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The **HULK**

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How we work…

1. *Isolate* key questions by **fielding complex** *systems*
2. *Augment* or *invent* new techniques to **solve the problem**
3. *Repeat*…


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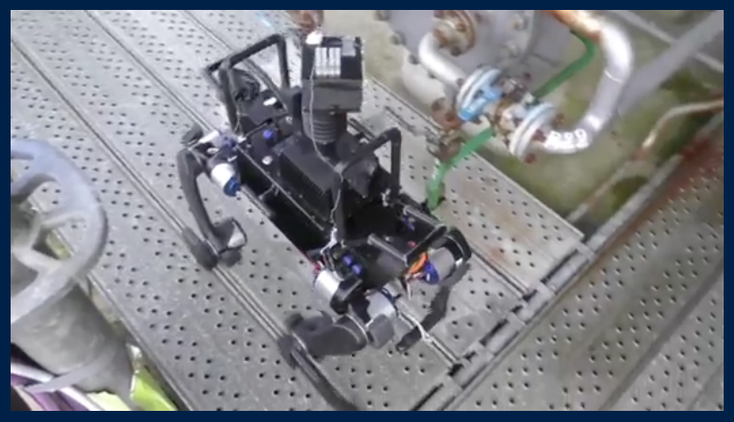
GATEway
GREENWICH AUTOMATED TRANSPORT

