Robot Path Planning for Nuclear Decommissioning Tasks in Complex Environments

Dr Vijay M. Pawar | v.pawar@ucl.ac.uk, UCL

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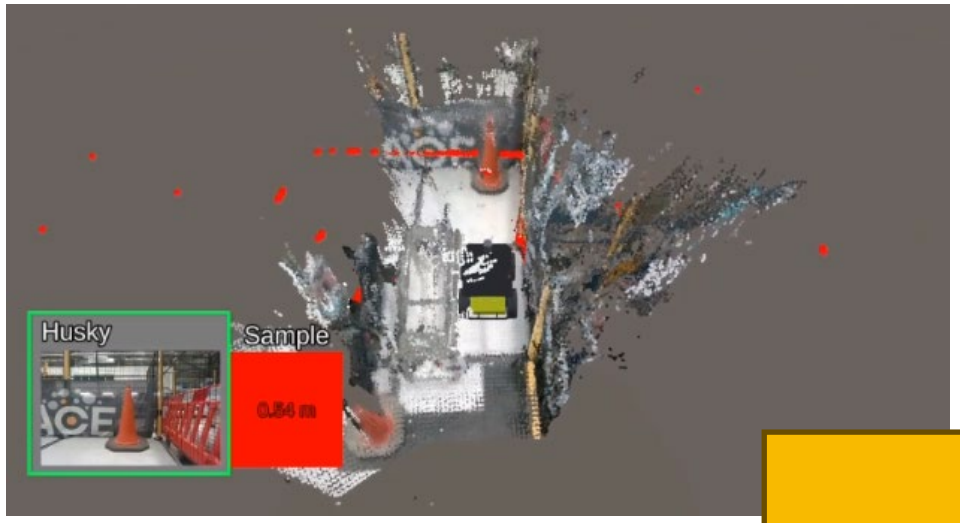
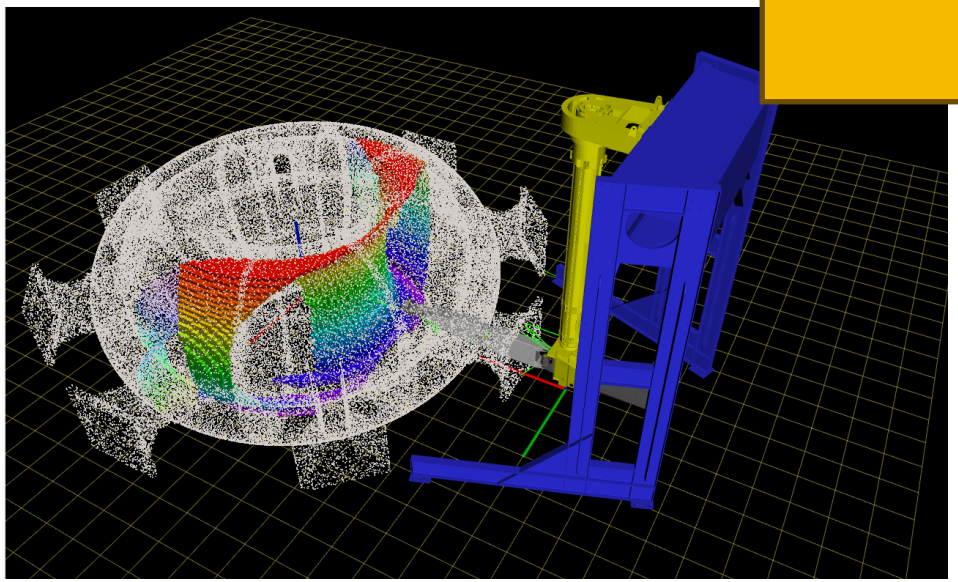
Problem Statement – Robot Planning Tools for Nuclear Decommissioning





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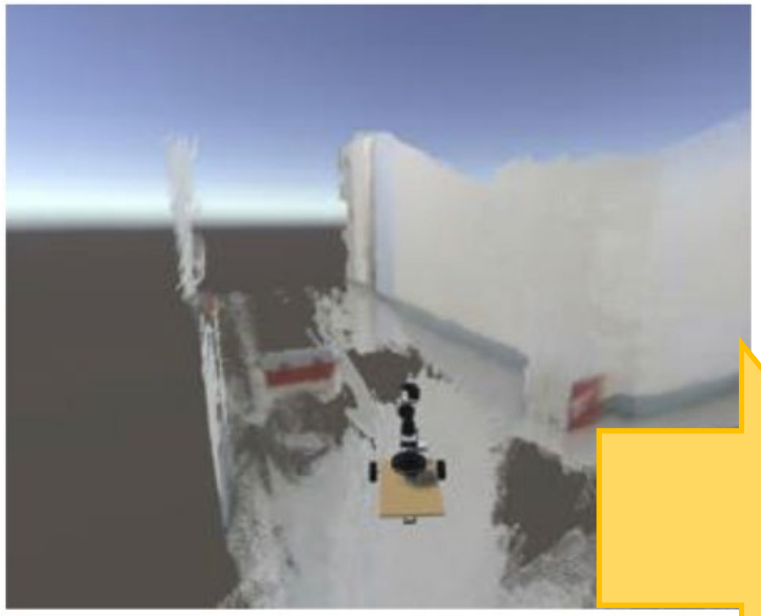
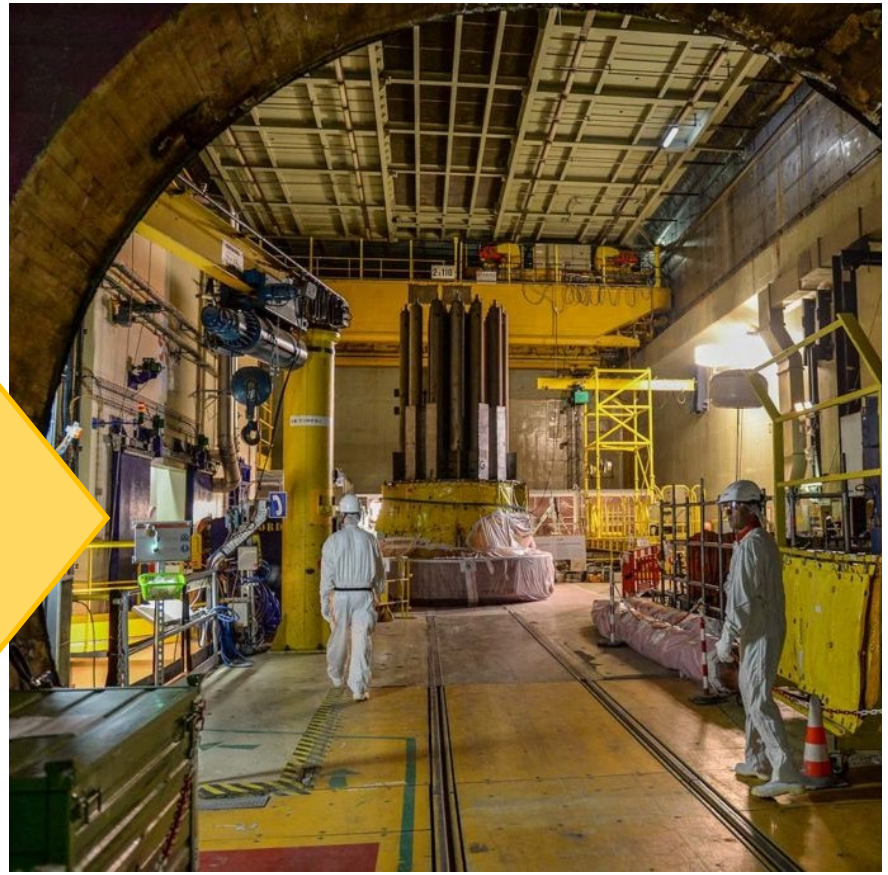
Existing Research

Stokto et al, A VR system for immersive teleoperation and live exploration with a mobile robot. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 3630-3637). IEEE



Chen-Yu Kuo et al, Development of an immersive SLAM-based VR system for teleoperation of a mobile manipulator in an unknown environment. *Computers in Industry*, *132*, p.103502.



