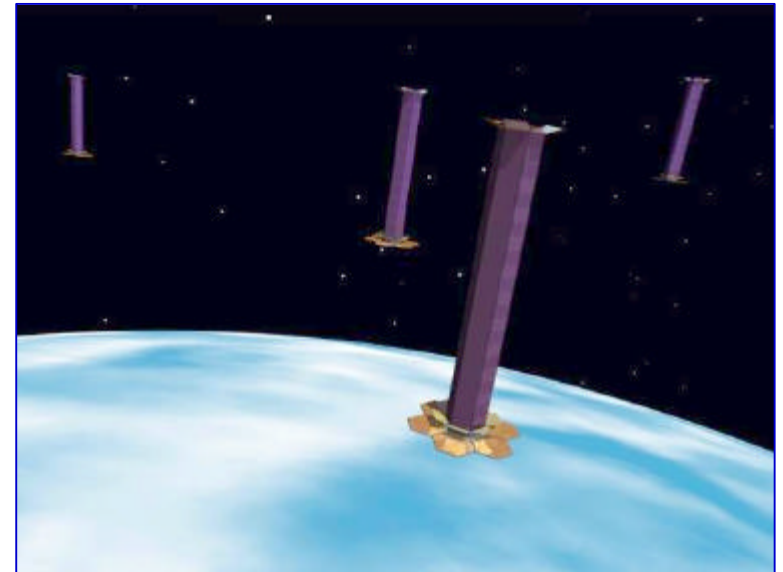


# Techsat 21



- To explore the technologies required to enable a Distributed Satellite System
- Sparse Aperture Space Based Radar
- Full operational system of 35 clusters of 8 satellites to provide global coverage
- 2003 Flight experiment with 3 spacecraft
- Spacecraft will be equipped with PPTs
  - 2 large PPTs for orbit raising and de-orbit
  - 10 micro-PPTs for full three-axis control



## Techsat 21 Flight Experiment

Number of Spacecraft	: 3
Spacecraft Mass	: 129.4 kg
Cluster Size	: 500 m
Orbital Altitude	: 600 km
Orbital Period	: 84 mins
Geo-location size	: 5000 m

\* Figure courtesy of AFOSR Techsat21  
Research Review (29 Feb - 1 Mar 2000)

# Equations of Motions

- First order perturbation about natural circular Keplerian orbit
- Hill's Equations:

$$a_x \approx x - 3n^2 x - 2ny$$

$$a_y \approx y - 2nx$$

$$a_z \approx z - n^2 z$$

- Homogenous Solution:

$$x \approx A_0 \cos(nt) + x_{offset}$$

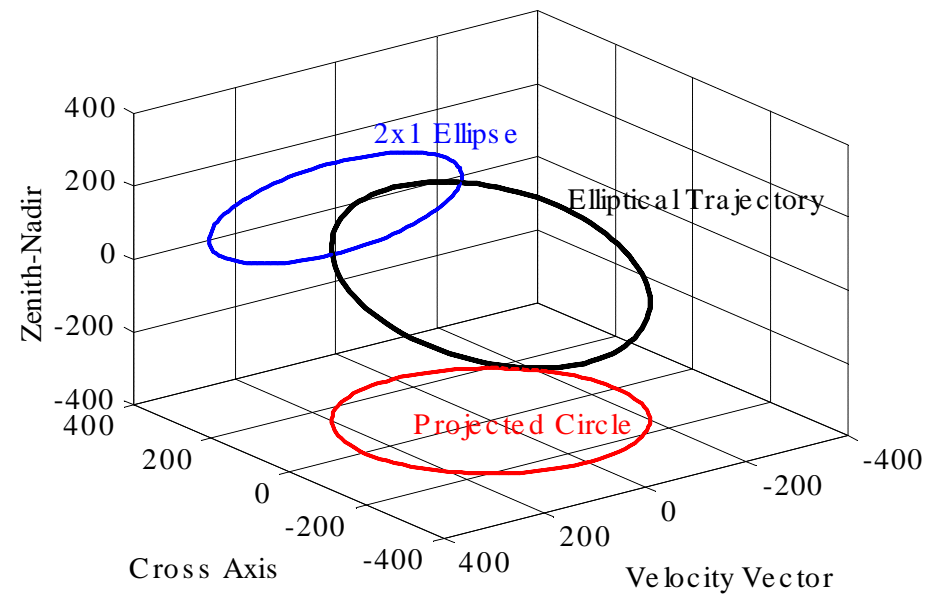
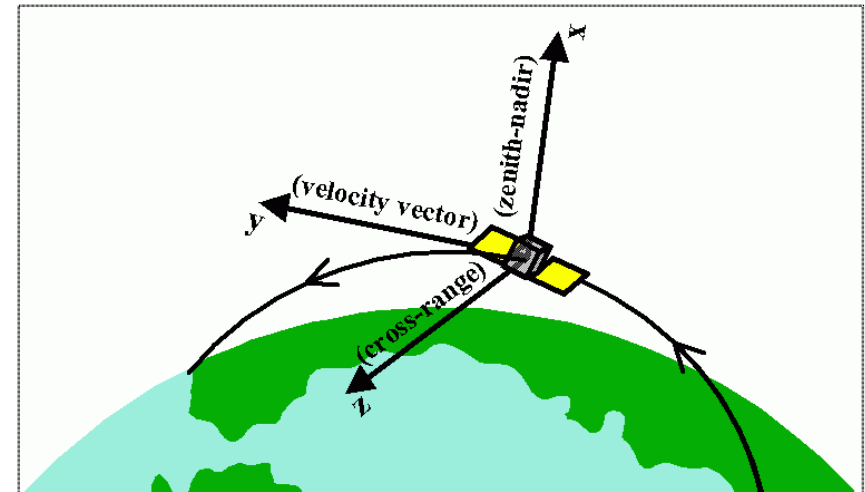
$$y \approx 2A_0 \sin(nt) + \frac{3}{2}nx_{offset} + y_{offset}$$

