

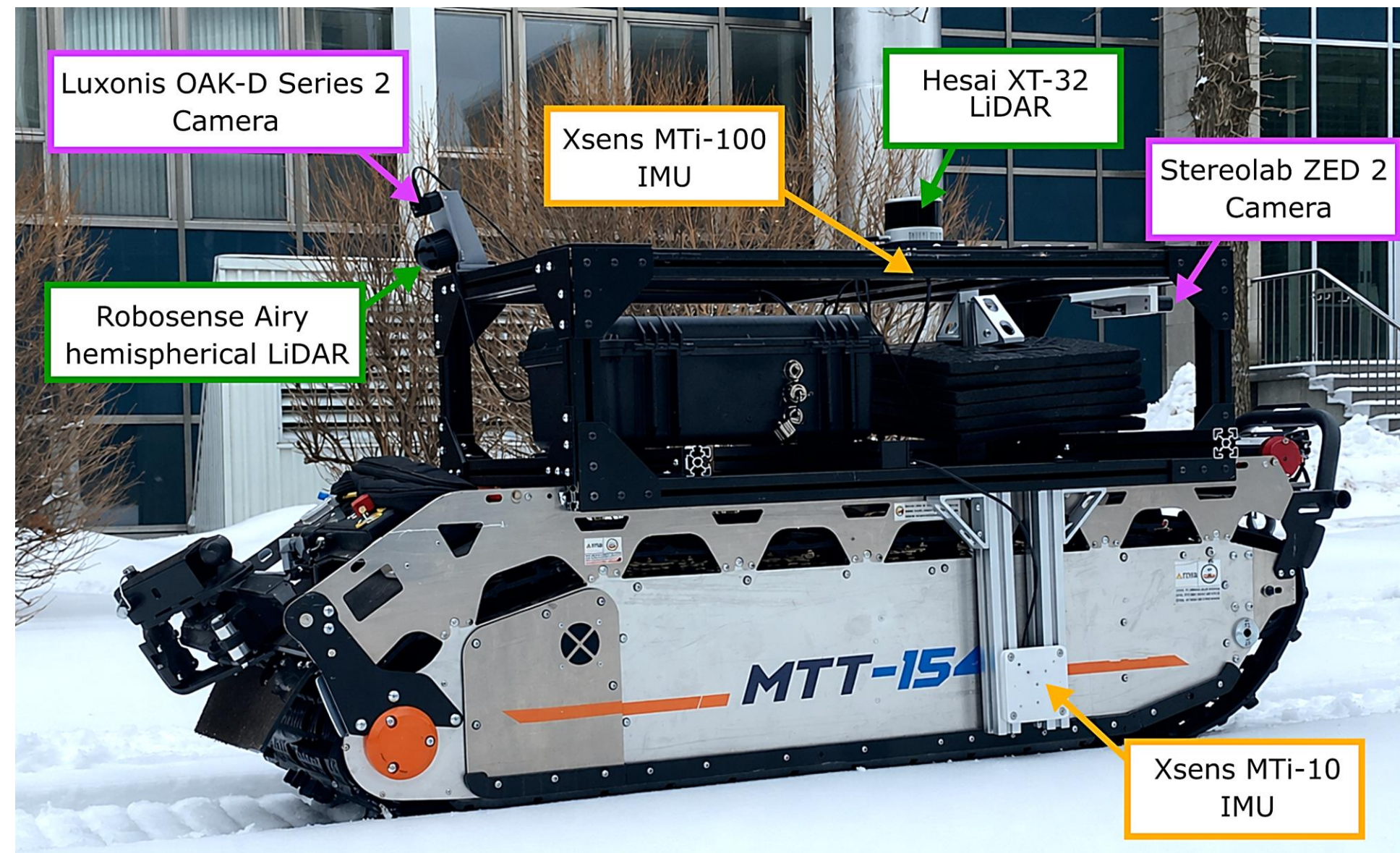
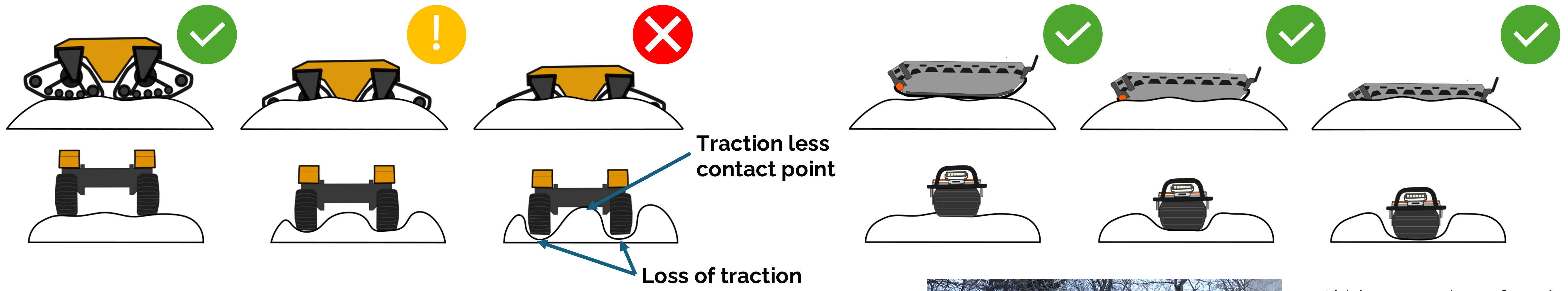
Towards high mobility in snow : Analyzing the effect of center of mass on deep snow locomotion

