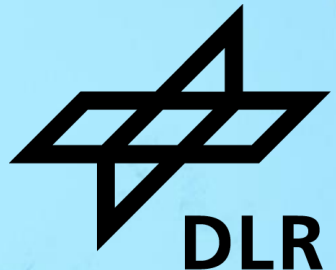


USING AUGMENTED REALITY FOR COLLABORATIVE CONCURRENT ENGINEERING

M.Sc. Anna Bahn Müller

German Aerospace Center (DLR)
Institute for Software Technology (SC)



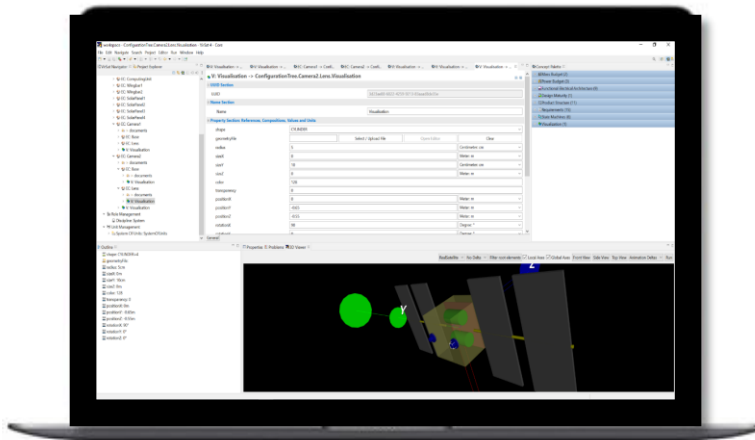
Motivation



GOAL: Supporting Concurrent Engineering with Augmented Reality/ Mixed Reality for Digital Twin

CEF:

Special meeting room where experts discuss mission design for spacecraft using Virtual Satellite Software



to visualization

@ CEF in Bremen

Motivation

GOAL: Supporting Concurrent Engineering with Augmented Reality/ Mixed Reality for Digital Twin

IDEA:

1. Connection “Virtual Satellite” Software with AR-device (HoloLens)
2. Visualization of a digital Satellite from VS in real world
3. Common collaboration of several people on one satellite
4. Interaction and Visualization of information data
5. Remote collaboration

WHY:

1. Intuitive
2. Immersive
3. “Fast and Easy”
4. Better understanding due to visualization

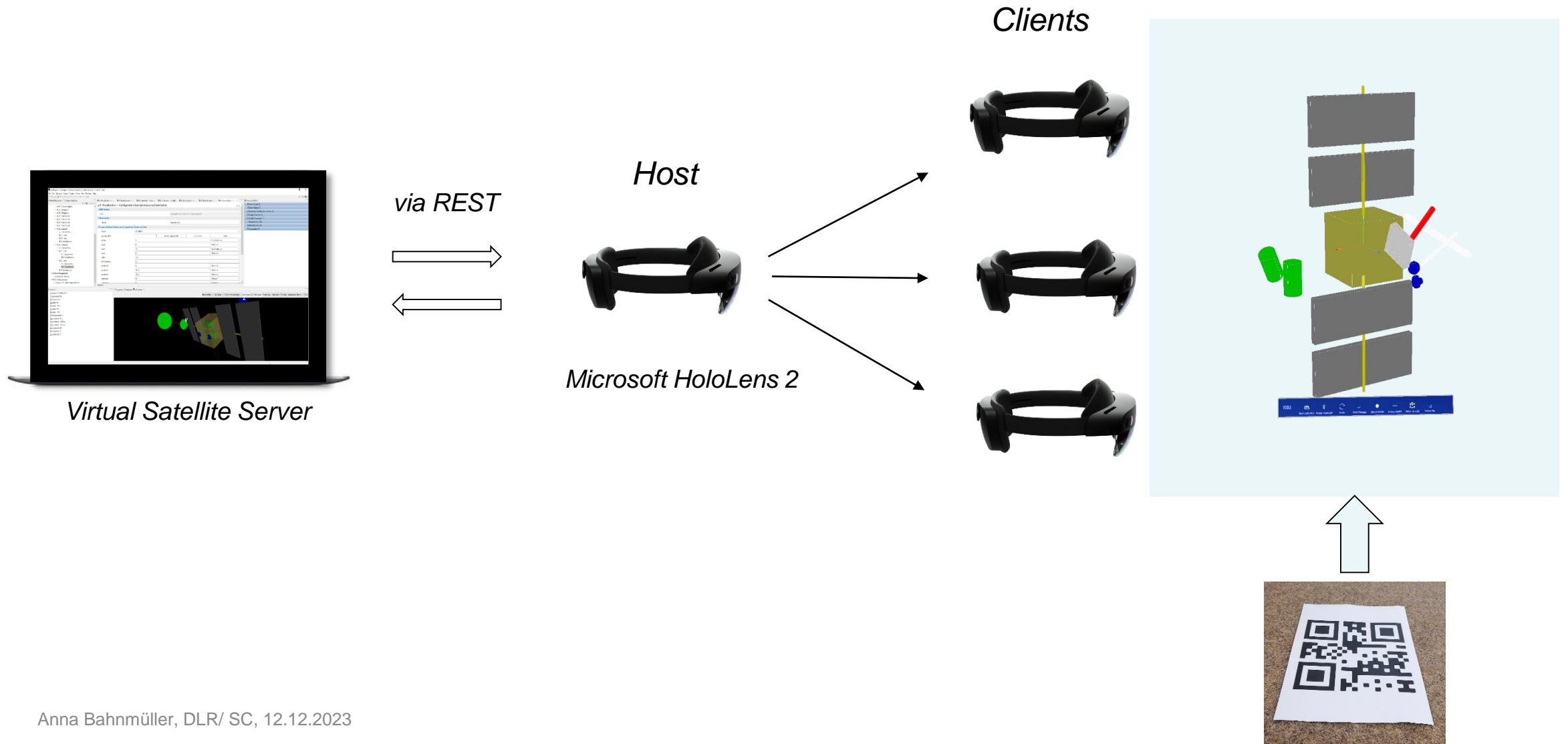


What do we want to find out?

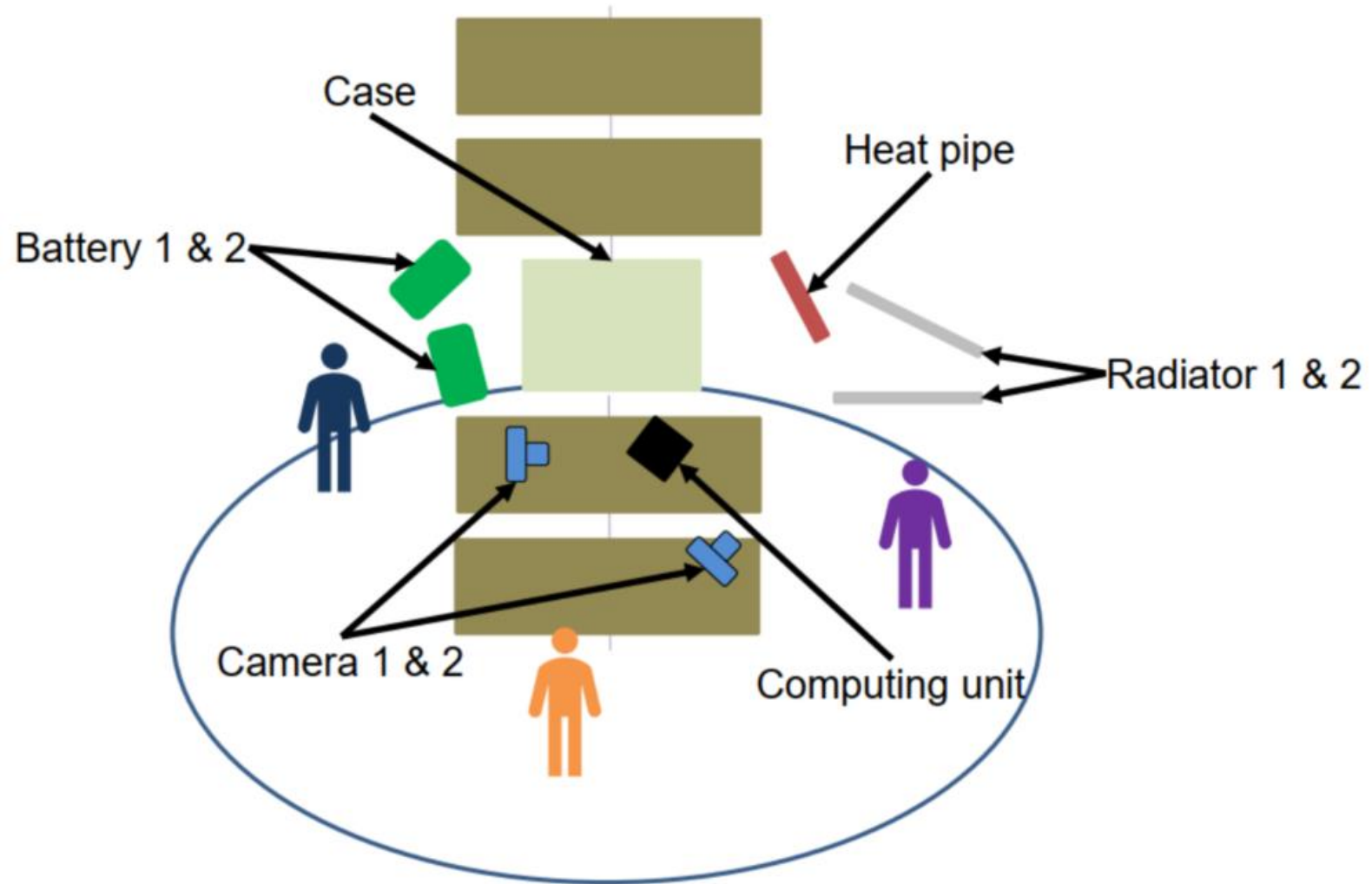


- How well does face-to-face collaboration with AR technology work in the CEF?
- How high is the potential for resolving conflicts between disciplines in the CEF's spacecraft configuration process using AR?
- How much is the acceptance of AR technology in the CEF?

