

Craig Stephenson

Curriculum Vitae

Applied mathematician with over 30 years experience on a multitude of (mainly ESA) space missions. Expertise in celestial mechanics, the three-body problem and flight dynamics, and experience with spacecraft operations.

Academic Qualifications

PhD in Mathematics, *Open University*, UK, 2012.

MSc in Mathematics, *Open University*, UK, 2000.

BSc (Hons) 2:1 in Mathematics, *University of Bristol*, UK, 1985.

Professional Experience

2022–Present **Flight Dynamics Engineer**, CGI DEUTSCHLAND B.V. & Co. KG, Darmstadt (DE).

Over the past 18 months I have assisted with the preparations to provide flight dynamics support to the H2Sat mission. I have developed standalone software tools in Python, both to ingest the database and to visualize the orbit, and have resolved several issues with the main PLENITER[®] flight dynamics software.

2013–2019 **Spacecraft Operations Engineer**, TELESPAZIO VEGA UK SL, Madrid (ES).

Returning to the European Space Astronomy Centre (ESAC), initially on a five-month temporary contract, I was given the task of validating the ground-based pointing reconstruction for the HERSCHEL spacecraft. After discovering and correcting a number of important defects in the method, I continued in this role until the operational deployment of the software in late 2015. During this period, I also performed a critical study of the somewhat naïve method which had been used to quantify the achieved pointing accuracy and acted as a moderator at the HERSCHEL Lessons Learned meeting.

For the ROSETTA mission, I developed the software which checked the safety of the patchwork of trajectories used by the spacecraft to observe the comet 67P/CHURYUMOV–GERASIMENKO and, more recently, for the GAIA mission I extended the code which performs the core astrometric processing. Much of my focus here was on the detection of ‘micro-clanks’ and on the estimation of the fluctuations in the angle between the spacecraft’s two telescopes.

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- 2003–2009 **Project Manager**, DEIMOS SPACE SL, Madrid (ES).
Whilst based at ESAC, I designed, coded and maintained the pointing reconstruction software for the Japanese AKARI satellite. Later, for the DEIMOS-1 microsatellite, I performed a study to assess the feasibility of using a ground-based estimator to improve the accuracy of the attitude determination. This involved the prototyping of a non-linear smoother based on extended Kalman filters and the development of an improved sun sensor bias model. For the Multi-constellation GNSS Regional System, I investigated various strategies which had been proposed for 'overbounding' random processes and was involved with designing and coding the software for the Integrity Processing Facility.
- 2001–2003 **Flight Dynamics Engineer**, SciSYS (SPACE & DEFENCE) LTD, Darmstadt (DE).
Worked in the Flight Dynamics Division at the European Space Operations Centre (ESOC), Darmstadt, on the testing and validation (from the development of test tools through to the participation in system tests and simulations) of the manoeuvre optimization and orbit determination subsystems for the ROSETTA, MARS EXPRESS and SMART-1 missions.
- 1995–1999 **Flight Dynamics Engineer**, SCIENCE SYSTEMS (SPACE) LTD, Darmstadt (DE) & Madrid (ES).
Whilst working in the Flight Dynamics Division at ESOC, I developed software for the checking of star programming commands for ENVISAT and for the simulation of example orbit and attitude strategies for the near comet phase of the ROSETTA mission. In addition, I was responsible for the maintenance of a large suite of software used to provide star catalogues for ESA missions.

Between January 1996 and June 1998 I was seconded from ESOC to what was formerly the ESA Villafranca Satellite Tracking Station (now ESAC) to provide flight dynamics support for the Infrared Space Observatory (ISO) satellite. My responsibilities included mission planning tasks, contingency support and software maintenance. In addition to fulfilling these duties, I played a key role in improving the pointing accuracy through the in-flight estimation of the sensor misalignments, and performed studies related to the momentum biasing of the satellite.
- 1994–1995 **Senior Software Engineer**, CRAY SYSTEMS LTD, Darmstadt (DE).
Before moving to the Flight Dynamics Division, my first job at ESOC was to develop software for the Telemetry Processing and the On-board Software Maintenance subsystems of the CLUSTER Mission Control System.
- 1992–1994 **Senior Analyst/Programmer**, SCIENCE SYSTEMS (SPACE) LTD, Bristol (GB).
Developed software for the METEOSAT Transition Programme and for a generic EUROSTAR Launch and Early Orbit Phase Telemetry Processing System.

