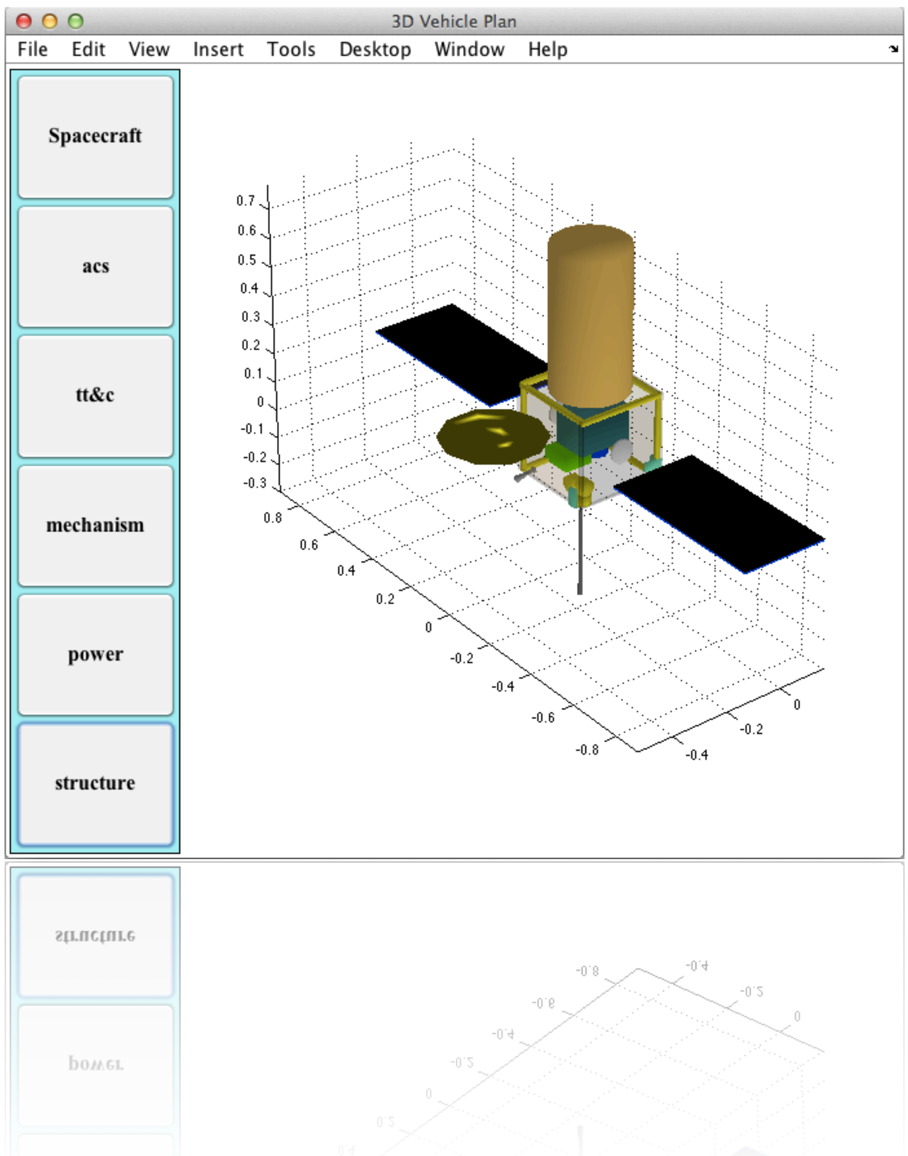
2014 Toolbox Release

Princeton Satellite Systems, Inc. is a small company extending the state-of-the-art in aerospace systems. Our 2014 toolbox release provides greatly expanded functionality across our entire product line. Whether you are a new customer or an existing customer, you will find exciting new tools to accelerate your research and development.



