

Soft Tire Deformation Affects Yaw Dynamics

Overview

- In-place **rotation** involves highly non-linear **tire forces** which are **hard to predict**
- Heavy robots** will store **potential energy** in **tire** or **chassis bending**
- Release** of that **potential energy** abruptly changes yaw



75 kg (Husky)

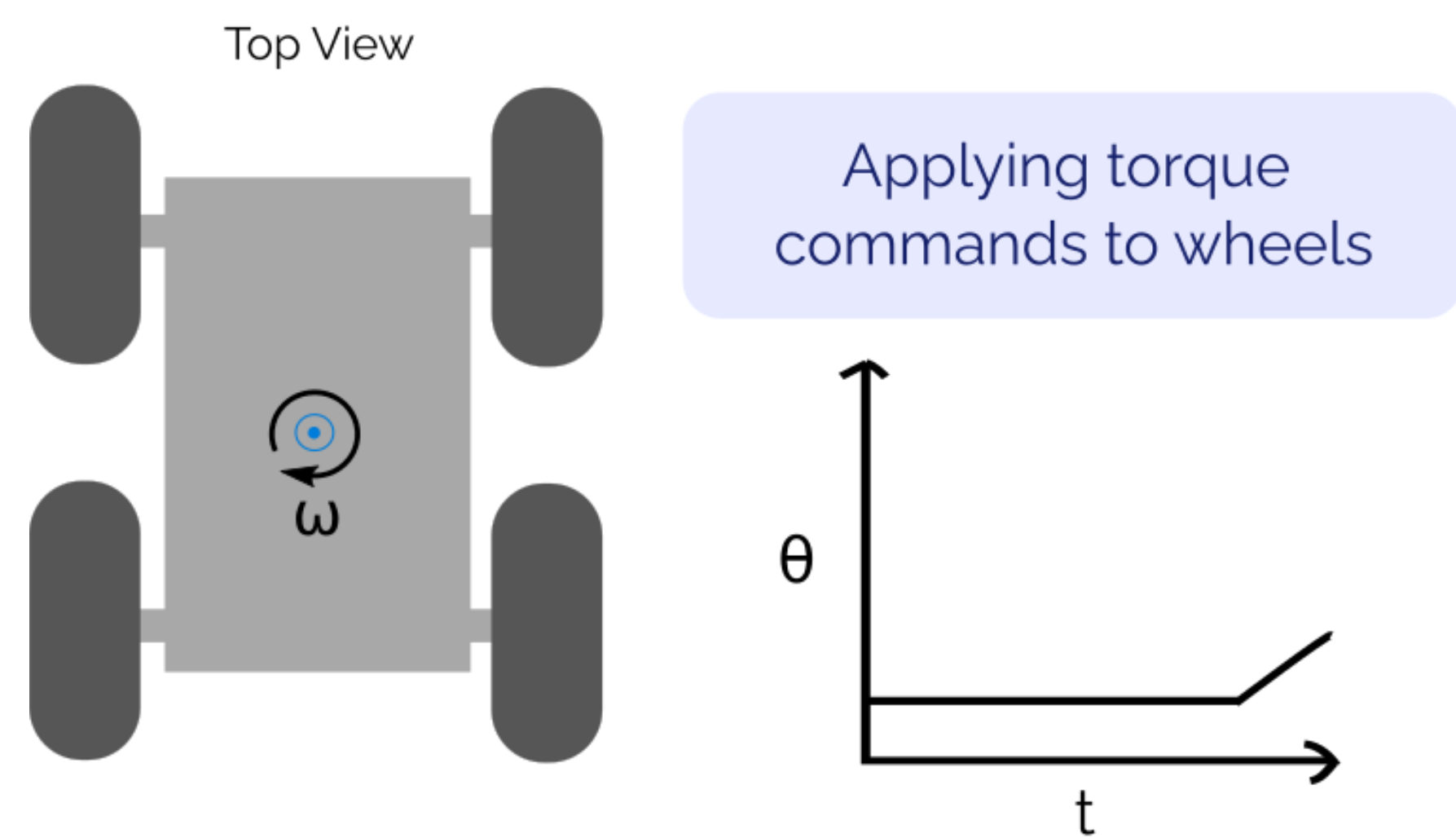


400 kg (Warthog)

