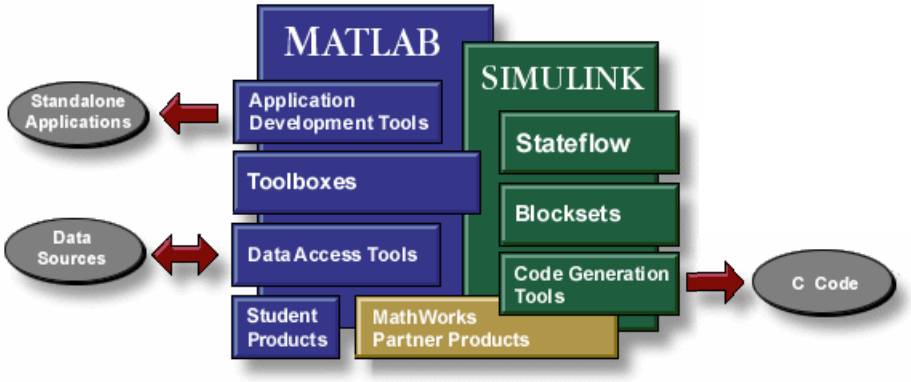
Shaping the Future of Aerospace

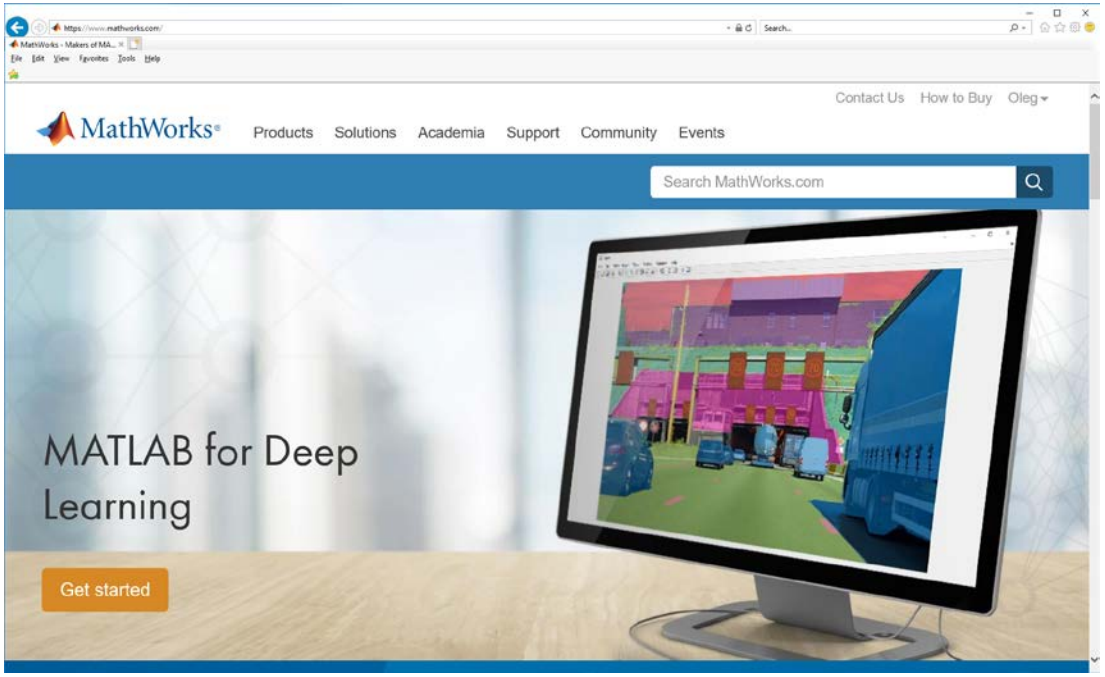
Chapter 1. MATLAB/Simulink as a Technical Computing Language



Outline

- 1.1 Introduction
- 1.2 History of MATLAB Creation and Development
- 1.3 Capabilities and Resources
- 1.4 Aerospace Application Tools
- 1.5 Overview of MathWorks Products
- 1.6 Installing Mathworks Products
- 1.7 MATLAB Online

The Mathworks



Fast Facts

- Founded in 1984
- Software installations at over 80,000 business, government, and university sites
- Customers in over 180 countries
- There are more than:
  - 2 million users of MATLAB worldwide
  - 4 million files downloaded from File Exchange on MATLAB Central in 2016
  - 225,000 contributors worldwide to MATLAB Central apps
  - 500 third-party solutions that build on MATLAB and Simulink
  - Over 2,000 MATLAB based books in 28 languages

MATLAB Origins

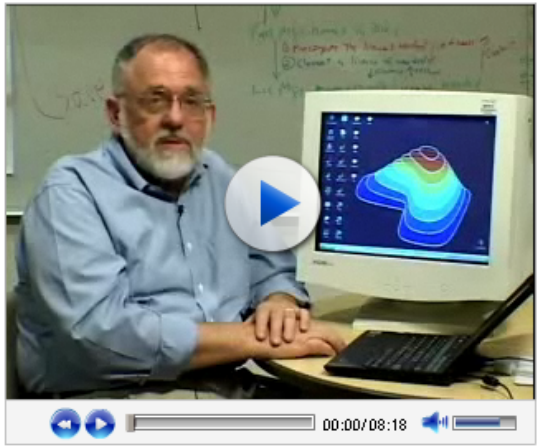
www.mathworks.com/company/newsletters/news_notes/clevescorner/dec04.html

- Newsletters Main Page
- News & Notes
  - Current Issue
  - Cleve's Corner
  - Past Issues
- MATLAB Digest
  - Current Issue
  - Past Issues
- MATLAB Digest - Academic Edition
  - Current Issue
  - Past Issues
- MATLAB Digest - Biotech and Pharmaceutical Edition
  - Current Issue
  - Past Issues
- User Stories

MATLAB News & Notes - December 2004

Cleve's Corner

The Origins of MATLAB



Video: The Origins of MATLAB 8:18
Cleve Moler describes his inspiration for authoring MATLAB.

www.mathworks.com/company/newsletters/news_notes/clevescorner/jan06.pdf

The Growth of MATLAB and The MathWorks over Two Decades

Jack Little left his job at the consulting company and bought a new COMPAQ portable computer at Sears. The machine had only 256 KB of memory and no hard disc; Jack had to swap 5-1/4-inch floppies to compile programs. Jack and Steve took a year and a half to rewrite MATLAB in C, adding new features they had envisioned. Steve wrote the parser/interpreter, and Jack wrote the math libraries, including translations to C of about a dozen routines from LINPACK and MATLAB. Jack also wrote the first Control System Toolbox. Some of their original code is still used in MATLAB today.

1983 MATLAB rewritten

Jack Little used this COMPAQ portable to develop MATLAB 1.0.

Jack suggested making MATLAB a matrix-based programming language to which we could easily add new functions, organized into toolboxes. He wanted the system to be available on a wide range of machines, from PCs and workstations to mainframes. He also wanted it to take advantage of graphics where they were available. I readily agreed.

There was considerable concern about code size in the initial versions of MATLAB. On the PC, MATLAB had to share 256KB of memory with the DOS operating system and still leave room to store a few matrices. I designed a simple, single-shift, complex QZ algorithm that was not in EISPACK. It required little memory and could be used for most of the matrix eigenvalue problems. We even used it for polynomial zeros to save code.

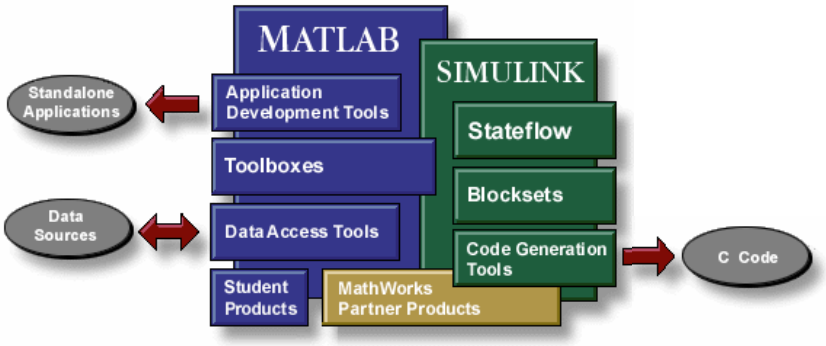
In 1984, Jack, Steve, and I founded The MathWorks. The first mailing address was a rented A-frame cabin where Jack lived in the hills above Stanford University in Portola Valley, California.

1984 The MathWorks founded

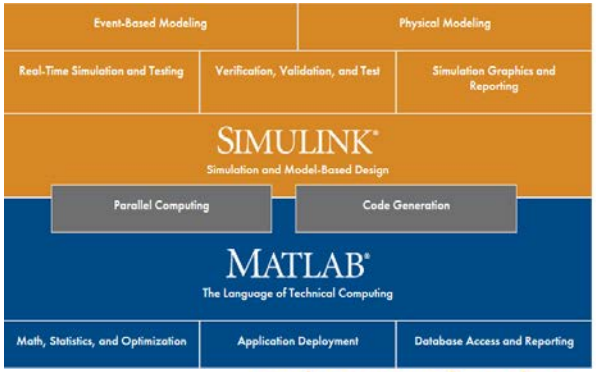
The MathWorks released MATLAB 1.0, implemented in C for MS-DOS PCs. MATLAB made its commercial debut at the IEEE Conference on Design and Control in Las Vegas, Nevada.