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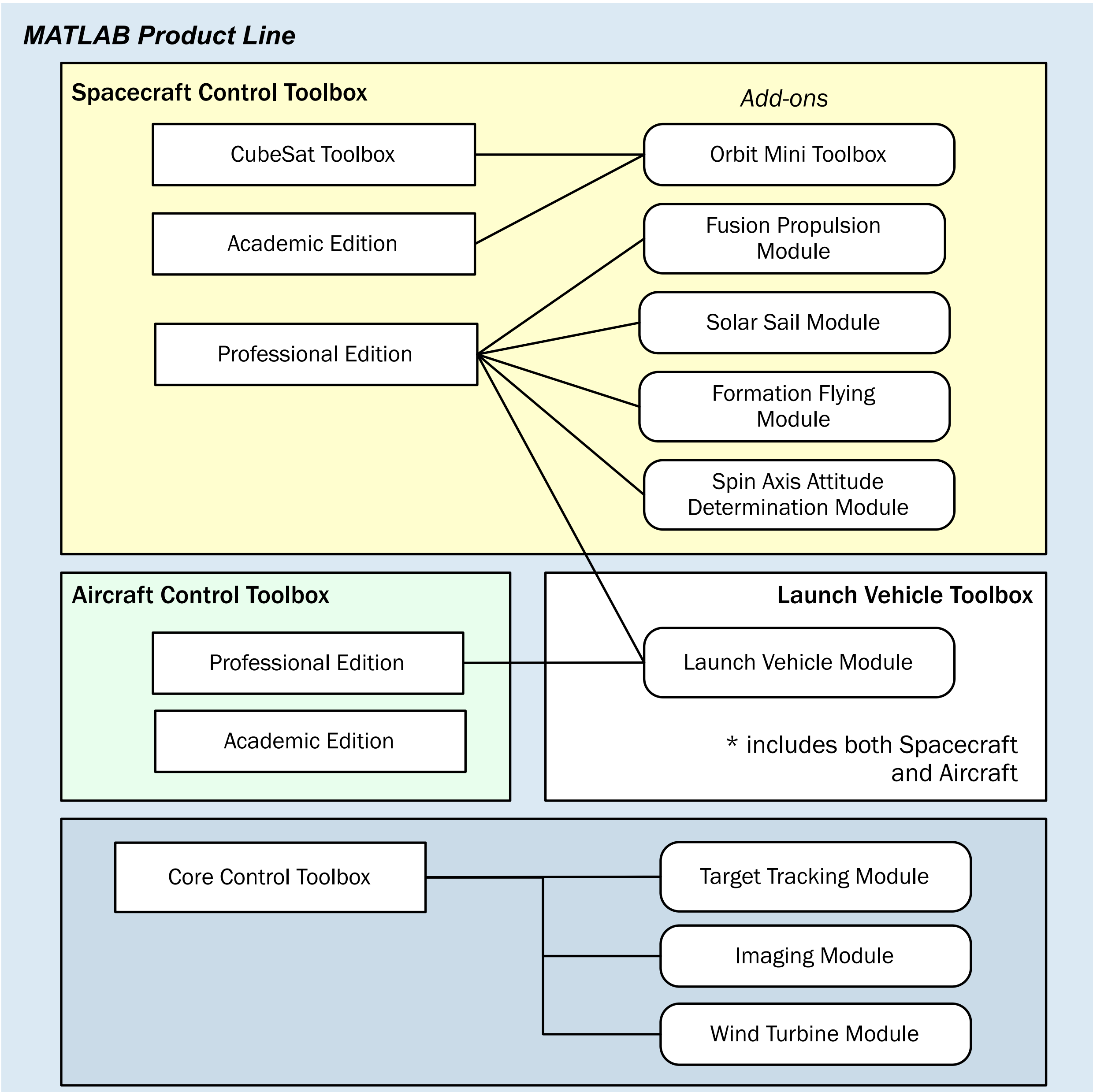
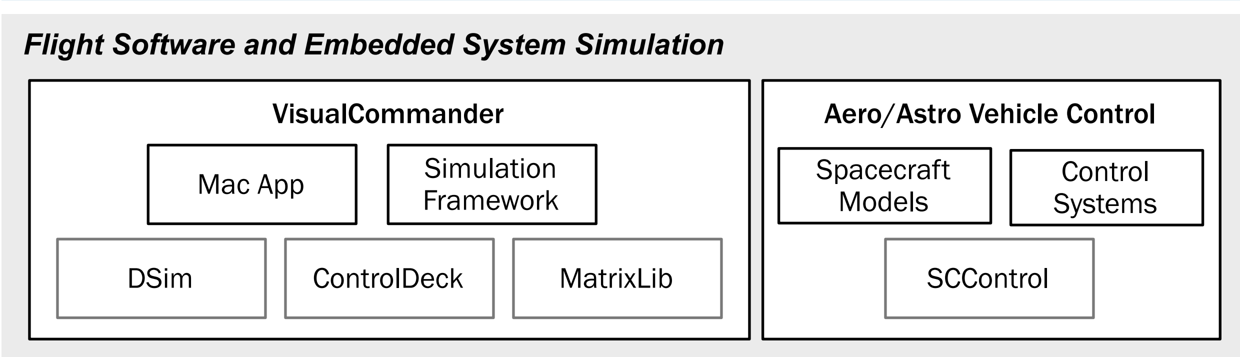
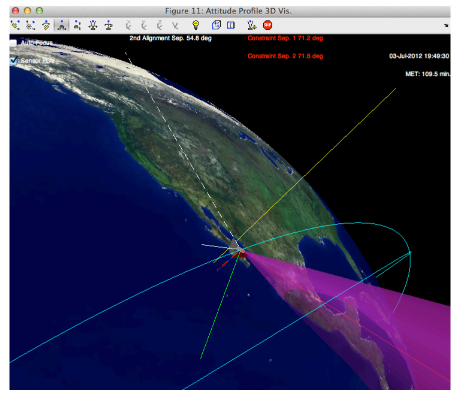

MATLAB Product Line
Spacecraft Control Toolbox
Add-ons
CubeSat Toolbox
Academic Edition
Professional Edition
Orbit Mini Toolbox
Fusion Propulsion Module
Solar Sail Module
Formation Flying Module
Spin Axis Attitude Determination Module
Aircraft Control Toolbox
Professional Edition
Academic Edition
Launch Vehicle Toolbox
Launch Vehicle Module
* includes both Spacecraft and Aircraft
Core Control Toolbox
Target Tracking Module
Imaging Module
Wind Turbine Module

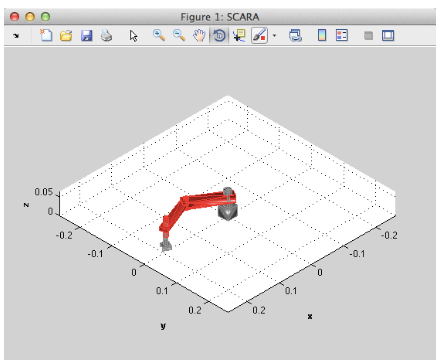

Flight Software and Embedded System Simulation
VisualCommander
Mac App
Simulation Framework
DSim
ControlDeck
MatrixLib
Aero/Astro Vehicle Control
Spacecraft Models
Control Systems
SCControl

Princeton Satellite Systems MATLAB® Toolboxes

Princeton Satellite Systems sells MATLAB toolboxes for spacecraft, aircraft, wind turbine and industrial problems. Modules for these toolboxes include the Target Tracking Module for robust target tracking, the Nuclear Fusion Propulsion Module, the Spin Axis Attitude Determination Module for satellite launch operations and the Solar Sail Module for solar sail design, analysis and simulation.

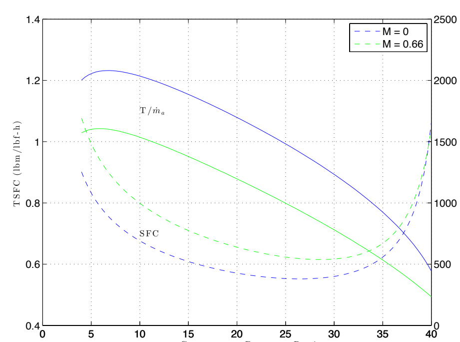


The toolboxes allow engineers to design vehicles, analyze them and simulate them, all within the MATLAB environment. The toolboxes include extensive control and estimation design functions, as well as complete source code---a necessity for advanced systems development. Extensive documentation and help systems make our toolboxes accessible to engineers at every level and students from high school to graduate school.



The toolboxes are used internally for all of our work and they are constantly refined and updated. We have had dozens of contacts with NASA, the Air Force, Navy, Army, ESTEC and many commercial organizations.

We used our toolboxes to develop the Indostar-1 attitude control systems, the Prisma safe mode guidance system, the TechSat-21 formation flying system, the ATDRS momentum management system and many others.



We developed the Optical Navigation System for NASA with our Spacecraft Control Toolbox. Recently we designed a magnetic hysteresis control system for a CubeSat using our CubeSat toolbox. We are currently developing an ultra-precision pointing control system for small satellites.

