SpaceMaster Diploma Thesis Review
- supervisor -

Name of student: Maximilian Roth

Thesis topic: Non Linear Optimal Control Strategies For Geostationary Spacecraft Orbit Station Keeping Using Electrical Propulsion Only

Technical supervisors: Pau Hebrero Casasayas and Livio Tucci,
SCISYS Deutschland GmbH

CTU Supervisor: Doc.Ing. Martin Hromčík, Ph.D., DCE FEE CTU in Prague

Maximilian spent last six months in the SCISYS Deutschland GmbH company in Germany. He worked there, under supervision of Pau Hebrero Casasayas and Livio Tucci, on a project of design and validation of nonlinear optimal control laws for upcoming geostatinary satellites using electrical propulsion systems.

Upon my own reading of the thesis, I concur fully with the positive reviews by the Technical Supervisors that I recieved (see them attached). I appreciate the breadth of challenging and advanced concepts covered by the thesis, ranging from modeling and simulation of complex mechanical systems, design of nonlinear LQ optimal control laws using the recent methodologies of SDRE and ASRE, and fair assessment and discussion of results.

Question: Discuss the benefits and gains of using the nonlinear control laws (like SDRE, ASRE) compared to linear controllers based on local linearization (like, say, LQ).

Based on the above arguments, and on recommendations by the Technical Supervisors, my suggestion is

grade A

in accordance to ECTS.

Supervisor:

Doc.Ing. Martin Hromčík, Ph.D.

2016/09/06

Date

Signature

MAXIMILIAN ROTH - THESIS ASSESSMENT

OBJECTIVE	The main objective is based on up-to-date space software development. The objective of the thesis was accomplished: the student provided an artefact capable of optimizing the electric thruster profile of a geostationary satellite for a generic control box requirement. The student was highly motivated to keep improvement the work once the main objective had been reached, providing unexpected, but very much needed functionalities, such as the integration of the project into other flight dynamic tools.
PROFOUNDNESS OF THE RESEARCH	Sufficient research was done in the course of the first weeks in order to comprehend and analysis the state of the art of station keeping for electric satellites.
INTERNAL CONSISTENCY	The structure and design of the project was well-thought, consistent and planned in the first stages of the thesis. The student was capable of designing a flight dynamics model for Earth satellites, the optimization functionality for the electric station keeping and its later integration into other flight dynamics tools. All tools developed were designed and chained in order to provide coherent results.
STRUCTURE & DESIGN	The Thesis followed a logical and relevant structure, building up the needed knowledge to understand the objective. The designed and implemented tools by the student were in line with the internal requirements of the company. The student respected the modularity requirements making the tool easy to integrate in the future.
ANALYSIS	The analysis and interpretation of the data was accurate, reliable and comprehensive. Sufficient data was provided to verify the potential usage of the tool. The student was capable of analysing the data properly to spot potential modifications for future improvements throughout the whole development.
CONCLUSION	**The student has rapidly adapted to any of the guidelines that have been given, and has been able to work autonomously raising up questions when needed.** **We consider that the scope of the project is of high difficulty and up-to-date in the space environment, and that the work that the student has done has been of first quality.**

Darmstadt, 30th August 2016.

Pau Hebrero Casasayas
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CTU Diploma Project Review
Kiruna, September 7 2016

CTU Diploma Project review- 2nd reviewer's evaluation of master thesis with title "Non Linear Optimal Control Strategies for Geostationary Spacecraft Station Keeping Usin Electric Propulsion Only " by Space Master student Maximilian Roth.

I find that the goal of the thesis project well fulfils the requirements of a master thesis in space technology. The work concerns development of a model for station keeping of a geostationary spacecraft using electric propulsion.

The thesis includes setting up models for the disturbances acting on the spacecraft. Included in the validation of the model are different constellations of Earth perturbations, Sun and the Moon as point masses. In the model solar pressure and differences in forces acting on the spacecraft due to Earths shadow is also included for better accuracy.

The theory for the control laws is presented in a clear and concise way and to a relevant depth.

The model is validated using simulations and also through a comparison with an example presented in literature. If possible (if more examples similar to Losa is accessible) the thesis would have benefited from more comparisons.

The thesis includes both analysis, modelling and validation, and the presentation of the disturbance models and the discussion regarding the results clearly reveals that the student has a deep understanding of the subject and has been able to perform the analysis and modelling independently.

The result of the thesis project contributes to finding solutions for more economic use of fuel in geostationary missions, and it seems as if the model also may be adopted to be used for other types of orbits.

Based on the review above I recommend to grade the thesis by A(*excellent).* The oral presentation is still to be graded.

This review serves solely for the purposes of the diploma project defense at CTU. LTU official evaluation for the SpaceMaster double degree will follow the thesis defense and may differ from this review report and suggested grade.

Dr. Anita Enmark
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