Aerospace Toolbox 2

User's Guide

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Aerospace Toolbox User's Guide

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Getting Started

What Is Aerospace Toolbox?

Aerospace Toolbox extends the MATLAB® technical computing environment by providing reference standards, environment models, and aerodynamic coefficient importing for performing advanced aerospace analysis to develop and evaluate your designs. Aerospace Toolbox provides the following to enable you to visualize flight data in a three-dimensional environment and reconstruct behavioral anomalies in flight-test results:

- Aero.Animation, Aero.Body, Aero.Camera, and Aero.Geometry objects and associated methods
- An interface to the FlightGear flight simulator
- An interface to Virtual Reality Toolbox

To ensure design consistency, Aerospace Toolbox provides utilities for unit conversions, coordinate transformations, and quaternion math, as well as standards-based environmental models for the atmosphere, gravity, and magnetic fields. You can import aerodynamic coefficients directly from the U.S. Air Force Digital Data Compendium (DATCOM) to carry out preliminary control design and vehicle performance analysis.

The toolbox provides you with the following main features:

- Provides standards-based environmental models for atmosphere, gravity, and magnetic fields.
- Converts units and transforms coordinate systems and spatial representations.
- Implements predefined utilities for aerospace parameter calculations, time calculations, and quaternion math.
- Imports aerodynamic coefficients directly from DATCOM.
- Interfaces to the FlightGear flight simulator, enabling visualization of vehicle dynamics in a three-dimensional environment.

Aerospace Toolbox can be used in applications such as aircraft technology, telemetry data reduction, flight control analysis, navigation analysis, visualization for flight simulation, and environmental modeling, and can help you perform the following tasks:

- Analyze, initialize, and visualize a broad range of large aerospace system architectures, including aircraft, missiles, spacecraft (probes, satellites, manned and unmanned), and propulsion systems (engines and rockets), while reducing development time.
- Support and define new requirements for aerospace systems.
- Perform complex calculations and analyze data to optimize and implement your designs.
- Test the performance of flight tests.

Aerospace Toolbox maintains and updates the algorithms, tables, and standard environmental models, eliminating the need to provide internal maintenance and verification of the models and reducing the cost of internal software maintenance.

Related Products

Aerospace Toolbox requires MATLAB.

In addition to Aerospace Toolbox, the Aerospace product family includes Aerospace Blockset. Aerospace Toolbox provides static data analysis capabilities, while Aerospace Blockset provides an environment for dynamic modeling and vehicle component modeling and simulation. Aerospace Blockset uses part of the functionality of Aerospace Toolbox as an engine. Use these products together to model aerospace systems in MATLAB and Simulink®.

Other related products are listed in the Aerospace Toolbox product page at the MathWorks Web site. They include toolboxes and blocksets that extend the capabilities of MATLAB and Simulink. These products will enhance your use of Aerospace Toolbox in various applications.

For more information about any MathWorks software products, see either

- The online documentation for that product if it is installed
- The MathWorks Web site at `www.mathworks.com`

Getting Online Help

In this section...

Exploring the Toolbox

A list of the toolbox functions is available to you by typing

```
help aero
```

You can view the code for any function by typing

```
type function_name
```

Using the MATLAB Help System for Documentation and Demos

The MATLAB Help browser allows you to access the documentation and demo models for all the MATLAB and Simulink based products that you have installed. The online Help includes an online index and search system.

Consult the Help for Using MATLAB section of the MATLAB Desktop Tools and Development Environment documentation for more information about the MATLAB Help system.

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Using Aerospace Toolbox

Defining Coordinate Systems

In this section...

Fundamental Coordinate System Concepts

Coordinate systems allow you to keep track of an aircraft or spacecraft's position and orientation in space. The Aerospace Toolbox coordinate systems are based on these underlying concepts from geodesy, astronomy, and physics.

Definitions

Aerospace Toolbox uses *right-handed* (RH) Cartesian coordinate systems. The *right-hand rule* establishes the *x-y-z* sequence of coordinate axes.

An *inertial frame* is a nonaccelerating motion reference frame. Loosely speaking, acceleration is defined with respect to the distant cosmos. In an inertial frame, Newton's second law (force = mass X acceleration) holds.

Strictly defined, an inertial frame is a member of the set of all frames not accelerating relative to one another. A *noninertial frame* is any frame accelerating relative to an inertial frame. Its acceleration, in general, includes both translational and rotational components, resulting in *pseudoforces* (*pseudogravity*, as well as *Coriolis* and *centrifugal forces*).

The toolbox models the Earth's shape (the *geoid*) as an oblate spheroid, a special type of ellipsoid with two longer axes equal (defining the *equatorial plane*) and a third, slightly shorter (*geopolar*) axis of symmetry. The equator is the intersection of the equatorial plane and the Earth's surface. The geographic poles are the intersection of the Earth's surface and the geopolar axis. In general, the Earth's geopolar and rotation axes are not identical.

Latitudes parallel the equator. Longitudes parallel the geopolar axis. The *zero longitude* or *prime meridian* passes through Greenwich, England.

Approximations

Aerospace Toolbox makes three standard approximations in defining coordinate systems relative to the Earth.

- The Earth's surface or geoid is an oblate spheroid, defined by its longer equatorial and shorter geopolar axes. In reality, the Earth is slightly deformed with respect to the standard geoid.
- The Earth's rotation axis and equatorial plane are perpendicular, so that the rotation and geopolar axes are identical. In reality, these axes are slightly misaligned, and the equatorial plane wobbles as the Earth rotates. This effect is negligible in most applications.
- The only noninertial effect in Earth-fixed coordinates is due to the Earth's rotation about its axis. This is a *rotating*, *geocentric* system. The toolbox ignores the Earth's motion around the Sun, the Sun's motion in the Galaxy, and the Galaxy's motion through cosmos. In most applications, only the Earth's rotation matters.

  This approximation must be changed for spacecraft sent into deep space, i.e., outside the Earth-Moon system, and a heliocentric system is preferred.

Motion with Respect to Other Planets

Aerospace Toolbox uses the standard WGS-84 geoid to model the Earth. You can change the equatorial axis length, the flattening, and the rotation rate.

You can represent the motion of spacecraft with respect to any celestial body that is well approximated by an oblate spheroid by changing the spheroid size, flattening, and rotation rate. If the celestial body is rotating westward (retrogradely), make the rotation rate negative.

Coordinate Systems for Modeling

Modeling aircraft and spacecraft is simplest if you use a coordinate system fixed in the body itself. In the case of aircraft, the forward direction is modified by the presence of wind, and the craft's motion through the air is not the same as its motion relative to the ground.

Body Coordinates

The noninertial body coordinate system is fixed in both origin and orientation to the moving craft. The craft is assumed to be rigid.

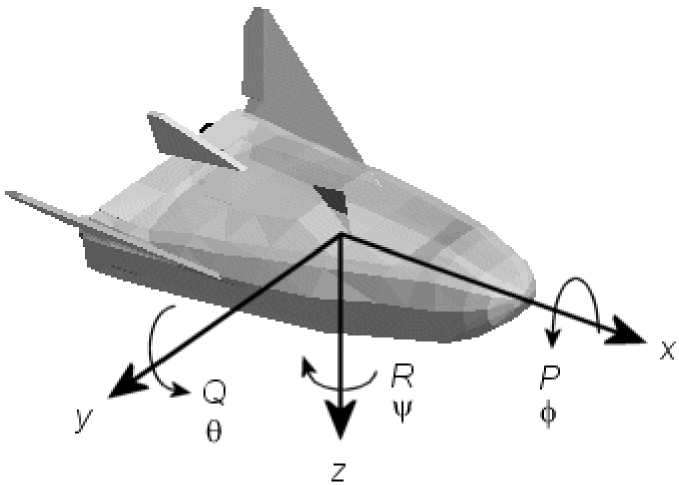
The orientation of the body coordinate axes is fixed in the shape of body.

- The x-axis points through the nose of the craft.
- The y-axis points to the right of the x-axis (facing in the pilot's direction of view), perpendicular to the x-axis.
- The z-axis points down through the bottom of the craft, perpendicular to the x-y plane and satisfying the RH rule.

Translational Degrees of Freedom. Translations are defined by moving along these axes by distances x, y, and z from the origin.

Rotational Degrees of Freedom. Rotations are defined by the Euler angles P, Q, R or Φ, Θ, Ψ. They are

- P or Φ: Roll about the x-axis
- Q or Θ: Pitch about the y-axis
- R or Ψ: Yaw about the z-axis



Wind Coordinates

The noninertial wind coordinate system has its origin fixed in the rigid aircraft. The coordinate system orientation is defined relative to the craft's velocity V.

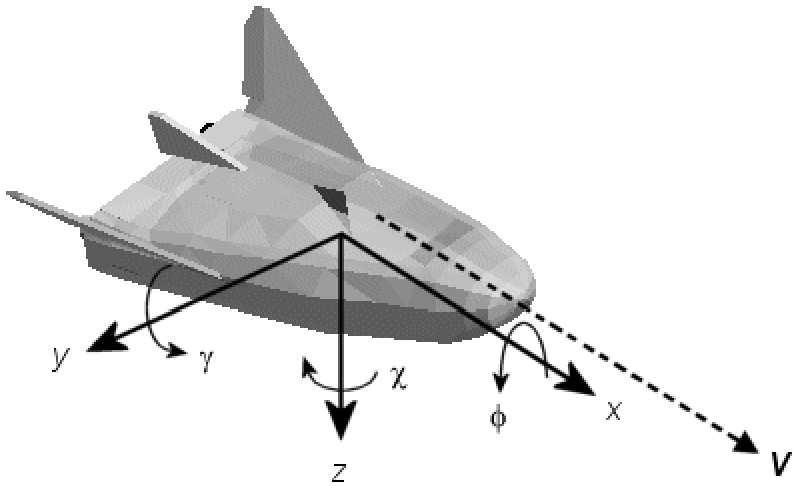
The orientation of the wind coordinate axes is fixed by the velocity V.

- The *x*-axis points in the direction of V.
- The *y*-axis points to the right of the *x*-axis (facing in the direction of V), perpendicular to the *x*-axis.
- The *z*-axis points perpendicular to the *x*-*y* plane in whatever way needed to satisfy the RH rule with respect to the *x*- and *y*-axes.

Translational Degrees of Freedom. Translations are defined by moving along these axes by distances *x*, *y*, and *z* from the origin.

Rotational Degrees of Freedom. Rotations are defined by the Euler angles Φ, γ, χ. They are

- Φ: Bank angle about the *x*-axis
- γ: Flight path about the *y*-axis
- χ: Heading angle about the *z*-axis



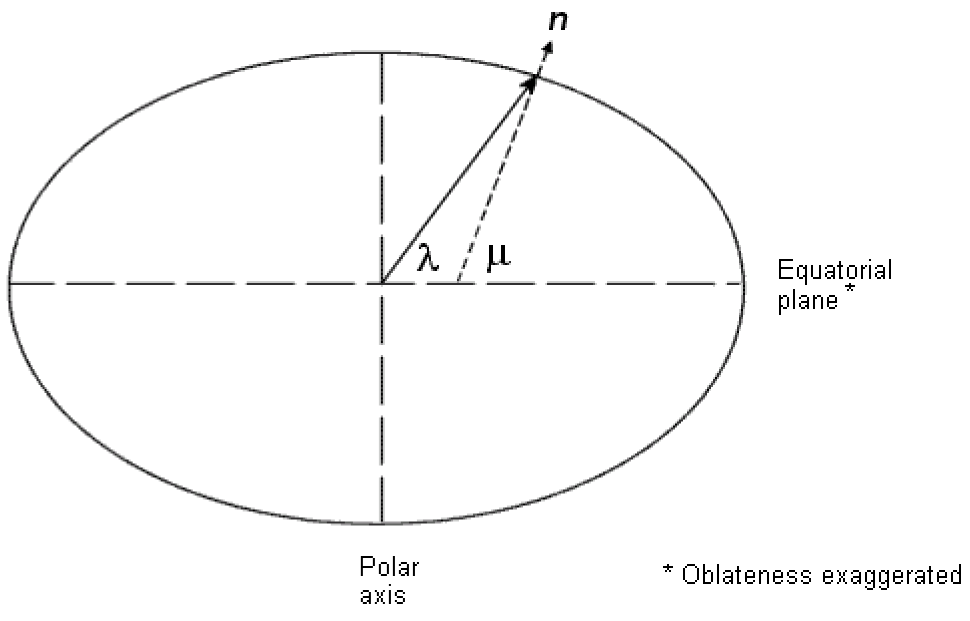
Coordinate Systems for Navigation

Modeling aerospace trajectories requires positioning and orienting the aircraft or spacecraft with respect to the rotating Earth. Navigation coordinates are defined with respect to the center and surface of the Earth.

Geocentric and Geodetic Latitudes

The *geocentric latitude* λ on the Earth's surface is defined by the angle subtended by the radius vector from the Earth's center to the surface point with the equatorial plane.

The *geodetic latitude* μ on the Earth's surface is defined by the angle subtended by the surface normal vector n and the equatorial plane.

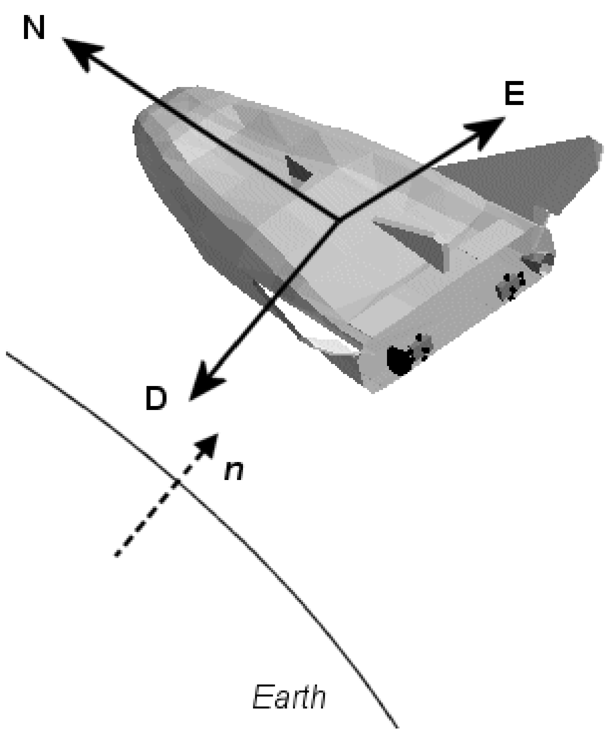


NED Coordinates

The north-east-down (NED) system is a noninertial system with its origin fixed at the aircraft or spacecraft's center of gravity. Its axes are oriented along the geodetic directions defined by the Earth's surface.

- The *x*-axis points north parallel to the geoid surface, in the polar direction.
- The *y*-axis points east parallel to the geoid surface, along a latitude curve.
- The *z*-axis points downward, toward the Earth's surface, antiparallel to the surface's outward normal *n*.

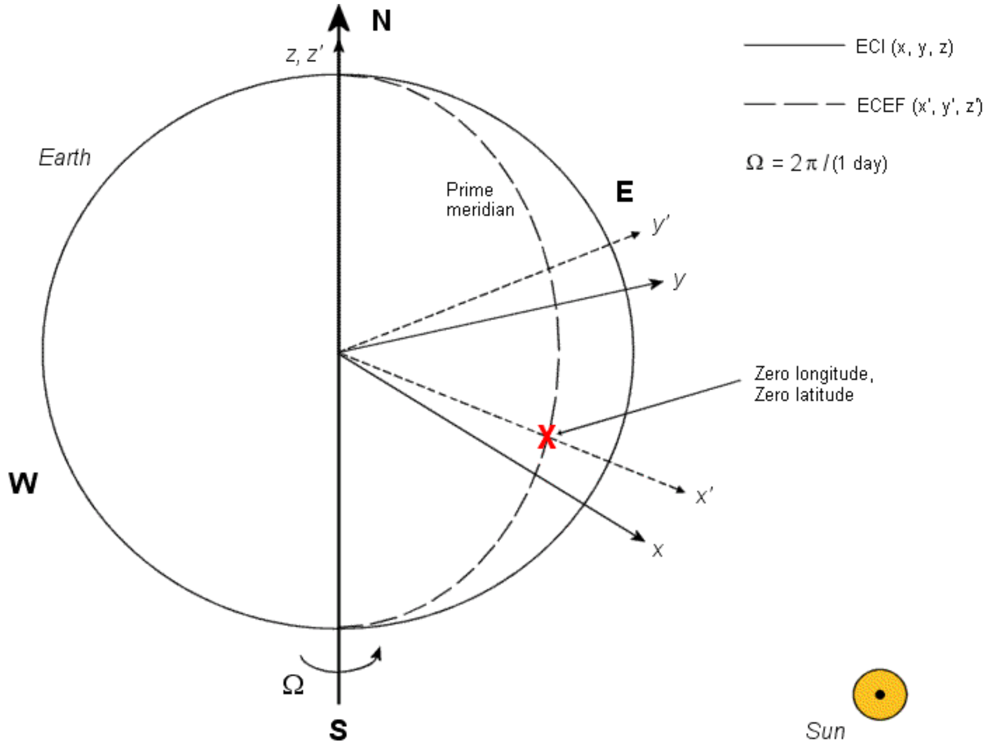
  Flying at a constant altitude means flying at a constant *z* above the Earth's surface.



ECI Coordinates

The Earth-centered inertial (ECI) system is a mixed inertial system. It is oriented with respect to the Sun. Its origin is fixed at the center of the Earth.

- The *z*-axis points northward along the Earth's rotation axis.
- The *x*-axis points outward in the Earth's equatorial plane exactly at the Sun. (This rule ignores the Sun's oblique angle to the equator, which varies with season. The actual Sun always remains in the *x*-*z* plane.)
- The *y*-axis points into the eastward quadrant, perpendicular to the *x*-*z* plane so as to satisfy the RH rule.



Earth-Centered Coordinates

ECEF Coordinates

The Earth-center, Earth-fixed (ECEF) system is a noninertial system that rotates with the Earth. Its origin is fixed at the center of the Earth.

- The *z*-axis points northward along the Earth's rotation axis.
- The *x*-axis points outward along the intersection of the Earth's equatorial plane and prime meridian.
- The *y*-axis points into the eastward quadrant, perpendicular to the *x*-*z* plane so as to satisfy the RH rule.

Coordinate Systems for Display

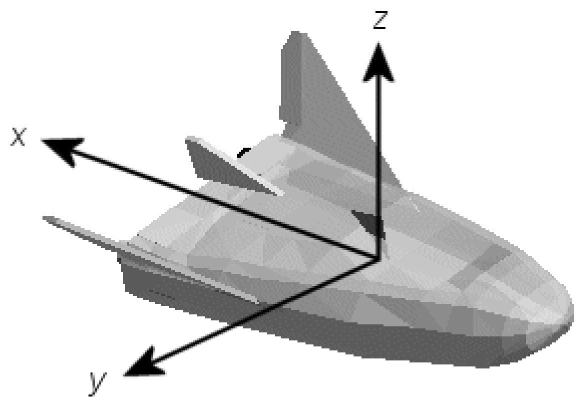
Aerospace Toolbox lets you use FlightGear coordinates for rendering motion.

FlightGear is an open-source, third-party flight simulator with an interface supported by Aerospace Toolbox.

- "Working with the Flight Simulator Interface" on page 2-53 discusses the toolbox interface to FlightGear.
- See the FlightGear documentation at www.flightgear.org for complete information about this flight simulator.

The FlightGear coordinates form a special body-fixed system, rotated from the standard body coordinate system about the *y*-axis by -180 degrees:

- The *x*-axis is positive toward the back of the vehicle.
- The *y*-axis is positive toward the right of the vehicle.
- The *z*-axis is positive upward, e.g., wheels typically have the lowest *z* values.



References

Recommended Practice for Atmospheric and Space Flight Vehicle Coordinate Systems, R-004-1992, ANSI/AIAA, February 1992.

Mapping Toolbox User's Guide, The MathWorks, Inc., Natick, Massachusetts. `www.mathworks.com/access/helpdesk/help/toolbox/map/`.

Rogers, R. M., *Applied Mathematics in Integrated Navigation Systems*, AIAA, Reston, Virginia, 2000.

Stevens, B. L., and F. L. Lewis, *Aircraft Control and Simulation*, 2nd ed., Wiley-Interscience, New York, 2003.

Thomson, W. T., *Introduction to Space Dynamics*, John Wiley & Sons, New York, 1961/Dover Publications, Mineola, New York, 1986.

World Geodetic System 1984 (WGS 84), `http://earth-info.nga.mil/GandG/wgs84`.

Defining Aerospace Units

Aerospace Toolbox functions support standard measurement systems. The Unit Conversion functions provide means for converting common measurement units from one system to another, such as converting velocity from feet per second to meters per second and vice versa.

The unit conversion functions support all units listed in this table.

Quantity	MKS (SI)	English
Acceleration	meters/second^2 (m/s^2), kilometers/second^2 (km/s^2), (kilometers/hour)/second (km/h-s), g-unit (*g*)	inches/second^2 (in/s^2), feet/second^2 (ft/s^2), (miles/hour)/second (mph/s), g-unit (*g*)
Angle	radian (rad), degree (deg), revolution	radian (rad), degree (deg), revolution
Angular acceleration	radians/second^2 (rad/s^2), degrees/second^2 (deg/s^2), revolutions/minute (rpm), revolutions/second (rps)	radians/second^2 (rad/s^2), degrees/second^2 (deg/s^2), revolutions/minute (rpm), revolutions/second (rps)
Angular velocity	radians/second (rad/s), degrees/second (deg/s), revolutions/minute (rpm)	radians/second (rad/s), degrees/second (deg/s), revolutions/minute (rpm)
Density	kilogram/meter^3 (kg/m^3)	pound mass/foot^3 (lbm/ft^3), slug/foot^3 (slug/ft^3), pound mass/inch^3 (lbm/in^3)
Force	newton (N)	pound (lb)
Inertia	kilogram-meter^2 (kg-m^2)	slug-foot^2 (slug-ft^2)
Length	meter (m)	inch (in), foot (ft), mile (mi), nautical mile (nm)

Quantity	MKS (SI)	English
Mass	kilogram (kg)	slug (slug), pound mass (lbm)
Pressure	pascal (Pa)	pound/inch^2 (psi), pound/foot^2 (psf), atmosphere (atm)
Temperature	kelvin (K), degrees Celsius (°C)	degrees Fahrenheit (°F), degrees Rankine (°R)
Torque	newton-meter (N-m)	pound-feet (lb-ft)
Velocity	meters/second (m/s), kilometers/second (km/s), kilometers/hour (km/h)	inches/second (in/sec), feet/second (ft/sec), feet/minute (ft/min), miles/hour (mph), knots

Importing Digital DATCOM Data

In this section...

Overview

Aerospace Toolbox enables bringing United States Air Force (USAF) Digital DATCOM files into MATLAB by using the `datcomimport` function. For more information, see the `datcomimport` function reference page. This section explains how to import data from a USAF Digital DATCOM file.

The example used in the following topics is available as an Aerospace Toolbox demo. You can run the demo either by entering `astimportddatcom` in the MATLAB Command Window or by finding the demo entry (Importing from USAF Digital DATCOM Files) in the Demos browser and clicking **Run in the Command Window** on its demo page.

Example of a USAF Digital DATCOM File

The following is a sample input file for USAF Digital DATCOM for a wing-body-horizontal tail-vertical tail configuration running over five alphas, two Mach numbers, and two altitudes and calculating static and dynamic derivatives. You can also view this file by entering `type astdatcom.in` in the MATLAB Command Window.

```
$FLTCON NMACH=2.0,MACH(1)=0.1,0.2$
$FLTCON NALT=2.0,ALT(1)=5000.0,8000.0$
$FLTCON NALPHA=5.,ALSCHD(1)=-2.0,0.0,2.0,
 ALSCHD(4)=4.0,8.0,LOOP=2.0$
$OPTINS SREF=225.8,CBARR=5.75,BLREF=41.15$
$SYNTHS XCG=7.08,ZCG=0.0,XW=6.1,ZW=-1.4,ALIW=1.1,XH=20.2,
```

```
   ZH=0.4,ALIH=0.0,XV=21.3,ZV=0.0,VERTUP=.TRUE.$
 $BODY NX=10.0,
   X(1)=-4.9,0.0,3.0,6.1,9.1,13.3,20.2,23.5,25.9,
   R(1)=0.0,1.0,1.75,2.6,2.6,2.6,2.0,1.0,0.0$
 $WGPLNF CHRDTP=4.0,SSPNE=18.7,SSPN=20.6,CHRDR=7.2,SAVSI=0.0,CHSTAT=0.25,
   TWISTA=-1.1,SSPNDD=0.0,DHDADI=3.0,DHDADO=3.0,TYPE=1.0$
NACA-W-6-64A412
 $HTPLNF CHRDTP=2.3,SSPNE=5.7,SSPN=6.625,CHRDR=0.25,SAVSI=11.0,
   CHSTAT=1.0,TWISTA=0.0,TYPE=1.0$
NACA-H-4-0012
 $VTPLNF CHRDTP=2.7,SSPNE=5.0,SSPN=5.2,CHRDR=5.3,SAVSI=31.3,
   CHSTAT=0.25,TWISTA=0.0,TYPE=1.0$
NACA-V-4-0012
CASEID SKYHOGG BODY-WING-HORIZONTAL TAIL-VERTICAL TAIL CONFIG
DAMP
NEXT CASE
```

The output file generated by USAF Digital DATCOM for the same wing-body-horizontal tail-vertical tail configuration running over five alphas, two Mach numbers, and two altitudes can be viewed by entering `type astdatcom.out` in the MATLAB Command Window.

Importing Data from DATCOM Files

Use the `datcomimport` function to bring the Digital DATCOM data into MATLAB.

```
alldata = datcomimport('astdatcom.out', true, 0);
```

Examining Imported DATCOM Data

The `datcomimport` function creates a cell array of structures containing the data from the Digital DATCOM output file.

```
data = alldata{1}
data =

        case: 'SKYHOGG BODY-WING-HORIZONTAL TAIL-VERTICAL TAIL CONFIG'
        mach: [0.1000 0.2000]
         alt: [5000 8000]
       alpha: [-2 0 2 4 8]
```

```
      nmach: 2
       nalt: 2
     nalpha: 5
      rnnub: []
     hypers: 0
       loop: 2
       sref: 225.8000
       cbar: 5.7500
      blref: 41.1500
        dim: 'ft'
      deriv: 'deg'
     stmach: 0.6000
     tsmach: 1.4000
       save: 0
      stype: []
       trim: 0
       damp: 1
      build: 1
       part: 0
    highsym: 0
    highasy: 0
    highcon: 0
       tjet: 0
     hypeff: 0
         lb: 0
        pwr: 0
       grnd: 0
      wsspn: 18.7000
      hsspn: 5.7000
     ndelta: 0
      delta: []
     deltal: []
     deltar: []
        ngh: 0
     grndht: []
     config: [1x1 struct]
         cd: [5x2x2 double]
         cl: [5x2x2 double]
         cm: [5x2x2 double]
         cn: [5x2x2 double]
```

```
            ca: [5x2x2 double]
           xcp: [5x2x2 double]
           cla: [5x2x2 double]
           cma: [5x2x2 double]
           cyb: [5x2x2 double]
           cnb: [5x2x2 double]
           clb: [5x2x2 double]
         qqinf: [5x2x2 double]
           eps: [5x2x2 double]
      depsdalp: [5x2x2 double]
           clq: [5x2x2 double]
           cmq: [5x2x2 double]
          clad: [5x2x2 double]
          cmad: [5x2x2 double]
           clp: [5x2x2 double]
           cyp: [5x2x2 double]
           cnp: [5x2x2 double]
           cnr: [5x2x2 double]
           clr: [5x2x2 double]
```

Filling in Missing DATCOM Data

By default, missing data points are set to 99999 and data points are set to NaN where no DATCOM methods exist or where the method is not applicable.

It can be seen in the Digital DATCOM output file and examining the imported data that $C_{Y\beta}$, $C_{n\beta}$, C_{lq}, and C_{mq} have data only in the first alpha value. Here are the imported data values.

```
data.cyb
ans(:,:,1) =

  1.0e+004 *

   -0.0000   -0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
```

```
ans(:,:,2) =

  1.0e+004 *

   -0.0000   -0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999

data.cnb
ans(:,:,1) =

  1.0e+004 *

    0.0000    0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999


ans(:,:,2) =

  1.0e+004 *

    0.0000    0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999

data.clq
ans(:,:,1) =

  1.0e+004 *

    0.0000    0.0000
    9.9999    9.9999
```

```
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999


ans(:,:,2) =

  1.0e+004 *

    0.0000    0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999

data.cmq
ans(:,:,1) =

  1.0e+004 *

   -0.0000   -0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999


ans(:,:,2) =

  1.0e+004 *

   -0.0000   -0.0000
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
    9.9999    9.9999
```

The missing data points will be filled with the values for the first alpha, since these data points are meant to be used for all alpha values.

```
aerotab = {'cyb' 'cnb' 'clq' 'cmq'};

for k = 1:length(aerotab)
    for m = 1:data.nmach
        for h = 1:data.nalt
            data.(aerotab{k})(:,m,h) = data.(aerotab{k})(1,m,h);
        end
    end
end
```

Here are the updated imported data values.

```
data.cyb
ans(:,:,1) =

   -0.0035   -0.0035
   -0.0035   -0.0035
   -0.0035   -0.0035
   -0.0035   -0.0035
   -0.0035   -0.0035


ans(:,:,2) =

   -0.0035   -0.0035
   -0.0035   -0.0035
   -0.0035   -0.0035
   -0.0035   -0.0035
   -0.0035   -0.0035

data.cnb
ans(:,:,1) =

  1.0e-003 *

    0.9142    0.8781
    0.9142    0.8781
    0.9142    0.8781
    0.9142    0.8781
    0.9142    0.8781
```

```
ans(:,:,2) =

  1.0e-003 *

    0.9190    0.8829
    0.9190    0.8829
    0.9190    0.8829
    0.9190    0.8829
    0.9190    0.8829

data.clq
ans(:,:,1) =

    0.0974    0.0984
    0.0974    0.0984
    0.0974    0.0984
    0.0974    0.0984
    0.0974    0.0984


ans(:,:,2) =

    0.0974    0.0984
    0.0974    0.0984
    0.0974    0.0984
    0.0974    0.0984
    0.0974    0.0984

data.cmq
ans(:,:,1) =

   -0.0892   -0.0899
   -0.0892   -0.0899
   -0.0892   -0.0899
   -0.0892   -0.0899
   -0.0892   -0.0899
```

```
ans(:,:,2) =

   -0.0892   -0.0899
   -0.0892   -0.0899
   -0.0892   -0.0899
   -0.0892   -0.0899
   -0.0892   -0.0899
```

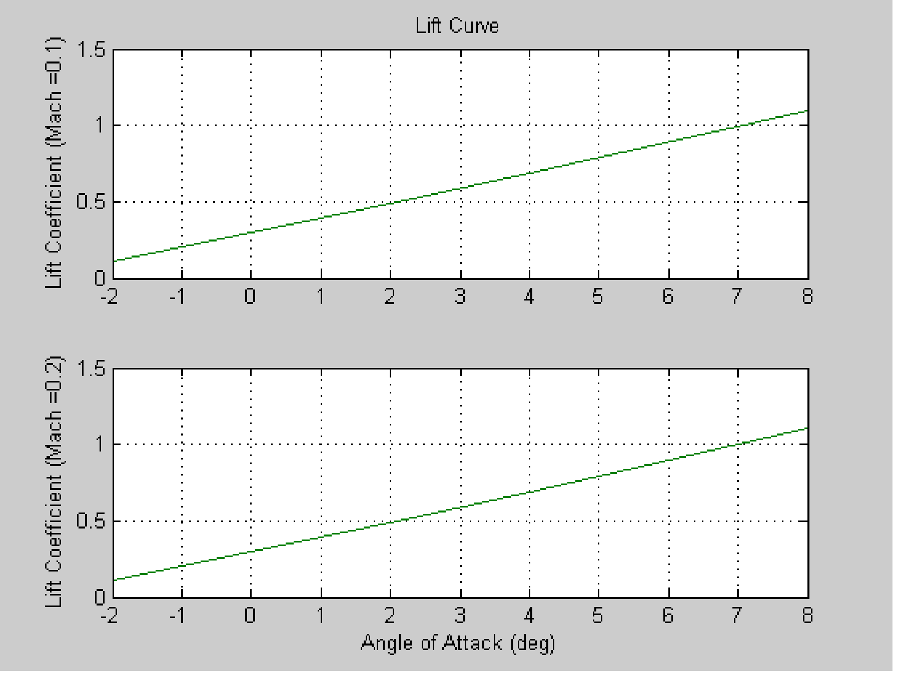
Plotting Aerodynamic Coefficients

You can now plot the aerodynamic coefficients:

- "Plotting Lift Curve Moments" on page 2-22
- "Plotting Drag Polar Moments" on page 2-23
- "Plotting Pitching Moments" on page 2-24

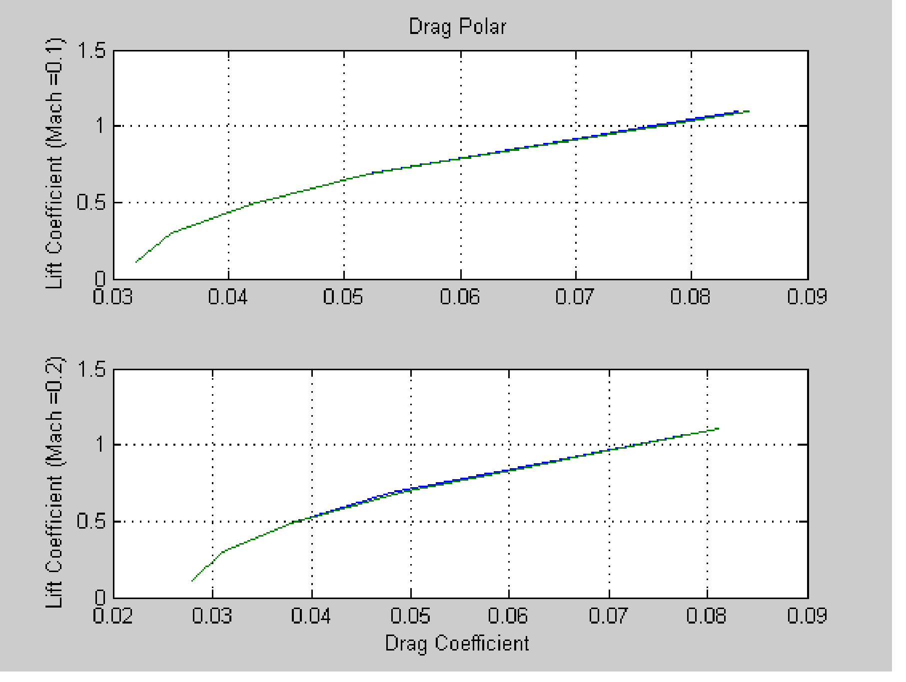
Plotting Lift Curve Moments

```
h1 = figure;
figtitle = {'Lift Curve' ''};
for k=1:2
    subplot(2,1,k)
    plot(data.alpha,permute(data.cl(:,k,:),[1 3 2]))
    grid
    ylabel(['Lift Coefficient (Mach =' num2str(data.mach(k)) ')'])
    title(figtitle{k});
end
xlabel('Angle of Attack (deg)')
```



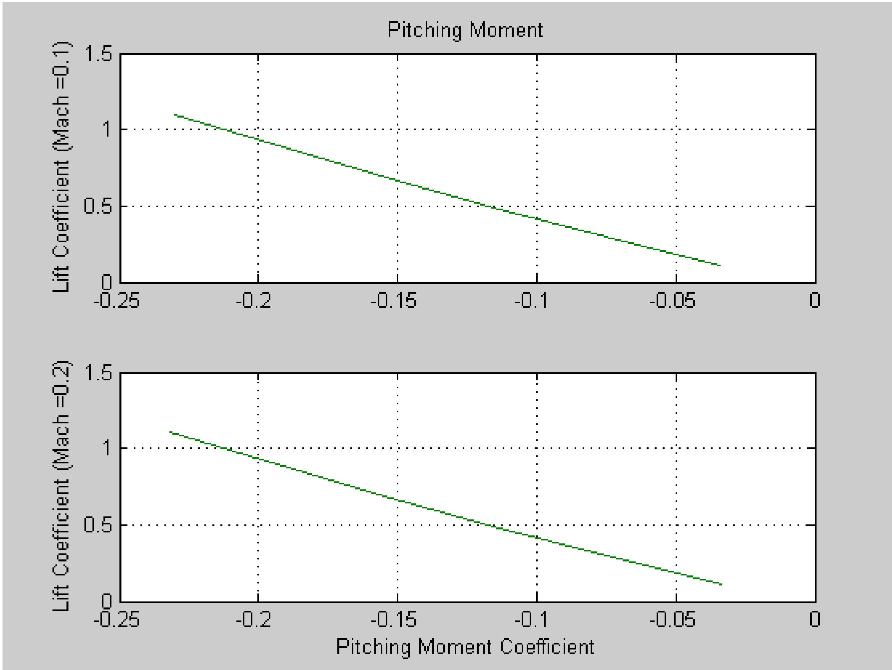
Plotting Drag Polar Moments

```
h2 = figure;
figtitle = {'Drag Polar' ''};
for k=1:2
    subplot(2,1,k)
    plot(permute(data.cd(:,k,:),[1 3 2]),permute(data.cl(:,k,:),[1 3 2]))
    grid
    ylabel(['Lift Coefficient (Mach =' num2str(data.mach(k)) ')'])
    title(figtitle{k})
end
xlabel('Drag Coefficient')
```



Plotting Pitching Moments

```
h3 = figure;
figtitle = {'Pitching Moment' ''};
for k=1:2
    subplot(2,1,k)
    plot(permute(data.cm(:,k,:),[1 3 2]),permute(data.cl(:,k,:),[1 3 2]))
    grid
    ylabel(['Lift Coefficient (Mach =' num2str(data.mach(k)) ')'])
    title(figtitle{k})
end
xlabel('Pitching Moment Coefficient')
```


Pitching Moment
Lift Coefficient (Mach =0.1)
1.5
1
0.5
0
-0.25
-0.2
-0.15
-0.1
-0.05
0
Lift Coefficient (Mach =0.2)
1.5
1
0.5
0
-0.25
-0.2
-0.15
-0.1
-0.05
0
Pitching Moment Coefficient

3-D Flight Data Playback

In this section...

