

Hierarchical Control for Constrained Multi-timescale Energy Management

Justin Koeln, University of Texas at Dallas

<https://escl.utdallas.edu/>

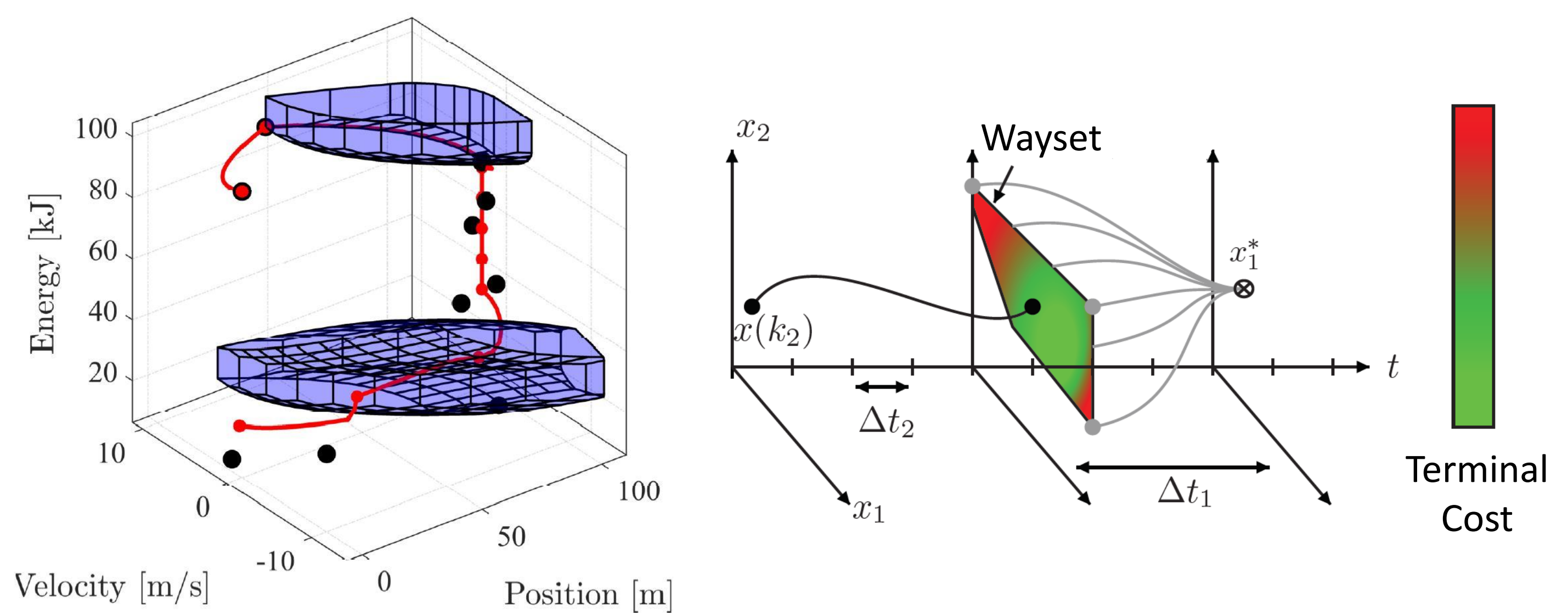
Understanding model-based hierarchical control synthesis, analysis, and performance for provable control behavior of constrained multi-timescale CPS

Challenge:

- Hierarchical control is widely used for aircraft, water distribution, smart power grids, and chemical plants
- Existing hierarchical control techniques lack guaranteed constraint satisfaction and provable system performance
- Need for novel hierarchical control coordination mechanisms for strategic operation and closed-loop system analysis

