Optimization-Based Planning and Control for Assured Autonomy

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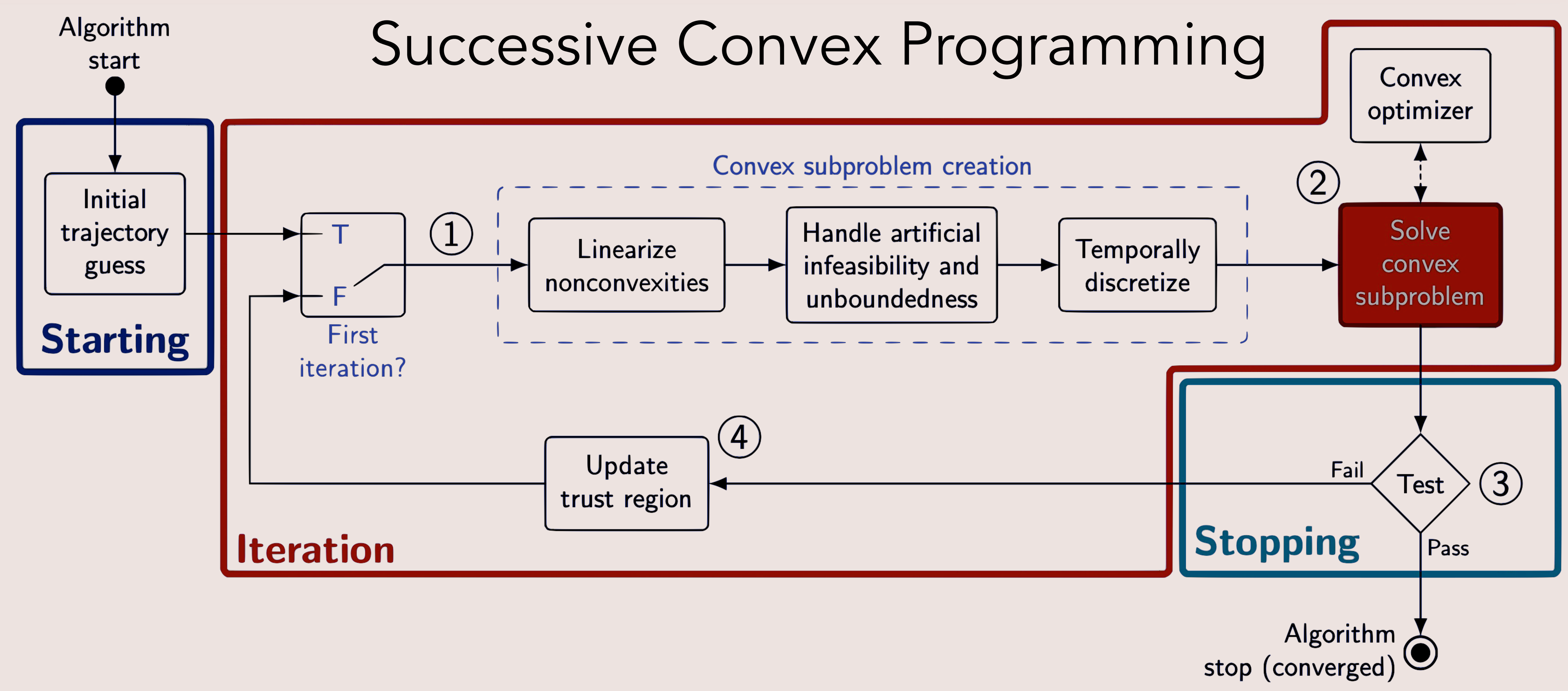
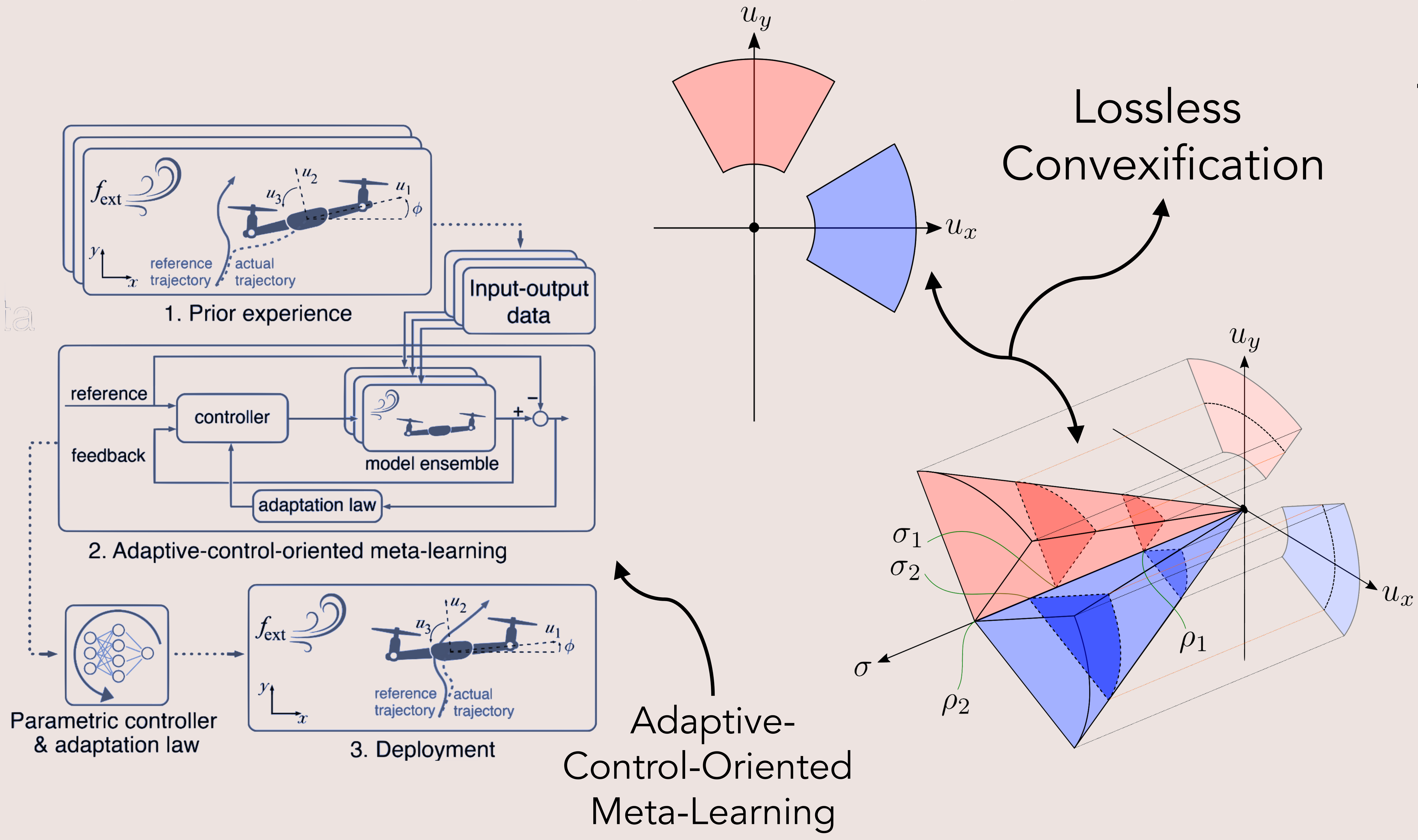
Project Objectives

