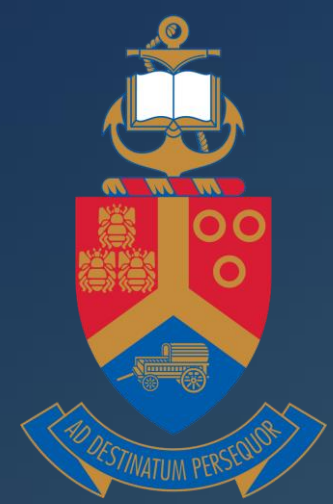




Faculty of Engineering,
Built Environment and
Information Technology



A **Traction Estimation Digital Twin** case study for a skid-steered ULP vehicle

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Other team members: Prof PS Heyns

Research Activity in Mechanised Mining Systems (RAMMS) - SAMERDI
University of Pretoria



The CMTI MT1800B Roof Bolter



Spec. sheet:

- ✓ Electric drivetrain with four independently controlled motors
- ✓ Designed for underground roof bolting operations
- ✓ Uses skid-steering to navigate challenging terrain



? Key question: How do we estimate the **traction** between this machine and the surface it drives on?

Why **traction** is important?



Safety

-  Uncontrollable skidding a potential problem at steep dip angles
-  Potential to skid into nearby workers
-  Traction estimate can limit dangerous movements



Productivity

-  Machine can get stuck against rockface
-  Traction knowledge can be used to optimize machine movement
-  This leads to lower energy use, lower part wear and higher productivity.



Advanced insights



Mine condition insights



Adapts to mine conditions



Foundation to a plethora of other useful technologies.

How do we estimate traction?



Challenge: Traction can't be "measured" directly from a sensor



Physics

Use physics to describe the relationship between vehicle and terrain.



Data

Use data to keep measurable physics quantities up to date (speeds, angles, power, etc.).



Hybrid

Combine both domains (physics and data) to create a hybrid methodology.



Key Insight: We can **infer** traction from a combination of **physics-based** knowledge and measured **data**.

Traction itself is not an actionable insight!



The Challenge (for everyone)

- ✗ DTM2023 left me with the feeling that miners are digitalizing.
- ✗ However, they do not know what to do with newfound data.
- ✗ Data-driven insights are often not useful, meaning value of digitalization is unclear.
- ✗ I believe one of the reasons, is that the insights are not actionable, leading to a gap between data and decisions.



How can we do better?

- ✓ Digital Twins!
- ✓ Digital twins create a bridge between insight and action.
- ✓ We therefore propose a traction estimation **digital twin**

Today's format



Help me wrap up my PhD?



I am completing my PhD, and would like to gauge industry opinion of the digital twin concept.



I will showcase the development of our traction estimation digital twin.



Could you be so kind as to scan the QR, and when prompted, vote whether you think the shown technology is a "digital twin"?



They are simple Yes/No questions so do not take long at all.

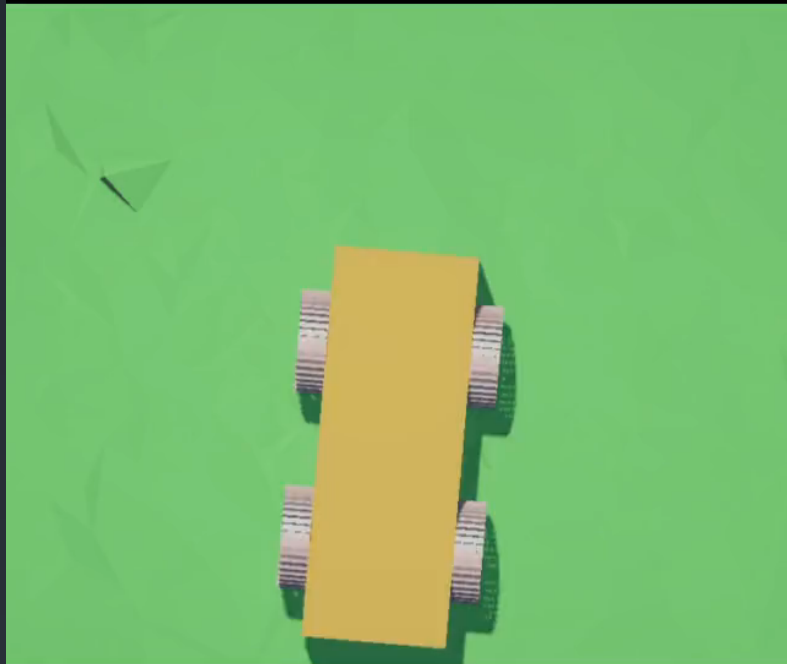


If you feel comfortable, please share your role in your organization.



