AARHUS UNIVERSITY

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INTERNATIONAL GROUP FOR LEAN CONSTRUCTION

LEAN CONSTRUCTION IN A SERIOUS GAME USING A MULTIPLAYER VIRTUAL REALITY ENVIRONMENT

Emil L. Jacobsen

Nikolaj S. Strange

Jochen Teizer

AGENDA

- Motivation
- Background
- Method
- Scenario design
- Results
- Limitations and outlook

Motivation

- Purpose is to educate lean construction principles
  - Make it as realistic as it is in the field
- Existing lean simulation games require
  - Experts to set up and facilitate
  - Physical models (move and replenish parts)
- Benefits and limitations are
  - Motivate collaboration among trades
  - Lack in realism
  - Manual data collection and analysis (biased data)

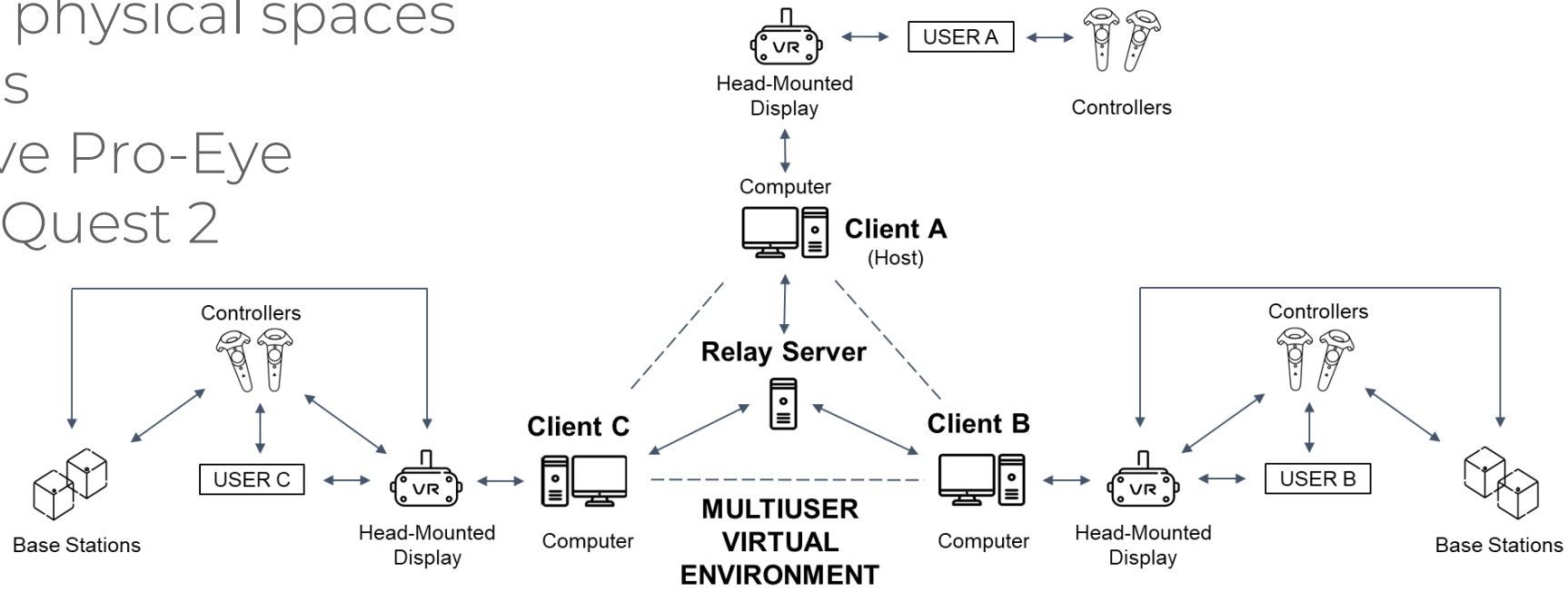
Background

- Virtual Reality (VR) offers
  - Configurable scenarios that mimic reality
  - Data collection (Solberg et al., 2020; Golovina et al., 2019)

- Drawbacks of VR serious games
  - Include non-construction related tasks (Dallasega et al., 2020)
  - Are mostly single player environments
  - Few multiplayer environments exist

Method

- Multiplayer VR environment
  - 3 separated physical spaces
  - 3 VR stations
    - 2 HTC Vive Pro-Eye
    - 1 Oculus Quest 2



