Graphics Display of Satellite Ground Tracks, Orbits and Maps

This document describes two MATLAB scripts that demonstrate how to graphically display satellite ground tracks, orbits and maps. The second script demonstrates how to read and display the MicroWorld Database II binary data files.

satplot.m – graphics display of satellite orbits

This MATLAB script can be used to create the following types of graphic displays:

- ground track – rectangular display
- orbit and/or ground track – orthographic display
- site-to-satellite visibility – azimuth/elevation polar plot
- site-to-satellite visibility – rectangular display
- site-to-satellite visibility – orthographic display

This script can propagate a satellite orbit using either Kozai's analytic method or numerical integration. The numerical integration option is "hardwired" for J_2 equations of motion but can easily be changed to other forms of orbital differential equations.

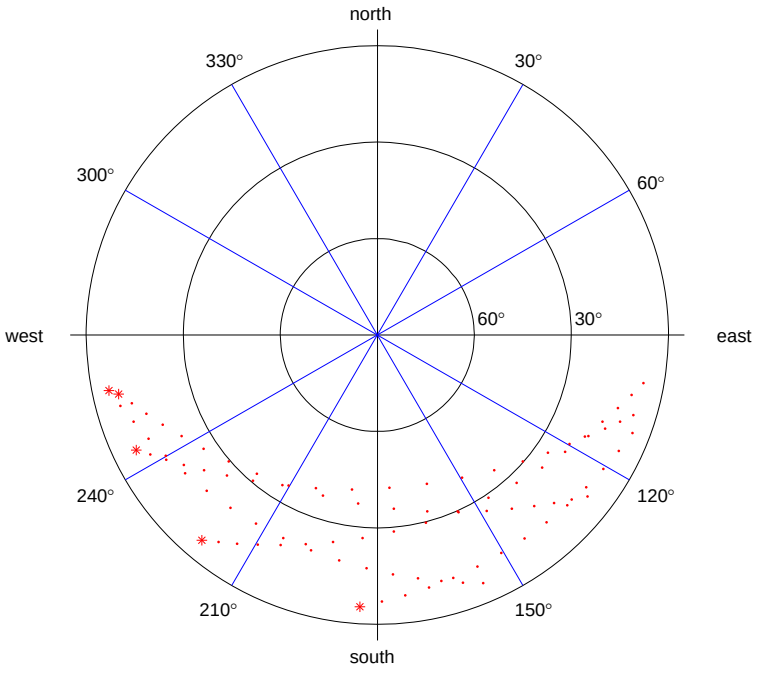
The following is a typical user interaction with this program.

```
                program satplot

  graphics display of ground tracks and orbits


please input the calendar date
(1 <= month <= 12, 1 <= day <= 31, year = all digits!)
? 1,1,1998

please input the universal time
(0 <= hours <= 24, 0 <= minutes <= 60, 0 <= seconds <= 60)
? 0,0,0


classical orbital elements

please input the semimajor axis (kilometers)
(semimajor axis > 0)
? 8000

please input the orbital eccentricity (non-dimensional)
(0 <= eccentricity < 1)
? 0

please input the orbital inclination (degrees)
(0 <= inclination <= 180)
? 28.5
```

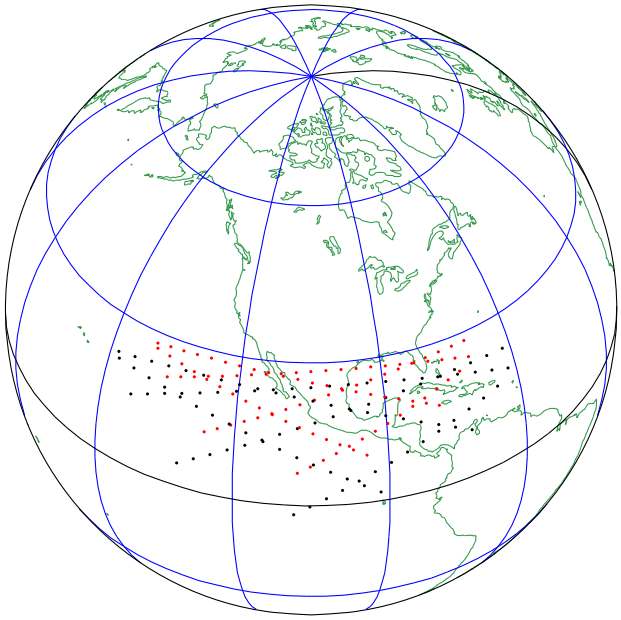
```
please input the right ascension of the ascending node (degrees)
(0 <= raan <= 360)
? 100

please input the true anomaly (degrees)
(0 <= true anomaly <= 360)
? 0

     orbit propagation menu

  <1> Kozai method

  <2> numerical integration

 selection? 2


        satplot graphics menu

  <1> ground track - rectangular display

  <2> orbit and/or ground track - orthographic display

  <3> site-to-sat visibility - azimuth/elevation polar plot

  <4> site-to-sat visibility - rectangular display

  <5> site-to-sat visibility - orthographic display

 selection? 3


would you like to enforce a minimum elevation angle constraint
(y = yes, n = no)
? y

please input the minimum elevation angle constraint in degrees
(0 <= constraint <= +90)
? 5


observer coordinates

please input the geographic latitude of the ground site
(-90 <= degrees <= +90, 0 <= minutes <= 60, 0 <= seconds <= 60)
(north latitude is positive, south latitude is negative)
? 40,0,0

please input the geographic longitude of the ground site
(0 <= degrees <= 360, 0 <= minutes <= 60, 0 <= seconds <= 60)
(east longitude is positive, west longitude is negative)
? -105,0,0

please input the altitude of the ground site (meters)
(positive above sea level, negative below sea level)
? 0
```

```
please input the simulation duration in days
? 1


please input the step size in minutes
? 1
```