We also use our toolboxes to provide custom solutions to customers. These solutions can include new scripts and new functions. We actively seek feedback from customers so that we can improve our products and provide features that our customers need.

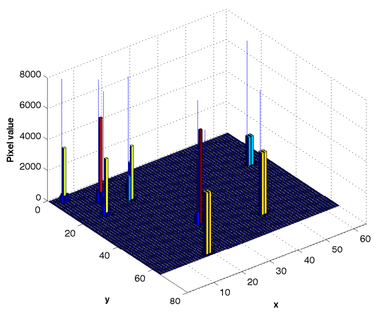
Our toolboxes are used worldwide by over a hundred organizations including the Canadian Space Agency, NASA, ESTEC, Energia in Russia, NEC, Lockheed Martin, Raytheon, General Dynamics, Orbital Sciences Corporation and many others.

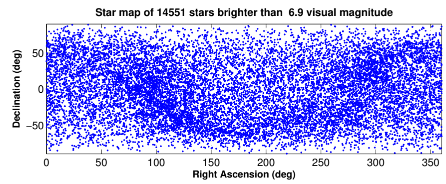
The following sections highlight the new features in our latest release!

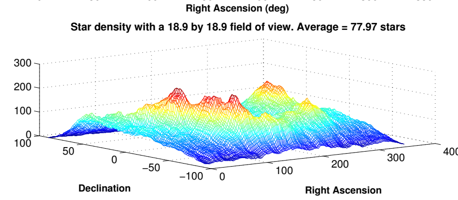
Spacecraft Control Toolbox

Stellar Attitude Determination System Design

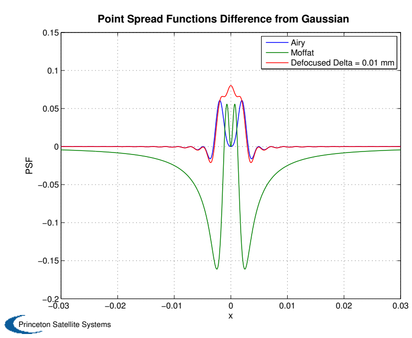
Star cameras have always been the choice for high accuracy pointing. More satellites today are using star cameras to provide 3-axis attitude, even in applications where high accuracy is not required. The Spacecraft Control Toolbox provides you with functions to guide you through each step of stellar attitude determination system design from camera design through algorithm implementation.



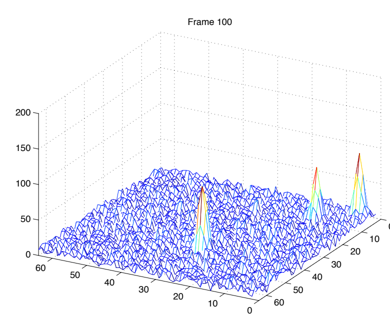




Our new functions in this release provide high accuracy models of the pixel array. An example showing the pixel output for a sensor is shown above on the left. Designing the optics is equally important. The example on the right shows the star field evaluation function that computes the star density for combinations of imager and focal length. You can see the Milky Way in the images.



The Spacecraft Control Toolbox includes new functions for point-spread functions. These include functions for focused and defocused cameras. The plot on the left shows the difference between diffraction limited star images in the focal plane for different point spread functions. Moffat and Gaussian are common approximations used for diffraction limited star images.

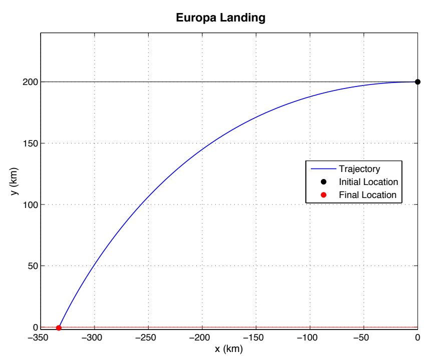


We have a new detector noise models that includes all sources of CCD or CMOS sensor noise such as dark current and shot noise. The figure on the right shows three stars with detector noise.