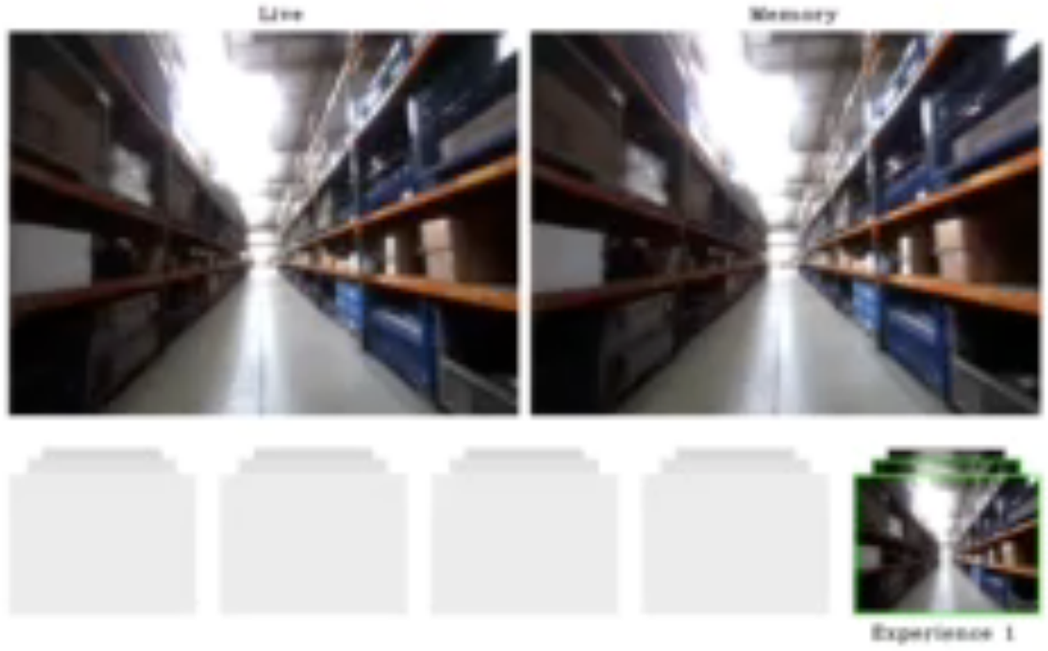

OXBOTICA

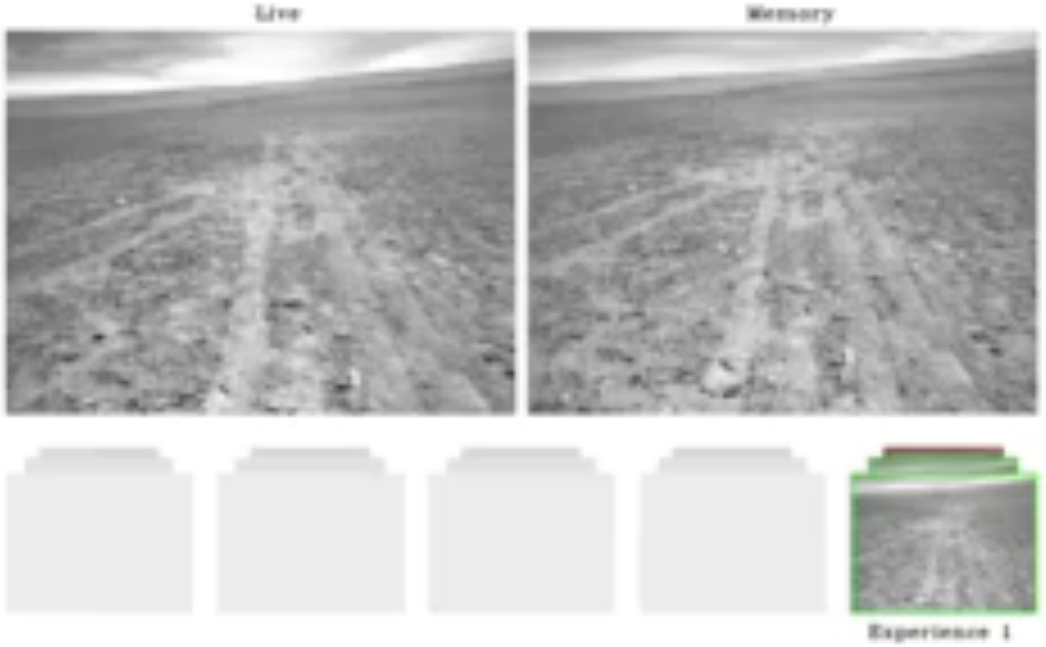


Why build a new platform?

Path Proposals

D. Barnes, W. Maddern, and I. Posner, "Find Your Own Way: Weakly-Supervised Segmentation of Path Proposals for Urban Autonomy", ICRA 2017





C. Linegar, W. Churchill, and P. Newman, “Work Smart, Not Hard: Recalling Relevant Experiences for Vast-Scale but Time-Constrained Localisation”, ICRA 2015.

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- Unstructured/rough terrain
- Long term autonomy
- Unsupervised operation

Rough Terrain

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meangreenproducts.com

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- Unstructured/rough terrain ✅
- Long term autonomy ✅
- Unsupervised operation

