STK/EOIR

Electro-optical Infrared Sensor Performance

Overview

STK/EOIR models detection, tracking and imaging performance of electro-optical and infrared sensors for earth science, missile defense and space situational awareness applications.

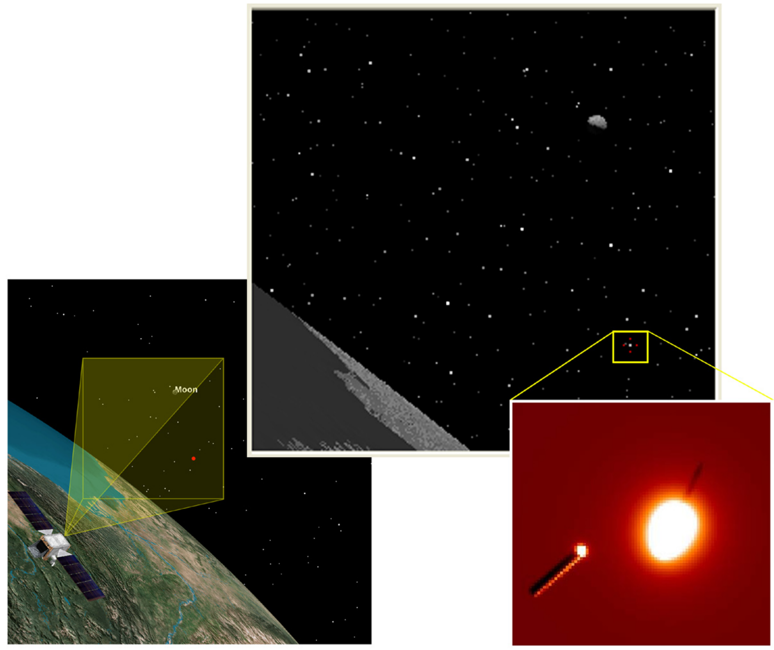
STK/EOIR lets anyone who understands basic system-level sensor specifications improve their STK mission model with radiometric sensor performance prediction. This is a unique alternative to complex stand-alone sensor simulations.

STK/EOIR is developed by Space Dynamics Laboratory (SDL), an AGI business partner and industry leader in electro-optical and infrared sensor systems. For over 50 years SDL has designed, fabricated, tested, and deployed space sensors for a variety of customers including NASA, the U.S. Air Force and the U.S. Missile Defense Agency (MDA).

STK/EOIR has been successfully anchored against measured data from an operational missile defense sensor. A full report is available through the MDA — please contact AGI for details.

Applications

- **Concept Development**: rapidly compose and evaluate mission architectures including a variety of sensors, sensor platforms, communications and more
- **Design:** define performance goals for detailed sensor design; represent detailed designs in a full mission model; support requirements allocation trades across mission subsystems
- **Field Test:** establish sensor platform locations, relative geometry and timing of observations to satisfy test objectives; develop a priori predictions to aid real-time anomaly detection; reconstruct tests to support post-event analysis
- **Operations Support:** optimize collection planning; assist post-collection analysis and interpretation; support anomaly investigation



Example application:
Ballistic missile detection, tracking and imaging

Technical description

STK/EOIR models a "universe" of observable objects contained in the STK mission scenario. Observable objects include celestial bodies, satellites, space debris and missiles. Multiple independent EOIR sensor objects can simultaneously view this "universe", generating both images and performance metrics across short wave ultra violet, visible and infrared wavelengths (0.28 to 28.0 microns).

A scene generator associated with each sensor object synthesizes a physics based rendering of the "universe" as a sensor input image based on the sensor's defined Line of Sight, Field of View, and light wavelength band pass and spectral resolution.