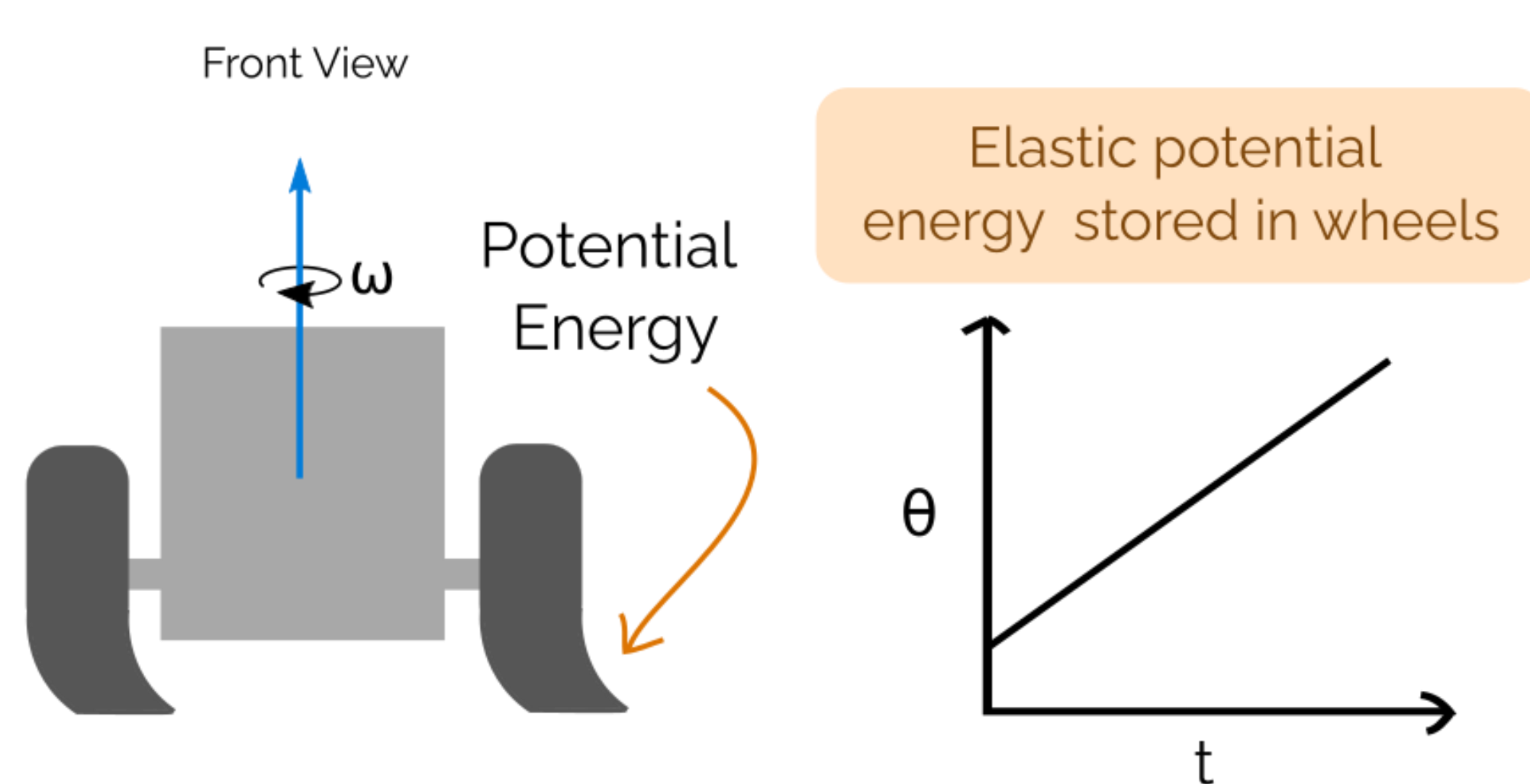


2200 kg (CXT)