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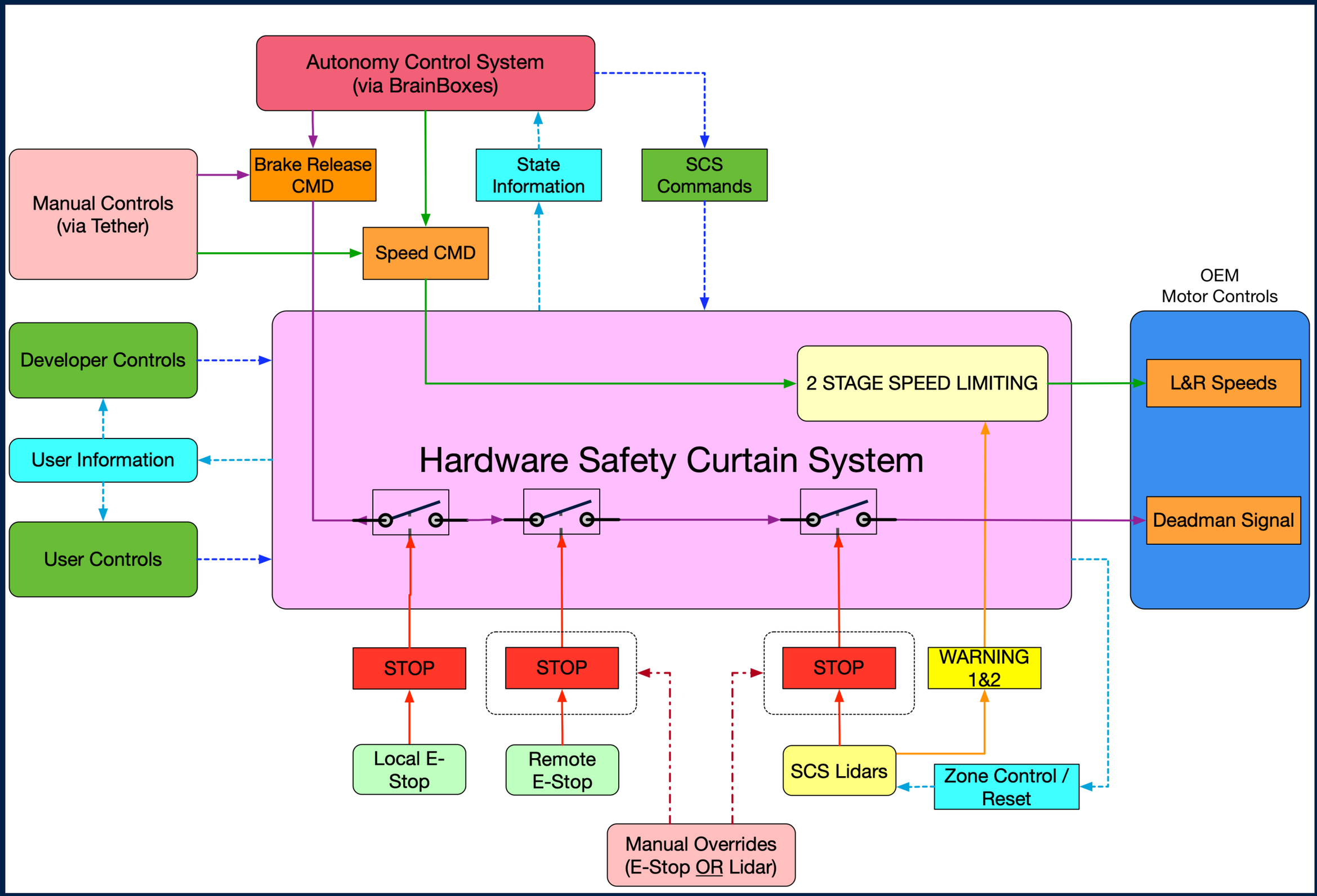
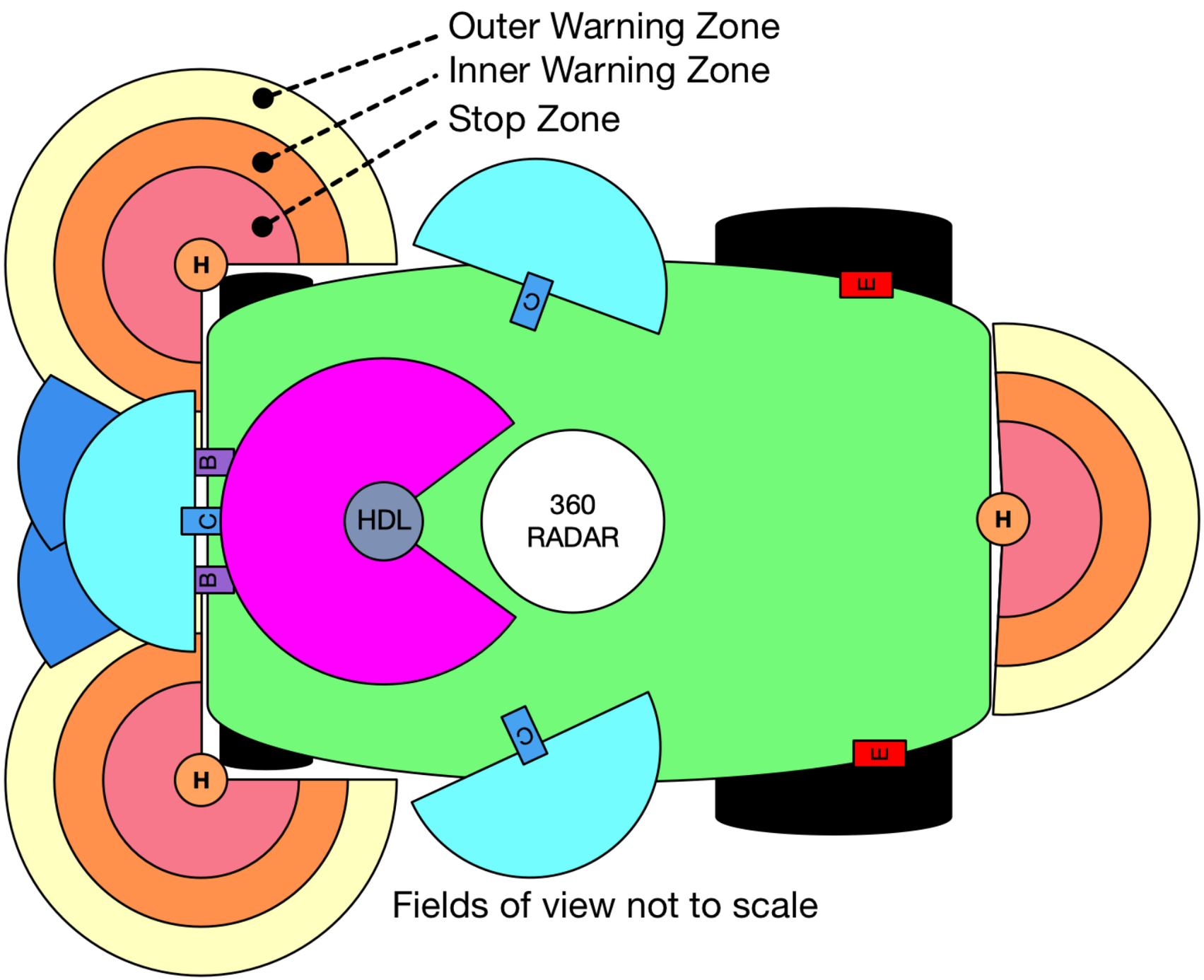
Don’t trust software!

