

I. IDENTIFICATION DATA

Thesis name:	Vertical landing flight envelope definition
Author's name:	Jack Charles Hooper
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis supervisor:	Ing. Tomas Hanis, Ph.D.
Supervisor's department:	Department of Control Engineering

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	challenging
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Evaluation of thesis difficulty of assignment.

The reusability of launch vehicles seems to be new trend in aerospace now. The goal of presented thesis is to investigate descent phase initial states limits for selected vehicle types and landing zone. The descent phase flight simulator tool was created considering dominant physical effects. Finally, the trajectory generation tool was develop based on optimization techniques. The broad expertise needed to fulfill the assignment makes it challenging.

Satisfaction of assignment	fulfilled
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Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

The assignment was fulfilled in all points.

Activity and independence when creating final thesis	B - very good.
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Assess that student had positive approach, time limits were met, conception was regularly consulted and was well prepared for consultations. Assess student's ability to work independently.

Mr. Hooper was very enthusiastic about the thesis with positive approach. The consultations were regular and well prepared until COVID 19 restriction, where we unfortunately lost any contact.

Technical level	A - excellent.
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Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The thesis is on good technical level. Student has proven the capability to deliver solid results based on theoretical knowledge gain during studies and literature survey.

Formal and language level, scope of thesis	C - good.
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Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The thesis is well written and organized. The main drawback of the thesis is missing equation numbering making any referencing impossible. Finally, few misspelled or double words are present mainly towards the end of the thesis.

Selection of sources, citation correctness	C - good.
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Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

Student has proven ability to work effectively with literature, however the citation discipline needs to be improved as many of clearly adopted figures were not properly cited.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

The thesis presents study of launch and/or re-entry vehicle trajectories. The important contribution of the thesis is definition of descend phase initial configuration for which preselected landing side is reachable. Student has proven capability to work independently and has mastered principles of flight dynamics. He has implemented re-entry simulation tool considering dominant effects for two types of vehicles. Presented work is limited to 2D – planar trajectories to simplify trajectory generation task and reduce computational effort. Finally, the re-entry trajectories were generated and verified. The readability of thesis is reduced by omitted equation numbering, on top of that several clearly adopted figures and tables are not properly referenced to original source.

I evaluate handed thesis with classification grade **B - very good**.

Date: **1.9.2020**

Signature:

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Type of thesis:	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Kamil Dolinský
Reviewer's department:	Garrett Motion Prague – department of control engineering

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment challenging

Evaluation of thesis difficulty of assignment.

I think that the difficulty of the topic of the thesis is appropriate.

Satisfaction of assignment fulfilled

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

The assignment was to do the following:

- 1) Get familiar with typical launch vehicles and missions.
- 2) Develop mathematical model of system dynamics and verify model against existing software.
- 3) Define the space of landable states (Flight envelop definition).
- 4) Verify flight envelope based on simulations

1) and 2): I would say that first two points were meet to a good extent. I think that putting together the model of the space shuttle is a challenging task. Nevertheless, the student managed to accomplish this it. The model is presented in a detailed form for both the space plane concept and VTVL concept.

- I would appreciate some list of variables that were used. So that the reader can have an overview of what each variable stands for and what physical quantity it represents.

3) Flight envelope was calculated. Therefore, the student managed to put together all the tools and math needed to approximately solve the problem of the optimal trajectory planning.

- As author mentions the grid used for sampling the optimal solution would need refinement. If I understood correctly, the flight envelope was found only for VTVL concept? Space plane concept – “Space orbiter spacecraft” – was not converging and therefore the optimization was not successful. Author expects that scaling the model should solve the issue. Was author considering using also a different solver?

Method of conception correct

Assess that student has chosen correct approach or solution methods.

I think that the approach in general is correct. However, since author reported problems with convergence for space plane concept. I would expect more focus on trying different optimization solvers or methods.

Technical level C - good.

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

I think that the technical level is good. The work would could be improved if the student could finish some of the started work – e.g. scaling of the model, comparison of solvers, different optimization methods.

Formal and language level, scope of thesis

B - very good.

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

Unfortunately, equations are not numbered. Also, I think that creating either a list of variables or some table would benefit the work. I had the feeling that the variables were not always introduced. So I had to guess what variable stands for.

Selection of sources, citation correctness

C - good.

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

Unfortunately, due to time constraints I was not able to properly assess if all the relevant sources were cited. The author uses citations for most of the modeling work he has carried out. In the chapters dealing with the optimal control I assume that the problem definition and associated math was carried out by the author, so the citation is not necessary.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

Please insert your commentary (voluntary evaluation).

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

The thesis deals with a complex problem of evaluating feasible flight envelope for vertical landing spacecraft. In my opinion the goal of the thesis was met. Author managed to develop a simplified model for VTVL and space plane concepts. Also overcome the difficulty of model parametrization. The design of the optimal flight paths and thus the definition of the feasible flight envelope was carried out for VTVL spacecraft concept. I think more work on the optimal control design would improve the results. Nevertheless, I think that the amount and the quality of presented work is high.

Was author considering using also a different optimization method? If not, why?

Was author considering using also a different solver? If not, why?

I evaluate handed thesis with classification grade **B - very good.**

Date: 3.9.2020

Signature: