Aerospace Blockset 3

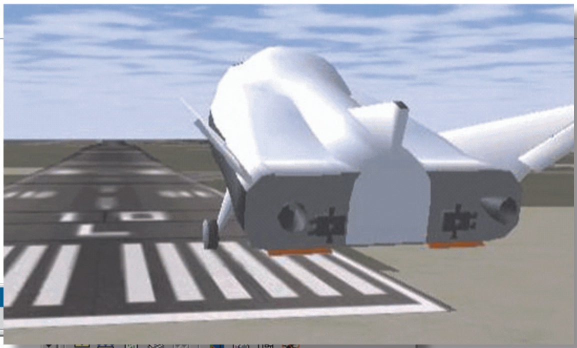
Model and simulate aircraft, spacecraft, and propulsion systems

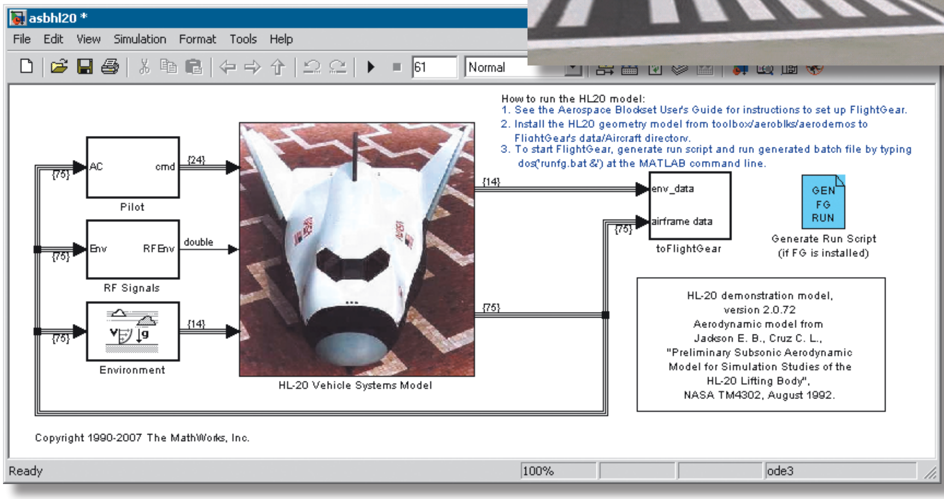
Aerospace Blockset extends Simulink® with blocks for modeling and simulating aircraft, spacecraft, rocket, and propulsion systems, as well as unmanned airborne vehicles. It also includes blocks that implement mathematical representations from aerospace standards, common references, and first principles. Blocks for modeling equations of motion and for navigation, gain scheduling, visualization, unit conversion, and other key operations are also provided.

Standards-based reference blocks, including environmental models for gravity, atmosphere, and wind, enable you to verify and validate your vehicle system design. Graphical switching capabilities let you alternate between mathematical representations, enabling you to rapidly modify modeling conditions without changing the model. You can automatically generate code for production deployment and for real-time execution in rapid prototyping and hardware-in-the-loop systems by using Aerospace Blockset with Real-Time Workshop® and xPC Target (both available separately).

KEY FEATURES

- Simulates aerospace vehicle components, including propulsion systems, control systems, mass properties, and actuators
- Models flight dynamics, including three- and six-degrees-of-freedom equations of motion with fixed or variable mass
- Provides options for visualizing vehicle dynamics in a three-dimensional environment, including an interface to FlightGear flight simulator
- Includes standards-based environmental models for atmosphere, gravity, wind, geoid height, and magnetic field
- Implements predefined utilities for converting units, transforming coordinate systems and spatial representations, and performing common aerospace math operations





Using Simulink and Aerospace Blockset to model and simulate vehicle dynamics of a NASA HL-20 lifting body (left). The system is visualized with FlightGear flight simulator (above).

The MathWorks
Accelerating the pace of engineering and science

Simulating Aerospace Vehicle Components

The aerospace vehicle component block libraries in Aerospace Blockset let you design and test a complete vehicle simulation in a single model. For example, you can perform analyses and trade-off studies to understand system behavior under a variety of environmental conditions and parameter constraints and use prebuilt guidance, navigation, and control (GNC) components to verify the response of a radar system before full system specification.

The **GNC library** includes guidance blocks for calculating the range between two crafts given their respective positions. Navigation blocks for modeling a three-axis accelerometer, a gyroscope, and an inertial measurement unit are also included. Multiple controller forms let you investigate the effects of implementation architecture on your design. Forms include predefined state-space controller blocks for one-, two-, and three-dimensional gain scheduling; linear interpolation; observer- and self-conditioned forms; and one-, two-, and three-dimensional matrix interpolation.

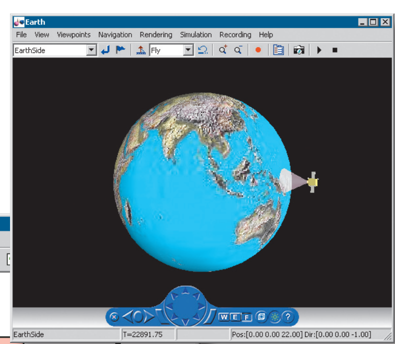
The **Propulsion library** includes a turbofan engine system block that implements a first-order representation of the engine and the controller. It computes the thrust and fuel flow at a specific throttle position, Mach number, and altitude.

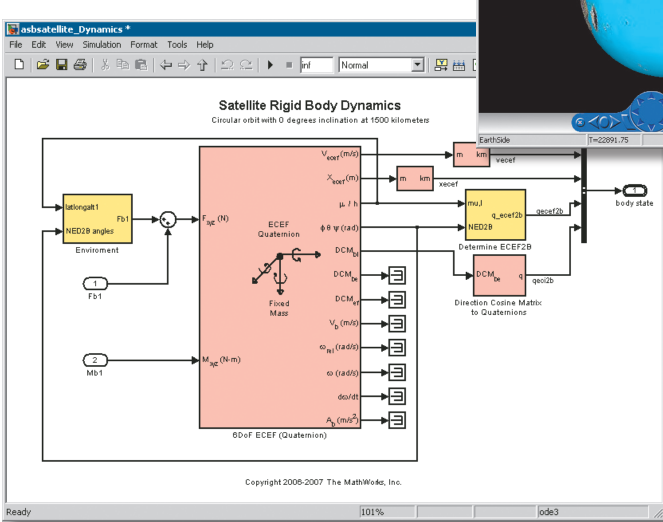
The **Actuators library** includes component blocks for simulating second-order linear and nonlinear actuators.

The **Mass Properties library** includes blocks for estimating inertia tensor and symmetric inertia tensor and for calculating moments about center of gravity due to forces.

Modeling and Visualizing Flight Dynamics

With Aerospace Blockset you can quickly construct the dynamics of your system, perform simulations, and understand system behavior under a variety of conditions.





Aerospace Blockset (left) used with Virtual Reality Toolbox (above) to animate vehicle motion during a simulation of a satellite orbiting the Earth.

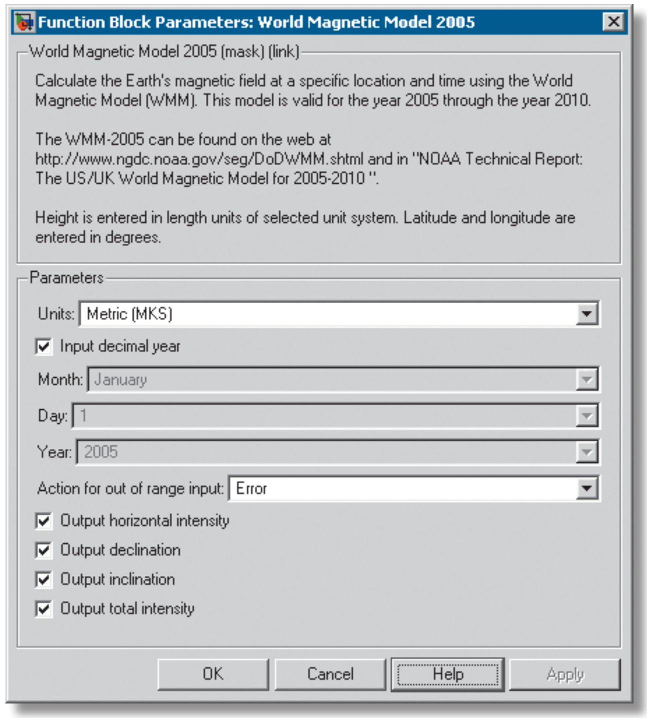
The **Equations of Motion library** includes blocks for simulating three- and six-degrees-of-freedom equations of motion with fixed and variable mass. Coordinate representations of the equations of motion include body, wind, and Earth-centered Earth-fixed (ECEF). Fourth- and sixth-order point mass equations of motion provide simplified representations of vehicle dynamics for multiple body modeling.

