COMP4DRONES

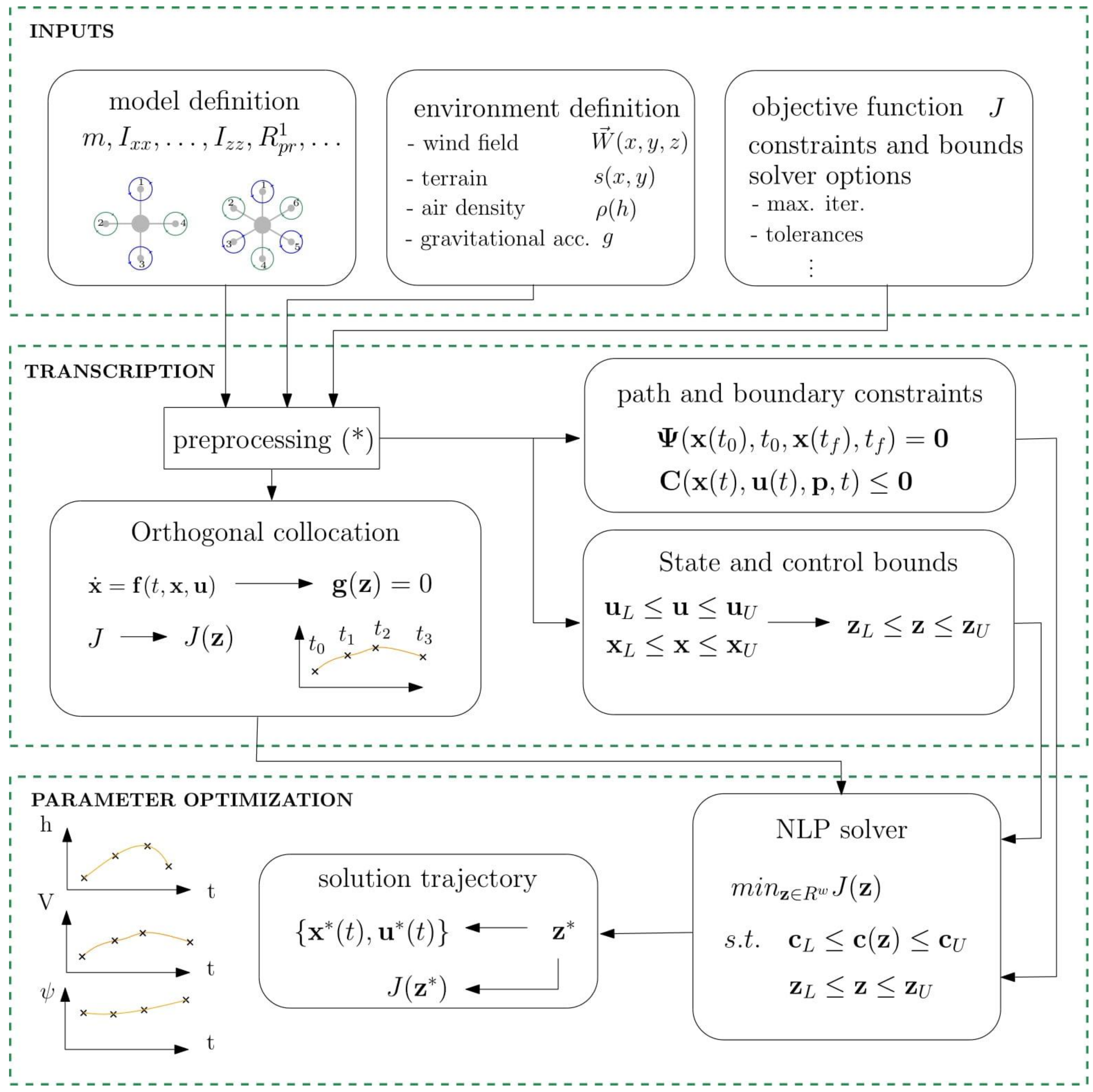
Framework of Key Enabling Technologies for Safe and Autonomous Drones

BUT: Mission design and optimization tool

BRNO UNIVERSITY OF TECHNOLOGY

COMPONENT DESCRIPTION

The trajectory optimization tool is designed to construct **optimal trajectories** with regards to a specified objective function and constraints such as no-fly zones or terrain. The trajectory is found using knowledge of the environment including wind conditions and the knowledge of a dynamical model which can be specified using a dedicated **model configuration tool**. The dynamical model can be a kinematic generalization of arbitrary aerial vehicle or it can be a high-fidelity model of a general multirotor UAV. The selection of the dynamics and its size affects the required computational power needed to construct the trajectory. The optimization tool can be initialized through the mission designer application developed in Python programming language. The optimization is performed by specification of an **optimal control problem** and its transcription using NonLinear Programming (NLP).