How do we estimate **traction**?

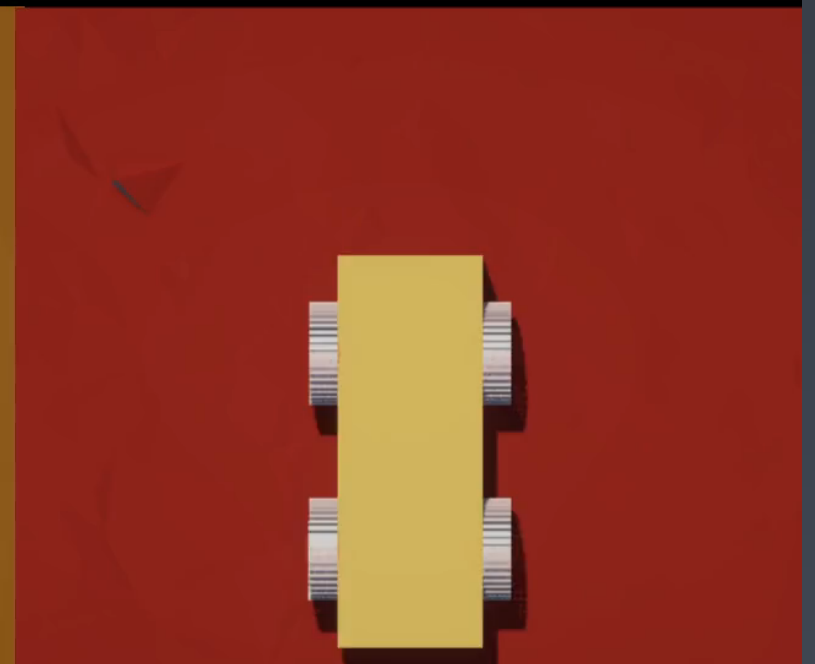
Same power input
High skid rate
Low traction



Same power input
Medium skid rate
Medium traction



Same power input
Slow skid rate
High traction



What do we need to estimate **traction**?

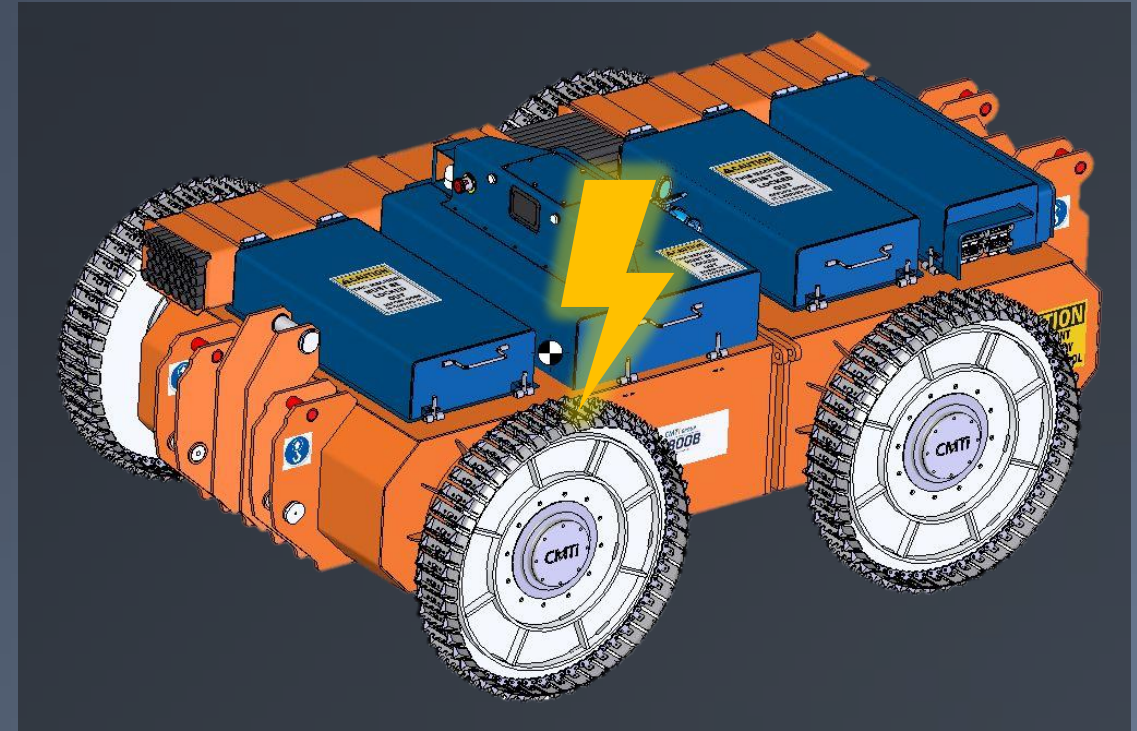
Pose (Vehicle angle)