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Mobility in deep snow is challenging



Robot Platform

MTT-154 in single-track configuration

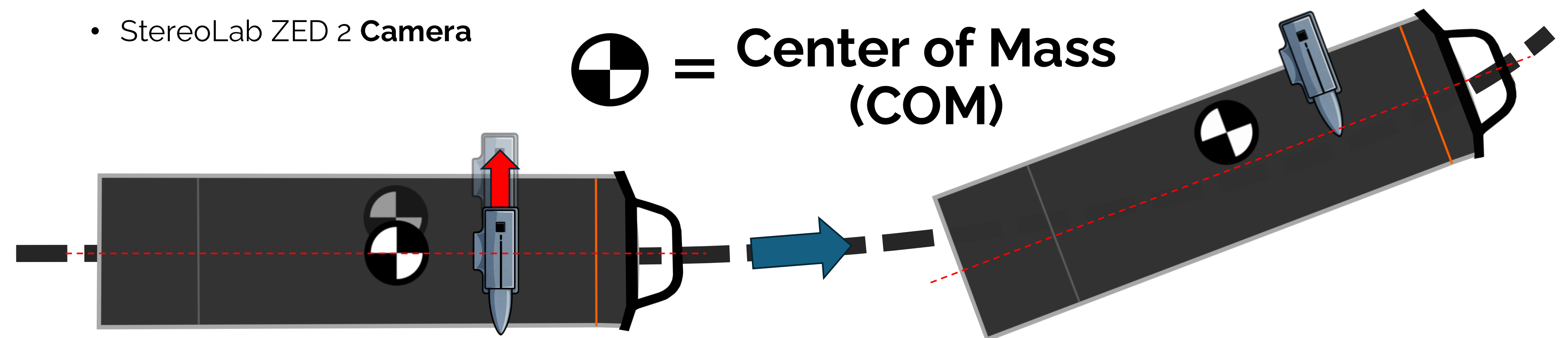
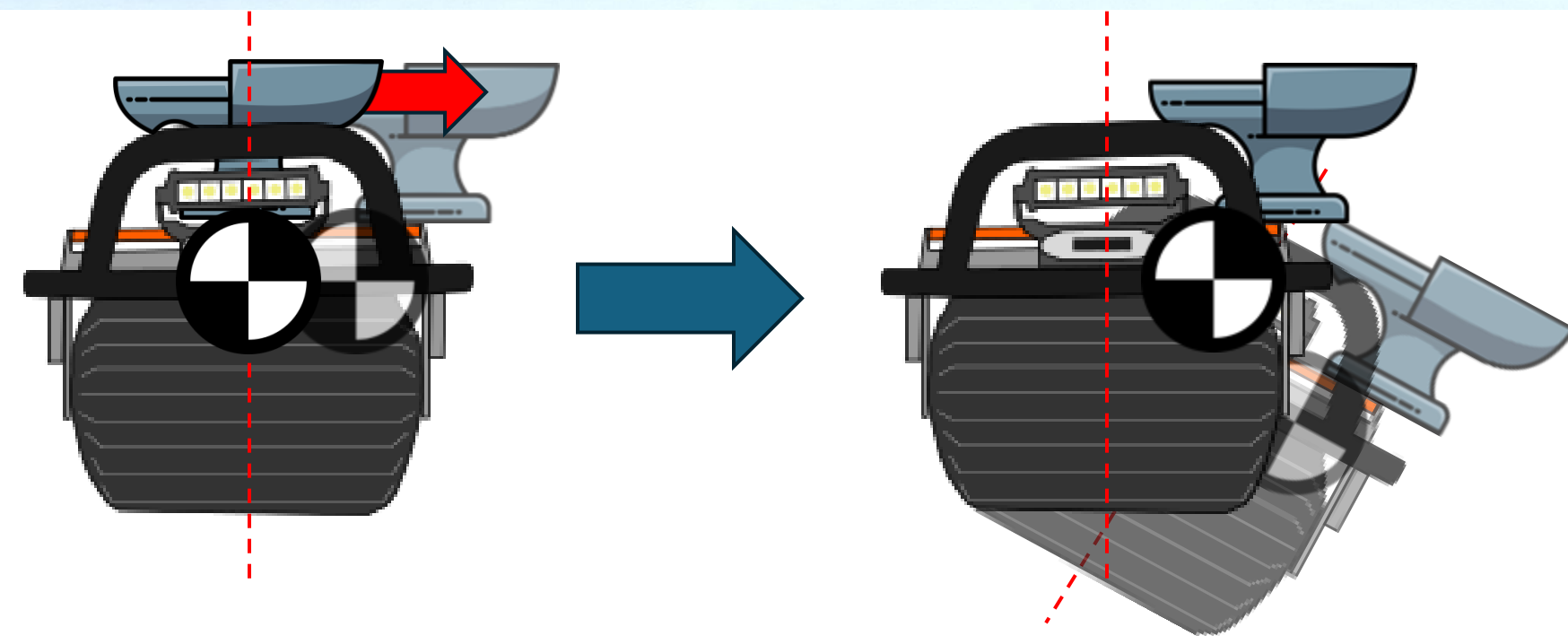
- Mass : **245 kg**
- Sensors :
 - Hesai XT-32 **LiDAR**
