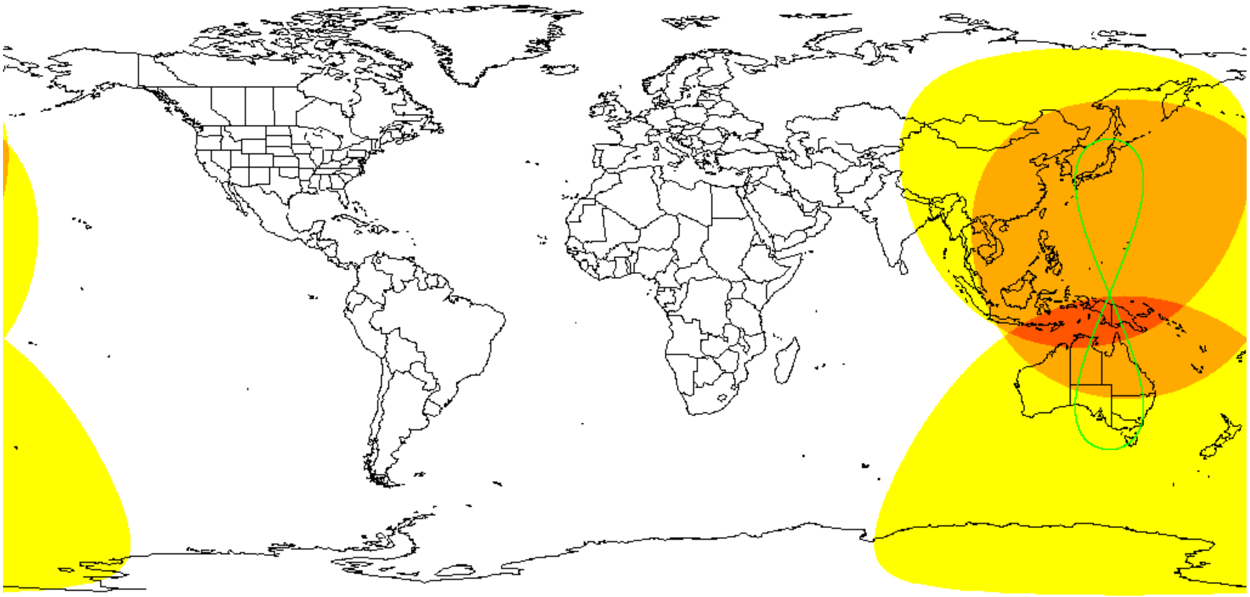
SaVi - satellite constellation visualization

SOLUTIONS TO EXERCISES

1. Quasi-geostationary Japanese system



Starting with the suggested Clarke geostationary script gives the three satellites needed, at the right altitude. Running the simulation continuously as you edit parameters of each satellite in the Edit box (by double-clicking on each satellite parameter line) allows you to immediately see the effects of changes.

Japan is at approximately 140 degrees East, so we know that the longitude of the ascending node for at least one satellite is likely to be 140 degrees. So we change the longitude for each satellite to 140 degrees, so that they overlap. A high terminal mask angle is needed for high-frequency broadband service, and is hinted at by the coverage screenshot and the exercise instructions, so raise that to 40 degrees. The satellites require inclined orbits, so increase the inclination to 45 degrees. The three satellites are now in the same place, forming a figure of eight (as shown by turning on 'record groundtracks' after asking to project forwards 24 hours in the coverage panel). The satellites just have to be spaced around the orbit so that they follow each other rather than being superimposed.

We now need to separate the satellites and space them around their new orbit, so that they follow each other and fill in coverage. We begin by altering the time to periapsis. Although the orbits are circular and there is no perigee low point in altitude, the time to periapsis indicates where in the orbit the satellite is. The period of a geosynchronous orbit is a day, so we need to space the satellites equally around 24 hours (a sidereal day is slightly less, but we can take 24 hours as an approximatrion, and adjust for the exact time later). 24 hours is 86400 minutes; dividing by 3 gives us 28800. So we need to space the satellites at 0, 28800 and 57600 seconds around their orbits, and we enter these values in the 'time to periapsis' box at the bottom of the Edit box for each satellite. The satellites are now crossing the Equator at different times – but they're spaced around the Earth again.

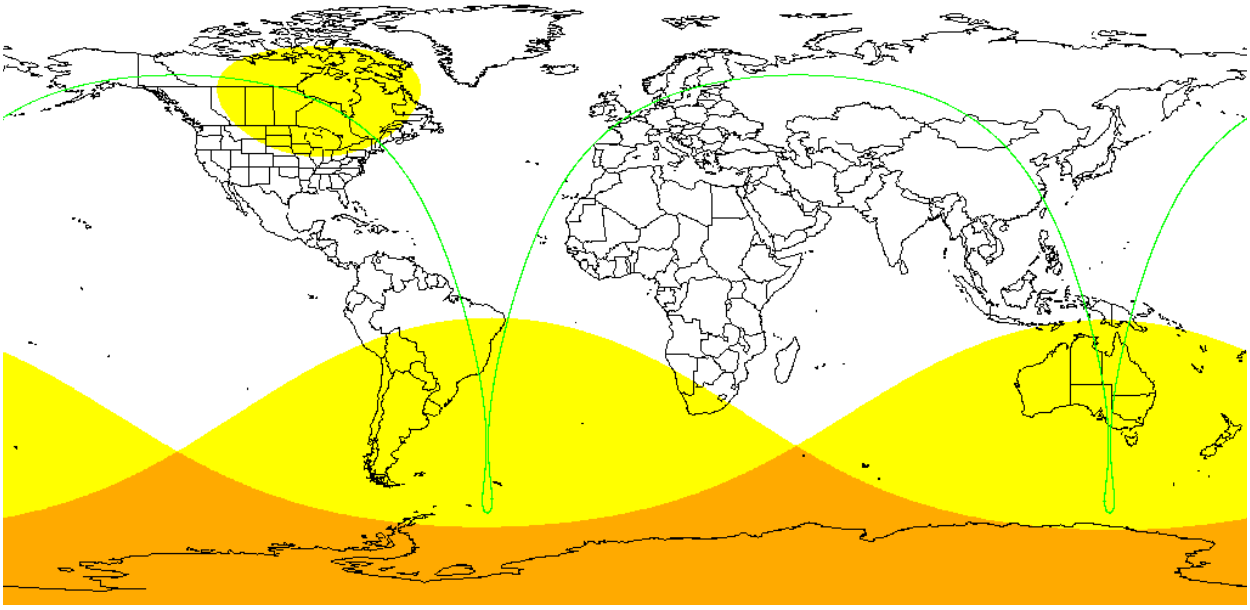
To move the satellites back over Japan, we space out the longitudes of ascending nodes again; 360/3 = 120. 140 – 120 = 20; 140 + 120 = 260 degrees.
So we enter these values in the longitude of ascending node box for each satellite. Once the right angle is matched to the right time to periapsis, the constellation coverage will circle in the figure eight over Japan.

The longitudes can all be tweaked westwards to give better coverage of East Asis, or eastwards so that New Zealand is fully covered in the Southern Hemisphere. Another five similar sets of satellites can be spaced around the world to give global coverage. This is discussed by Tarik Taleb in his papers; See chapter 6 of T. Taleb, Internetworking over Next-Generation NGEO/IP-based Satellite Communications Systems, PhD thesis, Tohoku University, August 2005.
http://www.nemoto.ecei.tohoku.ac.jp/%7Etaleb/Library/phd_thesis.pdf

Clicking on Japan and bringing up the fisheye window and clicking 'Enter new coordinates' will show that the satellites are high in the sky, with one satellite arriving at apogee as the previous satellite leaves. This is higher in the sky and gives better coverage than a satellite in geostationary orbit, which is 45 degrees above the horizon at best.

A script simulating this quasi-geostationary system and the introduction to *SaVi* have now been added to *SaVi* development releases, and will be packaged with *SaVi* in the next *SaVi* release.

2. Molnya in the southern hemisphere



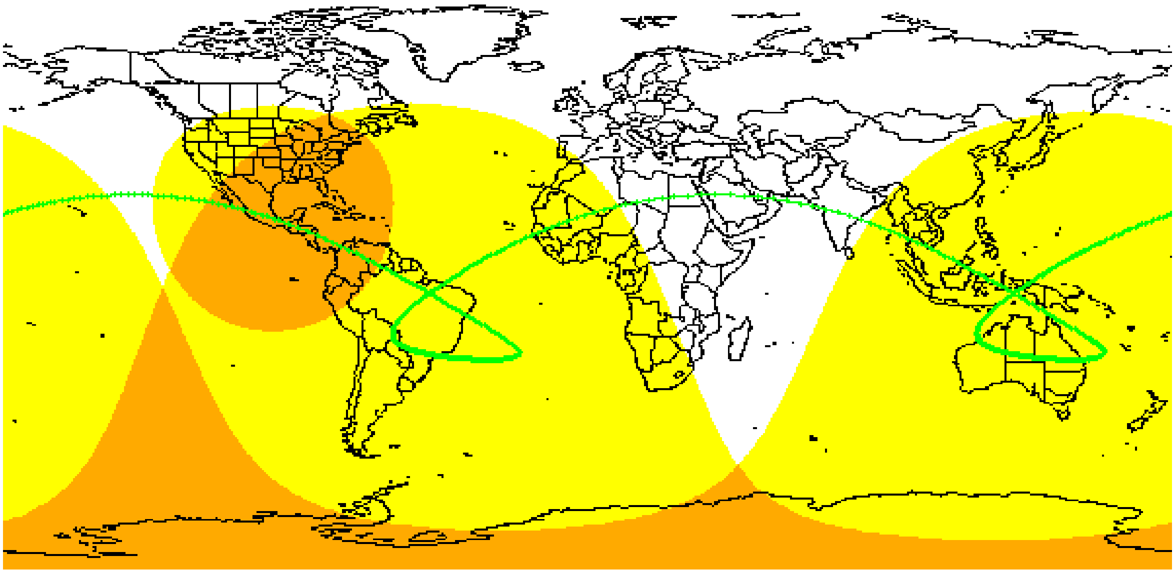
Those comfortable with programming will simply read the Molnya script in *SaVi*'s `data/` directory, and see the comments:

```
# inclination must be  63.435 (stationary apogee in northern hemisphere)
#                   or -63.435 (stationary apogee in southern hemisphere)
```

…which is a very useful hint. Once the inclination is changed, projecting forwards 8 hours and then turning on 'Record ground tracks' in the coverage panel will show you an inverted Molnya.

The longitudes of the ascending nodes of the satellites must be altered to move one apogee point over Australia; spacing around 140 degrees works, so again we enter 20/140/260 degrees for the three satellies, in the right order.

The apogee of the inverted Molnya shown is actually about as far south of Australia as geostationary orbit is north; using both Molnya and a geostationary satellite together here could give diversity of coverage here. We can get higher elevation and better visibility in the fisheye view for terminals in Australia by dropping the inclination to -25 degrees to get a larger loop over Australia, where the satellite apogee path passes over the middle of Australia.



Inverted Molnya adjusted to -25 degree inclination.

Molnya and Tundra orbits are described in detail in ch. 7 of Maral and Bousquet's *Satellite Communication Systems* – copies of this book are held in the library.

Have fun playing with *SaVi*!

Further information at:
http://savi.sf.net/

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