THANK YOU!

- Questions, comments?
- This is just a rough starting point!
- Please get in touch to discuss, or to learn more about Next-Generation Concurrent Engineering!
  - marc.chavy-macdonald@epfl.ch
  - Or chat in person today!