



a.i. solutions Inc.
"The smarter the better."

Mission Design & Navigation

Harnessing New Technology to Enable Science



Trajectory Design
& Optimization



Maneuver
Planning



Orbit
Determination
& Analysis



Attitude
Services

Mission Design is the process of analyzing and selecting a spacecraft's orbit trajectory in order to satisfy a set of goals, requirements, and mission constraints. **a.i. solutions'** support of this activity involves engineering and planning services in the following:

- Mission Concept Studies
- Requirements Definition & Analysis
- Trajectory Design & Optimization
- Orbit & Attitude Related Analysis
- Maneuver Planning
- Ground System Design & Development
- Launch Support
- Routine Operations Support
- Conjunction Assessment
- End-of-Life Disposal Support

a.i. solutions provides mission design and planning for **GSFC**-based spacecraft missions on the **FDSS** contract; for NASA ELVs on the **ELVIS** contract; and for various spacecraft programs in support of **a.i. solutions'** **FreeFlyer[®]** mission design software. We have provided mission design and planning support for numerous missions including **EOS (Terra, Aqua, Aura)**, **STEREO**, **ST-5**, **GOES** series (including **N-O**), **SDO**, **LRO**, **NPP**, **GPM**, **MMS**, **JWST**, **GPS**, and **DMSP**.

Trajectory Design and Optimization

a.i. solutions commands extensive experience in designing optimized trajectories that satisfy the mission objectives and spacecraft operational constraints, using analytical or differential correction methods available in mission design software, such as **FreeFlyer[®]**, **STK Astrogator**, **Swingby**, and **GMAT**.

The **Magnetospheric MultiScale (MMS)** mission is one of the many successful examples where **a.i. solutions** has demonstrated the capability to design complex formation flying missions, and to use advanced concepts to compute spacecraft positioning and timing information.

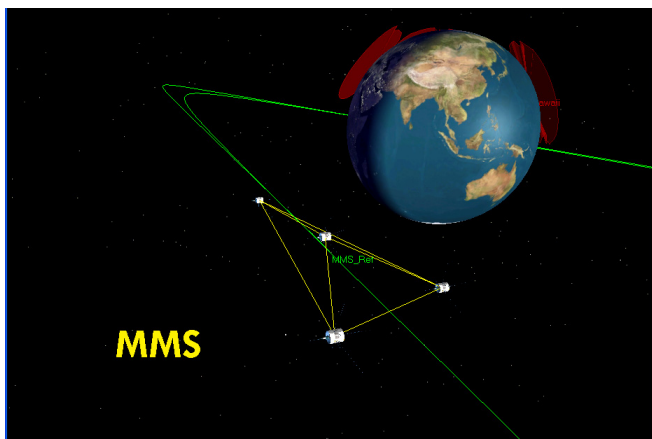


Figure 1: MMS formation orbit



Maneuver Planning

a.i. solutions' vast analytical and operational maneuver planning experience consists of planning hundreds of orbit and attitude maneuvers for a wide variety of **NASA**, **NOAA**, and **DoD** spacecraft in every orbit regime including LEO, GEO, Lunar, Sun-Earth Libration Point, Heliocentric, and Interplanetary.

a.i. solutions' work on the geosynchronous Solar Dynamics Observatory (**SDO**) mission consisted of designing a series of 13 maneuvers to steadily raise perigee, slow the drift of the spacecraft relative to the earth, and phase it into the required longitude box.

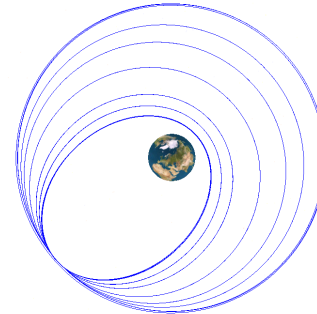


Figure 2: SDO orbit during apogee raising maneuver phase

Navigation is the process used to find the present and predict the future position and orientation of a spacecraft using a series of **GPS**, ranging, and/or instrument measurements. Since 1996, our work at **a.i. solutions** on spacecraft navigation has been based on an overall systems engineering approach to ensure the success of the mission. **a.i. solutions** provides navigation research, analysis, and engineering support to flight project teams, future mission study teams, and NASA Goddard Space Flight Center. This support includes the

- Pre-Mission Error Analysis
- Orbit Determination & Prediction
- Attitude Services
- Assessment of Tracking Systems
- Assessment of Ground System Design

With many of our employees being published in the field of navigation, and possessing an average of 25 years of experience, spacecraft navigation remains one of our core competencies. Throughout our history, we have provided navigation support for over 150 missions, often supplying a mission critical presence inside the mission operations center.



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Orbit Determination and Analysis

Orbit determination is the major function associated with space navigation and is a strong suit in **a.i. solutions'** range of competencies.

