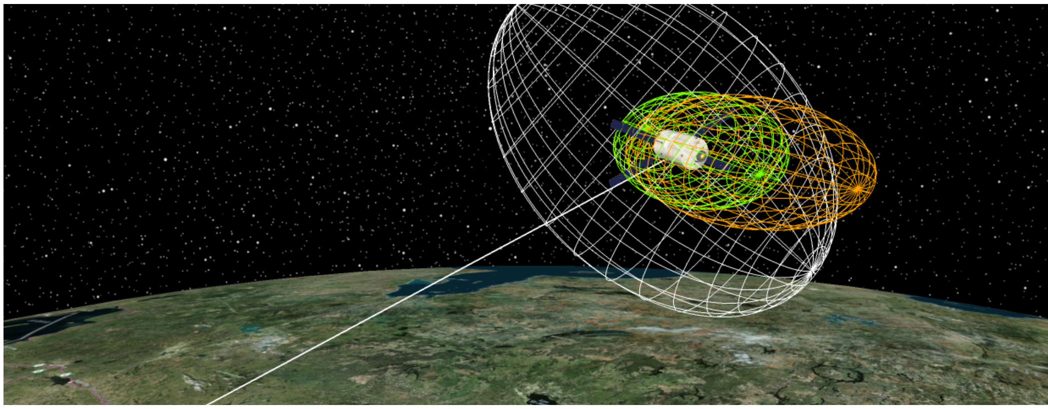
ODTK

AGI

Orbit Determination Tool Kit (ODTK) provides orbit determination and orbit analysis support for the entire life cycle of satellites and their tracking systems

ODTK is built with the same verified astrodynamic functions as Systems Tool Kit (STK). With ODTK, you can:

- Process a wide variety of traditional and non-traditional measurements.
- Leverage a state-of-the-art optimal sequential filter and matched smoother to generate orbits with realistic covariance.
- Use a tracking measurement simulator for tracking system design and analysis when real tracking measurements are not available.



Process measurement data

All measurement types that can be filtered can also be simulated. Supported measurement types include:

Ground-based tracking

- Range
- Azimuth, elevation
- Doppler
- Right ascension, declination
- Satellite laser ranging
- X, Y, or U, V angles
- Direction cosines
- Deep Space Network (DSN) Doppler, three-way Doppler, TCP, three-way TCP, sequential ranging

Multiply relayed ground tracking

- Bistatic ranging
- Time-Difference of Arrival (TDOA)
- Frequency-Difference of Arrival (FDOA)
- TDOA rate
- Single differenced TDOA and FDOA
- TDRS 4-legged range
- 3- and 5-legged Doppler
- BRTS range and Doppler
- GNSS 2-legged pseudo-range (GNSS to GEO to Ground)

Space based tracking

- Range
- Azimuth, elevation
- Doppler
- Right ascension, declination
- Space-based TDOA, TDOA rate, and FDOA

GNSS receiver tracking of GPS signal

- C/A pseudo-range
- L/A phase (also called ADR)
- L1 & L1 Phase
- P1 & P2 pseudo-range
- Dual frequency corrected pseudo-range and/or phase
- Single differenced pseudo-range and phase
- Double differenced pseudo-range and phase.

Supported data formats

ODTK accommodates any measurement format, such as:

- SSN archived and transmit B3 obs
- Satellite Laser Ranging (SLR)
- RINEX (GPS)
- NASA UTDF and GEOS-C
- DSN TRK-2-34
- CCSDS Tracking Data Message (TDM)

Custom readers can natively load any custom data format

Use custom data editing to achieve control over the OD process

Employ Initial Orbit Determination (IOD) methods including Gooding, Herrick-Gibbs, GPS navigation solution, and Geosynchronous to determine the initial state of a satellite. Utilities to use TLEs and existing ephemeris are also available.

A *batch least squares* algorithm can be used to refine the initial orbit state estimate and model coefficients and biases for filter initialization.

Generate orbits with realistic covariance

An optimal sequential filter uses measurement updates similar to a Kalman filter to estimate orbits while using physics-based process noise models for time updates.

Fixed interval and variable lag smoothers combine filtered state and covariance information for a best post-pass ephemeris and covariance.