We aim to fill the gap between the successful point-design solutions for autonomous planning and control for NASA missions and their generalizations to a wide range of applications.

To this end, we will unify our insights under a rigorous optimization-based computational framework by building:

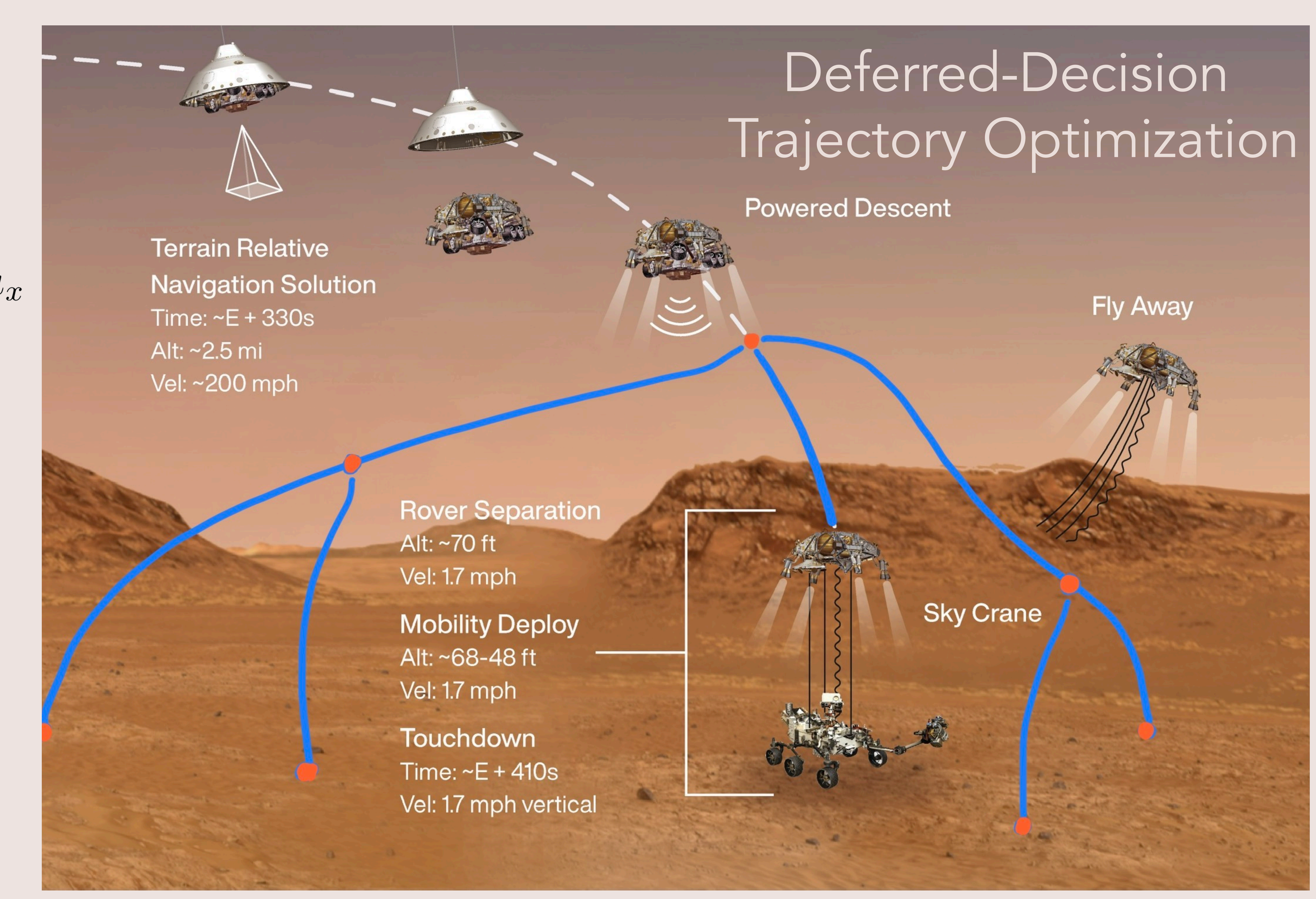
- A unified formulation of planning and control problems formalizing mission specifications, system constraints, and uncertainty sources.
- Solution algorithms to optimize mission objectives within the specifications and constraints.
- Real-time executable numerical solution algorithms that can be rigorously verified.