 - Robosense Airy **hemispherical LiDAR**
 - Xsens MTi-100 and MTi-10 **IMUs**
 - OAK-D Series 2 **Camera**
 - StereoLab ZED 2 **Camera**



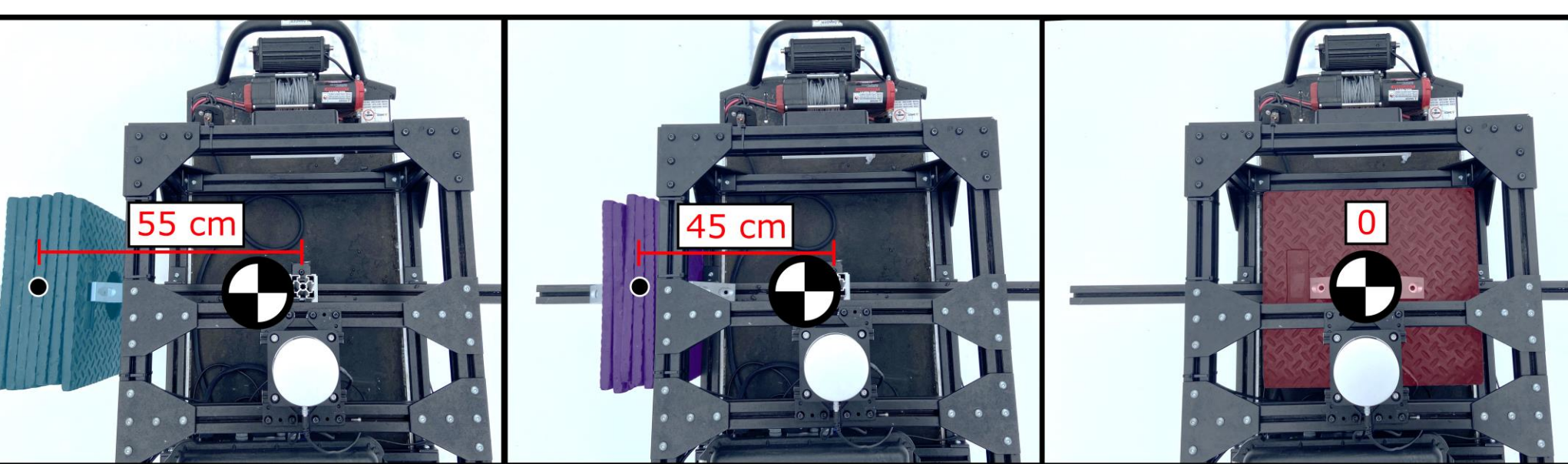
Skid-steer robots face important mobility challenges in deep snow [1], whereas a single-track robot is less prone to entrapment