HOW?



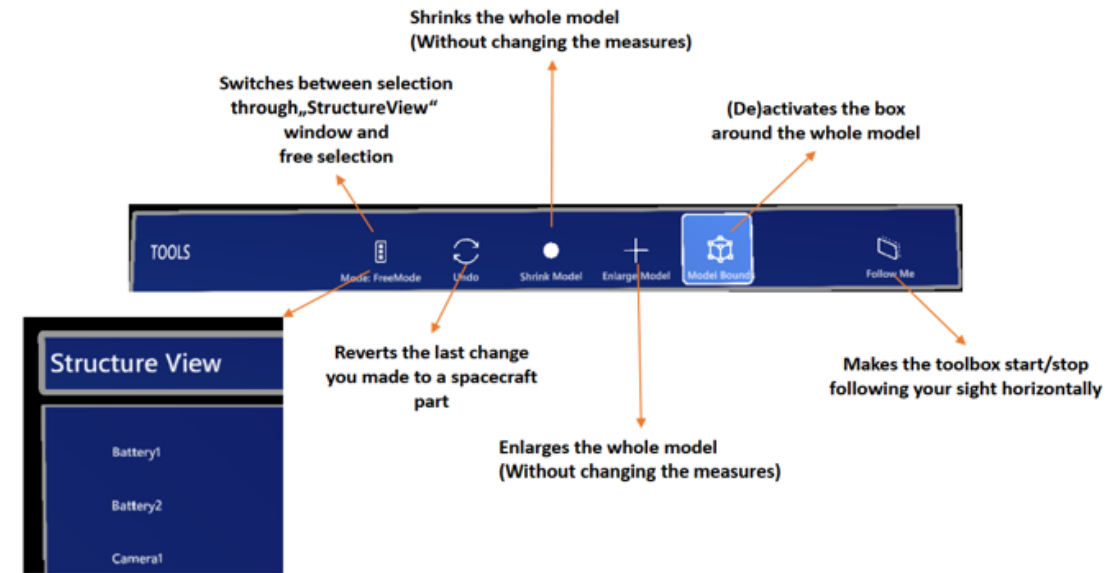
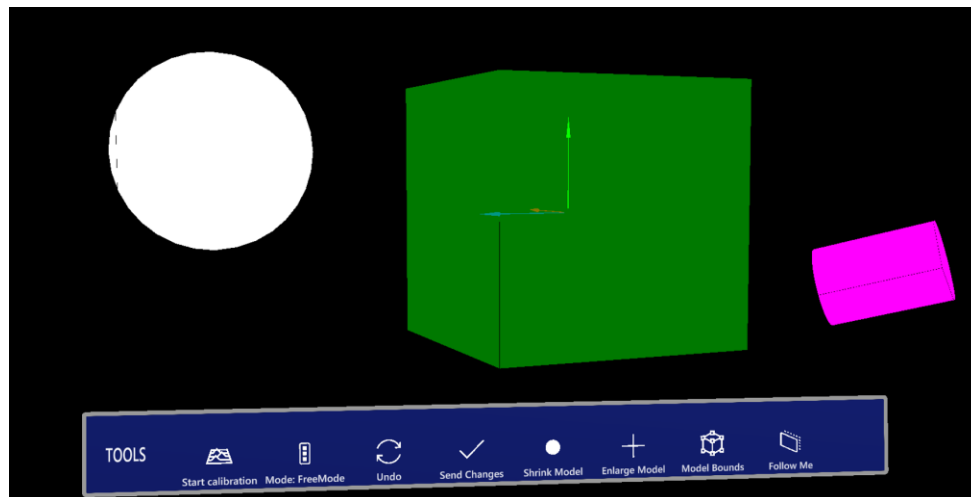
User Study Concept



User Study

- User Study in Germany, Bremen at CEF
- 11 participants (10 male, 1 female)
- Age: 25-56 years (Ø 40,73 years)
- **Tutorial:** Get to know interaction system and menu
- **Task:** 1 group: 3 people (energy supply, technical devices, thermal control) each is responsible for 1-2 components with conditions
- **Questionnaire:** Experience, Nasa TLX (workload), SUS (usability), Collaboration in CEF

Tutorial-Scene



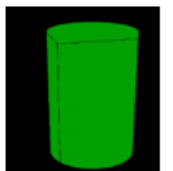
Camera 1 & 2	Computing unit	Heat pipe	Radiator 1 & 2
Satellite			

Your role:

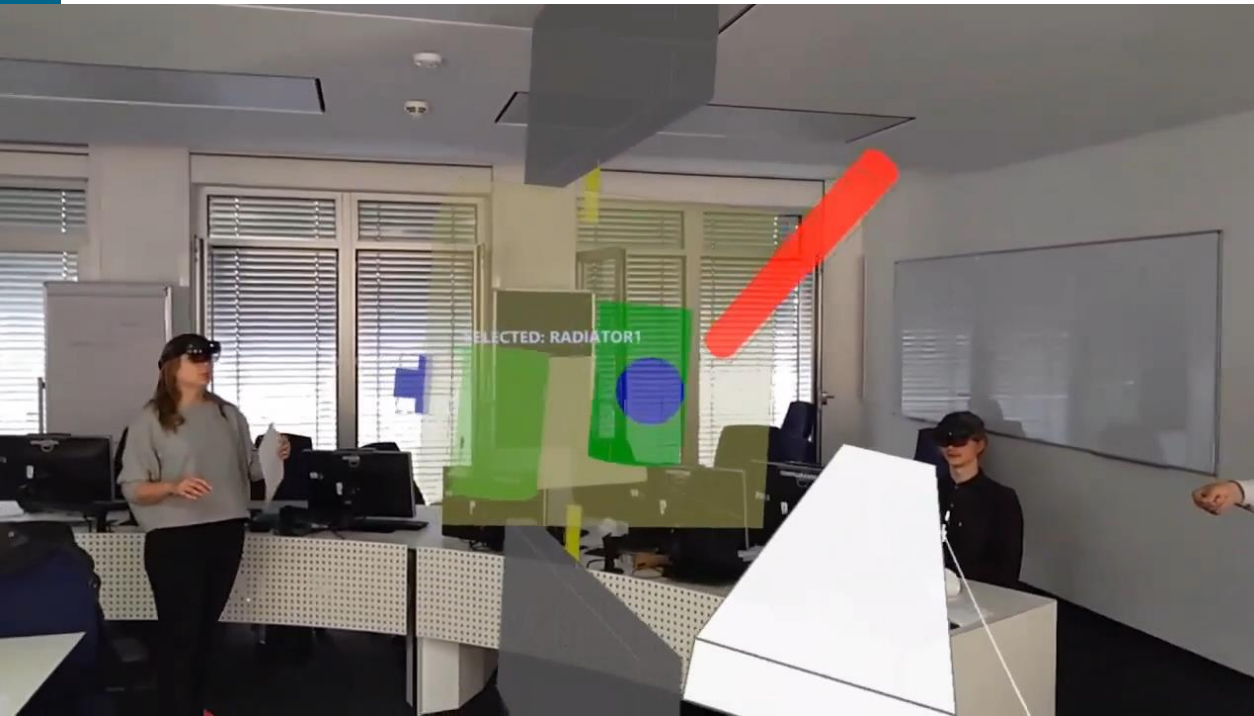
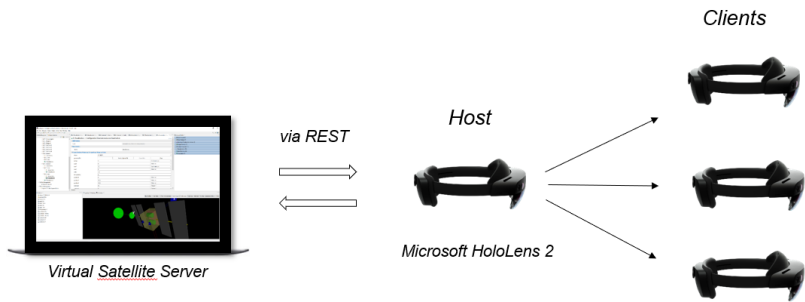
Expert for energy supply

Battery 1 & 2

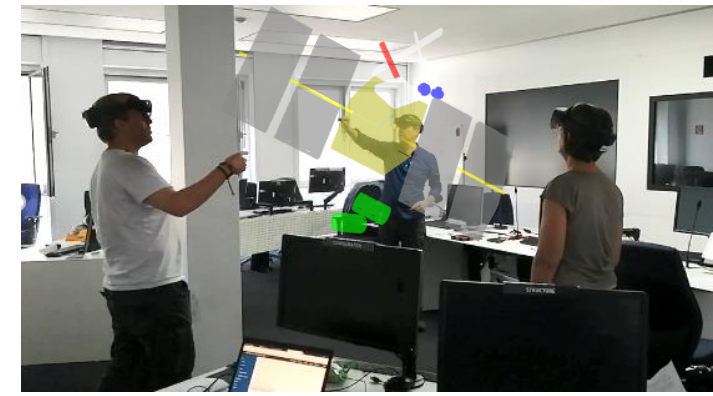
- Has to be placed inside the *case*
- Has to be placed near a *camera*
- Must touch a *radiator*