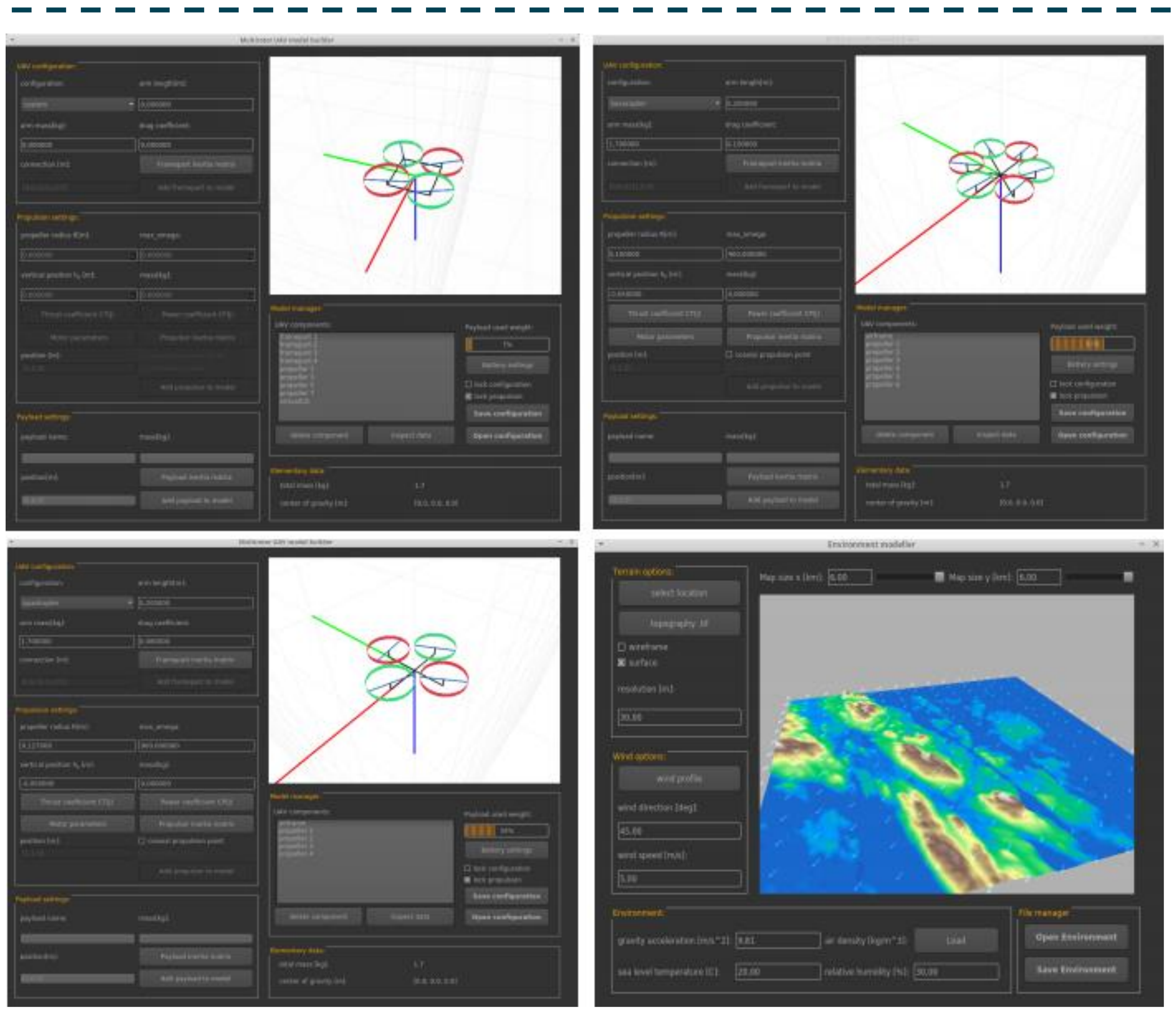
The mission design and optimization tool follows a model-based design approach. The functionalities addressed by the tool are summarized in the following list:

- **Direct transcription** using Lagrange interpolating polynomials used to represent state and control histories.
- **Generalized UAV model** for configuration management.
- **Mission constraints** for model (e.g. battery capacity) and environment (e.g. no-fly zones) enforced.
- **Energy optimal** trajectories in stationary wind fields respecting 6-DoF dynamics.
- **Parameter optimization** of required battery mass.