However, it only **has 1 degree of freedom** (forward/backward).

In deep snow, **turning** motion mechanic based on contact grip (such as articulated, differential or Ackermann) are **ineffective**. [2]

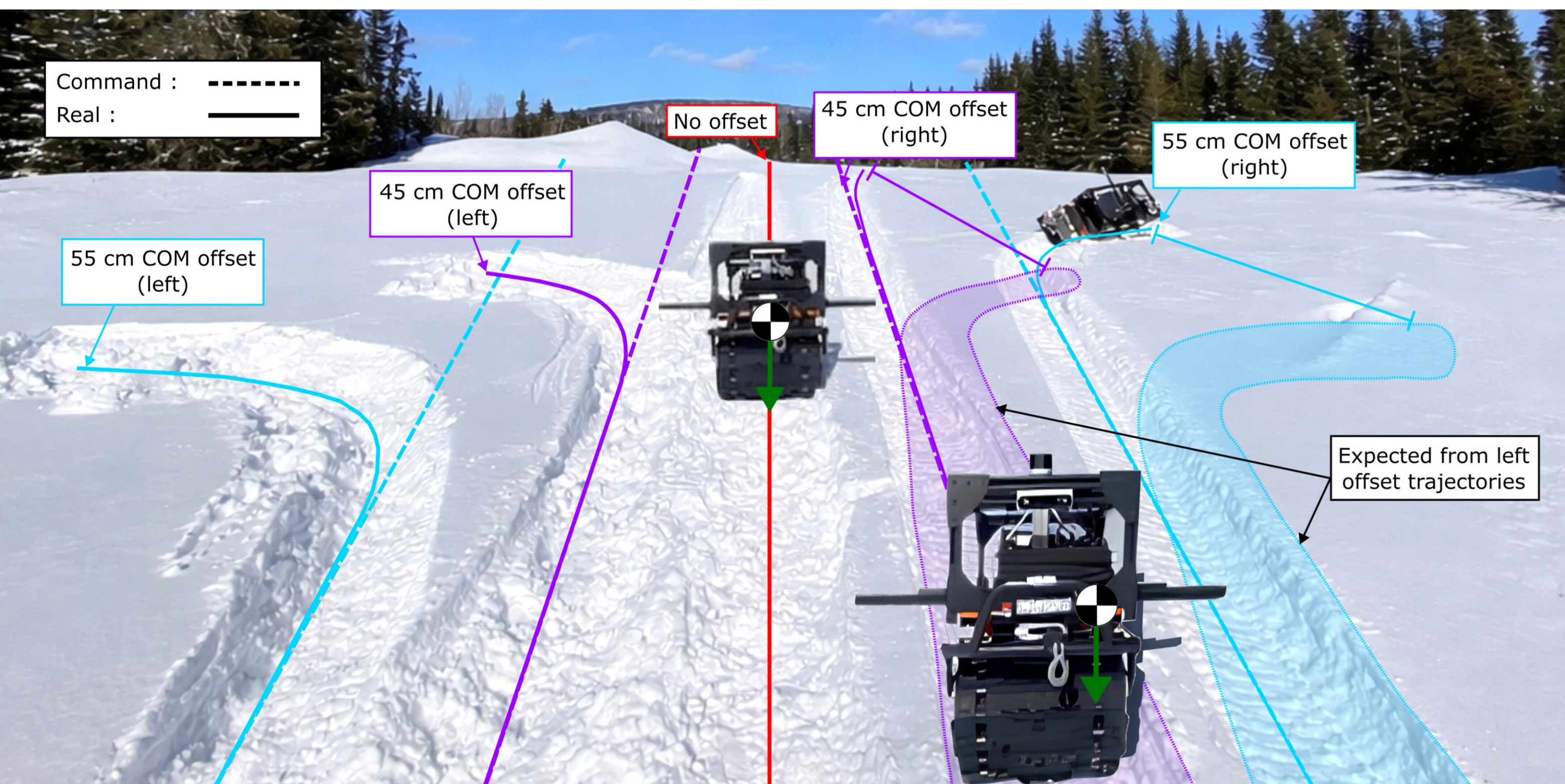


Experiments

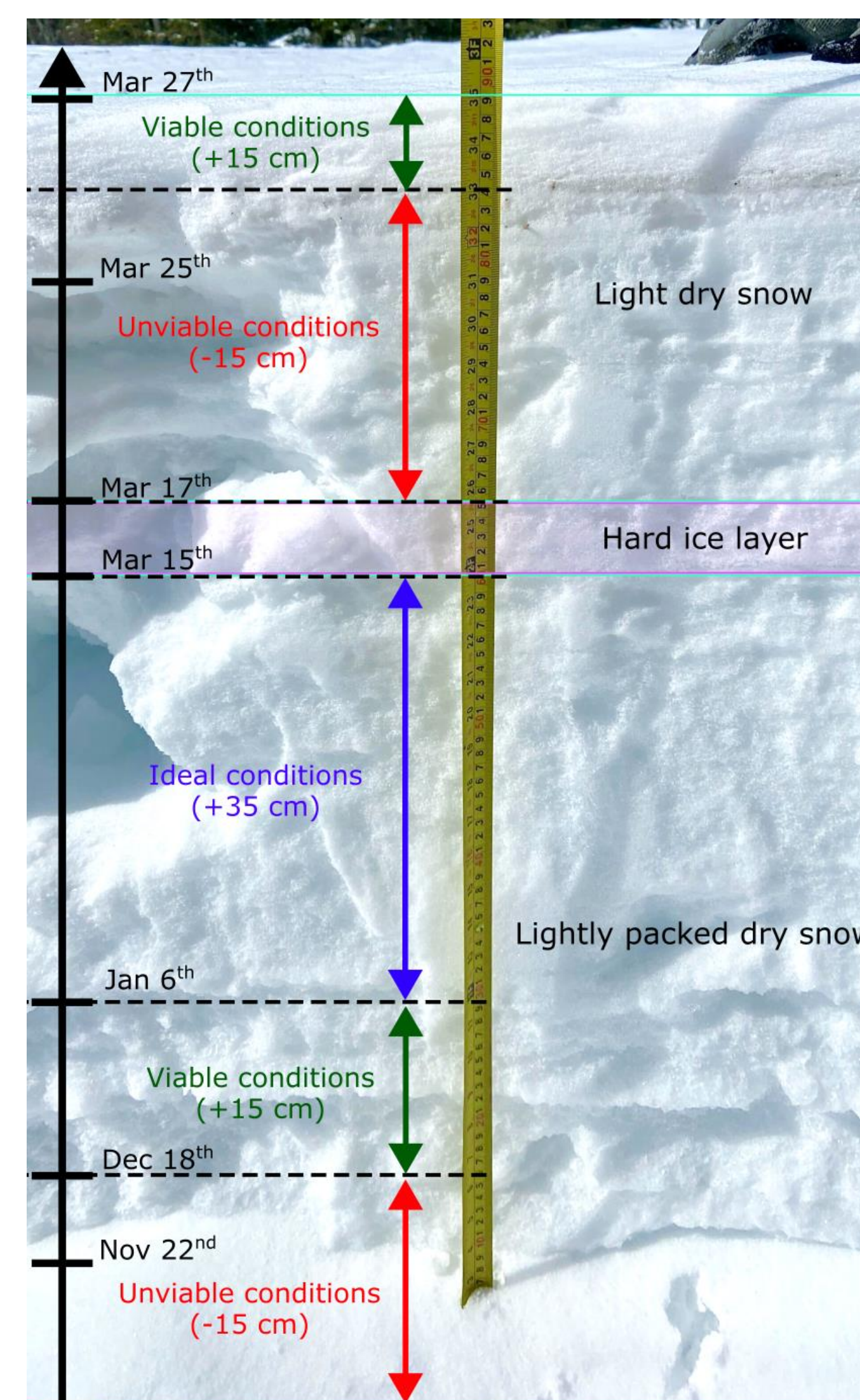