Reprinted from The MathWorks News & Notes | January 2006 | www.mathworks.com

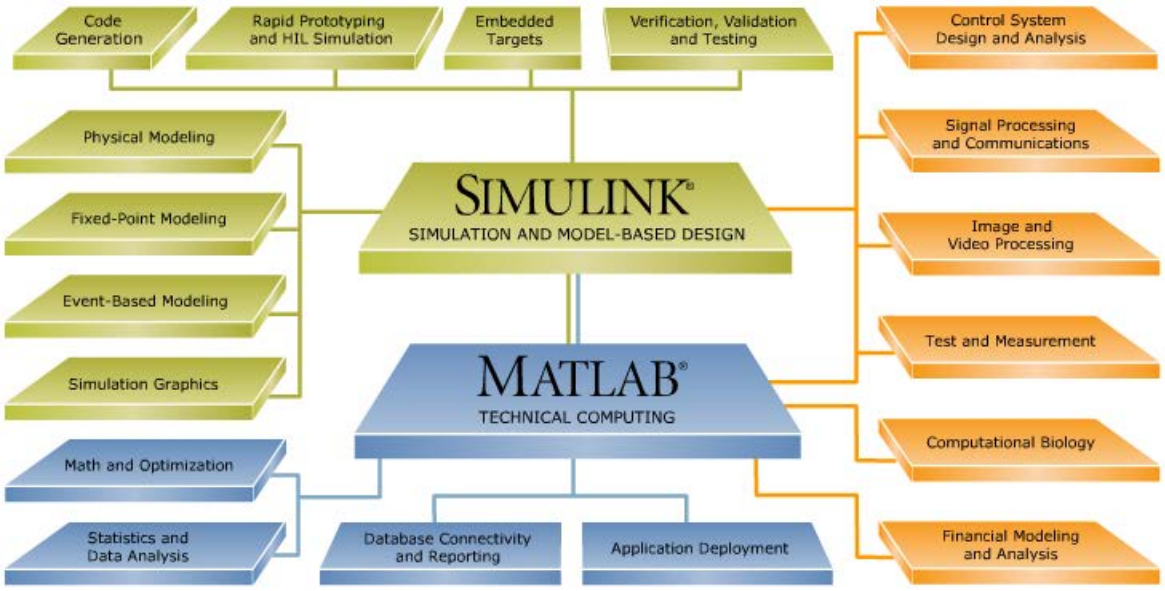
MATLAB Product Family



Simulink Product Family



Application-Specific Products

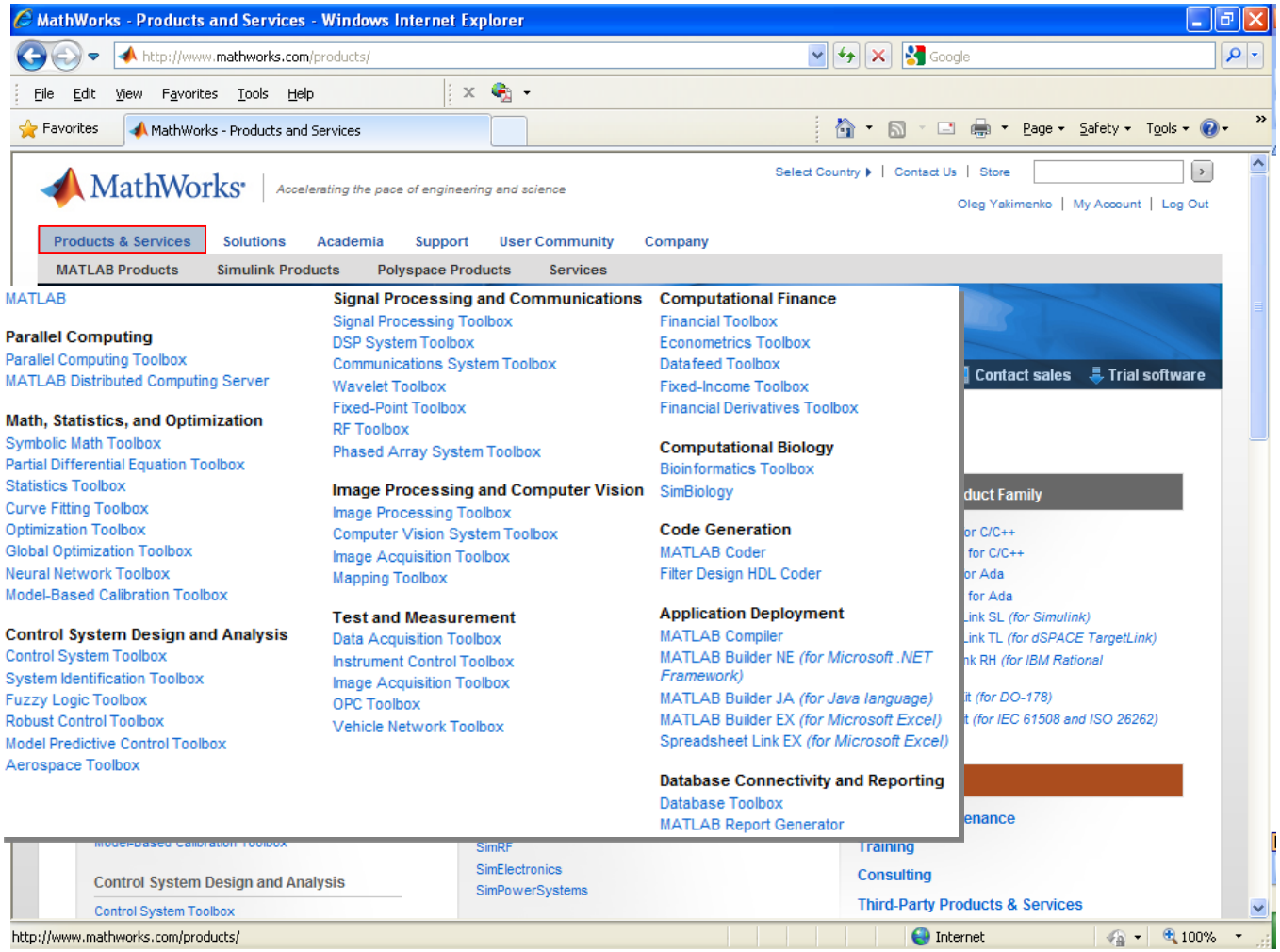


MATLAB Product Family

Latest Release Highlights

- **R2012b** – new Desktop features (Toolstrip interface that replaced menus and toolbars, Apps gallery presenting apps from the MATLAB product family, redesigned Help system), command line suggestions; new Simulink Editor, smart signal routing and simulation tools
- R2013b – new types of data (`table` data container, `categorical` array)
- R2014a – new way to display Command History window (pop-up window rather than static window)
- **R2014b** – new graphics system, new types of data (`datetime`, `duration`, and `calendarDuration`), suggested corrections for syntax errors in the Command Window, packaging a sharing tool, big data analysis tools (`datastore` and others)
- R2016a – Live Editor to create and run live scripts with embedded output), App Designer
- R2016b – new types of data (`timetable` data container, `timeseries` objects, `string` array), working with missing data (`fillmissing`) and big data (`tall`)
- R2017a – MATLAB Online to use MATLAB through the web browser, working with outliers (`filloutliers` and others)
- R2017b – MATLAB Drive providing a common free cloud-based storage of 250Mb), plotting in geographic coordinates, `wordcloud` function, contextual hints for function arguments in Live Editor
- R2018a – improved graphic (`axes`, `legend`)
- R2018b – new plotting functions (`xline`, `yline`, `geoaxes`, `stackedplot`, `scatterhistogram` and others), axes toolbar, Deep Learning Toolbox
- R2019a – new tabular data reading functions (`readmatrix` and others), `parallelplot`, graphics export, object detection using you-only-look-once (YOLO) v2 detectors, Reinforcement Learning Toolbox
- **R2019b** – Simulink Toolstrip and other tools, Git integration with MATLAB, map-based data visualization, Live Editor Tasks, function argument validation, Navigation, Robotics System and ROS Toolboxes