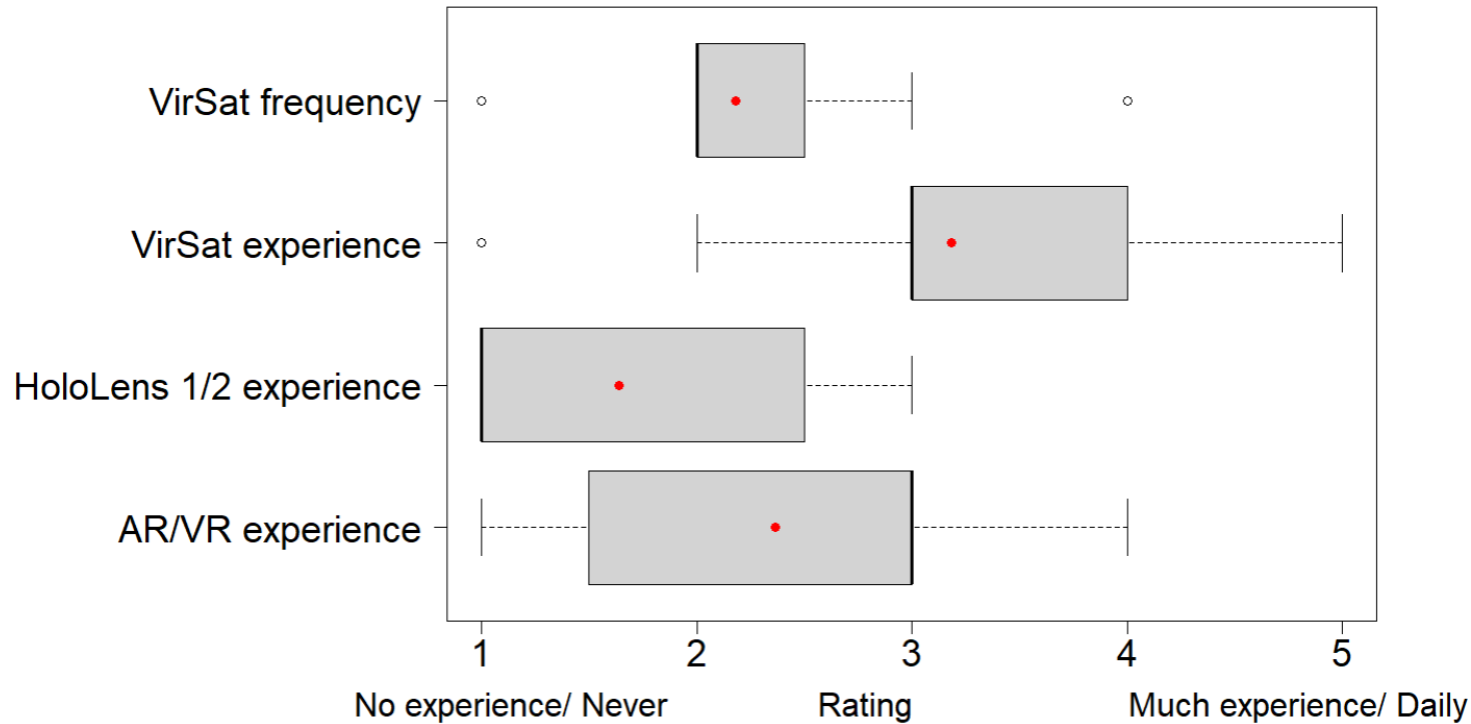
User Study



Results - Prior Experience

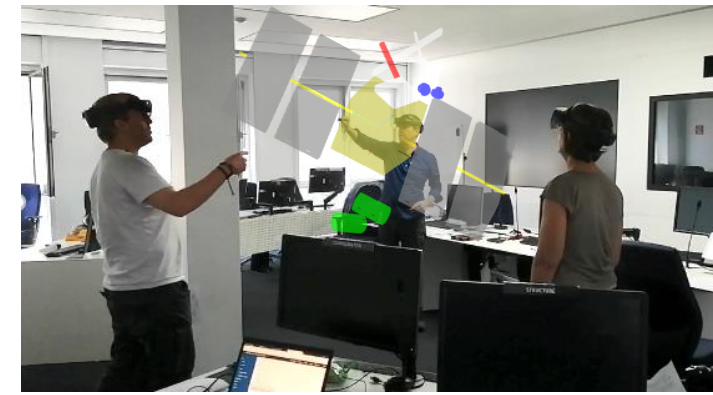


Rating per question (Experience)

