

## FreeFlyer Features List

### FreeFlyer is available in two Editions:

1. FreeFlyer Engineer provides comprehensive analysis and full mission design functionality.
2. FreeFlyer Mission provides turnkey mission design functionality and seamless ground system integration for automated spacecraft operations.

Below you will find a product feature map showing a summary of the FreeFlyer Editions.

### Edition Functionality

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	•	•
Globe layers to support coastlines, coastal offsets, political boundaries, and user-defined line layer element sets	•	•
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	•	•

Lists of any object type and Structs of any collection of types	•	•
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	•	•
<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	•	•
Complete native RF link budget analysis support	•	•
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	•	•
Complete GroundVehicle propagation and analysis	•	•
Simple Motion or Waypoint propagation models for GroundVehicle objects	•	•
Mean of J2000 Earth Equator, VLT, and ENU attitude reference frames for GroundVehicle objects	•	•

Euler angles, quaternion, and attitude matrix attitude modeling for GroundVehicle objects	•	•
<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	•	•
<b>Interplanetary Analysis</b>	<b>Engineer</b>	<b>Mission</b>
SPICE Ephemeris read/write support	•	•
Full propagator control for a custom CelestialObject with a host of specific and generic interplanetary reference frames	•	•
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	•	•
Rotating-pulsating coordinate system calculation and visualization support for interplanetary mission design	•	•
<b>Interfacing with External Resources</b>	<b>Engineer</b>	<b>Mission</b>
MATLAB interface	•	•
TCP/IP socket interface	•	•
Customizable graphic user interface (GUI)	•	•
Generic ASCII and Binary FileInterface for user-defined ephemeris/state and other I/O applications	•	•
ODBC database-compliant interface with transactional mode		•
Run command to spawn external 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, MATLAB®, or Python application		•
<b>Orbit Determination</b>	<b>Engineer</b>	<b>Mission</b>
Extended Kalman Filter, Batch Least Squares, Unscented Kalman Filter, Square Root Information 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		•
DSN 60-byte and three-way Doppler 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		•
<b>Terrain Modeling</b>	<b>Engineer</b>	<b>Mission</b>
Integration for modeling GroundVehicle state during propagation		•
Ability to load and evaluate multiple Terrain Data File formats		•
Occulting Terrain modeling with VisibilitySegment objects		•
<b>Miscellaneous</b>	<b>Engineer</b>	<b>Mission</b>
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) and Linux (FF.exe, API)	•	•
Extensive Help File with all property definitions, syntax, guides, and examples	•	•
Dedicated FreeFlyer Technical Support Team available for assistance	•	•