Enabling technologies for solving large NLP problems include:

- **IPOPT** – Primal-dual interior point solver exploiting Jacobian and Hessian partial derivatives is robust to initial solution.
- **Autograd** -Automatic differentiation package allowing differentiation of native python and numpy code.

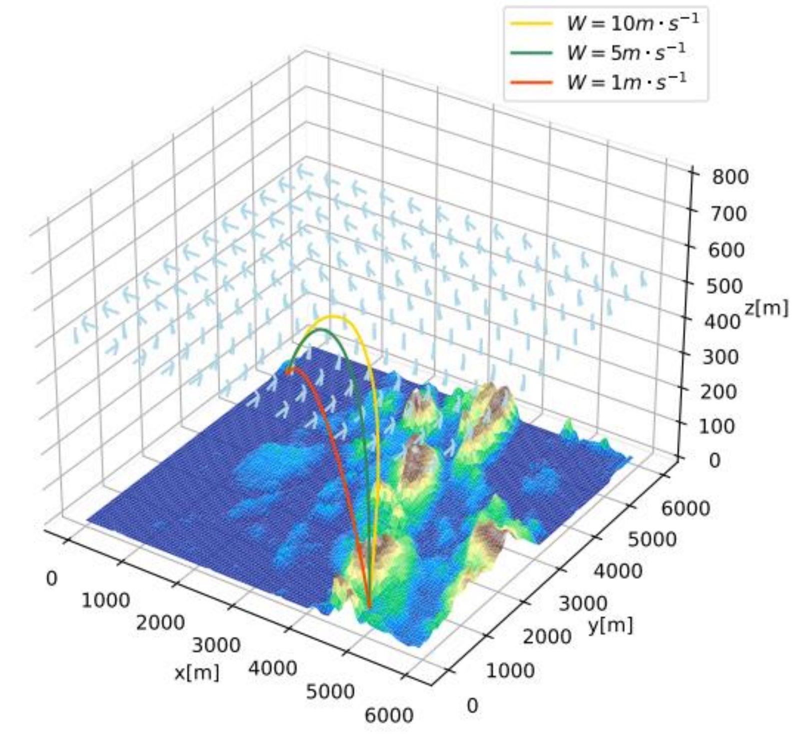
Model and environment configuration tool

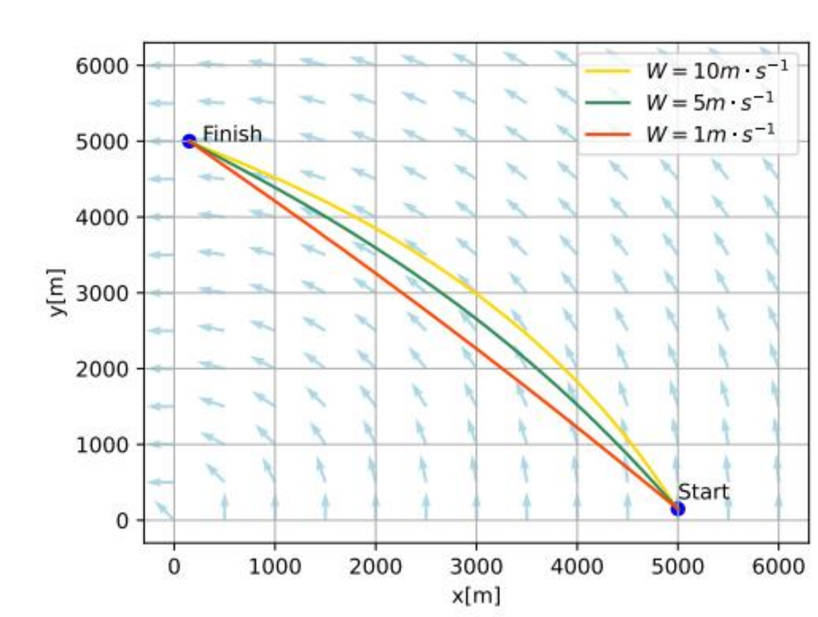


Trajectory optimization in wind field

Example: Quadcopter minimum energy problem

Stationary rotating wind field with changing wind speed. Applying battery State of Charge (SoC) constraints and optimizing for minimum energy. Rotor angular speed constrained in operational range.





COMP4DRONES has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826610. The JU receives support from the European Union’s Horizon 2020 research and innovation programme and Spain, Austria, Belgium, Czech Republic, France, Italy, Latvia, Netherlands.

ECSEL Joint Undertaking — Electronic Components and Systems for European Leadership

BRNO UNIVERSITY OF TECHNOLOGY

https://www.vut.cz/en/ https://www.comp4drones.eu/ @ECSEL_C4D