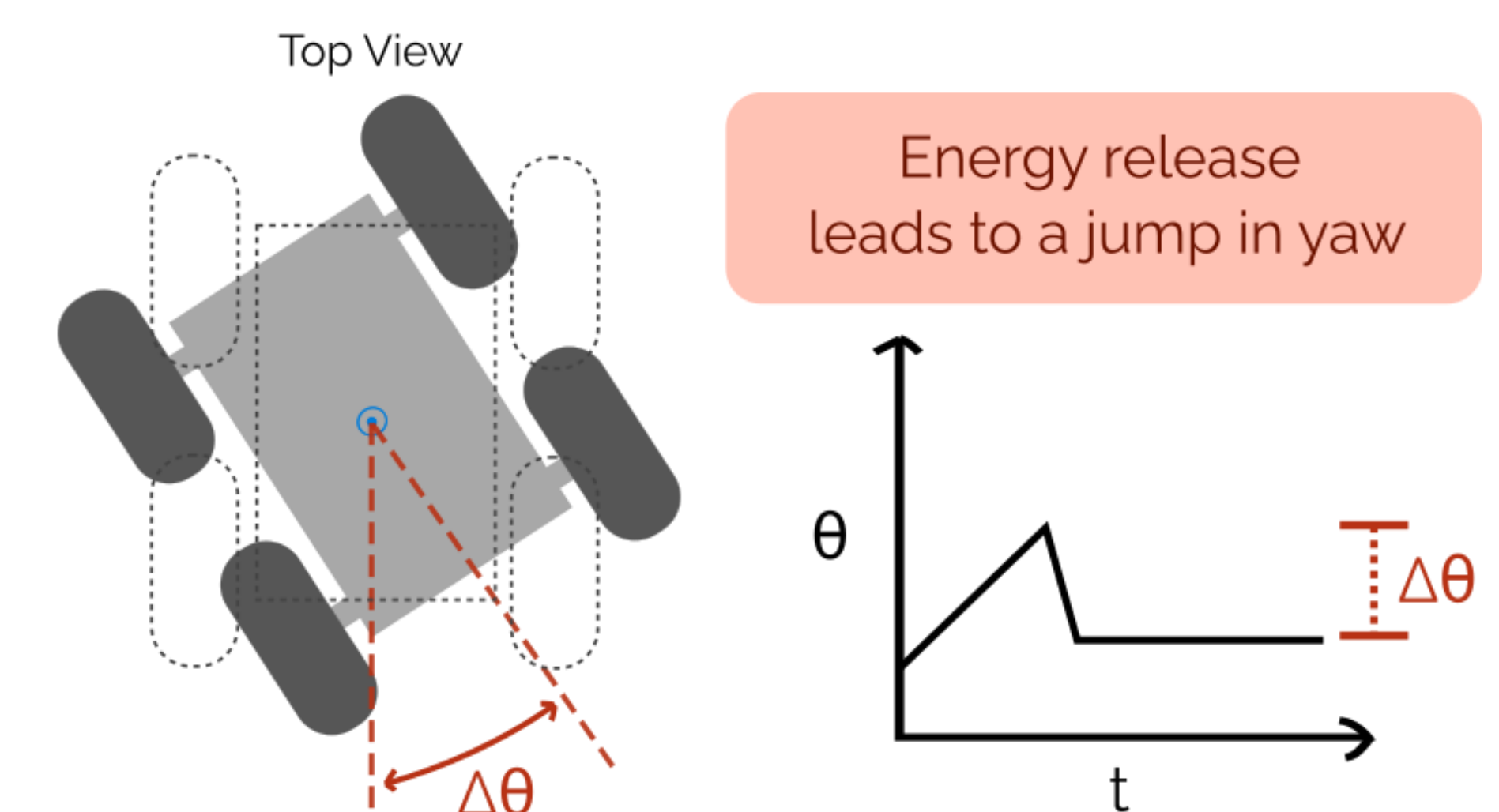
1 Twist



2 Store

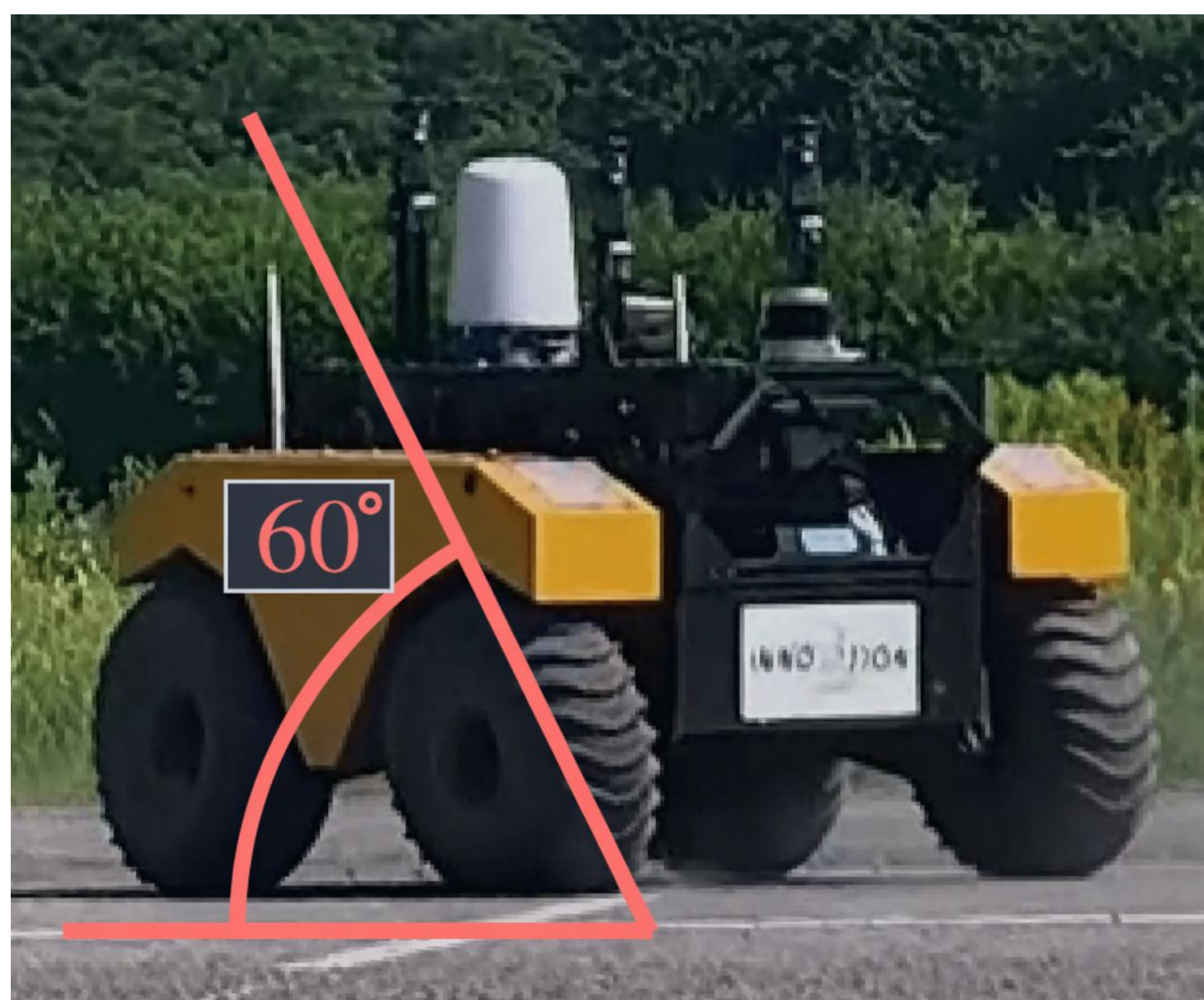


3 Release



Research Scope

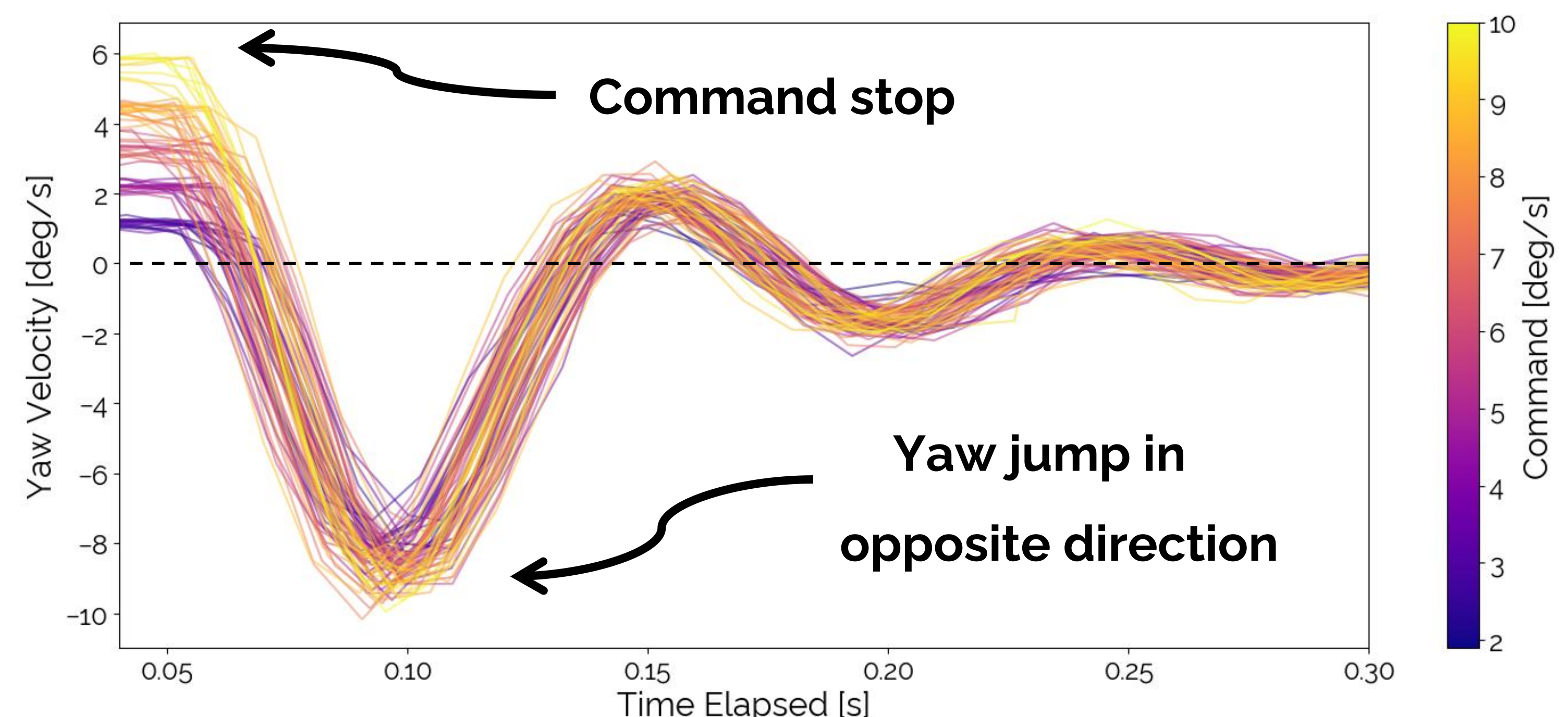
- In-place rotation** is a **subset** of the problem of **3D dynamics**
- On **soft grounds**, **terrain deformation** is **dominant** over tire deformation
- Only significant** on **high friction** surfaces
- Same phenomenon at **high speed** with **quick change of direction**

Warthog performing a rapid **change of direction**, **bending the tires** even more