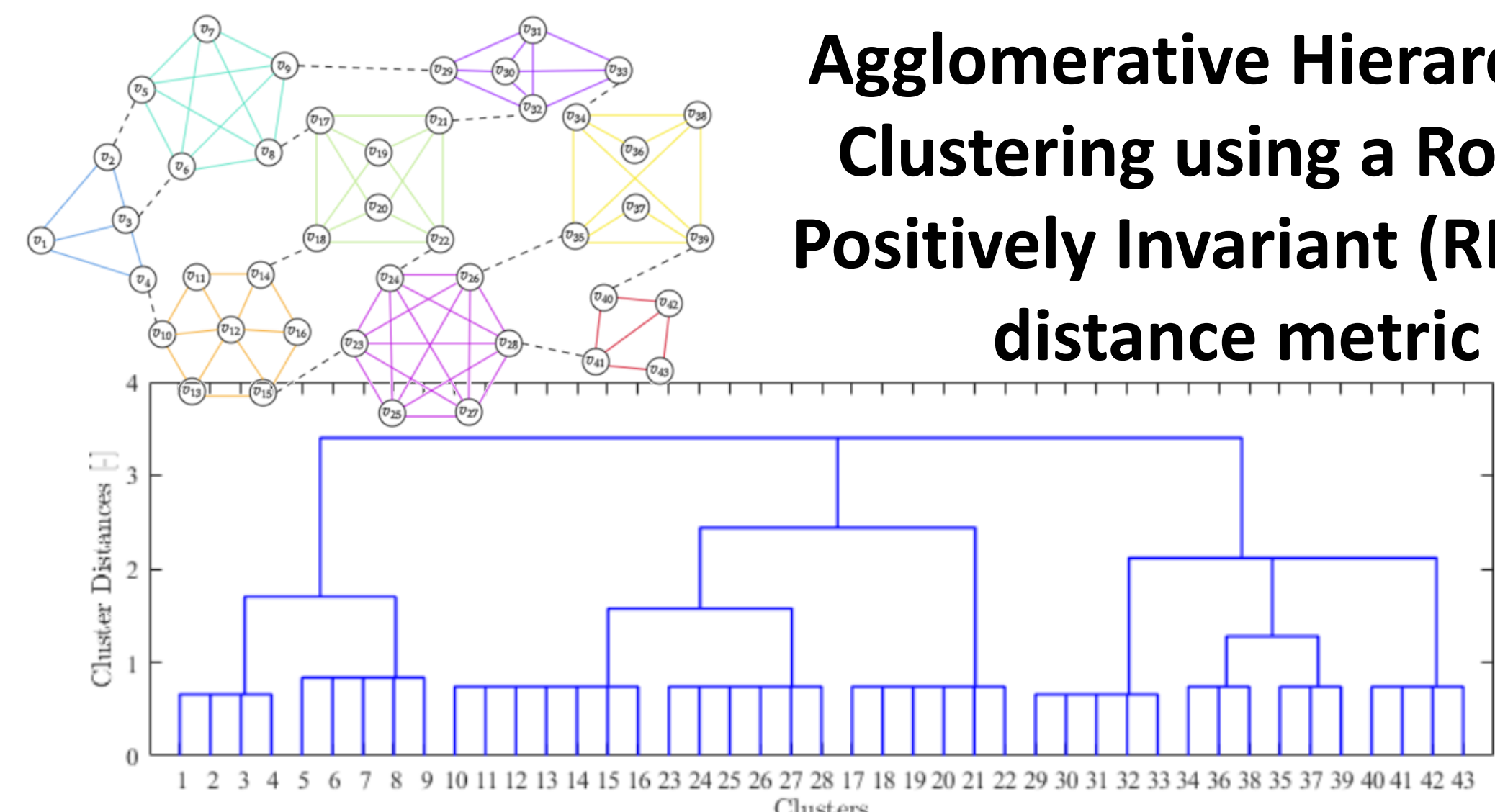
Solutions:

Set-based hierarchical MPC



Hierarchical Coordination using Waysets and Terminal Costs

Set-based hierarchical control architecture design



Agglomerative Hierarchical Clustering using a Robust Positively Invariant (RPI) set distance metric

Broader Impacts:

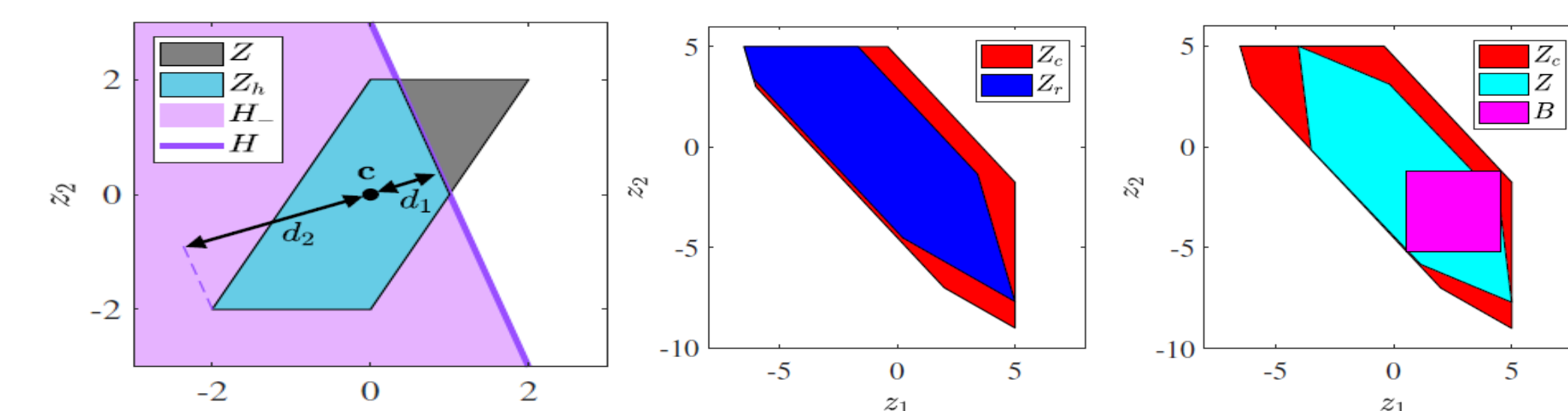
- Enhanced energy management solutions for coupled electro-thermal systems in commercial and military aircraft, on- and off-road hybrid vehicles, and ships

- Enable set-based approaches for the control, estimation, and reachability analysis of complex systems
- Graduate and undergraduate education in MPC and thermal energy management

Scientific Impact:

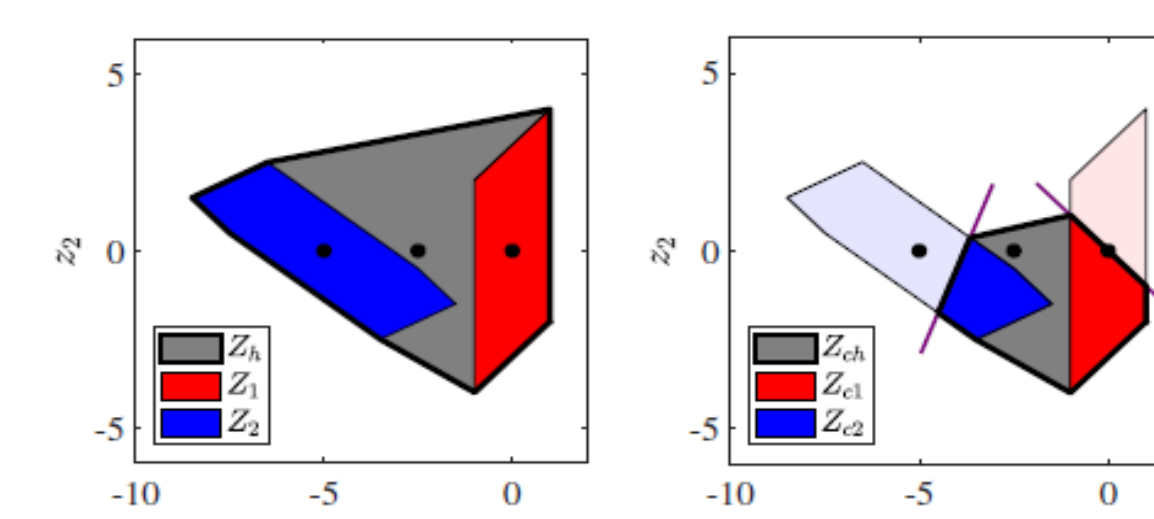
- Set-based techniques for control, estimation, and reachability-analysis
- Constrained zonotopes set operations/reduction
- New complex system decomposition techniques