Aerospace Toolbox Animation Objects

To visualize flight data in Aerospace Toolbox, you can use the following Aerospace Toolbox animation objects and their associated methods:

- `Aero.Animation` — You can use this animation object to visualize flight data without any other tool or toolbox. The following objects support this object.
  - `Aero.Body`
  - `Aero.Camera`
  - `Aero.Geometry`
- `Aero.VirtualRealityAnimation` — You can use this animation object to visualize flight data with Virtual Reality Toolbox. The following objects support this object.
  - `Aero.Node`
  - `Aero.Viewpoint`
- `Aero.FlightGearAnimation`

  You can use this animation object to visualize flight data with the FlightGear simulator.

Using Aero.Animation Objects

Aerospace Toolbox provides an interface to animation objects, implemented using MATLAB Handle Graphics®. The demo, Overlaying Simulated and Actual Flight Data (`astmlanim`), visually compares simulated and actual flight trajectory data. It does this by creating animation objects, creating bodies for those objects, and loading the flight trajectory data. This section describes what happens when the demo runs.

1 Create and configure an animation object.
   a Configure the animation object.
   b Create and load bodies for that object.
2 Load recorded data for flight trajectories.
3 Display body geometries in a figure window.
4 Play back flight trajectories using the animation object.
5 Manipulate the camera.
6 Manipulate bodies, as follows:
   a Move and reposition bodies.
   b Create a transparency in the first body.
   c Change the color of the second body.
   d Turn off the landing gear of the second body.

Running the Demo

1 Start MATLAB.
2 Run the demo either by entering `astmlanim` in the MATLAB Command Window or by finding the demo entry (Overlaying Simulated and Actual Flight Data) in the Demos browser and clicking **Run in the Command Window** on its demo page.

   While running, the demo performs several steps by issuing a series of commands, as explained below.

Creating and Configuring an Animation Object

This series of commands creates an animation object and configures the object.

1 Create an animation object.

```
h = Aero.Animation;
```

2 Configure the animation object to set the number of frames per second (`FramesPerSecond`) property. This controls the rate at which frames are displayed in the figure window.

```
h.FramesPerSecond = 10;
```

3 Configure the animation object to set the seconds of animation data per second time scaling (`TimeScaling`) property.

```
h.TimeScaling = 5;
```

The combination of `FramesPerSecond` and `TimeScaling` property determine the time step of the simulation. The settings in this demo result in a time step of approximately 0.5 s.

4 Create and load bodies for the animation object. The demo will use these bodies to work with and display the simulated and actual flight trajectories. The first body is orange; it represents simulated data. The second body is blue; it represents the actual flight data.

```
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
idx2 = h.createBody('pa24-250_blue.ac','Ac3d');
```

Both bodies are AC3D format files. AC3D is one of several file formats that the animation objects support. FlightGear uses the same file format. The animation object reads in the bodies in the AC3D format and stores them as patches in the geometry object within the animation object.

Loading Recorded Data for Flight Trajectories

This series of commands loads the recorded flight trajectory data, which is contained in files in the *`matlabroot`*`\toolbox\aero\astdemos` directory.

- `simdata` – Contains simulated flight trajectory data, which is set up as a 6DoF array.
- `fltdata` – Contains actual flight trajectory data, which is set up in a custom format. To access this custom format data, the demo needs to set the body object **TimeSeriesSourceType** parameter to `Custom`, then specify a custom read function.

1 Load the flight trajectory data.

```
load simdata
load fltdata
```

2 Set the time series data for the two bodies.

```
h.Bodies{1}.TimeSeriesSource = simdata;
h.Bodies{2}.TimeSeriesSource = fltdata;
```

3 Identify the time series for the second body as custom.

```
h.Bodies{2}.TimeSeriesSourceType = 'Custom';
```

4 Specify the custom read function to access the data in `fltdata` for the second body. The demo provides the custom read function in *`matlabroot`*`\toolbox\aero\astdemos\CustomReadBodyTSData.m`.

```
h.Bodies{2}.TimeseriesReadFcn = @CustomReadBodyTSData;
```

Displaying Body Geometries in a Figure Window

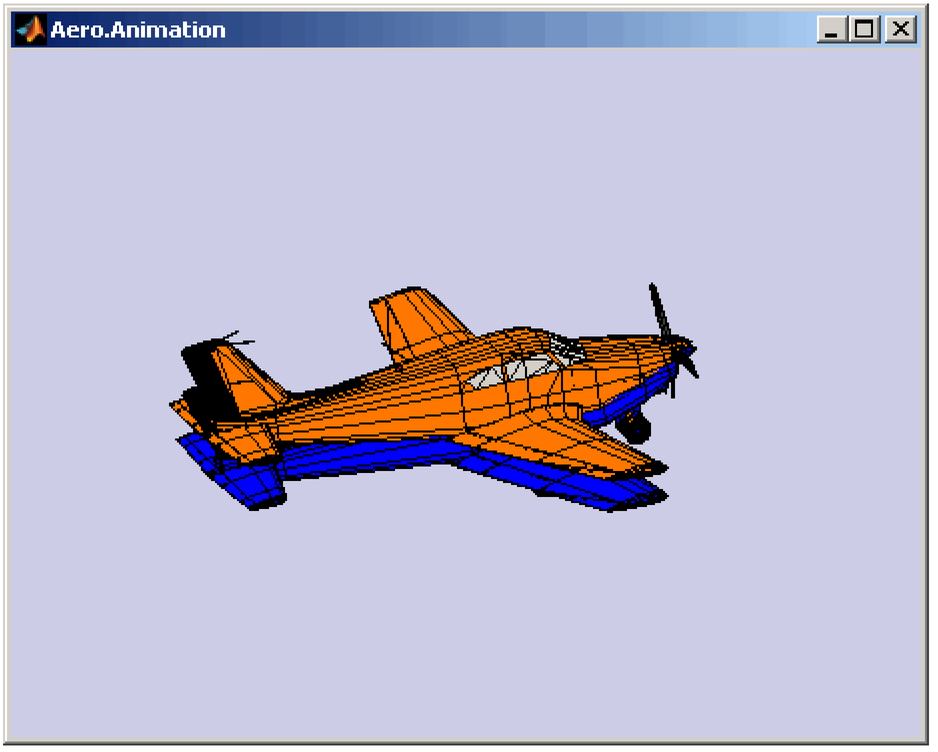
This command creates a figure object for the animation object.

```
h.show();
```

Playing Back Flight Trajectories Using the Animation Object

This command plays the animation bodies for the duration of the time series data. This illustrates the differences between the simulated and actual flight data.

```
h.play();
```



Manipulating the Camera

This command series describes how you can manipulate the camera on the two bodies, and redisplay the animation. The `PositionFcn` property of a camera object controls the camera position relative to the bodies in the animation. In the section "Playing Back Flight Trajectories Using the Animation Object" on page 2-29, the camera object uses a default value for the `PositionFcn` property. In this command series, the demo references a custom `PositionFcn` function, which uses a static position based on the position of the bodies; no dynamics are involved. The custom `PositionFcn` function is located in the *`matlabroot`*`\toolbox\aero\astdemos` directory.

1. Set the camera `PositionFcn` to the custom function `staticCameraPosition`.

```
h.Camera.PositionFcn = @staticCameraPosition;
```

2 Run the animation again.

```
h.play();
```

Manipulating Bodies

This section illustrates some of the actions you can perform on bodies.

Moving and Repositioning Bodies. This series of commands illustrates how to move and reposition bodies.

1 Set the starting time to 0.

```
t = 0;
```

2 Move the body to the starting position that is based on the time series data. Use the Aero.Animation object `updateBodies` method.

```
h.updateBodies(t);
```

3 Update the camera position using the custom `PositionFcn` function set in the previous section. Use the Aero.Animation object `updateCamera` method.

```
h.updateCamera(t);
```

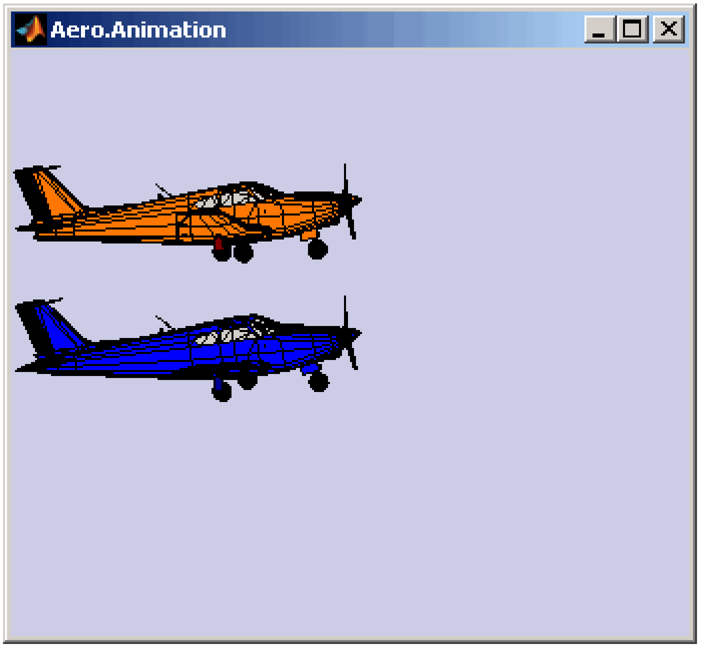
4 Reposition the bodies by first getting the current body position, then separating the bodies.

   a Get the current body positions and rotations from the objects of both bodies.

   ```
   pos1 = h.Bodies{1}.Position;
   rot1 = h.Bodies{1}.Rotation;
   pos2 = h.Bodies{2}.Position;
   rot2 = h.Bodies{2}.Rotation;
   ```

   b Separate and reposition the bodies by moving them to new positions.

   ```
   h.moveBody(1,pos1 + [0 0 -3],rot1);
   h.moveBody(2,pos1 + [0 0  0],rot2);
   ```



Creating a Transparency in the First Body. This series of commands illustrates how to create and attach a transparency to a body. The animation object stores the body geometry as patches. This example manipulates the transparency properties of these patches (see "Creating 3-D Models with Patches" in the MATLAB documentation).

Note The use of transparencies might decrease animation speed on platforms that use software OpenGL rendering (see `opengl` in the MATLAB documentation).

---

1 Change the body patch properties. Use the Aero.Body `PatchHandles` property to get the patch handles for the first body.

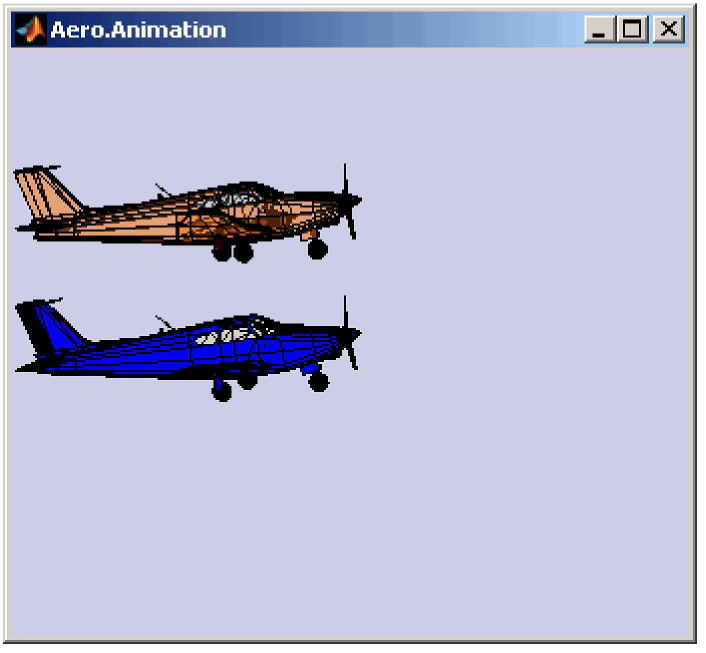
```
patchHandles2 = h.Bodies{1}.PatchHandles;
```

2 Set the desired face and edge alpha values for the transparency.

```
desiredFaceTransparency = .3;
desiredEdgeTransparency = 1;
```

3 Get the current face and edge alpha data and change all values to the desired alpha values. In the figure, note the first body now has a transparency.

```
for k = 1:size(patchHandles2,1)
    tempFaceAlpha = get(patchHandles2(k),'FaceVertexAlphaData');
    tempEdgeAlpha = get(patchHandles2(k),'EdgeAlpha');
    set(patchHandles2(k),...
        'FaceVertexAlphaData',repmat(desiredFaceTransparency,size(tempFaceAlpha)));
    set(patchHandles2(k),...
        'EdgeAlpha',repmat(desiredEdgeTransparency,size(tempEdgeAlpha)));
end
```



Changing the Color of the Second Body. This series of commands illustrates how to change the color of a body. The animation object stores the body geometry as patches. This example will manipulate the `FaceVertexColorData` property of these patches.

1 Change the body patch properties. Use the Aero.Body `PatchHandles` property to get the patch handles for the first body.

```
patchHandles3 = h.Bodies{2}.PatchHandles;
```

2 Set the patch color to red.

```
desiredColor = [1 0 0];
```

3 Get the current face color and data and propagate the new patch color, red, to the face. Note the following:

- The `if` condition prevents the windows from being colored.
- The `name` property is stored in the body geometry data (`h.Bodies{2}.Geometry.FaceVertexColorData(k).name`).
- The code changes only the indices in `patchHandles3` with nonwindow counterparts in the body geometry data.

Note If you cannot access the `name` property to determine the parts of the vehicle to color, you must use an alternative way to selectively color your vehicle.

```
for k = 1:size(patchHandles3,1)
    tempFaceColor = get(patchHandles3(k),'FaceVertexCData');
    tempName = h.Bodies{2}.Geometry.FaceVertexColorData(k).name;
    if isempty(strfind(tempName,'Windshield')) &&...
       isempty(strfind(tempName,'front-windows')) &&...
       isempty(strfind(tempName,'rear-windows'))
    set(patchHandles3(k),...
        'FaceVertexCData',repmat(desiredColor,[size(tempFaceColor,1),1]));
    end
end
```

Turning Off the Landing Gear of the Second Body. This command series illustrates how to turn off the landing gear on the second body by turning off the visibility of all the vehicle parts associated with the landing gear.

Note The indices into the `patchHandles3` vector are determined from the `name` property. If you cannot access the `name` property to determine the indices, you must use an alternative way to determine the indices that correspond to the geometry parts.

```
for k = [1:8,11:14,52:57]
    set(patchHandles3(k),'Visible','off')
end
```

Using Aero.VirtualRealityAnimation Objects

Aerospace Toolbox provides an interface to virtual reality animation objects, using Virtual Reality Toolbox. See `Aero.VirtualRealityAnimation`, `Aero.Node`, and `Aero.Viewpoint` for details.

1. Create and configure an animation object.
   a. Configure the animation object.
   b. Initialize that object.
2. Enable the tracking of changes to virtual worlds.
3. Load the animation world.
4. Load time series data for simulation.
5. Set coordination information for the object.
6. Add a chase helicopter to the object.
7. Load time series data for chase helicopter simulation.
8. Set coordination information for the new object.
9. Add a new viewpoint for the helicopter.

10 Play the animation.

11 Create a new viewpoint.

12 Add a route.

13 Add another helicopter.

14 Remove bodies.

15 Revert to the original world.

Running the Demo

1 Start MATLAB.

2 Run the demo either by entering `astvranim` in the MATLAB Command Window or by finding the demo entry (Visualize Aircraft Takeoff via the Virtual Reality Toolbox) in the Demos browser and clicking **Run in the Command Window** on its demo page.

   While running, the demo performs several steps by issuing a series of commands, as explained below.

Creating and Configuring a Virtual Reality Animation Object

This series of commands creates an animation object and configures the object.

1 Create an animation object.

```
h = Aero.VirtualRealityAnimation;
```

2 Configure the animation object to set the number of frames per second (`FramesPerSecond`) property. This controls the rate at which frames are displayed in the figure window.

```
h.FramesPerSecond = 10;
```

3 Configure the animation object to set the seconds of animation data per second time scaling (`TimeScaling`) property.

```
h.TimeScaling = 5;
```

The combination of FramesPerSecond and TimeScaling property determine the time step of the simulation. The settings in this demo result in a time step of approximately 0.5 s.

4 Specify the .wrl file for the vrworld object.

```
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
```

The virtual reality animation object reads in the .wrl file.

Enabling Aero.VirtualRealityAnimation Methods to Track Changes to Virtual Worlds

Aero.VirtualRealityAnimation methods that change the current virtual reality world use a temporary .wrl file to manage those changes. To enable these methods to work in a write-protected directory such as astdemos, type the following.

1 Copy the virtual world file, vrtkoff.wrl, to a temporary directory.

```
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
```

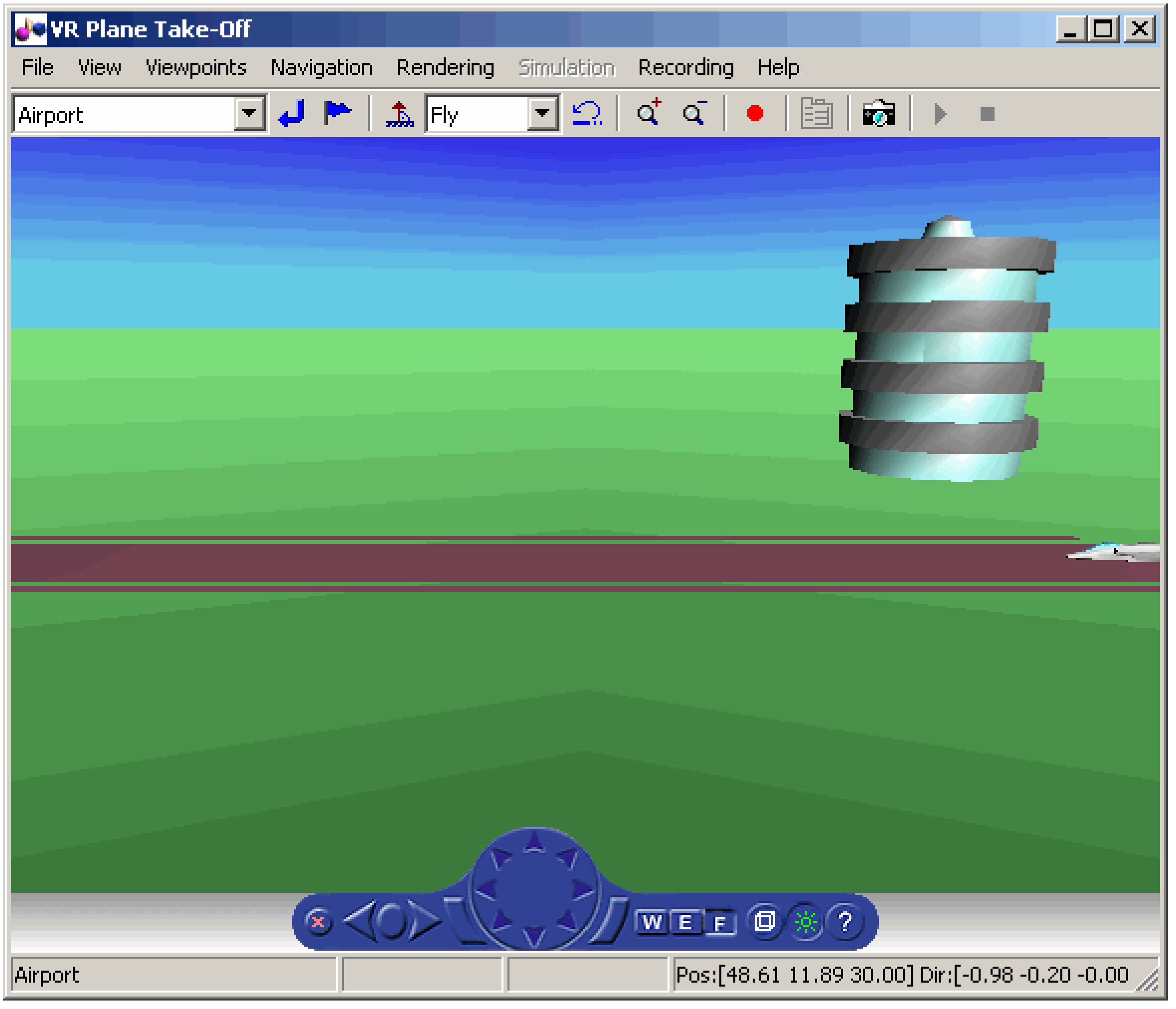
2 Set the vrtkoff.wrl world filename to the copied .wrl file.

```
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
```

Loading the Animation World

Load the animation world described in the VRWorldFilename field of the animation object. When parsing the world, this method creates node objects for existing nodes with DEF names. The initialize method also opens the Virtual Reality Toolbox Viewer.

```
h.initialize();
```



Displaying Figures

While working with this demo, you can capture a view of a scene with the `takeVRCapture` tool. This tool is specific to the `astvranim` demo. To display the initial scene, type

```
takeVRCapture(h.VRFigure);
```

A MATLAB figure window displays with the initial scene.

Loading Time Series Data for Simulation

To prepare for simulation, set the simulation time series data. `takeoffData.mat` contains logged simulated data that you can use to set the time series data. `takeoffData` is set up as the Simulink structure`'StructureWithTime'`, which is a default data format.

1 Load the `takeoffData`.

```
load takeoffData
```

2 Set the time series data for the node.

```
h.Nodes{7}.TimeseriesSource = takeoffData;
h.Nodes{7}.TimeseriesSourceType = 'StructureWithTime';
```

Aligning the Position and Rotation Data with Surrounding Virtual World Objects

The virtual reality animation object expects positions and rotations in aerospace body coordinates. If the input data coordinate system is different, as is the case in this demo, you must create a coordinate transformation function to correctly line up the position and rotation data with the surrounding objects in the virtual world. This code should set the coordinate transformation function for the virtual reality animation. The custom transfer function for this demo is *`matlabroot`*`/toolbox/aero/astdemos/vranimCustomTransform.m`. In this demo, if the input translation coordinates are `[x1,y1,z1]`, the custom transform function must adjust them as:

```
[X,Y,Z] = -[y1,x1,z1]
```

To run this custom transformation function, type:

```
h.Nodes{7}.CoordTransformFcn = @vranimCustomTransform;
```

Viewing the Nodes in a Virtual Reality Animation Object

While working with this demo, you can view all the nodes currently in the virtual reality animation object with the `nodeInfo` method.

```
h.nodeInfo;
```

This method displays the nodes currently in your demo:

```
Node Information
1 _v1
2 Lighthouse
3 _v3
4 Terminal
5 Block
6 _V2
7 Plane
8 Camera1
```

Adding a Chase Helicopter

As part of the demo, add a chase helicopter node to your demo. Use the `addNode` method to add another node to the virtual reality animation object.

Note By default, each time you add or remove a node, or when you call the `saveas` method, Aerospace Toolbox displays a message about the current `.wrl` file location. To disable this message, set the `'ShowSaveWarning'` property in the virtual reality animation object. You can disable this message before adding the chase helicopter.

---

1 Disable the message.

```
h.ShowSaveWarning = false;
```

2 Add the chase helicopter node.

```
h.addNode('Lynx',[matlabroot,'/toolbox/aero/astdemos/chaseHelicopter.wrl']);
```

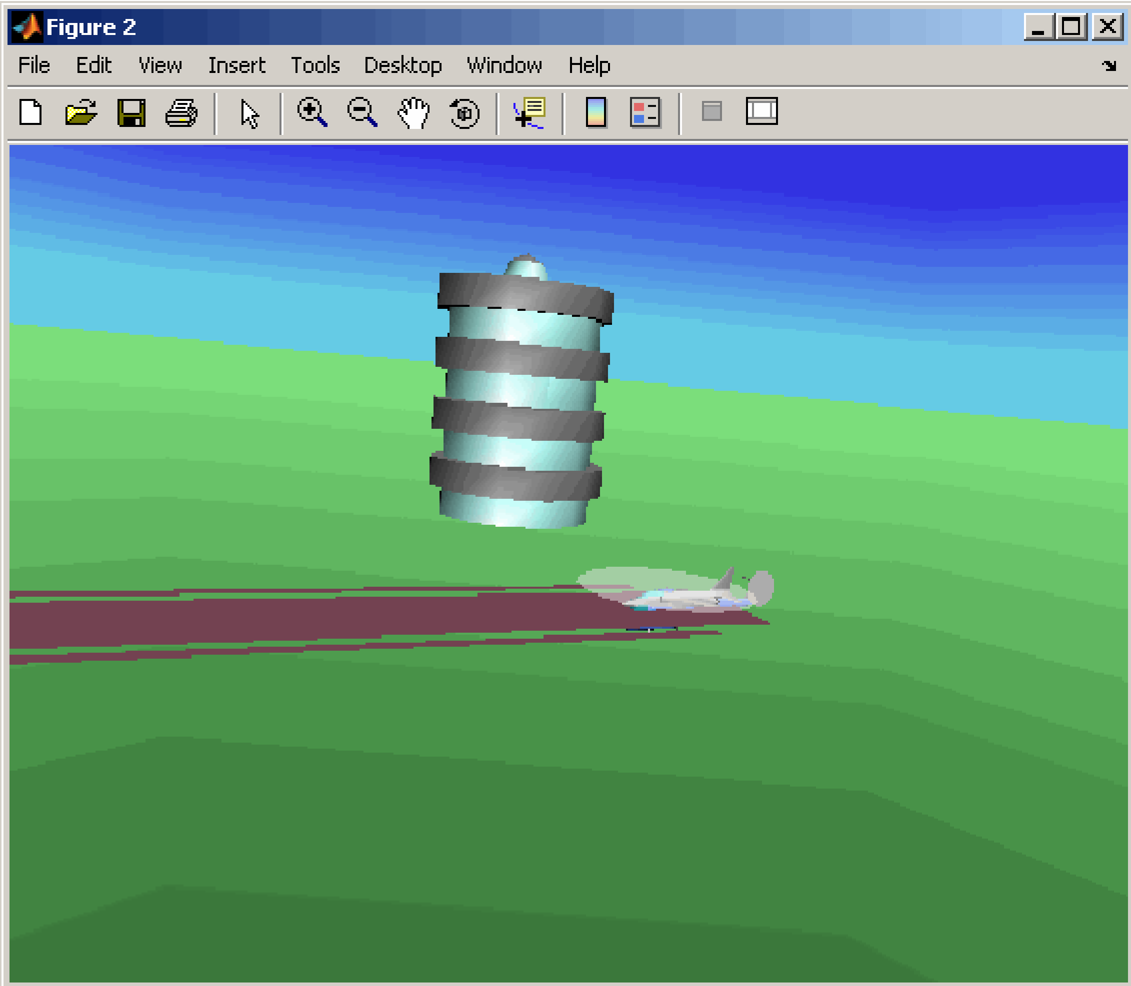
The helicopter appears in the Virtual Reality Toolbox Viewer.

3 Move the camera angle of the virtual reality figure to view the aircraft and newly added helicopter.

```
set(h.VRFigure,'CameraDirection',[0.45 0 -1]);
```

4 View the scene with the chase helicopter.

```
takeVRCapture(h.VRFigure);
```



Loading Time Series Data for Simulation

To prepare to simulate the chase helicopter, set the simulation time series data. `chaseData.mat` contains logged simulated data that you can use to set the time series data. `chaseData` is set up as the Simulink structure`'StructureWithTime'`, which is a default data format.

1 Load the `chaseData`.

```
load chaseData
```

2 Set the time series data for the node.

```
h.Nodes{2}.TimeseriesSource = chaseData;
```

Aligning the Chase Helicopter Position and Rotation Data with Surrounding Virtual World Objects

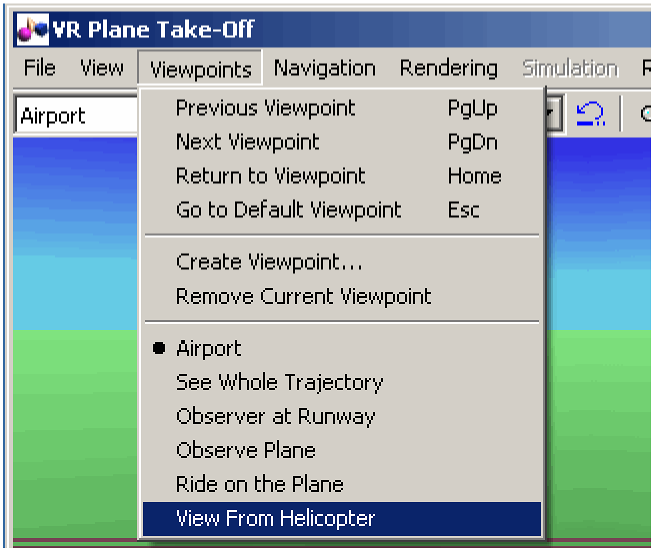
Use the custom transfer function to align the chase helicopter.

```
h.Nodes{2}.CoordTransformFcn = @vranimCustomTransform;
```

Adding a New Viewpoint

To add a viewpoint for the chase helicopter, use the `addViewpoint` method. New viewpoints appear in the **Viewpoints** menu of the Virtual Reality Toolbox Viewer. Type the following to add the viewpoint `View From Helicopter` to the **Viewpoints** menu.

```
h.addViewpoint(h.Nodes{2}.VRNode,'children','chaseView','View From Helicopter');
```



Playing Back the Simulation

The `play` command animates the virtual reality world for the given position and angle for the duration of the time series data. Set the orientation of the viewpoint first.

1 Set the orientation of the viewpoint via the vrnode object associated with the node object for the viewpoint.

```
setfield(h.Nodes{1}.VRNode,'orientation',[0 1 0 convang(160,'deg','rad')]);
set(h.VRFigure,'Viewpoint','View From Helicopter');
```

2 Play the animation.

```
h.play();
```

Adding a Route to the Camera1 Node

The vrworld has a `Ride on the Plane` viewpoint. To enable this viewpoint to function as intended, connect the plane position to the Camera1 node with the `addRoute` method. This method adds a VRML `ROUTE` statement.

```
h.addRoute('Plane','translation','Camera1','translation');
```

Adding Another Helicopter and Viewing All Bodies Simultaneously

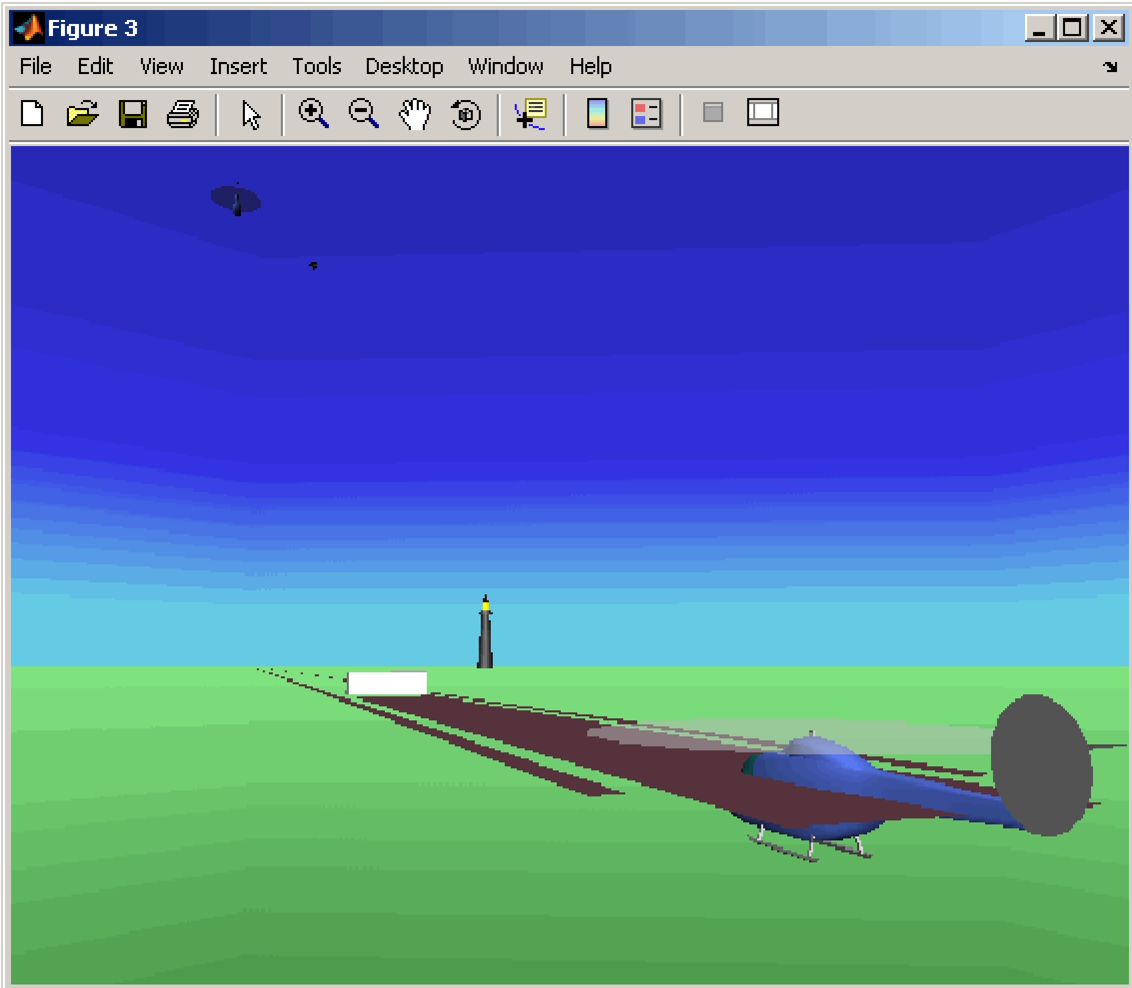
You can add another helicopter to the scene and also change the viewpoint to one that views all three bodies in the scene at once.