Inspections in nuclear - Chooz, Prest

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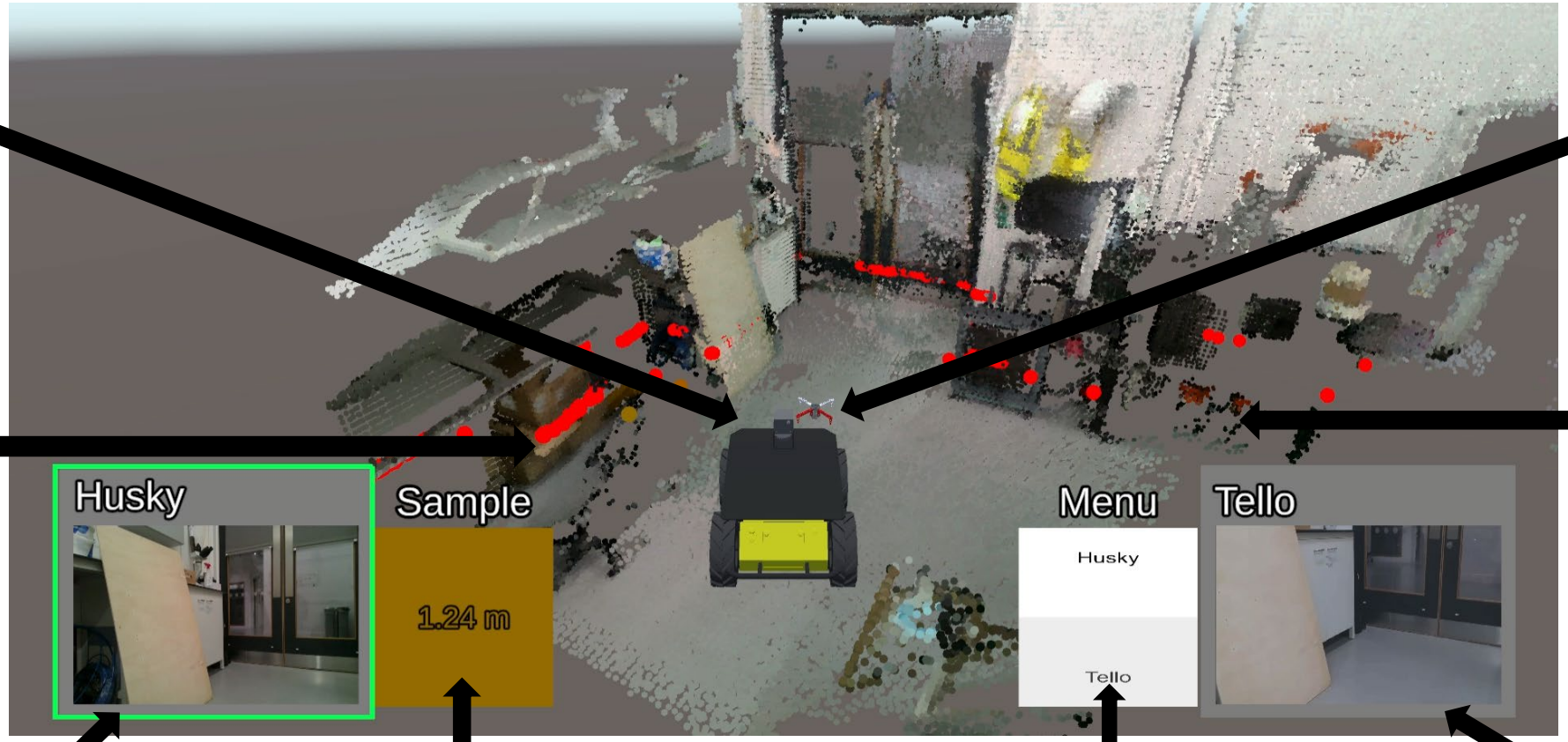
Background: VRTAB-Map



Husky position

Tello position

Lidar render

RTABmap pointcloud render

Husky video render

Simulated alpha sampling procedure

UGV/UAV swapping procedure

Tello video render

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Background: VRTAB-Map

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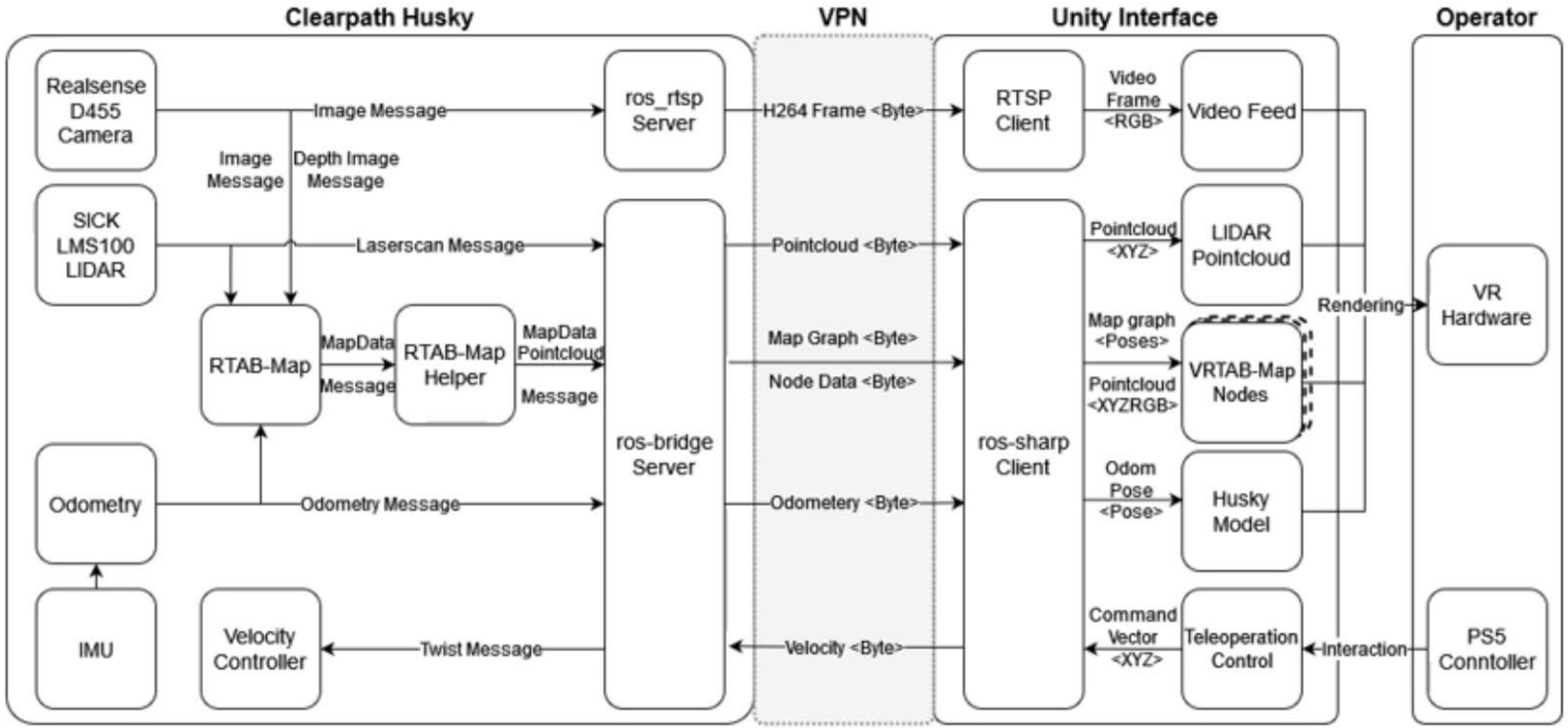
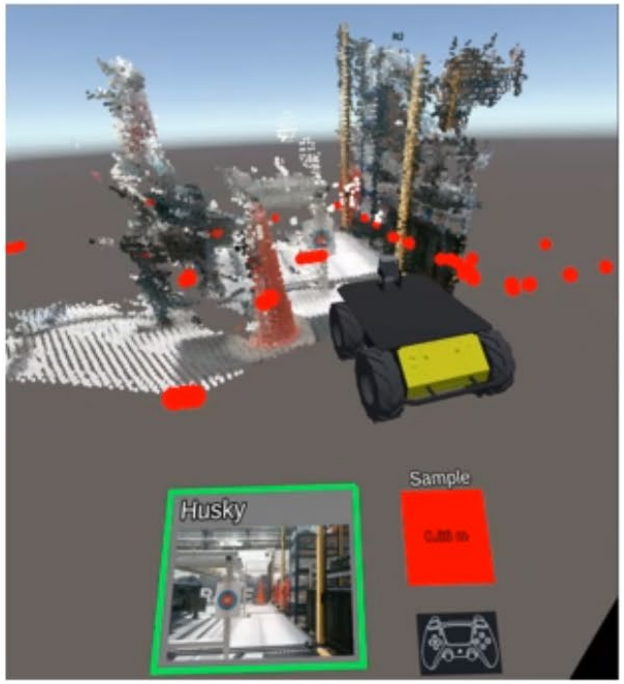
System Technical Architecture:





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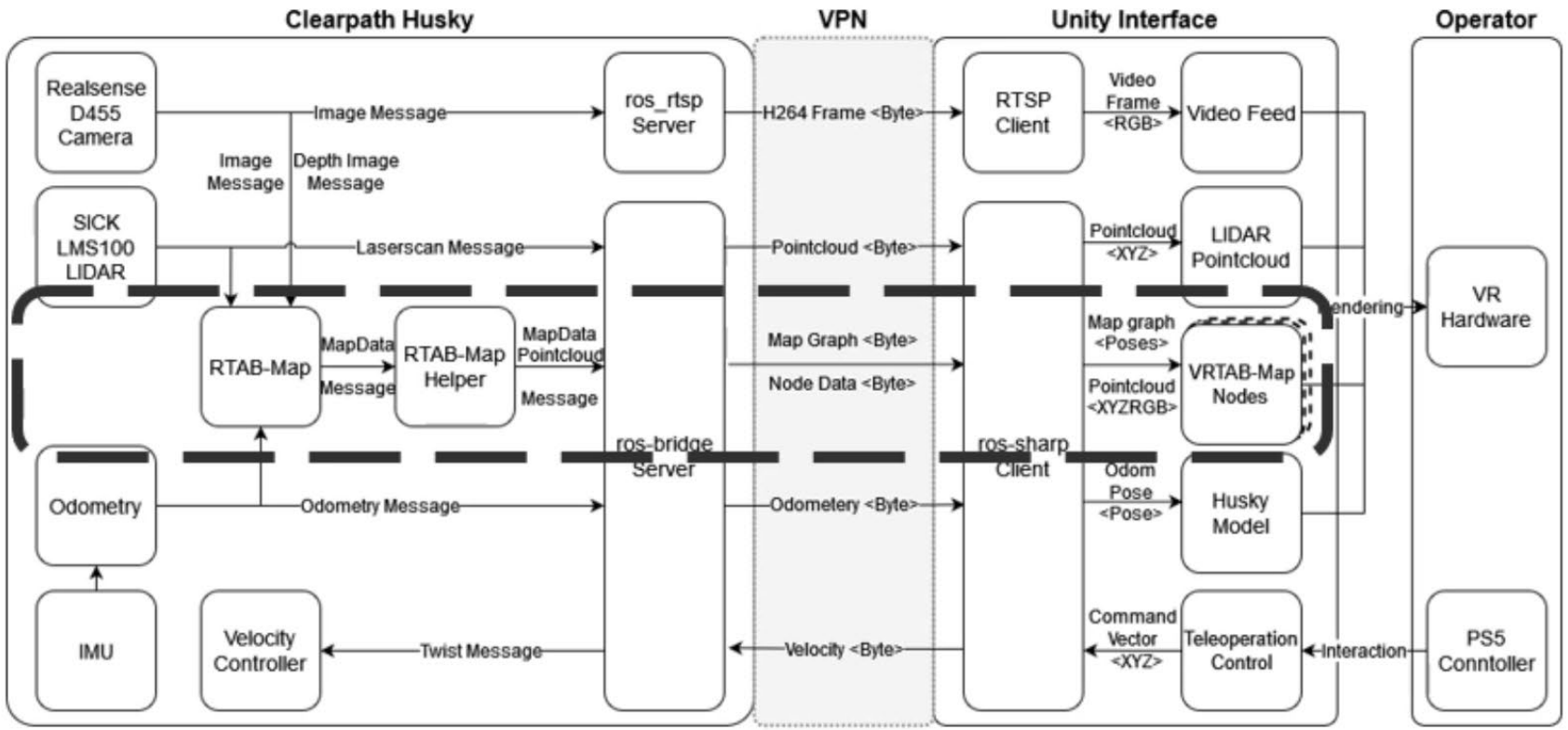

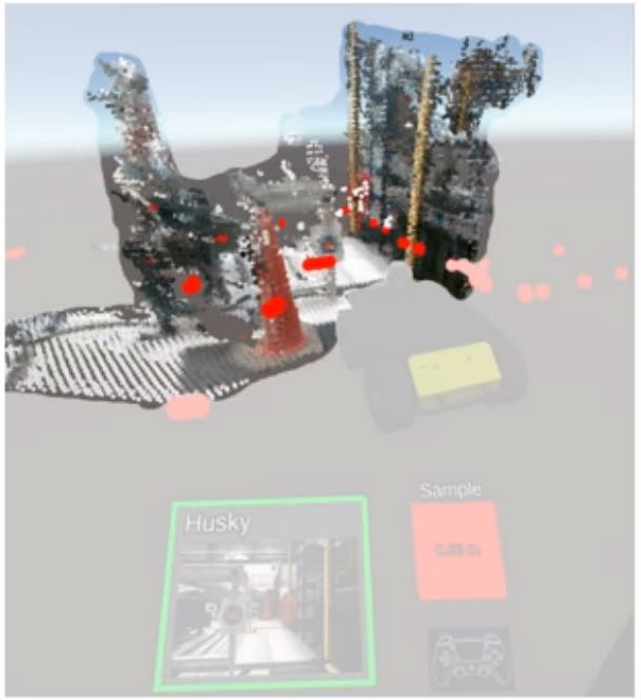

- Interface Features:
- Dense environment reconstruction using RTAB-Map SLAM algorithm

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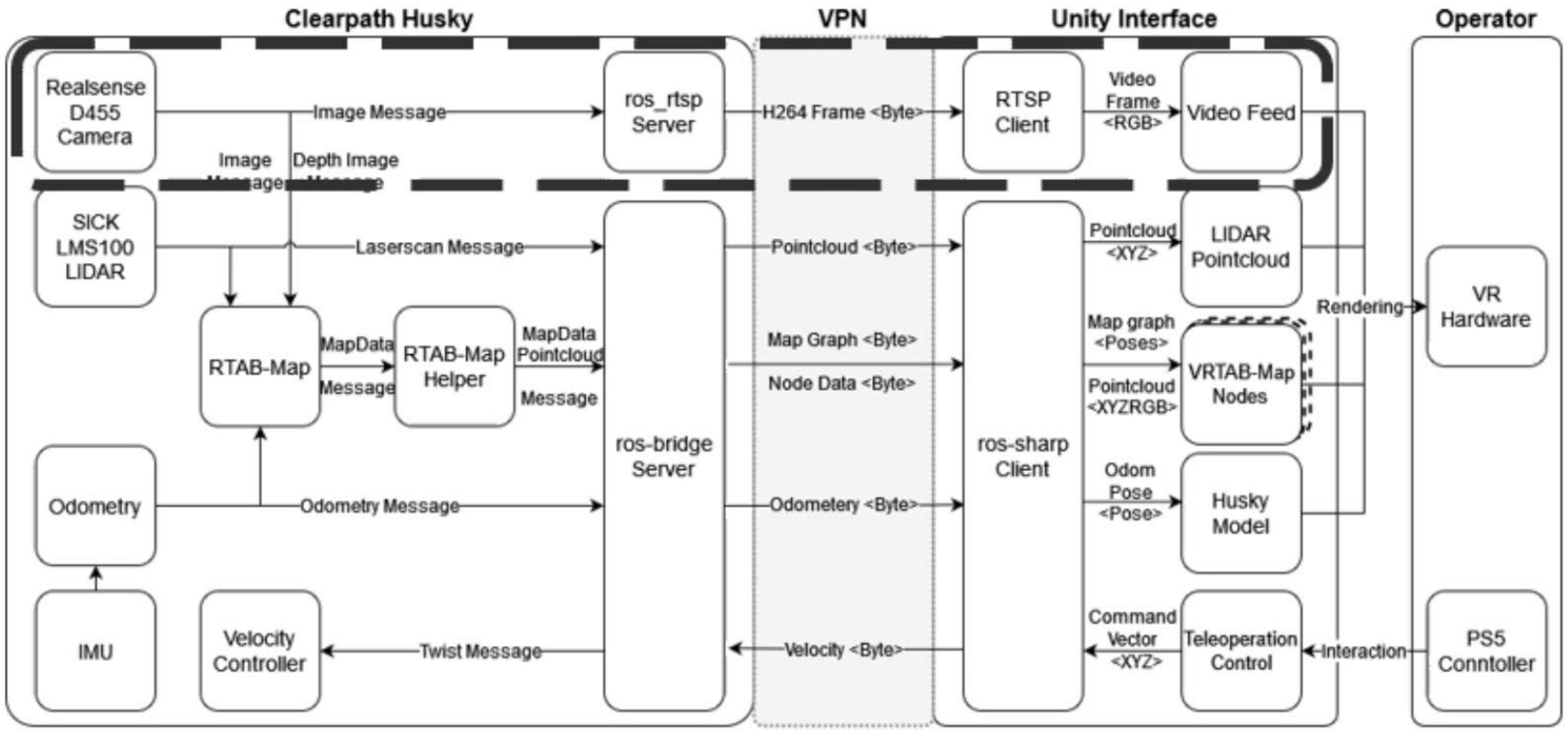