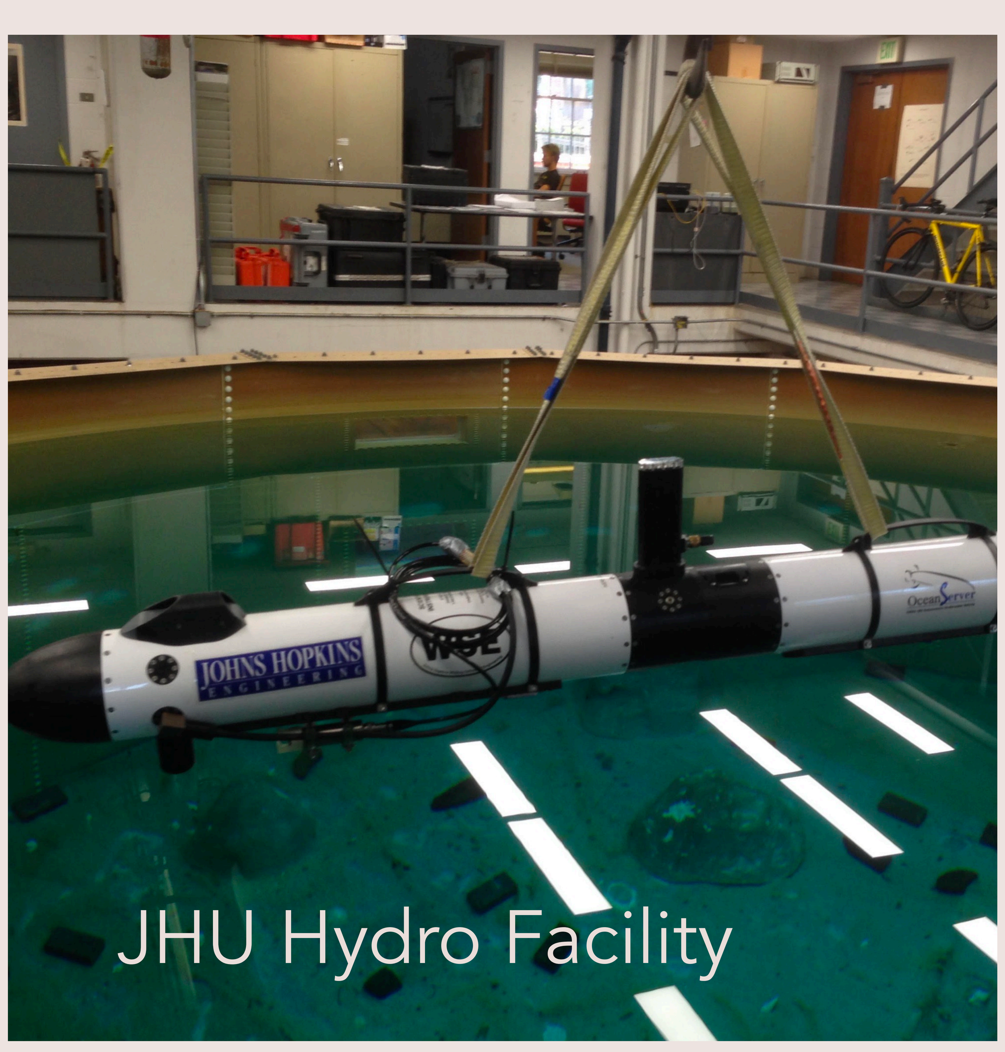
Thrust I – Convexification for Assured Nominal Motion Planning