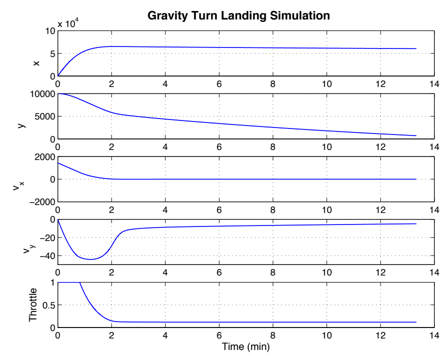
New coarse and precise centroiding algorithms are also included. You can combine these tools with our suite of Kalman Filter based stellar attitude determination algorithms for a complete solution. The Spacecraft Control Toolbox allows you to design your attitude determination system and predict your satellite performance in MATLAB quickly and at low cost.

Planetary Landers

The latest missions are focused on landing on solar system moons and possibly sample return missions to launch from moons. This release has new algorithms for optimal trajectories to and from the surface of moons and planets. A terminal approach controller is also included that corrects velocity errors near the surface.



The lander functions provide an excellent starting point for control systems that will need to accommodate the irregular surface of the target moons. Demonstrations of 2D and 3D landing and takeoff control are included for the moon, Europa, Enceladus and Mars.

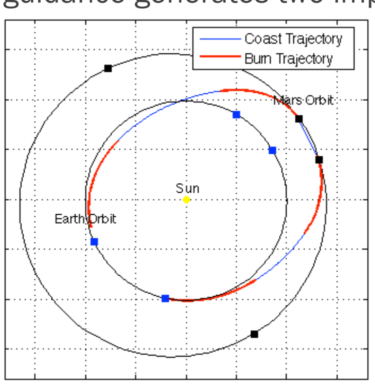


Another new function is for gravity turn trajectories. This is the simplest possible landing control function.

Our `PID3Axis` function provides the core functionality you need for attitude control of your lander. It allows maneuvering about all 3-axes and can be used with thrusters, reaction wheels, gimbaled thrusters and combinations of the three. It incorporates rate filtering so you may not need a pre-filter. It also has a number of convenient pointing modes that simplify your attitude control system design.

Interplanetary Missions

New tools for designing interplanetary trajectories include a Lambert delta-v planner. Lambert guidance generates two impulse burns to rendezvous with a target. The new planner allows you to create burn/coast burn trajectories with finite thrust.



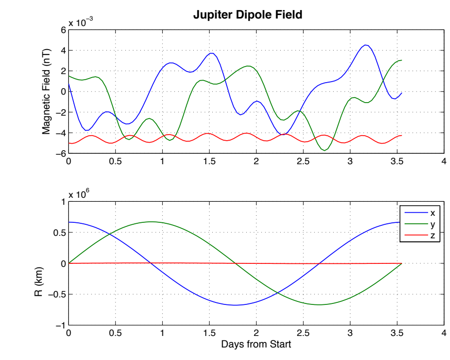
Another new function designs a double rendezvous mission planner. It allows you create trajectories going to a planet and then returning with a stay in orbit about the planet.

We designed a moderate thrust human Mars orbital mission with these functions. We've also designed missions to Europa and to asteroids. Recent work using these tools was for an asteroid rendezvous and deflection mission.

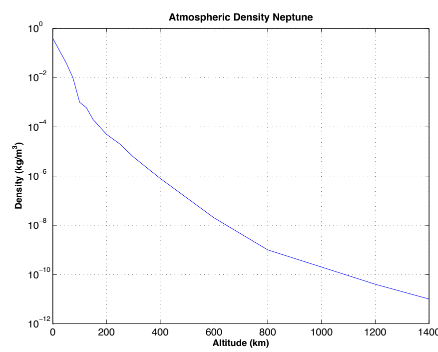
We also have tools for low thrust spirals and for impulse velocity changes that, together with our new functions, provide a full suite of easy to use mission design tools. You can design missions using chemical, nuclear or electric propulsion. With our optional Solar Sail Module you can design the same missions using sails!

Planetary Environments

When designing missions to the outer planets you have to know the environment. The Spacecraft Control Toolbox has new environment functions for the planets. The figure on the left shows the Jovian magnetic field in the vicinity of Europa.