Unsupervised Operation

- Use COTS Safety laser scanner
- Hokuyo UAM-05LP-T301


Autonomy Control System
(via BrainBoxes)
Brake Release
CMD
State
Information
SCS
Commands
Manual Controls
(via Tether)
Speed CMD
OEM
Motor Controls
Developer Controls
2 STAGE SPEED LIMITING
L&R Speeds
User Information
Hardware Safety Curtain System
User Controls
Deadman Signal
STOP
STOP
STOP
WARNING
1&2
Local E-
Stop
Remote
E-Stop
SCS Lidars
Zone Control /
Reset
Manual Overrides
(E-Stop OR Lidar)



Fields of view not to scale

H 3 x 2D lidar
- Hokuyo UAM-05LP

E 2 x Local E-Stop switch

360 radar - highest sensor
- NavTech CTS-350X

HDL 3D lidar - Velodyne HDL32

Cameras:

C <u>Situational awareness:</u>
3 x Flir U3-31S4C-CS
(180deg FOV)

B <u>Visual Odometry:</u>
1 x Flir BB2-08S2C-38

The **Hulk**

- Unstructured/rough terrain ✅
- Long term autonomy ✅
- Unsupervised operation ✅

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What are we going to do with it?

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3. *Repeat*…

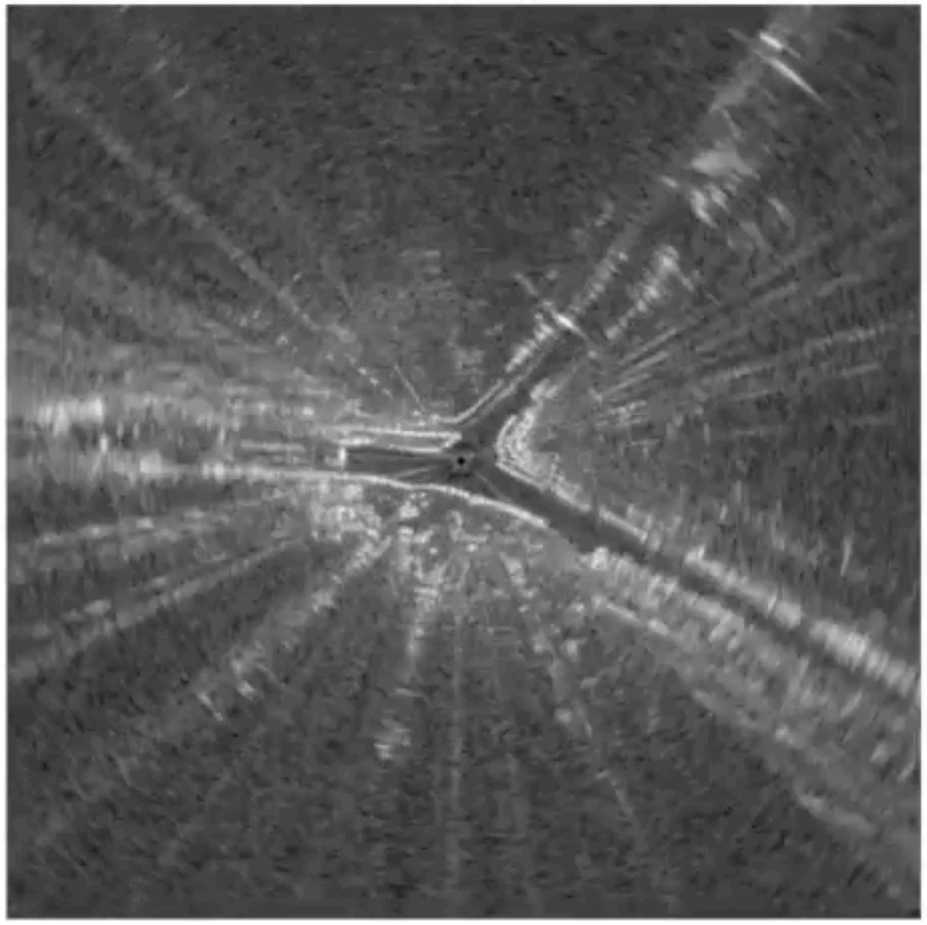
Radar

Radar is ideal for autonomy in challenging environments as it is good at detecting stable environmental features under adverse weather and lighting conditions.