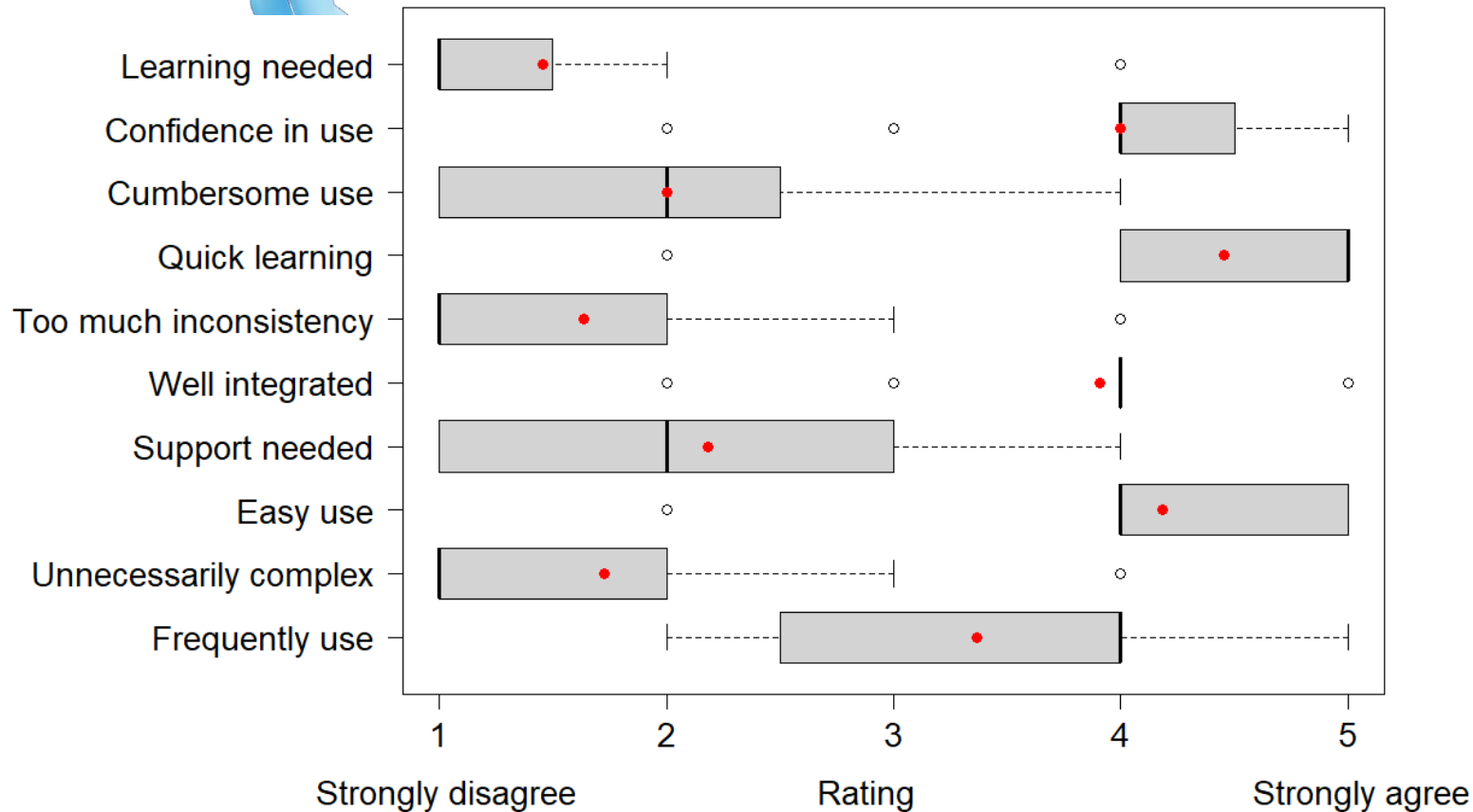


	median	Mean
Experience with AR/ VR in general	3	2.36
Prior experience with HoloLens 1 2	1	1.64
Experience using Virtual Satellite (VirSat)	3	3.18
Using VirSat frequently	2	2.18

Results - Usability



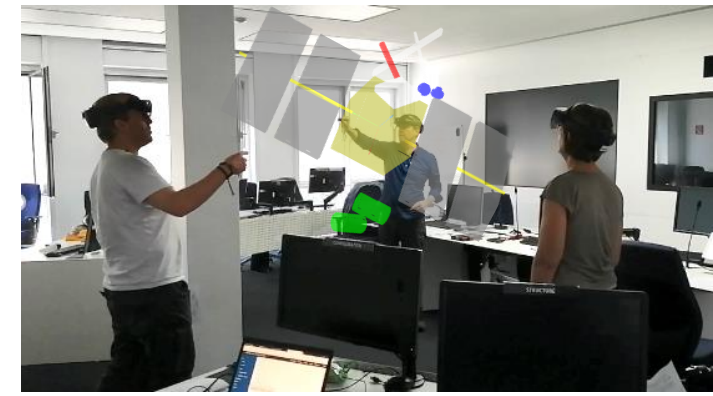
Rating per question (SUS)