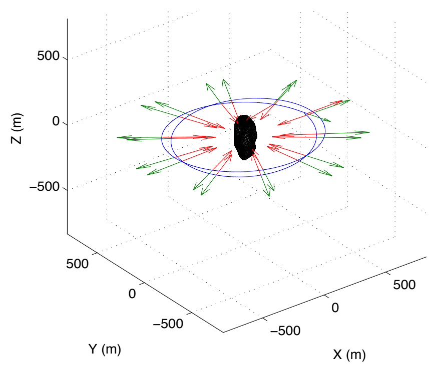
The figure on the right shows the density of the Neptunian atmosphere. We used this function to design a Neptunian airship with our Aircraft Control Toolbox airship module. Atmosphere models are available for several of the planets and moons of the gas giants.



Spacecraft Dynamics

Several new dynamics functions have been added to facilitate simulation in the Spacecraft Control Toolbox. `RHSRigidBody6DOF` is used to simulate proximity operations around an asteroid.

The simulation shown in the figure shows the thrust vectors for a satellite doing a perfectly circular orbit around the asteroid Apophis. Two orbits are shown. The spacecraft starts stationary behind the asteroid and then fires its reaction control thrusters to start a circular trajectory. The gravity of the asteroid is negligible so the spacecraft must thrust continuously.

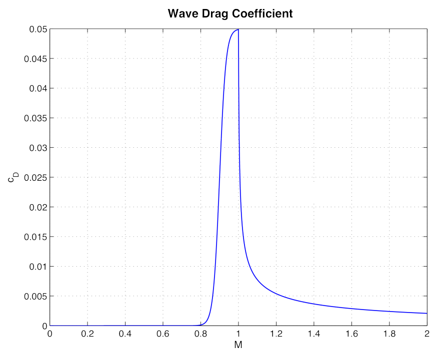


Functions are available for alternative approaches, such as a triangle maneuver with impulsive firings at each apex.

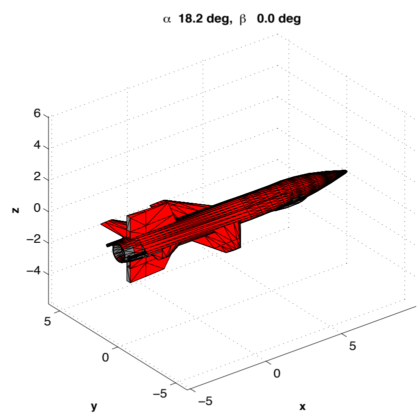
Aircraft Control Toolbox

Aerodynamics

We have revised the aerodynamic functions in the toolbox to provide a consistent interface and more options for the user. One new function is based on the Jones-Sears-Haack model. This model includes terms for lift induced drag, vortex drag and drag based on skin friction and volume. It includes a subsonic model so it can be used from zero Mach to hypersonic speeds.



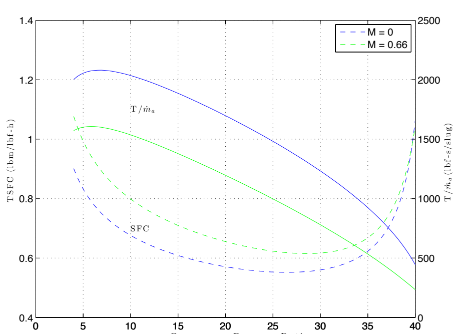
These functions are ideal for simulation work, trajectory analysis and for preliminary aircraft design. The plot to the left shows a wave drag function that is essential for transonic aircraft modeling and simulation.



Also included are combined models that integrate subsonic, supersonic and hypersonic lift and drag models to cover the full range of atmospheric flight. The figure on the right shows the hypersonic panel model applied to an X-15 aircraft.

Aircraft Engines

We've added new functions for turbojets, turbofans, ramjets and turbofan ramjets. The last is a type of mixed cycle engine. The SR-71 used a turbofan ramjet based on the J58 engine.



In a turbofan ramjet the afterburner becomes the ramjet and the airf lows around the turbine core to feed the afterburner. This type of engine has been proposed for Mach 5. Such airplanes have been proposed for flights from Newark airport to Singapore and other very long haul routes.

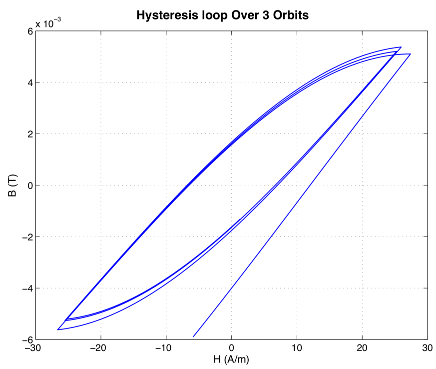
These engines functions supplement existing airbreathing engine functions but are easier to use and faster in simulations.