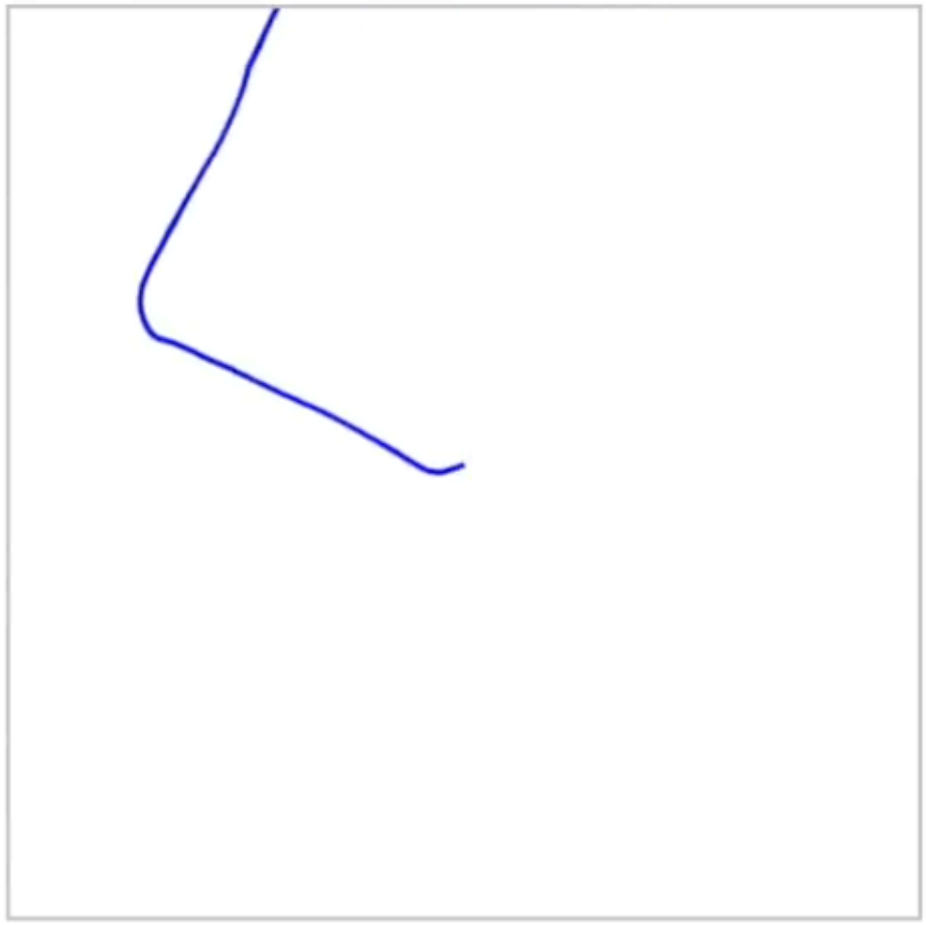
Radar

ACCURATE RADAR-ONLY MOTION ESTIMATION

INPUT: RADAR IMAGE



OUTPUT: MOTION ESTIMATION



Advantages of our method:

No additional sensors

No outlier detection

No model-reliant filtering on motion

No map creation

Few free parameters

Handles any displacement given sufficient overlap

S. H. Cen and P. Newman, “Precise Ego-Motion Estimation with Millimeter-Wave Radar under Diverse and Challenging Conditions,” in ICRA 2018.