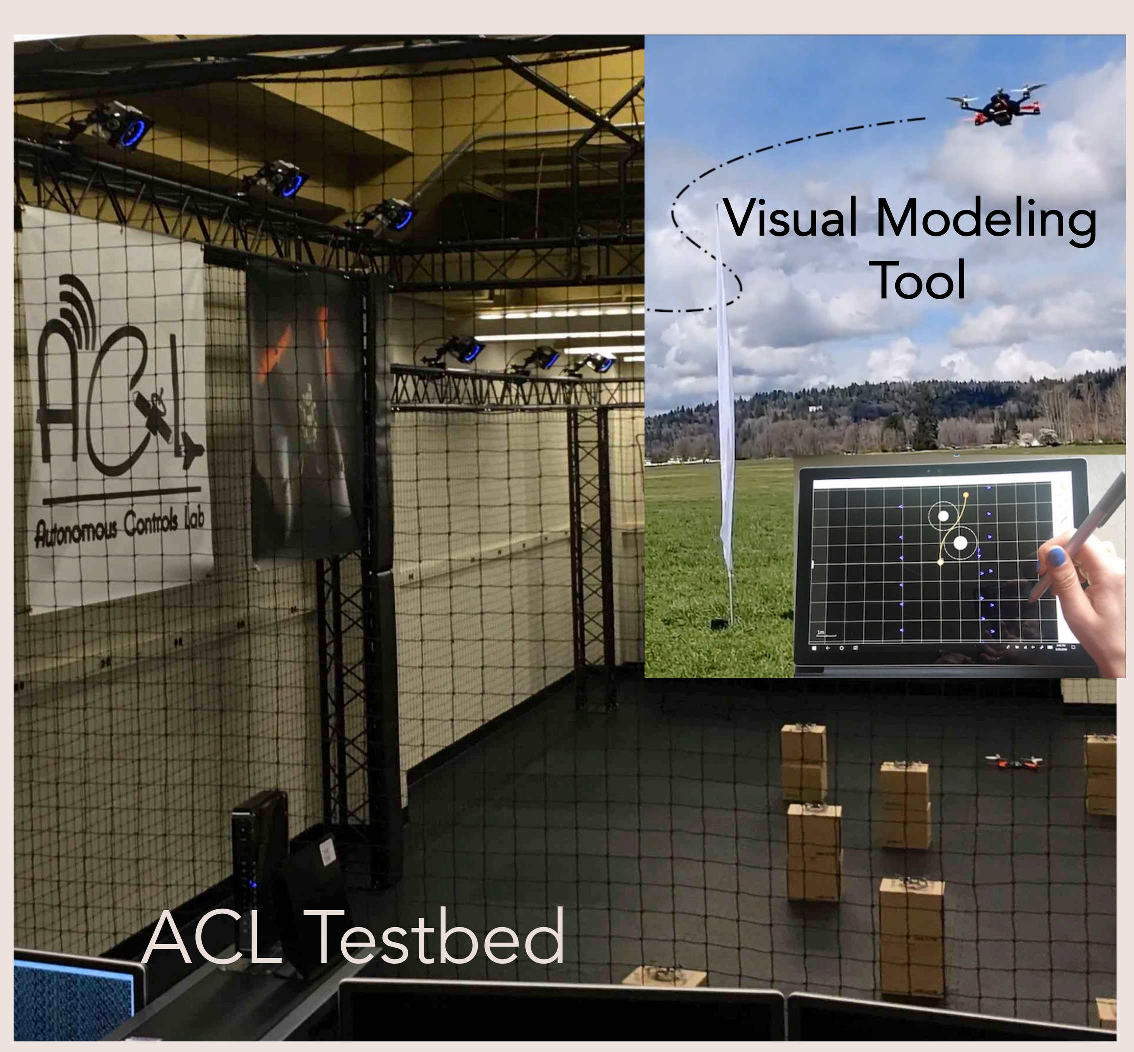
- What are the proper mission metrics to optimize for and what is their proper prioritization in case of conflicts?
- What are the best representations of state and control constraints? What are the class of non-convex constraints that can be losslessly convexified?