CubeSat Toolbox

Magnetic Hysteresis Damping

CubeSats have caused a renewed interested in magnetic control of satellites, and passive hysteresis damping in particular. This technology was invented in the 1960's before active computer control became practical.

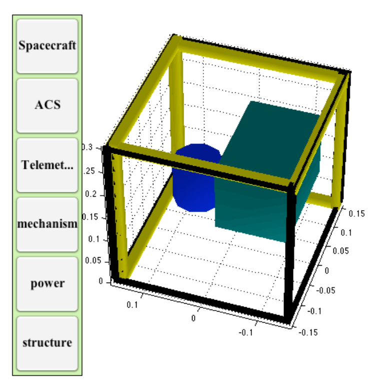
Modeling actual hysteresis rods on a satellite is not trivial, and generally requires empirical data on the properties of the damper rods. Our newest CubeSat functions accurately simulate damping using rods in any orbit. Combinations of permanent magnets and damping rods can be modeled and simulated to demonstrate the performance of magnetic control systems.



Since the rods produce only a small amount of damping per orbit, simulations lasting several days are required to see significant damping – in some passive satellites, the total time allotted for stabilization is two months! These kinds of simulations are easily done with the CubeSat toolbox. You can also mix magnetic and reaction wheel control for hybrid or highly redundant control systems.

Magnetic Torquers

Magnetic torquers are popular in CubeSats because of their low cost and simple operation. The CubeSat toolbox provides both air core and steel core magnetic torquer functions. The air core functions design optimal torquers given mass and power constraints.



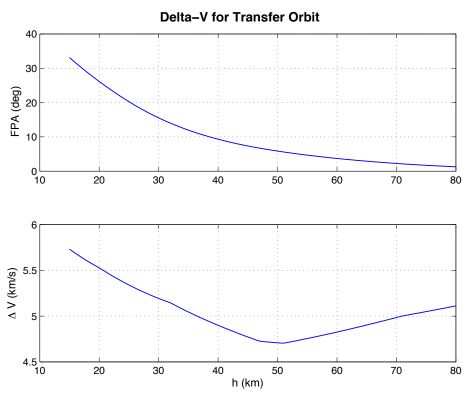
The toolbox CAD functions allow you to place the torquers in the spacecraft. The figure on the right shows three air core torquers (gold colored) in a 30 cm box with a CD&H chassis and optical IMU.

The toolbox provides magnetic field models for the Earth. You can create complete spacecraft simulations including orbital and attitude dynamics and control system models using the supplied actuator, environment and dynamics functions.

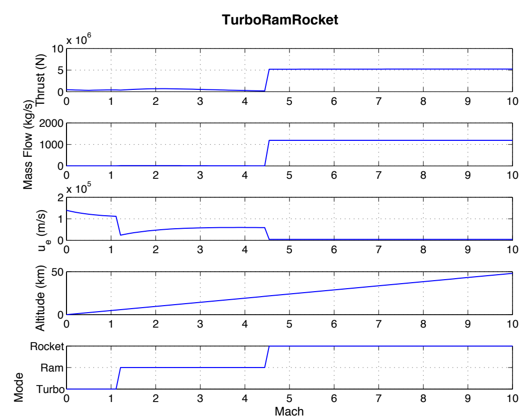
Launch Vehicle Toolbox

The Launch Vehicle Toolbox provides functions for the design, analysis and simulation of launch vehicles from the surface of the Earth. It requires both the Aircraft Control Toolbox and the Spacecraft Control Toolbox. This release contains all of the new functions in both toolboxes.

A new function computes the optimal flight path angle and separation angle for an upper stage. The plot to the left shows the results. The upper stage is assumed to follow a Hohmann trajectory into the final circular orbit.



This plot is for a two stage to orbit system. The optimal separation altitude is 50 km in this case. The function accounts for atmospheric drag at the separation altitude so the transfer is not an ideal Hohmann transfer.



The figure to the right shows a new model of a combined cycle engine with a turbofan, ramjet, and rocket. This kind of combined cycle engine has been proposed for single and two stage to orbit vehicles. It requires onboard oxygen only for rocket mode. This model uses our new Turbofan and Turbojet models in the Aircraft Control Toolbox.