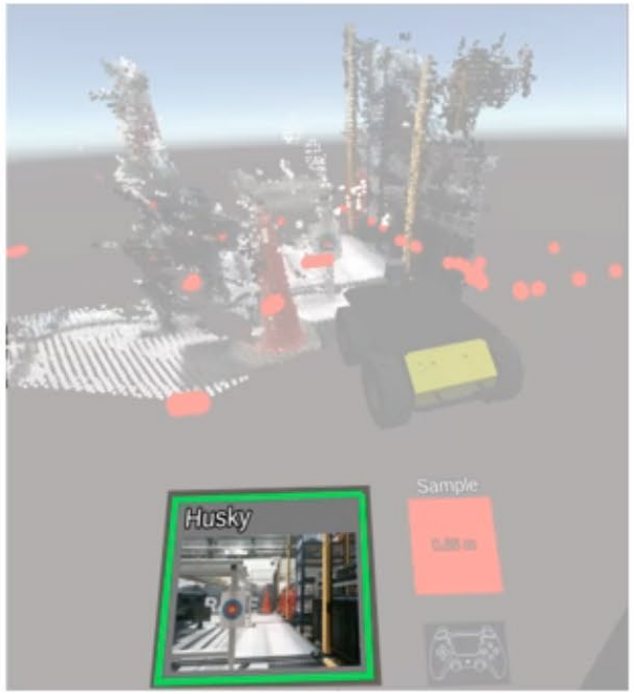

- Interface Features:
- Dense environment reconstruction using RTAB-Map SLAM algorithm
- Real-time video feed from a low latency RTSP video pipeline

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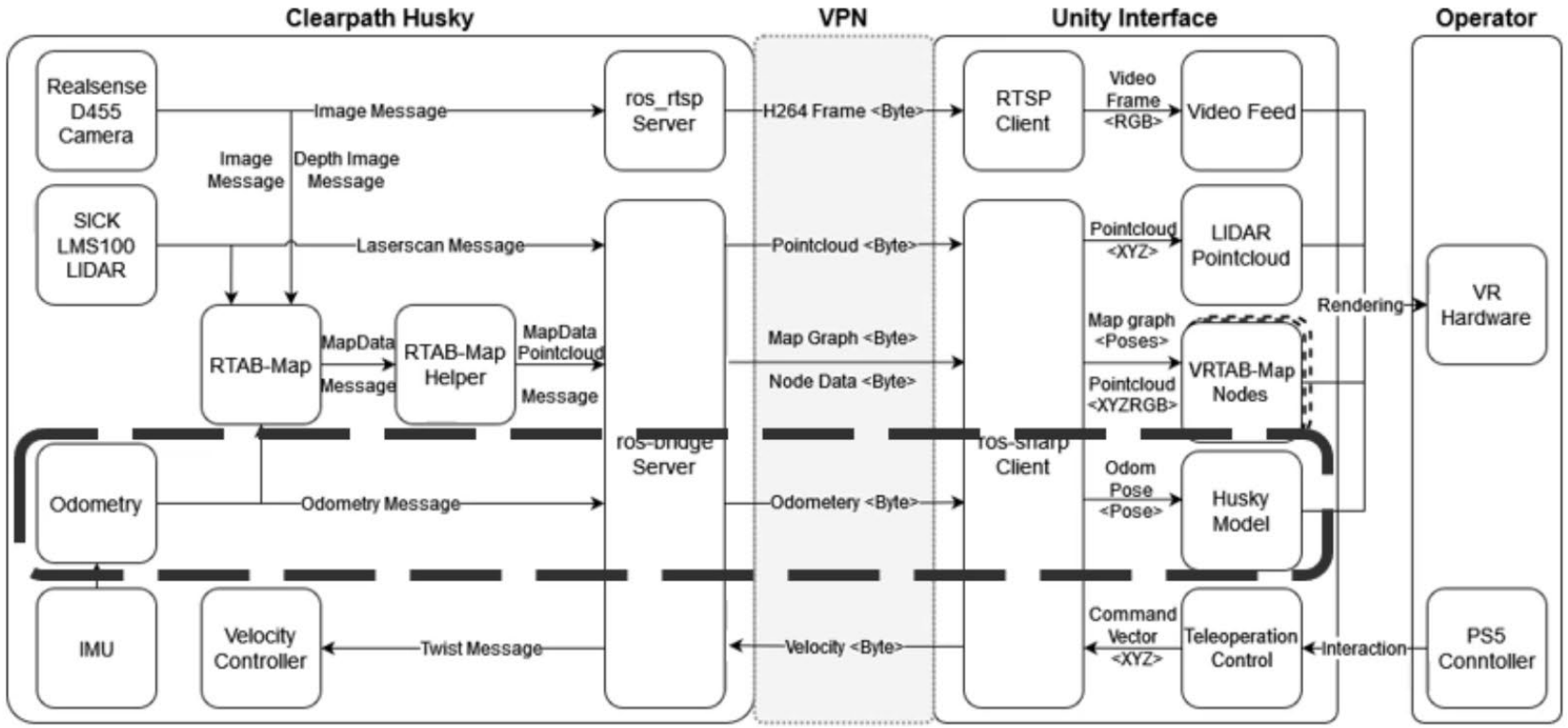

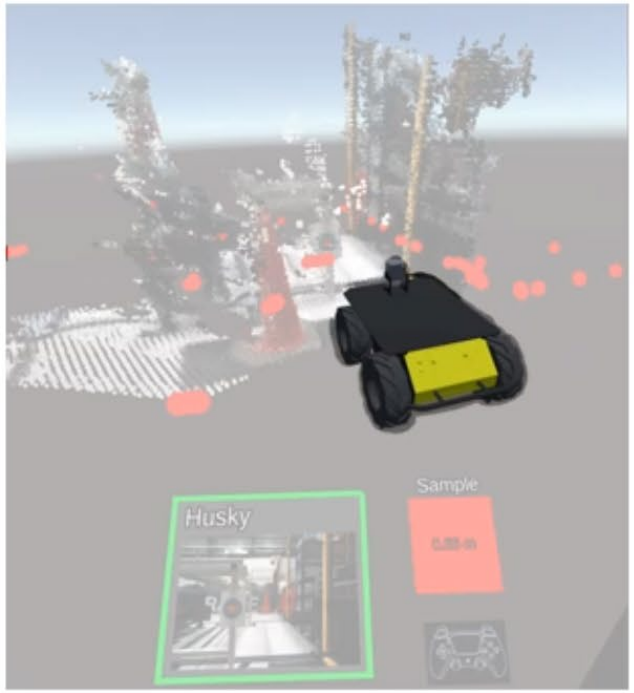

- Interface Features:
- Dense environment reconstruction using RTAB-Map SLAM algorithm
- Real-time video feed from a low latency RTSP video pipeline
- Overlayed LiDAR pointcloud for increased 3D spatial awareness