Method

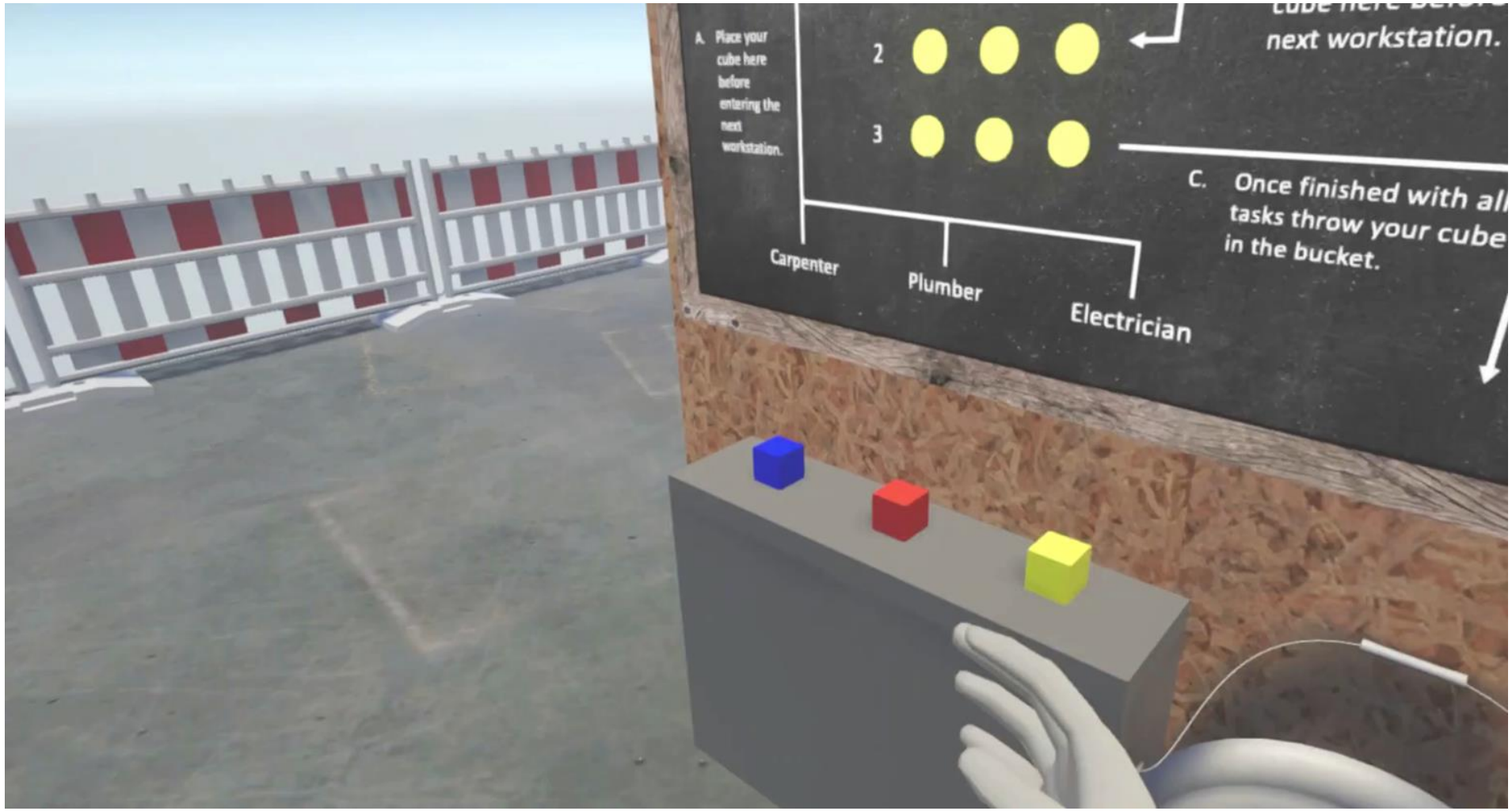
- Run-time data collection

Data type	Timestamp	Object	Location	Action	Trade

3/1/2021 5:47:16 PM, WS4 Toilet, Material Pickup Zone 4.1, Pick-Up, Plumber
3/1/2021 5:47:17 PM, WS4 Toilet, WS4 Toilet drop zone, Place, Plumber
3/1/2021 5:47:19 PM, WS4 Small Pipe Bottom, Material Pickup Zone 4.1, Pick-Up, Plumber
3/1/2021 5:47:19 PM, WS4 Small Pipe Top, Material Pickup Zone 4.1, Pick-Up, Plumber
3/1/2021 5:47:20 PM, WS4 Small Pipe Bottom, Material Pickup Zone 4.1, Pick-Up, Plumber
3/1/2021 5:47:21 PM, WS4 Small Pipe Top, Material Pickup Zone 4.1, Pick-Up, Plumber
3/1/2021 5:47:29 PM, WS4 Small Pipe Bottom, WS4 Small Pipe Bottom drop zone, Place, Plumber