Turning rate (Yaw rate)

Vehicle velocity

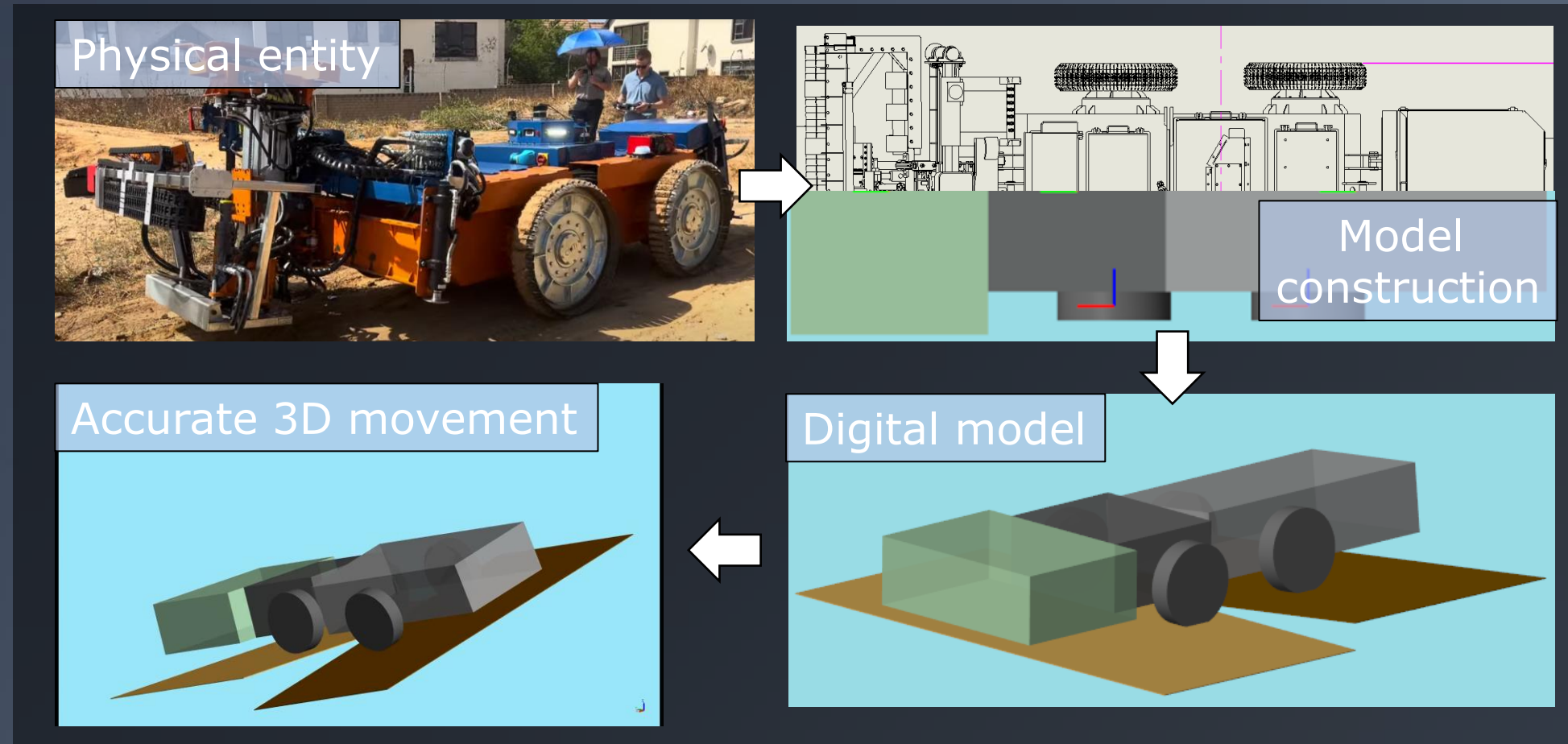