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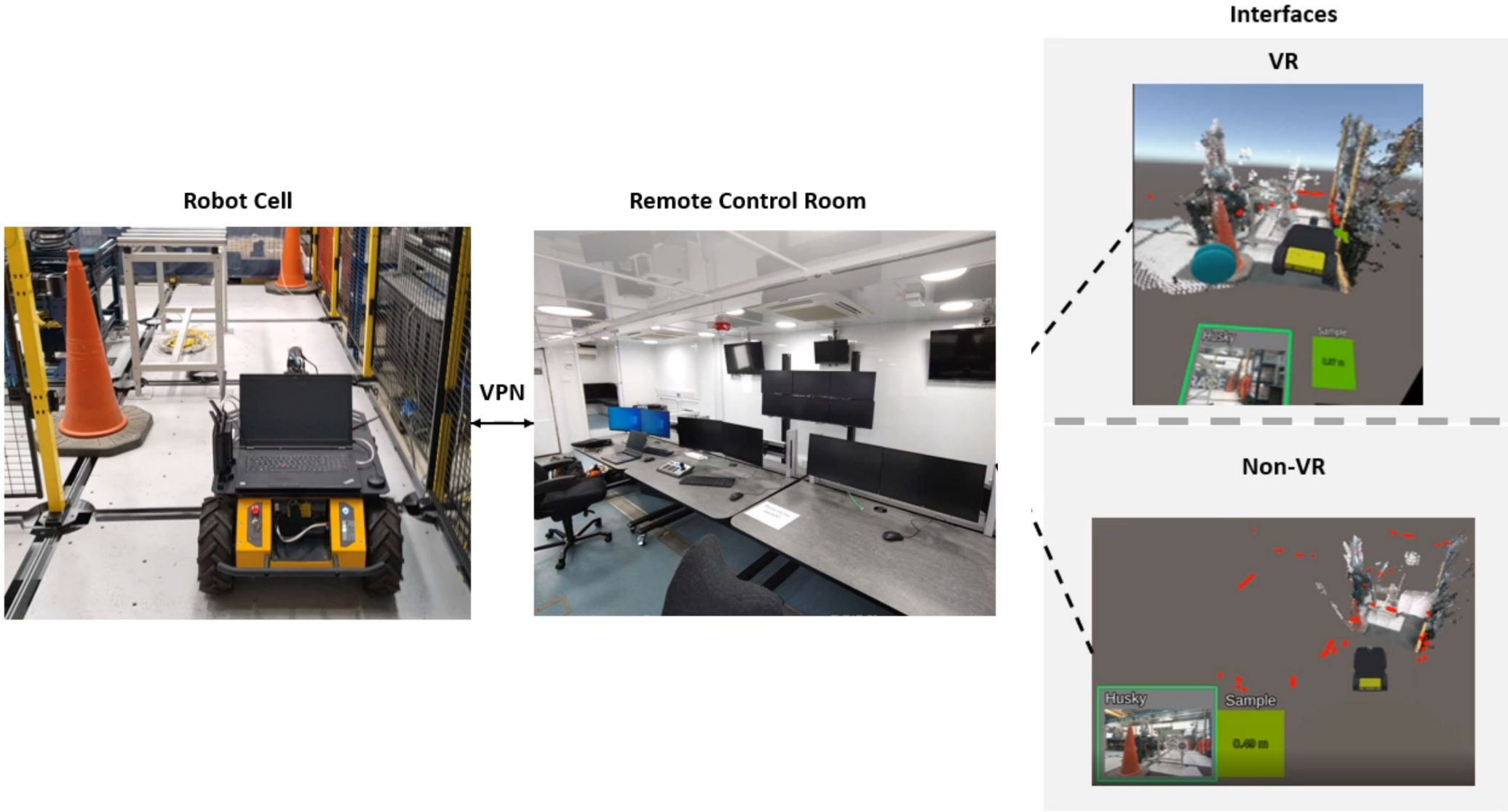
Experiment Design: Methodology



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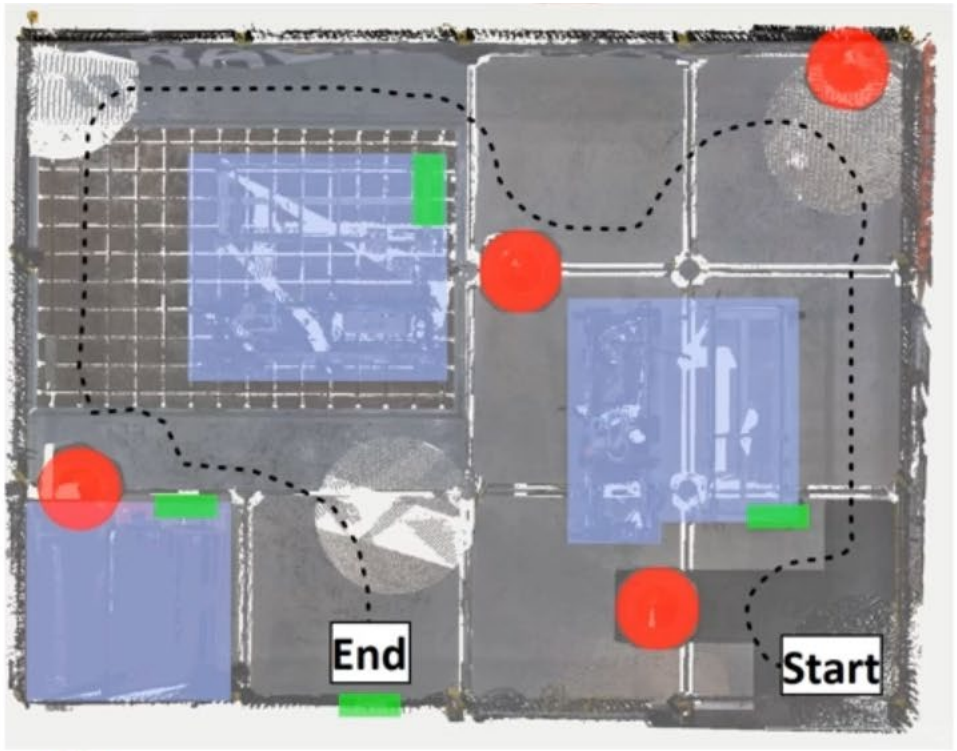

- Traffic cone (Alpha sample location)
- Paper target (Visual inspection location)
- Physical barrier
- Critical Path

NNUF National Nuclear User Facility

RACE

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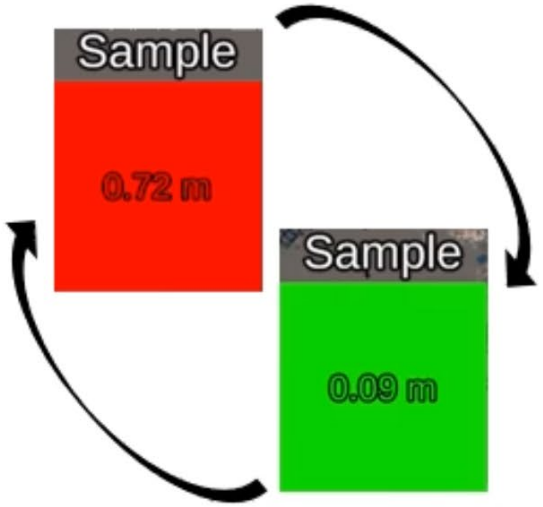
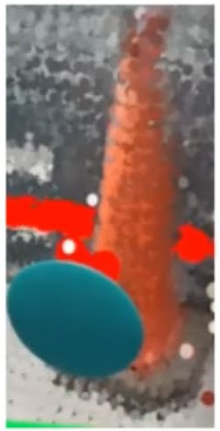
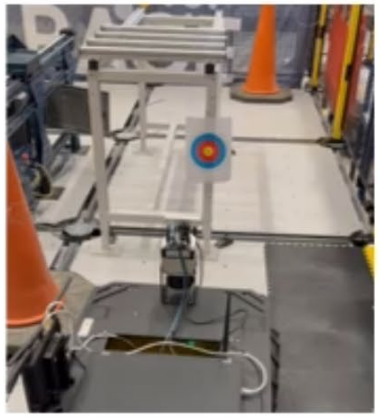
Experiment Design: Methodology

