SUPERVISOR'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	Simulation of Attitude and Orbit Control for APEXCubeSat
Author's name:	Niels de Graaf
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Control Engineering
Thesis supervisor:	Ing. Daniel Štefl, Ph.D.
Supervisor's department:	Huld s.r.o (previously Space Systems Czech s.r.o.)

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment   **challenging**

Evaluation of thesis difficulty of assignment.

The assignment was to create a Software Verification Facility and demonstrate the relevance of using opensource software and standardized communication using the APEX CubeSat that will orbit the asteroid Didymos as mission basis. Deep space missions are relatively rare and up to now were developed by national and international agencies like NASA, JAXA or ESA. The latest similar space probe built by the ESA was Rosetta launched in 2000 to perform a detailed study of comet 67P/Churyumov–Gerasimenko (67P).

It is obviously challenging to create a model of the dynamics of the CubeSat and its disturbance environment to plot its trajectories using python libraries developed for orbital dynamics. The attitude and orbital control were implemented as hardware in the loop programmed on a microcontroller to calculate the new trajectories for the simulation, increasing further the complexity of the task.

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 thesis completely met the assignment and exceeded it by adding performance comparison of the Python libraries by created equivalent application on his platform as well as on Matlab and STK. The author chose Poliastro open source libraries and implemented asteroid environment simulation based on them. After comparison of relevant microcontrollers, he decided to implement the hardware testing facility on STM32F446RET6, which is a choice closely matching the APEX hardware. The CAN bus communication was enabled by adding MCP2551 connected on breadboard.

Activity and independence when creating final thesis   **A - excellent.**

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.

The student was autonomous in both implementing the platform and writing the report. Where needed, he sought support from senior staff and were always perfectly prepared.

Technical level   **A - excellent.**

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

The technical level of the work is very high. The final solution required studying a lot of materials to solve the assignment and to understand all the related complexity.

Formal and language level, scope of thesis   **A - excellent.**

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

The report is written in English using perfect grammar and expected formal language. The typographical level of the report is excellent with high quality diagrams documenting the work done in easy to understand way.

Selection of sources, citation correctness	A - excellent.

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.

The bibliography is relevant. It has 38 items and covers the studied binary asteroid mission, orbital mechanics, ECSS standards of the ESA and the engineering sources necessary to implement the verification facility.

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.

The thesis is exceptional. It is given by the selection of the topic, which combines two future trends is space – asteroid exploration and nanosatellites, and it is also given by the excellent implementation of the verification facility and its perfect documentation in the final report. I estimate that the time allocation to deliver such exceptional work is above 1000 working hours.

If there is an award given by CVUT for exceptional master thesis or a prize of the dean, I would like to nominate Niels de Graaf to it.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

The thesis addresses important space engineering topics and solves them with open source tools and low-cost hardware. Therefore, it contributes to further democratizing access to space. Technically, it is on a very high level and can be used as a basis for further work on a similar mission.

I evaluate handed thesis with classification grade **A - excellent.**

Date: **28.8.2020**   Signature: Daniel Štefl