Power consumption

Wheel rotation rate

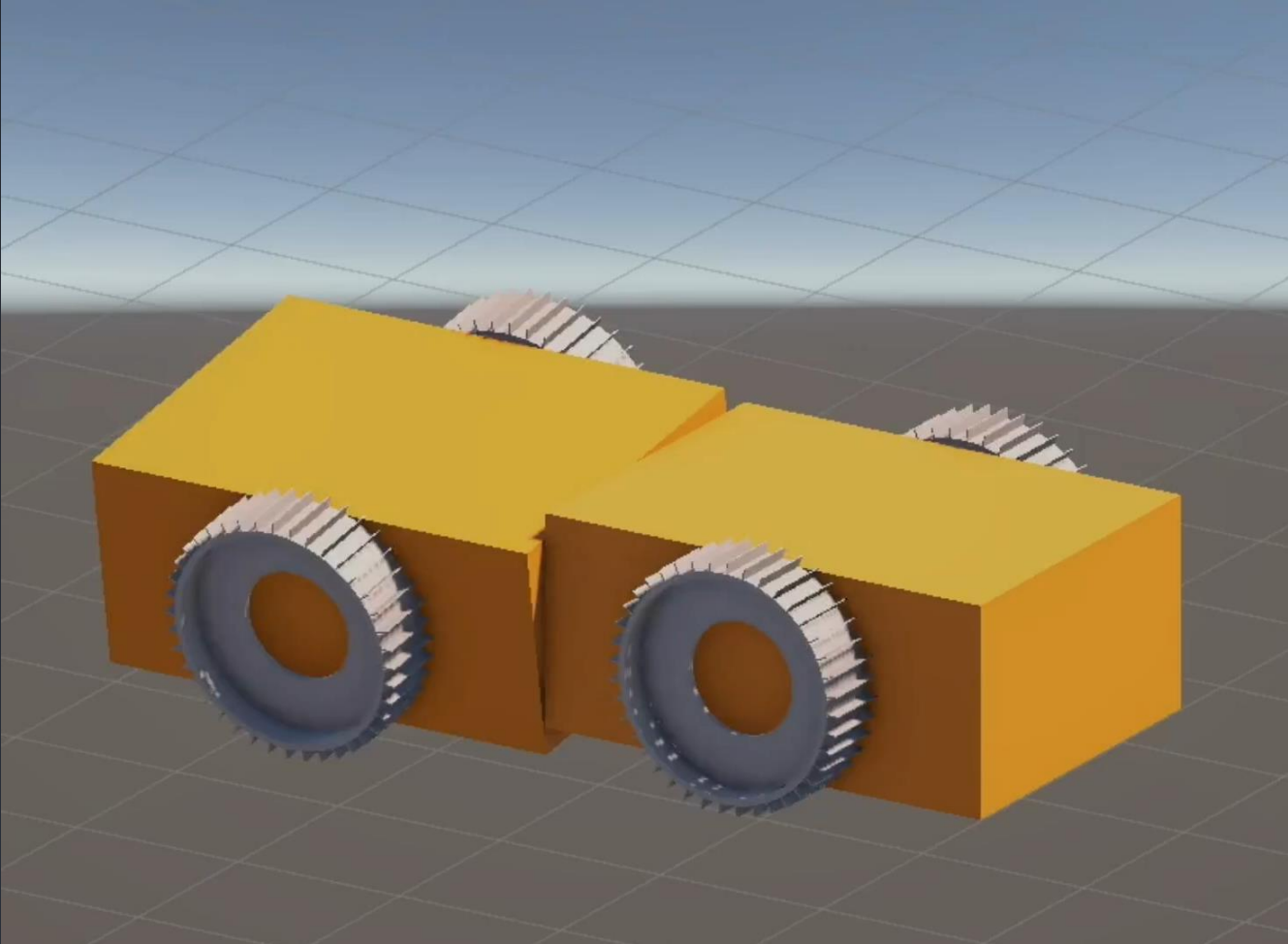


Current sensor