1989–1992 **Spacecraft Dynamicist**, BRITISH AEROSPACE (SPACE SYSTEMS) LTD, Bristol (GB).

As a member of a small team charged with investigating the dynamics of the spin-stabilised CLUSTER spacecraft, I developed mathematical models to study: the various boom deployments (including the effects of propellant slosh, boom flexibility and nutational motion); the effect on the principal axis tilt of boom deployments and propellant redistribution; and the performance of the cable boom root dampers. I also developed models of the on-board accelerometers and wrote generic spectral analysis software.

Prior to the start of the CLUSTER project, I spent some months working on the design of the Attitude and Orbit Control System (AOCS) for the Solar and Heliospheric Observatory (SOHO), developing models of the various on-board sensors and integrating these into an in-house simulator. This I then used to assess the performance of several candidate attitude controllers designed for use during station-keeping manoeuvres. Finally, I performed short studies on the design of XMM/PRISMA (optimizing the reaction wheel system and performing an attitude sensor trade-off).

1985–1989 **Scientific Officer**, TRANSPORT AND ROAD RESEARCH LABORATORY, Crowthorne (GB).

Developed computer simulations to model the response of heavy goods vehicles to road profiles and wrote software to perform digital signal processing and spectral analysis of experimental test data.

1984–1984 **Vacation Student in Wind Energy Group**, SIR ROBERT MCALPINE & SONS LTD, London (GB).

Calculated (analytically) the modal response of a vertical-axis wind turbine to turbulence.

Computer skills

Languages Python (and Jython), MATLAB, Fortran, Java, Maple, \LaTeX , C, IDL
Operating systems macOS, SOLARIS/Unix, VAX/VMS, Windows
Software applications Spyder, Jupyter Notebook, Eclipse, Orekit, Git/GitLab, Subversion

Languages

English Native speaker
Spanish Nivel alto
German Eingerostet
French Passable

PhD Thesis

- Title *Periodic Orbits of the Three-Body Problem: F.R. Moulton's quest for a new lunar theory*
- Supervisors Professor June Barrow-Green and Professor Jeremy Gray
- Description The focus of my research was on the periodic solutions of the restricted three-body problem and the contribution to the subject by the mathematical astronomer Forest Ray Moulton and his research students at the University of Chicago. After a detailed description of the pioneering work of Hill, Darwin and Poincaré, my thesis reveals how Moulton's *Periodic Orbits*, published in 1920 and running to some 500 pages, arose from Moulton's ambitious goal of creating an entirely new lunar theory.
- This research has been presented at several mathematical meetings, including the British Mathematical Colloquium (Edinburgh, 2010) and the Joint Mathematics Meeting (San Antonio, 2015), and in 2021 was published in book form by the American Mathematical Society.

Selected Publications

- C. A. Stephenson. *Periodic Orbits: F. R. Moulton's Quest for a New Lunar Theory*, volume 45 of *History of Mathematics*. American Mathematical Society, May 2021.
- C. A. Stephenson. George Darwin's lectures on Hill's lunar theory. *BSHM Bulletin: Journal of the British Society for the History of Mathematics*, 24(3): 159–171, Nov 2009.
- A. J. Batten and C. A. Stephenson. ISO: In-orbit calibration of the AOCS sensors and maximisation of pointing performance. In T. D. Guyenne, editor, *Proceedings of the 12th International Symposium on Spaceflight Dynamics (Darmstadt, 2–6 June 1997)*, 245–250. ESA Publications, ESA SP-403, Aug 1997.
- C. A. Stephenson. ISO momentum biasing studies. In T. D. Guyenne, editor, *Proceedings of the 12th International Symposium on Spaceflight Dynamics (Darmstadt, 2–6 June 1997)*, 191–196. ESA Publications, ESA SP-403, Aug 1997.
- C. A. Stephenson. The dynamics of the Cluster spacecraft. In W. R. Burke, editor, *Proceedings of the First ESA International Conference on Spacecraft guidance, navigation and control systems (Noordwijk, 4–7 June 1991)*, 589–594. ESA Publications, ESA SP-323, Dec 1991.

Professional Memberships

2015–Present American Mathematical Society (AMS)

2006–Present British Society for the History of Mathematics (BSHM)

2020–Present Real Sociedad Matemática Española (RSME)