1 Add a new node, Lynx1.

```
h.addNode('Lynx1',[matlabroot,'/toolbox/aero/astdemos/chaseHelicopter.wrl']);
```

2 Change the viewpoint to one that views all three bodies.

```
set(h.VRFigure,'Viewpoint','See Whole Trajectory');
```



Removing Bodies

Use the `removeNode` method to remove the second helicopter. To obtain the name of the node to remove, use the `nodeInfo` method.

1 View all the nodes.

```
h.nodeInfo
```

```
Node Information
1 Lynx1_Inline
2 Lynx1
3 chaseView
4 Lynx_Inline
5 Lynx
6 _v1
7 Lighthouse
8 _v3
9 Terminal
10 Block
11 _V2
12 Plane
13 Camera1
```

2 Remove the `Lynx1` node.

```
h.removeNode('Lynx1');
```

3 Change the viewpoint to one that views the whole trajectory.

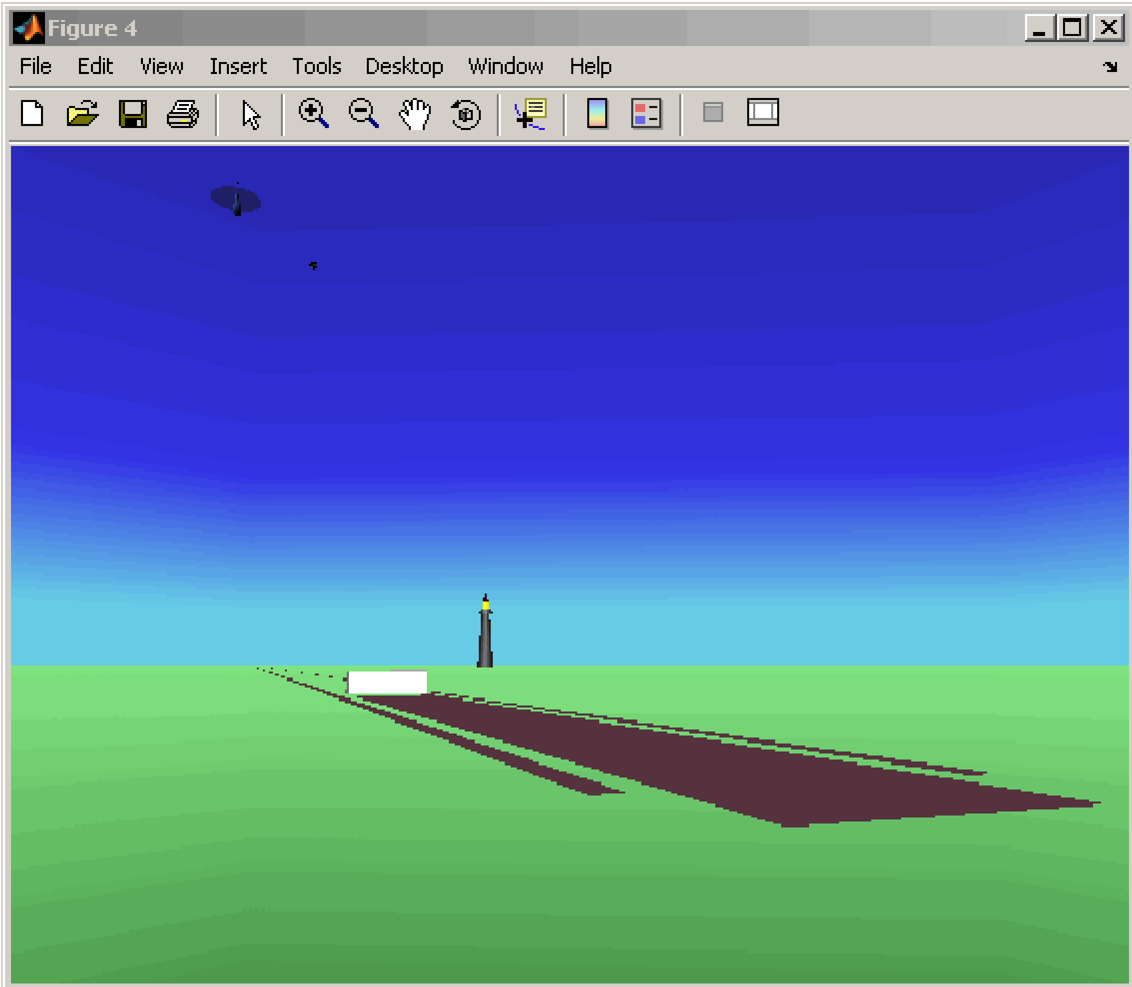
```
set(h.VRFigure,'Viewpoint','See Whole Trajectory');
```

4 Check that you have removed the node.

```
h.nodeInfo

Node Information
1 chaseView
2 Lynx_Inline
3 Lynx
4 _v1
5 Lighthouse
6 _v3
7 Terminal
8 Block
9 _V2
10 Plane
11 Camera1
```

The following figure is a view of the entire trajectory with the third body removed.



Reverting to the Original World

The original file name is stored in the `'VRWorldOldFilename'` property of the virtual reality animation object. To display the original world, set `'VRWorldFilename'` to the original name and reinitialize it.

1 Revert to the original world, 'VRWorldFilename'.

```
h.VRWorldFilename = h.VRWorldOldFilename{1};
```

2 Reinitialize the restored world.

```
h.initialize();
```

Closing and Deleting Worlds

To close and delete a world, use the `delete` method.

```
h.delete();
```

Using Aero.FlightGearAnimation Object

Aerospace Toolbox provides an interface to the FlightGear flight simulator, which enables you to visualize flight data in a three-dimensional environment. The third-party FlightGear simulator is an open source software package available through a GNU General Public License (GPL). This section explains how to obtain and install the third-party FlightGear flight simulator. It then explains how to play back 3-D flight data by using a FlightGear demo, provided with Aerospace Toolbox, as an example.

- "About the FlightGear Interface" on page 2-48
- "Configuring Your Computer for FlightGear" on page 2-49
- "Installing and Starting FlightGear" on page 2-52
- "Working with the Flight Simulator Interface" on page 2-53
- "Running the Demo" on page 2-56

About the FlightGear Interface

The FlightGear flight simulator interface included with Aerospace Toolbox is a unidirectional transmission link from MATLAB to FlightGear using FlightGear's published `net_fdm` binary data exchange protocol. Data is transmitted via UDP network packets to a running instance of FlightGear. Aerospace Toolbox supports multiple standard binary distributions of FlightGear. See "Working with the Flight Simulator Interface" on page 2-53 for interface details.

FlightGear is a separate software entity neither created, owned, nor maintained by The MathWorks.

- To report bugs in or request enhancements to the Aerospace Toolbox FlightGear interface, contact the MathWorks Technical Support at http://www.mathworks.com/contact_TS.html.
- To report bugs or request enhancements to FlightGear itself, visit `www.flightgear.org` and use the contact page.

Obtaining FlightGear. You can obtain FlightGear from `www.flightgear.org` in the download area or by ordering CDs from FlightGear. The download area contains extensive documentation for installation and configuration. Because FlightGear is an open source project, source downloads are also available for customization and porting to custom environments.

Configuring Your Computer for FlightGear

You must have a high performance graphics card with stable drivers to use FlightGear. For more information, see the FlightGear CD distribution or the hardware requirements and documentation areas of the FlightGear Web site, `www.flightgear.org`.

MathWorks tests of FlightGear's performance and stability indicate significant sensitivity to computer video cards, driver versions, and driver settings. You need OpenGL support with hardware acceleration activated. The OpenGL settings are particularly important. Without proper setup, performance can drop from about a 30 frames-per-second (fps) update rate to less than 1 fps.

Graphics Recommendations for Windows. The MathWorks recommends the following for Windows users:

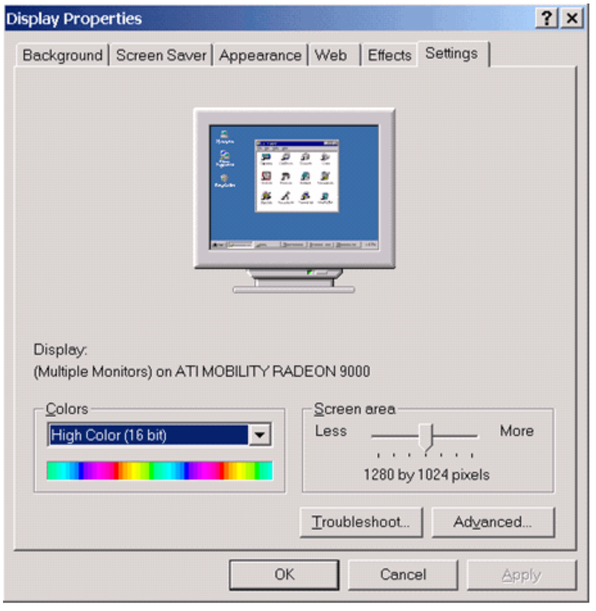
- Choose a graphics card with good OpenGL performance.
- Always use the latest tested and stable driver release for your video card. Test the driver thoroughly on a few computers before deploying to others.

  For Microsoft Windows 2000 or XP systems running on x86 (32-bit) or AMD-64/EM64T chip architectures, the graphics card operates in the unprotected kernel space known as Ring Zero. This means that glitches in the driver can cause Windows to lock or crash. Before buying a large number of computers for 3-D applications, test, with your vendor, one or two computers to find a combination of hardware, operating system, drivers, and settings that are stable for your applications.

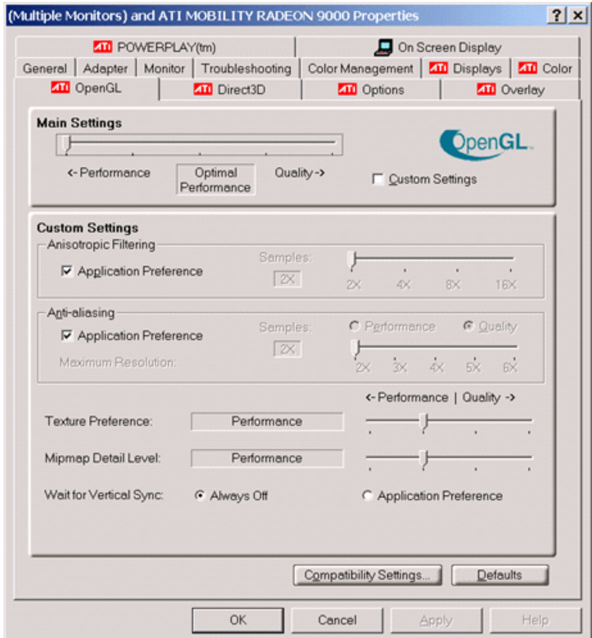
Setting Up OpenGL Graphics on Windows. For complete information on OpenGL settings, refer to the documentation at the OpenGL Web site, `www.opengl.org`.

Follow these steps to optimize your video card settings. Your driver's panes might look different.

1 Ensure that you have activated the OpenGL hardware acceleration on your video card. On Windows, access this configuration through **Start > Settings > Control Panel > Display**, which opens the following dialog box. Select the **Settings** tab.



2 Click the **Advanced** button in the lower right of the dialog box, which opens the graphics card's custom configuration dialog box, and go to the **OpenGL** tab. For an ATI Mobility Radeon 9000 video card, the **OpenGL** pane looks like this:



3 For best performance, move the **Main Settings** slider near the top of the dialog box to the **Performance** end of the slider.

4 If stability is a problem, try other screen resolutions, other color depths in the **Displays** pane, and other OpenGL acceleration modes.

Many cards perform much better at 16 bits-per-pixel color depth (also known as 65536 color mode, 16-bit color). For example, on an ATI Mobility Radeon 9000 running a given model, 30 fps are achieved in 16-bit color mode, while 2 fps are achieved in 32-bit color mode.

Setup on Linux, Macintosh, and Other Platforms. FlightGear distributions are available for Linux, Macintosh, and other UNIX platforms from the FlightGear Web site, `www.flightgear.org`. Installation on these platforms, like Windows, requires careful configuration of graphics cards and drivers. Consult the documentation and hardware requirements sections at the FlightGear Web site.

Using MATLAB Graphics Controls to Configure Your OpenGL Settings. You can also control your OpenGL rendering from the MATLAB command line with the MATLAB Graphics `opengl` command. Consult the `opengl` command reference for more information.

Installing and Starting FlightGear

The extensive FlightGear documentation guides you through the installation in detail. Consult the documentation section of the FlightGear Web site for complete installation instructions: `www.flightgear.org`.

Keep the following points in mind:

- Generous central processor speed, system and video RAM, and virtual memory are essential for good flight simulator performance.

  The MathWorks recommends a minimum of 512 megabytes of system RAM and 128 megabytes of video RAM for reasonable performance.

- Be sure to have sufficient disk space for the FlightGear download and installation.
- The MathWorks recommends configuring your computer's graphics card before you install FlightGear. See the preceding section, "Configuring Your Computer for FlightGear" on page 2-49.
- Shutting down all running applications (including MATLAB) before installing FlightGear is recommended.
- MathWorks tests indicate that the operational stability of FlightGear is especially sensitive during startup. It is best to not move, resize, mouse over, overlap, or cover up the FlightGear window until the initial simulation scene appears after the startup splash screen fades out.
- The current releases of FlightGear are optimized for flight visualization at altitudes below 100,000 feet. FlightGear does not work well or at all with very high altitude and orbital views.

Aerospace Toolbox supports FlightGear on a number of platforms (`http://www.mathworks.com/products/aerotb/requirements.html`). The following table lists the properties you should be aware of before you start to use FlightGear.

FlightGear Property	Directory Description	Platforms	Typical Location
`FlightGearBase-Directory`	FlightGear installation directory.	Windows	`C:\Program Files\FlightGear` (default)
		Solaris or Linux	Directory into which you installed FlightGear
		Mac	`/Applications` (directory to which you dragged the FlightGear icon)
`GeometryModelName`	Model geometry directory	Windows	`C:\Program Files\-FlightGear\data\-Aircraft\HL20` (default)
		Solaris or Linux	`$FlightGearBaseDirectory/-data/Aircraft/HL20`
		Mac	`$FlightGearBaseDirectory/-FlightGear.app/Contents/-Resources/data/Aircraft/HL20`

Working with the Flight Simulator Interface

Aerospace Toolbox provides a demo named Displaying Flight Trajectory Data, which shows you how you can visualize flight trajectories with FlightGear Animation object. The demo is intended to be modified depending on the particulars of your FlightGear installation. This section explains how to run this demo. Use this demo as an example to play back your own 3-D flight data with FlightGear.

You need to have FlightGear installed and configured before attempting to simulate this model. See “About the FlightGear Interface” on page 2-48.

To run the demo:

1 Import the aircraft geometry into FlightGear.

2 Run the demo. The demo performs the following steps:

   a Loads recorded trajectory data

b Creates a time series object from trajectory data

c Creates a FlightGearAnimation object

3 Modify the animation object properties, if needed.

4 Create a run script for launching FlightGear flight simulator.

5 Start FlightGear flight simulator.

6 Play back the flight trajectory.

The following sections describe how to perform these steps in detail.

Importing the Aircraft Geometry into FlightGear. Before running the demo, copy the aircraft geometry model into FlightGear. From the following procedures, choose the one appropriate for your platform. This section assumes that you have read "Installing and Starting FlightGear" on page 2-52.

If your platform is Windows:

1 Go to your installed FlightGear directory. Open the `data` directory, then the `Aircraft` directory: *`FlightGear`*`\data\Aircraft\`.

2 You may already have an `HL20` subdirectory there, if you have previously run the Aerospace Blockset NASA HL-20 with FlightGear Interface demo. In this case, you don't have to do anything, because the geometry model is the same.

   Otherwise, copy the `HL20` folder from the *`matlabroot`*`\toolbox\aero\aerodemos\` directory to the *`FlightGear`*`\data\Aircraft\` directory. This folder contains the preconfigured geometries for the HL-20 simulation and `HL20-set.xml`. The file *`matlabroot`*`\toolbox\aero\aerodemos\HL20\models\HL20.xml` defines the geometry.

If your platform is Solaris or Linux:

1 Go to your installed FlightGear directory. Open the `data` directory, then the `Aircraft` directory: *`$FlightGearBaseDirectory`*`/data/Aircraft/`.

2. You may already have an `HL20` subdirectory there, if you have previously run the Aerospace Blockset NASA HL-20 with FlightGear Interface demo. In this case, you do not have to do anything, because the geometry model is the same.

   Otherwise, copy the `HL20` folder from the *`matlabroot`*`/toolbox/aero/aerodemos/` directory to the *`$FlightGearBaseDirectory`*`/data/Aircraft/` directory. This directory contains the preconfigured geometries for the HL-20 simulation and `HL20-set.xml`. The file *`matlabroot`*`/toolbox/aero/aerodemos/HL20/models/HL20.xml` defines the geometry.

If your platform is Mac:

1. Open a terminal.

2. List the contents of the Aircraft directory. For example, type

   ```
   ls $FlightGearBaseDirectory/data/Aircraft/
   ```

3. You may already have an `HL20` subdirectory there, if you have previously run the Aerospace Blockset NASA HL-20 with FlightGear Interface demo. In this case, you do not have to do anything, because the geometry model is the same. Continue to "Running the Demo" on page 2-27.

   Otherwise, copy the `HL20` folder from the

   ```
   matlabroot/toolbox/aero/aerodemos/
   ```

   directory to the

   ```
   $FlightGearBaseDirectory/FlightGear.app/Contents/Resources/data/Aircraft/
   ```

   directory. This directory contains the preconfigured geometries for the HL-20 simulation and `HL20-set.xml`. The file *`matlabroot`*`/toolbox/aero/aerodemos/HL20/models/HL20.xml` defines the geometry.

Running the Demo

1 Start MATLAB.

2 Run the demo either by entering `astfganim` in the MATLAB Command Window or by finding the demo entry (Displaying Flight Trajectory Data) in the Demos browser and clicking **Run in the Command Window** on its demo page.

   While running, the demo performs several steps by issuing a series of commands, as explained below.

Loading Recorded Flight Trajectory Data. The flight trajectory data for this example is stored in a comma separated value formatted file. Using `csvread`, the data is read from the file starting at row 1 and column 0, which skips the header information.

```
tdata = csvread('asthl20log.csv',1,0);
```

Creating a Time Series Object from Trajectory Data. The time series object, `ts`, is created from the latitude, longitude, altitude, and Euler angle data along with the time array in `tdata` using the MATLAB `timeseries` command. Latitude, longitude, and Euler angles are also converted from degrees to radians using the `convang` function.

```
ts = timeseries([convang(tdata(:,[3 2]),'deg','rad') ...
        tdata(:,4) convang(tdata(:,5:7),'deg','rad')],tdata(:,1));
```

Creating a FlightGearAnimation Object. This series of commands creates a FlightGearAnimation object:

1 Opening a FlightGearAnimation object.

   ```
   h = fganimation;
   ```

2 Setting FlightGearAnimation object properties for the time series.

   ```
   h.TimeseriesSourceType = 'Timeseries';
   h.TimeseriesSource = ts;
   ```

3 Setting FlightGearAnimation object properties relating to FlightGear. These properties include the path to the installation directory, the version

number, the aircraft geometry model, and network information for the FlightGear flight simulator.

```
h.FlightGearBaseDirectory = 'D:\Applications\FlightGear0910';
h.FlightGearVersion = '0.9.10';
h.GeometryModelName = 'HL20';
h.DestinationIpAddress = '127.0.0.1';
h.DestinationPort = '5502';
```

4 Setting the initial conditions (location and orientation) for the FlightGear flight simulator.

```
h.AirportId = 'KSFO';
h.RunwayId = '10L';
h.InitialAltitude = 7224;
h.InitialHeading = 113;
h.OffsetDistance = 4.72;
h.OffsetAzimuth = 0;
```

5 Setting the seconds of animation data per second of wall-clock time.

```
h.TimeScaling = 5;
```

6 Checking the FlightGearAnimation object properties and their values.

```
get(h)
```

At this point, the demo stops running and returns the FlightGearAnimation object, `h`:

```
         TimeseriesSource: [196x1 timeseries]
     TimeseriesSourceType: 'Timeseries'
        TimeseriesReadFcn: @TimeseriesRead
              TimeScaling: 5
          FramesPerSecond: 12
        FlightGearVersion: '0.9.10'
           OutputFileName: 'runfg.bat'
  FlightGearBaseDirectory: 'D:\Applications\FlightGear0910'
        GeometryModelName: 'HL20'
     DestinationIpAddress: '127.0.0.1'
          DestinationPort: '5502'
                AirportId: 'KSFO'
```

```
           RunwayId: '10L'
    InitialAltitude: 7224
     InitialHeading: 113
     OffsetDistance: 4.7200
      OffsetAzimuth: 0
```

You can now set the object properties for data playback (see “Modifying the FlightGearAnimation Object Properties” on page 2-58).

Modifying the FlightGearAnimation Object Properties. Modify the FlightGearAnimation object properties as needed. If your FlightGear installation directory is other than that in the demo (for example, `FlightGear`), modify the `FlightGearBaseDirectory` property by issuing the following command:

```
h.FlightGearBaseDirectory = 'D:\Applications\FlightGear';
```

Similarly, if you want to use a particular file name for the run script, modify the `OutputFileName` property.

Verify the FlightGearAnimation object properties:

```
get(h)
```

You can now generate the run script (see “Generating the Run Script” on page 2-58).

Generating the Run Script. To start FlightGear with the desired initial conditions (location, date, time, weather, operating modes), it is best to create a run script by using the `GenerateRunScript` command:

```
GenerateRunScript(h)
```

By default, `GenerateRunScript` saves the run script as a text file named `runfg.bat`. You can specify a different name by modifying the `OutputFileName` property of the FlightGearAnimation object, as described in the previous step.

This file does not need to be generated each time the data is viewed, only when the desired initial conditions or FlightGear information changes.

You are now ready to start FlightGear (see "Starting the FlightGear Flight Simulator" on page 2-59).

Starting the FlightGear Flight Simulator. To start FlightGear from the MATLAB command prompt, use the `system` command to execute the run script. Provide the name of the output file created by GenerateRunScript as the argument:

```
system('runfg.bat &');
```

FlightGear starts in a separate window.

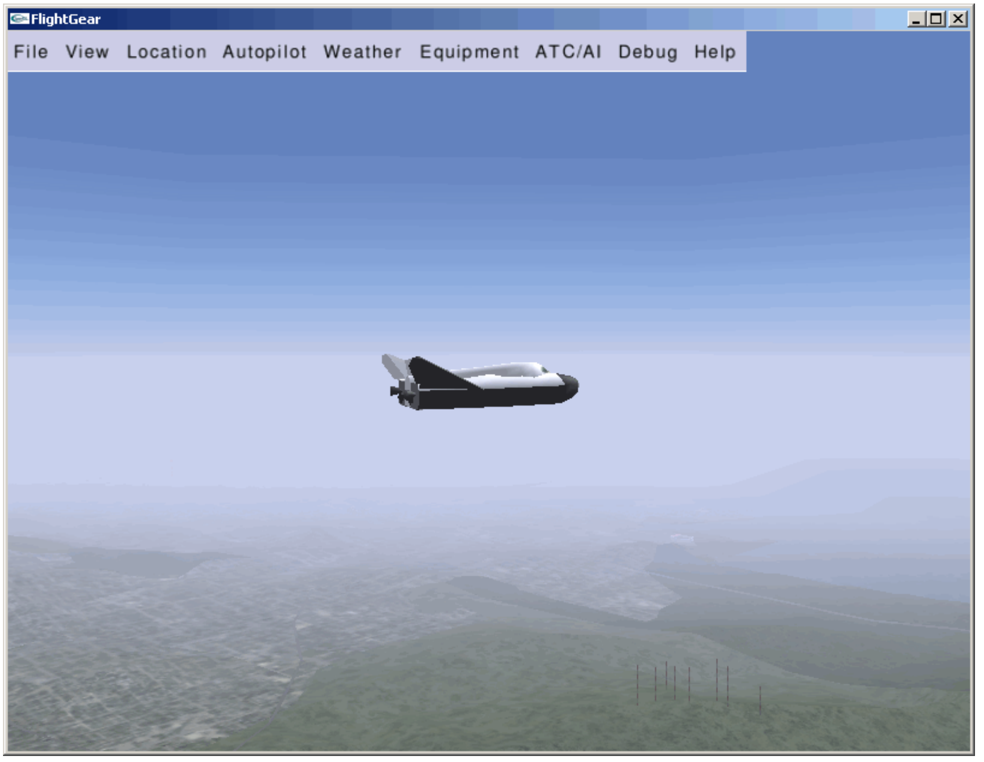
Tip With the FlightGear window in focus, press the **V** key to alternate between the different aircraft views: cockpit view, helicopter view, chase view, and so on.

You are now ready to play back data (see "Playing Back the Flight Trajectory" on page 2-59).

Playing Back the Flight Trajectory. Once FlightGear is running, the FlightGearAnimation object can start to communicate with FlightGear. To animate the flight trajectory data, use the play command:

```
play(h)
```

The following illustration shows a snapshot of flight data playback in tower view without yaw.


FlightGear
File View Location Autopilot Weather Equipment ATC/AI Debug Help

3

Functions — By Category

Quaternion Math (p. 3-12)	Common mathematical and matrix operations, including quaternion multiplication, division, normalization, and rotating vector by quaternion
Time (p. 3-13)	Time calculations, including Julian dates, decimal year, and leap year
Unit Conversion (p. 3-13)	Convert common measurement units from one system to another, such as converting acceleration from feet per second to meters per second and vice versa

Aero.Animation

`addBody (Aero.Animation)`	Add loaded body to animation object and generate its patches
`Animation (Aero.Animation)`	Construct animation object
`createBody (Aero.Animation)`	Create body for animation object
`delete (Aero.Animation)`	Destroy animation object
`hide (Aero.Animation)`	Hide animation object figure
`initialize (Aero.Animation)`	Create animation object figure and axes and build patches for bodies
`initIfNeeded (Aero.Animation)`	Initialize animation object graphics
`moveBody (Aero.Animation)`	Move body in animation object
`play (Aero.Animation)`	Animate `Aero.Animation` object given position/angle time series
`removeBody (Aero.Animation)`	Remove one body from animation
`show (Aero.Animation)`	Show animation object figure
`updateBodies (Aero.Animation)`	Update bodies of animation object
`updateCamera (Aero.Animation)`	Update camera in animation object

Aero.Body

`Body (Aero.Body)`	Construct body object for use with animation object
`findstartstoptimes (Aero.Body)`	Return start and stop times of time series data
`generatePatches (Aero.Body)`	Generate patches for body with loaded face, vertex, and color data
`load (Aero.Body)`	Get geometry data from source
`move (Aero.Body)`	Change animation body position and orientation
`update (Aero.Body)`	Change body position and orientation as function of time

Aero.Camera

`Camera (Aero.Camera)`	Construct camera object for use with animation object
`update (Aero.Camera)`	Update camera position based on time and position of other Aero.Body objects

Aero.FlightGearAnimation

`delete (Aero.FlightGearAnimation)`	Destroy FlightGear animation object
`fganimation (Aero.FlightGearAnimation)`	Construct FlightGear animation object
`GenerateRunScript (Aero.FlightGearAnimation)`	Generate run script for FlightGear flight simulator
`initialize (Aero.FlightGearAnimation)`	Set up FlightGear animation object
`play (Aero.FlightGearAnimation)`	Animate FlightGear flight simulator using given position/angle time series
`update (Aero.FlightGearAnimation)`	Update position data to FlightGear animation object

Aero.Geometry

`Geometry (Aero.Geometry)`	Construct 3-D geometry for use with animation object
`read (Aero.Geometry)`	Read geometry data using current reader

Aero.Node

`findstartstoptimes (Aero.Node)`	Return start and stop times for time series data
`move (Aero.Node)`	Change node translation and rotation
`Node (Aero.Node)`	Create node object for use with virtual reality animation
`update (Aero.Node)`	Change node position and orientation versus time data

Aero.Viewpoint

`Viewpoint (Aero.Viewpoint)`	Create viewpoint object for use in virtual reality animation

Aero.VirtualRealityAnimation

`addNode (Aero.VirtualRealityAnimation)`	Add existing node to current virtual reality world
`addRoute (Aero.VirtualRealityAnimation)`	Add VRML ROUTE statement to virtual reality animation
`addViewpoint (Aero.VirtualRealityAnimation)`	Add viewpoint for virtual reality animation
`delete (Aero.VirtualRealityAnimation)`	Destroy virtual reality animation object
`initialize (Aero.VirtualRealityAnimation)`	Create and populate virtual reality animation object
`nodeInfo (Aero.VirtualRealityAnimation)`	Create list of nodes associated with virtual reality animation object
`play (Aero.VirtualRealityAnimation)`	Animate virtual reality world for given position and angle in time series data
`removeNode (Aero.VirtualRealityAnimation)`	Remove node from virtual reality animation object
`removeViewpoint (Aero.VirtualRealityAnimation)`	Remove viewpoint node from virtual reality animation
`saveas (Aero.VirtualRealityAnimation)`	Save virtual reality world associated with virtual reality animation object
`updateNodes (Aero.VirtualRealityAnimation)`	Change virtual reality animation node position and orientation as function of time
`VirtualRealityAnimation (Aero.VirtualRealityAnimation)`	Construct virtual reality animation object

Axes Transformations

`angle2dcm`	Create direction cosine matrix from rotation angles
`angle2quat`	Convert rotation angles to quaternion
`dcm2alphabeta`	Convert direction cosine matrix to angle of attack and sideslip angle
`dcm2angle`	Create rotation angles from direction cosine matrix
`dcm2latlon`	Convert direction cosine matrix to geodetic latitude and longitude
`dcm2quat`	Convert direction cosine matrix to quaternion
`dcmbody2wind`	Convert angle of attack and sideslip angle to direction cosine matrix
`dcmecef2ned`	Convert geodetic latitude and longitude to direction cosine matrix
`ecef2lla`	Convert Earth-centered Earth-fixed (ECEF) coordinates to geodetic coordinates
`geoc2geod`	Convert geocentric latitude to geodetic latitude
`geod2geoc`	Convert geodetic latitude to geocentric latitude
`lla2ecef`	Convert geodetic coordinates to Earth-centered Earth-fixed (ECEF) coordinates
`quat2angle`	Convert quaternion to rotation angles
`quat2dcm`	Convert quaternion to direction cosine matrix

Environment

`atmoscira`	Use COSPAR International Reference Atmosphere 1986 model
`atmoscoesa`	Use 1976 COESA model
`atmosisa`	Use International Standard Atmosphere model
`atmoslapse`	Use Lapse Rate Atmosphere model
`atmosnonstd`	Use climatic data from MIL-STD-210 or MIL-HDBK-310
`atmosnrlmsise00`	Implement mathematical representation of 2001 United States Naval Research Laboratory Mass Spectrometer and Incoherent Scatter Radar Exosphere
`atmospalt`	Calculate pressure altitude based on ambient pressure
`gravitywgs84`	Implement 1984 World Geodetic System (WGS84) representation of Earth's gravity
`wrldmagm`	Use World Magnetic Model

File Reading

`datcomimport`	Bring USAF Digital DATCOM file into MATLAB

Flight Parameters

`airspeed`	Compute airspeed from velocity
`alphabeta`	Compute incidence and sideslip angles
`correctairspeed`	Calculate equivalent airspeed (EAS), calibrated airspeed (CAS), or true airspeed (TAS) from one of other two airspeeds
`dpressure`	Compute dynamic pressure using velocity and density
`geocradius`	Estimate radius of ellipsoid planet at geocentric latitude
`machnumber`	Compute Mach number using velocity and speed of sound
`rrdelta`	Compute relative pressure ratio
`rrsigma`	Compute relative density ratio
`rrtheta`	Compute relative temperature ratio

Quaternion Math

`quatconj`	Calculate conjugate of quaternion
`quatdivide`	Divide quaternion by another quaternion
`quatinv`	Calculate inverse of quaternion
`quatmod`	Calculate modulus of quaternion
`quatmultiply`	Calculate product of two quaternions
`quatnorm`	Calculate norm of quaternion
`quatnormalize`	Normalize quaternion
`quatrotate`	Rotate vector by quaternion

Time

`decyear`	Calculate decimal year
`juliandate`	Calculate Julian date
`leapyear`	Determine leap year
`mjuliandate`	Calculate modified Julian date

Unit Conversion

`convacc`	Convert from acceleration units to desired acceleration units
`convang`	Convert from angle units to desired angle units
`convangacc`	Convert from angular acceleration units to desired angular acceleration units
`convangvel`	Convert from angular velocity units to desired angular velocity units
`convdensity`	Convert from density units to desired density units
`convforce`	Convert from force units to desired force units
`convlength`	Convert from length units to desired length units
`convmass`	Convert from mass units to desired mass units
`convpres`	Convert from pressure units to desired pressure units

`convtemp`	Convert from temperature units to desired temperature units
`convvel`	Convert from velocity units to desired velocity units

Functions — Alphabetical List

addBody (Aero.Animation)

Purpose Add loaded body to animation object and generate its patches

Syntax

```
idx = addBody(h,b)
idx = h.addBody(b)
```

Description `idx = addBody(h,b)` and `idx = h.addBody(b)` add a loaded body, `b`, to the animation object `h` and generates its patches. `idx` is the index of the body to be added.

Examples Add a second body to the list that is a pointer to the first body. This means that if you change the properties of one body, the properties of the other body change correspondingly.

```
h = Aero.Animation;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
b = h.Bodies{1};
idx2 = h.addBody(b);
```

See Also `createBody`, `moveBody`, `removeBody`, `updateBodies`

Purpose

Add existing node to current virtual reality world

Syntax

```
addNode(h, node_name, wrl_file)
h.addNode(node_name, wrl_file)
```

Description

`addNode(h, node_name, wrl_file)` and `h.addNode(node_name, wrl_file)` add an existing node, `node_name`, to the current virtual reality world. The `wrl_file` is the file from which the new node is taken. `addNode` adds a new node named `node_name`, which contains (or points to) the `wrl_file`. `node_name` must be unique from other node names in the same `.wrl` file. `wrl_file` must contain the node to be added. You must specify the full path for this file. The vrnode object associated with the node object must be defined using a `DEF` statement in the `.wrl` file. This method creates a node object on the world of type Transform.

When you use the `addNode` method to add a node, all the objects in the `.wrl` file will be added to the virtual reality animation object under one node. If you want to add separate nodes for the objects in the `.wrl` file, place each node in a separate `.wrl` file.

Example

Add node to world defined in `chaseHelicopter.wrl`.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
h.addNode('Lynx',[matlabroot,'/toolbox/aero/astdemos/chaseHelicopter.wrl']);
```

See Also

`Aero.Node`, `move`, `removeNode`, `updateNodes`,

`Aero.VirtualRealityAnimation`

addRoute (Aero.VirtualRealityAnimation)

Purpose

Add VRML ROUTE statement to virtual reality animation

Syntax

```
addRoute(h, nodeOut, eventOut, nodeIn, eventIn)
h.addNode(nodeOut, eventOut, nodeIn, eventIn)
```

Description

`addRoute(h, nodeOut, eventOut, nodeIn, eventIn)` and `h.addNode(nodeOut, eventOut, nodeIn, eventIn)` add a VRML ROUTE statement to the virtual reality animation, where `nodeOut` is the node from which information is routed, `eventOut` is the event (property), `nodeIn` is the node to which information is routed, and `eventIn` is the receiving event (property).

Examples

Add a ROUTE command to connect the Plane position to the Camera1 node.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
h.addNode('Lynx',[matlabroot,'/toolbox/aero/astdemos/chaseHelicopter.wrl']);
h.addRoute('Plane','translation','Camera1','translation');
```

See Also

`addViewpoint`

Purpose

Add viewpoint for virtual reality animation

Syntax

```
addViewpoint(h, parent_node, parent_field, node_name)
h.addViewpoint(parent_node, parent_field, node_name)
addViewpoint(h, parent_node, parent_field, node_name,
   description)
h.addViewpoint(parent_node, parent_field, node_name,
   description)
addViewpoint(h, parent_node, parent_field, node_name,
   description, position)
h.addViewpoint(parent_node, parent_field, node_name,
   description, position)
addViewpoint(h, parent_node, parent_field, node_name,
   description, position, orientation)
h.addViewpoint(parent_node, parent_field, node_name,
   description, position, orientation)
```

Description

addViewpoint(h, parent_node, parent_field, node_name) and h.addViewpoint(parent_node, parent_field, node_name) add a viewpoint named node_name whose parent_node is the parent node field of the vrnode object and whose parent_field is a valid parent field of the vrnode object to the virtual world animation object, h.

addViewpoint(h, parent_node, parent_field, node_name, description)and h.addViewpoint(parent_node, parent_field, node_name, description) add a viewpoint named node_name whose parent_node is the parent node field of the vrnode object and whose parent_field is a valid parent field of the vrnode object to the virtual world animation object, h. description is the string you want to describe the viewpoint.

addViewpoint(h, parent_node, parent_field, node_name, description, position) and h.addViewpoint(parent_node, parent_field, node_name, description, position) add a viewpoint named node_name whose parent_node is the parent node field of the vrnode object and whose parent_field is a valid parent field of the vrnode object to the virtual world animation object, h. description is the string you want to describe the viewpoint and position is the position of the viewpoint. Specify position using VRML coordinates (*x y z*).

addViewpoint(h, parent_node, parent_field, node_name, description, position, orientation) and h.addViewpoint(parent_node, parent_field, node_name, description, position, orientation) add a viewpoint named node_name whose parent_node is the parent node field of the vrnode object and whose parent_field is a valid parent field of the vrnode object to the virtual world animation object, h. description is the string you want to describe the viewpoint, position is the position of the viewpoint, and orientation is the orientation of the viewpoint. Specify position using VRML coordinates (*x y z*). Specify orientation in a VRML axes angle format (*x y z* Θ).