Alpha Sampling





Visual Inspection



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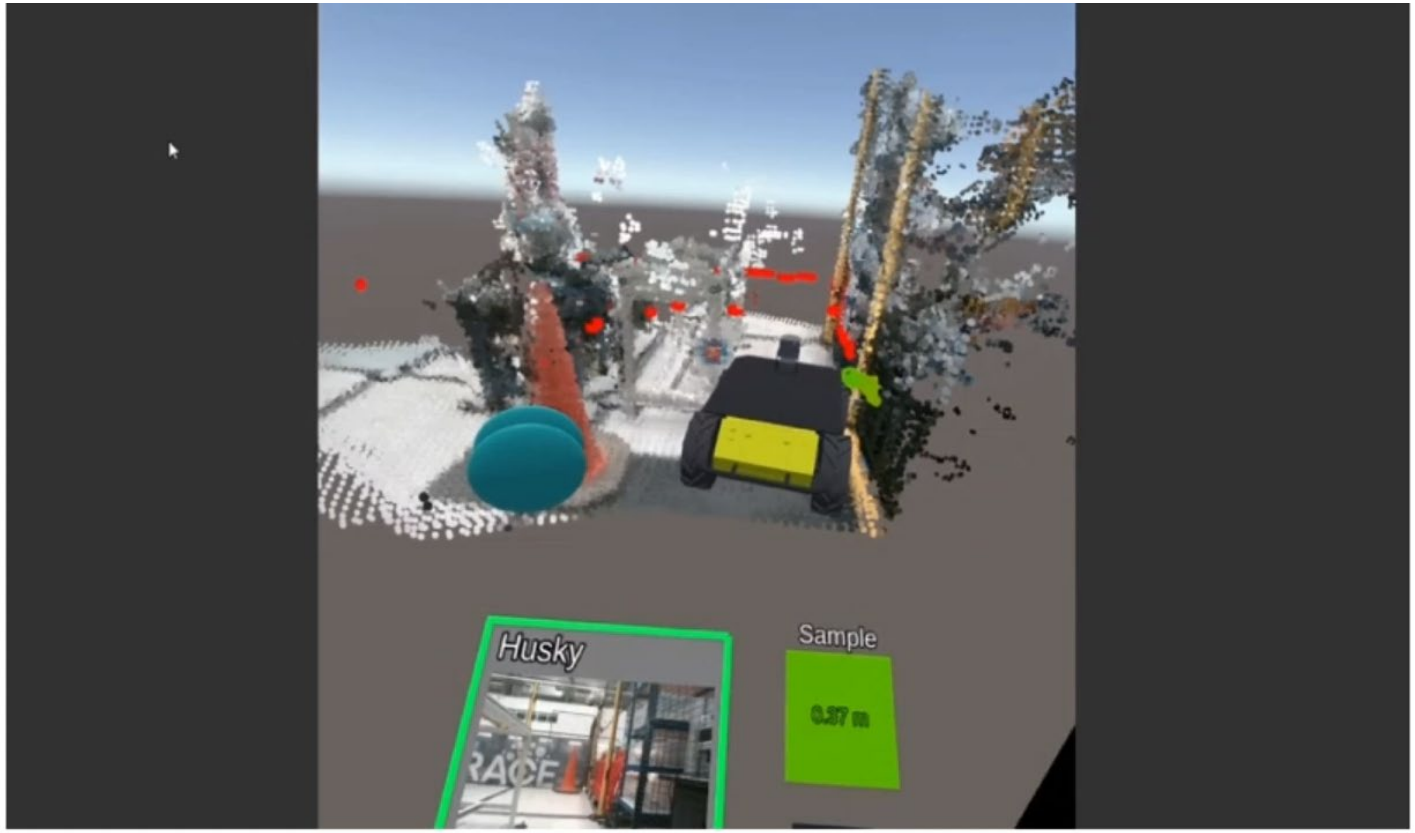
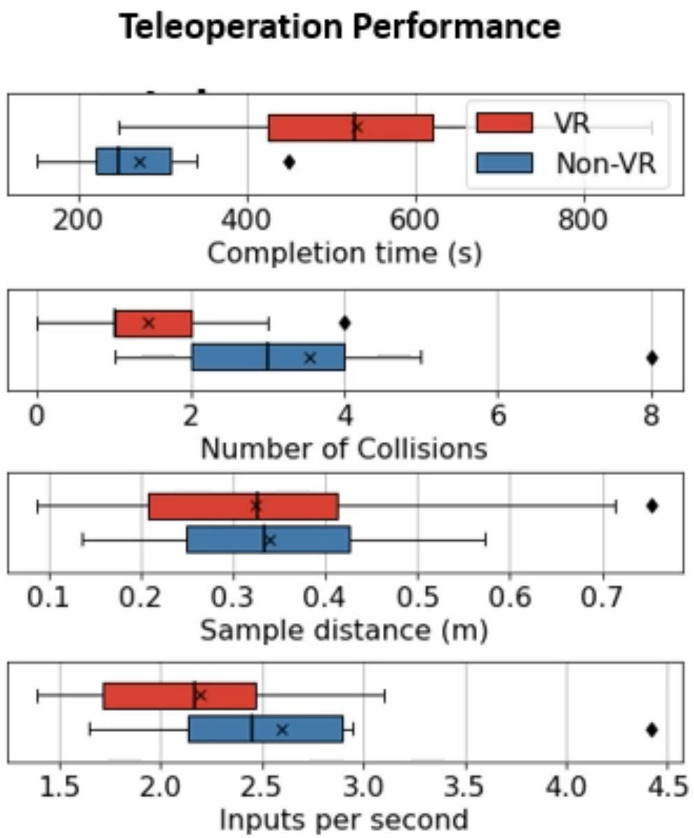
Experiment Design: Methodology

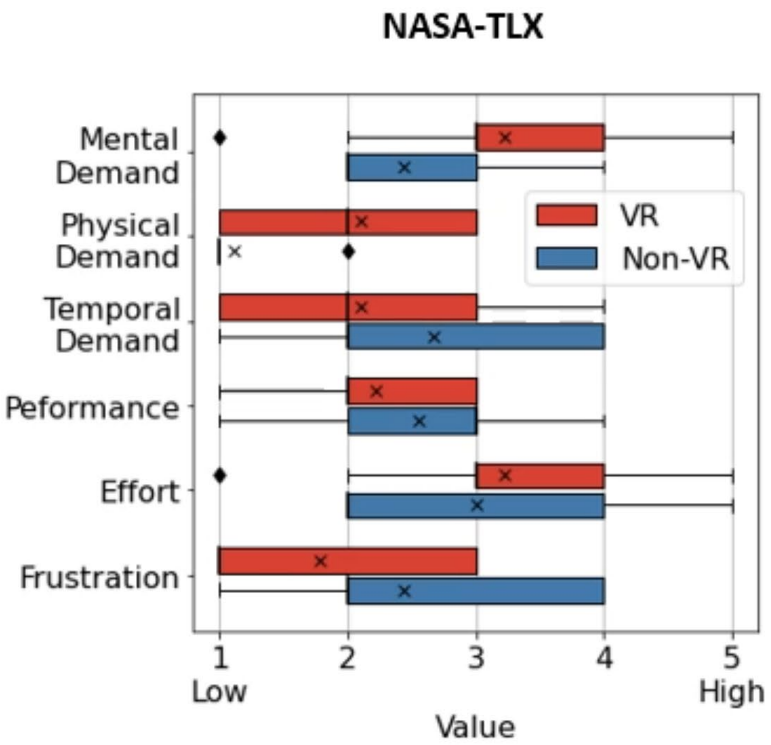
- 18 expert participants from RACE
- Teleoperation and Task Performance Metrics
  - Completion Time
  - Collisions
  - Alpha Sample Accuracy
  - Number of Inputs
- NASA-TLX (cognitive workload)
- SART (situational awareness)
- Physiological responses from Empatica E4 wearable sensor
- Usability questionnaire

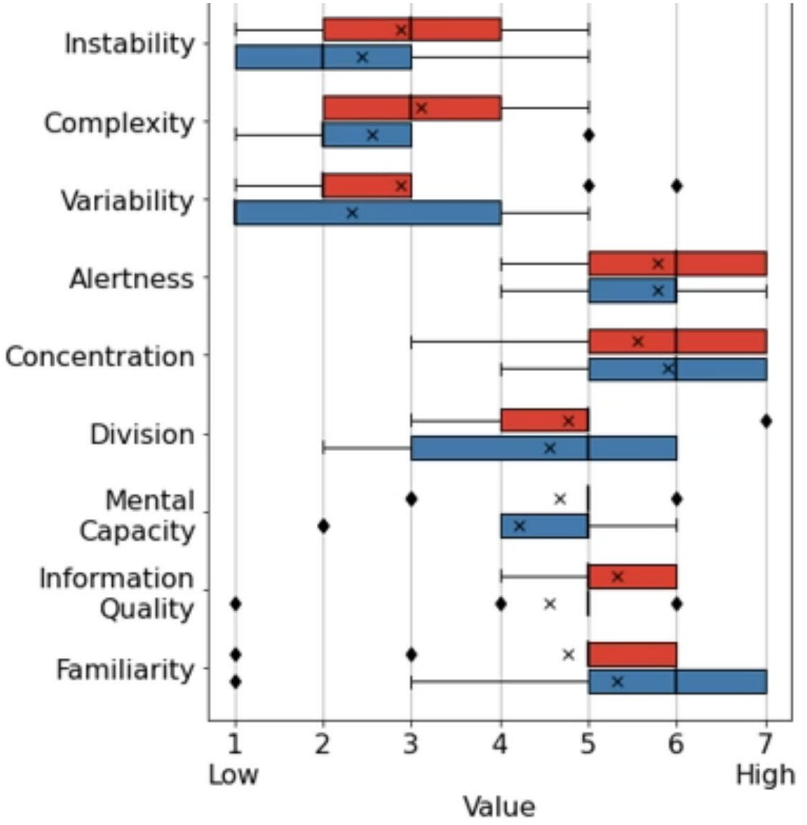


Footage is x2 realtime

Results Summary







- Operators in VR took longer to complete the experiment and had less collisions
- Operators in VR reported significant increase in physical demand