Scenario Design

Scenario Design



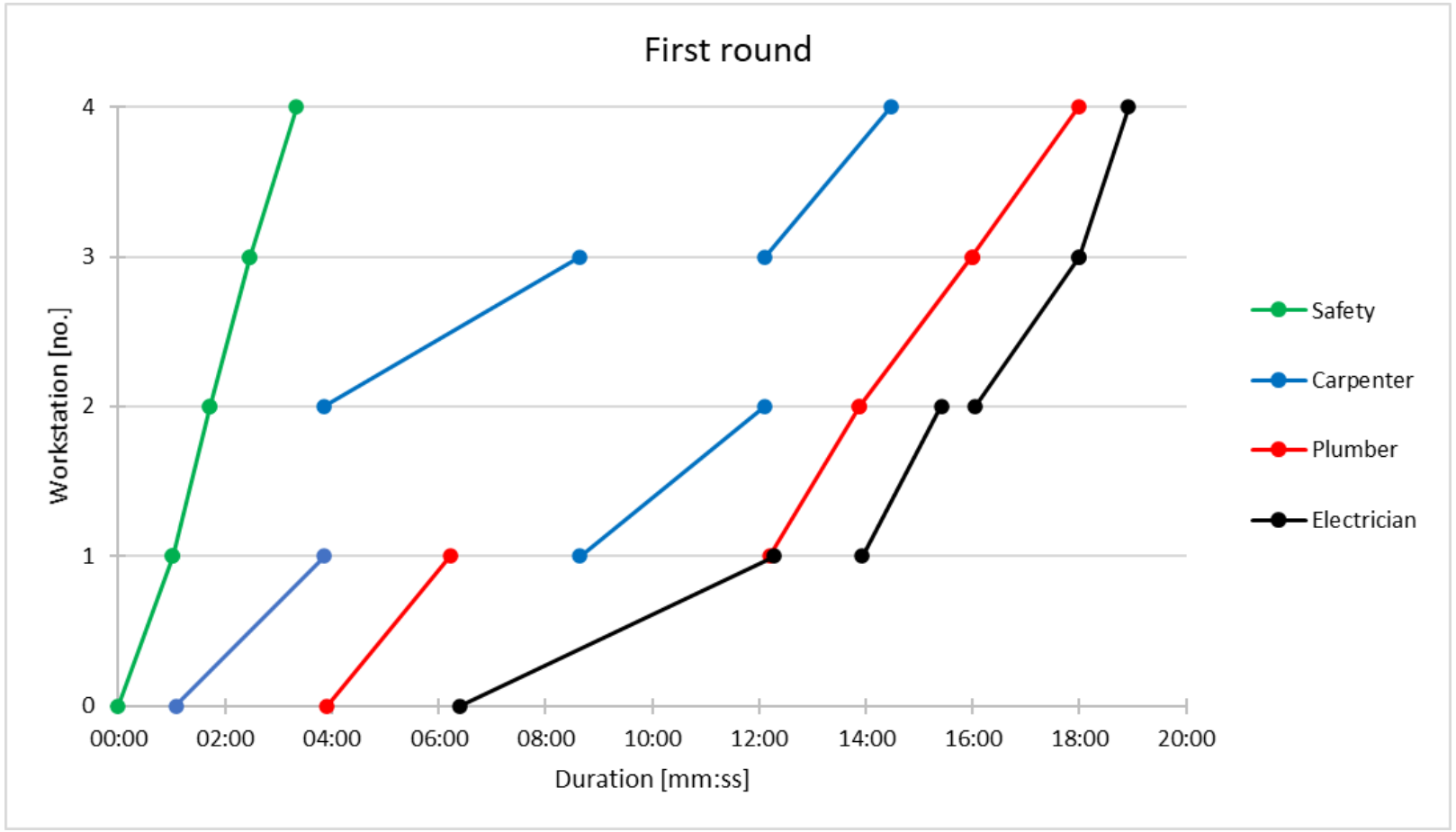
Challenges in developing a VR serious game

- *Preparation is key*
- Physical interaction between avatar and objects
- Adjacent colliders