Note If you call addViewpoint with only the description argument, you must set the position and orientation of the viewpoint with the Virtual Reality Toolbox vrnode/setfield function. This requires you to use VRML coordinates.

Examples

Add a viewpoint named chaseView.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
h.addViewpoint(h.Nodes{2}.VRNode,'children','chaseView','View From Helicopter');
```

See Also

addRoute, removeViewpoint

Purpose Compute airspeed from velocity

Syntax

```
as = airspeed(v)
```

Description `as = airspeed(v)` computes `m` airspeeds, `as`, from an `m`-by-3 array of velocities, `v`.

Examples Determine the airspeed for velocity in feet per second:

```
as = airspeed([84.3905  33.7562  10.1269])

as =

   91.4538
```

Determine the airspeed for velocity in knots:

```
as = airspeed([50 20 6; 5 0.5 2])

as =

   54.1849
    5.4083
```

See Also `alphabeta`, `correctairspeed`, `dpressure`, `machnumber`

alphabeta

Purpose

Compute incidence and sideslip angles

Syntax

```
[a b] = alphabeta(v)
```

Description

`[a b] = alphabeta(v)` computes `m` incidence and sideslip angles, `a` and `b`, between the velocity vector and the body. `v` is an `m`-by-3 array of velocities in body-axes. `a` and `b` are in radians.

Examples

Determine the incidence and sideslip angles for velocity in feet per second:

```
[alpha beta] = alphabeta([84.3905  33.7562  10.1269])

alpha =

    0.1194


beta =

    0.3780
```

Determine the incidence and sideslip angles for velocity in knots:

```
[alpha beta] = alphabeta([50 20 6; 5 0.5 2])

alpha =

    0.1194
    0.3805


beta =

    0.3780
    0.0926
```

See Also `airspeed`, `machnumber`

angle2dcm

Purpose

Create direction cosine matrix from rotation angles

Syntax

```
n = angle2dcm(r1, r2, r3)
n = angle2dcm(r1, r2, r3, s)
```

Description

`n = angle2dcm(r1, r2, r3)` calculates the direction cosine matrix, `n`, for a given set of rotation angles, `r1`, `r2`, `r3`. `r1` is an `m` array of first rotation angles. `r2` is an `m` array of second rotation angles. `r3` is an `m` array of third rotation angles. `n` returns a 3-by-3-by-`m` matrix containing `m` direction cosine matrices. Rotation angles are input in radians.

`n = angle2dcm(r1, r2, r3, s)` calculates the direction cosine matrix, `n`, for a given set of rotation angles, `r1`, `r2`, `r3`, and a specified rotation sequence, `s`.

The default rotation sequence is `'ZYX'`, where `r1` is *z*-axis rotation, `r2` is *y*-axis rotation, and `r3` is *x*-axis rotation.

Supported rotation sequence strings are `'ZYX'`, `'ZYZ'`, `'ZXY'`, `'ZXZ'`, `'YXZ'`, `'YXY'`, `'YZX'`, `'YZY'`, `'XYZ'`, `'XYX'`, `'XZY'`, and `'XZX'`.

Examples

Determine the direction cosine matrix from rotation angles:

```
yaw = 0.7854;
pitch = 0.1;
roll = 0;
dcm = angle2dcm(yaw, pitch, roll)

dcm =

    0.7036    0.7036   -0.0998
   -0.7071    0.7071         0
    0.0706    0.0706    0.9950
```

Determine the direction cosine matrix from multiple rotation angles:

```
yaw = [0.7854 0.5];
pitch = [0.1 0.3];
roll = [0 0.1];
```

```
dcm = angle2dcm(pitch, roll, yaw, 'YXZ')

dcm(:,:,1) =

    0.7036    0.7071   -0.0706
   -0.7036    0.7071    0.0706
    0.0998         0    0.9950


dcm(:,:,2) =

    0.8525    0.4770   -0.2136
   -0.4321    0.8732    0.2254
    0.2940   -0.0998    0.9506
```

See Also

`angle2dcm`, `dcm2angle`, `dcm2quat`, `quat2dcm`, `quat2angle`

angle2quat

Purpose Convert rotation angles to quaternion

Syntax

```
q = angle2quat(r1,r2,r3)
q = angle2quat(r1,r2,r3,s)
```

Description `q = angle2quat(r1,r2,r3)` calculates the quaternion, `q`, for the three rotation angles, `r1`, `r2`, `r3`. `q` returns an `m`-by-4 matrix containing `m` quaternions. `q` has its scalar number as the first column. Rotation angles are input in radians.

`r1`	m array of first rotation angles.
`r2`	m array of second rotation angles.
`r3`	m array of third rotation angles.

`q = angle2quat(r1,r2,r3,s)` calculates the quaternion, `q`, for a given set of rotation angles, `r1`, `r2`, `r3`, and a specified rotation sequence, `s`.

The default rotation sequence is `'ZYX'`, where `r1` is `z`-axis rotation, `r2` is `y`-axis rotation, and `r3` is `x`-axis rotation.

Supported rotation sequence strings, `s`, are `'ZYX'`, `'ZYZ'`, `'ZXY'`, `'ZXZ'`, `'YXZ'`, `'YXY'`, `'YZX'`, `'YZY'`, `'XYZ'`, `'XYX'`, `'XZY'`, and `'XZX'`.

Examples Determine the quaternion from rotation angles:

```
yaw = 0.7854;
pitch = 0.1;
roll = 0;
q = angle2quat(yaw, pitch, roll)
q =
    0.9227   -0.0191    0.0462    0.3822
```

Determine the quaternion from multiple rotation angles:

```
yaw = [0.7854 0.5];
pitch = [0.1 0.3];
roll = [0 0.1];
```

```
q = angle2quat(pitch, roll, yaw, 'YXZ')
q =
    0.9227    0.0191    0.0462    0.3822
    0.9587    0.0848    0.1324    0.2371
```

See Also

angle2dcm, dcm2angle, dcm2quat, quat2angle, quat2dcm

Animation (Aero.Animation)

Purpose Construct animation object

Syntax

```
h = Aero.Animation
```

Description `h = Aero.Animation` constructs an animation object. The animation object is returned to `h`.

See `Aero.Animation` for further details.

See Also `Aero.Animation`

Purpose

Use 1976 COESA model

Syntax

```
[T, a, P, rho] = atmoscoesa(h, action)
```

Description

`[T, a, P, rho] = atmoscoesa(h, action)` implements the mathematical representation of the 1976 Committee on Extension to the Standard Atmosphere (COESA) United States standard lower atmospheric values for absolute temperature, pressure, density, and speed of sound for the input geopotential altitude.

Inputs for `atmoscoesa` are:

`h`	An array of `m` geopotential heights, in meters
`action`	A string to determine action for out-of-range input. Specify if out-of-range input invokes a `'Warning'`, `'Error'`, or no action (`'None'`). The default is `'Warning'`.

Outputs calculated for the COESA model are:

`T`	An array of `m` temperatures, in kelvin
`a`	An array of `m` speeds of sound, in meters per second
`P`	An array of `m` air pressures, in pascal
`rho`	An array of `m` air densities, in kilograms per meter cubed

Examples

Calculate the COESA model at 1000 meters with warnings for out-of-range inputs:

```
[T, a, P, rho] = atmoscoesa(1000)
```

```
T =

  281.6500


a =

  336.4341


P =

  8.9875e+004


rho =

    1.1116
```

Calculate the COESA model at 1000, 11,000, and 20,000 meters with errors for out-of-range inputs:

```
[T, a, P, rho] = atmoscoesa([1000 11000 20000], 'Error')


T =

  281.6500  216.6500  216.6500


a =

  336.4341  295.0696  295.0696


P =
```

```
   1.0e+004 *

     8.9875    2.2632    0.5475


 rho =

     1.1116    0.3639    0.0880
```

Assumptions and Limitations

Below the geopotential altitude of 0 m (0 feet) and above the geopotential altitude of 84,852 m (approximately 278,386 feet), temperature values are extrapolated linearly and pressure values are extrapolated logarithmically. Density and speed of sound are calculated using a perfect gas relationship.

References

U.S. Standard Atmosphere, 1976, U.S. Government Printing Office, Washington, D.C.

See Also

`atmosisa`, `atmoslapse`, `atmosnonstd`, `atmospalt`

Purpose

Use COSPAR International Reference Atmosphere 1986 model

Syntax

```
[T alt zwind] = atmoscira(lat, ctype, coord, mtype, month,
   action)
```

Description

`[T alt zwind] = atmoscira(lat, ctype, coord, mtype, month, action)` implements the mathematical representation of the Committee on Space Research (COSPAR) International Reference Atmosphere (CIRA) from 1986 model. The CIRA 1986 model provides a mean climatology of temperature, zonal wind, and geopotential height or pressure with nearly pole-to-pole coverage (80 degrees S to 80 degrees N) for 0 to 120 kilometers, encompassing the troposphere, middle atmosphere, and lower thermosphere. You can use this mathematical representation as a function of pressure or geopotential height.

Inputs for `atmoscira` are:

`lat`	An array of `m` geopotential heights, in meters.
`ctype`	A string to determine representation of coordinate type. Specify: • `'Pressure'` Uses pressure in pascal. • `'GPHeight'` Uses geopotential height in meters.
`coord`	Depending on the value of `ctype`, this argument specifies one of the following arrays: • `m` pressures in pascal • `m` geopotential height in meters

`mtype`	A string that selects one of the following mean value types: • `'Monthly'` Monthly values. This is the default. • `'Annual'` Annual values. Valid when `ctype` has a value of `'Pressure'`.
`month`	A scalar value that selects the month in which the mean values are taken. This argument applies only when `mtype` has a value of `'Monthly'`. Valid are `1` (January) through `12` (December). The default value is `1`.
`action`	A string to determine action for out-of-range input. Specify if out-of-range input invokes a `'Warning'`, `'Error'`, or no action (`'None'`). The default is `'Warning'`.

Outputs calculated for the CIRA 1986 model are:

`T`	An array of temperatures. • If `m` is `'Monthly'`, an array of `m` temperatures, in kelvin. • If `mtype` is `'Annual'`, an array of `m`-by-7 values. See "T Array if mtype is Annual" on page 4-21 for a description of the values in this array.
`alt`	If `mtype` is `'Monthly'`, an array of `m` geopotential heights or `m` air pressures. • If `ctype` is `'Pressure'` This is an array `m` geopotential heights. • If `ctype` is `'GPHeight'` This is an array `m` air pressure. If `mtype` is `'Annual'`, an array of `m`-by-7 values for geopotential heights . This array is defined only for the northern hemisphere (`lat` is greater than `0`). See "alt Array if mtype is Annual" on page 4-21 for a description of the values in this array.
`zwind`	An array of zonal winds: • If `mtype` is `'Monthly'` This is an array in meters per second • If `mtype` is `'Annual'`, an array of `m-by-7` values. See "zwind if mtype is Annual" on page 4-21 for a description of the values in this array.

T Array if mtype is Annual

- If `mtype` is `'Annual'`

  This is an array of `m-by-7` values. These values are:

  - Annual mean temperature in kelvin
  - Annual temperature cycle amplitude in kelvin
  - Annual temperature cycle phase in month of maximum
  - Semiannual temperature cycle amplitude in kelvin
  - Semiannual temperature cycle phase in month of maximum
  - Terannual temperature cycle amplitude in kelvin
  - Terannual temperature cycle phase in month of maximum

alt Array if mtype is Annual

If `mtype` is `'Annual'`, `alt` is array of `m`-by-7 with the following values:

- Annual mean geopotential heights in meters
- Annual geopotential heights cycle amplitude in meters
- Annual geopotential heights cycle phase in month of maximum
- Semiannual geopotential heights cycle amplitude in meters
- Semiannual geopotential heights cycle phase in month of maximum
- Terannual geopotential heights cycle amplitude in meters
- Terannual geopotential heights cycle phase in month of maximum

zwind if mtype is Annual

If `mtype` is `'Annual'`, `zwind` is an array of `m`-by-7 with the following values:

- Annual mean zonal winds in meters per second
- Annual zonal winds cycle amplitude in meters per second

- Annual zonal winds cycle phase in month of maximum
- Semiannual zonal winds cycle amplitude in meters per second
- Semiannual zonal winds cycle phase in month of maximum
- Terannual zonal winds cycle amplitude in meters per second
- Terannual zonal winds cycle phase in month of maximum

Examples

Calculate the mean monthly values for temperature (T), geopotential height (alt), and zonal wind (zwind) using the CIRA 1986 model at 45 degrees latitude and 101,300 pascal for January with out-of-range actions generating warnings:

```
[T alt zwind] = atmoscira( 45, 'Pressure', 101300 )
T =
  280.6000
alt =
   -18
zwind =
    3.3000
```

Calculate the mean monthly values for temperature (T), pressure (pres), and zonal wind (zwind) using the CIRA 1986 model at 45 degrees latitude and 20,000 meters for October with out-of-range actions generating warnings:

```
[T pres zwind] = atmoscira( 45, 'GPHeight', 20000, 'Monthly', 10)
T =
  215.8500
pres =
  5.5227e+003
zwind =
    9.5000
```

Calculate the mean monthly values for temperature (T), pressure (pres), and zonal wind (zwind) using the CIRA 1986 model at 45 and -30 degrees latitude and 20,000 meters for October with out-of-range actions generating errors:

```
[T pres zwind] = atmoscira( [45 -30], 'GPHeight', 20000, 10, 'error')
T =
  215.8500  213.9000
pres =
  1.0e+003 *
    5.5227    5.6550
zwind =
    9.5000    4.3000
```

Calculate the mean monthly values for temperature (T) , geopotential height (alt) , and zonal wind (zwind) using the CIRA 1986 model at 45 degrees latitude and 2000 pascal and at -30 degrees latitude and 101,300 pascal for September with out-of-range actions generating warnings:

```
[T alt zwind] = atmoscira( [45 -30], 'Pressure', [2000 101300], 9)
T =
  223.5395  290.9000
alt =
  1.0e+004 *
    2.6692    0.0058
zwind =
    0.6300   -1.1000
```

Calculate the annual values for temperature (T) , geopotential height (alt) , and zonal wind (zwind) using the CIRA 1986 model at 45 degrees latitude and 2000 pascal with out-of-range actions generating warnings:

```
[T alt zwind] = atmoscira( 45, 'Pressure', 2000, 'Annual' )
T =
  221.9596    5.0998    6.5300    1.9499    1.3000    1.0499    1.3000
alt =
  1.0e+004 *
    2.6465    0.0417    0.0007    0.0087    0.0001    0.0015    0.0002
zwind =
    4.6099   14.7496    0.6000    1.6499    4.6000    0.5300    1.4000
```

Assumptions and Limitations

This function uses a corrected version of the CIRA data files provided by J. Barnett in July 1990 in ASCII format.

This function has the limitations of the CIRA 1986 model. The values for the CIRA 1986 model are limited to the regions of 80 degrees S to 80 degrees N on the Earth and geopotential heights of 0 to 120 kilometers. In each monthly mean data set, values at 80 degrees S for 101,300 pascal or 0 meters were omitted because these levels are within the Antarctic land mass. Zonal mean pressure in constant altitude coordinates: pressure data was not available below 20 kilometers. Therefore, this is the bottom level of the CIRA climatology.

References

Fleming, E. L., Chandra, S., Shoeberl, M. R., Barnett, J. J., *Monthly Mean Global Climatology of Temperature, Wind, Geopotential Height and Pressure for 0-120 k*m, NASA TM100697, February 1988

`http://modelweb.gsfc.nasa.gov/atmos/cospar1.html`

See Also

`atmoscoesa`, `atmosisa`, `atmoslapse`, `atmosnonstd`, `atmospalt`

Purpose

Use International Standard Atmosphere model

Syntax

`[T, a, P, rho] = atmosisa(h)`

Description

`[T, a, P, rho] = atmosisa(h)` implements the mathematical representation of the International Standard Atmosphere values for ambient temperature, pressure, density, and speed of sound for the input geopotential altitude.

Input required by `atmosisa` is:

`h`	An array of `m` geopotential heights, in meters

Outputs calculated for the International Standard Atmosphere are:

`T`	An array of `m` temperatures, in kelvin
`a`	An array of `m` speeds of sound, in meters per second
`P`	An array of `m` air pressures, in pascal
`rho`	An array of `m` air densities, in kilograms per meter cubed

Examples

Calculate the International Standard Atmosphere at 1000 meters:

```
[T, a, P, rho] = atmosisa(1000)


T =

  281.6500


a =

  336.4341
```

```
P =

  8.9875e+004


rho =

    1.1116
```

Calculate the International Standard Atmosphere at 1000, 11,000, and 20,000 meters:

```
[T, a, P, rho] = atmosisa([1000 11000 20000])


T =

  281.6500  216.6500  216.6500


a =

  336.4341  295.0696  295.0696


P =

  1.0e+004 *

    8.9875    2.2632    0.5475


rho =

    1.1116    0.3639    0.0880
```

Assumptions and Limitations

Below the geopotential altitude of 0 km and above the geopotential altitude of the tropopause, temperature and pressure values are held. Density and speed of sound are calculated using a perfect gas relationship.

References

U.S. Standard Atmosphere, 1976, U.S. Government Printing Office, Washington, D.C.

See Also

`atmoscoesa`, `atmoslapse`, `atmosnonstd`, `atmospalt`

atmoslapse

Purpose

Use Lapse Rate Atmosphere model

Syntax

```
[T, a, P, rho] = atmoslapse(h, g, gamma, r, l, hts, htp, rho0,
   p0, t0)
```

Description

`[T, a, P, rho] = atmoslapse(h, g, gamma, r, l, hts, htp, rho0, p0, t0)` implements the mathematical representation of the lapse rate atmospheric equations for ambient temperature, pressure, density, and speed of sound for the input geopotential altitude. This atmospheric model is customizable by specifying the atmospheric properties in the function input.

Inputs required by `atmoslapse` are:

`h`	An array of `m` geopotential heights, in meters
`g`	A scalar of acceleration due to gravity, in meters per second squared
`gamma`	A scalar of specific heat ratio
`r`	A scalar of characteristic gas constant, in joule per kilogram-kelvin
`l`	A scalar of lapse rate, in kelvin per meter
`hts`	A scalar of height of troposphere, in meters
`htp`	A scalar of height of tropopause, in meters
`rho0`	A scalar of air density at mean sea level, in kilograms per meter cubed
`p0`	A scalar of static pressure at mean sea level, in pascal
`t0`	A scalar of absolute temperature at mean sea level, in kelvin

Outputs calculated for the lapse rate atmosphere are:

`T`	An array of `m` temperatures, in kelvin
`a`	An array of `m` speeds of sound, in meters per second
`P`	An array of `m` air pressures, in pascal
`rho`	An array of `m` air densities, in kilograms per meter cubed

Examples

Calculate the atmosphere at 1000 meters with the International Standard Atmosphere input values:

```
[T, a, P, rho] = atmoslapse(1000, 9.80665, 1.4, 287.0531, 0.0065, ...
    11000, 20000, 1.225, 101325, 288.15 )


T =

  281.6500


a =

  336.4341


P =

  8.9875e+004


rho =

    1.1116
```

Assumptions and Limitations

Below the geopotential altitude of 0 km and above the geopotential altitude of the tropopause, temperature and pressure values are held. Density and speed of sound are calculated using a perfect gas relationship.

References

U.S. Standard Atmosphere, 1976, U.S. Government Printing Office, Washington, D.C.

See Also

`atmoscoesa`, `atmosisa`, `atmosnonstd`, `atmospalt`

Purpose

Implement mathematical representation of 2001 United States Naval Research Laboratory Mass Spectrometer and Incoherent Scatter Radar Exosphere

Syntax

```
[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec)
[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, lst)
[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, f107a,
   f107, aph)
[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, flags)
[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, otype)
[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec,
   action)
```

Description

`[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec)` and implement the mathematical representation of the 2001 United States Naval Research Laboratory Mass Spectrometer and Incoherent Scatter Radar Exosphere (NRLMSISE-00). NRLMSISE-00 calculates the neutral atmosphere empirical model from the surface to lower exosphere (0 to 1,000,000 meters) with the option of including contributions from anomalous oxygen which can affect satellite drag above 500,000 meters.

`[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, lst)` lets you specify an array of `m` local apparent solar time (hours).

`[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, f107a, f107, aph)` lets you specify an array of `m` 81 day average of F10.7 flux (centered on `doy`), an array of `m` daily F10.7 flux for previous day, and an array of `m`-by-7 of magnetic index information.

`[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, flags)` lets you specify an array of 23 to enable or disable particular variations for the outputs.

`[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, otype)` lets you specify a string for total mass density output.

`[T rho] = atmosnrlmsise00(h, lat, lon, year, doy, sec, action)` lets you specify out-of-range input action.

Inputs for `atmosnrlmsise00` are:

`h`	An array of `m` altitudes, in meters.
`lat`	An array of `m` geodetic latitudes, in meters.
`long`	An array of `m` longitudes, in degrees.
`year`	Depending on the value of `ctype`, this argument specifies one of the following arrays: • `m` pressures in pascal • `m` geopotential height in meters
`doy`	An array `m` day of year.
`sec`	An array of `m` seconds in day in universal time (UT)
`lst`	An array of `m` local apparent solar time (hours). To obtain a physically realistic value, lst is set to (`sec/3600 + lon/15`) by default. See "Limitations" on page 4-36 for more information.
`F107a`	An array of `m` 81 day average of F10.7 flux (centered on day of year (`doy`)). If `F107A` is input, `F107` and `aph` must also be input. The effects of `F107A` are neither large nor well established below 80,000 meters; therefore, the default value is set to 150. See "Limitations" on page 4-36 for more information.
`F107`	An array of `m` daily F10.7 flux for previous day. If `F107` is input, `F107A` and `aph` must also be input. The effects of F107 are neither large nor well established below 80,000 meters; therefore, the default value is set to 150. See "Limitations" on page 4-36 for more information.

aph	An array of m-by-7 of magnetic index information. If aph is input, F107a and F107 must also be input. This information consists of daily magnetic index (AP), 3 hour AP for current time, 3 hour AP for 3 hours before current time, 3 hour AP for 6 hours before current time, 3 hour AP for 9 hours before current time, average of eight 3 hour AP indices from 12 to 33 hours prior to current time, and average of eight 3 hour AP indices from 36 to 57 hours prior to current time. The effects of daily magnetic index are neither large nor well established below 80,000 meters. As a result, the default value is set to 4. See "Limitations" on page 4-36 for more information.
flags	An array of 23 to enable or disable particular variations for the outputs. See following table.
otype	A string for total mass density output. `Oxygen' Total mass density outputs include anomalous oxygen number density.  `NoOxygen' Total mass density outputs do not include anomalous oxygen number density.
action	A string to determine action for out-of-range input. Specify if out-of-range input invokes a 'Warning', 'Error', or no action ('None'). The default is 'Warning'.

These flags, associated with the eleventh input, enable or disable particular variations for the outputs.

Field	Description
`Flags(1)`	F10.7 effect on mean
`Flags(2)`	Independent of time
`Flags(3)`	Symmetrical annual
`Flags(4)`	Symmetrical semiannual
`Flags(5)`	Asymmetrical annual
`Flags(6)`	Asymmetrical semiannual
`Flags(7)`	Diurnal
`Flags(8)`	Semidiurnal
`Flags(9)`	Daily AP. If you set this field to -1, the block uses the entire matrix of magnetic index information (APH) instead of `APH(:,1)`
`Flags(10)`	All UT, longitudinal effects
`Flags(11)`	Longitudinal
`Flags(12)`	UT and mixed UT, longitudinal
`Flags(13)`	Mixed AP, UT, longitudinal
`Flags(14)`	Terdiurnal
`Flags(15)`	Departures from diffusive equilibrium
`Flags(16)`	All exospheric temperature variations
`Flags(17)`	All variations from 120,000 meter temperature (TLB)
`Flags(18)`	All lower thermosphere (TN1) temperature variations
`Flags(19)`	All 120,000 meter gradient (S) variations
`Flags(20)`	All upper stratosphere (TN2) temperature variations
`Flags(21)`	All variations from 120,000 meter values (ZLB)
`Flags(22)`	All lower mesosphere temperature (TN3) variations
`Flags(23)`	Turbopause scale height variations

Outputs calculated for the neutral atmosphere empirical model are:

Field	Description
T	An array of N-by-2 values of temperature, in kelvin. The first column is exospheric temperature in kelvin, the second column is temperature at altitude, in kelvin.
rho	An array of N-by-9 values of densities (kg/m^3 or 1/m^3) in selected density units. The column order is: Density of He, in 1/m^3 Density of O, in 1/m^3 Density of N2, in 1/m^3 Density of O2, in 1/m^3 Density of Ar, in 1/m^3 Total mass density, in 1/m^3 Density of H, in 1/m^3 Density of N, in 1/m^3 Anomalous oxygen number density, in 1/m^3 `rho(6)`, total mass density, is defined as the sum of the mass densities of He, O, N2, O2, Ar, H, and N. Optionally, `rho(6)` can include the mass density of anomalous oxygen making `rho(6)`, the effective total mass density for drag.

Examples

Calculate the temperatures, densities not including anomalous oxygen using the NRLMSISE-00 model at 10,000 meters, 45 degrees latitude, -50 degrees longitude, on January 4, 2007 at 0 UT using default values for flux, magnetic index data, and local solar time with out of range actions generating warnings:

```
[T rho] = atmosnrlmsise00( 10000, 45, -50, 2007, 4, 0)
```

Calculate the temperatures, densities not including anomalous oxygen using the NRLMSISE-00 model at 10,000 meters, 45 degrees latitude, -50 degrees longitude, and at 25,000 meters, 47 degrees latitude, -55 degrees longitude on January 4, 2007 at 0 UT using default values for flux, magnetic index data, and local solar time with out of range actions generating warnings:

```
[T rho] = atmosnrlmsise00( [10000; 25000], [45; 47],
[-50; -55], [2007; 2007], [4; 4], [0; 0])
```

Calculate the temperatures, densities including anomalous oxygen using the NRLMSISE-00 model at 10,000 meters, 45 degrees latitude, -50 degrees longitude, on January 4, 2007 at 0 UT using default values for flux, magnetic index data, and local solar time with out of range actions generating errors:

```
[T rho] = atmosnrlmsise00( 10000, 45, -50, 2007,
4, 0, 'Oxygen', 'Error')
```

Calculate the temperatures, densities including anomalous oxygen using the NRLMSISE-00 model at 100,000 meters, 45 degrees latitude, -50 degrees longitude, on January 4, 2007 at 0 UT using defined values for flux, and magnetic index data, and default local solar time with out of range actions generating no message:

```
aph = [17.375 15 20 15 27 (32+22+15+22+9+18+12+15)/8 (39+27+9+32+39+9+7+12)/8]
f107 = 87.7
nov_6days  = [ 78.6 78.2 82.4 85.5 85.0 84.1]
dec_31daymean = 84.5
jan_31daymean = 83.5
feb_13days = [ 89.9 90.3 87.3 83.7 83.0 81.9 82.0 78.4 76.7 75.9 74.7 73.6 72.7]
f107a = (sum(nov_6days) + sum(feb_13days) + (dec_31daymean + jan_31daymean)*31)/81
flags = ones(1,23)
flags(9) = -1
[T rho] = atmosnrlmsise00( 100000, 45, -50, 2007, 4, 0, f107a, f107,
aph, flags, 'Oxygen', 'None')
```

Limitations

If `flags` array length, `m`, is 23 and all available inputs are not specified, this function assumes that `flags` is set.

This function has the limitations of the NRLMSISE-00 model. For more information, see the NRLMSISE-00 model documentation.

The NRLMSISE-00 model uses `sec`, `lst`, and `lon` independently. These arguments are not of equal importance for every situation. For the most physically realistic calculation, choose these three variables to be consistent by default:

```
lst = sec/3600 + lon/15
```

Departures from this equation for `lst` can be included if available but are of minor importance.

The F107 and F107A values that are used to generate the model correspond to the 10.7 cm radio flux at the actual distance of the Earth from the Sun rather than the radio flux at 1 AU. The following site provides both classes of values: `ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_RADIO/FLUX/`

References

`http://uap-www.nrl.navy.mil/models_web/msis/msis_home.htm`

See Also

`atmoscira`

atmosnonstd

Purpose

Use climatic data from MIL-STD-210 or MIL-HDBK-310

Syntax

```
[T, a, P, rho] = atmosnonstd(h, atype, extreme, freq, extalt,
   action, spec)
```

Description

`[T, a, P, rho] = atmosnonstd(h, atype, extreme, freq, extalt, action, spec)` implements a portion of the climatic data of the MIL-STD-210C or MIL-HDBK-310 worldwide air environment to 80 km geometric (or approximately 262,000 feet geometric) for absolute temperature, pressure, density, and speed of sound for the input geopotential altitude.

Inputs for `atmosnonstd` are:

`h`	An array of `m` geopotential heights, in meters
`atype`	A string selecting the representation of `'Profile'` or `'Envelope'` for the atmospheric data. `'Profile'` is the realistic atmospheric profiles associated with extremes at specified altitudes. `'Profile'` is recommended for simulation of vehicles vertically traversing the atmosphere, or when the total influence of the atmosphere is needed. `'Envelope'` uses extreme atmospheric values at each altitude. `'Envelope'` is recommended for vehicles traversing the atmosphere horizontally, without much change in altitude.
`extreme`	A string selecting the atmospheric parameter which is the extreme value. Atmospheric parameters that can be specified are `'High temperature'`, `'Low temperature'`, `'High density'`, `'Low density'`, `'High pressure'` and `'Low pressure'`. `'High pressure'` and `'Low pressure'` are available only when `atype` is `'Envelope'`.

freq	A string selecting percent of time the extreme values would occur. Valid values for freq include 'Extreme values', '1%', '5%', '10%', and '20%'. 'Extreme values', '5%', and '20%' are available only when atype is 'Envelope'. When using atype of 'Envelope' and freq of '5%', '10%', and '20%', only the extreme parameter selected (temperature, density, or pressure) has a valid output. All other parameter outputs are zero.
extalt	A scalar value, in kilometers, selecting geometric altitude at which the extreme values occur. extalt applies only when atype is 'Profile'. Valid values for extalt include 5 (16404 ft), 10 (32808 ft), 20 (65617 ft), 30 (98425 ft), and 40 (131234 ft).
action	A string to determine action for out-of-range input. Specify if out-of-range input invokes a 'Warning', 'Error', or no action ('None'). The default is 'Warning'.
spec	A string specifying the atmosphere model, MIL-STD-210C or MIL-HDBK-310: '210c' or '310'. The default is '310'.

Outputs calculated for the lapse rate atmosphere are:

T	An array of m temperatures, in kelvin
a	An array of m speeds of sound, in meters per second
P	An array of m air pressures, in pascal
rho	An array of m air densities, in kilograms per meter cubed

Examples

Calculate the nonstandard atmosphere profile with high density occurring 1% of the time at 5 kilometers from MIL-HDBK-310 at 1000 meters with warnings for out-of-range inputs:

```
[T, a, P, rho] = atmosnonstd( 1000,'Profile','High density','1%',5 )


T =

  248.1455


a =

  315.7900


P =

  8.9893e+004


rho =

    1.2620
```

Calculate the nonstandard atmosphere envelope with high pressure occurring 20% of the time from MIL-STD-210C at 1000, 11,000, and 20,000 meters with errors for out-of-range inputs:

```
[T, a, P, rho] = atmosnonstd([1000 11000 20000],'Envelope', ...
                              'High pressure','20%','Error','210c' )



T =

  0     0     0
```

```
a =

  0     0     0


P =

  1.0e+004 *
    9.1598    2.5309    0.6129


rho =

    0     0     0
```

Assumptions and Limitations

All values are held below the geometric altitude of 0 m (0 feet) and above the geometric altitude of 80,000 meters (approximately 262,000 feet). The envelope atmospheric model has a few exceptions where values are held below the geometric altitude of 1 kilometer (approximately 3281 feet) and above the geometric altitude of 30,000 meters (approximately 98,425 feet). These exceptions are due to lack of data in MIL-STD-210 or MIL-HDBK-310 for these conditions.

In general, temperature values are interpolated linearly and density values are interpolated logarithmically. Pressure and speed of sound are calculated using a perfect gas relationship. The envelope atmospheric model has a few exceptions where the extreme value is the only value provided as an output. Pressure in these cases is interpolated logarithmically. These envelope atmospheric model exceptions apply to all cases of high and low pressure, high and low temperature, and high and low density, excluding the extreme values and 1% frequency of occurrence. These exceptions are due to lack of data in MIL-STD-210 or MIL-HDBK-310 for these conditions.

A limitation is that climatic data for the region south of 60 degrees S latitude is excluded from consideration in MIL-STD-210 or MIL-HDBK-310.

This function uses the metric version of data from the MIL-STD-210 or MIL-HDBK-310 specifications. A limitation of this is some inconsistent data between the metric and English data. Locations where these inconsistencies occur are within the envelope data for low density, low temperature, high temperature, low pressure, and high pressure. The most noticeable differences occur in the following values:

- For low density envelope data with 5% frequency, the density values in metric units are inconsistent at 4 km and 18 km and the density values in English units are inconsistent at 14 km.
- For low density envelope data with 10% frequency, the density values in metric units are inconsistent at 18 km and the density values in English units are inconsistent at 14 km.
- For low density envelope data with 20% frequency, the density values in English units are inconsistent at 14 km.
- For high pressure envelope data with 10% frequency, the pressure values at 8 km are inconsistent.

References

Global Climatic Data for Developing Military Products (MIL-STD-210C), 9 January 1987, Department of Defense, Washington, D.C.

Global Climatic Data for Developing Military Products (MIL-HDBK-310), 23 June 1997, Department of Defense, Washington, D.C.

See Also

`atmoscoesa`, `atmosisa`, `atmoslapse`, `atmospalt`

Purpose

Calculate pressure altitude based on ambient pressure

Syntax

```
h = atmospalt(p, action)
```

Description

`h = atmospalt(p, action)` computes the pressure altitude based on ambient pressure. Pressure altitude is the altitude with specified ambient pressure in the 1976 Committee on Extension to the Standard Atmosphere (COESA) United States standard. Pressure altitude is also known as the mean sea level (MSL) altitude.

Inputs for `atmospalt` are:

`P`	An array of `m` ambient pressures, in pascal
`action`	A string to determine action for out-of-range input. Specify if out-of-range input invokes a `'Warning'`, `'Error'`, or no action (`'None'`). The default is `'Warning'`.

Output is:

`h`	An array of `m` pressure altitudes or MSL altitudes, in meters

Examples

Calculate the pressure altitude at a static pressure of 101,325 Pa with warnings for out-of-range inputs:

```
h = atmospalt(101325)


h =

     0
```

Calculate the pressure altitude at static pressures of 101,325 and 26,436 Pa with errors for out-of-range inputs:

```
h = atmospalt([101325 26436], 'Error' )


h =

   1.0e+004 *

         0    1.0000
```

Assumptions and Limitations

Below the pressure of 0.3961 Pa (approximately 0.00006 psi) and above the pressure of 101,325 Pa (approximately 14.7 psi), altitude values are extrapolated logarithmically. Air is assumed to be dry and an ideal gas.

References

U.S. Standard Atmosphere, 1976, U.S. Government Printing Office, Washington, D.C.

See Also

`atmoscoesa`

Purpose

Construct body object for use with animation object

Syntax

```
h = Aero.Body
```

Description

`h = Aero.Body` constructs a body for an animation object. The animation object is returned in `h`. To use the Aero.Body object, you typically:

1. Create the animation body.
2. Configure or customize the body object.
3. Load the body.
4. Generate patches for the body (requires an axes from a figure).
5. Set the source for the time series data.
6. Move or update the body.

The animation object has the following properties:

By default, an `Aero.Body` object natively uses aerospace body coordinates for the body geometry and the time series data. Convert time series data from other coordinate systems on the fly by registering a different `CoordTransformFcn` function.

See `Aero.Body` for further details.

See Also

`Aero.Body`

Camera (Aero.Camera)

Purpose

Construct camera object for use with animation object

Syntax

```
h = Aero.Camera
```

Description

`h = Aero.Camera` constructs a camera object `h` for use with an animation object. The camera object uses the registered coordinate transform. By default, this is an aerospace body coordinate system. Axes of custom coordinate systems must be orthogonal.

The animation object has the following properties:

By default, an `Aero.Body` object natively uses aerospace body coordinates for the body geometry and the time series data. Convert time series data from other coordinate systems on the fly by registering a different `CoordTransformFcn` function.

See `Aero.Camera` for further details.

See Also

`Aero.Camera`

Purpose

Convert from acceleration units to desired acceleration units

Syntax

```
a = convacc(v, ui, uo)
```

Description

`a = convacc(v, ui, uo)` computes the conversion factor from specified input acceleration units, `ui`, to specified output acceleration units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

`'ft/s^2'`	Feet per second squared
`'m/s^2'`	Meters per second squared
`'km/s^2'`	Kilometers per second squared
`'in/s^2'`	Inches per second squared
`'km/h-s'`	Kilometers per hour per second
`'mph/s'`	Miles per hour per second
`'G''s'`	g-units

Examples

Convert three accelerations from feet per second squared to meters per second squared:

```
a = convacc([3 10 20],'ft/s^2','m/s^2')

a =

    0.9144    3.0480    6.0960
```

See Also

`convang`, `convangacc`, `convangvel`, `convdensity`, `convforce`, `convlength`, `convmass`, `convpres`, `convtemp`, `convvel`

Purpose Convert from angle units to desired angle units

Syntax

```
a = convang(v, ui, uo)
```

Description `a = convang(v, ui, uo)` computes the conversion factor from specified input angle units, `ui`, to specified output angle units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

'deg'	Degrees
'rad'	Radians
'rev'	Revolutions

Examples Convert three angles from degrees to radians:

```
a = convang([3 10 20],'deg','rad')

a =

    0.0524    0.1745    0.3491
```

See Also `convacc`, `convangacc`, `convangvel`, `convdensity`, `convforce`, `convlength`, `convmass`, `convpres`, `convtemp`, `convvel`

Purpose

Convert from angular acceleration units to desired angular acceleration units

Syntax

```
a = convangacc(v, ui, uo)
```

Description

a = convangacc(v, ui, uo) computes the conversion factor from specified input angular acceleration units, ui, to specified output angular acceleration units, uo, and applies the conversion factor to the input, v, to produce the output, a, in the desired units. v and a are floating-point arrays of size m-by-n. All of the values in v must have the same unit conversions from ui to uo. ui and uo are strings.

Supported unit strings are:

'deg/s^2'	Degrees per second squared
'rad/s^2'	Radians per second squared
'rpm/s'	Revolutions per minute per second

Examples

Convert three angular accelerations from degrees per second squared to radians per second squared:

```
a = convangacc([0.3 0.1 0.5],'deg/s^2','rad/s^2')

a =

    0.0052    0.0017    0.0087
```

See Also

convacc, convang, convangvel, convdensity, convforce, convlength, convmass, convpres, convtemp, convvel

Purpose

Convert from angular velocity units to desired angular velocity units

Syntax

```
a = convangvel(v, ui, uo)
```

Description

`a = convangvel(v, ui, uo)` computes the conversion factor from specified input angular velocity units, `ui`, to specified output angular velocity units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

`'deg/s'`	Degrees per second
`'rad/s'`	Radians per second
`'rpm'`	Revolutions per minute

Examples

Convert three angular velocities from degrees per second to radians per second:

```
a = convangvel([0.3 0.1 0.5],'deg/s','rad/s')

a =

    0.0052    0.0017    0.0087
```

See Also

`convacc`, `convang`, `convangacc`, `convdensity`, `convforce`, `convlength`, `convmass`, `convpres`, `convtemp`, `convvel`

Purpose

Convert from density units to desired density units

Syntax

```
a = convdensity(v, ui, uo)
```

Description

`a = convdensity(v, ui, uo)` computes the conversion factor from specified input density units, `ui`, to specified output density units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

`'lbm/ft^3'`	Pound mass per feet cubed
`'kg/m^3'`	Kilograms per meters cubed
`'slug/ft^3'`	Slugs per feet cubed
`'lbm/in^3'`	Pound mass per inch cubed

Examples

Convert three densities from pound mass per feet cubed to kilograms per meters cubed:

```
a = convdensity([0.3 0.1 0.5],'lbm/ft^3','kg/m^3')

a =

    4.8055    1.6018    8.0092
```

See Also

`convacc`, `convang`, `convangacc`, `convangvel`, `convforce`, `convlength`, `convmass`, `convpres`, `convtemp`, `convvel`

convforce

Purpose

Convert from force units to desired force units

Syntax

```
a = convforce(v, ui, uo)
```

Description

`a = convforce(v, ui, uo)` computes the conversion factor from specified input force units, `ui`, to specified output force units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

'lbf'	Pound force
'N'	Newton

Examples

Convert three forces from pound force to newtons:

```
a = convforce([120 1 5],'lbf','N')

a =

   533.7866    4.4482   22.2411
```

See Also

`convacc`, `convang`, `convangacc`, `convangvel`, `convdensity`, `convlength`, `convmass`, `convpres`, `convtemp`, `convvel`

Purpose Convert from length units to desired length units

Syntax

```
a = convlength(v, ui, uo)
```

Description

`a = convlength(v, ui, uo)` computes the conversion factor from specified input length units, `ui`, to specified output length units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

'ft'	Feet
'm'	Meters
'km'	Kilometers
'in'	Inches
'mi'	Miles
'naut mi'	Nautical miles

Examples

Convert three lengths from feet to meters:

```
a = convlength([3 10 20],'ft','m')

a =

    0.9144    3.0480    6.0960
```

See Also

`convacc`, `convang`, `convangacc`, `convangvel`, `convdensity`, `convforce`, `convmass`, `convpres`, `convtemp`, `convvel`

convmass

Purpose Convert from mass units to desired mass units

Syntax

```
a = convmass(v, ui, uo)
```

Description `a = convmass(v, ui, uo)` computes the conversion factor from specified input mass units, `ui`, to specified output mass units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

`'lbm'`	Pound mass
`'kg'`	Kilograms
`'slugs'`	Slugs

Examples Convert three masses from pound mass to kilograms:

```
a = convmass([3 1 5],'lbm','kg')

a =

    1.3608    0.4536    2.2680
```

See Also `convacc`, `convang`, `convangacc`, `convangvel`, `convdensity`, `convforce`, `convlength`, `convpres`, `convtemp`, `convvel`

Purpose

Convert from pressure units to desired pressure units

Syntax

```
a = convpres(v, ui, uo)
```

Description

a = convpres(v, ui, uo) computes the conversion factor from specified input pressure units, ui, to specified output pressure units, uo, and applies the conversion factor to the input, v, to produce the output, a, in the desired units. v and a are floating-point arrays of size m-by-n. All of the values in v must have the same unit conversions from ui to uo. ui and uo are strings.

Supported unit strings are:

'psi'	Pound force per square inch
'Pa'	Pascal
'psf'	Ppound force per square foot
'atm'	Atmosphere

Examples

Convert two pressures from pound force per square inch to atmospheres:

```
a = convpres([14.696  35],'psi','atm')

a =

    1.0000    2.3816
```

See Also

convacc, convang, convangacc, convangvel, convdensity, convforce, convlength, convmass, convtemp, convvel

Purpose Convert from temperature units to desired temperature units

Syntax

```
a = convtemp(v, ui, uo)
```

Description `a = convtemp(v, ui, uo)` computes the conversion factor from specified input temperature units, `ui`, to specified output temperature units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

`'K'`	Kelvin
`'F'`	Degrees Fahrenheit
`'C'`	Degrees Celsius
`'R'`	Degrees Rankine

Examples Convert three temperatures from degrees Celsius to degrees Fahrenheit:

```
a = convtemp([0 100 15],'C','F')

a =

    32.0000  212.0000   59.0000
```

See Also `convacc`, `convang`, `convangacc`, `convangvel`, `convdensity`, `convforce`, `convlength`, `convmass`, `convpres`, `convvel`

Purpose

Convert from velocity units to desired velocity units

Syntax

```
a = convvel(v, ui, uo)
```

Description

`a = convvel(v, ui, uo)` computes the conversion factor from specified input velocity units, `ui`, to specified output velocity units, `uo`, and applies the conversion factor to the input, `v`, to produce the output, `a`, in the desired units. `v` and `a` are floating-point arrays of size `m`-by-`n`. All of the values in `v` must have the same unit conversions from `ui` to `uo`. `ui` and `uo` are strings.

Supported unit strings are:

`'ft/s'`	Feet per second
`'m/s'`	Meters per second
`'km/s'`	Kilometers per second
`'in/s'`	Inches per second
`'km/h'`	Kilometers per hour
`'mph'`	Miles per hour
`'kts'`	Knots
`'ft/min'`	Feet per minute

Examples

Convert three velocities from feet per minute to meters per second:

```
a = convvel([30 100 250],'ft/min','m/s')

a =

    0.1524    0.5080    1.2700
```

See Also

`convacc`, `convang`, `convangacc`, `convangvel`, `convdensity`, `convforce`, `convlength`, `convmass`, `convpres`, `convtemp`

correctairspeed

Purpose

Calculate equivalent airspeed (EAS), calibrated airspeed (CAS), or true airspeed (TAS) from one of other two airspeeds

Syntax

```
as = correctairspeed(v, a, p0, ai, ao)
```

Description

`as = correctairspeed(v, a, p0, ai, ao)` computes the conversion factor from specified input airspeed, `ai`, to specified output airspeed, `ao`, using speed of sound, `a`, and static pressure `p0`. The conversion factor is applied to the input airspeed, `v`, to produce the output, `as`, in the desired airspeed. `v`, `as`, `a`, and `p0` are floating-point arrays of size `m`. All of the values in `v` must have the same airspeed conversions from `ai` to `ao`. `ai` and `ao` are strings.

Input required by `correctairspeed` is:

`v`	Airspeed in meters per second
`a`	Speed of sound in meters per second
`p0`	Static air pressure in pascal
`ai`	Input airspeed string
`ao`	Output airspeed string

Supported airspeed strings are:

`'TAS'`	True airspeed
`'CAS'`	Calibrated airspeed
`'EAS'`	Equivalent airspeed

Output, `as`, is calculated as airspeed in meters per second.

Examples

Convert three airspeeds from true airspeed to equivalent airspeed at 1000 meters:

```
as = correctairspeed([25.7222; 10.2889; 3.0867], 336.4, 89874.6,'TAS','EAS')

as =
```

```
   24.5057
    9.8023
    2.9407
```

Convert airspeeds from true airspeed to equivalent airspeed at 1000 and 0 meters:

```
ain = [25.7222; 10.2889; 3.0867];
sos = [336.4; 340.3; 340.3];
P0 = [89874.6; 101325; 101325];
as = correctairspeed(ain, sos, P0,'TAS','EAS')

as =

   24.5057
   10.2887
    3.0866
```

Assumptions and Limitations

Based on assumption of compressible, isentropic (subsonic flow), dry air with constant specific heat ratio (gamma).

References

Lowry, J.T., *Performance of Light Aircraft*, AIAA Education Series, Washington, D.C., 1999

Aeronautical Vestpocket Handbook, United Technologies Pratt & Whitney, August, 1986

See Also

`airspeed`

createBody (Aero.Animation)

Purpose

Create body for animation object

Syntax

```
idx = createBody(h,bodyDataSrc)
idx = h.createBody(bodyDataSrc)
idx = createBody(h,bodyDataSrc,geometrysource)
idx = h.createBody(bodyDataSrc,geometrysource)
```

Description

`idx = createBody(h,bodyDataSrc)` and `idx = h.createBody(bodyDataSrc)` create a new body using the `bodyDataSrc`, makes its patches, and adds it to the animation object `h`. This command assumes a default geometry source type set to `Auto`.

`idx = createBody(h,bodyDataSrc,geometrysource)` and `idx = h.createBody(bodyDataSrc,geometrysource)` create a new body using the `bodyDataSrc` file, makes its patches, and adds it to the animation object `h`. `geometrysource` is the geometry source type for the body.

By default *geometrysource* is set to `Auto`, which recognizes `.mat` extensions as Mat-files, `.ac` extensions as Ac3d files, and structures containing fields of `name`, `faces`, `vertices`, and `cdata` as MATLAB variables. If you want to use alternate file extensions or file types, enter one of the following:

- `Auto`
- `Variable`
- `MatFile`
- `Ac3d`
- `Custom`

Examples

Create a body for the animation object, `h`. Use the Ac3d format data source `pa24-250_orange.ac`, for the body.

```
h = Aero.Animation;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
```

See Also addBody, moveBody, play, removeBody, show, updateBodies

datcomimport

Purpose

Bring USAF Digital DATCOM file into MATLAB

Syntax

```
aero = datcomimport(file)
aero = datcomimport(file, usenan)
aero = datcomimport(file, usenan, verbose)
```

Description

`aero = datcomimport(file)` takes a filename as a string, or a cell array of filenames as strings, `file`, and imports aerodynamic data from `file` into a cell array of structures, `aero`. Prior to reading DATCOM file, values are initialized to 99999, in order to show when there is not a full set of data for the DATCOM case.

`aero = datcomimport(file, usenan)` is an alternate method allowing using NaN or zero to replace data points where no DATCOM methods exist or where the method is not applicable. The default value for `usenan` is `true`.

`aero = datcomimport(file, usenan, verbose)` is an alternate method allowing additional specification of how the status of the DATCOM file being read is displayed. The default value for `verbose` is `2`, which displays a wait bar. Other options are `0`, which displays no information, and `1`, which displays text to the MATLAB Command window.

The fields of `aero` are dependent on the data within the DATCOM file. Common fields are the following:

`case`	A string containing the `caseid`. The default value is `[]`.
`mach`	An array of Mach numbers. The default value is `[]`.
`alt`	An array of altitudes. The default value is `[]`.
`alpha`	An array of angles of attack. The default value is `[]`.
`nmach`	The number of Mach numbers. The default value is `0`.

nalt	The number of altitudes. The default value is 0.
nalpha	The number of angles of attack. The default value is 0.
rnnub	An array of Reynolds numbers. The default value is [].
hypers	A logical denoting, when true, that mach numbers above tsmach are hypersonic. The default value is false and those values are supersonic.
loop	A scalar denoting the type of looping done to generate the DATCOM file. When loop is 1, mach and alt are varied together. When loop is 2, mach varies while alt is fixed. Altitude is then updated and Mach numbers are cycled through again. When loop is 3, mach is fixed while alt varies. mach is then updated and altitudes are cycled through again. The default value is 1.
sref	A scalar denoting the reference area for the case. The default value is [].
cbar	A scalar denoting the longitudinal reference length. The default value is [].
blref	A scalar denoting the lateral reference length. The default value is [].
dim	A string denoting the specified system of units for the case. The default value is 'ft'.
deriv	A string denoting the specified angle units for the case. The default value is 'deg'.
stmach	A scalar value setting the upper limit of subsonic Mach numbers. The default value is 0.6.

`tsmach`	A scalar value setting the lower limit of supersonic Mach numbers. The default value is `1.4`.
`save`	A logical denoting whether the input values for this case are used in the next case. The default value is `false`.
`stype`	A scalar denoting the type of asymmetric flap for the case. The default value is `[]`.
`trim`	A logical denoting the reading of trim data for the case. When trim runs are read, this value is set to `true`. The default value is `false`.
`damp`	A logical denoting the reading of dynamic derivative data for the case. When dynamic derivative runs are read, this value is set to `true`. The default value is `false`.
`build`	A scalar denoting the reading of build data for the case. When build runs are read, this value is set to 10. The default value is 1.
`part`	A logical denoting the reading of partial data for the case. When partial runs were written for each Mach number, this value is set to `true`. The default value is `false`.
`highsym`	A logical denoting the reading of symmetric flap high lift data for the case. When symmetric flap runs are read, this value is set to `true`. The default value is `false`.
`highasy`	A logical denoting the reading of asymmetric flap high lift data for the case. When asymmetric flap runs are read, this value is set to `true`. The default value is `false`.

`highcon`	A logical denoting the reading of control/trim tab high lift data for the case. When control/trim tab runs are read, this value is set to `true`. The default value is `false`.
`tjet`	A logical denoting the reading of transverse-jet control data for the case. When transverse-jet control runs are read, this value is set to `true`. The default value is `false`.
`hypeff`	A logical denoting the reading of hypersonic flap effectiveness data for the case. When hypersonic flap effectiveness runs are read, this value is set to `true`. The default value is `false`.
`lb`	A logical denoting the reading of low aspect ratio wing or lifting body data for the case. When low aspect ratio wing or lifting body runs are read, this value is set to `true`. The default value is `false`.
`pwr`	A logical denoting the reading of power effects data for the case. When power effects runs are read, this value is set to `true`. The default value is `false`.
`grnd`	A logical denoting the reading of ground effects data for the case. When ground effects runs are read, this value is set to `true`. The default value is `false`.
`wsspn`	A scalar denoting the semi-span theoretical panel for wing. This value is used to determine if the configuration contains a canard. The default value is `1`.
`hsspn`	A scalar denoting the semi-span theoretical panel for horizontal tail. This value is used to determine if the configuration contains a canard. The default value is `1`.

ndelta	The number of control surface deflections: delta, deltal, or deltar. The default value is 0.
delta	An array of control-surface streamwise deflection angles. The default value is [].
deltal	An array of left lifting surface streamwise control deflection angles. The default value is [] and is defined positive for trailing-edge down.
deltar	An array of right lifting surface streamwise control deflection angles. The default value is [] and is defined positive for trailing-edge down.
ngh	A scalar denoting the number of ground altitudes. The default value is 0.
grndht	An array of ground heights. The default value is [].
config	A logical denoting whether the case contains horizontal tails. The default value is false.

Static longitude and lateral stability fields available are:

cd	A matrix of drag coefficients. These coefficients are a function of alpha, mach, alt, build, grndht, and delta and are defined positive for an aft acting load.
cl	A matrix of lift coefficients. These coefficients are a function of alpha, mach, alt, build, grndht, and delta and are defined positive for an up acting load.
cm	A matrix of pitching-moment coefficients. These coefficients are a function of alpha, mach, alt, build, grndht, and delta and are defined positive for a nose-up rotation.

`cn`	A matrix of normal-force coefficients. These coefficients are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta` and are defined positive for a normal force in the +Z direction.
`ca`	A matrix of axial-force coefficients. These coefficients are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta` and are defined positive for a normal force in the +X direction.
`xcp`	A matrix of distances between moment reference center and the center of pressure divided by the longitudinal reference length. These distances are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta` and are defined positive for a location forward of the center of gravity.
`cla`	A matrix of derivatives of lift coefficients with respect to `alpha`. These derivatives are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.
`cma`	A matrix of derivatives of pitching-moment coefficients with respect to `alpha`. These derivatives are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.
`cyb`	A matrix of derivatives of side-force coefficients with respect to sideslip angle. These derivatives are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.
`cnb`	A matrix of derivatives of yawing-moment coefficients with respect to sideslip angle. These derivatives are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.

`clb`	A matrix of derivatives of rolling-moment coefficients with respect to sideslip angle. These derivatives are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.
`qqinf`	A matrix of ratios of dynamic pressure at the horizontal tail to the freestream value. These ratios are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.
`eps`	A matrix of downwash angle at horizontal tail in degrees. These angles are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.
`depsdalp`	A matrix of downwash angle with respect to angle of attack. These angles are a function of `alpha`, `mach`, `alt`, `build`, `grndht`, and `delta`.

Dynamic derivative fields are:

`clq`	A matrix of rolling-moment derivatives due to pitch rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`cmq`	A matrix of pitching moment derivatives due to pitch rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`clad`	A matrix of lift force derivatives due to rate of angle of attack. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`cmad`	A matrix of pitching moment derivatives due to rate of angle of attack. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`clp`	A matrix of rolling moment derivatives due to roll rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.

`cyp`	A matrix of lateral force derivatives due to roll rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`cnp`	A matrix of yawing moment derivatives due to roll rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`cnr`	A matrix of yawing moment derivatives due to yaw rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.
`clr`	A matrix of rolling moment derivatives due to yaw rate. These derivatives are a function of `alpha`, `mach`, `alt`, and `build`.

High lift and control fields for symmetric flaps are:

`dcl_sym`	A matrix of incremental lift coefficients due to deflection of control surface, valid in the linear-lift angle of attack range. These coefficients are a function of `delta`, `mach`, and `alt`.
`dcm_sym`	A matrix of incremental pitching-moment coefficients due to deflection of control surface, valid in the linear-lift angle of attack range. These coefficients are a function of `delta`, `mach`, and `alt`.
`dclmax_sym`	A matrix of incremental maximum lift coefficients. These coefficients are a function of `delta`, `mach`, and `alt`.
`dcdmin_sym`	A matrix of incremental minimum drag coefficients due to control or flap deflection. These coefficients are a function of `delta`, `mach`, and `alt`.

`clad_sym`	A matrix of the lift-curve slope of the deflected, translated surface. These coefficients are a function of `delta`, `mach`, and `alt`.
`cha_sym`	A matrix of control-surface hinge-moment derivatives due to angle of attack. These derivatives are a function of `delta`, `mach`, and `alt` and, when defined positive, will tend to rotate the flap trailing edge down.
`chd_sym`	A matrix of control-surface hinge-moment derivatives due to control deflection. These derivatives are a function of `delta`, `mach`, and `alt` and, when defined positive, will tend to rotate the flap trailing edge down.
`dcdi_sym`	A matrix of incremental induced drag coefficients due to flap detection. These coefficients are a function of `alpha`, `delta`, `mach`, and `alt`.

High lift and control fields available for asymmetric flaps are:

`xsc`	A matrix of streamwise distances from wing leading edge to spoiler tip. These distances are a function of `delta`, `mach`, and `alt`.
`hsc`	A matrix of projected height of spoiler measured from normal to airfoil meanline. These distances are a function of `delta`, `mach`, and `alt`.
`ddc`	A matrix of projected height of deflector for spoiler-slot-deflector control. These distances are a function of `delta`, `mach`, and `alt`.
`dsc`	A matrix of projected height of spoiler control. These distances are a function of `delta`, `mach`, and `alt`.

`clroll`	A matrix of incremental rolling moment coefficients due to asymmetrical deflection of control surface. These coefficients are a function of `delta`, `mach`, and `alt`, or a function of `alpha`, `delta`, `mach`, and `alt` for differential horizontal stabilizer, and are defined positive when right wing is down.
`cn_asy`	A matrix of incremental yawing moment coefficients due to asymmetrical deflection of control surface. These coefficients are a function of `delta`, `mach`, and `alt`, or a function of `alpha`, `delta`, `mach`, and `alt` for plain flaps, and are defined positive when nose is right.

High lift and control fields available for control/trim tabs are:

`fc_con`	A matrix of stick forces or stick force coefficients. These forces or coefficients are a function of `alpha`, `delta`, `mach`, and `alt`.
`fhmcoeff_free`	A matrix of flap hinge moment coefficients tab free. These coefficients are a function of `alpha`, `delta`, `mach`, and `alt`.
`fhmcoeff_lock`	A matrix of flap hinge moment coefficients tab locked. These coefficients are a function of `alpha`, `delta`, `mach`, and `alt`.
`fhmcoeff_gear`	A matrix of flap hinge moment coefficients due to gearing. These coefficients are a function of `alpha`, `delta`, `mach`, and `alt`.
`ttab_def`	A matrix of trim tab deflections for zero stick force. These deflections are a function of `alpha`, `delta`, `mach`, and `alt`.

High lift and control fields available for trim are:

`cl_utrim`	A matrix of untrimmed lift coefficients. These coefficients are a function of `alpha`, `mach`, and `alt`, and are defined positive for an up acting load.
`cd_utrim`	A matrix of untrimmed drag coefficients. These coefficients are a function of `alpha`, `mach`, and `alt`, and are defined positive for an aft acting load.
`cm_utrim`	A matrix of untrimmed pitching moment coefficients. These coefficients are a function of `alpha`, `mach`, and `alt`, and are defined positive for a nose-up rotation.
`delt_trim`	A matrix of trimmed control-surface streamwise deflection angles. These angles are a function of `alpha`, `mach`, and `alt`.
`dcl_trim`	A matrix of trimmed incremental lift coefficients in the linear-lift angle of attack range due to deflection of control surface. These coefficients are a function of `alpha`, `mach`, and `alt`.
`dclmax_trim`	A matrix of trimmed incremental maximum lift coefficients. These coefficients are a function of `alpha`, `mach`, and `alt`.
`dcdi_trim`	A matrix of trimmed incremental induced drag coefficients due to flap deflection. These coefficients are a function of `alpha`, `mach`, and `alt`.
`dcdmin_trim`	A matrix of trimmed incremental minimum drag coefficients due to control or flap deflection. These coefficients are a function of `alpha`, `mach`, and `alt`.

cha_trim	A matrix of trimmed control-surface hinge-moment derivatives due to angle of attack. These derivatives are a function of alpha, mach, and alt.
chd_trim	A matrix of trimmed control-surface hinge-moment derivatives due to control deflection. These derivatives are a function of alpha, mach, and alt.
cl_tailutrim	A matrix of untrimmed stabilizer lift coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for an up acting load.
cd_tailutrim	A matrix of untrimmed stabilizer drag coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for an aft acting load.
cm_tailutrim	A matrix of untrimmed stabilizer pitching moment coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for a nose-up rotation.
hm_tailutrim	A matrix of untrimmed stabilizer hinge moment coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for a stabilizer rotation with leading edge up and trailing edge down.
aliht_tailtrim	A matrix of stabilizer incidence required to trim. These coefficients are a function of alpha, mach, and alt.
cl_tailtrim	A matrix of trimmed stabilizer lift coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for an up acting load.

cd_tailtrim	A matrix of trimmed stabilizer drag coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for an aft acting load.
cm_tailtrim	A matrix of trimmed stabilizer pitching moment coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for a nose-up rotation.
hm_tailtrim	A matrix of trimmed stabilizer hinge moment coefficients. These coefficients are a function of alpha, mach, and alt, and are defined positive for a stabilizer rotation with leading edge up and trailing edge down.
cl_trimi	A matrix of lift coefficients at trim incidence. These coefficients are a function of alpha, mach, and alt, and are defined positive for an up acting load.
cd_trimi	A matrix of drag coefficients at trim incidence. These coefficients are a function of alpha, mach, and alt, and are defined positive for an aft acting load.

Transverse jet control fields are:

time	A matrix of times. These times are stored with indices of mach, alt, and alpha.
ctrlfrc	A matrix of control forces. These forces are stored with indices of mach, alt, and alpha.
locmach	A matrix of local Mach numbers. These Mach numbers are stored with indices of mach, alt, and alpha.

reynum	A matrix of Reynolds numbers. These Reynolds numbers are stored with indices of mach, alt, and alpha.
locpres	A matrix of local pressures. These pressures are stored with indices of mach, alt, and alpha.
dynpres	A matrix of dynamic pressures. These pressures are stored with indices of mach, alt, and alpha.
blayer	A cell array of strings containing the state of the boundary layer. These states are stored with indices of mach, alt, and alpha.
ctrlcoeff	A matrix of control force coefficients. These coefficients are stored with indices of mach, alt, and alpha.
corrcoeff	A matrix of corrected force coefficients. These coefficients are stored with indices of mach, alt, and alpha.
sonicamp	A matrix of sonic amplification factors. These factors are stored with indices of mach, alt, and alpha.
ampfact	A matrix of amplification factors. These factors are stored with indices of mach, alt, and alpha.
vacthr	A matrix of vacuum thrusts. These thrusts are stored with indices of mach, alt, and alpha.
minpres	A matrix of minimum pressure ratios. These ratios are stored with indices of mach, alt, and alpha.
minjet	A matrix of minimum jet pressures. These pressures are stored with indices of mach, alt, and alpha.
jetpres	A matrix of jet pressures. These pressures are stored with indices of mach, alt, and alpha.

massflow	A matrix of mass flow rates. These rates are stored with indices of mach, alt, and alpha.
propelwt	A matrix of propellant weights. These weights are stored with indices of mach, alt, and alpha.

Hypersonic fields are:

df_normal	A matrix of increments in normal force per spanwise foot of control. These increments are stored with indices of alpha, delta, and mach.
df_axial	A matrix of increments in axial force per spanwise foot of control. These increments are stored with indices of alpha, delta, and mach.
cm_normal	A matrix of increments in pitching moment due to normal force per spanwise foot of control. These increments are stored with indices of alpha, delta, and mach.
cm_axial	A matrix of increments in pitching moment due to axial force per spanwise foot of control. These increments are stored with indices of alpha, delta, and mach.
cp_normal	A matrix of center of pressure locations of normal force. These locations are stored with indices of alpha, delta, and mach.
cp_axial	A matrix of center of pressure locations of axial force. These locations are stored with indices of alpha, delta, and mach.

Auxiliary and partial fields available are:

wetarea_b	A matrix of body wetted area. These areas are stored with indices of mach, alt, and number of runs.
xcg_b	A matrix of longitudinal locations of the center of gravity. These locations are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
zcg_b	A matrix of vertical locations of the center of gravity. These locations are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
basearea_b	A matrix of body base area. These areas are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
cd0_b	A matrix of body zero lift drags. These drags are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
basedrag_b	A matrix of body base drags. These drags are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
fricdrag_b	A matrix of body friction drags. These drags are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
presdrag_b	A matrix of body pressure drags. These drags are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
lemac	A matrix of leading edge mean aerodynamic chords. These chords are stored with indices of mach and alt.
sidewash	A matrix of sidewash. These values are stored with indices of mach and alt.

hiv_b_w	A matrix of iv-b(w). These values are stored with indices of alpha, mach, and alt.
hiv_w_h	A matrix of iv-w(h). These values are stored with indices of alpha, mach, and alt.
hiv_b_h	A matrix of iv-b(h). These values are stored with indices of alpha, mach, and alt.
gamma	A matrix of gamma*2*pi*alpha*v*r. These values are stored with indices of alpha, mach, and alt.
gamma2pialpvr	A matrix of gamma*(2*pi*alpha*v*r)t. These values are stored with indices of alpha, mach, and alt.
clpgammacl0	A matrix of clp(gamma=cl=0). These values are stored with indices of mach and alt.
clpgammaclp	A matrix of clp(gamma)/cl (gamma=0). These values are stored with indices of mach and alt.
cnptheta	A matrix of cnp/theta. These values are stored with indices of mach and alt.
cypgamma	A matrix of cyp/gamma. These values are stored with indices of mach and alt.
cypcl	A matrix of cyp/cl (cl=0). These values are stored with indices of mach and alt.
clbgamma	A matrix of clb/gamma. These values are stored with indices of mach and alt.
cmothetaw	A matrix of (cmo/theta)w. These values are stored with indices of mach and alt.
cmothetah	A matrix of (cmo/theta)h. These values are stored with indices of mach and alt.
espeff	A matrix of (epsoln)eff. These values are stored with indices of alpha, mach, and alt.

despdalpeff	A matrix of d(epsoln)/d(alpha) eff. These values are stored with indices of alpha, mach, and alt.
dragdiv	A matrix of drag divergence mach number. These values are stored with indices of mach and alt.
cd0mach	A matrix of four Mach numbers for the zero lift drag. These values are stored with indices of index, mach, and alt.
cd0	A matrix of four zero lift drags. These values are stored with indices of index, mach, and alt.
clbclmfb_****	A matrix of (clb/cl)mfb, where **** is either wb (wing-body) or bht (body-horizontal tail). These values are stored with indices of mach and alt.
cnam14_****	A matrix of (cna)m=1.4, where **** is either wb (wing-body) or bht (body-horizontal tail). These values are stored with indices of mach and alt.
area_*_**	A matrix of areas, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These areas are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).

taperratio_*_**	A matrix of taper ratios, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These ratios are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
aspectratio_*_**	A matrix of aspect ratios, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These ratios are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
qcsweep_*_**	A matrix of quarter chord sweeps, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These sweeps are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
mac_*_**	A matrix of mean aerodynamic chords, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These chords are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).

qcmac_*_**	A matrix of quarter chord x(mac), where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
ymac_*_**	A matrix y(mac), where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
cd0_*_**	A matrix of zero lift drags, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These drags are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
friccoeff_*_**	A matrix of friction coefficients, where * is either w (wing), ht (horizontal tail), vt (vertical tail), or vf (ventral fin) and ** is either tt (total theoretical), ti (theoretical inboard), te (total exposed), ei (exposed inboard), or o (outboard). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).

cla_b_***	A matrix of cla-b(***), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
cla_***_b	A matrix of cla-***(b), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
k_b_***	A matrix of k-b(***), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
k_***_b	A matrix of k-***(b), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
xacc_b_***	A matrix of xac/c-b(***), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach, alt, and number of runs (normally 1, 2 for hypers = true).
cdlcl2_***	A matrix of cdl/cl^2, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
clbcl_***	A matrix of clb/cl, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
fmach0_***	A matrix of force break Mach numbers with zero sweep, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.

fmach_***	A matrix of force break Mach numbers with sweep, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
macha_***	A matrix of mach(a), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
machb_***	A matrix of mach(b), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
claa_***	A matrix of cla(a), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
clab_***	A matrix of cla(b), where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
clbm06_***	A matrix of (clb/cl)m=0.6, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
clbm14_***	A matrix of (clb/cl)m=1.4, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of mach and alt.
clalpmach_***	A matrix of five Mach numbers for the lift curve slope, where *** is either w (wing) or ht (stabilizer). These Mach numbers are stored with indices of index, mach, and alt.
clalp_***	A matrix of five lift curve slope values, where *** is either w (wing) or ht (stabilizer). These values are stored with indices of index, mach, and alt.

Examples

Read the USAF Digital DATCOM output file datcom.out:

```
aero = datcomimport('datcom.out')
```

Read the USAF Digital DATCOM output file datcom.out using zeros to replace data points where no DATCOM methods exist and displaying status information in the MATLAB Command window:

```
usenan = false;
aero = datcomimport('datcom.out', usenan, 1 )
```

Assumptions and Limitations

The operational limitations of Digital DATCOM apply to the data contained in AERO. For more information on Digital DATCOM limitations, see [1], section 2.4.5.

USAF Digital DATCOM data for wing section, horizontal tail section, vertical tail section and ventral fin section are not read.

References

1. AFFDL-TR-79-3032: *The USAF Stability and Control DATCOM*, Volume 1, Users Manual

Purpose

Convert direction cosine matrix to angle of attack and sideslip angle

Syntax

```
[a b] = dcm2alphabeta(n)
```

Description

`[a b] = dcm2alphabeta(n)` calculates the angle of attack and sideslip angle, `a` and `b`, for a given direction cosine matrix, `n`. `n` is a 3-by-3-by-`m` matrix containing `m` orthogonal direction cosine matrices. `a` is an `m` array of angles of attack. `b` is an `m` array of sideslip angles. `n` performs the coordinate transformation of a vector in body-axes into a vector in wind-axes. Angles of attack and sideslip angles are output in radians.

Examples

Determine the angle of attack and sideslip angle from direction cosine matrix:

```
dcm = [ 0.8926    0.1736    0.4162; ...
       -0.1574    0.9848   -0.0734; ...
       -0.4226         0    0.9063];
[alpha beta] = dcm2alphabeta(dcm)

alpha =

    0.4363


beta =

    0.1745
```

Determine the angle of attack and sideslip angle from multiple direction cosine matrices:

```
dcm = [ 0.8926    0.1736    0.4162; ...
       -0.1574    0.9848   -0.0734; ...
       -0.4226         0    0.9063];
dcm(:,:,2) = [ 0.9811    0.0872    0.1730; ...
              -0.0859    0.9962   -0.0151; ...
              -0.1736         0    0.9848];
```

```
[alpha beta] = dcm2alphabeta(dcm)


alpha =

    0.4363
    0.1745


beta =

    0.1745
    0.0873
```

See Also `angle2dcm`, `dcm2angle`, `dcmbody2wind`

Purpose

Create rotation angles from direction cosine matrix

Syntax

```
[r1 r2 r3] = dcm2angle(n)
[r1 r2 r3] = dcm2angle(n, s)
[r1 r2 r3] = dcm2angle(n, s, lim)
```

Description

`[r1 r2 r3] = dcm2angle(n)` calculates the set of rotation angles, `r1`, `r2`, `r3`, for a given direction cosine matrix, `n`. `n` is a 3-by-3-by-`m` matrix containing `m` direction cosine matrices. `r1` returns an `m` array of first rotation angles. `r2` returns an `m` array of second rotation angles. `r3` returns an `m` array of third rotation angles. Rotation angles are output in radians.

`[r1 r2 r3] = dcm2angle(n, s)` calculates the set of rotation angles, `r1`, `r2`, `r3`, for a given direction cosine matrix, `n`, and a specified rotation sequence, `s`.

The default rotation sequence is `'ZYX'`, where `r1` is *z*-axis rotation, `r2` is *y*-axis rotation, and `r3` is *x*-axis rotation.

Supported rotation sequence strings are `'ZYX'`, `'ZYZ'`, `'ZXY'`, `'ZXZ'`, `'YXZ'`, `'YXY'`, `'YZX'`, `'YZY'`, `'XYZ'`, `'XYX'`, `'XZY'`, and `'XZX'`.

`[r1 r2 r3] = dcm2angle(n, s, lim)` calculates the set of rotation angles, `r1`, `r2`, `r3`, for a given direction cosine matrix, `n`, a specified rotation sequence, `s`, and a specified angle constraint, `lim`. `lim` is a string specifying either `'Default'` or `'ZeroR3'`. See “Assumptions and Limitations” on page 4-89 for full definitions of angle constraints.

Examples

Determine the rotation angles from direction cosine matrix:

```
dcm = [0 1 0; 1 0 0; 0 0 1];
[yaw pitch roll] = dcm2angle(dcm)

yaw =

    1.5708
```

```
pitch =

     0


roll =

     0
```

Determine the rotation angles from multiple direction cosine matrices:

```
dcm        = [ 0 1 0; 1 0 0; 0 0 1];
dcm(:,:,2) = [ 0.85253103550038   0.47703040785184  -0.21361840626067; ...
              -0.43212157513194   0.87319830445628   0.22537893734811; ...
               0.29404383655186  -0.09983341664683   0.95056378592206];
[pitch roll yaw] = dcm2angle(dcm, 'YXZ')


pitch =

         0
    0.3000


roll =

         0
    0.1000


yaw =

    1.5708
    0.5000
```

Assumptions and Limitations

The 'Default' limitations for the 'ZYX', 'ZXY', 'YXZ', 'YZX', 'XYZ', and 'XZY' implementations generate an r2 angle that lies between ±90 degrees, and r1 and r3 angles that lie between ±180 degrees.

The 'Default' limitations for the 'ZYZ', 'ZXZ', 'YXY', 'YZY', 'XYX', and 'XZX' implementations generate an r2 angle that lies between 0 and 180 degrees, and r1 and r3 angles that lie between ±180 degrees.

The 'ZeroR3' limitations for the 'ZYX', 'ZXY', 'YXZ', 'YZX', 'XYZ', and 'XZY' implementations generate an r2 angle that lies between ±90 degrees, and r1 and r3 angles that lie between ±180 degrees. However, when r2 is ±90 degrees, r3 is set to 0 degrees.

The 'ZeroR3' limitations for the 'ZYZ', 'ZXZ', 'YXY', 'YZY', 'XYX', and 'XZX' implementations generate an r2 angle that lies between 0 and 180 degrees, and r1 and r3 angles that lie between ±180 degrees. However, when r2 is 0 or ±180 degrees, r3 is set to 0 degrees.

See Also

angle2dcm, dcm2quat, quat2dcm, quat2angle

dcm2latlon

Purpose

Convert direction cosine matrix to geodetic latitude and longitude

Syntax

`[lat lon] = dcm2latlon(n)`

Description

`[lat lon] = dcm2latlon(n)` calculates the geodetic latitude and longitude, `lat` and `lon`, for a given direction cosine matrix, `n`. `n` is a 3-by-3-by-`m` matrix containing `m` orthogonal direction cosine matrices. `lat` is an `m` array of geodetic latitudes. `lon` is an `m` array of longitudes. `n` performs the coordinate transformation of a vector in Earth-centered Earth-fixed (ECEF) axes into a vector in north-east-down (NED) axes. Geodetic latitudes and longitudes are output in degrees.

Examples

Determine the geodetic latitude and longitude from direction cosine matrix:

```
dcm = [ 0.3747    0.5997    0.7071; ...
        0.8480   -0.5299         0; ...
        0.3747    0.5997   -0.7071];
[lat lon] = dcm2latlon(dcm)

lat =

   44.9995


lon =

 -122.0005
```

Determine the geodetic latitude and longitude from multiple direction cosine matrices:

```
dcm = [ 0.3747    0.5997    0.7071; ...
        0.8480   -0.5299         0; ...
        0.3747    0.5997   -0.7071];
dcm(:,:,2) = [-0.0531    0.6064    0.7934; ...
               0.9962    0.0872         0; ...
```

```
                -0.0691    0.7903   -0.6088];
[lat lon] = dcm2latlon(dcm)


lat =

   44.9995
   37.5028


lon =

 -122.0005
  -84.9975
```

See Also

angle2dcm, dcm2angle, dcmecef2ned

dcm2quat

Purpose Convert direction cosine matrix to quaternion

Syntax

```
q = dcm2quat(n)
```

Description `q = dcm2quat(n)` calculates the quaternion, `q`, for a given direction cosine matrix, `n`. Input `n` is a 3-by-3-by-`m` matrix of orthogonal direction cosine matrices. The direction cosine matrix performs the coordinate transformation of a vector in inertial axes to a vector in body axes. `q` returns an `m`-by-4 matrix containing `m` quaternions. `q` has its scalar number as the first column.

Examples Determine the quaternion from direction cosine matrix:

```
dcm = [0 1 0; 1 0 0; 0 0 1];
q = dcm2quat(dcm)

q =

    0.7071         0         0         0
```

Determine the quaternions from multiple direction cosine matrices:

```
dcm        = [ 0 1 0; 1 0 0; 0 0 1];
dcm(:,:,2) = [ 0.4330    0.2500   -0.8660; ...
               0.1768    0.9186    0.3536; ...
               0.8839   -0.3062    0.3536];
q = dcm2quat(dcm)

q =

    0.7071         0         0         0
    0.8224    0.2006    0.5320    0.0223
```

See Also `angle2dcm`, `dcm2angle`, `angle2quat`, `quat2dcm`, `quat2angle`

Purpose

Convert angle of attack and sideslip angle to direction cosine matrix

Syntax

```
n = dcmbody2wind(a, b)
```

Description

`n = dcmbody2wind(a, b)` calculates the direction cosine matrix, `n`, for given angle of attack and sideslip angle, `a`, `b`. `a` is an `m` array of angles of attack. `b` is an `m` array of sideslip angles. `n` returns a 3-by-3-by-`m` matrix containing `m` direction cosine matrices. `n` performs the coordinate transformation of a vector in body-axes into a vector in wind-axes. Angles of attack and sideslip angles are input in radians.

Examples

Determine the direction cosine matrix from angle of attack and sideslip angle:

```
alpha = 0.4363;
beta = 0.1745;
dcm = dcmbody2wind(alpha, beta)

dcm =

    0.8926    0.1736    0.4162
   -0.1574    0.9848   -0.0734
   -0.4226         0    0.9063
```

Determine the direction cosine matrix from multiple angles of attack and sideslip angles:

```
alpha = [0.4363 0.1745];
beta = [0.1745 0.0873];
dcm = dcmbody2wind(alpha, beta)

dcm(:,:,1) =

    0.8926    0.1736    0.4162
   -0.1574    0.9848   -0.0734
   -0.4226         0    0.9063
```

```
dcm(:,:,2) =

    0.9811    0.0872    0.1730
   -0.0859    0.9962   -0.0151
   -0.1736         0    0.9848
```

See Also

`angle2dcm`, `dcm2alphabeta`, `dcm2angle`

Purpose

Convert geodetic latitude and longitude to direction cosine matrix

Syntax

```
n = dcmecef2ned(lat, lon)
```

Description

`n = dcmecef2ned(lat, lon)` calculates the direction cosine matrix, `n`, for a given set of geodetic latitude and longitude, `lat`, `lon`. `lat` is an `m` array of geodetic latitudes. `lon` is an `m` array of longitudes. `n` returns a 3-by-3-by-`m` matrix containing `m` direction cosine matrices. `n` performs the coordinate transformation of a vector in Earth-centered Earth-fixed (ECEF) axes into a vector in north-east-down (NED) axes. Geodetic latitudes and longitudes are input in degrees.

Examples

Determine the direction cosine matrix from geodetic latitude and longitude:

```
lat = 45;
lon = -122;
dcm = dcmecef2ned(lat, lon)

dcm =

    0.3747    0.5997    0.7071
    0.8480   -0.5299         0
    0.3747    0.5997   -0.7071
```

Determine the direction cosine matrix from multiple geodetic latitudes and longitudes:

```
lat = [45 37.5];
lon = [-122 -85];
dcm = dcmecef2ned(lat, lon)

dcm(:,:,1) =

    0.3747    0.5997    0.7071
    0.8480   -0.5299         0
    0.3747    0.5997   -0.7071
```

```
dcm(:,:,2) =

   -0.0531    0.6064    0.7934
    0.9962    0.0872         0
   -0.0691    0.7903   -0.6088
```

See Also

angle2dcm, dcm2angle, dcm2latlon

Purpose

Calculate decimal year

Syntax

```
dy = decyear(v)
dy = decyear(s,f)
dy = decyear(y,mo,d)
dy = decyear([y,mo,d])
dy = decyear(y,mo,d,h,mi,s)
dy = decyear([y,mo,d,h,mi,s])
```

Description

`dy = decyear(v)` converts one or more date vectors, `v`, into decimal year, `dy`. Input `v` can be an `m`-by-6 or `m`-by-3 matrix containing `m` full or partial date vectors, respectively. `decyear` returns a column vector of `m` decimal years.

A date vector contains six elements, specifying year, month, day, hour, minute, and second. A partial date vector has three elements, specifying year, month, and day. Each element of `v` must be a positive double-precision number.

`dy = decyear(s,f)` converts one or more date strings, `s`, to decimal year, `dy`, using format string `f`. `s` can be a character array where each row corresponds to one date string, or a one-dimensional cell array of strings. `decyear` returns a column vector of `m` decimal years, where `m` is the number of strings in `s`.

All of the date strings in `s` must have the same format `f`, which must be composed of date format symbols listed in the `datestr` function reference page. Formats containing the letter `Q` are not accepted by `decyear`.

Certain formats may not contain enough information to compute a date number. In those cases, hours, minutes, and seconds default to 0, days default to 1, months default to January, and years default to the current year. Date strings with two-character years are interpreted to be within the 100 years centered around the current year.

`dy = decyear(y,mo,d)` and `dy = decyear([y,mo,d])` return the decimal year for corresponding elements of the `y,mo,d` (year,month,day) arrays. `y`, `mo`, and `d` must be arrays of the same size (or any of them can be a scalar).

`dy = decyear(y,mo,d,h,mi,s)` and `dy = decyear([y,mo,d,h,mi,s])` return the decimal year for corresponding elements of the `y,mo,d,h,mi,s` (year,month,day,hour,minute,second) arrays. The six arguments must be arrays of the same size (or any of them can be a scalar).

Examples

Calculate decimal year for May 24, 2005:

```
dy = decyear('24-May-2005','dd-mmm-yyyy')

dy =

  2.0054e+003
```

Calculate decimal year for December 19, 2006:

```
dy = decyear(2006,12,19)

dy =

  2.0070e+003
```

Calculate decimal year for October 10, 2004, at 12:21:00 p.m.:

```
dy = decyear(2004,10,10,12,21,0)

dy =

  2.0048e+003
```

Assumptions and Limitations

The calculation of decimal year does not take into account leap seconds.

See Also

`juliandate`, `leapyear`, `mjuliandate`

Purpose

Destroy animation object

Syntax

```
delete(h)
h.delete
```

Description

`delete(h)` and `h.delete` destroy the animation object `h`. This function also destroys the animation object figure, and any objects that the animation object contained (for example, bodies, camera, and geometry).

Examples

Delete the animation object, `h`.

```
h=Aero.Animation;
h.delete;
```

See Also

`initialize`, `initIfNeeded`

delete (Aero.FlightGearAnimation)

Purpose Destroy FlightGear animation object

Syntax

```
delete(h)
h.delete
```

Description `delete(h)` and `h.delete` destroy the FlightGear animation object `h`. This function also destroys the animation object timer, and closes the socket that the FlightGear animation animation object contains.

Examples Delete the FlightGear animation object, `h`.

```
h=Aero.FlightGearAnimation;
h.delete;
```

See Also `initialize`

delete (Aero.VirtualRealityAnimation)

Purpose

Destroy virtual reality animation object

Syntax

```
delete(h)
h.delete
```

Description

`delete(h)` and `h.delete` destroy the virtual reality animation object `h`. This function also destroys the temporary file, if it exists, cleans up the vrfigure object, the animation object timer, and closes the vrworld object.

Examples

Delete the virtual reality animation object, h.

```
h=Aero.VirtualRealityAnimation;
h.delete;
```

See Also

`initialize`

dpressure

Purpose Compute dynamic pressure using velocity and density

Syntax

```
q = dpressure(v, r)
```

Description `q = dpressure(v, r)` computes `m` dynamic pressures, `q`, from an `m`-by-3 array of velocities, `v`, and an array of `m` densities, `r`. `v` and `r` must have the same length units.

Examples Determine dynamic pressure for velocity in feet per second and density in slugs per feet cubed:

```
q = dpressure([84.3905  33.7562  10.1269], 0.0024)


q =

    10.0365
```

Determine dynamic pressure for velocity in meters per second and density in kilograms per meters cubed:

```
q = dpressure([25.7222 10.2889 3.0867], [1.225  0.3639])


q =

  475.9252
  141.3789
```

Determine dynamic pressure for velocity in meters per second and density in kilograms per meters cubed:

```
q = dpressure([50 20 6; 5 0.5 2], [1.225  0.3639])


q =
```

```
     1.0e+003 *

        1.7983
        0.0053
```

See Also

airspeed, machnumber

Purpose

Convert Earth-centered Earth-fixed (ECEF) coordinates to geodetic coordinates

Syntax

```
lla = ecef2lla(p)
lla = ecef2lla(p, model)
lla = ecef2lla(p, f, Re)
```

Description

`lla = ecef2lla(p)` converts the `m`-by-3 array of ECEF coordinates, `p`, to an `m`-by-3 array of geodetic coordinates (latitude, longitude and altitude), `lla`. `lla` is in [degrees degrees meters]. `p` is in meters. The default ellipsoid planet is WGS84.

`lla = ecef2lla(p, model)` is an alternate method for converting the coordinates for a specific ellipsoid planet. Currently only `'WGS84'` is supported for `model`.

`lla = ecef2lla(p, f, Re)` is another alternate method for converting the coordinates for a custom ellipsoid planet defined by flattening, `f`, and the equatorial radius, `Re`, in meters.

Examples

Determine latitude, longitude, and altitude at a coordinate:

```
lla = ecef2lla([4510731 4510731 0])


lla =

         0   45.0000  999.9564
```

Determine latitude, longitude, and altitude at multiple coordinates, specifying WGS84 ellipsoid model:

```
lla = ecef2lla([4510731 4510731 0; 0 4507609 4498719], 'WGS84')


lla =

         0   45.0000  999.9564
```

```
    45.1358   90.0000  999.8659
```

Determine latitude, longitude, and altitude at multiple coordinates, specifying custom ellipsoid model:

```
f = 1/196.877360;
Re = 3397000;
lla = ecef2lla([4510731 4510731 0; 0 4507609 4498719], f, Re)


lla =

  1.0e+006 *

         0    0.0000    2.9821
    0.0000    0.0001    2.9801
```

See Also

`geoc2geod`, `geod2geoc`, `lla2ecef`

fganimation (Aero.FlightGearAnimation)

Purpose Construct FlightGear animation object

Syntax

```
h = fganimation
h = Aero.FlightGearAnimation
```

Description `h = fganimation` and `h = Aero.FlightGearAnimation` construct a FlightGear animation object. The FlightGear animation object is returned to `h`.

Examples Construct a FlightGear animation object, `h`:

```
h = fganimation
```

See Also `Aero.FlightGearAnimation`

Purpose

Return start and stop times of time series data

Syntax

```
[tstart,tstop] = findstartstoptimes(h,tsdata)
[tstart,stop] = h.findstartstoptimes(tsdata)
```

Description

`[tstart,tstop] = findstartstoptimes(h,tsdata)` and `[tstart,stop] = h.findstartstoptimes(tsdata)` return the start and stop times of time series data `tsdata` for the animation body object `h`.

Examples

Find the start and stop times of the time series data, *tsdata*.

```
b=Aero.Body;
b.load('pa24-250_orange.ac','Ac3d');
tsdata = [ ...
    0,  1,1,1, 0,0,0; ...
    10  2,2,2, 1,1,1; ];
 b.TimeSeriesSource = tsdata;
[tstart,tstop] = findstartstoptimes(b,tsdata);
```

See Also

`load`

findstartstoptimes (Aero.Node)

Purpose Return start and stop times for time series data

Syntax

```
[tstart,tstop] = findstartstoptimes(h,tsdata)
[tstart,stop] = h.findstartstoptimes(tsdata)
```

Description `[tstart,tstop] = findstartstoptimes(h,tsdata)` and `[tstart,stop] = h.findstartstoptimes(tsdata)` return the start and stop times of time series data `tsdata` for the virtual reality animation object `h`.

Examples Find the start and stop times of the time series data, `takeoffData`.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
load takeoffData;
h.Nodes{7}.TimeseriesSource = takeoffData;
h.Nodes{7}.TimeseriesSourceType = 'StructureWith Time';
[tstart,stop]=h.Nodes{7}.findstartstoptimes;
```

Purpose

Generate patches for body with loaded face, vertex, and color data

Syntax

```
generatePatches(h, ax)
h.generatePatches(ax)
```

Description

`generatePatches(h, ax)` and `h.generatePatches(ax)` generate patches for the animation body object `h` using the loaded face, vertex, and color data in `ax`.

Examples

Generate patches for `b` using the axes, *ax*.

```
b=Aero.Body;
b.load('pa24-250_orange.ac','Ac3d');
f = figure;
ax = axes;
b.generatePatches(ax);
```

See Also

`load`

GenerateRunScript (Aero.FlightGearAnimation)

Purpose

Generate run script for FlightGear flight simulator

Syntax

```
GenerateRunScript(h)
h.GenerateRunScript
```

Description

`GenerateRunScript(h)` and `h.GenerateRunScript` generate a run script for FlightGear flight simulator using the following FlightGear animation object properties:

`OutputFileName`	Specify the name of the output file. The file name is the name of the command you will use to start FlightGear with these initial parameters. The default value is `'runfg.bat'`.
`FlightGearBaseDirectory`	Specify the name of your FlightGear installation directory. The default value is `'D:\Applications\FlightGear'`.
`GeometryModelName`	Specify the name of the folder containing the desired model geometry in the *`FlightGear`*`\data\Aircraft` directory. The default value is `'HL20'`.
`DestinationIpAddress`	Specify your destination IP address. The default value is `'127.0.0.1'`.
`DestinationPort`	Specify your network flight dynamics model (fdm) port. This destination port should be an unused port that you can use when you launch FlightGear. The default value is `'5502'`.

`AirportId`	Specify the airport ID. The list of supported airports is available in the FlightGear interface, under **Location**. The default value is `'KSFO'`.
`RunwayId`	Specify the runway ID. The default value is `'10L'`.
`InitialAltitude`	Specify the initial altitude of the aircraft, in feet. The default value is `7224` feet.
`InitialHeading`	Specify the initial heading of the aircraft, in degrees. The default value is `113` degrees.
`OffsetDistance`	Specify the offset distance of the aircraft from the airport, in miles. The default value is `4.72` miles.
`OffsetAzimuth`	Specify the offset azimuth of the aircraft, in degrees. The default value is `0` degrees.

Examples

Create a run script, `runfg.bat`, to start FlightGear flight simulator using the default object settings:

```
h = fganimation
GenerateRunScript(h)
```

Create a run script, `myscript.bat`, to start FlightGear flight simulator using the default object settings:

```
h = fganimation
h.OutputFileName = 'myscript.bat'
GenerateRunScript(h)
```

See Also

`initialize`, `play`,`update`

geoc2geod

Purpose

Convert geocentric latitude to geodetic latitude

Syntax

```
gd = geoc2geod(gc, r)
gd = geoc2geod(gc, r, model)
gd = geoc2geod(gc, r, f, Re)
```

Description

`gd = geoc2geod(gc, r)` converts an array of `m` geocentric latitudes, `gc`, and an array of radii from the center of the planet, `r`, into an array of `m` geodetic latitudes, `gd`. Both `gc` and `gd` are in degrees. `r` is in meters.

`gd = geoc2geod(gc, r, model)` is an alternate method for converting from geocentric to geodetic latitude for a specific ellipsoid planet. Currently only `'WGS84'` is supported for `model`.

`gd = geoc2geod(gc, r, f, Re)` is another alternate method for converting from geocentric to geodetic latitude for a custom ellipsoid planet defined by flattening, `f`, and the equatorial radius, `Re`, in meters.

Geometric relationships are used to calculate the geodetic latitude in this noniterative method.

Examples

Determine geodetic latitude given a geocentric latitude and radius:

```
gd = geoc2geod(45, 6379136)


gd =

    45.1921
```

Determine geodetic latitude at multiple geocentric latitudes, given a radius and specifying WGS84 ellipsoid model:

```
gd = geoc2geod([0 45 90], 6379136, 'WGS84')


gd =

         0   45.1921   90.0000
```

Determine geodetic latitude at multiple geocentric latitudes, given a radius and specifying custom ellipsoid model:

```
f = 1/196.877360;
Re = 3397000;
gd = geoc2geod([0 45 90], 6379136, f, Re)


gd =

         0   45.1550   90.0000
```

Assumptions and Limitations

This implementation generates a geodetic latitude that lies between ±90 degrees.

References

Jackson, E.B., *Manual for a Workstation-based Generic Flight Simulation Program (LaRCsim) Version 1.4*, NASA TM 110164, April, 1995

Hedgley, D. R., Jr., *An Exact Transformation from Geocentric to Geodetic Coordinates for Nonzero Altitudes*, NASA TR R-458, March, 1976

Clynch, J. R., *Radius of the Earth — Radii Used in Geodesy*, Naval Postgraduate School, 2002, `http://www.oc.nps.navy.mil/oc2902w/geodesy/radiigeo.pdf`

Stevens, B. L., and F. L. Lewis, *Aircraft Control and Simulation*, John Wiley & Sons, New York, NY, 1992

Edwards, C. H., and D. E. Penny, *Calculus and Analytical Geometry*, 2nd Edition, Prentice-Hall, Englewood Cliffs, NJ, 1986

See Also

`geod2geoc`, `ecef2lla`, `lla2ecef`

geocradius

Purpose

Estimate radius of ellipsoid planet at geocentric latitude

Syntax

```
r = geocradius(lambda)
r = geocradius(lambda, model)
r = geocradius(lambda, f, Re)
```

Description

`r = geocradius(lambda)` estimates the radius, `r`, of an ellipsoid planet at a particular geocentric latitude, `lambda`. `lambda` is in degrees. `r` is in meters. The default ellipsoid planet is WGS84.

`r = geocradius(lambda, model)` is an alternate method for estimating the radius for a specific ellipsoid planet. Currently only `'WGS84'` is supported for `model`.

`r = geocradius(lambda, f, Re)` is another alternate method for estimating the radius for a custom ellipsoid planet defined by flattening, `f`, and the equatorial radius, `Re`, in meters.

Examples

Determine radius at 45 degrees latitude:

```
r = geocradius(45)


r =

  6.3674e+006
```

Determine radius at multiple latitudes:

```
r = geocradius([0 45 90])


r =

  1.0e+006 *

    6.3781    6.3674    6.3568
```

Determine radius at multiple latitudes, specifying WGS84 ellipsoid model:

```
r = geocradius([0 45 90], 'WGS84')


r =

  1.0e+006 *

    6.3781    6.3674    6.3568
```

Determine radius at multiple latitudes, specifying custom ellipsoid model:

```
f = 1/196.877360;
Re = 3397000;
r = geocradius([0 45 90], f, Re)


r =

  1.0e+006 *

    3.3970    3.3883    3.3797
```

References

Stevens, B. L., and F. L. Lewis, *Aircraft Control and Simulation*, John Wiley & Sons, New York, NY, 1992

Zipfel, P. H., and D. E. Penny, *Modeling and Simulation of Aerospace Vehicle Dynamics*, AIAA Education Series, Reston, VA, 2000

See Also

`geoc2geod`, `geod2geoc`

Purpose

Convert geodetic latitude to geocentric latitude

Syntax

```
gc = geod2geoc(gd, h)
gc = geod2geoc(gd, h, model)
gc = geod2geoc(gd, h, f, Re)
```

Description

`gc = geod2geoc(gd, h)` converts an array of `m` geodetic latitudes, `gd`, and an array of mean sea level altitudes, `h`, into an array of `m` geocentric latitudes, `gc`. Both `gc` and `gd` are in degrees. `h` is in meters.

`gc = geod2geoc(gd, h, model)` is an alternate method for converting from geodetic to geocentric latitude for a specific ellipsoid planet. Currently only `'WGS84'` is supported for `model`.

`gc = geod2geoc(gd, h, f, Re)` is another alternate method for converting from geodetic to geocentric latitude for a custom ellipsoid planet defined by flattening, `f`, and the equatorial radius, `Re`, in meters.

Examples

Determine geocentric latitude given a geodetic latitude and altitude:

```
gc = geod2geoc(45, 1000)


gc =

   44.8076
```

Determine geocentric latitude at multiple geodetic latitudes and altitudes, specifying WGS84 ellipsoid model:

```
gc = geod2geoc([0 45 90], [1000 0 2000], 'WGS84')


gc =

         0
   44.8076
   90.0000
```

Determine geocentric latitude at multiple geodetic latitudes, given an altitude and specifying custom ellipsoid model:

```
f = 1/196.877360;
Re = 3397000;
gc = geod2geoc([0 45 90], 2000, f, Re)


gc =

          0
    44.7084
    90.0000
```

Assumptions and Limitations

This implementation generates a geocentric latitude that lies between ±90 degrees.

References

Stevens, B. L., and F. L. Lewis, *Aircraft Control and Simulation*, John Wiley & Sons, New York, NY, 1992

See Also

`geoc2geod`, `ecef2lla`, `lla2ecef`

geoidegm96

Purpose

Calculates the geoid height as determined from the EGM96 Geopotential Model

Syntax

```
N = geoidegm96(lat, long)
N = geoidegm96(lat, long, action)
```

Description

`N = geoidegm96(lat, long)` calculates the geoid height as determined from the EGM96 Geopotential Model. It calculates geoid heights to 0.01 meters. This function interpolates geoid heights from a 15-minute grid of point values in the tide-free system, using the EGM96 Geopotential Model to the degree and order 360. The geoid undulations are relative to the WGS84 ellipsoid.

`N = geoidegm96(lat, long, action)` calculates the geoid height as determined from the EGM96 Geopotential Model. This function performs `action` if `latitude` or `longitude` are out of range.

Inputs required by `geoidegm96`:

`lat`	An array of `m` geocentric latitudes, in degrees, where north latitude is positive and south latitude is negative. `lat` must be of type single or double. If `lat` is not within the range -90 to 90, inclusive, this function wraps the value to be within the range.
`long`	An array of `m` geocentric longitudes, in degrees, where east longitude is positive and west longitude is negative. `long` must be of type single or double. If `long` is not within the range 0 to 360 inclusive, this function wraps the value to be within the range.
`action`	A string to determine action for out-of-range input. Specify if out-of-range input invokes a `'Warning'`, `'Error'`, or no action (`'None'`). The default is `'Warning'`.

Examples

Calculate the geoid height at 42.4 degrees N latitude and 71.0 degrees E longitude.

```
N = geoidegm96( 42.4, 71.0)
```

Calculate the geoid height at two different locations, with out-of-range actions generating warnings.

```
N = geoidegm96( [39.3,33.4], [-77.2, 36.5])
```

Calculate the geoid height with latitude wrapping, with out-of-range actions displaying no warnings.

```
N = geoidegm96(100,150,'None')
```

Limitations

This function has the limitations of the 1996 Earth Geopotential Model. For more information, see `http://www.ngdc.noaa.gov/seg/gravity/document/html/egm96.shtml`.

The WGS84 EGM96 geoid undulations have an error range of +/-0.5 to +/-1.0 meters worldwide.

References

NIMA TR8350.2: "Department of Defense World Geodetic System 1984, Its Definition and Relationship with Local Geodetic Systems."

NASA/TP-1998-206861: "The Development of the Joint NASA GSFC and NIMA Geopotential Model EGM96"

National Geospatial-Intelligence Agency Website: `http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm96/egm96.html`

See Also

`gravitywgs84`

Purpose

Construct 3-D geometry for use with animation object

Syntax

```
h = Aero.Geometry
```

Description

`h = Aero.Geometry` defines a 3-D geometry for use with an animation object.

See `Aero.Geometry` for further details.

See Also

`Aero.Geometry`

gravitywgs84

Purpose

Implement 1984 World Geodetic System (WGS84) representation of Earth's gravity

Syntax

```
g = gravitywgs84(h, lat)
g = gravitywgs84(h, lat, lon, method, [noatm, nocent, prec,
   jd], action)
gt = gravitywgs84(h, lat, lon, 'Exact', [noatm, nocent, prec,
   jd], action)
[g gn] = gravitywgs84(h, lat, lon, 'Exact', [noatm, nocent,
   prec, jd], action)
```

Description

`g = gravitywgs84(h, lat)` implements the mathematical representation of the geocentric equipotential ellipsoid of WGS84. Using `h`, an array of `m` altitudes in meters, and `lat`, an array of `m` geodetic latitudes in degrees, calculates `g`, an array of `m` gravity values in the direction normal to the Earth's surface at a specific location. The default calculation method is Taylor Series. Gravity precision is controlled via the `method` parameter.

`g = gravitywgs84(h, lat, lon, method, [noatm, nocent, prec, jd], action)` lets you specify both latitude and longitude, as well as other optional inputs, when calculating gravity values in the direction normal to the Earth's surface. In this format, `method` can be either `'CloseApprox'`or`'Exact'`.

`gt = gravitywgs84(h, lat, lon, 'Exact', [noatm, nocent, prec, jd], action)` calculates an array of total gravity values in the direction normal to the Earth's surface.

`[g gn] = gravitywgs84(h, lat, lon, 'Exact', [noatm, nocent, prec, jd], action)` calculates gravity values in the direction both normal and tangential to the Earth's surface.

Inputs for `gravitywgs84` are:

`h`	An array of `m` altitudes, in meters
`lat`	An array of `m` geodetic latitudes, in degrees, where north latitude is positive, and south latitude is negative
`lon`	An array of `m` geodetic longitudes, in degrees, where east longitude is positive, and west longitude is negative. This input is available only with `method` specified as `'CloseApprox'`or`'Exact'`.
`method`	A string specifying the method to calculate gravity: `'TaylorSeries'`, `'CloseApprox'`, or `'Exact'`. The default is `'TaylorSeries'`.
`noatm`	A logical value specifying the exclusion of Earth's atmosphere. Set to `true` for the Earth's gravitational field to exclude the mass of the atmosphere. Set to `false` for the value for the Earth's gravitational field to include the mass of the atmosphere. This option is available only with `method` specified as `'CloseApprox'`or`'Exact'`. The default is `false`.
`nocent`	A logical value specifying the removal of centrifugal effects. Set to `true` to calculate gravity based on pure attraction resulting from the normal gravitational potential. Set to `false` to calculate gravity including the centrifugal force resulting from the Earth's angular velocity. This option is available only with `method` specified as `'CloseApprox'`or`'Exact'`. The default is `false`.

`prec`	A logical value specifying the presence of a precessing reference frame. Set to `true` for the angular velocity of the Earth to be calculated using the International Astronomical Union (IAU) value of the Earth's angular velocity and the precession rate in right ascension. To obtain the precession rate in right ascension, Julian Centuries from Epoch J2000.0 is calculated using the Julian date, `jd`. If set to `false`, the angular velocity of the Earth used is the value of the standard Earth rotating at a constant angular velocity. This option is available only with `method` specified as `'CloseApprox'`or`'Exact'`. The default is `false`.
`jd`	A scalar value specifying Julian date used to calculate Julian Centuries from Epoch J2000.0. This input is available only with `method` specified as `'CloseApprox'`or`'Exact'`.
`action`	A string to determine action for out-of-range input. Specify if out-of-range input invokes a `'Warning'`, `'Error'`, or no action (`'None'`). The default is `'Warning'`.

Outputs calculated for the Earth's gravity include:

g	An array of m gravity values in the direction normal to the Earth's surface at a specific lat lon location. A positive value indicates a downward direction.
gt	An array of m total gravity values in the direction normal to the Earth's surface at a specific lat lon location. A positive value indicates a downward direction. This option is available only with method specified as 'Exact'.
gn	An array of m gravity values in the direction tangential to the Earth's surface at a specific lat lon location. A positive value indicates a northward direction. This option is available only with method specified as 'Exact'.