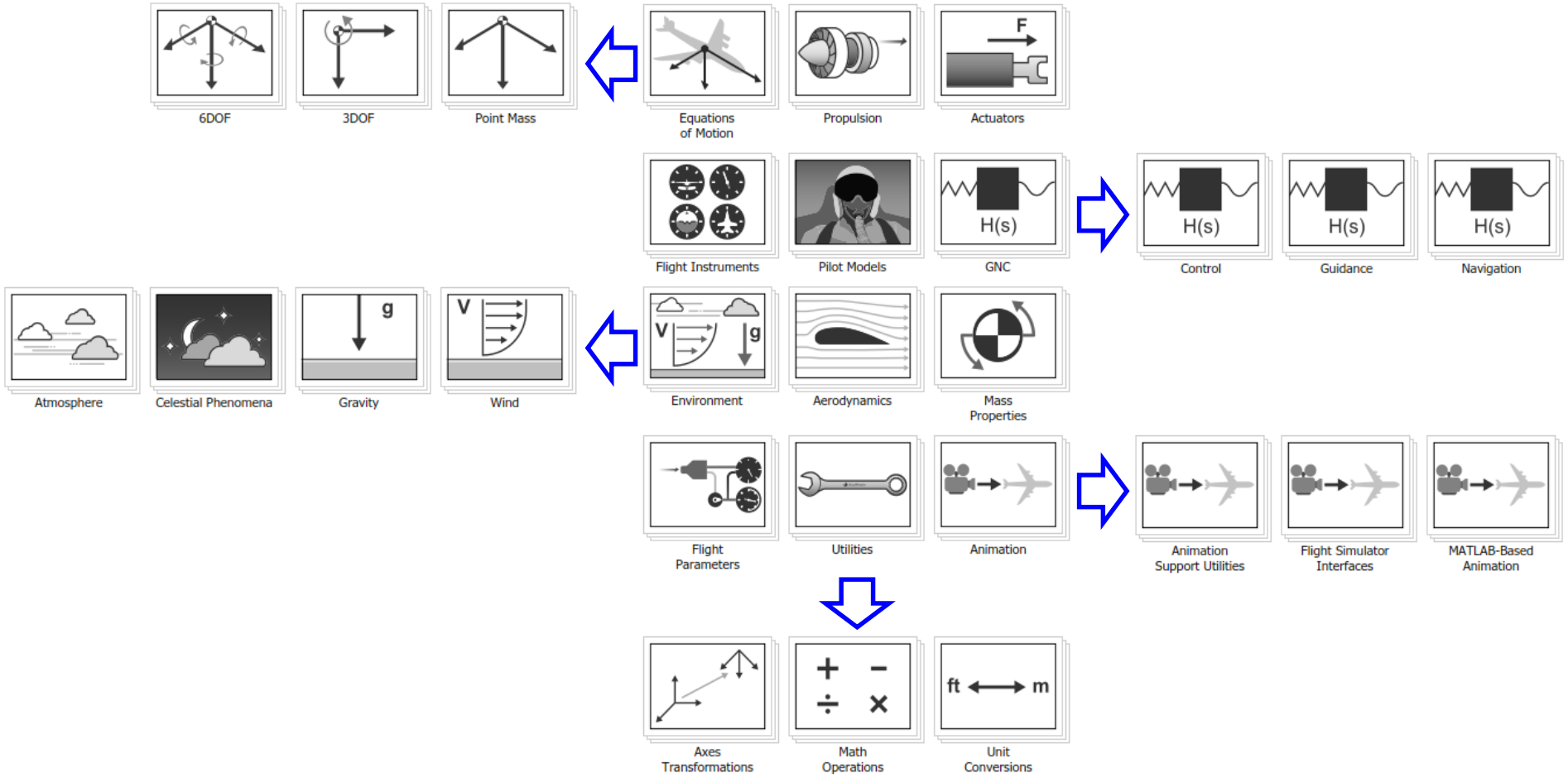
Toolboxes and Blocksets



Aerospace Toolbox

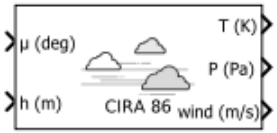
Subgroup	Brief Description
Axes Transformations	Transforms axes of coordinate systems to different types
Flight Parameters	Computes various flight parameters, including ideal airspeed correction, Mach number, and dynamic pressure
Quaternion Math	Assures common mathematical and matrix operations on a quaternion
Unit Conversion	Converts common measurement units from one system to another, and enables time calculations, including Julian dates, decimal year, and leap year
Environment	Simulates various aspects of aircraft environment, such as atmosphere conditions, gravity, magnetic fields, and wind
Gas Dynamics	Provides various gas dynamics tables
Trajectory and Attitude Visualization	Allows constructing FlightGear animation objects to be used in virtual reality animations

Aerospace Blockset Libraries

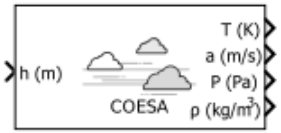


Aerospace Blockset Blocks

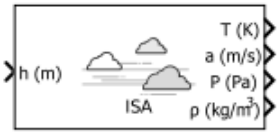
Shaping the Future of Aerospace



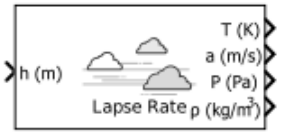
CIRA-86 Atmosphere Model



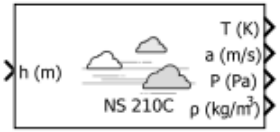
COESA Atmosphere Model



ISA Atmosphere Model

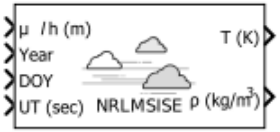


Lapse Rate Model



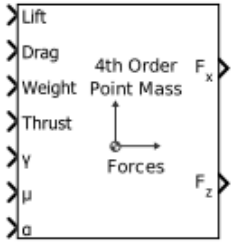
Non-Standard Day 210C

Non-Standard Day 310

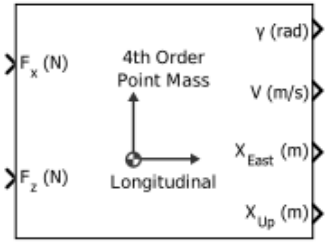


NRLMSISE-00 Atmosphere Model

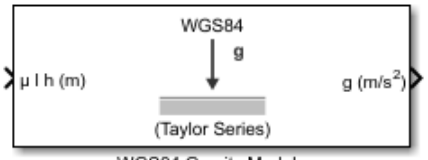
Pressure Altitude



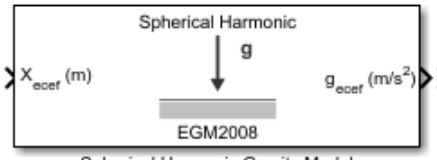
4th Order Point Mass Forces (Longitudinal)



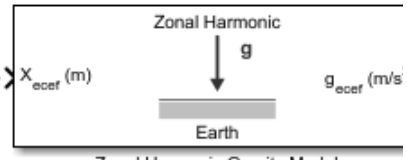
4th Order Point Mass (Longitudinal)



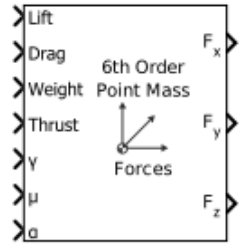
WGS84 Gravity Model



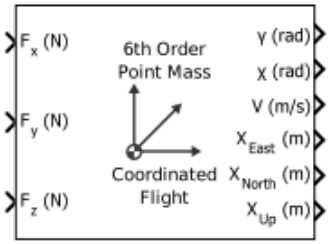
Spherical Harmonic Gravity Model



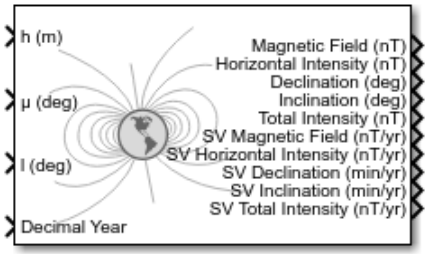
Zonal Harmonic Gravity Model



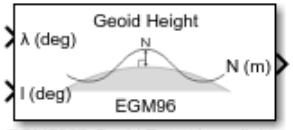
6th Order Point Mass Forces (Coordinated Flight)



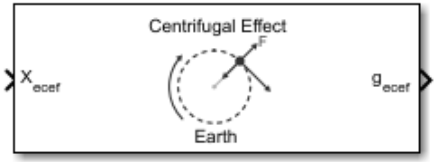
6th Order Point Mass (Coordinated Flight)



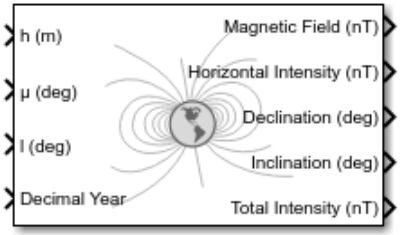
International Geomagnetic Reference Field



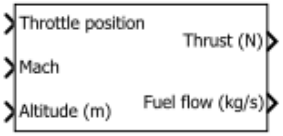
EGM2008 Geoid Data Unavailable



Centrifugal Effect Model

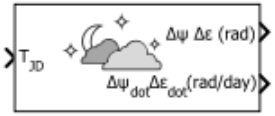


WMM2015 V2 (2015-2020)