Thrust II – Resilient Motion Planning and Control for Uncertainty Handling

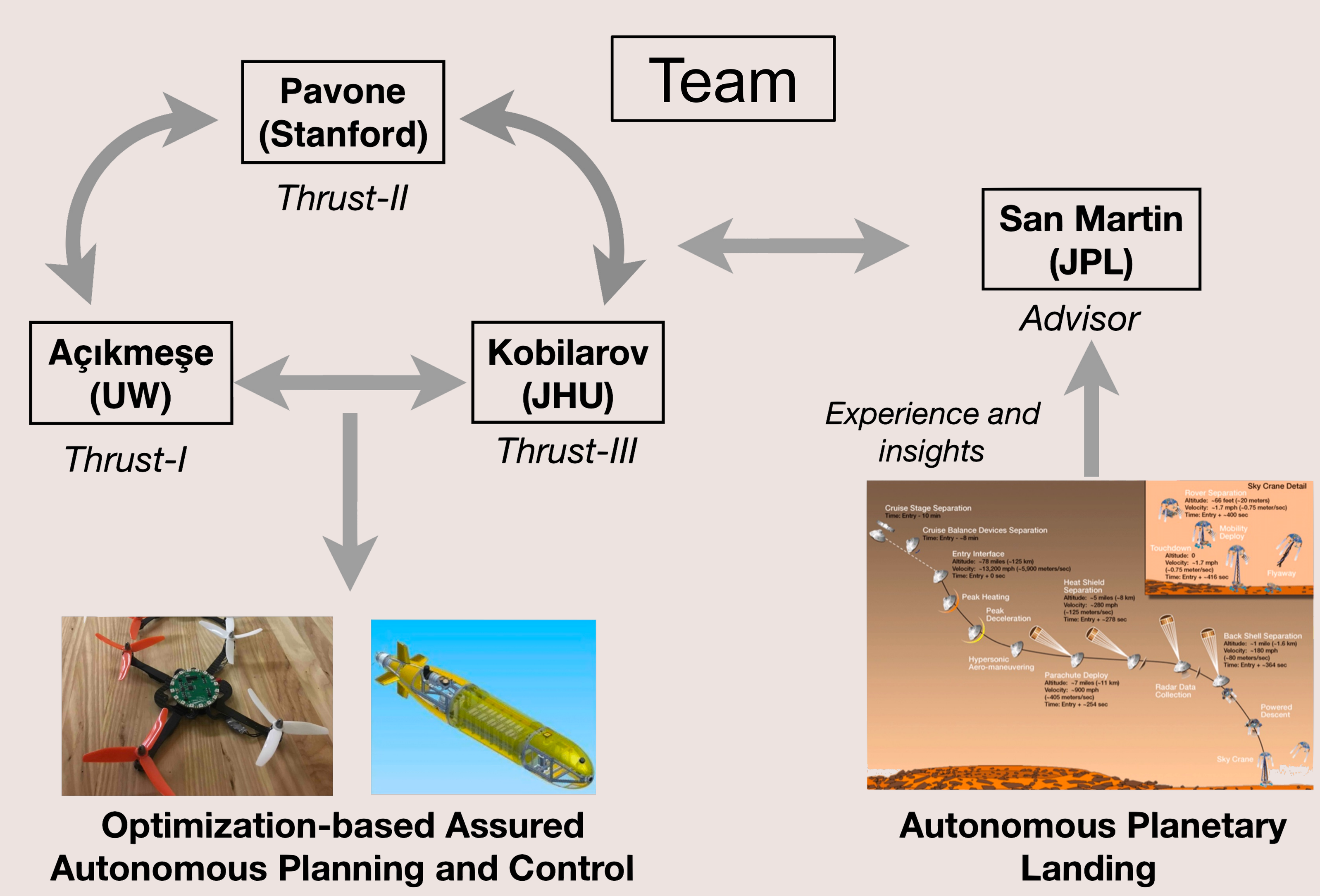
- Can we synthesize robust feedback control laws satisfying mixed frequency and time domain specifications to ensure constraint satisfaction in the presence of uncertainty in system the dynamics?
- How can we handle coupling between sensing and planning when the "separation principle" does not apply?





Thrust III – Real-world applications of autonomous UAVs and UUVs

- Can we replicate UAV landing scenarios analogous to space missions, where emergency diverts must be performed for safe landing in the presence of sensing uncertainty and wind gusts?
- How can we systematically validate the new algorithms via UW indoor/outdoor UAV test flights, JHU hydro-dynamic testing facility, and high-fidelity simulations



Broader Impact

- The development of a rigorous foundation for optimization-based planning and control will be transformative in a broad range of applications benefiting society, such as space exploration, autonomous vehicles, urban air transportation, mobile sensor networks monitoring arctic ice or oil spills, automated power networks, and automated drug dispensing.
- It will build confidence in advanced real-time computing, enabling the transition of many forms of reliable computing from offline to real-time in support of autonomy.