Metis

Metis Flight Dynamics Capabilities

Metis Technology Solutions retains expertise in orbit design and other associated flight dynamics functions, supporting spacecraft design, mission planning, and operations. Our largest focus is in analyzing and customizing orbit and trajectory characteristics to mission design requirements. Our technical approach leverages the engineering lifecycle from requirements definition through all project phases and mission operations. Specific capabilities include:

- Mission analysis and requirements definition
- Transfer trajectory design for Earth orbit, lunar, and interplanetary missions
- Orbit design for science and technical goals and constraints
- Attitude profile design for spacecraft and instrument pointing requirements
- Relative motion of multiple orbiting spacecraft
- Modeling and simulation
- Engineering analysis approach for trade studies, design margin, Monte Carlo analysis, and supporting all project review cycles
- Mission operations and operational planning
- AGI tools: STK/Astrogator and SOLIS
- Participation in interdisciplinary project teams for space missions in technical and leadership roles
- Formal documentation, presentations, and publication

Metis staffs the role of Subject Matter Expert (SME) in flight dynamics at NASA Ames Research Center (ARC) for internal reviews of proposed concepts in the areas of feasibility, trajectory, orbit requirements, spacecraft activity planning, and operations. Metis supports NASA Ames in its Mission Design Center (MDC) in development of mission concepts from early initiatives through the project life cycle. Metis expertise supports mission designs to planetary and lunar destinations, deep space trajectories departing the Earth-Moon system, and in Earth orbit.

Metis personnel are performing cutting edge development of mission simulations for swarms of multiple, interacting spacecraft, (distinct from conventional multi-spacecraft constellations, typically separated in orbit). Satellite swarm design and control involves Metis expertise in orbital mechanics, relative motion, software development, efficient maneuver design, and control algorithms. This groundbreaking work leverages heritage deriving from fundamentals of the Gemini era in combination with 21st century innovations in control, propulsion, and simulation.

Metis provides the Flight Dynamics lead on the Arcus mission, currently in Step 2 proposal for NASA's 2016 Astrophysics Medium Explorer (MIDEX) announcement of opportunity. The Arcus trajectory design includes a complex lunar gravity assist feature and an innovative lunar resonance pattern for long term stability. The High Earth Orbit (HEO) solution supports Arcus mission goals in providing thermally stable conditions, a low radiation environment above the Van Allen belts, low propellant usage, low disturbance torques, and an efficient operational cadence.

Additional in-house experience in detailed mission orbit design was for NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE) mission, on which Metis also provided the Flight Dynamics team lead. The LADEE lunar orbit was over constrained, calling for several years of concentrated orbit design activity to balance science goals, spacecraft capabilities, operational constraints, and the unique, low altitude gravitational environment. This effort included the development of customized design tools and ongoing collaboration with science and spacecraft engineering teams. Metis personnel supported LADEE Flight Dynamics activities from early project phases of design and analysis through operational readiness testing, launch, Earth and lunar orbit mission phases, until disposal after extended operations. LADEE mission ops included planning and support of the intense cadence of maneuvers and planning products and successfully met all mission and

science requirements.

Metis provided the expertise for another unprecedented equatorial, lunar orbit for the Dark Ages Radio Explorer (DARE) mission proposed proposal for NASA's 2016 Astrophysics Medium Explorer (MIDEX) announcement of opportunity. The newly discovered frozen equatorial orbit offered previously unavailable access to the radio quiet zone on the far side of the Moon, now a potential advantage for future Metis mission designs.

Additional mission orbit analysis performed by Metis addressed the constraints and requirements of cycler orbit flybys of Phobos and Deimos, considering orbit design options under mission design constraints, lighting geometry, spacecraft capabilities, and science goals.

Metis Flight Dynamics strengths include strong teamwork and collaboration, with leadership capabilities in Systems Engineering, mission design, and formal engineering processes. Advanced capabilities in modeling and simulation software augments our robust engineering expertise.

Metis Co-Authored References:

- Plice, L., et al., 2018. "Arcus Mission Design: Stable Lunar-resonant High Earth Orbit for X-ray Astronomy." 2018 AAS/AIAA Astrodynamics Specialist Conference, Aug. 19 – 23, Snowbird, UT. [Pending]
- Dono, A., L. Plice, J. Mueting, T. Conn, & M. Ho, 2018. "Propulsion Trade Studies for Spacecraft Swarm Mission Design." 2018 IEEE Aerospace Conference Proceedings, March 3-10, 2018. [Pending]
- Conn, T., L. Plice, A. Dono, & M. Ho, 2017. "Operating Small Sat Swarms as a Single Entity: Introducing SODA." 31st Annual AIAA/USU Conference on Small Satellites, Aug. 7 – 10, 2017, Logan, UT.
- Plice, L. & Galal, K. (2017). "DARE Mission Design: Low RFI Observations from a Low-altitude, Frozen Lunar Orbit." AAS 17-333, 2017 AAS/AIAA Space Flight Mechanics Meeting, San Antonio, TX, Feb. 5 – 9, 2017.
- R. K. Smith, et al., 2016. "Arcus: The X-ray Grating Spectrometer Explorer." Space Telescopes and Instrumentation 2016: Ultraviolet to Gamma Ray, edited by Jan-Willem A. den Herder, Tadayuki Takahashi, Marshall Bautz, Proc. of SPIE Vol. 9905
- Loucks, M., L. Plice, D. Cheke, C. Maunder, & B. Reich, 2015. "Trade Studies in LADEE Trajectory Design." AAS 15-396, 2015 AAS/AIAA Space Flight Mechanics Meeting, Jan. 22 - 15, 2015, Williamsburg, VA.
- Loucks, M., L. Plice, D. Cheke, C. Maunder, & B. Reich, 2015. "The LADEE Trajectory as Flown." AAS 15-400, 2015 AAS/AIAA Space Flight Mechanics Meeting, Jan. 22 - 15, 2015, Williamsburg, VA.
- Lee, P., et al., 2014. Poster "Phobos And Deimos & Mars Environment (PADME): A Proposed Discovery Mission." SSERVI Exploration Science Forum, July 21 – 23, 2014, NASA Ames Research Center.
- Plice, L. & T. Craychee, 2011. "A Design Method for Low Altitude, Near-Equatorial Lunar Orbits." AAS 11-451, 2011 AAS/AIAA Astrodynamics Specialist Conference, Aug. 1-4, 2011, Girdwood, AK