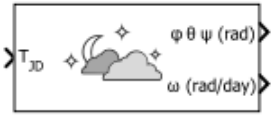
Turbofan Engine System

Delta UT1

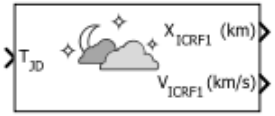


Earth Nutation

Earth Orientation Parameters

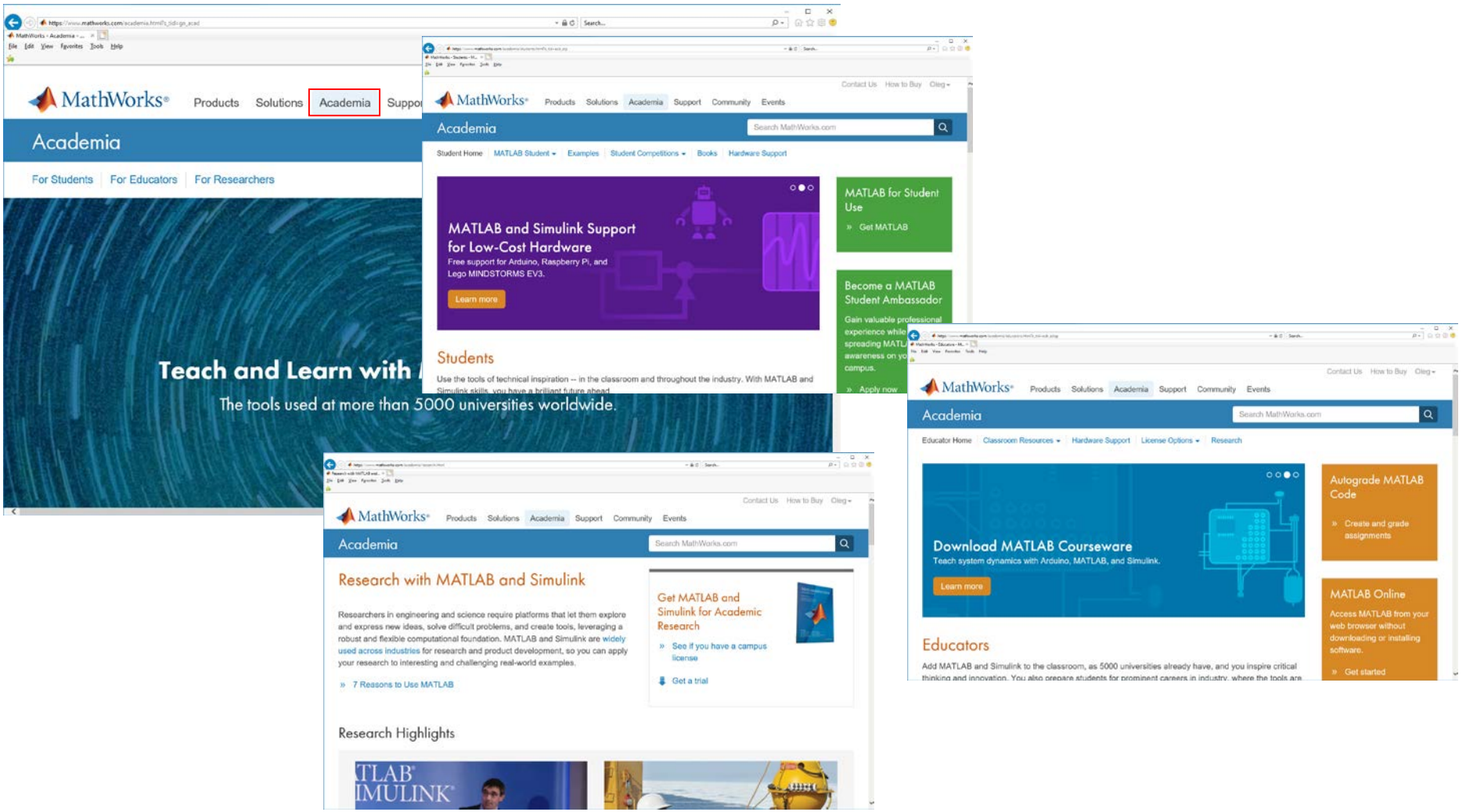


Moon Libration



Planetary Ephemeris

Mathworks for Academia



Student Versions

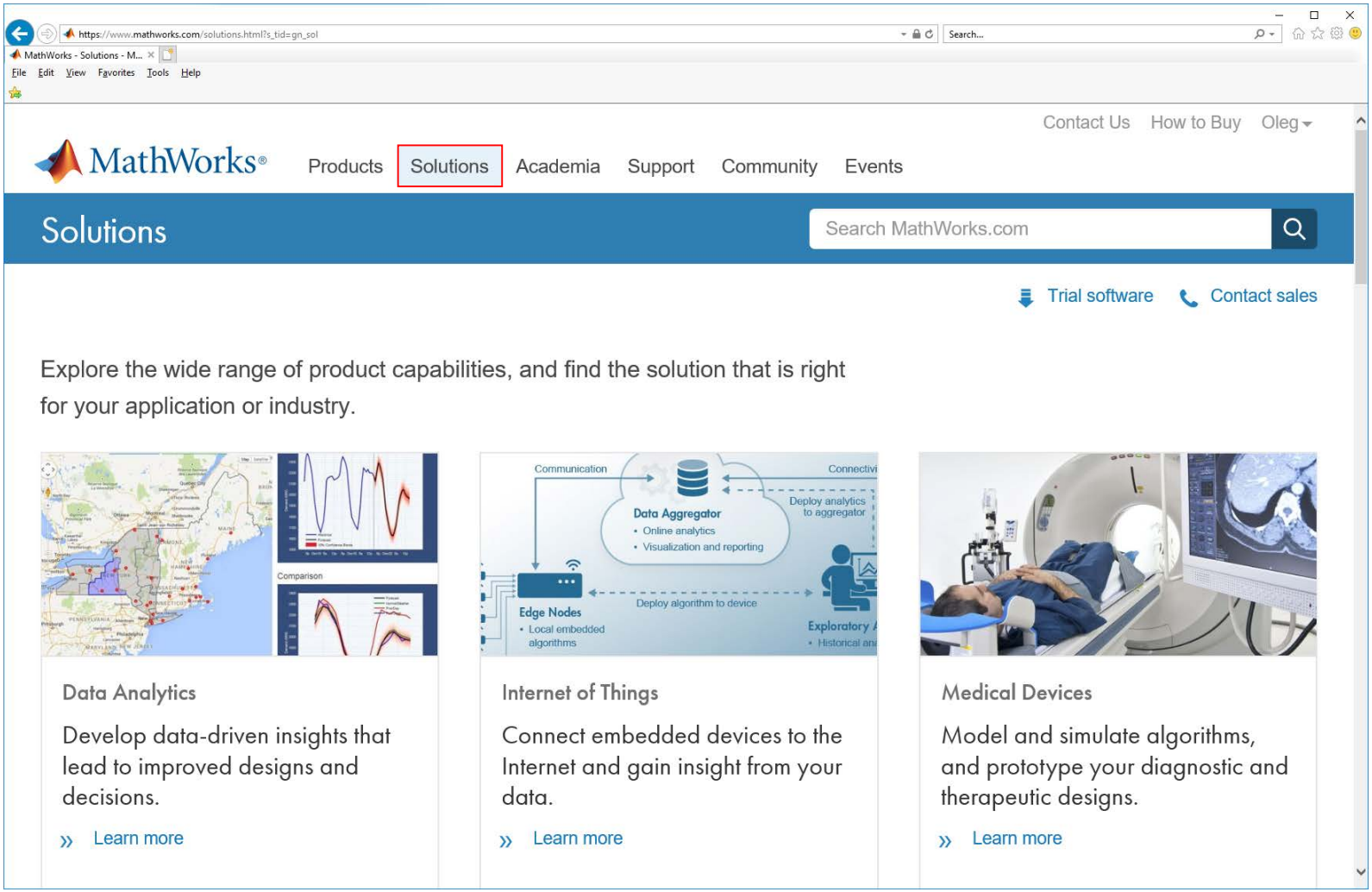
1. MATLAB Student version Includes MATLAB only, with the option to purchase add-on products for a variety of courses and applications.

2. MATLAB and Simulink Student Suite includes full-featured versions of MATLAB and Simulink (the student version of Simulink enables you to create models that include over 300 blocks) along with the key functions from:

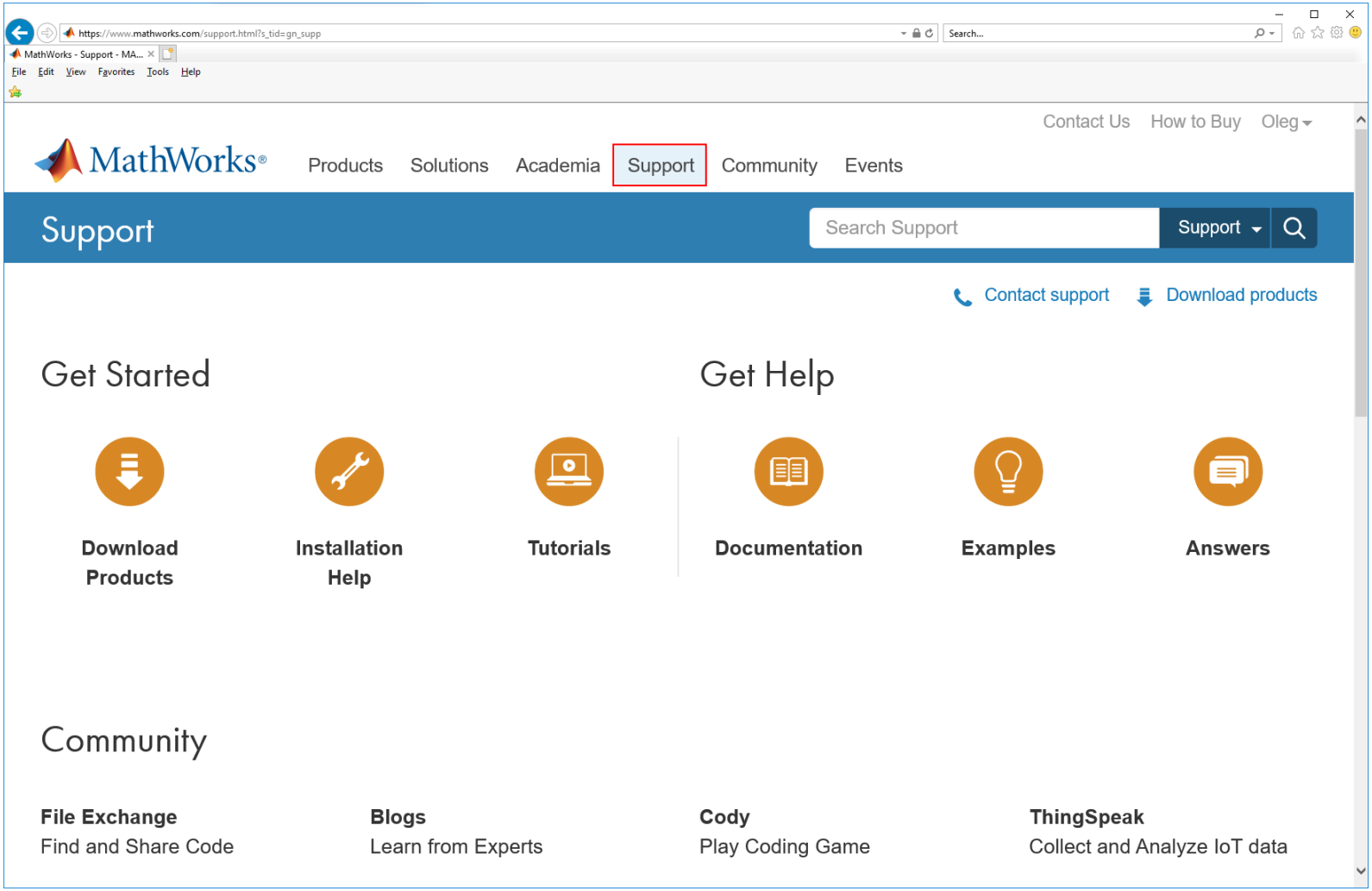
- Control System Toolbox
- Curve Fitting Toolbox
- DSP System Toolbox
- Image Processing Toolbox
- Instrument Control Toolbox
- Optimization Toolbox
- Parallel Computing Toolbox
- Signal Processing Toolbox
- Statistics and Machine Learning Toolbox
- Symbolic Math Toolbox