Experiment Parameters:

- **Shifted mass: 32 kg**
- **Speed target: 4 m/s**



Limitations



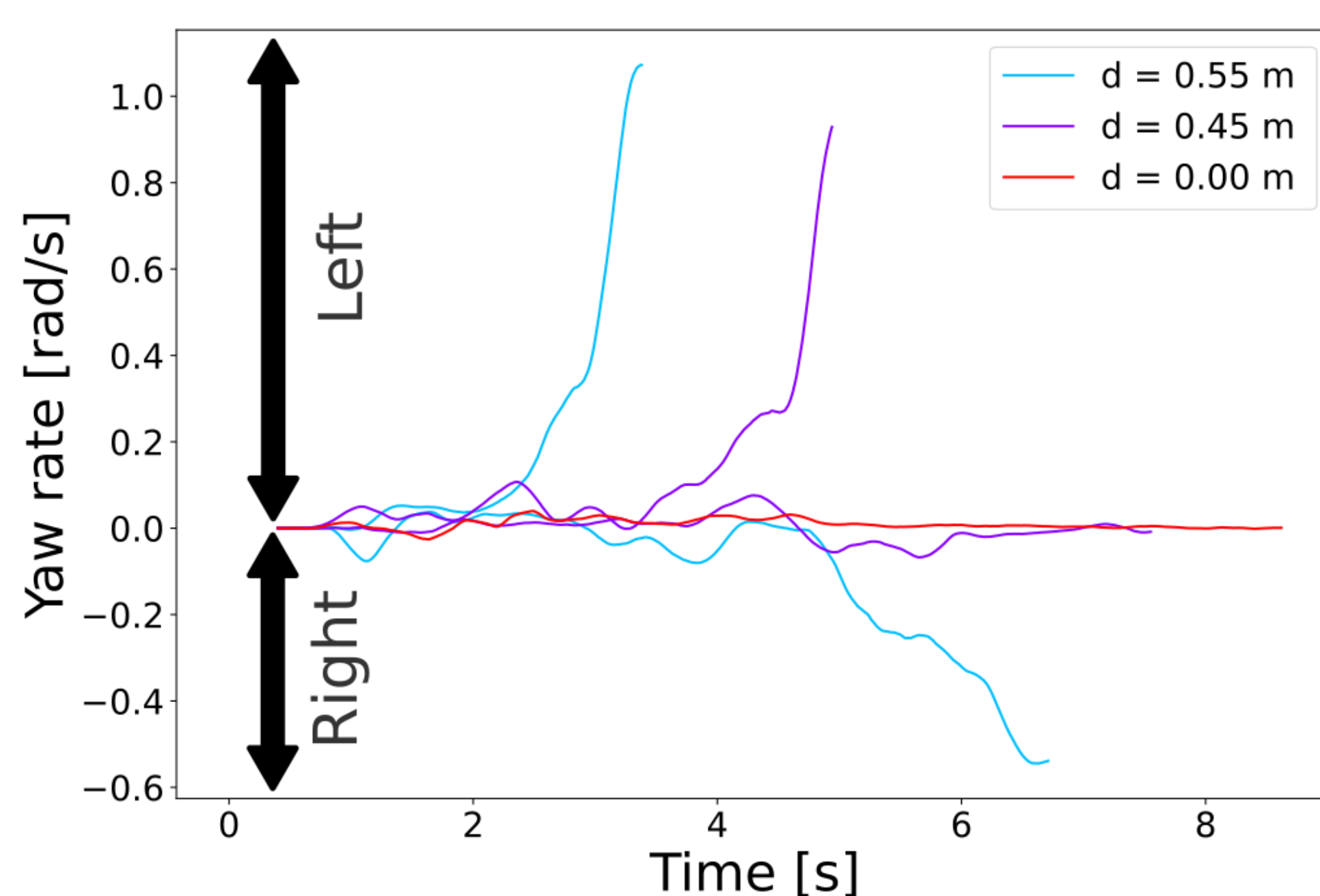
Snow conditions :