Examples

Calculate the normal gravity at 5000 meters and 55 degrees latitude using the Taylor Series approximation method with errors for out-of-range inputs:

```
g = gravitywgs84( 5000, 55, 'TaylorSeries', 'Error' )


g =

    9.7997
```

Calculate the normal gravity at 15,000 meters, 45 degrees latitude, and 120 degrees longitude using the Close Approximation method with atmosphere, centrifugal effects, and no precessing, with warnings for out-of-range inputs:

```
g = gravitywgs84( 15000, 45, 120, 'CloseApprox' )


g =
```

```
    9.7601
```

Calculate the normal and tangential gravity at 1000 meters, 0 degrees latitude, and 20 degrees longitude using the Exact method with atmosphere, centrifugal effects, and no precessing, with warnings for out-of-range inputs:

```
[g, gt] = gravitywgs84( 1000, 0, 20, 'Exact' )


g =

    9.7772


gt =

     0
```

Calculate the normal and tangential gravity at 1000 meters, 0 degrees latitude, and 20 degrees longitude and 11,000 meters, 30 degrees latitude, and 50 degrees longitude using the Exact method with atmosphere, centrifugal effects, and no precessing, with no actions for out-of-range inputs:

```
h = [1000; 11000];
lat = [0; 30];
lon = [20; 50];
[g, gt] = gravitywgs84( h, lat, lon, 'Exact', 'None' )


g =

    9.7772
    9.7594
```

```
gt =

  1.0e-004 *

         0
   -0.7751
```

Calculate the normal gravity at 15,000 meters, 45 degrees latitude, and 120 degrees longitude and 5000 meters, 55 degrees latitude, and 100 degrees longitude using the Close Approximation method with atmosphere, no centrifugal effects, and no precessing, with warnings for out-of-range inputs:

```
h = [15000 5000];
lat = [45 55];
lon = [120 100];
g = gravitywgs84( h, lat, lon, 'CloseApprox', [false true false 0] )


g =

    9.7771    9.8109
```

Calculate the normal and tangential gravity at 1000 meters, 0 degrees latitude, and 20 degrees longitude using the Exact method with atmosphere, centrifugal effects, and precessing at Julian date 2451545, with warnings for out-of-range inputs:

```
[g, gt] = gravitywgs84( 1000, 0, 20, 'Exact', ...
              [ false false true 2451545 ], 'Warning' )


g =

    9.7772
```

```
gt =

     0
```

Calculate the normal gravity at 15,000 meters, 45 degrees latitude, and 120 degrees longitude using the Close Approximation method with no atmosphere, with centrifugal effects, and with precessing at Julian date 2451545, with errors for out-of-range inputs:

```
g = gravitywgs84( 15000, 45, 120, 'CloseApprox', ...
        [ true false true 2451545 ], 'Error'  )


g =

    9.7601
```

Calculate the total normal gravity at 15,000 meters, 45 degrees latitude, and 120 degrees longitude using the Exact method with no atmosphere, with centrifugal effects, and with precessing at Julian date 2451545, with errors for out-of-range inputs:

```
g = gravitywgs84( 15000, 45, 120, 'Exact', ...
        [ true false true 2451545 ], 'Error'  )


g =

    9.7601
```

Assumptions and Limitations

The WGS84 gravity calculations are based on the assumption of a geocentric equipotential ellipsoid of revolution. Since the gravity potential is assumed to be the same everywhere on the ellipsoid, there must be a specific theoretical gravity potential that can be uniquely determined from the four independent constants defining the ellipsoid.

Use of the WGS84 Taylor Series model should be limited to low geodetic heights. It is sufficient near the surface when submicrogal precision is not necessary. At medium and high geodetic heights, it is less accurate.

Use of the WGS84 Close Approximation model should be limited to a geodetic height of 20,000.0 meters (approximately 65,620.0 feet). Below this height, it gives results with submicrogal precision.

References

NIMA TR8350.2: “Department of Defense World Geodetic System 1984, Its Definition and Relationship with Local Geodetic Systems.”

hide (Aero.Animation)

Purpose Hide animation object figure

Syntax

```
hide(h)
h.hide
```

Description `hide(h)` and `h.hide` hide (close) the figure for the animation object `h`. Use `show` to redisplay the animation object figure.

Examples Hide the animation object figure that the `show` method displays.

```
h=Aero.Animation;
h.show;
h.hide;
```

See Also `show`

initialize (Aero.Animation)

Purpose

Create animation object figure and axes and build patches for bodies

Syntax

```
initialize(h)
h.initialize
```

Description

`initialize(h)` and `h.initialize` create a figure and axes for the animation object `h`, and builds patches for the bodies associated with the animation object. If there is an existing figure, this function

1. Clears out the old figure and its patches.
2. Creates a new figure and axes with default values.
3. Repopulates the axes with new patches using the surface to patch data from each body.

Examples

Initialize the animation object, `h`.

```
h = Aero.Animation;
h.initialize();
```

See Also

`delete`, `initIfNeeded`, `play`

initialize (Aero.FlightGearAnimation)

Purpose Set up FlightGear animation object

Syntax

```
initialize(h)
h.initialize
```

Description `initialize(h)` and `h.initialize` set up the FlightGear version, IP address, and socket for the FlightGear animation object `h`.

Examples Initialize the animation object, `h`.

```
h = Aero.FlightGearAnimation;
h.initialize();
```

See Also `delete`, `play`, `GenerateRunScript`, `update`

initialize (Aero.VirtualRealityAnimation)

Purpose

Create and populate virtual reality animation object

Syntax

```
initialize(h)
h.initialize
```

Description

`initialize(h)` and `h.initialize` create a virtual reality animation world and populate the virtual reality animation object `h`. If a previously initialized virtual reality animation object existgs, and that object has user-specified data, this function saves the previous object to be reset after the initialization.

Examples

Initialize the virtual reality animation object, h.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
```

See Also

`delete`, `play`

initIfNeeded (Aero.Animation)

Purpose

Initialize animation object graphics

Syntax

```
initIfNeeded(h)
h.initIfNeeded
```

Description

`initIfNeeded(h)` and `h.initIfNeeded` initialize animation object graphics if necessary.

Examples

Initialize the animation object graphics of `h` as needed.

```
h=Aero.Animation;
h.initIfNeeded;
```

See Also

`initialize`, `delete`

Purpose

Calculate Julian date

Syntax

```
jd = juliandate(v)
jd = juliandate(s,f)
jd = juliandate(y,mo,d)
jd = juliandate([y,mo,d])
jd = juliandate(y,mo,d,h,mi,s)
jd = juliandate([y,mo,d,h,mi,s])
```

Description

`jd = juliandate(v)` converts one or more date vectors, `v`, into Julian date, `jd`. Input `v` can be an `m`-by-6 or `m`-by-3 matrix containing `m` full or partial date vectors, respectively. `juliandate` returns a column vector of `m` Julian dates, which are the number of days and fractions since noon Universal Time on January 1, 4713 BCE.

A date vector contains six elements, specifying year, month, day, hour, minute, and second. A partial date vector has three elements, specifying year, month, and day. Each element of `v` must be a positive double-precision number.

`jd = juliandate(s,f)` converts one or more date strings, `s`, into Julian date, `jd`, using format string `f`. `s` can be a character array where each row corresponds to one date string, or a one-dimensional cell array of strings. `juliandate` returns a column vector of `m` Julian dates, where `m` is the number of strings in `s`.

All of the date strings in `s` must have the same format `f`, which must be composed of date format symbols listed in the `datestr` function reference page. Formats containing the letter `Q` are not accepted by `juliandate`.

Certain formats may not contain enough information to compute a date number. In those cases, hours, minutes, and seconds default to 0, days default to 1, months default to January, and years default to the current year. Date strings with two-character years are interpreted to be within the 100 years centered around the current year.

`jd = juliandate(y,mo,d)` and `jd = juliandate([y,mo,d])` return the decimal year for corresponding elements of the `y,mo,d` (year,month,day) arrays. `y`, `mo`, and `d` must be arrays of the same size (or any of them can be a scalar).

`jd = juliandate(y,mo,d,h,mi,s)` and `jd = juliandate([y,mo,d,h,mi,s])` return the Julian dates for corresponding elements of the `y,mo,d,h,mi,s` (year,month,day,hour,minute,second) arrays. The six arguments must be arrays of the same size (or any of them can be a scalar).

Examples

Calculate Julian date for May 24, 2005:

```
jd = juliandate('24-May-2005','dd-mmm-yyyy')

jd =

  2.4535e+006
```

Calculate Julian date for December 19, 2006:

```
jd = juliandate(2006,12,19)

jd =

  2.4541e+006
```

Calculate Julian date for October 10, 2004, at 12:21:00 p.m.:

```
jd = juliandate(2004,10,10,12,21,0)

jd =

  2.4533e+006
```

Assumptions and Limitations

This function is valid for all common era (CE) dates in the Gregorian calendar.

The calculation of Julian date does not take into account leap seconds.

See Also

`decyear`, `leapyear`, `mjuliandate`

Purpose

Determine leap year

Syntax

```
ly = leapyear(year)
```

Description

`ly = leapyear(year)` determines whether one or more years are leap years or not. The output, `ly`, is a logical array. `year` should be numeric.

Examples

Determine whether 2005 is a leap year:

```
ly = leapyear(2005)

ly =

  0
```

Determine whether 2000, 2005, and 2020 are leap years:

```
ly = leapyear([2000 2005 2020])

ly =

  1     0     1
```

Assumptions and Limitations

The determination of leap years is done by Gregorian calendar rules.

See Also

`decyear`, `juliandate`, `mjuliandate`

Purpose

Convert geodetic coordinates to Earth-centered Earth-fixed (ECEF) coordinates

Syntax

```
p = lla2ecef(lla)
p = lla2ecef(lla, model)
p = lla2ecef(lla, f, Re)
```

Description

`p = lla2ecef(lla)` converts an `m`-by-3 array of geodetic coordinates (latitude, longitude and altitude), `lla`, to an `m`-by-3 array of ECEF coordinates, `p`. `lla` is in [degrees degrees meters]. `p` is in meters. The default ellipsoid planet is WGS84.

`p = lla2ecef(lla, model)` is an alternate method for converting the coordinates for a specific ellipsoid planet. Currently only `'WGS84'` is supported for `model`.

`p = lla2ecef(lla, f, Re)` is another alternate method for converting the coordinates for a custom ellipsoid planet defined by flattening, `f`, and the equatorial radius, `Re`, in meters.

Examples

Determine ECEF coordinates at a latitude, longitude, and altitude:

```
p = lla2ecef([0 45 1000])


p =

   1.0e+006 *

      4.5107    4.5107         0
```

Determine ECEF coordinates at multiple latitudes, longitudes, and altitudes, specifying WGS84 ellipsoid model:

```
p = lla2ecef([0 45 1000; 45 90 2000], 'WGS84')


p =
```

```
  1.0e+006 *

    4.5107    4.5107         0
    0.0000    4.5190    4.4888
```

Determine ECEF coordinates at multiple latitudes, longitudes, and altitudes, specifying custom ellipsoid model:

```
f = 1/196.877360;
Re = 3397000;
p = lla2ecef([0 45 1000; 45 90 2000], f, Re)


p =

  1.0e+006 *

    2.4027    2.4027         0
    0.0000    2.4096    2.3852
```

See Also

`ecef2lla`, `geoc2geod`, `geod2geoc`

load (Aero.Body)

Purpose

Get geometry data from source

Syntax

```
load(h, bodyDataSrc)
h.load(bodyDataSrc)
load(h, bodyDataSrc, geometrysource)
h.load(bodyDataSrc, geometrysource)
```

Description

`load(h, bodyDataSrc)` and `h.load(bodyDataSrc)` load the graphics data from the body graphics file. This command assumes a default geometry source type set to `Auto`.

`load(h, bodyDataSrc, geometrysource)` and `h.load(bodyDataSrc, geometrysource)` load the graphics data from the body graphics file, `bodyDataSrc`, into the face, vertex, and color data of the animation body object `h`. Then, when axes `ax` is available, you can use this data to generate patches with `generatePatches`. `geometrysource` is the geometry source type for the body.

By default *`geometrysource`* is set to `Auto`, which recognizes `.mat` extensions as Mat-files, `.ac` extensions as Ac3d files, and structures containing fields of `name`, `faces`, `vertices`, and `cdata` as MATLAB variables. If you want to use alternate file extensions or file types, enter one of the following:

- `Auto`
- `Variable`
- `MatFile`
- `Ac3d`
- `Custom`

Examples

Load the graphic data from the graphic data file, `pa24-250_orange.ac`, into `b`.

```
b=Aero.Body;
b.load('pa24-250_orange.ac','Ac3d');
```

See Also `generatePatches`, `move`, `update`

machnumber

Purpose

Compute Mach number using velocity and speed of sound

Syntax

```
mach = machnumber(v, a)
```

Description

`mach = machnumber(v, a)` computes `m` Mach numbers, `mach`, from an `m`-by-3 array of velocities, `v`, and an array of `m` speeds of sound, `a`. `v` and `a` must have the same length units.

Examples

Determine the Mach number for velocity and speed of sound in feet per second:

```
mach = machnumber([84.3905 33.7562 10.1269], 1116.4505)


mach =

    0.0819
```

Determine the Mach number for velocity and speed of sound in meters per second:

```
mach = machnumber([25.7222 10.2889 3.0867], [340.2941 295.0696])


mach =

    0.0819    0.0945
```

Determine the Mach number for velocity and speed of sound in knots:

```
mach = machnumber([50 20 6; 5 0.5 2], [661.4789 573.5694])


mach =

    0.0819
    0.0094
```

See Also

`airspeed`, `alphabeta`, `dpressure`

mjuliandate

Purpose

Calculate modified Julian date

Syntax

```
mjd = mjuliandate(v)
mjd = mjuliandate(s,f)
mjd = mjuliandate(y,mo,d)
mjd = mjuliandate([y,mo,d])
mjd = mjuliandate(y,mo,d,h,mi,s)
mjd = mjuliandate([y,mo,d,h,mi,s])
```

Description

`mjd = mjuliandate(v)` converts one or more date vectors, `v`, into modified Julian date, `mjd`. Input `v` can be an `m`-by-6 or `m`-by-3 matrix containing `m` full or partial date vectors, respectively. `mjuliandate` returns a column vector of `m` modified Julian dates. Modified Julian dates begin at midnight rather than noon and have the first two digits of the corresponding Julian date removed.

A date vector contains six elements, specifying year, month, day, hour, minute, and second. A partial date vector has three elements, specifying year, month, and day. Each element of `v` must be a positive double-precision number.

`mjd = mjuliandate(s,f)` converts one or more date strings, `s`, into modified Julian date, `mjd`, using format string `f`. `s` can be a character array where each row corresponds to one date string, or a one-dimensional cell array of strings. `mjuliandate` returns a column vector of `m` modified Julian dates, where `m` is the number of strings in `s`.

All of the date strings in `s` must have the same format `f`, which must be composed of date format symbols listed in the `datestr` function reference page. Formats containing the letter `Q` are not accepted by `mjuliandate`.

Certain formats may not contain enough information to compute a date number. In those cases, hours, minutes, and seconds default to 0, days default to 1, months default to January, and years default to the current year. Date strings with two-character years are interpreted to be within the 100 years centered around the current year.

`mjd = mjuliandate(y,mo,d)` and `mjd = mjuliandate([y,mo,d])` return the decimal year for corresponding elements of the `y,mo,d` (year,month,day) arrays. `y`, `mo`, and `d` must be arrays of the same size (or any of them can be a scalar).

`mjd = mjuliandate(y,mo,d,h,mi,s)` and `mjd = mjuliandate([y,mo,d,h,mi,s])` return the modified Julian dates for corresponding elements of the `y,mo,d,h,mi,s` (year,month,day,hour,minute,second) arrays. The six arguments must be arrays of the same size (or any of them can be a scalar).

Examples

Calculate the modified Julian date for May 24, 2005:

```
mjd = mjuliandate('24-May-2005','dd-mmm-yyyy')

mjd =

  53514
```

Calculate the modified Julian date for December 19, 2006:

```
mjd = mjuliandate(2006,12,19)

mjd =

  54088
```

Calculate the modified Julian date for October 10, 2004, at 12:21:00 p.m.:

```
mjd = mjuliandate(2004,10,10,12,21,0)

mjd =

  5.3289e+004
```

Assumptions and Limitations

This function is valid for all common era (CE) dates in the Gregorian calendar.

The calculation of modified Julian date does not take into account leap seconds.

See Also

`decyear`, `juliandate`, `leapyear`

Purpose

Change animation body position and orientation

Syntax

```
move(h, translation, rotation)
h.move(translation,rotation)
```

Description

`move(h, translation, rotation)` and `h.move(translation,rotation)` set a new position and orientation for the body object `h`. `translation` is a 1-by-3 matrix in the aerospace body *x*-*y*-*z* coordinate system. `rotation` is a 1-by-3 matrix, in radians, that specifies the rotations about the right-hand *x*-*y*-*z* sequence of coordinate axes. The order of application of the rotation is *z*-*y*-*x* (*r*-*q*-*p*).

Examples

Change animation body position to *newpos* and *newrot*.

```
h = Aero.Body;
h.load('ac3d_xyzisrgb.ac','Ac3d');
newpos = h.Position + 1.00;
newrot = h.Rotation + 0.01;
h.move(newpos,newrot);
```

See Also

`load`

move (Aero.Node)

Purpose

Change node translation and rotation

Syntax

```
move(h,translation,rotation)
h.move(translation,rotation)
```

Description

`move(h,translation,rotation)` and `h.move(translation,rotation)` set a new position and orientation for the node object `h`. `translation` is a 1-by-3 matrix in the aerospace body *x*-*y*-*z* coordinate system or another coordinate system. In the latter case, you can use the `CoordTransformFcn` function to move it into an aerospace body. `rotation` is a 1-by-3 matrix, in radians, that specifies the rotations about the right-hand *x*-*y*-*z* sequence of coordinate axes. The order of application of the rotation is *z*-*y*-*x* (*r*-*q*-*p*). This function uses the `CoordTransformFcn` to apply the translation and rotation from the input coordinate system to the aerospace body. The function then moves the translation and rotation from the aerospace body to the VRML *x*-*y*-*z* coordinates.

Examples

Move the Lynx body. This example uses the Virtual Reality Toolbox `vrnode/getfield` function to retrieve the translation and rotation. These coordinates are those used in Virtual Reality Toolbox.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
newtrans = getfield(h.Nodes{4}.VRNode,'translation') + 1.0;
newrot = getfield(h.Nodes{4}.VRNode,'rotation') + [.2 0.01 0.01 0.01];
h.Nodes{4}.move(newtrans,newrot);
```

Limitations

This function cannot get the node position in aerospace body coordinates; it needs to use the `CoordTransformFcn` to do so.

This function cannot set a viewpoint position or orientation (see `addViewpoint`).

See Also

addNode

moveBody (Aero.Animation)

Purpose Move body in animation object

Syntax

```
moveBody(h,idx,translation,rotation)
h.moveBody(idx,translation,rotation)
```

Description `moveBody(h,idx,translation,rotation)` and `h.moveBody(idx,translation,rotation)` set a new position and attitude for the body specified with the index `idx` in the animation object `h`. `translation` is a 1-by-3 matrix in the aerospace body coordinate system. `rotation` is a 1-by-3 matrix, in radians, that specifies the rotations about the right-hand *x-y-z* sequence of coordinate axes. The order of application of the rotation is *z-y-x (R-Q-P)*.

Examples Move the body with the index 1 to position offset from the original by `+ [0 0 -3]` and rotation, *rot1*.

```
h = Aero.Animation;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
pos1 = h.Bodies{1}.Position;
rot1 = h.Bodies{1}.Rotation;
h.moveBody(1,pos1 + [0 0 -3],rot1);
```

See Also `addBody`, `createBody`, `removeBody`, `updateBodies`

Purpose

Create node object for use with virtual reality animation

Syntax

```
h = Aero.Node
```

Description

`h = Aero.Node` creates a node object for use with virtual reality animation.

See `Aero.Node` for further details.

See Also

`Aero.Node`

nodeInfo (Aero.VirtualRealityAnimation)

Purpose

Create list of nodes associated with virtual reality animation object

Syntax

```
nodeInfo(h)
h.nodeInfo
n = nodeInfo(h)
n = h.nodeInfo
```

Description

`nodeInfo(h)` and `h.nodeInfo` create a list of nodes associated with the virtual reality animation object, `h`.

`n = nodeInfo(h)` and `n = h.nodeInfo` create a cell array (`n`) that contains the node information. The function stores the information in a cell array as follows:

```
N{1,n} = Node Index
N{2,n} = Node Name
N{3,n} = Node Type
```

where `n` is the number of nodes. You might want to use this function to find an existing node by name and then perform a certain action on it using the node index.

Examples

Create list of nodes associated with virtual reality animation object, `h`.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
h.initialize();
h.nodeInfo;
```

See Also

`addNode`

Purpose

Animate FlightGear flight simulator using given position/angle time series

Syntax

```
play(h)
h.play
```

Description

`play(h)` and `h.play` animate FlightGear flight simulator using specified time series data in `h`. The time series data can be set in `h` by using the property `'TimeseriesSource'`.

The time series data, stored in the property `'TimeseriesSource'`, is interpreted according to the `'TimeseriesSourceType'` property, which can be one of:

`'Timeseries'`	MATLAB time series data with six values per time: `latitude longitude altitude phi theta psi` The values are resampled.
`'StructureWithTime'`	Simulink struct with time (Simulink root outport logging `'Structure with time'`): • `signals(1).values:  latitude longitude altitude` • `signals(2).values:  phi theta psi` Signals are linearly interpolated vs. time using `interp1`.

'Array6DoF'	A double-precision array in n rows and 7 columns for 6-DoF data: time latitude longitude altitude phi theta psi. If a double-precision array of 8 or more columns is in 'TimeseriesSource', the first 7 columns are used as 6-DoF data.
'Array3DoF'	A double-precision array in n rows and 4 columns for 3-DoF data: time latitude altitude theta. If a double-precision array of 5 or more columns is in 'TimeseriesSource', the first 4 columns are used as 3-DoF data.
'Custom'	Position and angle data is retrieved from 'TimeseriesSource' by the currently registered 'TimeseriesReadFcn'.

The time advancement algorithm used by play is based on animation frames counted by ticks:

```
ticks = ticks + 1;
time  = tstart + ticks*FramesPerSecond*TimeScaling;
```

where

TimeScaling	Specify the seconds of animation data per second of wall-clock time.
FramesPerSecond	Specify the number of frames per second used to animate the 'TimeseriesSource'.

For default 'TimeseriesReadFcn' methods, the last frame played is the last time value.

Time is in seconds, position values are in the same units as the geometry model to be used by FlightGear (see the property `'GeometryModelName'`), and all angles are in radians. A possible result of using incorrect units is the early termination of the FlightGear flight simulator.

Note If there is a 15% difference between the expected time advance and the actual time advance, this method will generate the following warning:

```
TimerPeriod has been set to <value>. You may wish to modify the animation
TimeScaling and FramesPerSecond properties to compensate for the
millisecond limit of the TimerPeriod.  See documentation for details.
```

Examples

Animate FlightGear flight simulator using the given `'Array3DoF'` position/angle time series data:

```
data = [86.2667 -2.13757034184404 7050.896596 -0.135186746141248;...
        87.2833 -2.13753906554384 6872.545051 -0.117321084678936;...
        88.2583 -2.13751089592972 6719.405713 -0.145815609299676;...
        89.275  -2.13747984652232 6550.117118 -0.150635248762596;...
        90.2667 -2.13744993157894 6385.05883  -0.143124782831999;...
        91.275  -2.13742019116849 6220.358163 -0.147946202530756;...
        92.275  -2.13739055547779 6056.906647 -0.167529704309343;...
        93.2667 -2.13736104196014 5892.356118 -0.152547361677911;...
        94.2583 -2.13733161570895 5728.201718 -0.161979312941906;...
        95.2583 -2.13730231163081 5562.923808 -0.122276929636682;...
        96.2583 -2.13727405475022 5406.736322 -0.160421658944379;...
        97.2667 -2.1372440001805  5239.138477 -0.150591353731908;...
        98.2583 -2.13721598764601 5082.78798  -0.147737722951605];
h = fganimation
h.TimeseriesSource = data
h.TimeseriesSourceType = 'Array3DoF'
play(h)
```

See Also `GenerateRunScript`, `initialize`, `update`

Purpose

Animate `Aero.Animation` object given position/angle time series

Syntax

```
play(h)
play.h
```

Description

`play(h)` and `play.h` animate the loaded geometry in `h` for the current `TimeseriesDataSource` at the specified rate given by the `'TimeScaling'` property (in seconds of animation data per second of wall-clock time) and animated at a certain number of frames per second using the `'FramesPerSecond'` property.

The time series data is interpreted according to the `'TimeseriesSourceType'` property, which can be one of:

`'Timeseries'`	MATLAB time series data with six values per time: `x y z phi theta psi` The values are resampled.

`'Simulink.Timeseries'`	Simulink.Timeseries (Simulink signal logging):
	• First data item
	`x y z`
	• Second data item
	`phi theta psi`

`'StructureWithTime'`	Simulink struct with time (Simulink root outport logging `'Structure with time'`): • `signals(1).values:  x y z` • `signals(2).values:  phi theta psi` Signals are linearly interpolated vs. time using `interp1`.
`'Array6DoF'`	A double-precision array in `n` rows and 7 columns for 6-DoF data: `time x y z phi theta psi`. If a double-precision array of 8 or more columns is in `'TimeseriesSource'`, the first 7 columns are used as 6-DoF data.
`'Array3DoF'`	A double-precision array in `n` rows and 4 columns for 3-DoF data: `time x z theta`. If a double-precision array of 5 or more columns is in `'TimeseriesSource'`, the first 4 columns are used as 3-DoF data.
`'Custom'`	Position and angle data is retrieved from `'TimeseriesSource'` by the currently registered `'TimeseriesReadFcn'`.

The time advancement algorithm used by `play` is based on animation frames counted by ticks:

```
ticks = ticks + 1;
time  = tstart + ticks*FramesPerSecond*TimeScaling;
```

where

`TimeScaling`	Specify the seconds of animation data per second of wall-clock time.
`FramesPerSecond`	Specify the number of frames per second used to animate the `'TimeseriesSource'`.

For default `'TimeseriesReadFcn'` methods, the last frame played is the last time value.

Time is in seconds, position values are in the same units as the geometry data loaded into the animation object, and all angles are in radians.

Note If there is a 15% difference between the expected time advance and the actual time advance, this method will generate the following warning:

```
TimerPeriod has been set to <value>. You may wish to modify the animation
TimeScaling and FramesPerSecond properties to compensate for the
millisecond limit of the TimerPeriod.  See documentation for details.
```

Examples

Animate the body, `idx1`, for the duration of the time series data.

```
h = Aero.Animation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
load simdata;
h.Bodies{1}.TimeSeriesSource = simdata;
h.show();
h.play();
```

See Also

`show`, `createBody`, `updateBodies`, `updateCamera`, `initialize`

play (Aero.VirtualRealityAnimation)

Purpose

Animate virtual reality world for given position and angle in time series data

Syntax

```
play(h)
h.play
```

Description

`play(h)` and `h.play` animate the virtual reality world in `h` for the current `TimeseriesDataSource` at the specified rate given by the `'TimeScaling'` property (in seconds of animation data per second of wall-clock time) and animated at a certain number of frames per second using the `'FramesPerSecond'` property.

The time series data is interpreted according to the `'TimeseriesSourceType'` property, which can be one of:

`'timeseries'`	MATLAB time series data with six values per time: `x y z phi theta psi` The values are resampled.

`'Simulink.Timeseries'`	Simulink.Timeseries (Simulink signal logging):
	• First data item
	`x y z`
	• Second data item
	`phi theta psi`

`'StructureWithTime'`	Simulink struct with time (Simulink root outport logging `'Structure with time'`): • `signals(1).values:  x y z` • `signals(2).values:  phi theta psi` Signals are linearly interpolated vs. time using `interp1`.
`'Array6DoF'`	A double-precision array in `n` rows and 7 columns for 6-DoF data: `time x y z phi theta psi`. If a double-precision array of 8 or more columns is in `'TimeseriesSource'`, the first 7 columns are used as 6-DoF data.
`'Array3DoF'`	A double-precision array in `n` rows and 4 columns for 3-DoF data: `time x z theta`. If a double-precision array of 5 or more columns is in `'TimeseriesSource'`, the first 4 columns are used as 3-DoF data.
`'Custom'`	Position and angle data is retrieved from `'TimeseriesSource'` by the currently registered `'TimeseriesReadFcn'`.

The time advancement algorithm used by `play` is based on animation frames counted by ticks:

```
ticks = ticks + 1;
time  = tstart + ticks*FramesPerSecond*TimeScaling;
```

where

`TimeScaling`	Specify the seconds of animation data per second of wall-clock time.
`FramesPerSecond`	Specify the number of frames per second used to animate the `'TimeseriesSource'`.

For default `'TimeseriesReadFcn'` methods, the last frame played is the last time value.

Time is in seconds, position values are in the same units as the geometry data loaded into the animation object, and all angles are in radians.

Examples

Animate virtual reality world, `vrtkoff`.

```
h = Aero.VirtualRealityAnimation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
h.initialize();
load takeoffData
h.Nodes{7}.TimeseriesSource = takeoffData;
h.Nodes{7}.TimeseriesSourceType = 'StructureWithTime';
h.Nodes{7}.CoordTransformFcn = @vranimCustomTransform;
h.play();
```

See Also

`initialize`

Purpose

Convert quaternion to rotation angles

Syntax

```
[r1 r2 r3] = quat2angle(q)
[r1 r2 r3] = quat2angle(q, s)
```

Description

`[r1 r2 r3] = quat2angle(q)` calculates the set of rotation angles, `r1`, `r2`, `r3`, for a given quaternion, `q`. `q` is an `m`-by-4 matrix containing `m` quaternions. Each element of `q` must be a real number. `q` has its scalar number as the first column.

Rotation angles are output in radians.

`r1`
: Returns an `m` array of first rotation angles.

`r2`
: Returns an `m` array of second rotation angles.

`r3`
: Returns an `m` array of third rotation angles.

`[r1 r2 r3] = quat2angle(q, s)` calculates the set of rotation angles, `r1`, `r2`, `r3`, for a given quaternion, `q`, and a specified rotation sequence, `s`.

The default rotation sequence is `'ZYX'`, where `r1` is *z*-axis rotation, `r2` is *y*-axis rotation, and `r3` is *x*-axis rotation.

Supported rotation sequence strings are `'ZYX'`, `'ZYZ'`, `'ZXY'`, `'ZXZ'`, `'YXZ'`, `'YXY'`, `'YZX'`, `'YZY'`, `'XYZ'`, `'XYX'`, `'XZY'`, and `'XZX'`.

Examples

Determine the rotation angles from q = [1 0 1 0].

```
[yaw, pitch, roll] = quat2angle([1 0 1 0])
yaw =
     0
pitch =
    1.5708
roll =
     0
```

Determine the rotation angles from multiple quaternions.

```
q = [1 0 1 0; 1 0.5 0.3 0.1];
 [pitch, roll, yaw] = quat2angle(q, 'YXZ')
pitch =
    1.5708
    0.8073
roll =
         0
    0.7702
yaw =
         0
    0.5422
```

Assumptions and Limitations

The limitations for the `'ZYX'`, `'ZXY'`, `'YXZ'`, `'YZX'`, `'XYZ'`, and `'XZY'` implementations generate an `r2` angle that lies between ±90 degrees, and `r1` and `r3` angles that lie between ±180 degrees.

The limitations for the `'ZYZ'`, `'ZXZ'`, `'YXY'`, `'YZY'`, `'XYX'`, and `'XZX'` implementations generate an `r2` angle that lies between 0 and 180 degrees, and `r1` and `r3` angles that lie between ±180 degrees.

See Also

`angle2dcm`, `angle2quat`, `dcm2angle`, `dcm2quat`, `quat2dcm`

Purpose

Convert quaternion to direction cosine matrix

Syntax

```
n = quat2dcm(q)
```

Description

`n = quat2dcm(q)` calculates the direction cosine matrix, `n`, for a given quaternion, `q`. Input `q` is an `m`-by-4 matrix containing `m` quaternions. `n` returns a 3-by-3-by-`m` matrix of direction cosine matrices. The direction cosine matrix performs the coordinate transformation of a vector in inertial axes to a vector in body axes. Each element of `q` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Determine the direction cosine matrix from `q = [1 0 1 0]`:

```
dcm = quat2dcm([1 0 1 0])


dcm =

         0         0   -1.0000
         0    1.0000         0
    1.0000         0         0
```

Determine the direction cosine matrices from multiple quaternions:

```
q = [1 0 1 0; 1 0.5 0.3 0.1];
dcm = quat2dcm(q)


dcm(:,:,1) =

         0         0   -1.0000
         0    1.0000         0
    1.0000         0         0


dcm(:,:,2) =
```

```
0.8519    0.3704   -0.3704
0.0741    0.6148    0.7852
0.5185   -0.6963    0.4963
```

See Also

`angle2dcm`, `dcm2angle`, `dcm2quat`, `angle2quat`, `quat2angle`, `quatrotate`

Purpose

Calculate conjugate of quaternion

Syntax

```
n = quatconj(q)
```

Description

`n = quatconj(q)` calculates the conjugate, `n`, for a given quaternion, `q`. Input `q` is an `m`-by-4 matrix containing `m` quaternions. `n` returns an `m`-by-4 matrix of conjugates. Each element of `q` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Determine the conjugate of `q = [1 0 1 0]`:

```
conj = quatconj([1 0 1 0])


conj =

     1     0    -1     0
```

See Also

`quatdivide`, `quatinv`, `quatmod`, `quatmultiply`, `quatnorm`, `quatnormalize`, `quatrotate`

quatdivide

Purpose

Divide quaternion by another quaternion

Syntax

```
n = quatdivide(q,r)
```

Description

`n = quatdivide(q,r)` calculates the result of quaternion division, `n`, for two given quaternions, `q` and `r`. Inputs `q` and `r` can each be either an `m`-by-4 matrix containing `m` quaternions, or a single 1-by-4 quaternion. `n` returns an `m`-by-4 matrix of quaternion quotients. Each element of `q` and `r` must be a real number. Additionally, `q` and `r` have their scalar number as the first column.

Examples

Determine the division of two 1-by-4 quaternions:

```
q = [1 0 1 0];
r = [1 0.5 0.5 0.75];
d = quatdivide(q, r)


d =

    0.7273    0.1212    0.2424   -0.6061
```

Determine the division of a 2-by-4 quaternion by a 1-by-4 quaternion:

```
q = [1 0 1 0; 2 1 0.1 0.1];
r = [1 0.5 0.5 0.75];
d = quatdivide(q, r)


d =

    0.7273    0.1212    0.2424   -0.6061
    1.2727    0.0121   -0.7758   -0.4606
```

See Also

`quatconj`, `quatinv`, `quatmod`, `quatmultiply`, `quatnorm`, `quatnormalize`, `quatrotate`

Purpose

Calculate inverse of quaternion

Syntax

```
n = quatinv(q)
```

Description

`n = quatinv(q)` calculates the inverse, `n`, for a given quaternion, `q`. Input `q` is an `m`-by-4 matrix containing `m` quaternions. `n` returns an `m`-by-4 matrix of inverses. Each element of `q` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Determine the inverse of `q = [1 0 1 0]`:

```
qinv = quatinv([1 0 1 0])


qinv =

    0.5000         0   -0.5000         0
```

See Also

`quatconj`, `quatdivide`, `quatmod`, `quatmultiply`, `quatnorm`, `quatnormalize`, `quatrotate`

quatmod

Purpose

Calculate modulus of quaternion

Syntax

```
n = quatmod(q)
```

Description

`n = quatmod(q)` calculates the modulus, `n`, for a given quaternion, `q`. Input `q` is an `m`-by-4 matrix containing `m` quaternions. `n` returns a column vector of `m` moduli. Each element of `q` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Determine the modulus of `q = [1 0 0 0]`:

```
mod = quatmod([1 0 0 0])


mod =

     1
```

See Also

`quatconj`, `quatdivide`, `quatinv`, `quatmultiply`, `quatnorm`, `quatnormalize`, `quatrotate`

Purpose

Calculate product of two quaternions

Syntax

```
n = quatmultiply(q,r)
```

Description

`n = quatmultiply(q,r)` calculates the quaternion product, `n`, for two given quaternions, `q` and `r`. Inputs `q` and `r` can each be either an `m`-by-4 matrix containing `m` quaternions, or a single 1-by-4 quaternion. `n` returns an `m`-by-4 matrix of quaternion products. Each element of `q` and `r` must be a real number. Additionally, `q` and `r` have their scalar number as the first column.

Note Quaternion multiplication is not commutative.

Examples

Determine the product of two 1-by-4 quaternions:

```
q = [1 0 1 0];
r = [1 0.5 0.5 0.75];
mult = quatmultiply(q, r)


mult =

    0.5000    1.2500    1.5000    0.2500
```

Determine the product of a 1-by-4 quaternion with itself:

```
q = [1 0 1 0];
mult = quatmultiply(q)


mult =

     0     0     2     0
```

Determine the product of 1-by-4 and 2-by-4 quaternions:

```
q = [1 0 1 0];
r = [1 0.5 0.5 0.75; 2 1 0.1 0.1];
mult = quatmultiply(q, r)


mult =

    0.5000    1.2500    1.5000    0.2500
    1.9000    1.1000    2.1000   -0.9000
```

See Also

`quatconj`, `quatdivide`, `quatinv`, `quatmod`, `quatnorm`, `quatnormalize`, `quatrotate`

quatnorm

Purpose

Calculate norm of quaternion

Syntax

```
n = quatnorm(q)
```

Description

`n = quatnorm(q)` calculates the norm, `n`, for a given quaternion, `q`. Input `q` is an `m`-by-4 matrix containing `m` quaternions. `n` returns a column vector of `m` norms. Each element of `q` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Determine the norm of `q = [1 0 0 0]`:

```
norm = quatnorm([1 0 0 0])


norm =

     1
```

See Also

`quatconj`, `quatdivide`, `quatinv`, `quatmod`, `quatmultiply`, `quatnormalize`, `quatrotate`

quatnormalize

Purpose

Normalize quaternion

Syntax

```
n = quatnormalize(q)
```

Description

`n = quatnormalize(q)` calculates the normalized quaternion, `n`, for a given quaternion, `q`. Input `q` is an `m`-by-4 matrix containing `m` quaternions. `n` returns an `m`-by-4 matrix of normalized quaternions. Each element of `q` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Normalize `q = [1 0 1 0]`:

```
normal = quatnormalize([1 0 1 0])


normal =

    0.7071         0    0.7071         0
```

See Also

`quatconj`, `quatdivide`, `quatinv`, `quatmod`, `quatmultiply`, `quatnorm`, `quatrotate`

Purpose

Rotate vector by quaternion

Syntax

```
n = quatrotate(q,r)
```

Description

`n = quatrotate(q,r)` calculates the rotated vector, `n`, for a quaternion, `q`, and a vector, `r`. `q` is either an `m`-by-4 matrix containing `m` quaternions, or a single 1-by-4 quaternion. `r` is either an `m`-by-3 matrix, or a single 1-by-3 vector. `n` returns an `m`-by-3 matrix of rotated vectors. Each element of `q` and `r` must be a real number. Additionally, `q` has its scalar number as the first column.

Examples

Rotate a 1-by-3 vector by a 1-by-4 quaternion:

```
q = [1 0 1 0];
r = [1 1 1];
n = quatrotate(q, r)


n =

   -1.0000    1.0000    1.0000
```

Rotate a 1-by-3 vector by a 2-by-4 quaternion:

```
q = [1 0 1 0; 1 0.5 0.3 0.1];
r = [1 1 1];
n = quatrotate(q, r)


n =

   -1.0000    1.0000    1.0000
    0.8519    1.4741    0.3185
```

Rotate a 2-by-3 vector by a 1-by-4 quaternion:

```
q = [1 0 1 0];
r = [1 1 1; 2 3 4];
```

```
n = quatrotate(q, r)


n =

   -1.0000    1.0000    1.0000
   -4.0000    3.0000    2.0000
```

Rotate a 2-by-3 vector by a 2-by-4 quaternion:

```
q = [1 0 1 0; 1 0.5 0.3 0.1];
r = [1 1 1; 2 3 4];
n = quatrotate(q, r)


n =

   -1.0000    1.0000    1.0000
    1.3333    5.1333    0.9333
```

See Also

quatconj, quatinv, quatmod, quatmultiply, quatnorm, quatnormalize

Purpose Read geometry data using current reader

Syntax

```
read(h, source)
```

Description

`read(h, source)` reads the geometry data of the geometry object `h`. `source` can be:

- `'Auto'`

  Selects default reader.

- `'Variable'`

  Selects MATLAB variable of type structure structures that contains the fieldsname, `faces`, `vertices`, and `cdata` that define the geometry in the Handle Graphics® patches.

- `'MatFile'`

  Selects M-file reader.

- `'Ac3dFile'`

  Selects Ac3d file reader.

- `'Custom'`

  Selects a custom reader.

Examples

Read geometry data from Ac3d file, `pa24-250_orange.ac`.