Runs on Windows, Mac and Linux

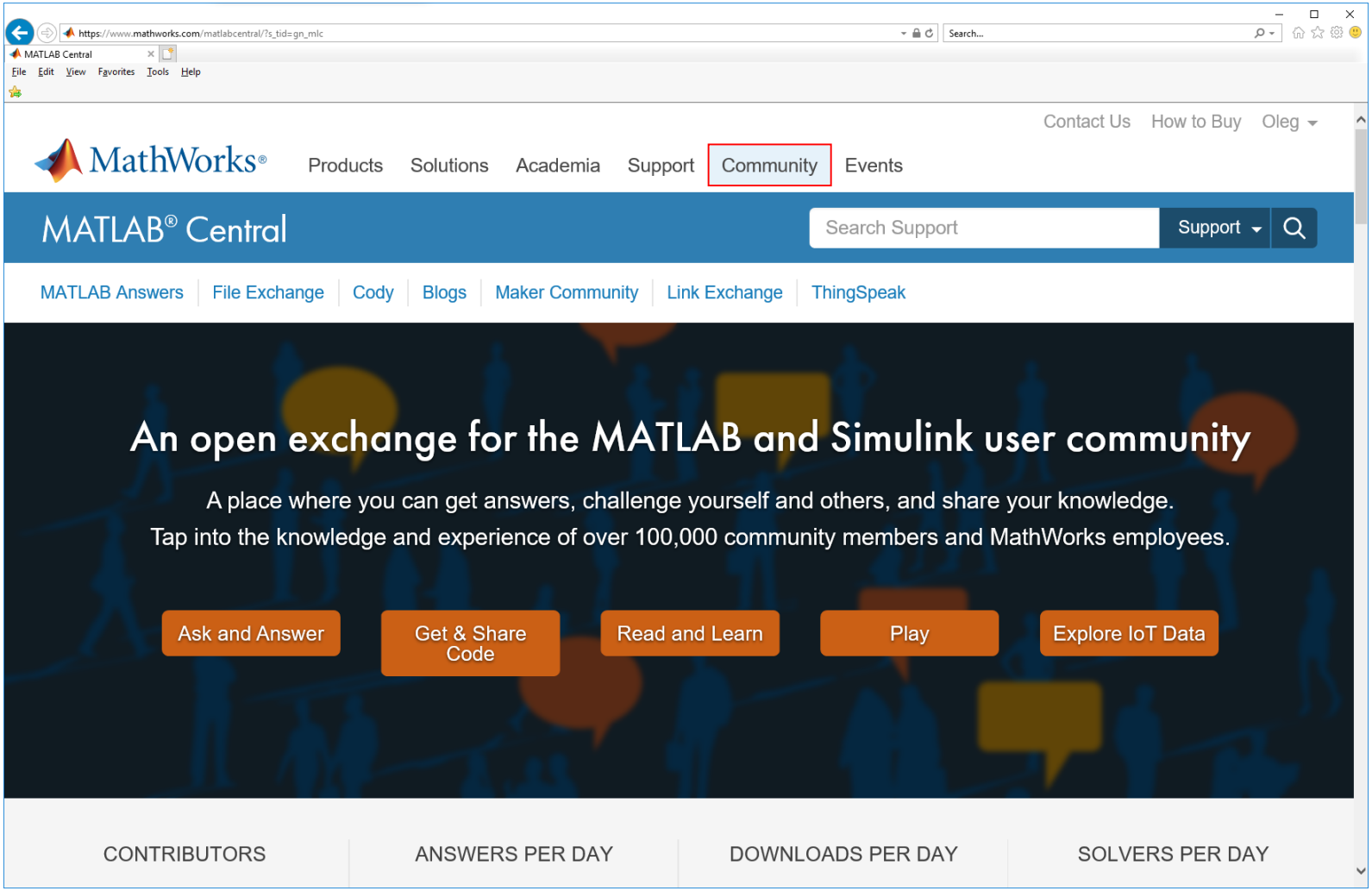
Solutions



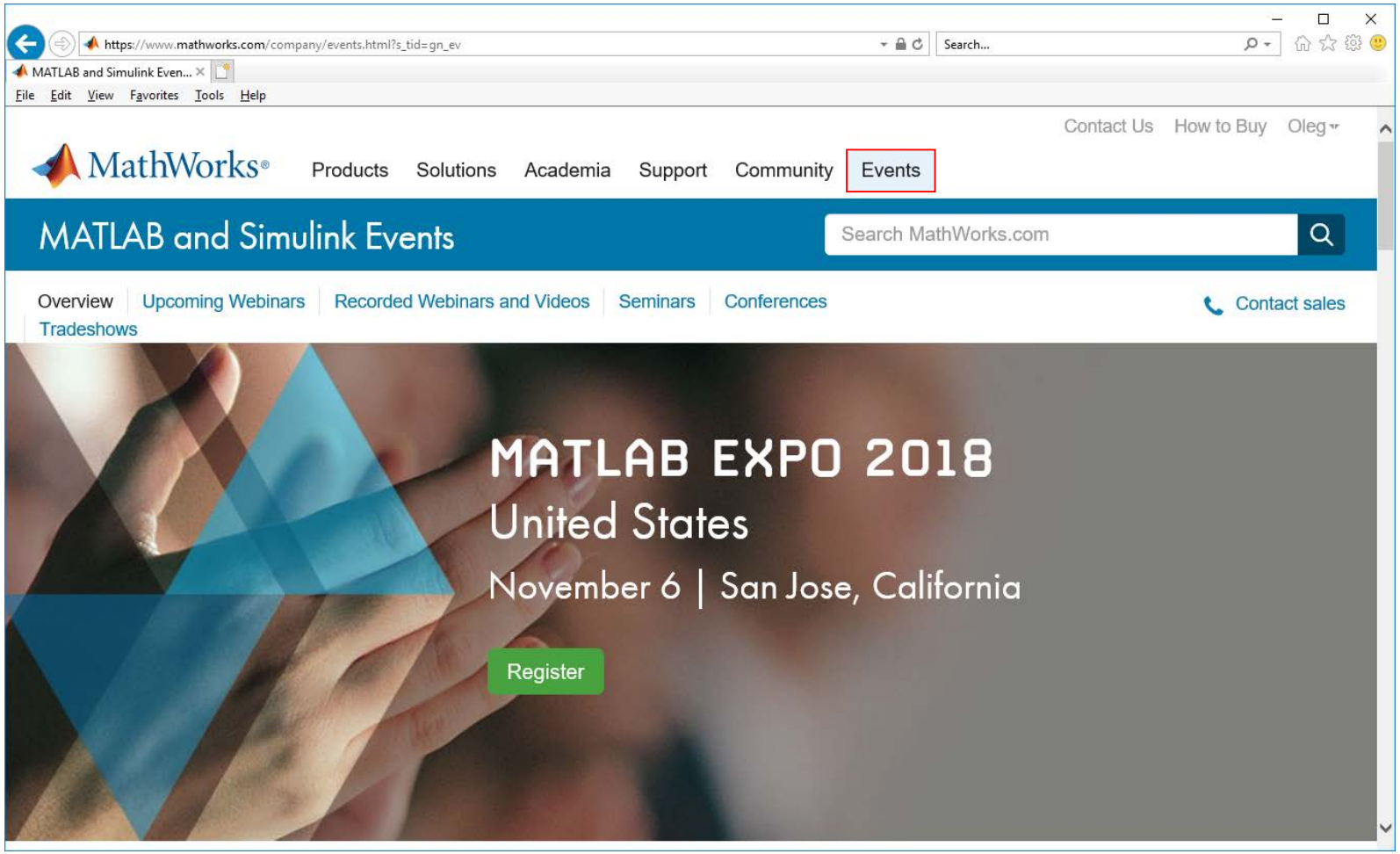
Support



User Community



Mathworks Training



MATLAB Scripts on the Web

Shaping the Future of Aerospace

From GPS measurements to ENU measurements: sample code

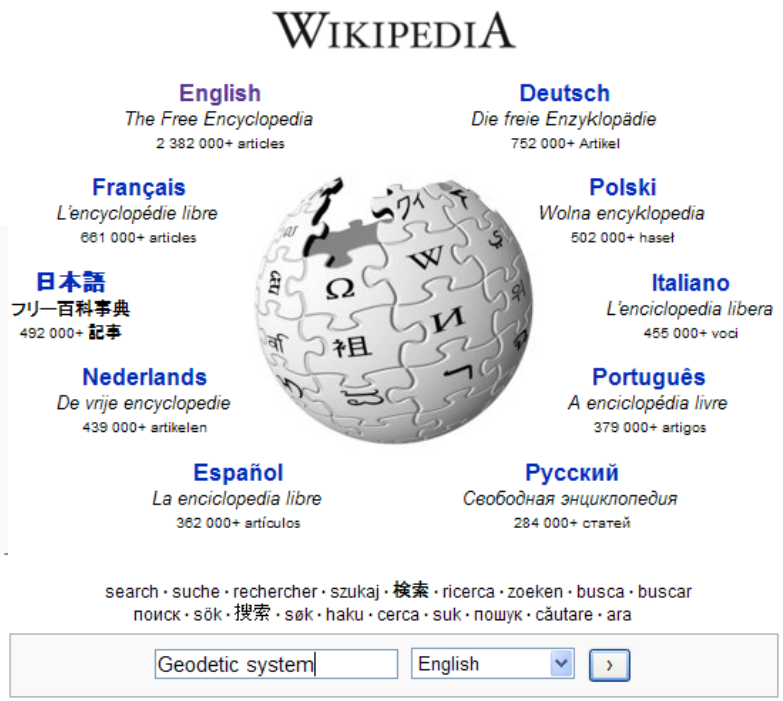
This code was written in *MATLAB*

Step 1: Convert GPS to ECEF

```
function [X,Y,Z] = llh2xyzTest(lat,long, h)
  % Convert lat, long, height in WGS84 to ECEF X,Y,Z
  %lat and long given in decimal degrees.
  lat = lat/180*pi; %converting to radians
  long = long/180*pi; %converting to radians
  a = 6378137.0; % earth semimajor axis in meters
  f = 1/298.257223563; % reciprocal flattening
  e2 = 2*f -f^2; % eccentricity squared

  chi = sqrt(1-e2*(sin(lat)).^2);
  X = (a./chi +h).*cos(lat).*cos(long);