SCENE

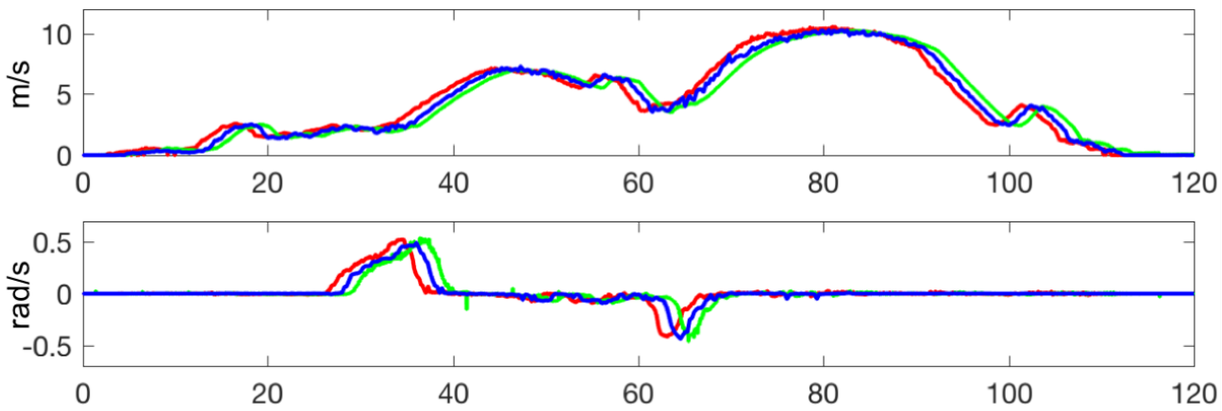
ODOMETRY RESULTS

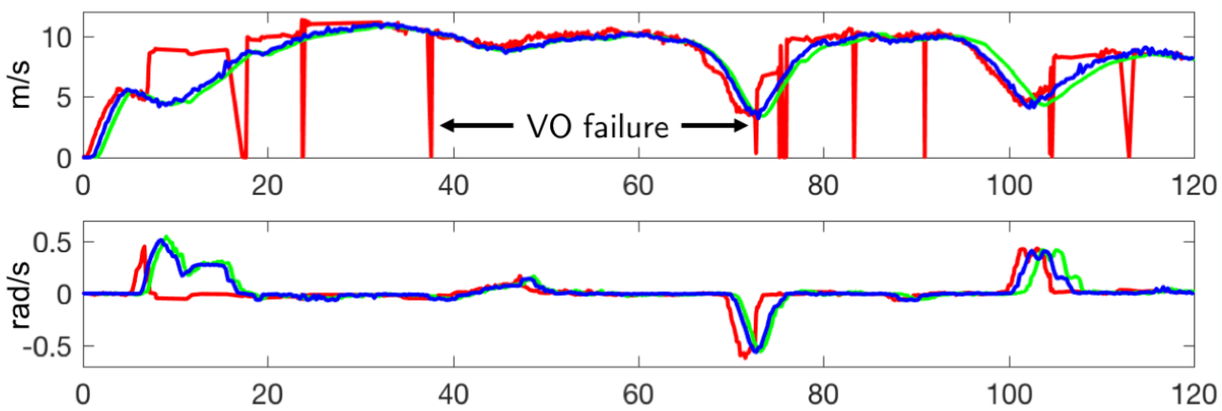
BRIGHT

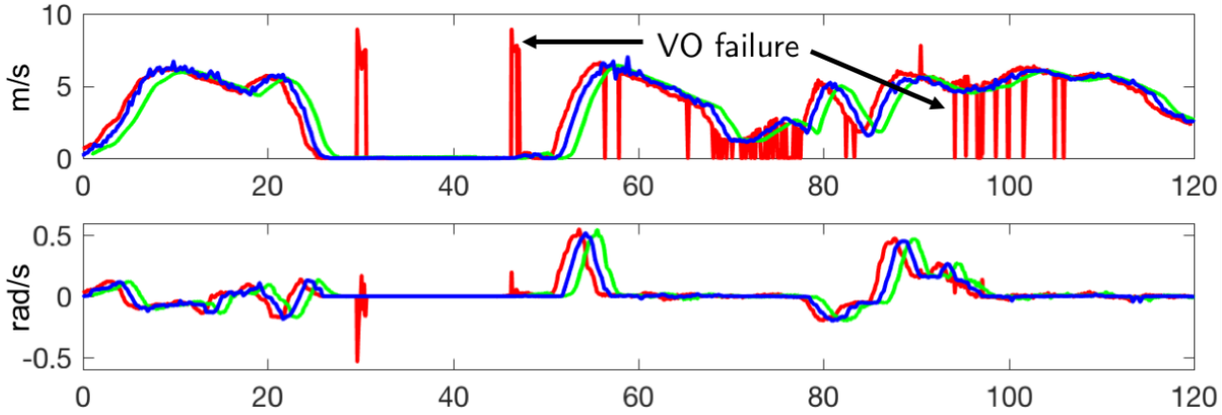
DARK

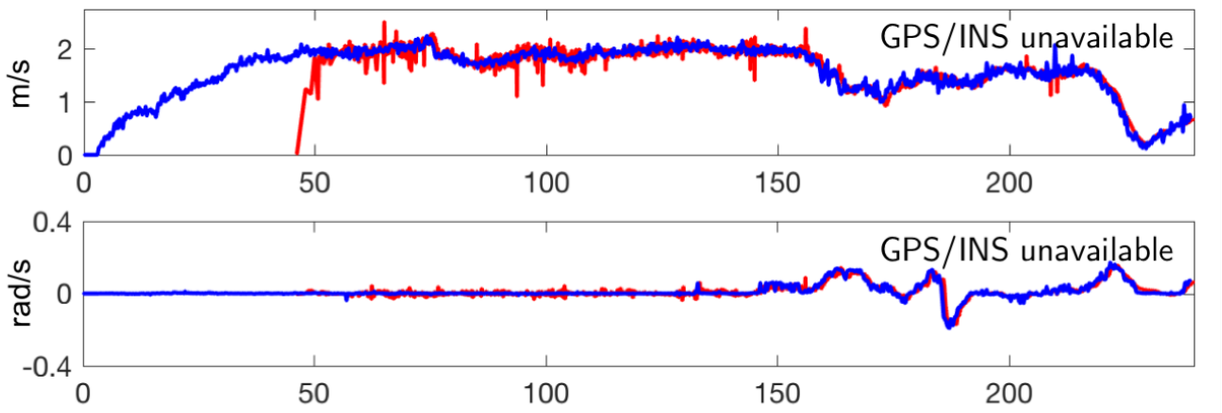
RAINY

INDOORS









GPS/INS VO RO