```
g = Aero.Geometry;
g.Source = 'Ac3d';
g.read('pa24-250_orange.ac');
```

removeBody (Aero.Animation)

Purpose

Remove one body from animation

Syntax

```
h = removeBody(h,idx)
h = h.removeBody(idx)
```

Description

`h = removeBody(h,idx)` and `h = h.removeBody(idx)` remove the body specified by the index `idx` from the animation object `h`.

Examples

Remove the body identified by the index, 1.

```
h = Aero.Animation;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
h = removeBody(h,1)
```

See Also

`addBody`, `createBody`, `moveBody`, `updateBodies`

Purpose

Remove node from virtual reality animation object

Syntax

```
removeNode(h,node)
h.removeNode(node)
```

Description

`removeNode(h,node)` and `h.removeNode(node)` remove the node specified by `node` from the virtual reality animation object `h`. `node` can be either the node name or the node index. This function can remove only one node at a time.

Note You can use only this function to remove a node added by `addNode`. If you need to remove a node from a previously defined `.wrl` file, use a VRML editor.

Examples

Remove the node, Lynx1.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
h.addNode('Lynx1',[matlabroot,'/toolbox/aero/astdemos/chaseHelicopter.wrl']);
h.removeNode('Lynx1');
```

See Also

`addNode`

removeViewpoint (Aero.VirtualRealityAnimation)

Purpose Remove viewpoint node from virtual reality animation

Syntax

```
removeViewpoint(h,viewpoint)
h.removeViewpoint(viewpoint)
```

Description `removeViewpoint(h,viewpoint)` and `h.removeViewpoint(viewpoint)` remove the viewpoint specified by `viewpoint` from the virtual reality animation object `h`. `viewpoint` can be either the viewpoint name or the viewpoint index. This function can remove only one viewpoint at a time.

Note You can use this function to remove a viewpoint added by `addViewpoint`. If you need to remove a viewpoint from a previously defined `.wrl` file, use a VRML editor.

Examples Remove the node, Lynx1.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
h.addViewpoint(h.Nodes{2}.VRNode,'children','chaseView','View From Helicopter');
h.removeViewpoint('chaseView');
```

See Also `addViewpoint`

Purpose

Compute relative pressure ratio

Syntax

```
d = rrdelta(p0, mach, g)
```

Description

`d = rrdelta(p0, mach, g)` computes `m` pressure relative ratios, `d`, from `m` static pressures, `p0`, `m` Mach numbers, `mach`, and `m` specific heat ratios, `g`. `p0` must be in pascals.

Examples

Determine the relative pressure ratio for three pressures:

```
delta = rrdelta([101325 22632.0672 4328.1393], 0.5, 1.4)


delta =

    1.1862    0.2650    0.0507
```

Determine the relative pressure ratio for three pressures and three different heat ratios:

```
delta = rrdelta([101325 22632.0672 4328.1393], 0.5, [1.4 1.35 1.4])


delta =

    1.1862    0.2635    0.0507
```

Determine the relative pressure ratio for three pressures at three different conditions:

```
delta = rrdelta([101325 22632.0672 4328.1393], [0.5 1 2], [1.4 1.35 1.4])


delta =

    1.1862    0.4161    0.3342
```

Assumptions and Limitations

For cases in which total pressure ratio is desired (Mach number is nonzero), the total pressures are calculated assuming perfect gas (with constant molecular weight, constant pressure specific heat, and constant specific heat ratio) and dry air.

References

Aeronautical Vestpocket Handbook, United Technologies Pratt & Whitney, August, 1986

See Also

`rrsigma`, `rrtheta`

Purpose

Compute relative density ratio

Syntax

```
s = rrsigma(rho, mach, g)
```

Description

`s = rrsigma(rho, mach, g)` computes `m` density relative ratios, `s`, from `m` static densities, `rho`, `m` Mach numbers, `mach`, and `m` specific heat ratios, `g`. `rho` must be in kilograms per meter cubed.

Examples

Determine the relative density ratio for three densities:

```
sigma = rrsigma([1.225 0.3639 0.0953], 0.5, 1.4)


sigma =

    1.1297    0.3356    0.0879
```

Determine the relative density ratio for three densities and three different heat ratios:

```
sigma = rrsigma([1.225 0.3639 0.0953], 0.5, [1.4 1.35 1.4])


sigma =

    1.1297    0.3357    0.0879
```

Determine the relative density ratio for three densities at three different conditions:

```
sigma = rrsigma([1.225 0.3639 0.0953], [0.5 1 2], [1.4 1.35 1.4])


sigma =

    1.1297    0.4709    0.3382
```

Assumptions and Limitations

For cases in which total density ratio is desired (Mach number is nonzero), the total density is calculated assuming perfect gas (with constant molecular weight, constant pressure specific heat, and constant specific heat ratio) and dry air.

References

Aeronautical Vestpocket Handbook, United Technologies Pratt & Whitney, August, 1986

See Also

`rrdelta`, `rrtheta`

Purpose

Compute relative temperature ratio

Syntax

```
th = rrtheta(t0, mach, g)
```

Description

`th = rrtheta(t0, mach, g)` computes `m` temperature relative ratios, `th`, from `m` static temperatures, `t0`, `m` Mach numbers, `mach`, and `m` specific heat ratios, `g`. `t0` must be in kelvin.

Examples

Determine the relative temperature ratio for three temperatures:

```
th = rrtheta([273.15 310.9278 373.15], 0.5, 1.4)


th =

    0.9953    1.1330    1.3597
```

Determine the relative temperature ratio for three temperatures and three different heat ratios:

```
th = rrtheta([273.15 310.9278 373.15], 0.5, [1.4 1.35 1.4])


th =

    0.9953    1.1263    1.3597
```

Determine the relative temperature ratio for three temperatures at three different conditions:

```
th = rrtheta([273.15 310.9278 373.15], [0.5 1 2], [1.4 1.35 1.4])


th =

    0.9953    1.2679    2.3310
```

Assumptions and Limitations

For cases in which total temperature ratio is desired (Mach number is nonzero), the total temperature is calculated assuming perfect gas (with constant molecular weight, constant pressure specific heat, and constant specific heat ratio) and dry air.

References

Aeronautical Vestpocket Handbook, United Technologies Pratt & Whitney, August, 1986

See Also

`rrdelta`, `rrsigma`

saveas (Aero.VirtualRealityAnimation)

Purpose

Save virtual reality world associated with virtual reality animation object

Syntax

```
saveas(h, filename)
h.saveas(filename)
```

Description

`saveas(h, filename)` and `h.saveas(filename)` save the world associated with the virtual reality animation object, `h`, into the `.wrl` file name specified in the `filename` variable. After saving, this function reinitializes the virtual reality animation object from the saved world.

Examples

Save the world associated with `h`.

```
h = Aero.VirtualRealityAnimation;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
h.saveas([tempdir,'my_vrtkoff.wrl']);
```

show (Aero.Animation)

Purpose

Show animation object figure

Syntax

```
show(h)
h.show
```

Description

`show(h)` and `h.show` create the figure graphics object for the animation object `h`. Use the `hide` function to close the figure.

Examples

Show the animation object, `h`.

```
h = Aero.Animation;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
h.show;
```

See Also

`createBody`, `hide`, `play`

Purpose

Change body position and orientation as function of time

Syntax

```
update(h,t)
h.update(t)
```

Description

`update(h,t)` and `h.update(t)` change body position and orientation of body `h` as a function of time `t`. *t* is a scalar in seconds.

Note This function requires that you load the body geometry and time series data first.

Examples

Update the body `b` with time in seconds of 5.

```
b=Aero.Body;
b.load('pa24-250_orange.ac','Ac3d');
tsdata = [ ...
    0,  1,1,1, 0,0,0; ...
    10  2,2,2, 1,1,1; ];
b.TimeSeriesSource = tsdata;
b.update(5);
```

See Also

`load`

update (Aero.Camera)

Purpose Update camera position based on time and position of other Aero.Body objects

Syntax

```
update(h,newtime,bodies)
h.update(newtime,bodies)
```

Description `update(h,newtime,bodies)` and `h.update(newtime,bodies)` update the camera object, `h`, position and aim point data based on the new time, `newtime`, and position of other `Aero.Body` objects, `bodies`. This function updates the camera object `PrevTime` property to `newtime`.

See Also `play`

Purpose

Update position data to FlightGear animation object

Syntax

```
update(h,time)
h.update(time)
```

Description

`update(h,time)` and `h.update(time)` update the position data to the FlightGear animation object via UDP. It sets the new position and attitude of body `h`. `time` is a scalar in seconds.

Note This function requires that you load the time series data and run FlightGear first.

Examples

Configure a body with `TimeSeriesSource` set to `simdata`, then update the body with time *`time`* equal to 0.

```
h = Aero.FlightGearAnimation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
load simdata;
h.TimeSeriesSource = simdata;
t = 0;
h.update(t);
```

See Also

`GenerateRunScript`, `initialize`, `play`

update (Aero.Node)

Purpose

Change node position and orientation versus time data

Syntax

```
update(h,t)
h.update(t)
```

Description

`update(h,t)` and `h.update(t)` change node position and orientation of node `h` as a function of time `t`. *`t`* is a scalar in seconds.

Note This function requires that you load the node and time series data first.

Examples

Move the Lynx body.

```
h = Aero.VirtualRealityAnimation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
load takeoffData
h.Nodes{7}.TimeseriesSource = takeoffData;
h.Nodes{7}.TimeseriesSourceType = 'StructureWithTime';
h.Nodes{7}.update(5);
```

See Also

`updateNodes`

Purpose

Update bodies of animation object

Syntax

```
h = updateBodies(h,time)
h.updateBodies(time)
```

Description

`h = updateBodies(h,time)` and `h.updateBodies(time)` set the new position and attitude of movable bodies in the animation object `h`. This function updates the bodies contained in the animation `object h`. `time` is a scalar in seconds.

Examples

Configure a body with `TimeSeriesSource` set to `simdata`, then update the body with time *t* equal to 0.

```
h = Aero.Animation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
load simdata;
h.Bodies{1}.TimeSeriesSource = simdata;
t = 0;
h.updateBodies(t);
```

See Also

`addBody`, `createBody`, `moveBody`, `play`, `removeBody`

updateCamera (Aero.Animation)

Purpose

Update camera in animation object

Syntax

```
updateCamera(h,time)
h.updateCamera(time)
```

Description

`updateCamera(h,time)` and `h.updateCamera(time)` update the camera in the animation object `h`. `time` is a scalar in seconds.

Note The `PositionFcn` property of a camera object controls the camera position relative to the bodies in the animation. The default camera `PositionFcn` follows the path of a first order chase vehicle. Therefore, it takes a few steps for the camera to position itself correctly in the chase plane position.

Examples

Configure a body with `TimeSeriesSource` set to `simdata`, then update the camera with time *t* equal to 0.

```
h = Aero.Animation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
idx1 = h.createBody('pa24-250_orange.ac','Ac3d');
load simdata;
h.Bodies{1}.TimeSeriesSource = simdata;
t = 0;
h.updateCamera(t);
```

See Also

`updateCamera`

updateNodes (Aero.VirtualRealityAnimation)

Purpose

Change virtual reality animation node position and orientation as function of time

Syntax

```
updateNodes(h,t)
h.updateNotes(t)
```

Description

`updateNodes(h,t)` and `h.updateNotes(t)` change node position and orientation of body `h` as a function of time `t`. *t* is a scalar in seconds.

Note This function requires that you load the node and time series data first.

Examples

Update the node `h` with time in 5 seconds.

```
h = Aero.VirtualRealityAnimation;
h.FramesPerSecond = 10;
h.TimeScaling = 5;
h.VRWorldFilename = [matlabroot,'/toolbox/aero/astdemos/vrtkoff.wrl'];
copyfile(h.VRWorldFilename,[tempdir,'vrtkoff.wrl'],'f');
h.VRWorldFilename = [tempdir,'vrtkoff.wrl'];
h.initialize();
load takeoffData
h.Nodes{7}.TimeseriesSource = takeoffData;
h.Nodes{7}.TimeseriesSourceType = 'StructureWithTime';
h.Nodes{7}.CoordTransformFcn = @vranimCustomTransform;
h.updateNodes(5);
```

See Also

`addNode`, `update`

Viewpoint (Aero.Viewpoint)

Purpose

Create viewpoint object for use in virtual reality animation

Syntax

```
h = Aero.Viewpoint
```

Description

`h = Aero.Viewpoint` creates a viewpoint object for use with virtual reality animation.

See `Aero.Viewpoint` for further details.

Purpose

Construct virtual reality animation object

Syntax

`h = Aero.VirtualRealityAnimation`

Description

`h = Aero.VirtualRealityAnimation` constructs a virtual reality animation object. The animation object is returned to `h`.

See `Aero.VirtualRealityAnimation` for further details.

See Also

`Aero.VirtualRealityAnimation`

wrldmagm

Purpose

Use World Magnetic Model

Syntax

```
[xyz, h, dec, dip, f] = wrldmagm(height, lat, lon, dyear)
[xyz, h, dec, dip, f] = wrldmagm(height, lat, lon, dyear,
   '2005')
[xyz, h, dec, dip, f] = wrldmagm(height, lat, lon, dyear,
   '2000')
```

Description

`[xyz, h, dec, dip, f] = wrldmagm(height, lat, lon, dyear)` calculates the Earth's magnetic field at a specific location and time using the World Magnetic Model (WMM). The default WMM is WMM-2005, which is valid from January 1, 2005, until December 31, 2009.

Inputs required by `wrldmagm` are:

`height`	A scalar value, in meters
`lat`	A scalar geodetic latitude, in degrees, where north latitude is positive, and south latitude is negative
`lon`	A scalar geodetic longitude, in degrees, where east longitude is positive, and west longitude is negative
`dyear`	A scalar decimal year. Decimal year is the desired year in a decimal format to include any fraction of the year that has already passed.

Outputs calculated for the Earth's magnetic field include:

`xyz`	Magnetic field vector in nanotesla (nT)
`h`	Horizontal intensity in nanotesla (nT)
`dec`	Declination in degrees

dip	Inclination in degrees
f	Total intensity in nanotesla (nT)

[xyz, h, dec, dip, f] = wrldmagm(height, lat, lon, dyear, '2005') is an alternate method for calling WMM-2005, or 2005 epoch.

[xyz, h, dec, dip, f] = wrldmagm(height, lat, lon, dyear, '2000') is the method for calling WMM-2000, or 2000 epoch.

Examples

Calculate the magnetic model 1000 meters over Natick, Massachusetts on July 4, 2005, using WMM-2005:

```
[XYZ, H, DEC, DIP, F] = wrldmagm(1000, 42.283, -71.35, 2005.5068 )


XYZ =

  1.0e+004 *

    1.8976
   -0.5167
    4.9555


H =

  1.9667e+004


DEC =

  -15.2324


DIP =
```

```
    68.3530


F =

    5.3315e+004
```

Assumptions and Limitations

The WMM specification produces data that is reliable five years after the epoch of the model, which begins January 1 of the model year selected. The WMM specification describes only the long-wavelength spatial magnetic fluctuations due to the Earth's core. Intermediate and short-wavelength fluctuations, contributed from the crustal field (the mantle and crust), are not included. Also, the substantial fluctuations of the geomagnetic field, which occur constantly during magnetic storms and almost constantly in the disturbance field (auroral zones), are not included.

References

`http://www.ngdc.noaa.gov/seg/WMM/DoDWMM.shtml`

"NOAA Technical Report: The US/UK World Magnetic Model for 2005–2010"

See Also

`decyear`

5

Objects — Alphabetical List

Aero.Animation

Purpose

Construct animation object

Syntax

`h = Aero.Animation`

Description

`h = Aero.Animation` constructs an animation object. The animation object is returned to `h`.

Note The `Aero.Animation` constructor does not retain the properties of previously created animation objects, even those that you have saved to a MAT-file. This means that subsequent calls to the animation object constructor always create animation objects with default properties.

The animation object has the following methods and properties:

Constructor Summary

Constructor	Description
`Animation`	Construct animation object.

Method Summary

Method	Description
`addBody`	Add loaded body to animation object and generate its patches.
`createBody`	Create body and its associated patches in animation.
`delete`	Destruct animation object.
`hide`	Hide animation figure.
`initialize`	Create animation figure and axes and build patches for bodies.
`initIfNeeded`	Initialize animation graphics if needed.
`moveBody`	Set new position and attitude of body in animation.

Method	Description
play	Animate loaded geometry for given position and angle in time series data.
removeBody	Remove one body from animation.
show	Show animation figure.
updateBodies	Set new position and attitude of movable items in animation.
updateCamera	Update camera in animation object.

Property Summary

Property	Description	Values
Name	Specify name of the animation object.	string
Figure	Specify name of the figure object.	MATLAB array
FigureCustomi-zationFcn	Specify figure customization function.	MATLAB array
Bodies	Specify the bodies that the animation object contains.	MATLAB array
Camera	Specify the camera that the animation object contains.	handle
TimeScaling	Specify the time, in seconds.	double
TStart	Specify start time.	double
TFinal	Specify end time.	double
TCurrent	Specify current time.	double
FramesPerSecond	Specify rate in frames per second.	MATLAB array

Purpose Create body object for use with animation object

Syntax `h = Aero.Body`

Description `h = Aero.Body` constructs a body for an animation object. The animation object is returned in `h`. To use the Aero.Body object, you typically:

1. Create the animation body.
2. Configure or customize the body object.
3. Load the body.
4. Generate patches for the body (requires an axes from a figure).
5. Set time series data source.
6. Move or update the body.

By default, an Aero.Body object natively uses aircraft *x-y-z* coordinates for the body geometry and the time series data. It expects the rotation order *z-y-x* (psi, theta, phi).

Convert time series data from other coordinate systems on the fly by registering a different `CoordTransformFcn` function.

Constructor Summary

Constructor	Description
`Body`	Construct body object for use with animation object.

Method Summary

Method	Description
`findstartstoptimes`	Return start and stop times of time series data.
`generatePatches`	Generate patches for body with loaded face, vertex, and color data.
`load`	Get geometry data from source.
`move`	Change Aero.Body position and orientation.
`update`	Changes body position and orientation versus time data.

Property Summary

Property	Description	Values
`CoordTransformFcn`	Specify a function that controls the coordinate transformation.	string
`Name`	Specify name of body.	
`Position`	Specify position of body.	MATLAB array
`Rotation`	Specify rotation of body.	MATLAB array
`Geometry`	Specify geometry of body.	handle
`PatchGeneration-Fcn`	Specify patch generation function.	MATLAB array
`PatchHandles`	Specify patch handles.	MATLAB array
`ViewingTransform`	Specify viewing transform.	MATLAB array
`TimeseriesSource`	Specify time series source.	MATLAB array

Property	Description	Values
TimeseriesSource-Type	Specify the type of time series data stored in 'TimeseriesSource'. Five values are available. They are listed in the following table. The default value is 'Array6DoF'.	string
TimeseriesReadFcn	Specify time series read function.	MATLAB array

The time series data, stored in the property 'TimeseriesSource', is interpreted according to the 'TimeseriesSourceType' property, which can be one of:

'Timeseries'	MATLAB time series data with six values per time: lat lon alt phi theta psi The values are resampled.
'StructureWithTime'	Simulink struct with time (Simulink root outport logging 'Structure with time'): • signals(1).values: lat lon alt • signals(2).values: phi theta psi Signals are linearly interpolated vs. time using interp1.

`'Array6DoF'`	A double-precision array in `n` rows and 7 columns for 6-DoF data: `time lat lon alt phi theta psi`. If a double-precision array of 8 or more columns is in `'TimeseriesSource'`, the first 7 columns are used as 6-DoF data.
`'Array3DoF'`	A double-precision array in `n` rows and 4 columns for 3-DoF data: `time lat alt theta`. If a double-precision array of 5 or more columns is in `'TimeseriesSource'`, the first 4 columns are used as 3-DoF data.
`'Custom'`	Position and angle data is retrieved from `'TimeseriesSource'` by the currently registered `'TimeseriesReadFcn'`.

See Also

`Aero.Geometry`

Aero.Camera

Purpose

Construct camera object for use with animation object

Syntax

```
h = Aero.Camera
```

Description

`h = Aero.Camera` constructs a camera object `h` for use with an animation object. The camera object uses the registered coordinate transform. By default, this is an aerospace body coordinate system. Axes of custom coordinate systems must be orthogonal.

By default, an `Aero.Body` object natively uses aircraft *x*-*y*-*z* coordinates for the body geometry and the time series data. Convert time series data from other coordinate systems on the fly by registering a different `CoordTransformFcn` function.

Constructor Summary

Constructor	Description
`Camera`	Construct camera object for use with animation object.

Method Summary

Method	Description
`update`	Update camera position based on time and position of other Aero.Body objects.

Property Summary

Property	Description	Values
`CoordTransformFcn`	Specify a function that controls the coordinate transformation.	MATLAB array
`PositionFcn`	Specify a function that controls the position of a camera relative to an animation body.	MATLAB array
`Position`	Specify position of camera.	MATLAB array `[-150,-50,0]`

Property	Description	Values
Offset	Specify offset of camera.	MATLAB array [-150,-50,0]
AimPoint	Specify aim point of camera.	MATLAB array [0,0,0]
UpVector	Specify up vector of camera.	MATLAB array [0,0,-1]
ViewAngle	Specify view angle of camera.	MATLAB array {3}
ViewExtent	Specify view extent of camera.	MATLAB array {[-50,50]}
xlim	Specify *x*-axis limit of camera.	MATLAB array {[-50,50]}
ylim	Specify *y*-axis limit of camera.	MATLAB array {[-50,50]}
zlim	Specify *z*-axis limit of camera.	MATLAB array {[-50,50]}
PrevTime	Specify previous time of camera.	MATLAB array {0}
UserData	Specify custom data.	MATLAB array {[]}

See Also

`Aero.Geometry`

Aero.FlightGearAnimation

Purpose

Construct FlightGear animation object

Syntax

```
h = Aero.FlightGearAnimation
```

Description

`h = Aero.FlightGearAnimation` constructs a FlightGear animation object. The FlightGear animation object is returned to `h`.

Constructor

Method	Description
`fganimation`	Construct FlightGear animation object.

Method Summary

Method	Description
`delete`	Destroy FlightGear animation object.
`initialize`	Set up FlightGear animation object.
`play`	Animate FlightGear flight simulator using given position/angle time series.
`update`	Update position data to FlightGear animation object.

Property Summary

Properties	Description
`TimeseriesSource`	Specify variable that contains the time series data.
`TimeseriesSource-Type`	Specify the type of time series data stored in `'TimeseriesSource'`. Five values are available. They are listed in the following table. The default value is `'Array6DoF'`.
`TimeseriesReadFcn`	Specify a function to read the time series data if `'TimeseriesSourceType'` is `'Custom'`.
`TimeScaling`	Specify the seconds of animation data per second of wall-clock time. The default ratio is `1`.

Properties	Description
FramesPerSecond	Specify the number of frames per second used to animate the 'TimeseriesSource'. The default value is 12 frames per second.
FlightGearVersion	Select your FlightGear software version: '0.9.3', '0.9.8', '0.9.9', or '0.9.10'. The default version is '0.9.10'.
OutputFileName	Specify the name of the output file. The file name is the name of the command you will use to start FlightGear with these initial parameters. The default value is 'runfg.bat'.
FlightGearBase-Directory	Specify the name of your FlightGear installation directory. The default value is 'D:\Applications\FlightGear'.
GeometryModelName	Specify the name of the folder containing the desired model geometry in the *FlightGear*\data\Aircraft directory. The default value is 'HL20'.
DestinationIp-Address	Specify your destination IP address. The default value is '127.0.0.1'.
DestinationPort	Specify your network flight dynamics model (fdm) port. This destination port should be an unused port that you can use when you launch FlightGear. The default value is '5502'.
AirportId	Specify the airport ID. The list of supported airports is available in the FlightGear interface, under **Location**. The default value is 'KSFO'.
RunwayId	Specify the runway ID. The default value is '10L'.
InitialAltitude	Specify the initial altitude of the aircraft, in feet. The default value is 7224 feet.

Properties	Description
`InitialHeading`	Specify the initial heading of the aircraft, in degrees. The default value is `113` degrees.
`OffsetDistance`	Specify the offset distance of the aircraft from the airport, in miles. The default value is `4.72` miles.
`OffsetAzimuth`	Specify the offset azimuth of the aircraft, in degrees. The default value is `0` degrees.

The time series data, stored in the property `'TimeseriesSource'`, is interpreted according to the `'TimeseriesSourceType'` property, which can be one of:

`'Timeseries'`	MATLAB time series data with six values per time: `lat lon alt phi theta psi` The values are resampled.
`'StructureWithTime'`	Simulink struct with time (Simulink root outport logging `'Structure with time'`): • `signals(1).values:  lat lon alt` • `signals(2).values:  phi theta psi` Signals are linearly interpolated vs. time using `interp1`.

`'Array6DoF'`	A double-precision array in `n` rows and 7 columns for 6-DoF data: `time lat lon alt phi theta psi`. If a double-precision array of 8 or more columns is in `'TimeseriesSource'`, the first 7 columns are used as 6-DoF data.
`'Array3DoF'`	A double-precision array in `n` rows and 4 columns for 3-DoF data: `time lat alt theta`. If a double-precision array of 5 or more columns is in `'TimeseriesSource'`, the first 4 columns are used as 3-DoF data.
`'Custom'`	Position and angle data is retrieved from `'TimeseriesSource'` by the currently registered `'TimeseriesReadFcn'`.

Examples

Construct a FlightGear animation object, `h`:

```
h = fganimation
```

See Also

`fganimation`, `generaterunscript`, `play`

Aero.Geometry

Purpose

Construct 3-D geometry for use with animation object

Syntax

```
h = Aero.Geometry
```

Description

`h = Aero.Geometry` defines a 3-D geometry for use with an animation object.

This object supports the attachment of transparency data from an Ac3d file to patch generation.

Constructor Summary

Constructor	Description
`Geometry`	Construct 3-D geometry for use with animation object.

Method Summary

Method	Description
`read`	Read geometry data using current reader.

Property Summary

Property	Description	Values
`Name`	Specify name of geometry.	string
`Source`	Specify geometry data source.	string {['Auto'], 'Variable', 'MatFile', 'Ac3dFile', 'Custom'}
`Reader`	Specify geometry reader.	MATLAB array
`FaceVertexColor-Data`	Specify the color of the geometry face vertex.	MATLAB array

See Also

`read`

Purpose

Create node object for use with virtual reality animation

Syntax

```
h = Aero.Node
```

Description

`h = Aero.Node` creates a node object for use with virtual reality animation. Typically, you do not need to create a node object with this method. This is because the `.wrl` file stores the information for a virtual reality scene. During the initialization of the virtual reality animation object, any node with a `DEF` statement in the specified `.wrl` file has a node object created.

Constructor Summary

Constructor	Description
`Node`	Create node object for use with virtual reality animation.

Method Summary

Method	Description
`findstart-stoptimes`	Return start and stop times for time series data.
`move`	Change node translation and rotation.
`update`	Change node position and orientation versus time data.

Property Summary

Property	Description	Values
`Name`	Specify name of the node object.	string

Property	Description	Values
VRNode	Return the handle to the vrnode object associated with the node object (see the *Virtual Reality Toolbox User's Guide*).	MATLAB array
CoordtransformFcn	Specify a function that controls the coordinate transformation.	MATLAB array
TimeseriesSource	Specify time series source.	MATLAB array
Timeseries-SourceType	Specify the type of time series data stored in 'TimeseriesSource'. Five values are available. They are listed in the following table. The default value is 'Array6DoF'.	string
Timeseries-ReadFcn	Specify time series read function.	MATLAB array

The time series data, stored in the property 'TimeseriesSource', is interpreted according to the 'TimeseriesSourceType' property, which can be one of:

`'Timeseries'`	MATLAB time series data with six values per time: `lat lon alt phi theta psi` The values are resampled.
`'StructureWithTime'`	Simulink struct with time (Simulink root outport logging `'Structure with time'`): • `signals(1).values: lat lon alt` • `signals(2).values: phi theta psi` Signals are linearly interpolated vs. time using `interp1`.
`'Array6DoF'`	A double-precision array in `n` rows and 7 columns for 6-DoF data: `time lat lon alt phi theta psi`. If a double-precision array of 8 or more columns is in `'TimeseriesSource'`, the first 7 columns are used as 6-DoF data.
`'Array3DoF'`	A double-precision array in `n` rows and 4 columns for 3-DoF data: `time lat alt theta`. If a double-precision array of 5 or more columns is in `'TimeseriesSource'`, the first 4 columns are used as 3-DoF data.
`'Custom'`	Position and angle data is retrieved from `'TimeseriesSource'` by the currently registered `'TimeseriesReadFcn'`.

Aero.Viewpoint

Purpose

Create viewpoint object for use in virtual reality animation

Syntax

```
h = Aero.Viewpoint
```

Description

`h = Aero.Viewpoint` creates a viewpoint object for use with virtual reality animation.

Constructor Summary

Constructor	Description
`Viewpoint`	Create node object for use with virtual reality animation.

Property Summary

Property	Description	Values
`Name`	Specify name of the node object.	string
`Node`	Specify node object that contains the viewpoint node.	MATLAB array

Purpose

Construct virtual reality animation object

Syntax

```
h = Aero.VirtualRealityAnimation
```

Description

`h = Aero.VirtualRealityAnimation` constructs a virtual reality animation object. The animation object is returned to `h`.

The animation object has the following methods and properties.

Constructor Summary

Constructor	Description
`VirtualReality-Animation`	Construct virtual reality animation object.

Method Summary

Method	Description
`addNode`	Add existing node to current virtual reality world.
`addRoute`	Add VRML ROUTE statement to virtual reality animation.
`addViewpoint`	Add viewpoint for virtual reality animation.
`delete`	Destroy virtual reality animation object.
`initialize`	Create and populate virtual reality animation object.
`nodeInfo`	Create list of nodes associated with virtual reality animation object.
`play`	Animate virtual reality world for given position and angle in time series data.
`removeNode`	Remove node from virtual reality animation object.
`removeViewpoint`	Remove viewpoint node from virtual reality animation.

Method	Description
`saveas`	Save virtual reality world associated with virtual reality animation object.
`updateNodes`	Set new translation and rotation of moveable items in virtual reality animation.

Notes on Aero.VirtualRealityAnimation Methods

Aero.VirtualRealityAnimation methods that change the current virtual reality world use a temporary `.wrl` file to manage those changes. These methods include:

- `addNode`
- `removeNode`
- `addViewpoint`
- `removeViewpoint`
- `addRoute`

Be aware of the following behavior:

- After the methods make the changes, they reinitialize the world, using the information stored in the temporary `.wrl` file.
- When you delete the virtual reality animation object, this action deletes the temporary file.
- Use the `saveas` method to save the temporary `.wrl` file.
- These methods do not affect user-created `.wrl` files.

Property Summary

Property	Description	Values
`Name`	Specify name of the animation object.	string

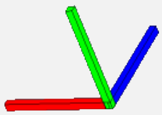
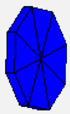
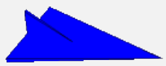
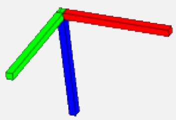
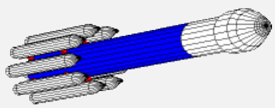
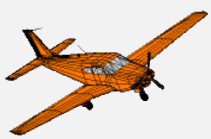
Property	Description	Values
VRWorld	Returns the vrworld object associated with the animation object.	MATLAB array
VRWorldFilename	Specify the .wrl file for the vrworld.	string
VRWorld-OldFilename	Specify the old .wrl files for the vrworld.	MATLAB array
VRWorld-TempFilename	Specify the temporary .wrl file for the animation object.	string
VRFigure	Returns the vrfigure object associated with the animation object.	MATLAB array
Nodes	Specify the nodes that the animation object contains.	MATLAB array
Viewpoints	Specify the viewpoints that the animation object contains.	MATLAB array
TimeScaling	Specify the time scaling, in seconds.	double
Tstart	Specify the time, in seconds.	double
TFinal	Specify end time, in seconds.	double
TCurrent	Specify current time, in seconds.	double

Property	Description	Values
`FramesPerSecond`	Specify rate, in frames per second.	double
`ShowSaveWarning`	Specify save warning display setting.	double

AC3D Files and Thumbnails

Overview

Aerospace Toolbox demos use the following AC3D files, located in the *matlabroot*\toolbox\aero\astdemos directory.

Thumbnail	AC3D File
	ac3d_xyzisrgb.ac
	blueoctagon.ac
	bluewedge.ac
	body_xyzisrgb.ac
	delta2.ac
	greenarrow.ac
	pa24 250_blue.ac
	pa24 250_orange.ac

Thumbnail	AC3D File
	redwedge.ac
	testrocket.ac

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