Experiments

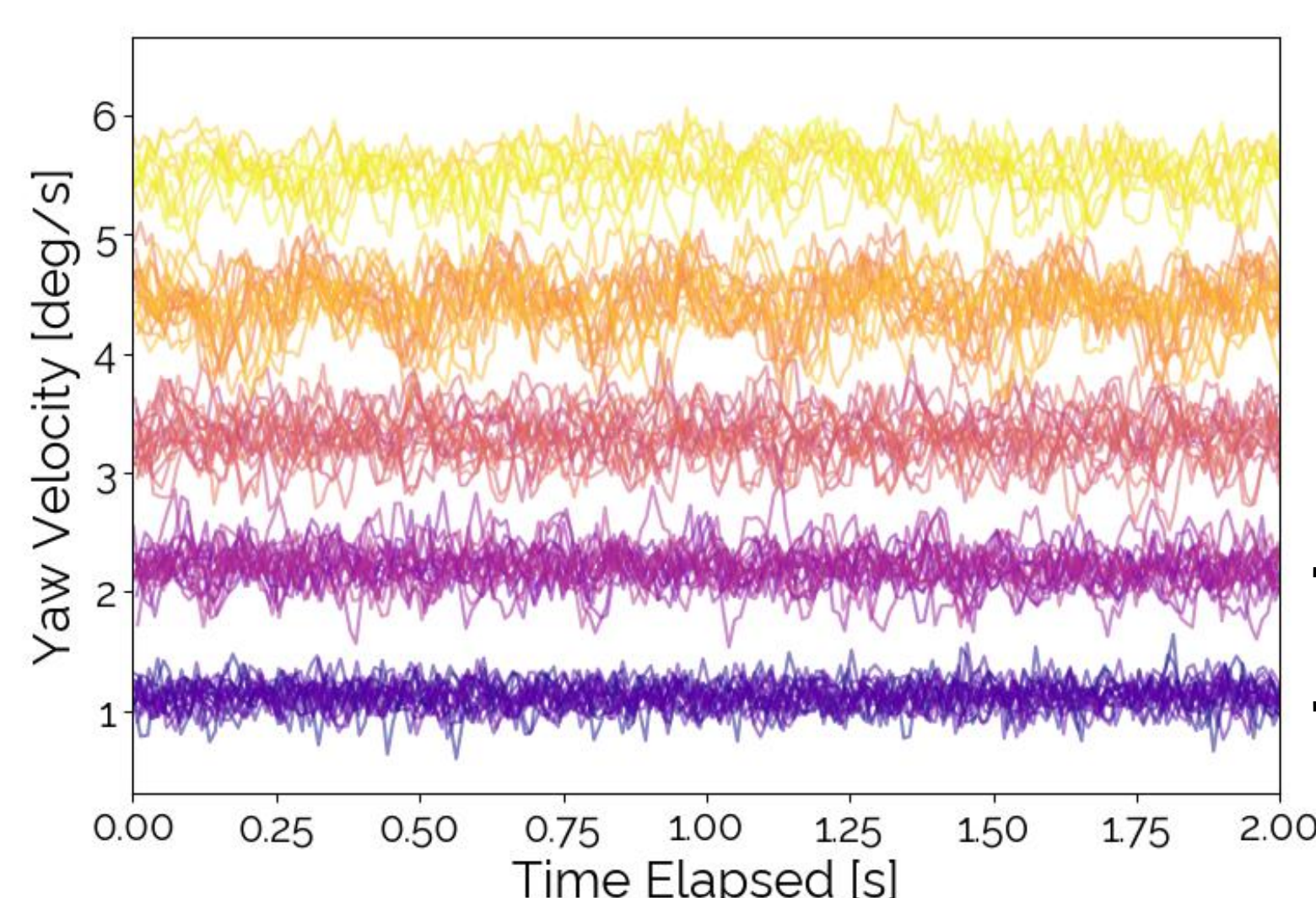
- Let the robot reach **angular steady-state**
- Send a **null command** to **stop** the rotation
- Repeat** 1-2 with **different** angular **commands**

Collected **~70 minutes** of data on **multiple terrains** (wet/dry asphalt, snow, slush and gravel)