  Y = (a./chi +h).*cos(lat).*sin(long);
  Z = (a*(1-e2)./chi + h).*sin(lat);
```

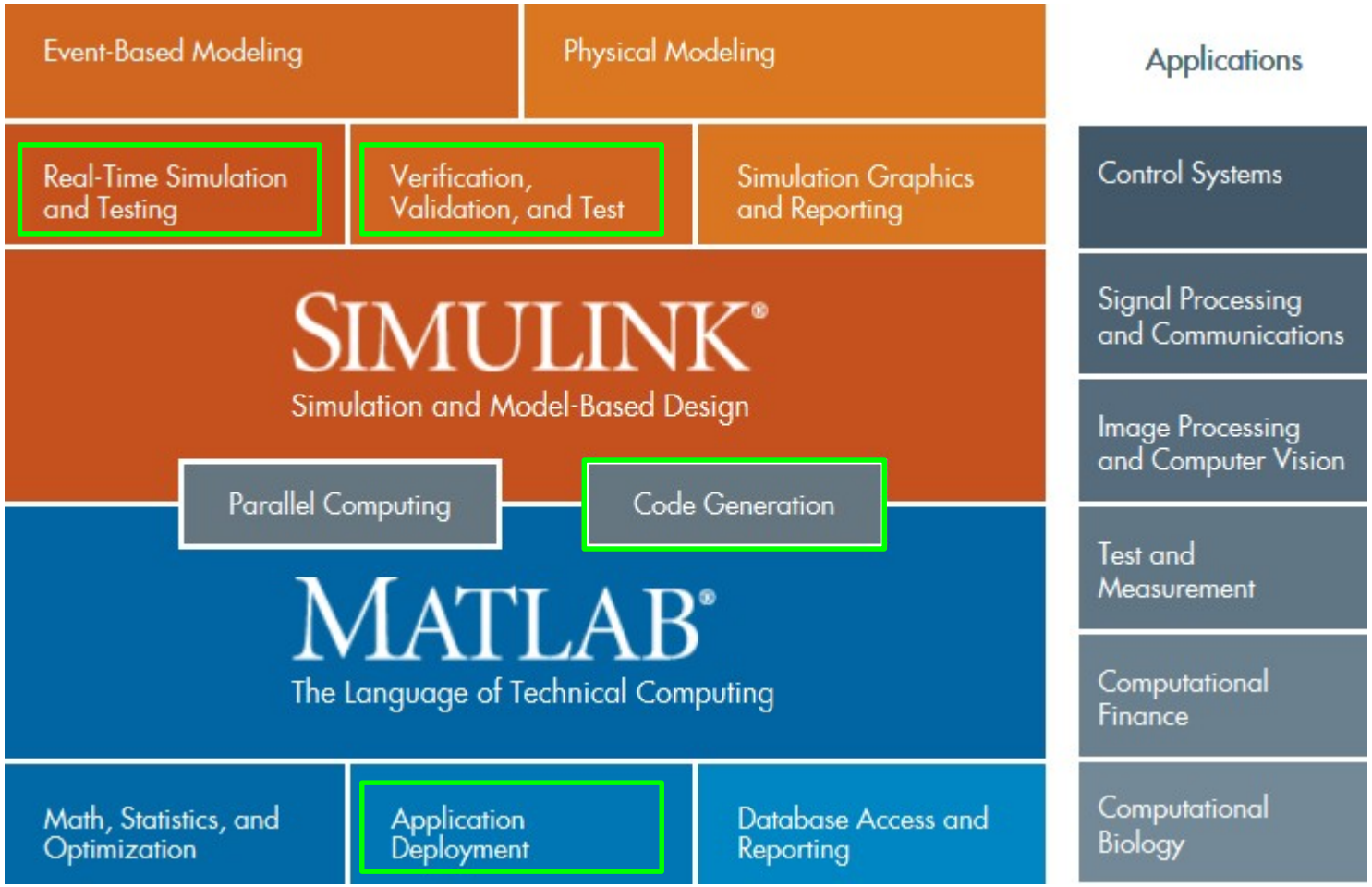
Step 2: Convert ECEF to ENU

```
function [e,n,u] = xyz2enuTest(Xr, Yr, Zr, X, Y, Z)
  % convert ECEF coordinates to local east, north, up

  phiP = atan2(Zr,sqrt(Xr^2 + Yr^2));
  lambda = atan2(Yr,Xr);

  e = -sin(lambda).*(X-Xr) + cos(lambda).*(Y-Yr);
  n = -sin(phiP).*cos(lambda).*(X-Xr) - sin(phiP).*sin(lambda).*(Y-Yr) + cos(phiP).*(Z-Zr);
  u = cos(phiP).*cos(lambda).*(X-Xr) + cos(phiP).*sin(lambda).*(Y-Yr) + sin(phiP).*(Z-Zr);
```



AIAA
Shaping the Future of Aerospace

MATLAB/Simulink: What's Next?



AIAA
Shaping the Future of Aerospace

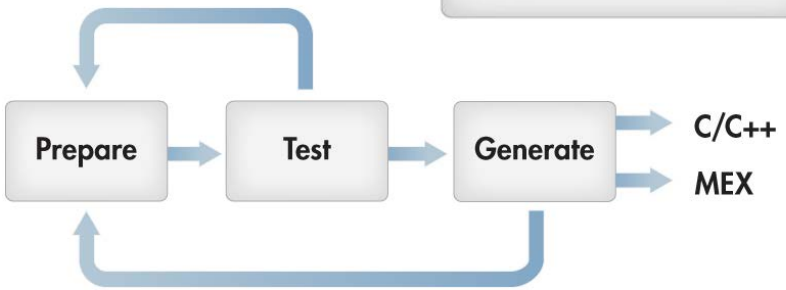
MATLAB Code Generation Tools

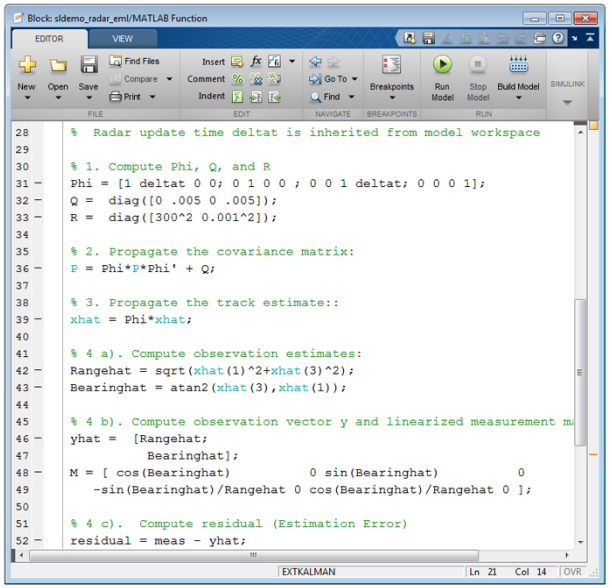
Integrate
algorithms with custom software