Wheel encoders
Voltage sensor

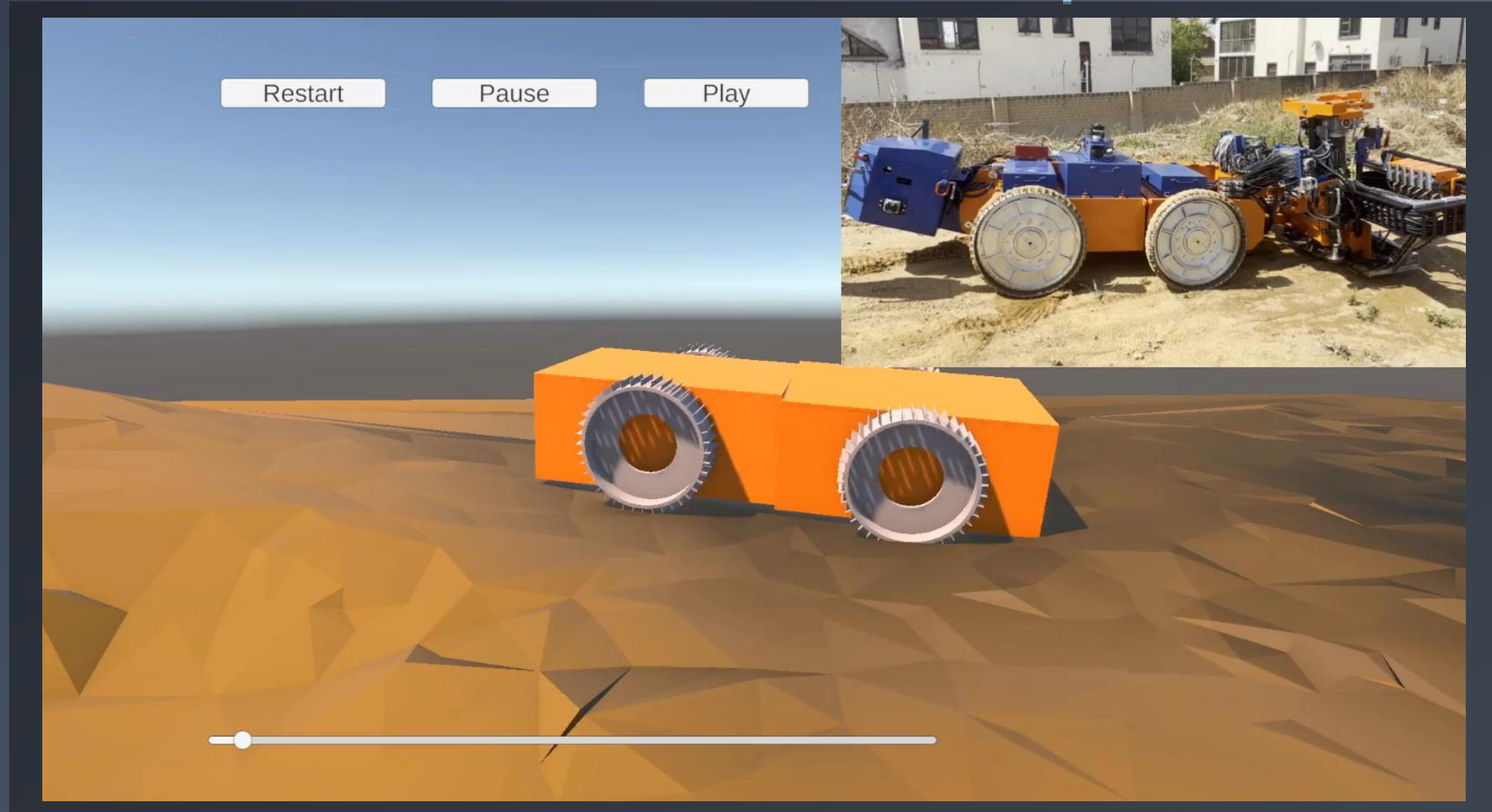
Let's start building