The **Flight Parameters library** provides blocks for calculating these common parameters: incidence, sideslip, airspeed, Mach number, dynamic pressure, relative ratios, equivalent airspeed, calibrated airspeed, wind angular rate vector, and, for a given geocentric latitude, planet radius.

The **Aerodynamics library** includes blocks for calculating aerodynamic forces and moments. You can supply aerodynamic coefficients in body, stability, or wind axes, or you can import aerodynamic coefficients from the U.S. Air Force Digital Data Compendium (Datcom). You can also specify whether forces and moments will be calculated in body or wind axes.

The **Animation library** includes an interface to FlightGear flight simulator for visualizing vehicle dynamics in a sophisticated three-dimensional simulation framework. The FlightGear Preconfigured 6DoF Animation block lets you control position and attitude of a vehicle in FlightGear flight simulator using double-precision values of longitude, latitude, altitude, roll, pitch, and yaw from Simulink. For more detailed FlightGear animation you can combine the blocks Pack net_fdm Packet for FlightGear and Send net_fdm Packet to FlightGear to visualize effects, such as control surface motion, instrument interface readings, and landing gear operation.

As an alternative to visualizing in FlightGear flight simulator, you can use one of the MATLAB® Handle Graphics® blocks. The 3DoF Animation and 6DoF Animation blocks animate three-dimensional motion with three and six degrees of freedom, respectively. The MATLAB Animation block lets you specify the bounding box, camera offset, and field of view to visualize the three-dimensional position and attitude of one or more user-defined vehicle geometries. You can define geometries with MATLAB variables, .mat files, AC3D files, or custom formats. All animation library blocks support Simulink external mode execution for visualizing your rapid prototyping and hardware-in-the-loop applications.



Menu for the World Magnetic Model 2005, one of the reference models included in the Environment library.

Incorporating Environmental Conditions

Aerospace Blockset provides standards based reference models that you can use in your simulation.

The **Environment library** includes standards-based references for modeling atmosphere, gravity, geoid height, magnetic field, and wind.

The **Atmosphere library** provides blocks that implement mathematical representations from the 1976 Committee on Extension to the Standard Atmosphere (COESA), International Standard Atmosphere (ISA), as well as nonstandard day models from U.S. military specifications (MIL-HDBK-310 and MILSTD-210C).

Additional Atmosphere library blocks implement mathematical representations from these models: 2001 United States Naval Research Laboratory Mass Spectrometer and Incoherent Scatter Radar Exosphere (NRLMSISE) and 1986 Committee on Space Research (COSPAR) International Reference Atmosphere (CIRA). The NRLMSISE model provides atmospheric temperatures and densities at altitudes from 0 to 1,000 kilometers for a specified location and time. The CIRA model provides mean climatic data for atmospheric temperature, zonal wind, and either geopotential height or pressure for altitudes from 0 to 120 kilometers.

The **Gravity library** includes these models: 1984 World Geodetic System, 1996 Earth Geopotential Model (EGM96), and the 2000 and 2005 versions of the World Magnetic Model (WMM). The EGM96 Geoid block provides the geoid height at a specified location using the EGM96 geopotential model.

The WMM blocks use the mathematical representation of the National Imagery and Mapping Agency (NIMA) standard and calculate the horizontal intensity, declination, inclination, total intensity, and vector of the Earth's magnetic field at a specified location and time.

The **Wind library** provides mathematical representations from MIL-F-8785C and MIL-HDBK-1797 to calculate wind shear and generate discrete wind gusts and Dryden and Von Kármán turbulence, as well as a horizontal wind block to simulate background wind. These blocks offer various combinations of angular rate signs (q, r), as defined in versions of the military specifications.