Constrained zonotopes set operations and reduction

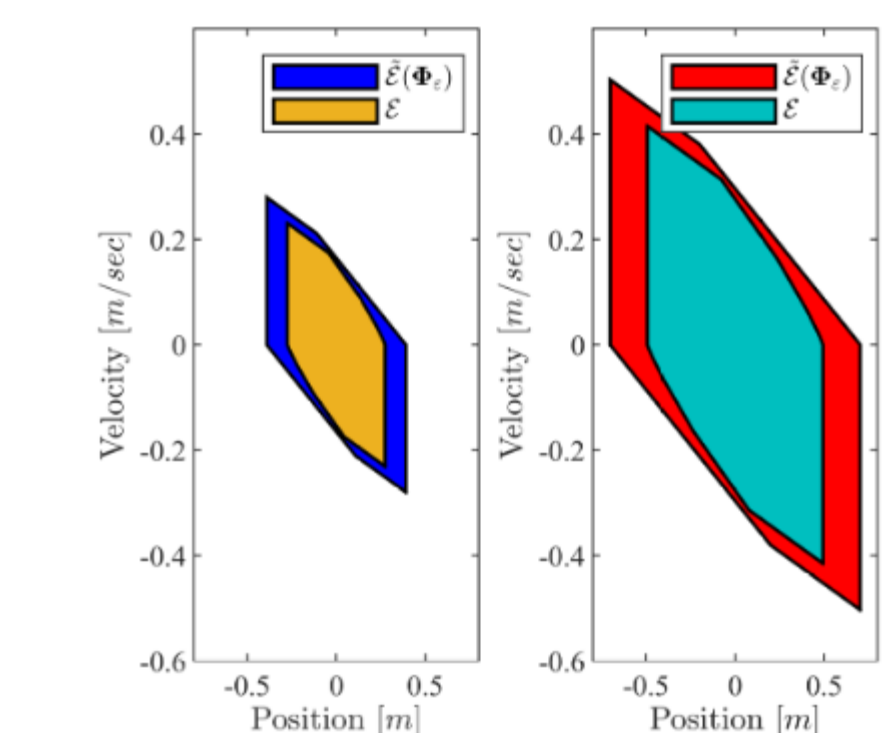


Halfspace Intersections

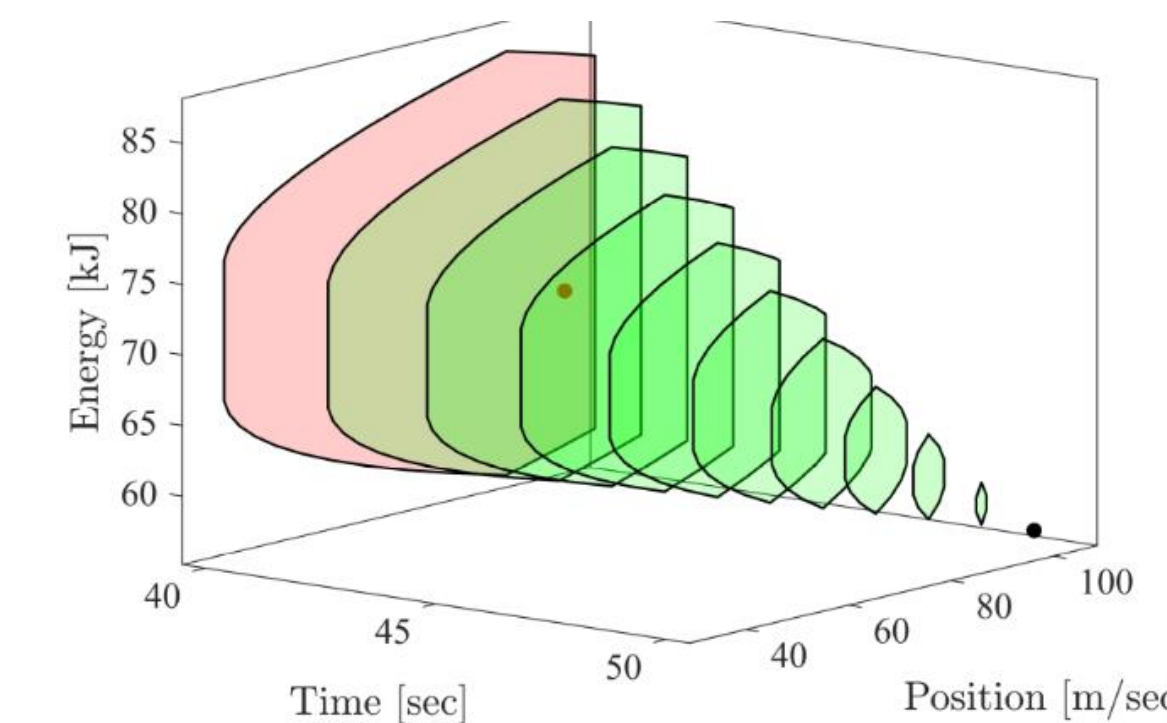
Inner Approximations



Convex Hulls



RPI Set Computations



Reachability Analysis