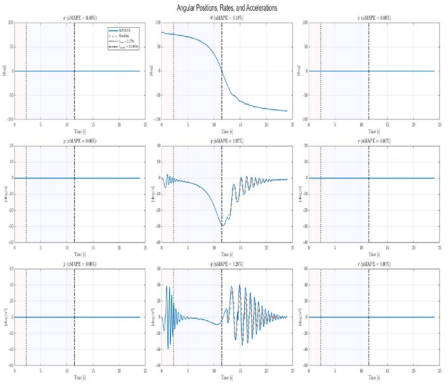
HSLU Hochschule Luzern

Technik & Architektur

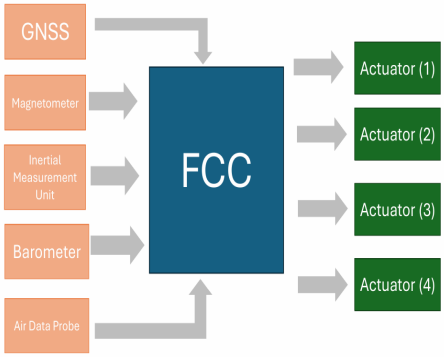
Masters' Thesis

Rocket Control System Design

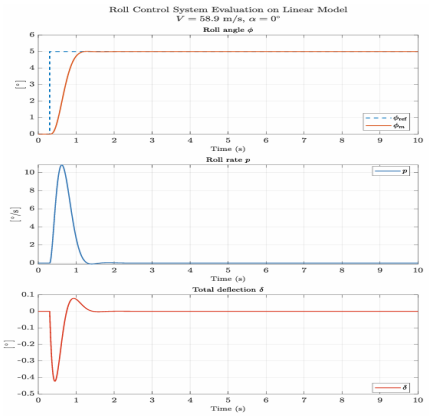
Linear Quadratic Integrator based Lateral Controller



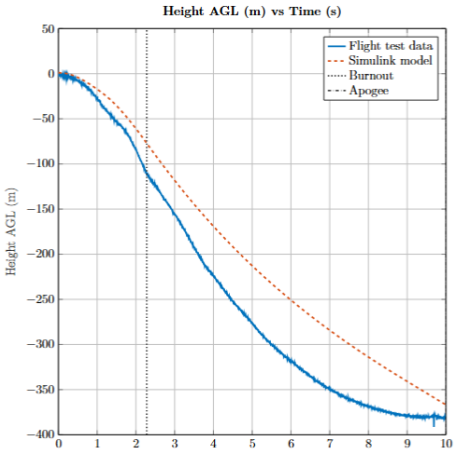
Mathematical Modelling and Verification



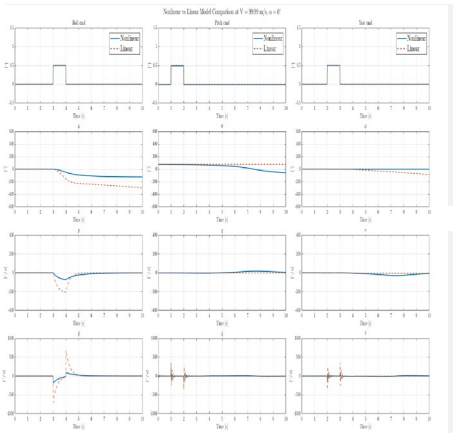
System avionics architecture



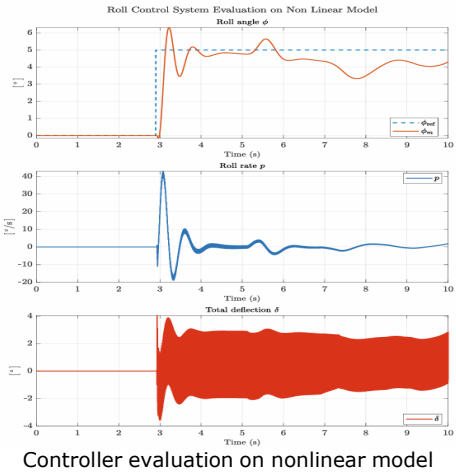
Controller evaluation on linear model



Validation with flight test data



Trimming and Linearization



Controller evaluation on nonlinear model

Problem Statement

To ensure that an experimental rocket follows a desired trajectory throughout its coasting phase an active control system is required. To develop such control system the following are required:

A mathematical model of the system;
Knowledge of the system state variables;
A control logic that uses the mathematical model and system state knowledge to generate actuation commands that enable the experimental rocket to follow a desired trajectory.

A mathematical model of the system was developed, verified and validated with flight test data. Following satisfactory results equilibrium points at which the system can operate in steady state were determined. The system was then decoupled into lateral and longitudinal models that were linearized. Analysis of the open loop system behaviour, aided in determining the unstable system modes and defining the control system tuning objectives.

Simultaneously a comprehensive review of control methods applicable to experimental rockets was conducted. A Linear Quadratic Integrator (LQI) architecture was identified as a suitable option.

The LQI controller was developed, tuned via a genetic algorithm and implemented via a gain scheduling approach based on velocity and incidence angle. It was tested satisfactorily on the linear system but underperformed when tested on the nonlinear system.

Improvement methods consists of retuning the controller with a different fitness function and testing alternative optimization algorithms such as particle swarm optimization (PSO) and Artificial Bee Colony(ABC).

The work done, provides a good foundation for testing of alternative optimal control algorithms like Linear Quadratic Gaussian (LQG).

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