Aerodynamic Study of the Side Elements of a Formula Student Vehicle

Proposal for Master Thesis
in Aerospace Engineering

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Goals

Despite the significant advances in computational fluid dynamic simulations in the last decades, they still under perform under conditions of flow separation and turbulence phenomena.

Consequently, wind tunnel experiments are used to validate aerodynamic design concepts in transportation, not only in aerospace but also in automotive.

This forecast capability is particularly important for the Formula Student (FST) road vehicle, that performs at relatively low Reynolds number and whose geometry creates significant regions of separated flow.

The objective of this proposal is to enhance an existing Formula Student aerodynamic design using both numerical tools and wind tunnel testing models.

Among the several vehicle aerodynamic parts that compose the aerodynamic package of the FST vehicle, focus will be given to the side elements, which include the side pod, lateral diffuser and side-cascade. The numerical tools should allow for an affordable comparison of different solutions, using the baseline design as reference, that allow for the evaluation of the impact of modified aerodynamic appendices.

Based on those numerical simulations, models of the design parts that exhibits the most promising aerodynamic efficiency gains are meant to be manufactured and tested using a complete 1:3 scale model of the FST vehicle. The modified complete vehicle model is then meant to be tested in an aerodynamic wind tunnel for validation of the numerical results.

In the end, a set of new aerodynamic side appendices is expected to obtained, whose efficiency gains have been demonstrated both numerically and experimentally. These parts can then become part of the new FST design in future competitions.

Tasks

To meet the goals proposed, the work should be composed of the following main tasks:

- Bibliography Review
  Literature research about road vehicle aerodynamics and wind tunnel testing, including details about the most relevant aerodynamic appendices.
  Estimated time: 3 weeks.

- Numerical and Experimental Setup
  Definition of the numerical simulations. Experimental wind tunnel setup and instrumentation calibration.
  Estimated time: 4 weeks.

- Baseline Aerodynamic Performance
  Detailed characterization of the aerodynamic performance of the baseline FST design, using available data from numerical simulations and wind tunnel testing, with focus on the side elements (lateral diffuser, side pod and side cascade).
  Estimated time: 5 weeks.

- Performance Gains Assessment
  Identification of regions of poor aerodynamic performance using numerical simulation tools. Benchmark of different promising alternative designs to select the solution of highest expected gain.
  Estimated time: 8 weeks.

- Vehicle Model Update
  Update of the side elements of the FST model vehicle with new design parts using additive manufacturing techniques.
  Estimated time: 4 weeks.

- Wind Tunnel Validation
  Back-to-back wind tunnel tests to evaluate the impact of the new aerodynamic parts. Validation of the numerical results.
  Estimated time: 6 weeks.

- Thesis Write-up
  Write-up of the dissertation thesis and corresponding oral presentation support material. The different technical topics covered should be described in detail, and a rigorous presentation is expected, both in visual and verbal terms, in a document logically structured.
  Estimated time: 5 weeks.

Requirements

The proposed work requires knowledge covered in courses such as:

- Additive Manufacturing
- Computational Fluid Mechanics
- Aerodynamics
- Instrumentation and Measurement

The courses mentioned are only illustrative of the scientific content of the work to be executed, so they are not mandatory requirements. As such, the student that shows interest in this proposal is advised to previously discuss it with the supervisor.

Localization

Instituto Superior Técnico (campus Alameda) and Laboratório Nacional de Engenharia Civil.

Observations

This work has been proposed and assigned to student Diogo Santos.

The student is strongly encouraged to start documenting the work since the first day. The recommended language for writing the dissertation is English.

Curriculum

- MEMAer - branch of Aircraft

Calendar

The work to be developed has an estimated duration of six months, in accordance to the present curricular plan at IST. During that period, the student is expected to meet on a regular basis with the supervisor for follow up and discussion of ideas.

The student has full autonomy to manage his time in the way it suits him best, however a calendar is suggested according to the tasks described previously.

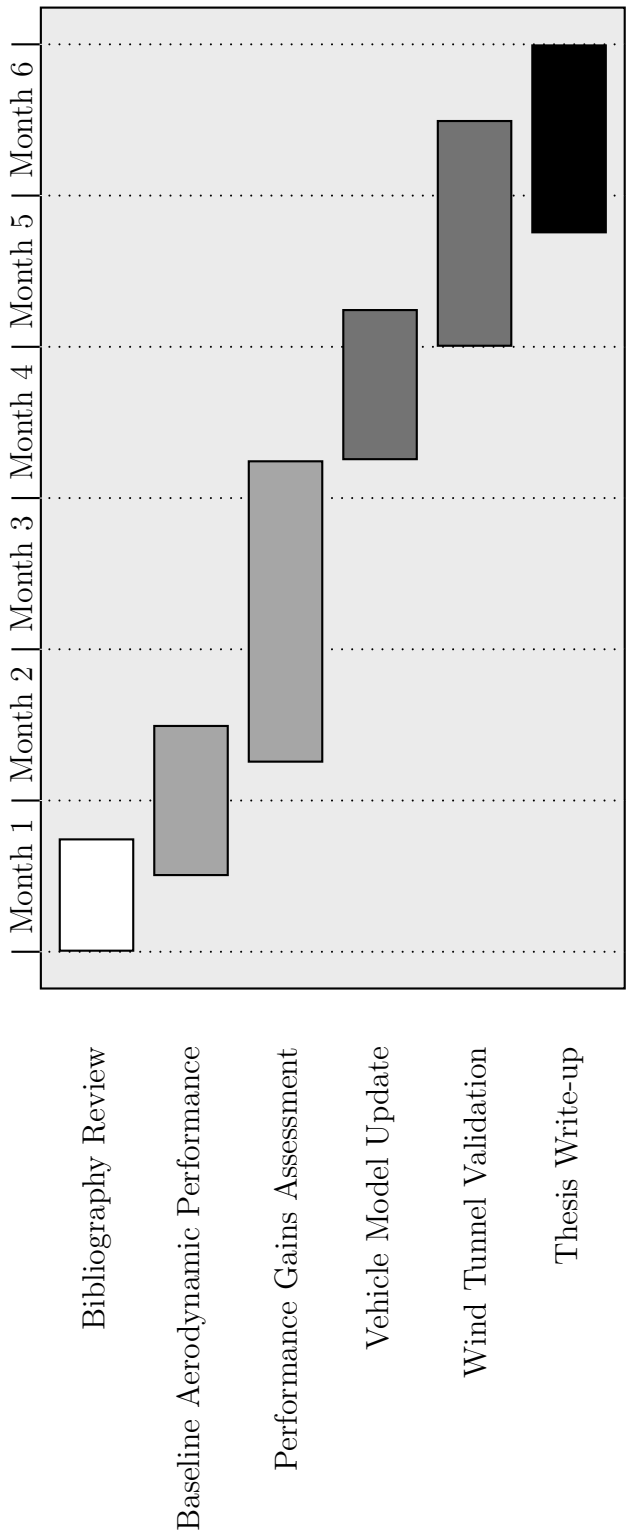

Table 1: Proposed Calendar