our digital twin



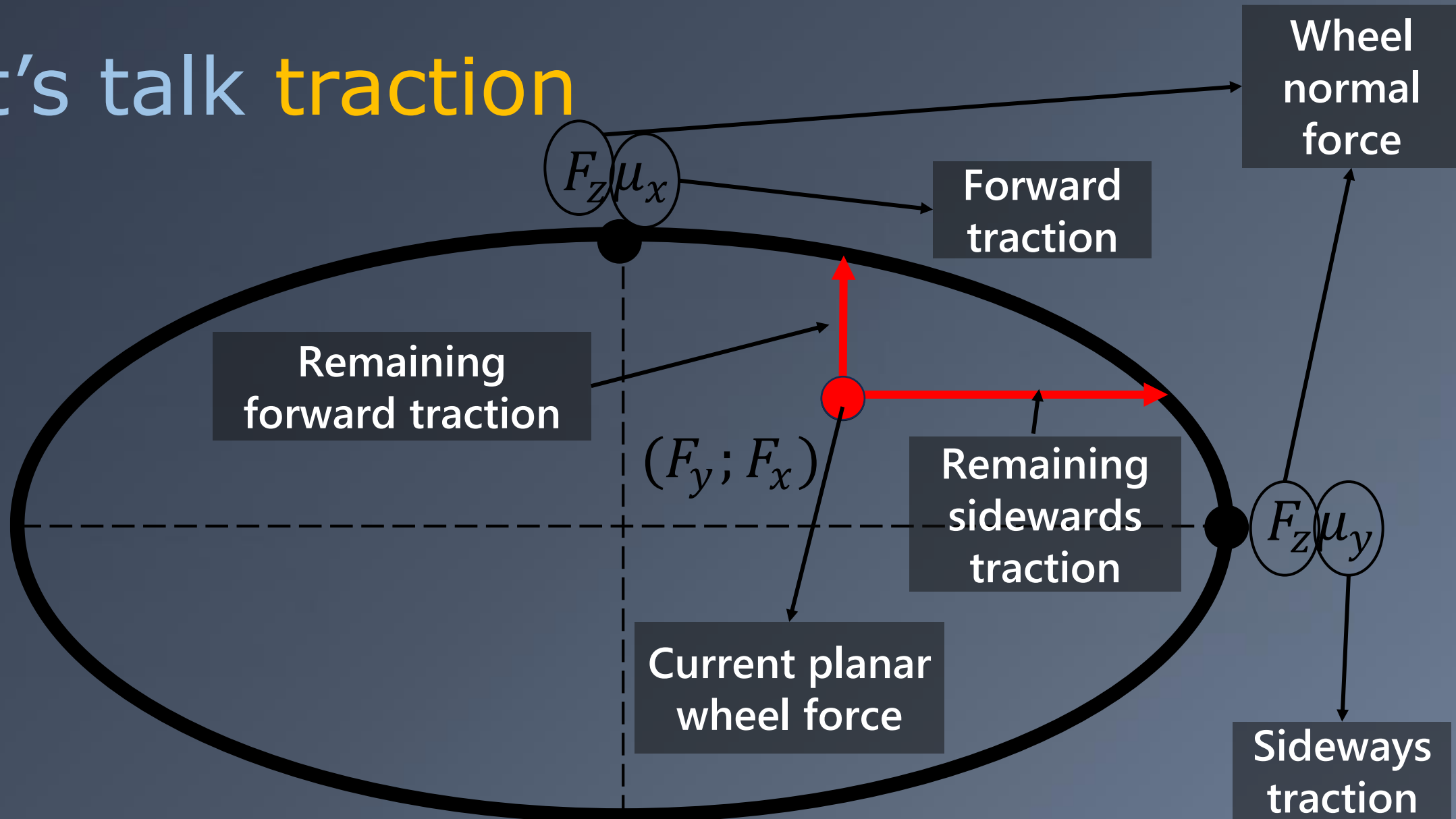
Is this a digital twin?