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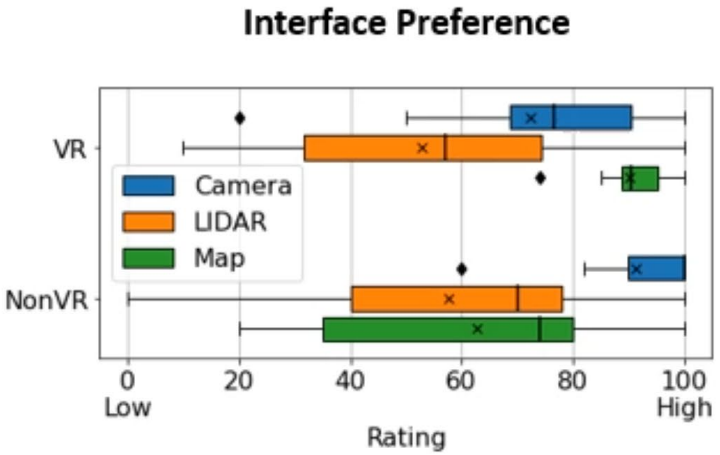
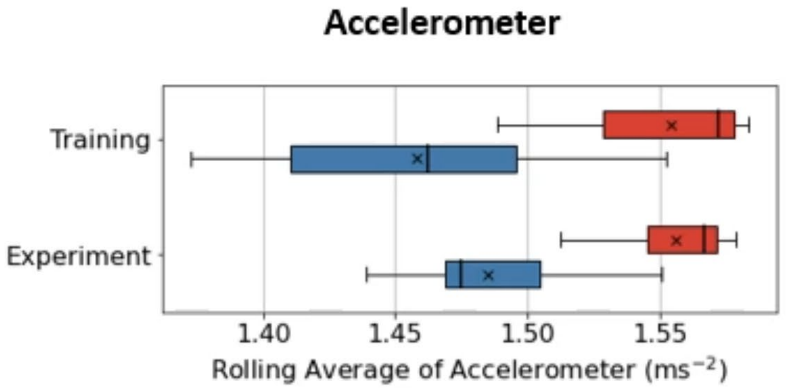
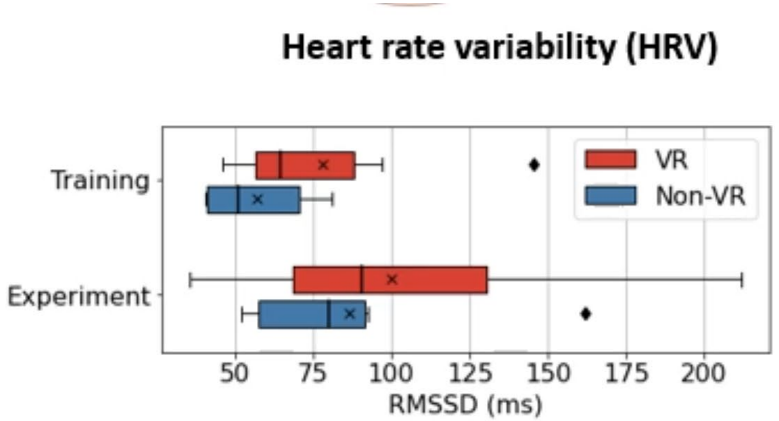


- Significantly higher preference for 3D maps in VR



- Higher Empatica accelerometer measurements in VR, correlating with increased physical demand ratings and fatigue



- Higher HRV in VR condition, indicating an increase in physical and cognitive load

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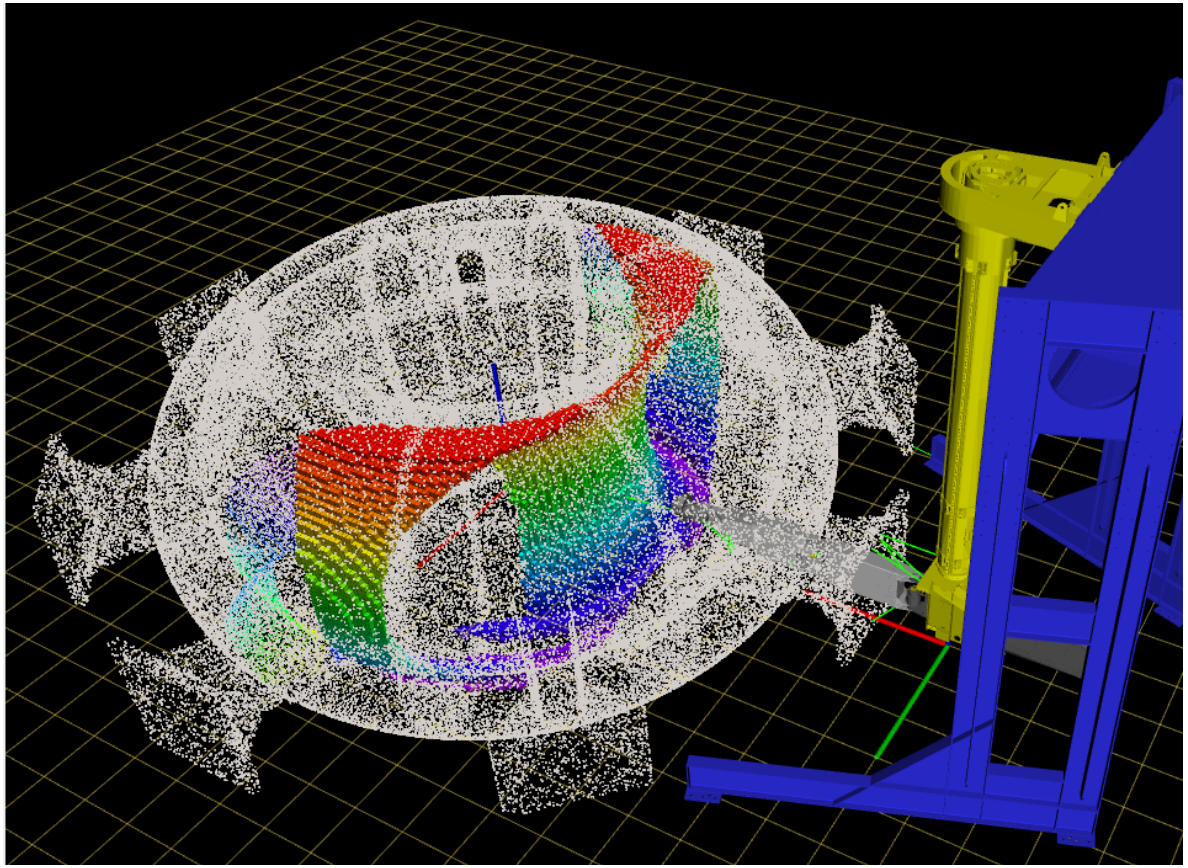
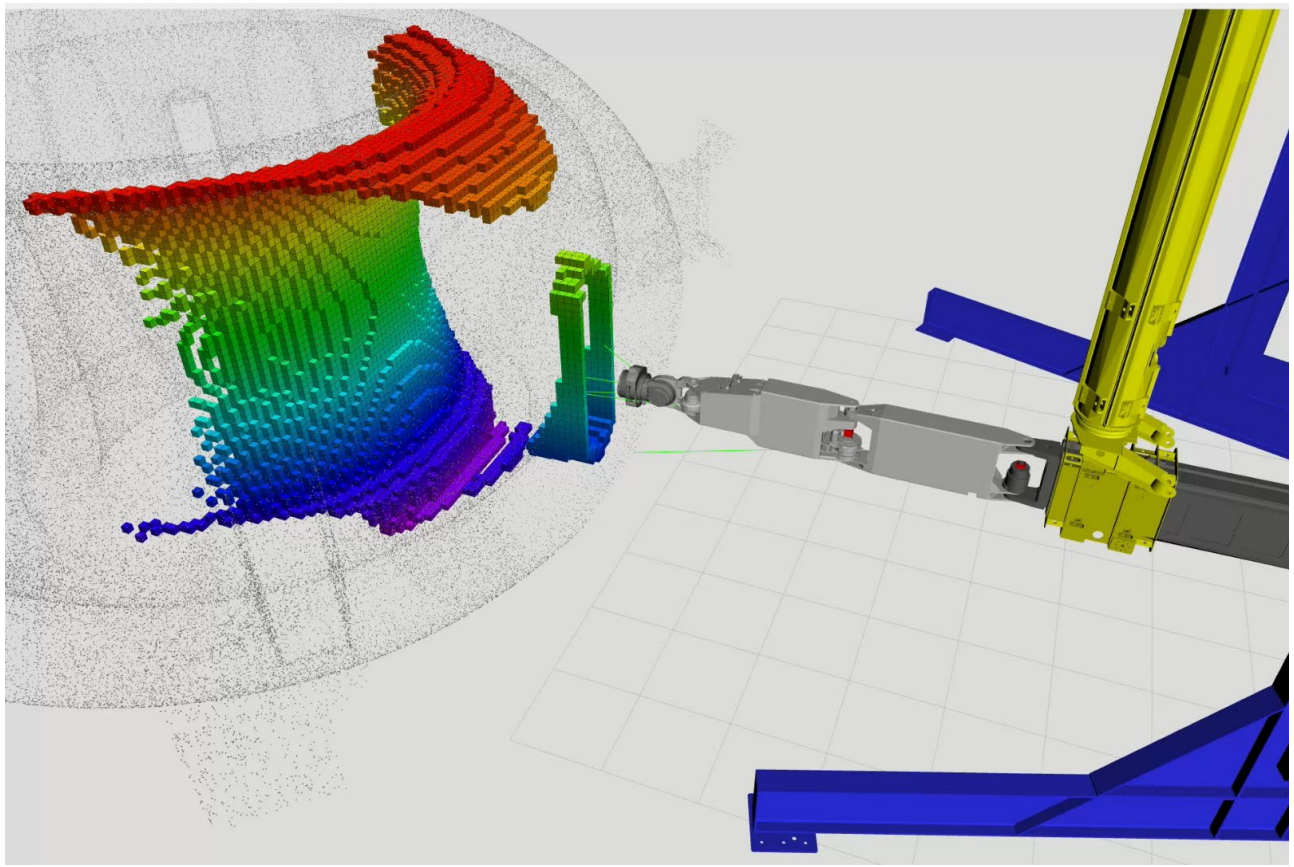
Extending NNUF Results to the Telescopic Articulated Remote Mast (TARM)





