Abstract

ESA multibody tool for launchers and spacecrafts: lesson learnt and future challenges

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Since the early 1980s, the multibody dynamics simulation tool DCAP (Dynamic and Control Analysis Package) has been progressively developed by the European Space Research and Technology Centre (ESTEC) of the European Space Agency (ESA) through several industrial contracts with Thales Alenia Space Italy (TAS-I) in Torino. Since 2014, ASTOS Solution GmbH has taken the lead on the software development and commercialization, with the continued support from the Agency.

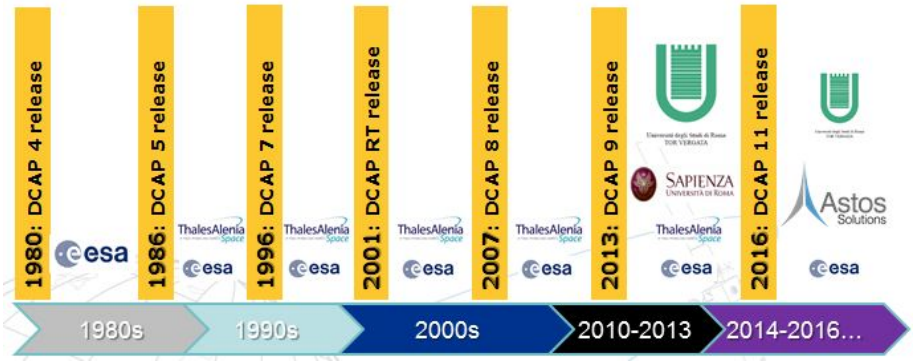

Fig. 1: DCAP development milestones

This software suite, which originates from NASA's DISCOS FORTRAN code, has become a no-frills, rational, fast multibody program designed for the dynamic simulation and stability analysis of passive and actively controlled space systems and devices.

With almost 40 years of space heritage, today DCAP is regarded by the (European) space community as an independently-coded, alternative benchmark for high fidelity multibody simulations and cross-validation of space dynamics problems.

This paper summarizes the major development milestones, achievements and success stories, and presents the most relevant lesson learnt throughout the software development.

In particular, the focus is placed on the multidisciplinary unique capabilities, particularly relevant to the development of rockets and space transportation systems [1]. The most innovative of which are the use of flexible elements for the launchers segments with variable mass and stiffness properties, implementation of separation shock response spectrum at payload interface, thrust profile based on real-time propellant consumption, aerothermodynamics input and sloshing dynamic contribution.

In this ongoing development, two major open challenges are identified:

- how to incorporate parametric distributed aerothermodynamics input in a multibody approach
- how to effectively model, in a multibody approach, the chaotic dynamic behavior of fluids' sloshing in a microgravity environment.

Finally, the envisioned development road-map is presented, from the Agency's prospective, aiming to an open discussion with the users community.

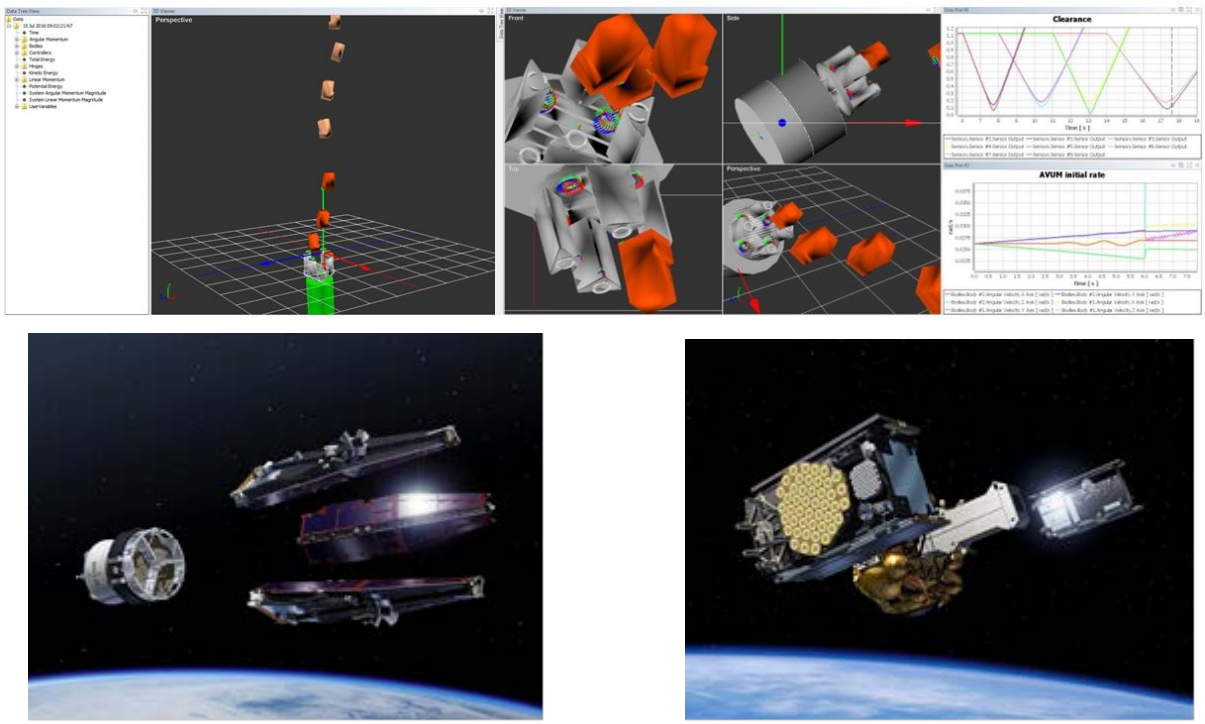

Fig. 2: Multi-payload separation study case (Credits: ESA/CNES/ARIANESPACE)

References

[1] G. Kehrl, “Mission Design Challenges for Multi-Manifest Missions”, 10th Annual CubeSat Developers Workshop, 2013

[2] "Propellant slosh loads", NASA report SP-8009, 1968

[3] B.N. Suresh, K. Sivan, "Integrated Design for Space Transportation System", Springer, 2015

[4] G.. Baldesi, M. Toso, “European Space Agency’s launcher multibody dynamics simulator used for system and subsystem level analyses”, CEAS Space Journal,Vol. 3, Iss 1-2 (2012-06), pp 27-48.

[5] "Structural vibration prediction", NASA report SP-8050, 1970

[6] N. Shah, O. Hsu, et al, "A Multibody Slosh Analysis for the Lunar Reconnaissance Orbiter", Proceedings of the 20th International Symposium on Space Flight Dynamics, Annapolis (USA), 2007

[7] "Flight separation mechanisms", NASA report Sp-8056, 1970

[8] M. Such Taboada, “High Fidelity FE Model of Clamp Band System with Catcher mechanism” NAFEMS European Conference: Coupled MBS-FE Applications: A New Trend in Simulation, 2013

[9] G. Baldesi, T. Voirin, A. Martinez Barrio, and M. Claeys, “Methodologies to perform GNC design and analyses for complex dynamic systems using multibody software”, Advances in Aerospace Guidance, Navigation and Control, pp. 431-450. Springer Berlin Heidelberg, 2011

[10] F. Mastroddi, G. Goppotelli, et al, "Vibro-acoustic response analysis to pressure oscillations in a solid rocket motor – comparisons with the experimental fire-test data", XIX Congresso Nazionale AIDAA, Forlì (Italy), 2007