The scene generator calculates the self radiance of observable objects based on thermal models and surface optical properties. Reflected radiances of objects are computed based on spectral and scattering (defined by the Bidirectional Radiance Distribution Function) surface optical properties. Celestial objects include the Sun, Mercury, Venus, Earth,

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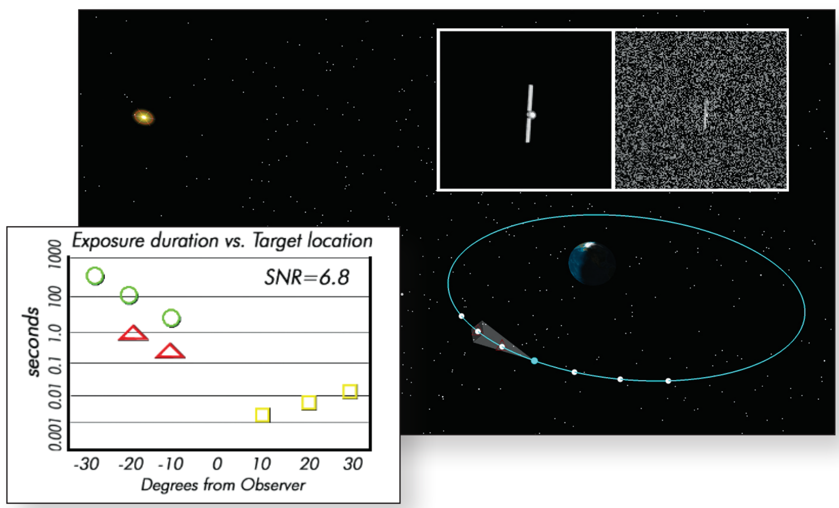
Moon, Mars, Jupiter, Saturn, Uranus, and Neptune. Each celestial object has a thermal model accounting for diurnal, latitudinal, and seasonal variations. The Earth, Moon, and Mars also have detailed surface optical properties maps at 0.93 km, 2.5 km, and 0.47 km resolution respectively. The earth's surface material types correspond to the 17 International Geosphere Biosphere Program (IGBP) Global Land Cover types plus Tundra as an 18th type. The Earth also includes an atmospheric radiative transport model with a choice of four aerosol models and a cloud model.

The scene generator renders stars from STK's catalog that includes over two million high quality astrometric star records from the Hipparcos and Tycho catalogs. Each star is treated as a point source of spectral irradiance based on its temperature and magnitude. Locations of stars and celestial bodies in an image are precisely determined from a physics based calculation of apparent position.

For satellite, debris and missile objects the user can specify shape, dimensions, surface material, and surface temperature. Shapes include: box, sphere, cylinder, and cone. Missile objects can be multi-staged; with each stage having independent shape, dimensions, surface material, surface temperature and solid black body plume model (temperature and emissivity).

Spectral radiant power arriving at the sensor aperture is computed using the physics of radiative transport. The sensor object converts the input image to sensor output pixels based on the following commonly used sensor parameters:

- Number of pixels in both horizontal and vertical directions
- Lower and upper spectral band edges
- F-number
- Effective focal length
- Diffraction wavelength
- Image quality (diffraction-limited [perfect optics] or negligible/mild/moderate aberrations (0.07, 0.14, 0.28 waves rms respectively)
- Longitudinal defocus
- Sensitivity (dark Noise Equivalent Irradiance/Radiance [NEI, NER] at one or more integration times)
- Dynamic range (Saturation Equivalent Irradiance/Radiance [SEI, SER] at one or more integration time)
- Current integration time
- RMS pointing jitter



Example application:
GEO belt survey analysis for space situational awareness

Resulting radiometric performance for point sources and extended objects can be reviewed in STK reports, graphs and dynamic displays. Metrics include sources target radiance/irradiance, background radiance/irradiance, scene photon signal-to-noise ratio (SNR), noise equivalent irradiance (NEI) and noise equivalent radiance (NER). Sensor output images can be displayed in a separate animation window in STK or output as ASCII text file for post-processing in MATLAB, MathCAD or Excel.

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To learn more or request an advanced demonstration please contact AGI by phone or e-mail listed below.

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