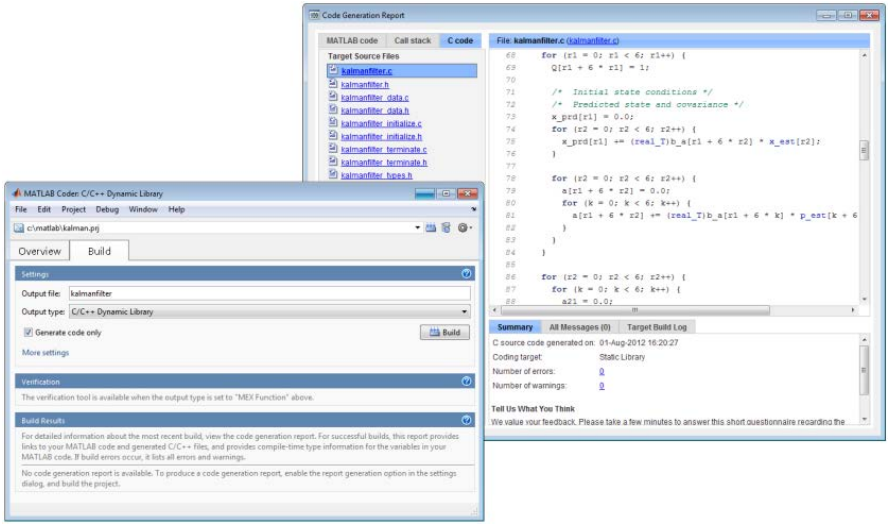
Prototype
algorithms on PCs

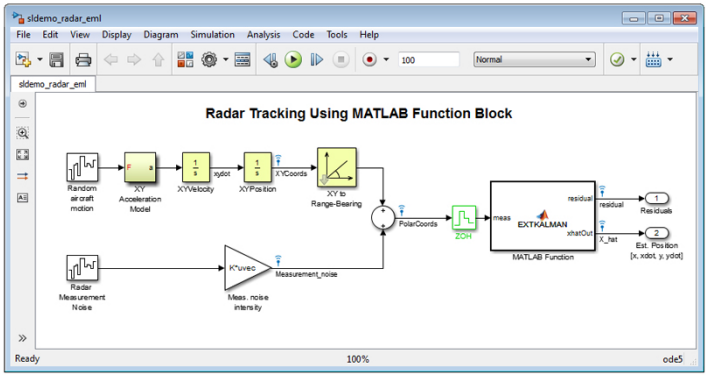
Accelerate
algorithm execution

Implement
algorithms on embedded processor

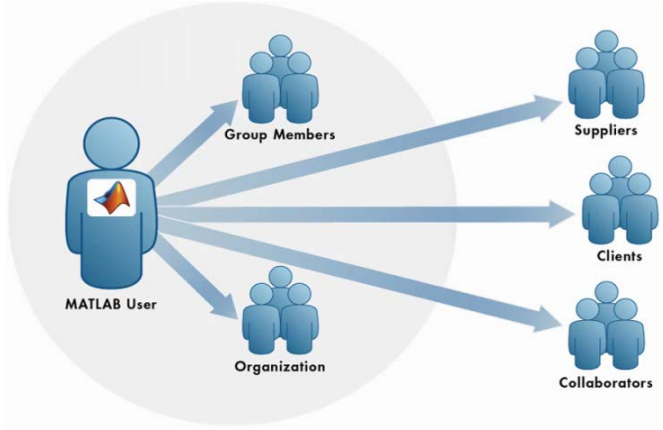


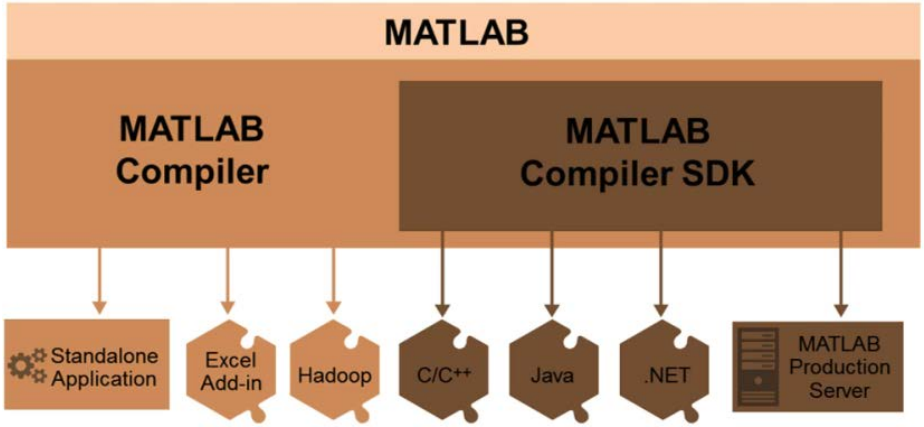


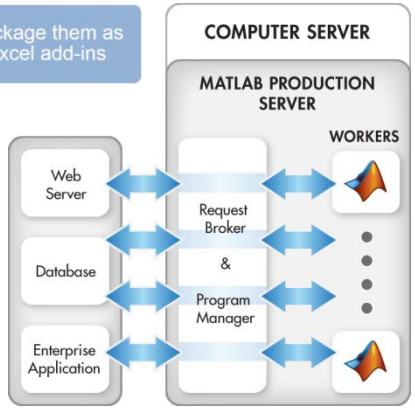




Application Deployment Tools

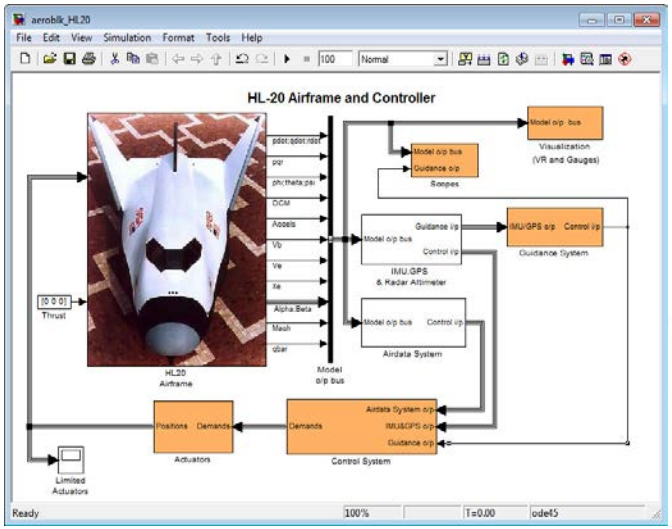


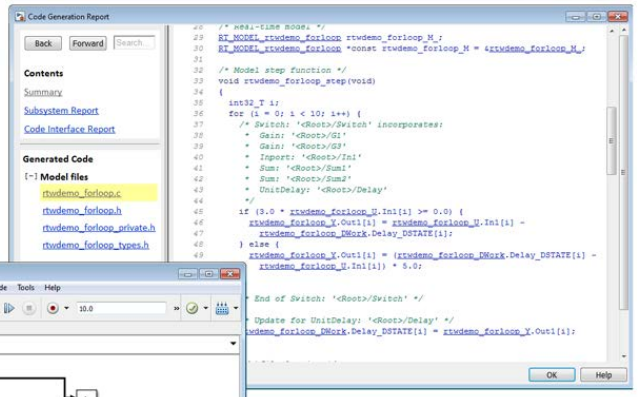


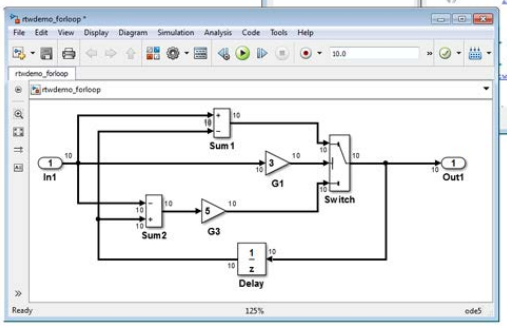


Shaping the Future of Aerospace

Simulink Coder & Simulink Real-Time

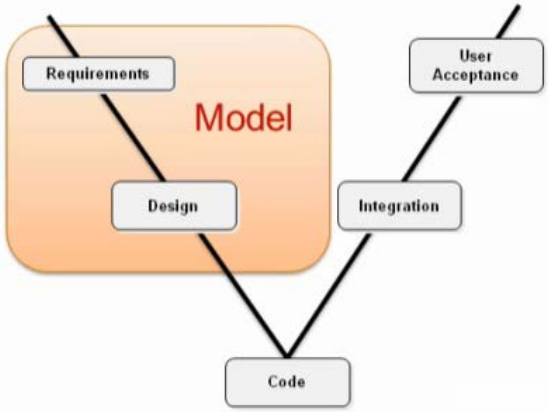


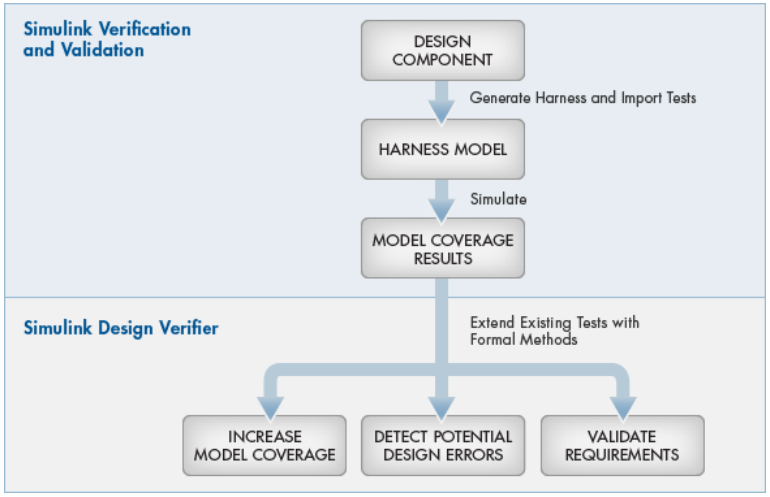


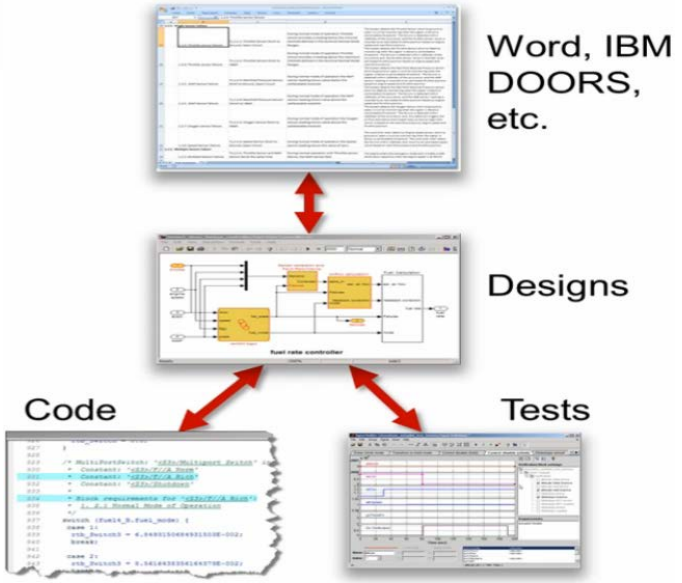


Simulink Model V&V Tools

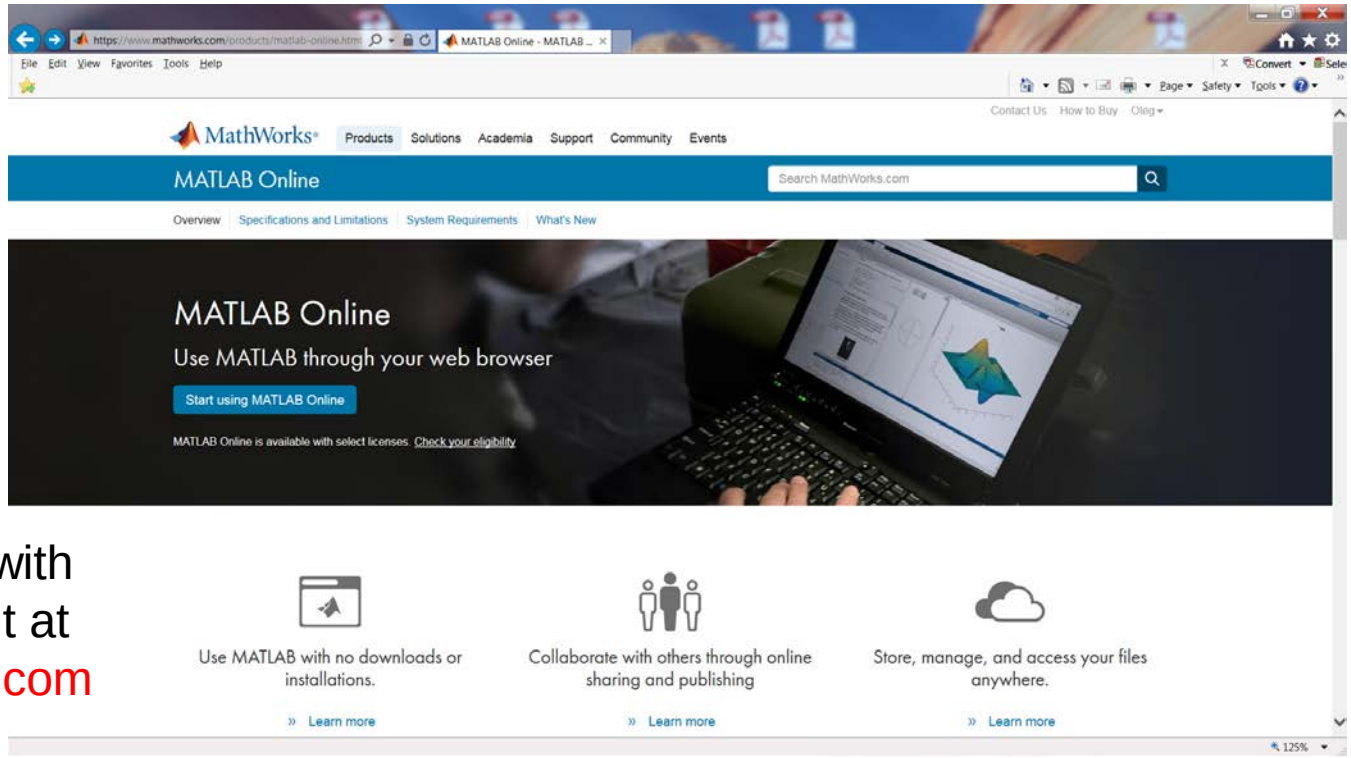
- Collaboration: modeling standards checks
- Track design changes: traceability analysis
- Structural verification: model coverage