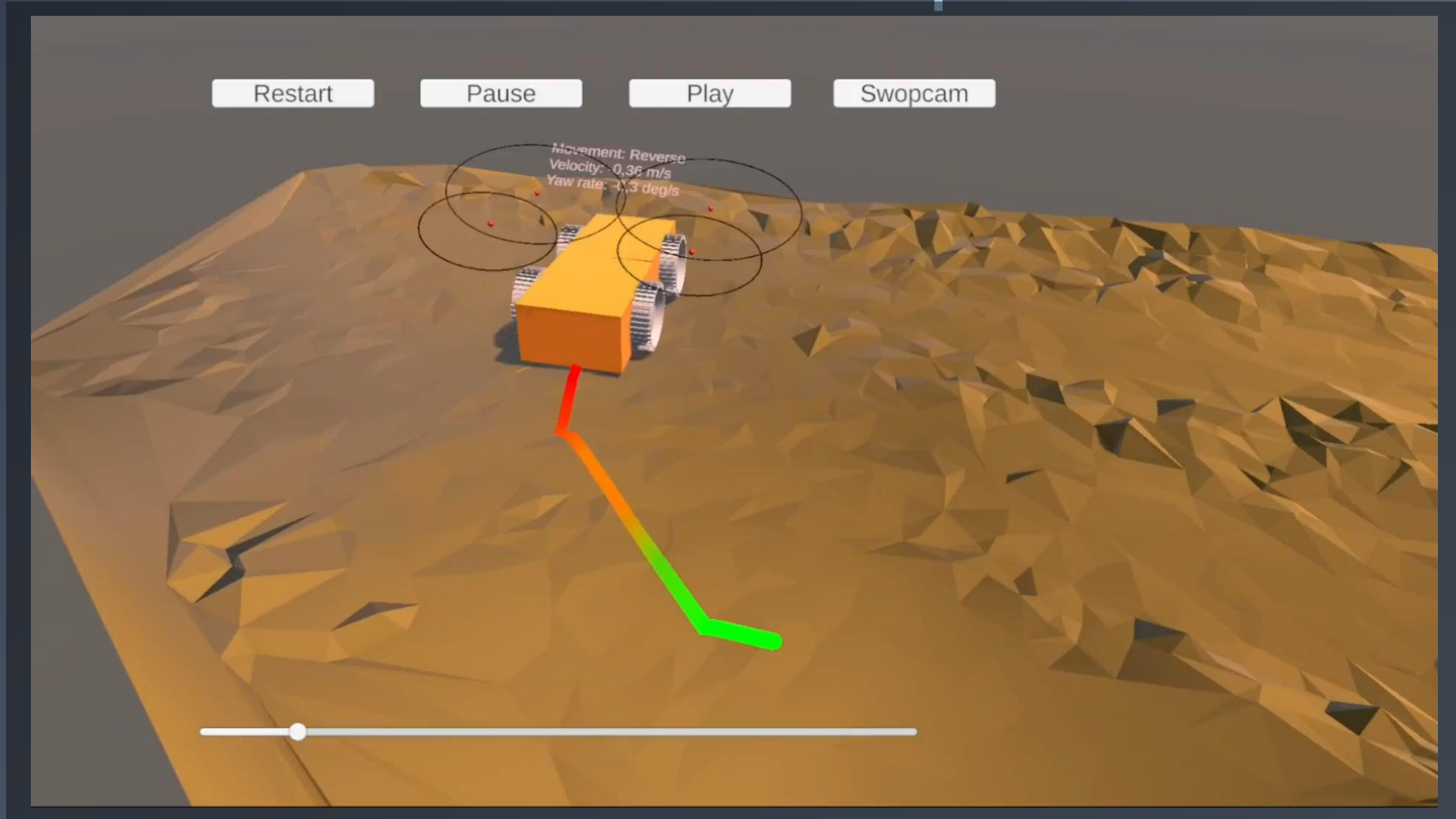
Let's continue the development



Let's talk traction



Let's finalise our development



Future possibilities



Energy Optimisation



Plan trajectories for minimal energy usage



Load Distribution



Equally distribute loads across wheels



Torque Adaptation



Adapt torque ratios between wheels



Fleet Insights



Mine surface hazard detection

Conclusion and next steps



Key Takeaways



Traction estimation is useful

Real-time traction estimation gives us actionable insights for safer and more productive mining.



Hybrid modelling is powerful

Hybrid modelling (physics + data) is a sensible approach to estimate traction.



Digital twins bridge insight-action gap

Digital twins bridge the gap between data insights and the ability to take action.



Next steps



Research

This technology lays the foundation for future technology, with applications such as:

- Energy usage prediction
- Traction control
- Terrain classification and many more...



Collaborate

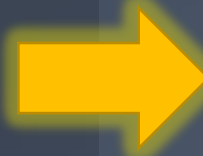
If you are interested in, or have potential applications for Digital Twins, please reach out to us, as we are doing active research in this field.

Thank you



Are you interested
in Digital Twins?

Please scan the QR code on the right
to read more about it!



Let's get in touch:

Luke.vaneyk@up.ac.za

Or get in touch with Prof Heyns:

Stephan.heyns@up.ac.za

