Internship Proposal: analysis, performance and control of space systems

Company: DyCSyT
Employment Type: Internship
Experience Level: Student
Job Type: Full Time (5/6 months)

The company

DyCSyT (DYnamics and Control of SYsTems) is a spin-off from ISAE-SUPAERO, specialized in the modeling and robust control of space systems. We sell the SDTlib, a state-of-art software that allows the GNC/AOCS engineer to model complex satellites with flexible elements and parametric uncertainties. DyCSyT is involved in projects with several companies and agencies: Infinite Orbits, Clearspace, Thalès Alenia Space, CNES, ESA, and has experience in various types of projects such as high-accuracy pointing control, in-orbit servicing, control-structure co-design...

Job Description

Recent collaborations between NASA and ESA highlighted the need for preliminary design tools able to guarantee spacecraft control performance robustly in the very early design phases [1]. ISAE-SUPAERO and DyCSyT develop a software, the Satellite Dynamics Toolbox library (SDTlib), which provides a multibody environment to quickly build the dynamical model of complex spacecrafts while taking into account uncertainties on the mechanical parameters. It is then possible to assess the robust performance of the mission very early in the project's life, but also to optimize it in the later stages of development. However, for missions involving fine pointing control of an optical payload or an antenna, the classical $\mathcal{H}_\infty$ metric may not be sufficient, and a statistical

approach analyzing the impact of all input disturbances on the pointing error can provide a more reliable pointing budget. The ultimate goal of this internship is to develop and integrate this feature into SDTlib, and validate the approach on realistic mission scenarios.
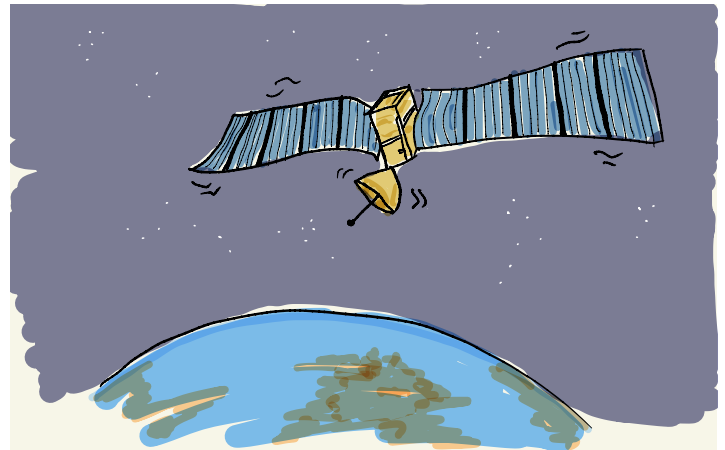

Figure 1: Example of large flexible spacecraft [2]

The Satellite Dynamics Toolbox library (SDTlib) is a MATLAB/Simulink library developed by ISAE-SUPAERO and DyCSyT able to model complex multibody space flexible structures [2]. This tool has been developed in the last ten years thanks to several collaborations with the European Space Agency (ESA) and many European aerospace companies. The main applications of the toolbox are: modeling of large flexible spacecraft [3], modeling of fine mechanism [4], modeling of stratospheric balloons [5], design and analysis of robust control law for flexible Space structures and fine pointing missions [6], control/structure co-design [7].

Work to be performed

The technical work to be performed will consist in:

- getting familiar with the SDTlib, the pointing error metrics of ESA, and the robust control and analysis tools;

- developing a statistic methodology to provide a reliable pointing budget of a closed-loop scenario implemented in SDTlib;

- developing a user friendly interface for the definition of the input source of perturbations;

- testing and validating the developed tools on a complete study case to show the entire modeling/analysis/validation process on a fine control mission;

- producing a rigorous documentation.

Your working environment

You will integrate the DyCSyt team in Toulouse, European capital for space research. In DyCSYt you will have the opportunity to collaborate with the major actors of the space industry and the European Space Agency (ESA).

Your Profile

You are preparing a Master degree in Aerospace Engineering. You have the following skills:

- Good knowledge in System Dynamics

- Good knowledge in Control Theory

- Good knowledge of `Matlab`/`Simulink`

How to apply

If interested in this opportunity, please send us your CV and motivation letter to the following mail address:

ervan.kassarian@dycsyt.com

References

[1] C. Dennehy and O. S. Alvarez-Salazar, "Spacecraft micro-vibration: a survey of problems, experiences, potential solutions, and some lessons learned," 2018.

[2] D. Alazard and F. Sanfedino, "Satellite dynamics toolbox for preliminary design phase," in *43rd Annual AAS Guidance and Control Conference*, vol. 30, 2020, pp. 1461–1472.

[3] F. Sanfedino, D. Alazard, V. Pommier-Budinger, A. Falcoz, and F. Boquet, "Finite element based n-port model for preliminary design of multibody systems," *Journal of Sound and Vibration*, vol. 415, pp. 128–146, 2018.

[4] F. Sanfedino, D. Alazard, V. Preda, and D. Oddenino, "Integrated modeling of microvibrations induced by solar array drive mechanism for worst-case end-to-end analysis and robust disturbance estimation," *Mechanical Systems and Signal Processing*, vol. 163, p. 108168, 2022.

[5] E. Kassarian, F. Sanfedino, D. Alazard, C.-A. Chevrier, and J. Montel, "Linear fractional transformation modeling of multibody dynamics around parameter-dependent equilibrium," *IEEE Transactions on Control Systems Technology*, vol. 31, no. 1, pp. 418–425, 2022.

[6] F. Sanfedino, G. Thiébaud, D. Alazard, N. Guercio, and N. Deslaef, "Advances in fine line-of-sight control for large space flexible structures," *Aerospace Science and Technology*, vol. 130, p. 107961, 2022.

[7] A. Finozzi, F. Sanfedino, and D. Alazard, "Parametric sub-structuring models of large space truss structures for structure/control co-design," *Mechanical Systems and Signal Processing*, vol. 180, p. 109427, 2022.