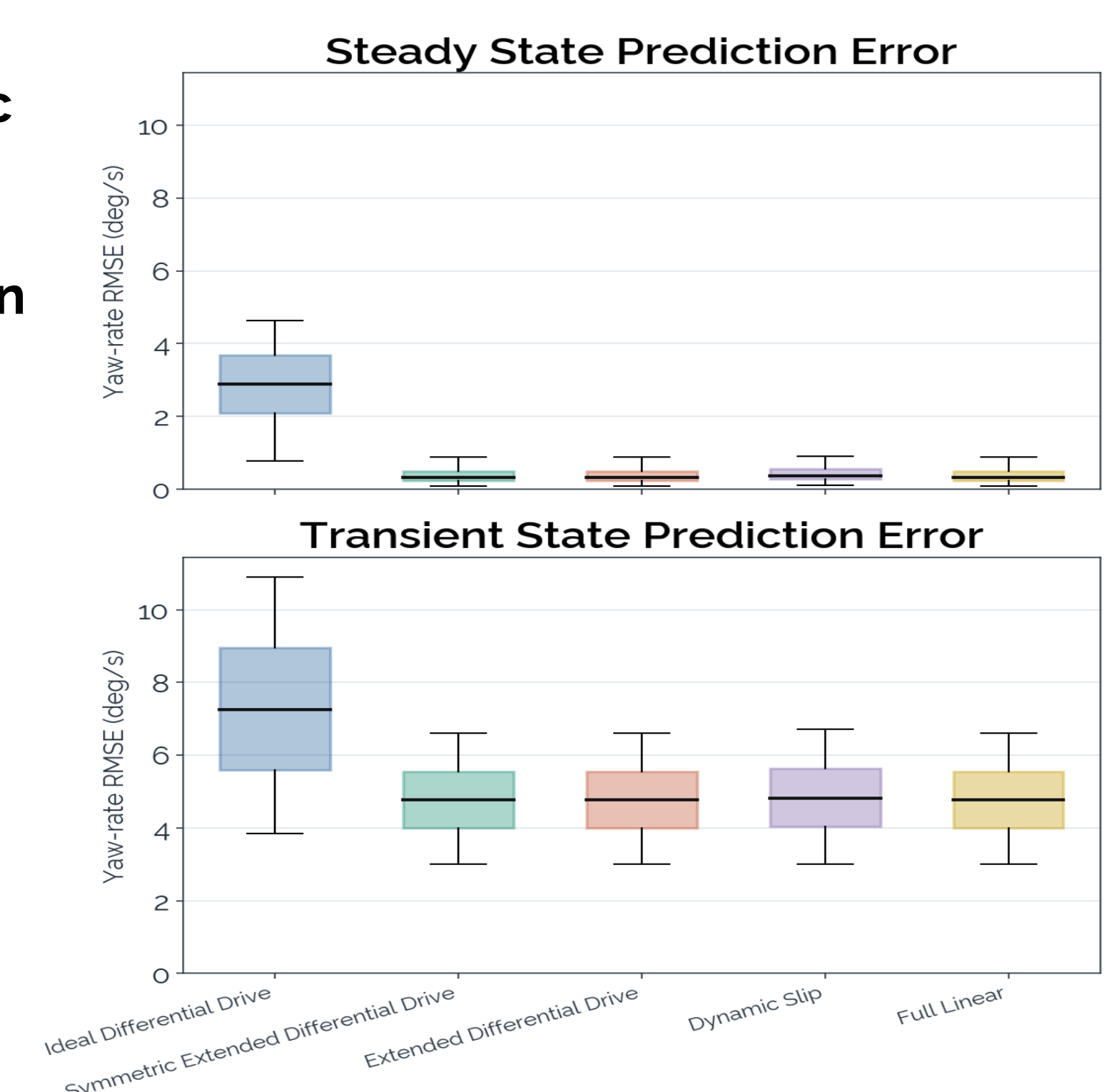
Lessons learned

- This **phenomenon** is **visible** even at **low robot weight** (e.g., 75 kg)
- Heavier robot** = **longer transient state** with **higher amplitude**
- Command space** is often **discretized**, not continuous
- Battery management** for the **Husky** can be complicated on the field



Future work

- Benchmark** state of the art **dynamic models** on this **dataset**
- Implement** an energy-aware **motion model** for rotation
- Collect data** with a **heavier robot** (CXT)
- Generalize** to the **full 3D dynamics** problem



References

- [1] Ni, J., & Hu, J. (2017). Dynamic modelling and experimental validation of a skid-steered vehicle in the pivotal steering condition. *Journal of Automobile Engineering*.
- [2] Seo, J., Byeon, K., Lee, H., Hwang, Y., Gui, Y., & Kim, W. (2025). Observer-Based Nonlinear Control Scheme to Reduce Oscillations and Zero Crossing in Skid-Steer Vehicles. *IEEE Access*.
- [3] Rabiee, S., & Biswas, J. (2019). A Friction-Based Kinematic Model for Skid-Steer Wheeled Mobile Robots. *2019 International Conference on Robotics and Automation (ICRA)*.