- Are **hard to anticipate** and to characterize, because its structure is a complex stack of **layers of different densities**.
- Can **vary locally** even though the surface does not always show it.
- Evolve over time and can **change drastically in a day**.
- **Varies** a lot **with depth**, especially when transitioning between **layers**.
- Are altered by the robot itself (Multi-pass effect).

Winter 2026:

- **2 months** of **ideal** conditions
- **3 months** of **viable** conditions

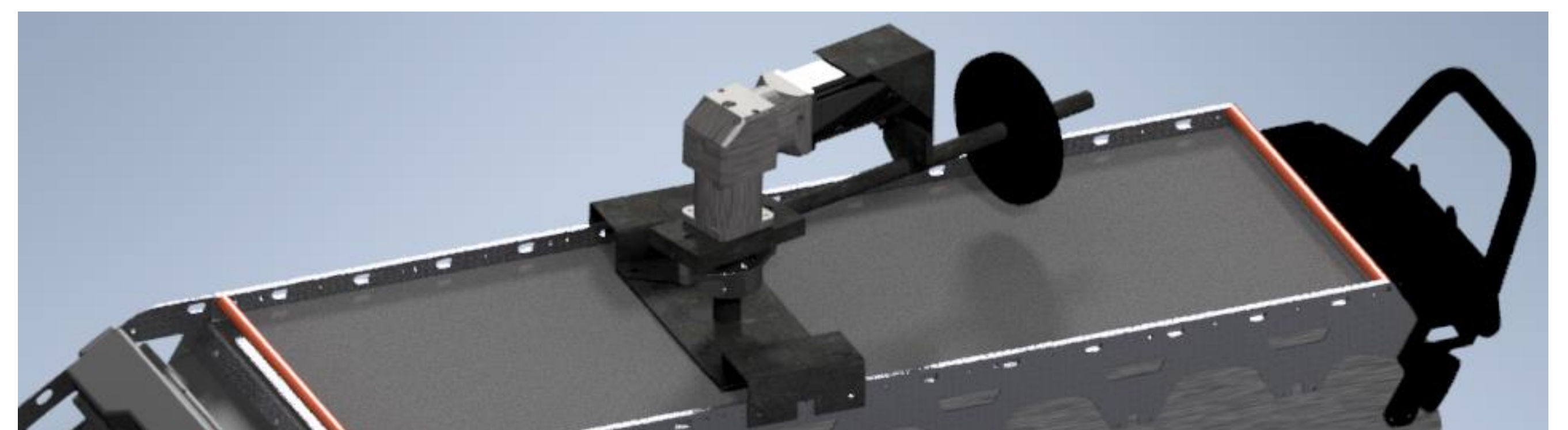
Lessons learned



- The dynamic in deep snow is **hard to predict and modelize**.
- **Trajectories depend on snow type**.
- Vehicle tips over in 2 seconds for constant mass shift
- Higher the roll angle, the higher the yaw rate

Future work

- **Control the COM dynamically** through a mechanism, because constant offset will inevitably lead to tip over.
- Implement **adaptive control** with standard steering configurations for maneuverability on **both granular and solid medium**.



References

- [1] J. H. Lever, A. A. Shoop, and J. D. Bernhard, "Mobility of a lightweight tracked robot over deep snow," *Journal of Terramechanics*, vol. 43, no. 4, pp. 483–506, Oct. 2006
- [2] H. Li, J. Sun, and J. M. Herrmann, "Beyond jamming grippers: granular material in robotics," *Advanced Robotics*, vol. 38, no. 11, pp. 715–729, May 2024