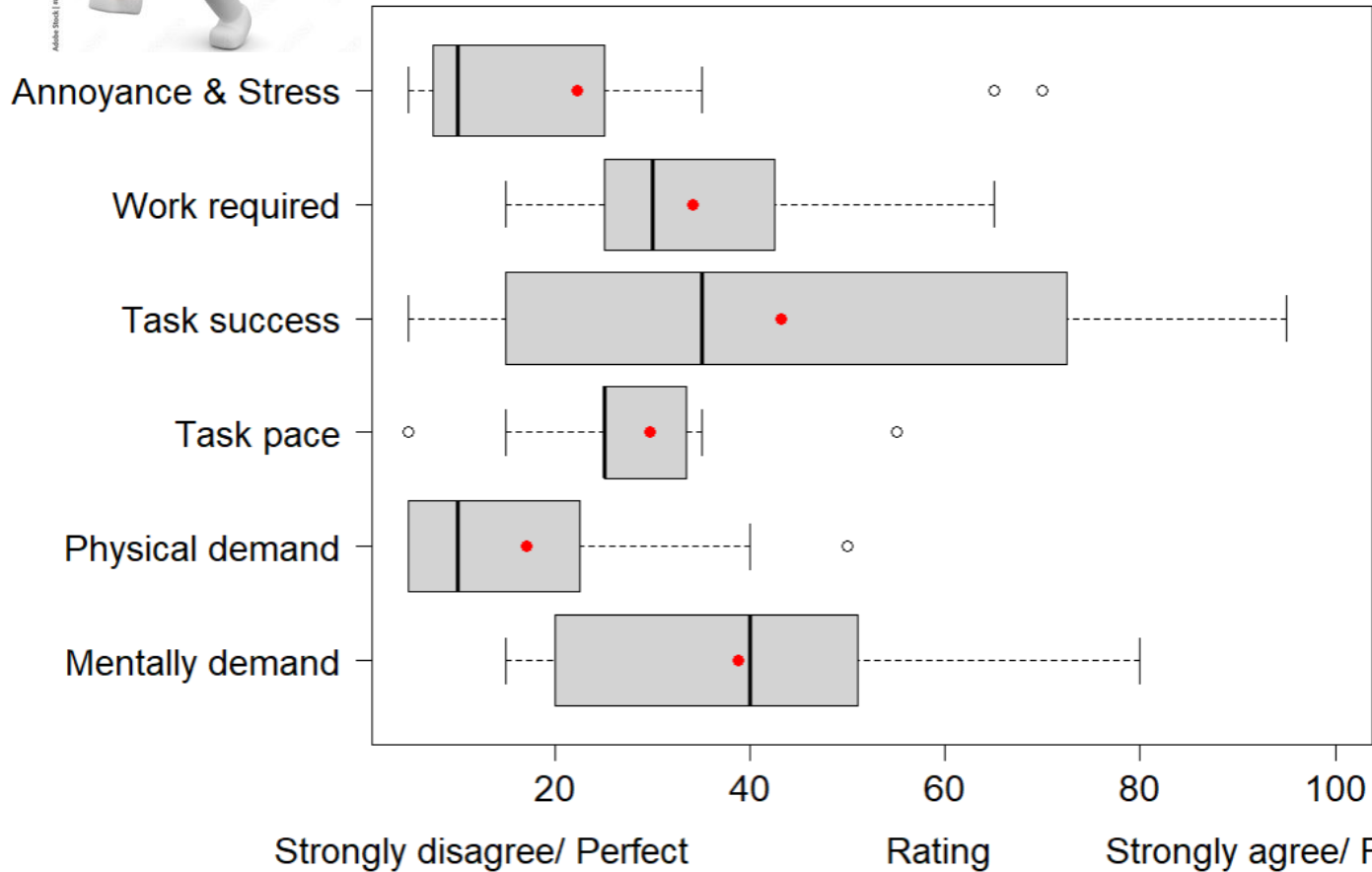
SUS = System Usability Scale

	median	Mean
Learning needed	1	1.45
Quick learning	5	4.45
Support needed	2	2.18
Easy use	4	4.18
Frequently use	4	3.36

Results – Task load



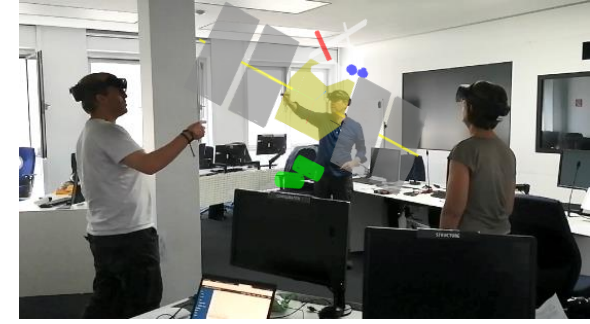
Rating per question (TLX)



