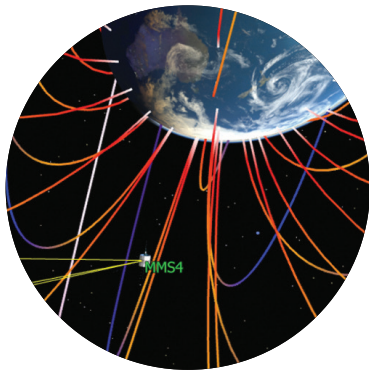




Software for Space Mission Design, Analysis and Operations

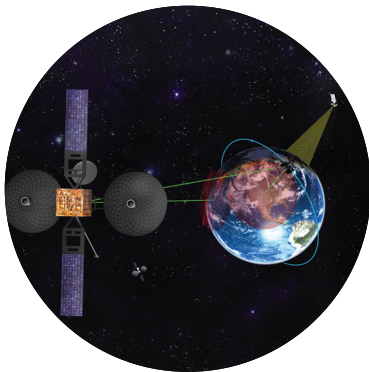
## SUPPORTING YOUR MISSION FROM THE GROUND UP

FreeFlyer provides complete astrodynamics functionality for missions of any size, any scale, any orbit regime. With customizable interfaces and cross-platform use, FreeFlyer supports the full life cycle of your mission.



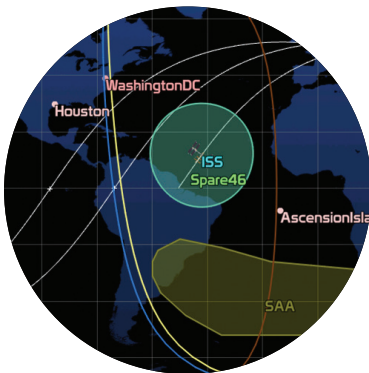
### DESIGN

Design satellite orbits in any regime, define constellation parameters, target maneuvers, and simulate the full mission life cycle from launch to nominal operations to disposal.



### ANALYSIS

Analyze any mission requirements, including spacecraft and ground sensor coverages; generate fuel consumption reports and perform parametric trade studies. Augment FreeFlyer's internal algorithms with user-defined math functions and custom computations, or use the native MATLAB API.



### OPERATIONS

Automate satellite operations for both routine and complex flight dynamics tasks and integration with ground system databases, 3rd party TT&C software, and custom / legacy code. Utilize FreeFlyer's Orbit Determination suite for reliable and accurate OD solutions.

## AT A GLANCE

### Core Functionality:

- Spacecraft Propagation
- Coverage & Contact Analysis
- Maneuver Modeling & Targeting
- Orbit Determination
- Attitude Modeling
- Custom Math & Algorithms
- External Interfacing

### Heritage:

- USAF Programs
- NASA Science Missions
- NOAA Science Missions
- International Space Station
- NASA MPCV
- Commercial Satellite Programs (U.S. and Abroad)

### Operationally Proven For:

- Space Situational Awareness
- Orbital Debris/Collision Avoidance
- Ground System Integration
- Automated Operations
- Mission Design & Analysis
- Wargame Strategies
- Constellations

## FREEFLYER TIERS

FreeFlyer is available in two tiers: Engineer and Mission. **FreeFlyer Engineer** provides comprehensive space mission design and analysis functionality. **FreeFlyer Mission** includes all the capabilities of FreeFlyer Engineer and adds support for seamless ground system integration automated flight dynamics operations.

| SPACECRAFT PROPAGATION   | ENGINEER | MISSION |
|--|----------|---------|
| Fixed or variable step (step size is user-definable)   | ●        | ●       |
| Supports nanosecond-level timing precision   | ●        | ●       |
| Runge Kutta 4(5), 7(8), 8(9), VOP, two body, Bulirsch Stoer, J2 Mean Elements, NORAD/SP/SGP4 propagators   | ●        | ●       |
| Planetary ephemeris (e.g. DE405, DE421, DE430)   | ●        | ●       |
| Solar System object editor   | ●        | ●       |
| Atmospheric drag/lift, solar radiation pressure  | ●        | ●       |
| Atmospheric density - Analytic, Jacchia Roberts, Harris Priester, MSIS models  | ●        | ●       |
| International Reference Ionosphere (IRI) modeling  | ●        | ●       |
| Celestial body gravitational potential (point mass, zonals and tesserals, solid tides)   | ●        | ●       |
| NORAD two-line elements, FreeFlyer ephemeris/state, STK ephemeris/state, SP3 Precise Ephemeris and CCSDS OEM file formats  | ●        | ●       |
| 8th and 10th order Lagrange ephemeris interpolation  | ●        | ●       |
| User-defined parameters and formatting in FreeFlyer ephemeris file formats   | ●        | ●       |
| Hundreds of orbit/trajectory properties calculated at each integration step  | ●        | ●       |
| Unlimited user-defined properties using embedded math libraries or MATLAB connection   | ●        | ●       |
| Full spacecraft mass properties modeling   | ●        | ●       |
| Customizable spacecraft Tanks (chemical or electrical) and Thrusters (mono-propellant, bi-propellant, or electrical)   | ●        | ●       |
| Formation/constellation modeling for unlimited numbers of objects  | ●        | ●       |
| Mean of J2000 Earth Equator/Earth Ecliptic, True of Date Earth Equator, True Equator Mean Equinox, Earth Fixed, CelestialObject fixed reference frames                                     | ●        | ●       |
| Cartesian, Keplerian/nonsingular Keplerian, Spherical/Spherical Lat/Long, Equinoctial, Modified Equinoctial, Brouwer-Lyddane Mean/J2, Brouwer-Lyddane Mean of 1950 orbital element systems | ●        | ●       |
| Launch vehicle coordinates (user-definable to launch vehicle vendor specs)   | ●        | ●       |
| Conversion functions to convert between numerous attitude and coordinate systems   | ●        | ●       |
| User-defined/custom coordinate systems with conversions  | ●        | ●       |
| LVLH, Mean of J2000 Earth Equator, Geodetic, UVW, VNB, and user-defined custom attitude reference frames   | ●        | ●       |
| Euler angles, Quaternion, Attitude matrix, Spinner attitude modeling   | ●        | ●       |
| Attitude history file (AHF) support  | ●        | ●       |

| <b>GENERATING OUTPUT</b>   | <b>ENGINEER</b> | <b>MISSION</b> |
|--|-----------------|----------------|
| Full 2D and 3D visualization with customizable camera Viewpoints               | ●               | ●              |
| Full-featured plotting library (XY and polar plots with Monitor option)        | ●               | ●              |
| User-defined custom ASCII reports  | ●               | ●              |
| 2000+ built-in parameters available for reporting and plotting                 | ●               | ●              |
| Unlimited user-defined parameters for reporting and plotting                   | ●               | ●              |
| GroundStation masking and sensor swath modeling                                | ●               | ●              |
| 2D/3D Sensor views   | ●               | ●              |
| ProximityZones, Regions, and PointGroups for coverage analysis                 | ●               | ●              |
| 2D/3D visualization HD movie recording and image saving                        | ●               | ●              |
| Unlimited output window tiling   | ●               | ●              |
| WatchWindow and GridWindow for configurable real-time data updates             | ●               | ●              |
| Output layout control for controlling size and location of output windows      | ●               | ●              |
| Pop output windows in/out of the FreeFlyer Workspace                           | ●               | ●              |
| Flexible Console Window for reporting data                                     | ●               | ●              |
| GraphicsOverlay and WindowOverlay for adding custom elements to visualizations | ●               | ●              |

| <b>FREEFLYER SCRIPTING</b>  | <b>ENGINEER</b> | <b>MISSION</b> |
|---|-----------------|----------------|
| Object-oriented scripting language to control all aspects of a FreeFlyer Mission Plan (objects, methods, commands, conditional logic, data inputs/outputs, and custom computations) | ●               | ●              |
| Full-featured FreeForm scripting language editor with general programming convenience functionality such as finding all references, smart indenting, and script auto-complete       | ●               | ●              |
| Logic to control actions based on any calculated property   | ●               | ●              |
| For, If, While, Pause, Stop, Achieve, Target, Vary, Break, Switch, Continue commands  | ●               | ●              |
| Drag and drop mission design sequence   | ●               | ●              |
| List of any object type   | ●               | ●              |
| Batch run/Command line capability   | ●               | ●              |
| Conversion between all supported time systems and formats   | ●               | ●              |
| Integrated development environment control for system administrators  | ●               | ●              |
| Integrated debugger   | ●               | ●              |
| Any property can be set/reset real-time during execution  | ●               | ●              |
| 30+ math operators for implementing custom algorithms   | ●               | ●              |
| Matrix math   | ●               | ●              |
| Random Number Generator   | ●               | ●              |
| Random and Gaussian noise distributions   | ●               | ●              |

| COVERAGE AND CONTACT ANALYSIS  | ENGINEER | MISSION |
|--|----------|---------|
| 400+ pre-defined GroundStation geodetic files and masking profiles   | ●        | ●       |
| Custom user-defined GroundStation position and masking   | ●        | ●       |
| Complex conic, rectangular, and user-defined sensor shapes   | ●        | ●       |
| Sensor obscuration masking   | ●        | ●       |
| Dynamic Sensor scanning  | ●        | ●       |
| Visibility period calculations between any objects (Spacecraft-to-Spacecraft, Spacecraft-to-GroundStation, Spacecraft-to-custom ground region, etc.) | ●        | ●       |
| Field of view, elevation angle, azimuth angle, range, and range rate   | ●        | ●       |
| Solar and lunar constraints, Lighting constraints, Beta angle constraints  | ●        | ●       |
| Temporal constraints (interval, duration, GMT, mean local time)  | ●        | ●       |
| Cross track, along track, range and range rates  | ●        | ●       |
| Vectors to/from any object   | ●        | ●       |
| Acquisition of Signal / Loss of Signal (AOS/LOS)   | ●        | ●       |
| Collision avoidance calculations (customizable ProximityZones)   | ●        | ●       |
| Sensor-to-Sensor, Sensor-to-Spacecraft, Sensor-to-GroundStation constraints  | ●        | ●       |
| Sensor tracking  | ●        | ●       |
| Magnetic field region modeling   | ●        | ●       |
| Numeric and analytic Earth refraction modeling   | ●        | ●       |
| Intersection of any vector and 3D model  | ●        | ●       |
| BlockageDiagram contact analysis   | ●        | ●       |

| INTERPLANETARY ANALYSIS   | ENGINEER | MISSION |
|---|----------|---------|
| SPICE Ephemeris support   | ●        | ●       |
| User-defined Regions on any CelestialObject   | ●        | ●       |
| B-plane targeting   | ●        | ●       |
| CelestialObject interference (all planets and star catalog)                                   | ●        | ●       |
| Occulting CelestialObject modeling as sphere or ellipsoid                                     | ●        | ●       |
| Target CelestialObject modeling as point, sphere, or ellipsoid                                | ●        | ●       |
| User-defined GroundStation location and masking profiles on any CelestialObject               | ●        | ●       |
| Generalized support for any Rotating Libration Point (RLP) system (L1-L5) in the Solar System | ●        | ●       |

| <b>COVERAGE AND CONTACT ANALYSIS</b>   | <b>ENGINEER</b> | <b>MISSION</b> |
|--|-----------------|----------------|
| 400+ pre-defined GroundStation geodetic files and masking profiles   | ●               | ●              |
| Custom user-defined GroundStation position and masking   | ●               | ●              |
| Complex conic, rectangular, and user-defined sensor shapes   | ●               | ●              |
| Sensor obscuration masking   | ●               | ●              |
| Dynamic Sensor scanning  | ●               | ●              |
| Visibility period calculations between any objects (Spacecraft-to-Spacecraft, Spacecraft-to-GroundStation, Spacecraft-to-custom ground region, etc.) | ●               | ●              |
| Field of view, elevation angle, azimuth angle, range, and range rate   | ●               | ●              |
| Solar and lunar constraints, Lighting constraints, Beta angle constraints  | ●               | ●              |
| Temporal constraints (interval, duration, GMT, mean local time)  | ●               | ●              |
| Cross track, along track, range and range rates  | ●               | ●              |
| Vectors to/from any object   | ●               | ●              |
| Acquisition of Signal / Loss of Signal (AOS/LOS)   | ●               | ●              |
| Collision avoidance calculations (customizable ProximityZones)   | ●               | ●              |
| Sensor-to-Sensor, Sensor-to-Spacecraft, Sensor-to-GroundStation constraints  | ●               | ●              |
| Sensor tracking  | ●               | ●              |
| Magnetic field region modeling   | ●               | ●              |
| Numeric and analytic Earth refraction modeling   | ●               | ●              |
| Intersection of any vector and 3D model  | ●               | ●              |
| BlockageDiagram contact analysis   | ●               | ●              |

| <b>MANEUVERING AND TARGETING</b>  | <b>ENGINEER</b> | <b>MISSION</b> |
|---|-----------------|----------------|
| Impulsive and finite maneuver modeling  | ●               | ●              |
| Maneuver targeting with differential correction algorithms  | ●               | ●              |
| Dynamic configuration of the Targeter for resetting initial guesses and use within conditional For/If/While loops | ●               | ●              |
| Support for standard chemical and low-thrust propulsion systems   | ●               | ●              |
| Thruster outgassing event modeling  | ●               | ●              |

| INTERFACING WITH EXTERNAL RESOURCES  | ENGINEER | MISSION |
|--|----------|---------|
| MATLAB interface   | ●        | ●       |
| TCP/IP socket interface  | ●        | ●       |
| ODBC database-compliant interface with transactional mode  |          | ●       |
| Run command to spawn external applications   |          | ●       |
| Customizable graphic user interface (GUI)  |          | ●       |
| Generic ASCII and Binary FileInterface for user-defined ephemeris/state and other I/O applications                               |          | ●       |
| Automatic e-mail notification based on user-defined rules  |          | ●       |
| FreeFlyer Extensions Software Development Kit (SDK) for custom force modeling, object definition, and 3rd party code integration |          | ●       |
| Runtime Application Program Interface (API) for for embedding FreeFlyer into an external C/C++, C#, Java, or MATLAB application  |          | ●       |

| ORBIT DETERMINATION   | ENGINEER | MISSION |
|---|----------|---------|
| Extended Kalman Filter, Batch Least Squares, Unscented Kalman Filter                                      |          | ●       |
| Customizable Batch/Kalman combinations implemented via script   |          | ●       |
| Orbit Determination error analysis  |          | ●       |
| Spacecraft Receivers and Transponders   |          | ●       |
| Tracking Data Simulator   |          | ●       |
| Tracking Data Editor with Sigma Threshold Editing that can view multiple measurement types simultaneously |          | ●       |
| Spacecraft covariance propagation   |          | ●       |
| Ground-based range/range rate/azimuth/elevation tracking data   |          | ●       |
| TDRS tracking two-way range/two-way Doppler tracking data   |          | ●       |
| GPS point solution and pseudorange tracking data  |          | ●       |
| Spacecraft-to-Spacecraft range/ range-rate/azimuth/elevation tracking data                                |          | ●       |
| Bilateration Ranging Transponder System (BRTS) tracking data  |          | ●       |
| Spacecraft Position, Velocity, Acceleration, Cd, Cr estimation  |          | ●       |
| Transponder delay estimation  |          | ●       |
| Maneuver and outgassing estimation (burn magnitude and direction)   |          | ●       |
| GroundStation location, antenna bias estimation   |          | ●       |
| Spacecraft antenna offset modeling  |          | ●       |

| MISCELLANEOUS   | ENGINEER | MISSION |
|---|----------|---------|
| Mission Plan Wizards for quick problem setup  | ●        | ●       |
| 150+ Sample Mission Plans included  | ●        | ●       |
| Customizable Home Screen  | ●        | ●       |
| Auto-save Mission Plan feature  | ●        | ●       |
| Available in Windows (FreeFlyer.exe, FF.exe, API, FreeFlyer Extensions, 32- and 64-bit) and Linux (FF.exe, API, 64-bit) | ●        | ●       |
| Extensive Help File with all property definitions, syntax, guides, and examples   | ●        | ●       |
| Dedicated FreeFlyer Technical Support Team available for assistance   | ●        | ●       |



For more information on FreeFlyer® visit  
[www.ai-solutions.com/freeflyer](http://www.ai-solutions.com/freeflyer)  
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