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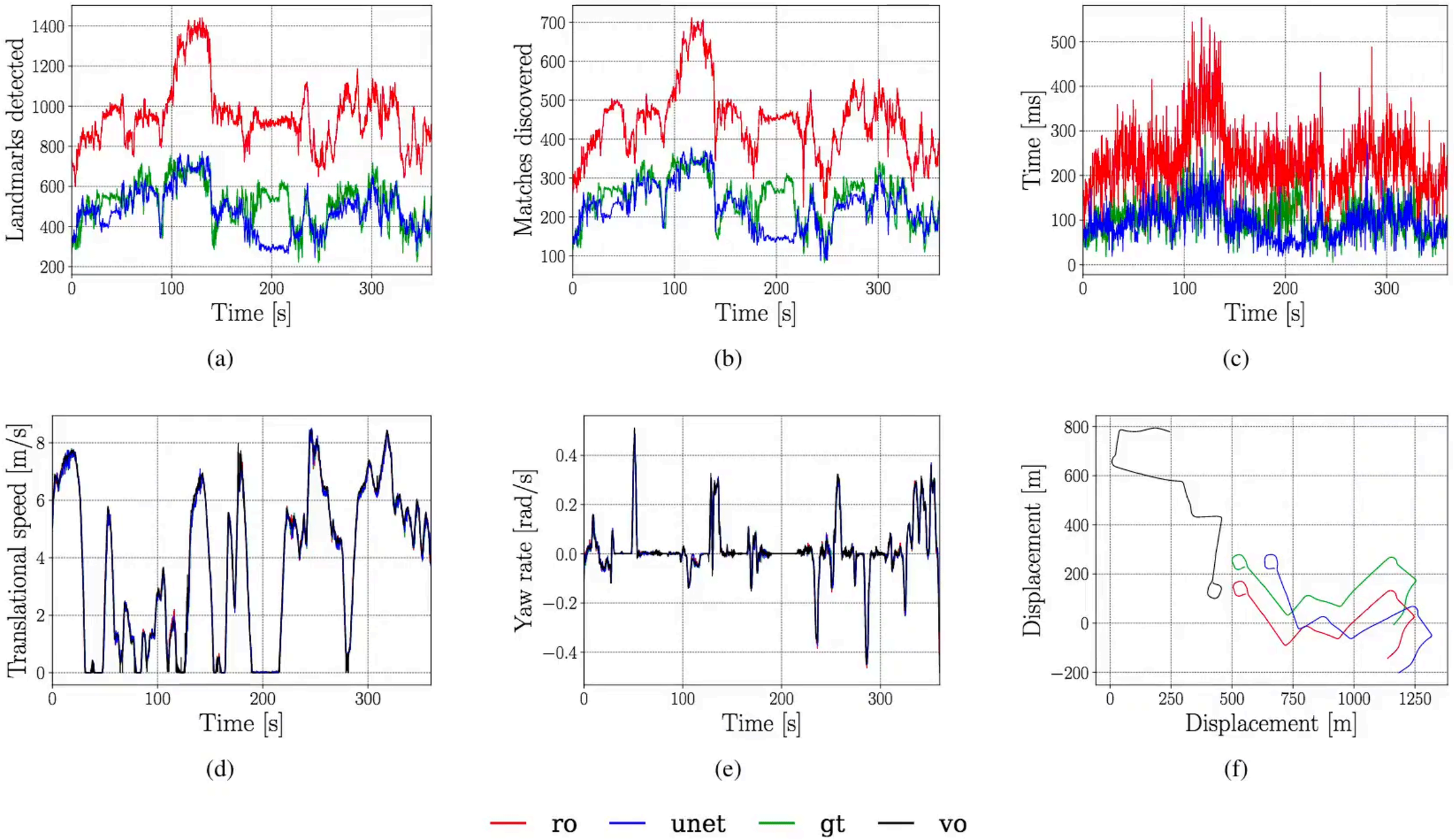

R. Aldera, D. De Martini, M. Gadd, and P. Newman, “Fast Radar Motion Estimation with a Learnt Focus of Attention using Weak Supervision,” in Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), Montreal, Canada, 2019.

H. Porav, T. Bruls, and P. Newman, “I Can See Clearly Now: Image Restoration via De-Raining.” ICRA 2019

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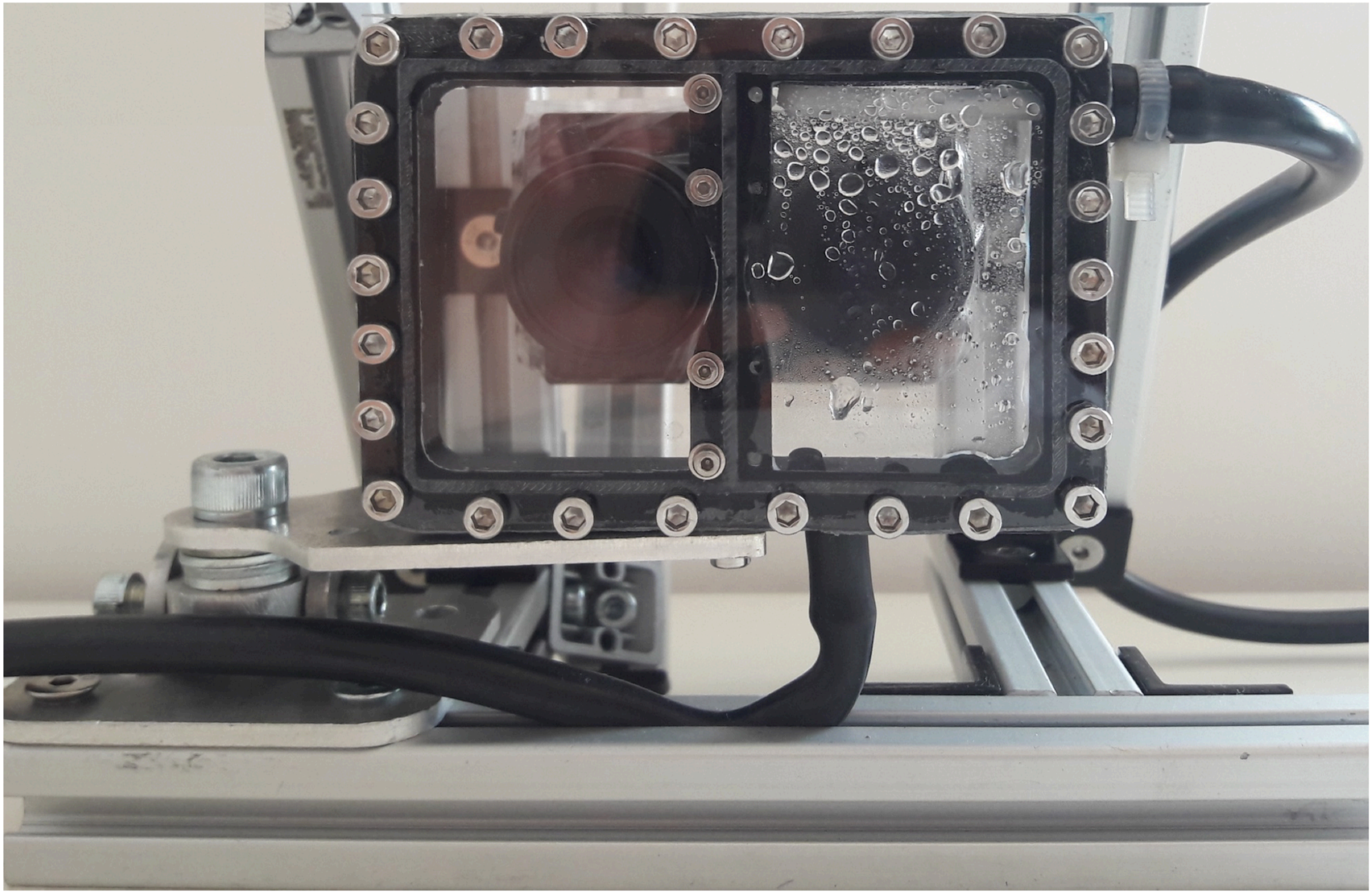

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Questions?