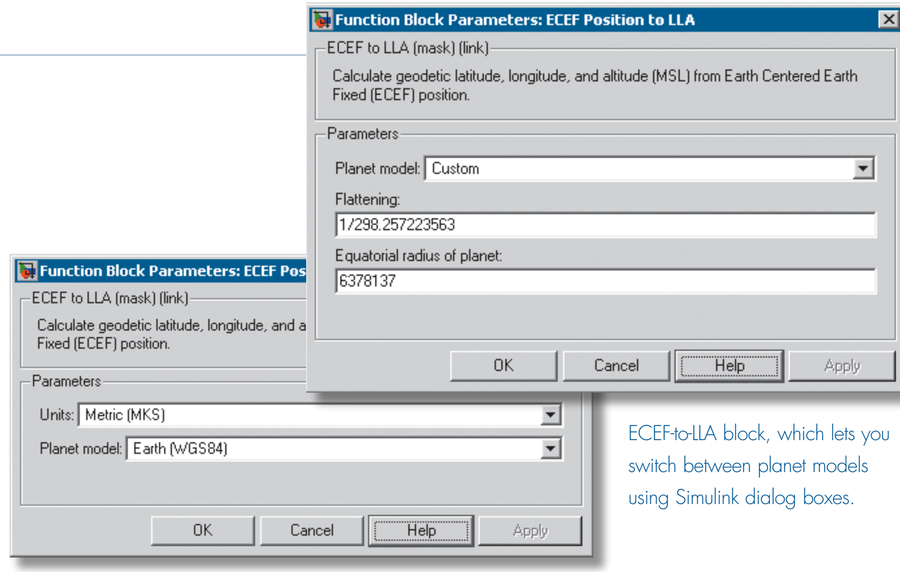
Fine-Tuning the Model

Aerospace Blockset includes block libraries that standardize units, transform axes representations and coordinate systems, and perform common math operations.

The **Unit Conversions library** provides blocks for converting typical physical property units, such as acceleration, density, and temperature, between metric and English units.

The **Axes Transformations library** includes blocks for converting spatial representations between Euler angles and quaternion vectors and for creating direction cosine matrices. The Euler angles can be in any of the twelve standard rotation sequences. The direction cosine (rotation) matrix transfers between coordinate systems such as body and inertial; body and wind; ECEF and north-east-down (NED); and ECEF and latitude, longitude, and altitude (LLA). Other representations include geocentric and geodetic latitude.

The **Math Operations library** provides blocks for calculating the cross product, creating and inverting 3 × 3 matrices, and calculating the determinant and adjoint of a 3 × 3 matrix. Quaternion math operations, such as the conjugate, division, inverse, and modulus, are also included.



ECEF-to-LLA block, which lets you switch between planet models using Simulink dialog boxes.

Required Products

MATLAB
Simulink
Aerospace Toolbox

Related Products

Real-Time Workshop. Generate C code from Simulink models and MATLAB code

Simulink® Control Design. Design and analyze control systems in Simulink

Stateflow®. Design and analyze control systems

Virtual Reality Toolbox. Animate and visualize Simulink systems in three dimensions

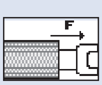
xPC Target. Perform real-time rapid prototyping and hardware-in-the-loop simulation using PC hardware

For more information on related products, visit *www.mathworks.com/products/aeroblks*

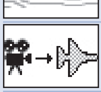
Platform and System Requirements

For platform and system requirements, visit *www.mathworks.com/products/aeroblks* ■

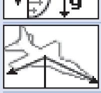
Sample Block Libraries

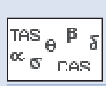

Actuators

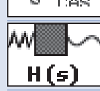

Aerodynamics


Animation


Environment

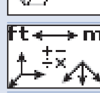

Equations of Motion


Flight Parameters


GNC


Mass Properties


Propulsion


Utilities

Aerospace Blockset specialized blocks for modeling, integrating, and simulating aerospace systems using mathematical representations from references and first principles.

Resources

VISIT
www.mathworks.com

TECHNICAL SUPPORT
www.mathworks.com/support

ONLINE USER COMMUNITY
www.mathworks.com/matlabcentral

DEMOS
www.mathworks.com/demos

TRAINING SERVICES
www.mathworks.com/training

THIRD-PARTY PRODUCTS AND SERVICES
www.mathworks.com/connections

WORLDWIDE CONTACTS
www.mathworks.com/contact

E-MAIL
info@mathworks.com

The MathWorks
Accelerating the pace of engineering and science

91035v05 09/07