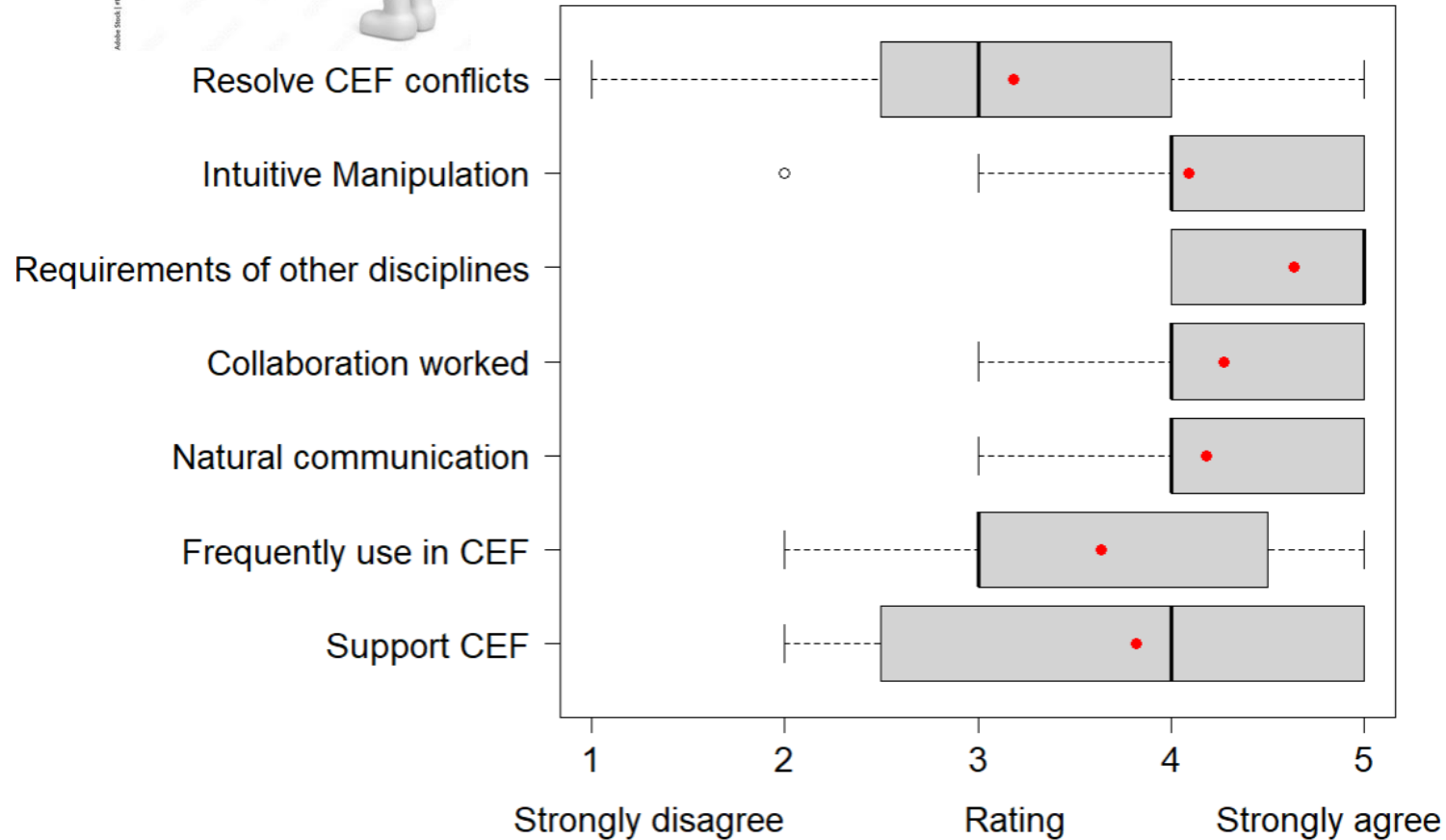
TLX = Task Load Index

	median	Mean
Mentally demand	40	38.8
Physically demand	10	17.1
Task success	35	43.2
Annoyance & Stress	10	22.27

Results - Collaboration



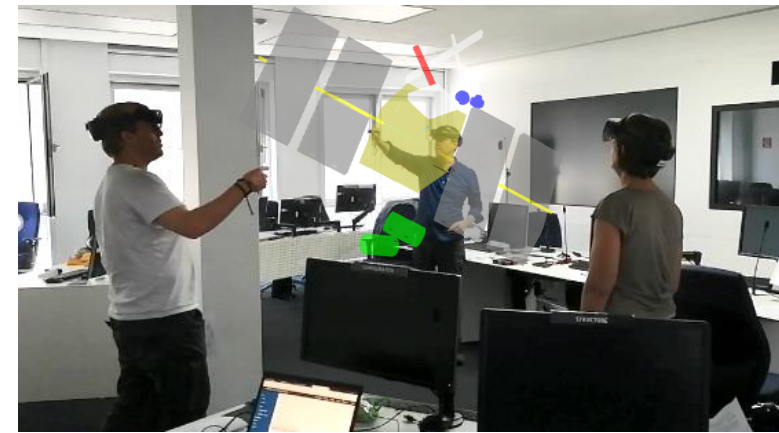
Rating per question (Collaboration)



	median	Mean
Natural communication	4	4.18
Collaboration worked well	4	4.27
Requirements of others well understandable	5	4.64
Intuitive object placement	4	4.09
Frequently use AR system in CEF	3	3.64
AR resolve CEF conflicts	3	3.18
AR support CEF	4	3.82

Further Comments of Participants

- Improving precision necessary using automatic snapping or smoothing of angles
- At the beginning of the task some participants reported grasping issues
- Lack of depth and realism of the virtual satellite
- Communication and cooperation was perceived as good, although most of the participants were focused on the task then on the gestures or facial expression of the others



- How well does face-to-face collaboration with AR technology work in the CEF?
 - Overall it worked well; With a few exceptions, the engineers rated a good usability and collaboration
- How high is the potential for resolving conflicts between disciplines in the CEF's spacecraft configuration process using AR?
 - Mixed result, but the potential is given
 - Our intention not to use during whole CEF-process, but only during the collaboration phase
- How much is the acceptance of AR technology in the CEF?
 - With few exceptions, acceptance was high -> The small random sample shows a tendency

And now?



- **Lessons learned:** AR in CEF is mostly accepted and can be beneficial in a small part of the satellite design process, but the results give only a small and first overview

What can be improved?

- More realistic satellite by including more advanced shadows, lightning and details
- Precision by integrating snapping tools
- Integration of information data
- Further cues to assist engineers and reduce work load
- Avatars to better identify intentions of other participants and for remote collaboration scenarios

Thank you!

Anna Bahn Müller

anna.bahnmueller@dlr.de

German Aerospace Center (DLR e.V.)

Institute for Software Technology (SC)

3D Interaction

LinkedIn Contact:

