

Why we need an expedition?

- In this volcanic expedition, we extend GrandTour³ with Boxi² and an ANYmal quadruped
- **Purposeful** field-deployments are key to success
- Represent the **relation of physical interaction to perception**
- Combine degraded sensory inputs to **analyze field-readiness**
- Test at the edge of state-of-the-art autonomy

²Frey, Tuna, Fu et al. 2025 RSS, ³Tuna and Frey et al. 2026 IJRR (Under Review)

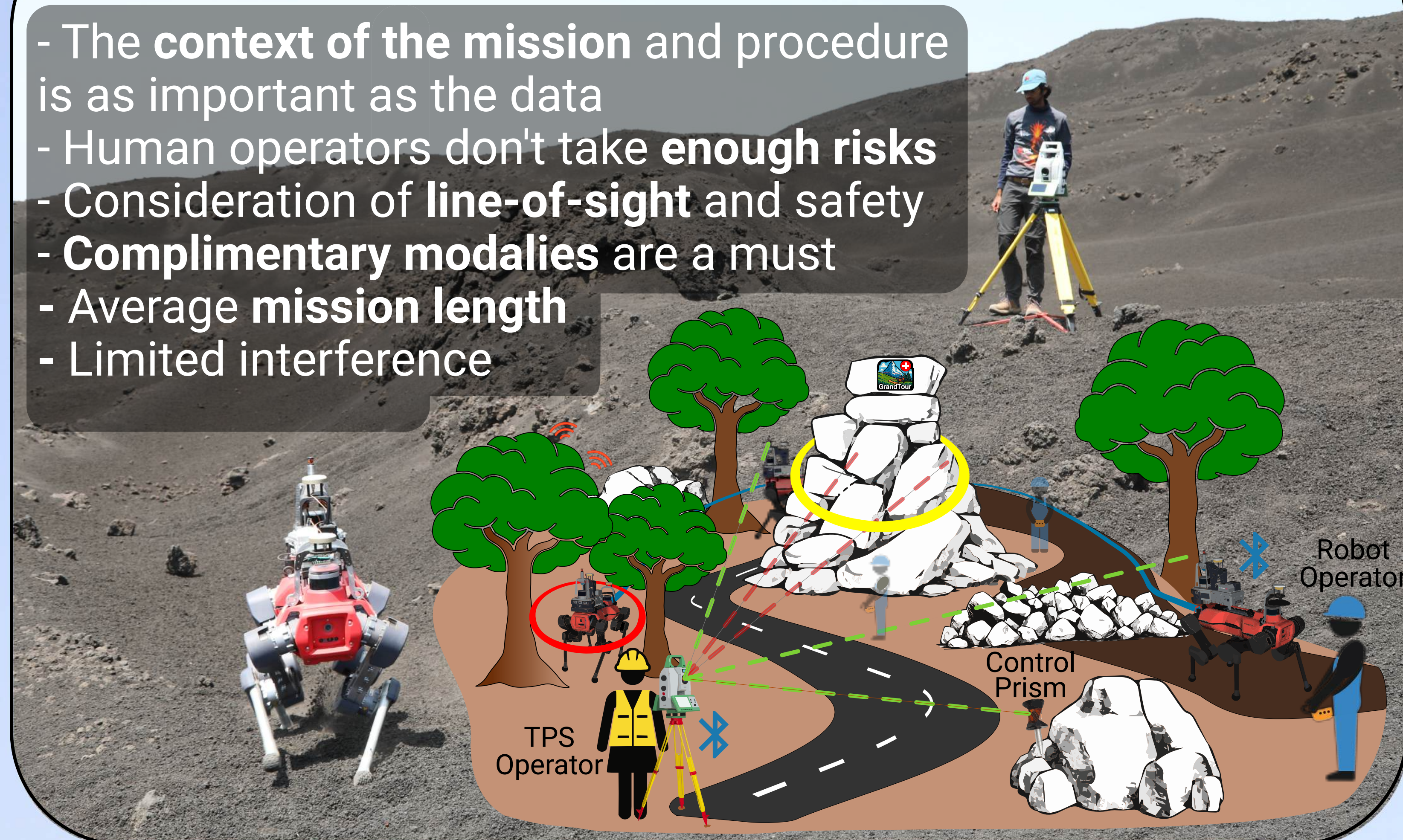


Example Deployments



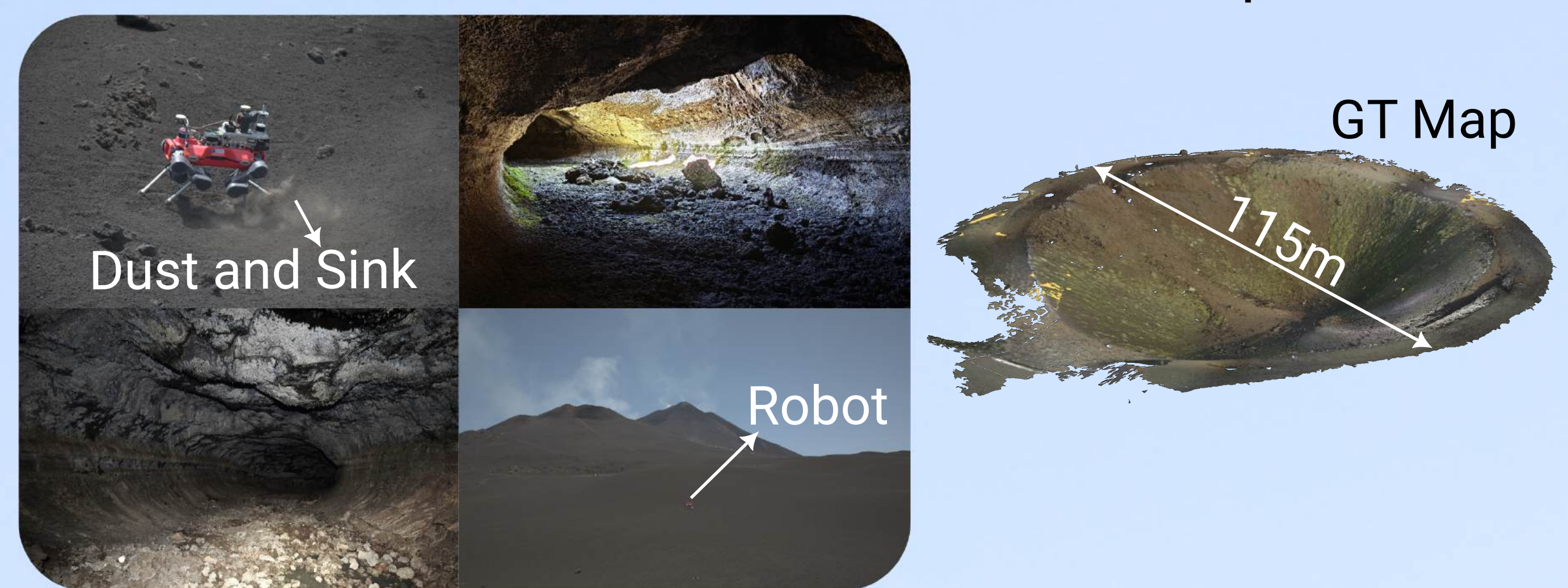
How to Collect the right Data?

- The **context of the mission** and procedure is as important as the data
- Human operators don't take **enough risks**
- Consideration of **line-of-sight** and safety
- **Complimentary modalies** are a must
- Average **mission length**
- Limited interference



Deployment Challenges

- Volcanic ash terrain
- Varying lighting
- Over-exposure
- Featureless-ness
- Particles in air
- Scale variety
- Bad GNSS
- Kinematic slip



Sensor Suite

- 3 LiDARs
- 10 Cameras
- 12 Joints
- 7 IMUs
- 6 Depth Cam
- 1 RGB-D Cam
- RTC360-Scans
- MS60 Tracking



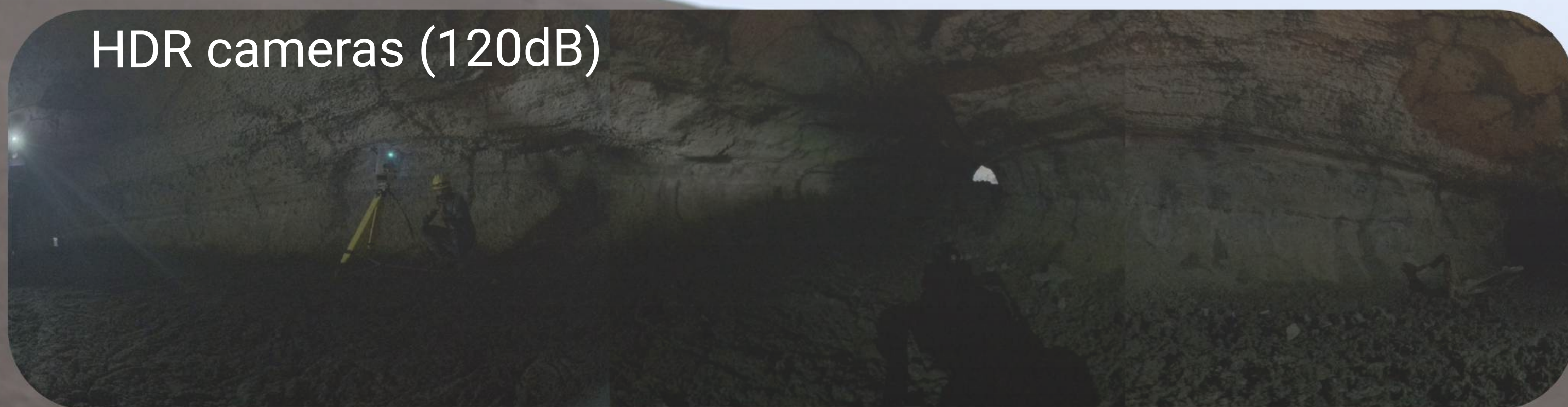
Future Work

- **Novel modalities** needs to be strategically added to aid accurate and robust sensor fusion for real-world robotics
- Algorithms must **be rated for robustness** not only accuracy
- A **data-collection guideline** is required for the community

Lessons and Analysis

- Complimentary modalities are required
- Adaptive parametrization is required in many cases
- Intense field-trials require intense pre-planning of missions
- Contact estimation on compliant terrain is challenging

HDR cameras (120dB)



CAM:0

CAM:1