The following is a typical azimuth/elevation graphic display created with this script. Rise conditions are marked with as asterisk.



The following is a typical plot created with the `site-to-sat visibility - orthographic display` option of this script. The ground track is red and the orbit during visibility is black.



This MATLAB script calls a support function that creates an orthographic display of the world with a coastline map. This function allows the user to select the map viewpoint and the latitude and longitude grid spacing.

The syntax of this function is

```
function plotmap2(vplat, vplong, dlat, dlong)

% plot orthographic world map

% input

%  vplat  = viewpoint latitude (degrees)
%           (-90 <= vplat <= 90)
%  vplong = viewpoint longitude (degrees)
%           (-180 <= vplong <= 180)
%  dlat   = latitude grid spacing (degrees)
%           (0 <= dlat <= 90)
%  dlong  = longitude grid spacing (degrees)
%           (0 <= dlong <= 360)
```

This script also calls a MATLAB function called `polarplt.m` which plots and labels a polar plot. This function has no calling arguments. The MATLAB function that creates the rectangular display is called `plotmap1.m`. It too has no calling arguments.

This MATLAB script uses two low-resolution map files for graphics. The file used for the rectangular display option is called `gmapll.dat` and includes latitude-longitude data pairs. The following is the first part of this data file. The two integers define the starting and ending indices of individual geographic coastline features within the file.

```
1             513
   -84.3333  -178.0000
   -84.4999  -174.0000
   -84.6668  -170.0000
   -84.9167  -166.0000
   -85.4165  -163.0000
   -85.4165  -158.0000
   -85.5830  -152.0000
   -85.3334  -146.0000
   -84.8333  -147.0000
   -84.4999  -151.0000
   -84.0000  -153.5000
   -83.5001  -153.0000
   -82.9999  -153.9999
   -82.5001  -154.0000
   -81.9999  -154.0000
   -81.5000  -154.5001
   -81.1666  -153.0001
   -80.9999  -150.0000
   -80.9168  -146.4999
   -80.6668  -145.5000
```

The orthographic display options of this script use a map file called `xyzmap.dat` which includes Earth-centered-fixed (ECF) *unit position vectors* of the coastlines.

The following is the first part of this data file. The two integers define the starting and ending indices of each geographic coastline within the file.

```
1  513
-9.868201E-02  -3.446028E-03  -.9951131
-.0953229  -.0100188  -.995396
-9.153587E-02  -1.614028E-02  -.995671
-8.597109E-02  -2.143502E-02  -.996067
-7.641932E-02  -2.336368E-02  -.996802
-7.409222E-02  -2.993519E-02  -.996802
-6.799931E-02  -3.615589E-02  -.99703
-.0674483  -4.549439E-02  -.996685
-7.552496E-02  -4.904645E-02  -.9959369
-8.383052E-02  -.046468  -.995396
-9.354573E-02  -4.664019E-02  -.9945219
-.1008639  -5.139264E-02  -.993572
-.1095365  -5.342475E-02  -.992546
-.1173149  -5.721841E-02  -.9914451
-.1250889  -6.100987E-02  -.9902679
-.1334101  -.0636331  -.9890159
```

demo_mwdb.m – read and display MicroWorld Database map files

This MATLAB script demonstrates how to read and display the MicroWorld Database binary map files. These map files with different levels of resolution can be downloaded from the *Orbital Mechanics with MATLAB* web site.

The map features that can be plotted using this utility are defined in the code by setting *integer flags* as follows:

```
% define plot features
% (set to 1 to activate);

allfeatures = 0;

coastlines = 1;

countries = 0;

states = 0;

islands = 1;

lakes = 0;

rivers = 0;
```

The following is a simple rectangular latitude/longitude plot created with this script.