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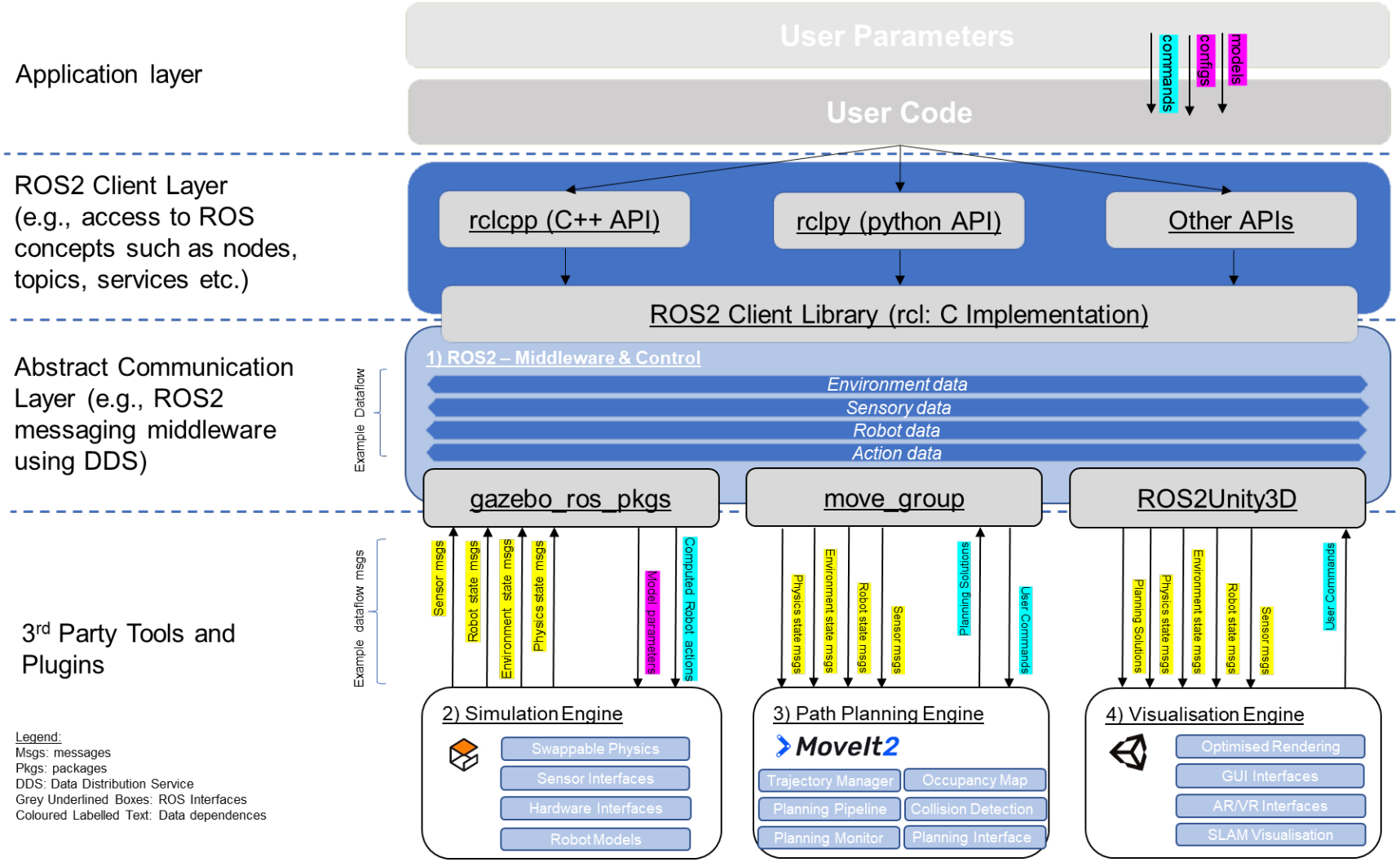

Legend:
Msgs: messages
Pkgs: packages
DDS: Data Distribution Service
Grey Underlined Boxes: ROS Interfaces
Coloured Labelled Text: Data dependences

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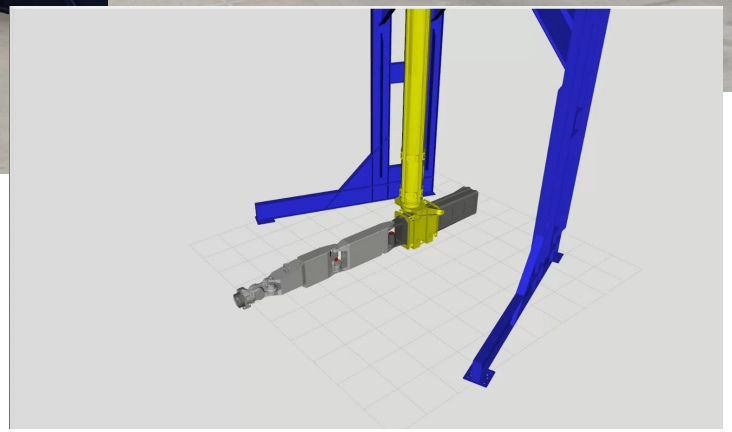

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Research Team

Harvey Stedman
harvey.stedman.18@ucl.ac.uk

Dr Vijay Pawar
v.pawar@ucl.ac.uk

Dr Basaran Bahadir Kocer
b.kocer@imperial.ac.uk

Prof. Mirco Kovac
m.kovac@imperial.ac.uk

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