- Formal verification:
  - test generation
  - static error detection
  - requirements proving







MATLAB Online



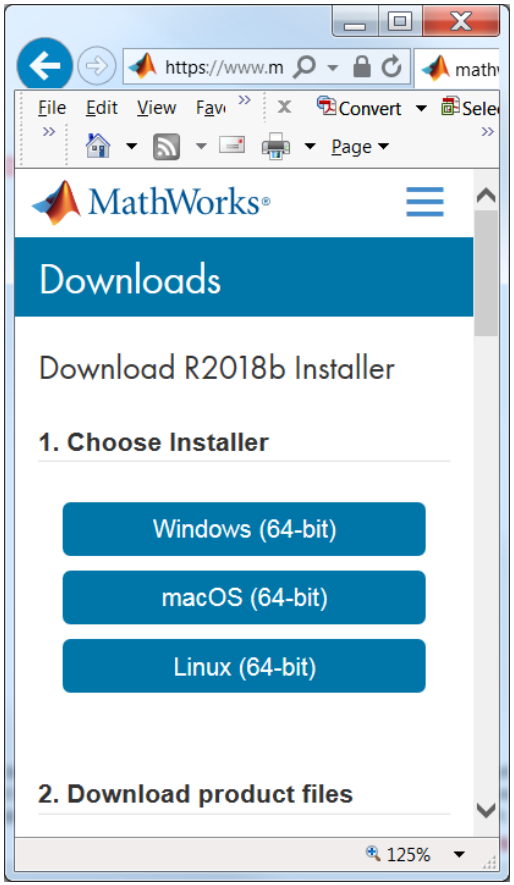
Access **MATLAB Online** with your Mathwork's account at www.matlab.mathworks.com

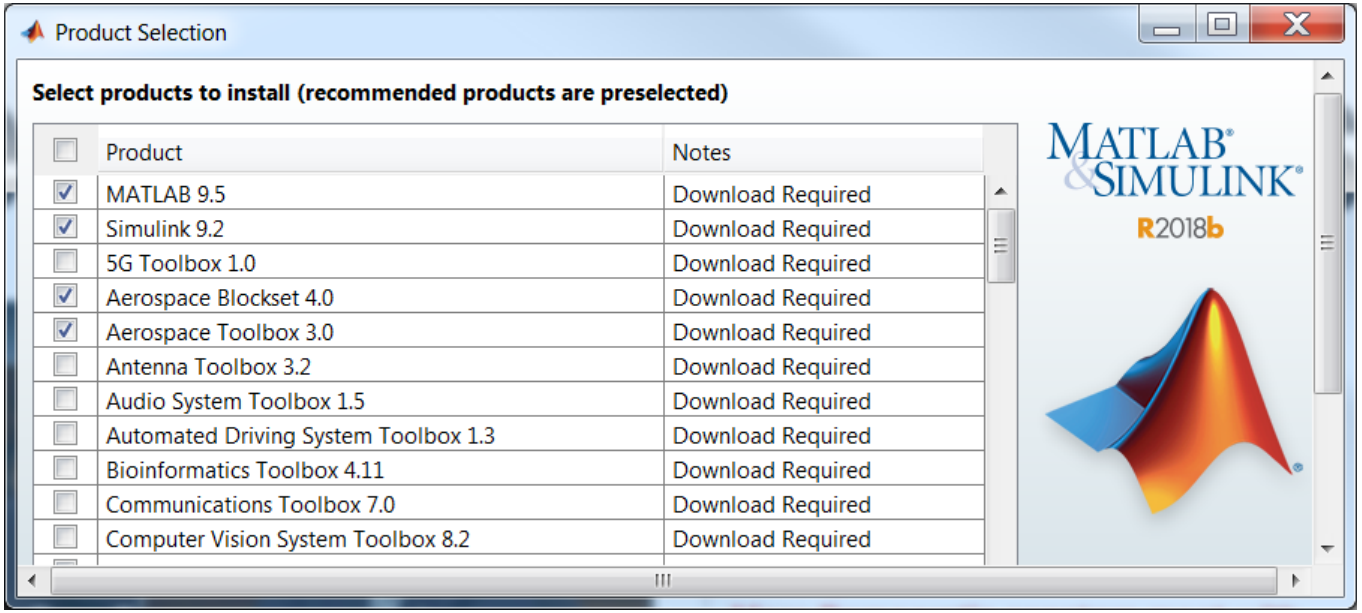
Enjoy Cloud Storage and Synchronization

- **MATLAB Drive** gives you up to 5Gb (250Gb free) to store, access, and manage your files from anywhere with MATLAB Online
- **MATLAB Drive Connector** enables synchronizing your files between your computers and MATLAB Online, eliminating the need for manual upload or download then

Installing MathWorks Products

www.mathworks.com/downloads/web_downloads/download_release?release=R20XXx





Between-release updates www.mathworks.com/downloads/web_downloads/download_update?release=R20XXx

Shaping the Future of Aerospace

The End of Chapter 1

Questions?