Estimate orbit position/velocity/covariance and tracker biases for multiple satellites simultaneously.

High fidelity measurement models

Various high fidelity models are employed to support high accuracy programs:

- **Earth-based station motion models**. Solid earth tides, polar tide, ocean loading, Tectonic plate drift, antenna-correction models (DSN receivers)
- **Ground based physical models**. Ionospheric refraction (IRI) model, Tropospheric refraction models (SCF model, Marini-Murray for laser ranging, Saastamoninen with Niell hydrostatic mapping function)
- **Satellite body motion models**. Antenna location defined in body coordinates, and body orientation defined by attitude rules, attitude profile (quaternions), attitude model (GPS satellites)

Central bodies

ODTK can perform simulation, filter, and smoother operations relative to the Earth, Moon, or Sun.

Estimation states

ODTK can estimate the following states during filter and smoother operations and deviate them during simulation.

Any number of states from any number of satellites and any number of trackers can be simulated and/or estimated simultaneously with ODTK.

Satellite. Position and velocity, drag coefficients, local atmospheric density, solar radiation pressure coefficients, clock bias, antenna location.

Measurement biases. Time-varying time-correlated bias on each measurement type, time-varying time-correlated bias for each transponder, facility location, clock bias, troposphere scale correction.

GNSS receivers: Clock phase, frequency, and (optional) aging, facility location, and location in satellite center of mass.

Finite maneuver

- Magnitude and/or direction
- Optional shared states between maneuvers

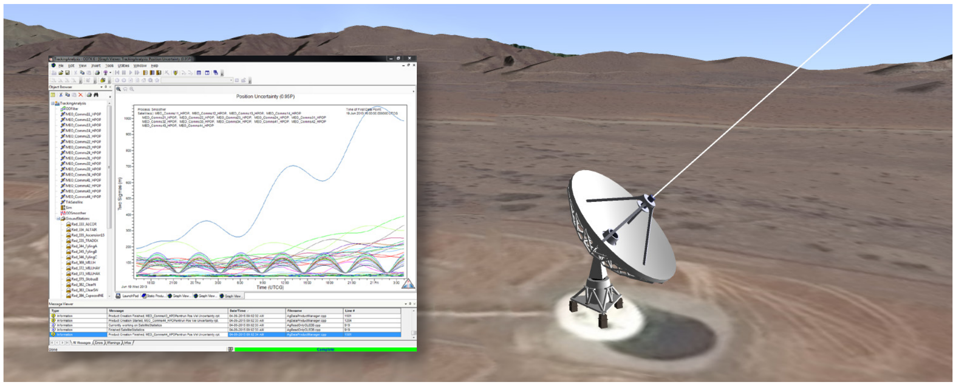
Apply full force modeling

A Variation of Parameters high-fidelity numerical integrator with full force modeling propagates the orbit and forms the state transition matrix.

Each implementation of the following force models conforms to international standards, as defined in IERS conventions and comparable sources.

Gravitational perturbations

- Numerous gravity-field models for Earth, Moon, and other 3rd bodies
- Luni-solar perturbation, planetary perturbations
- Solid-earth and ocean tide perturbations
- Relativistic accelerations



Atmospheric drag perturbations

- Spherical model, user-provided complex area model
- Several density models, user-provided density model

Solar radiation pressure perturbations

- Spherical model, GPS block-specific models, user-provided complex area model
- Dual cone eclipse model for Earth and lunar shadow

Thrust perturbations

- Impulsive or finite maneuvers (constant thrust or complex acceleration profiles) and shared thruster modeling to reflect repeated use of the same thrusters

Analyze results

- Use a wide variety of data providers for custom reporting and graphing.
- Generate static and dynamic output products to refine the orbit determination model and tighten orbit accuracy
- Export output data as text or CSV files to use in other analysis tools
- Load ODTK results into STK for further analysis

Multiplatform integration

- ODTK provides cross-platform libraries supporting Matlab, Python, and C++ integration on Windows and Linux
- ODTK is fully automatable and can be integrated into ground system using standard Component Object Model (COM) automation
- Numerous plug-in points allow for further customization of force models
- Custom alerting events for user notification can be triggered during “lights-out” operations
- Fully documented API allows for easy integration into flight dynamics solutions and automation of large scale enterprise systems