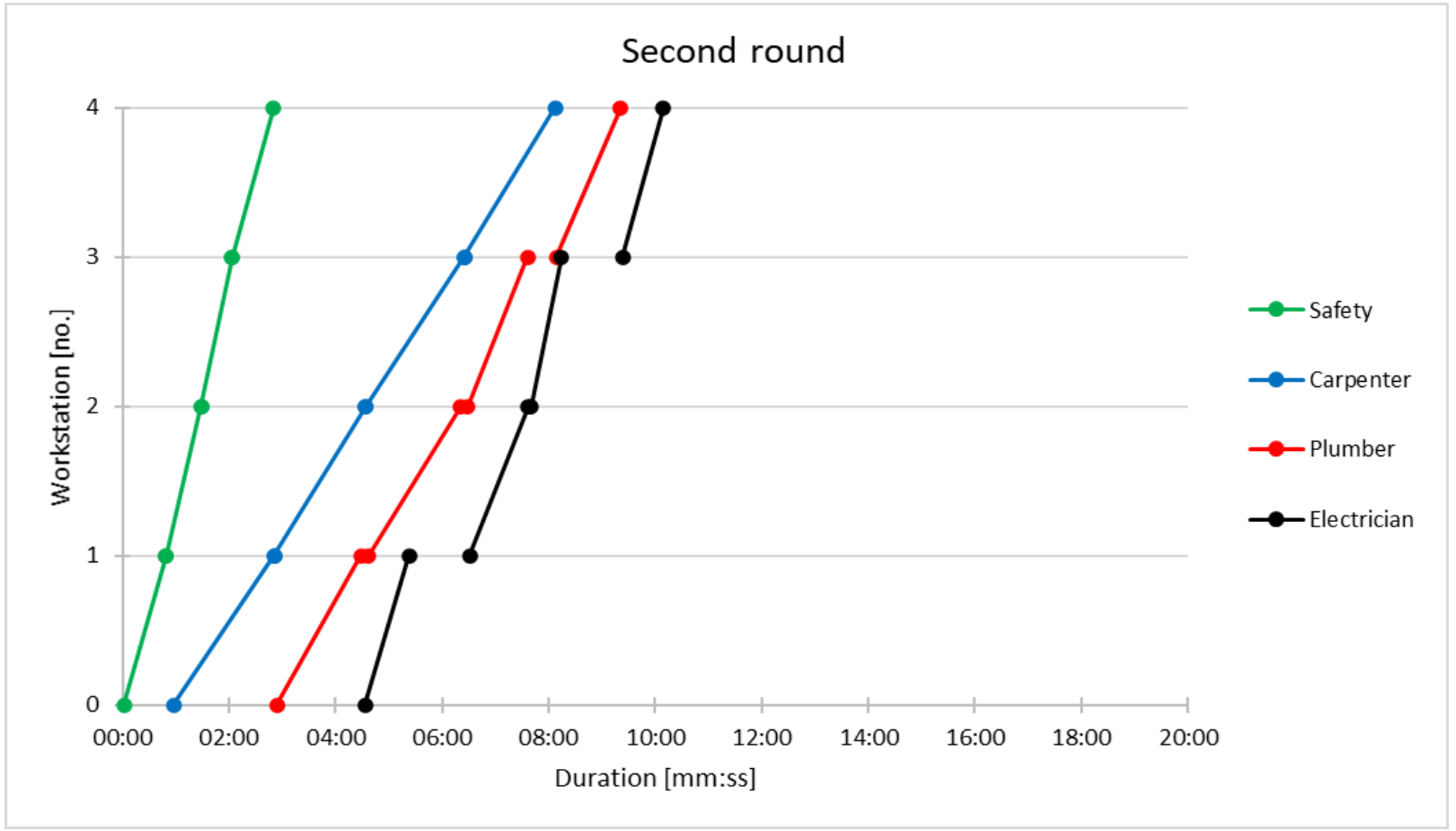
Results

	First round	Second round	Decrease
Time spent	18:55	10:09	8:46 (46.3%)
Double handling	205	153	52 (25.4%)
Quality issues	5	1	4 (80%)
Wait time	8:16	3:09	5:07 (61.9%)
Travel time	14:12	7:07	7:05 (49.9%)

Results


First round
Workstation [no.]
0
1
2
3
4
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
Duration [mm:ss]
Safety
Carpenter
Plumber
Electrician

Results


Second round
Workstation [no.]
0
1
2
3
4
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
Duration [mm:ss]
Safety
Carpenter
Plumber
Electrician

Limitations and outlook

- Virtual avatar modelling
- Trajectory data
- Experience factor between rounds
- Communication and interaction in multi-player VR
- Behavioural analysis (Psychology)

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Preparing the next generation work force

Emil L. Jacobsen – elj@cae.au.dk