Combined cycle engines have the potential to greatly reduce launch costs. The SR-71 aircraft flew a combined cycle turbojet/ramjet based on the J58 turbojet core – an engine designed in the 1950's! The Reaction Engines Limited Scimitar engine, currently under development, is another type of combined cycle engine.

Please note that the Launch Vehicle Toolbox is an ITAR-controlled product. An export license is required from the US Department of State and certain destination countries are prohibited. If you would like more information on this toolbox please contact us!

Core Control Toolbox

The Core Control toolbox has a new suite of Kalman Filter routines for conventional Kalman Filters, Extended Kalman Filters and Unscented Kalman Filters. The Unscented Filters have a new faster sigma point calculation algorithm. All of the filters can now handle multiple measurement sources that can be changed dynamically.

Add On Modules

Wind Turbine Control Module

The Wind Turbine Control Module can leverage all of the new control, estimation and mathematical functions in the Core Control Toolbox to provide enhanced wind turbine control system design capabilities.

Target Tracking Module

This module implements Multiple Hypothesis Testing (MHT) for tracking of multiple objects. It is essential for reliable tracking of objects in a noisy environment. Applications of MHT include automobile adaptive cruise control, people tracking in crowds and air traffic control. This module works with the Core Control Toolbox and contains a wide range of demos.

Solar Sail Module

This module adds solar sail functions to the Spacecraft Control Toolbox. It includes a full set of design and trajectory analysis tools.

Spin Axis Attitude Determination Module

Spin-axis attitude determination is a reliable way of attitude determination during transfer orbit. This module provides flight-tested software. A graphical user interface is provided to facilitate use in real-time. It is also very easy to customize for your own sensor set. The module includes batch and recursive estimators including our highly reliable nonlinear batch estimator.

Formation Flying Module

Constellations of small satellites are proving to be a cost-effective way of solving many remote sensing problems. The Formation Flying Module is an add-on to the Spacecraft Control Toolbox that gives you cutting edge algorithms, some of which were tested on the Prisma rendezvous robots mission! Formation control and planning tools are provided.

Founded in 1992, Princeton Satellite Systems is an innovative engineering firm pushing the state-of-the-art in Aerospace, Energy and Control. We help our customers implement control systems that are easy to use and understand. We have been an integral part of the control system development for the Cakrawarta-1 Communications Satellite, NASA ATDRS, the GPS IIR satellites and the Prisma Space Rendezvous Robots. Our extensive satellite operations experience includes Asiasat, Telstar and Koreasat. We have patented a wide range of innovative technologies, ranging from imaging sensors and spacecraft maneuvering algorithms, to wind turbines and nuclear fusion propulsion. Our staff provides user-focused engineering talent in developing and applying new and innovative solutions to any set of complex problems. PSS sells the MATLAB Spacecraft, Aircraft and Wind Turbine Control Toolboxes.

A variety of high tech organizations use Princeton Satellite Systems software products for their work. These include Energia (Russia), ESTEC, NASA, the Canadian Space Agency, the Swedish Space Corporation, Raytheon, General Dynamics, Lockheed Martin, Orbital Sciences Corporation, MIT Lincoln Laboratories, NEC, Boeing and many colleges and universities.

Princeton Satellite Systems regularly customizes and enhances our software to meet specific client requirements; we find this to be an effective way of enhancing our products and ensuring that they meet all of our clients' needs. Princeton Satellite Systems combines custom development with commercial software components to provide powerful control software in minimal time and with maximum flexibility to adapt to the latest customer requirements.

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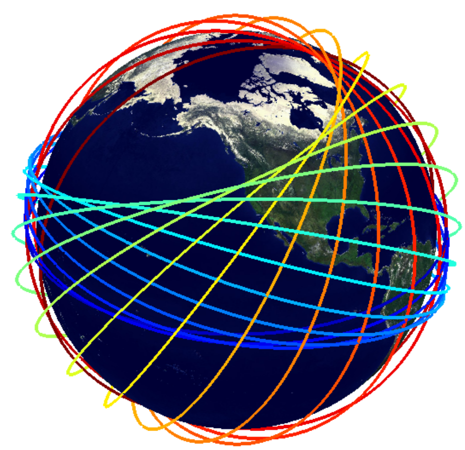

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