The Goddard Enhanced Onboard Navigation System (**GEONS**) is a software package that provides onboard orbit determination for LEO, GEO, HEO, and Libration Point orbiting spacecraft. **GEONS** offers a compact and accurate orbit determination solution for missions that use **GPS**, inter-spacecraft ranging, celestial object, Ground Network, and **TDRSS** measurements and can be adapted to determine highly accurate absolute positions and relative positions between spacecraft flying in formations. It has been integrated with the **GSFC**-developed **Navigator** receiver and is being used for the **MMS** mission.

a.i. solutions personnel provide daily operations using software tools such as the Goddard Trajectory Determination System (**GTDS**) and several COTS products to support the operational needs of the **GSFC** Flight Dynamics Facility (**FDF**). Lessons learned from daily support is also used to enhance OD functionality in **FreeFlyer**[®]. Currently we are providing operational orbit support for more than 25 **NASA** spacecraft.

In support of the Lunar Reconnaissance Orbiter (**LRO**) mission's launch, translunar, target insertion, and science phases, **a.i. solutions** performed high precision orbit determination in the Flight Dynamics Facility (**FDF**) and updated **GTDS** to process **LRO's** laser ranging data.

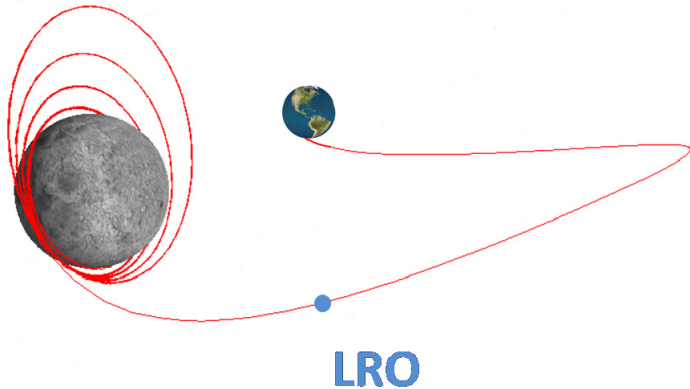


Figure 3: Overview of the LRO Translunar and Lunar Orbit Insertion Trajectory

a.i. solutions is currently providing premission navigation support for the James Webb Space Telescope (**JWST**). Our support included developing a high fidelity multi-Plate Solar Radiation Pressure model to predict radiation forces and a comprehensive toolset to model communication opportunities during powered flight.



Attitude Services

From being able to determine what a science instrument is viewing, to enabling antenna links for acquiring tracking and telemetry, precise knowledge of the spacecraft's attitude is a pre-requisite in every facet of spacecraft operations. Over the last 20 years, **a.i. solutions** employees have conceived and executed a comprehensive approach to attitude determination and calibration for three-axis stabilized and spinning spacecraft. The culmination of this program is the **MATLAB** based Attitude Ground Support System (**AGSS**) tool suite, which reads telemetry, converts and adjusts data, identifies stars, estimates attitude, compares results with the onboard computer (**OBC**) attitude, and provides a suite of additional analysis tools. Our major emphasis has been directed toward attitude determination, calibration, attitude prediction, and slew planning, however, attention is now being directed toward attitude control issues as well.

Calibration is necessary to correct for instrument misalignments, biases, and scale factor errors that may arise from a variety of unmodeled sources. It is particularly important in missions requiring high precision science data and tight attitude constraints. **a.i. solutions** is well versed in performing such instrument calibrations and has done so on missions such as **THEMIS**, **XTE**, **AURA**, **LRO**, **SDO**, and **STSS**.

The Attitude Maneuver Utility (**AttMan**) was developed by **a.i. solutions** to support the daily attitude activities of the Lunar Reconnaissance Orbiter (**LRO**). Its purpose is to plan attitude maneuvers while avoiding constraints and sensor interferences. This software not only satisfied operational requirements, but also proved to be a valuable planning tool due to its quick execution and flexible architecture.

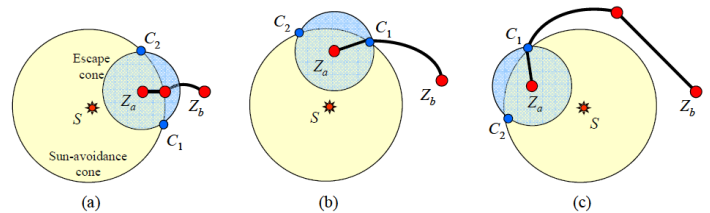


Figure 4: Graphical representation of the LRO Sun-Avoidance Maneuver N-Leg Method

Partnering with the flight project, **a.i. solutions** applies the lessons learned on previous missions and current innovations in technology to engineer reliable, cost effective, flight dynamics. **a.i. solutions** is proud to be the provider for the **NASA/Goddard Space Flight Center**.

For more information on our past accomplishments, our current endeavors, and how **a.i. solutions** can help your team, please visit our website at: www.ai-solutions.com