

## Coverage Characteristics of Satellite Constellations

This *Numerit* program (`coverag2`) can be used to assess the partial coverage performance of Walker and user-defined satellite constellations. The user can specify the total simulation time and a single geographic target, and the software will determine such coverage statistics as minimum, average, and maximum coverage time, and so forth. The user can also specify a minimum elevation angle constraint or "mask" at the target or ground site. During the simulation satellite orbits are propagated using Kozai's method and the Earth is modeled as an oblate spheroid.

This software will read simple ASCII data files that define the simulation. The following is a typical data file (`constell.dat`) that simulates a user-defined constellation and ground site. This constellation consists of six satellites and the order of the orbital elements data is semimajor axis, eccentricity, orbital inclination, argument of perigee, east longitude of the ascending node and mean anomaly.

```
number of satellites
6

initial orbital elements - satellite #1
6865.85585
0.0
39.0
0.0
348.17
0.0

initial orbital elements - satellite #2
6865.85585
0.0
39.0
0.0
22.83
201.21

initial orbital elements - satellite #3
6865.85585
0.0
39.0
0.0
57.5
42.42

initial orbital elements - satellite #4
6865.85585
0.0
39.0
0.0
168.57
180.0

initial orbital elements - satellite #5
6865.85585
0.0
```

## Orbital Mechanics with Numerit

```
39.0
0.0
203.23
21.21

initial orbital elements - satellite #6
6865.85585
0.0
39.0
0.0
237.9
222.42

ground site latitude (degrees)
30.0

ground site longitude (degrees)
0.0

ground site altitude (meters)
0.0

minimum elevation angle constraint (degrees)
5.0

simulation duration (days)
1.0
```

Walker constellations use the  $T/P/F$  method to define the constellation geometry. In this method  $T$  is the total number of satellites,  $P$  is the total number of orbit planes and  $F$  is the phasing unit. A Walker constellation has the following orbital characteristics

- $T$  satellites are equally divided among  $P$  orbital planes
- $P$  orbital planes are equally spaced in RAAN
- Satellites within an orbital plane are equally spaced in argument of latitude
- The phasing or mean anomaly difference between satellites in adjacent orbital planes is  $F \times 360^\circ / T$

The following is a typical Walker constellation data file (walker1.dat).

```
Walker T/P/F configuration
7,7,4

constellation semimajor axis (kilometers)
6865.222

constellation inclination (degrees)
38.0

ground site latitude (degrees)
30.0

ground site longitude (degrees)
240.0

ground site altitude (meters)
```

## Orbital Mechanics with Numerit

```
100.0

minimum elevation angle constraint (degrees)
5.0

simulation duration (days)
1.0
```

The following is a typical draft display created with this computer program. It illustrates the performance of a Walker 7/7/4 constellation relative to a ground site at 30° north latitude and 240° east longitude. For Walker constellations the software calculates and displays the east longitude of the ascending node and mean anomaly of each satellite.

```
program coverag2

< analysis of partial coverage constellations >

'constellation mean orbital elements

semimajor axis          6865.222 kilometers
inclination             38 degrees

satellite               east longitude of          mean anomaly
number                 ascending node (deg)      (degrees)

  1                     0                0                205.7142857
  2                    51.42857143          205.7142857
  3                    102.8571429         51.42857143
  4                    154.2857143         257.1428571
  5                    205.7142857         102.8571429
  6                    257.1428571         308.5714286
  7                    308.5714286         154.2857143

coverage statistics

target latitude         30 degrees
target east longitude   240 degrees
target altitude         100 meters

minimum elevation angle 5 degrees

total number of accesses 45

minimum coverage time   3.297437241 minutes
average coverage time   8.487977896 minutes
maximum coverage time   9.586443545 minutes
total coverage time     381.9590053 minutes

total number of gaps    46

minimum gap time        1.56397046 minutes
average gap time         23.00089119 minutes
maximum gap time         29.84184316 minutes
total gap time           1058.040995 minutes

total simulation time    1 days
```