$$z \approx B_0 \cos(nt)$$

- Techsat 21 operational trajectory

$$B_0 = 2A_0,$$

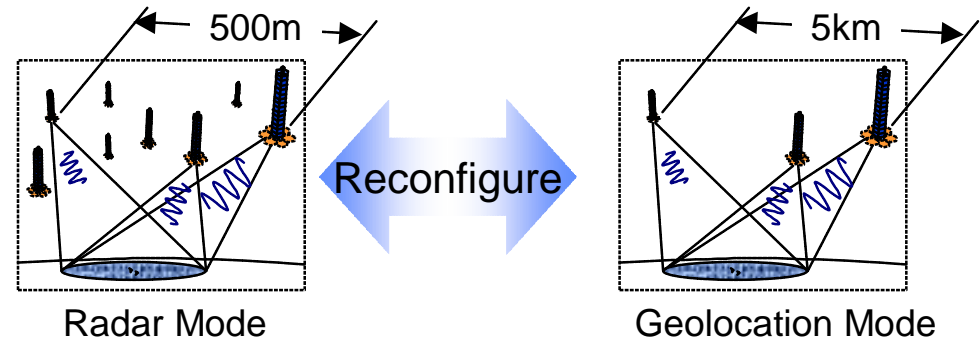
$$x_{offset} = y_{offset} = z_{offset} = 0$$



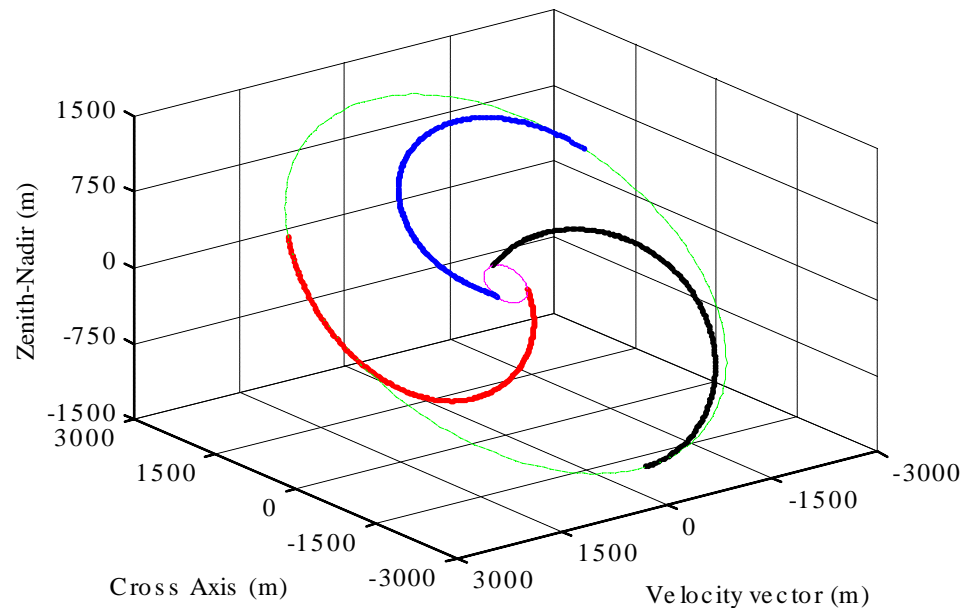


# Cluster Re-sizing (1)

- Objective of Techsat 21 Geo-location mission is to provide 10-50 m geo-location accuracy
- Geo-location accuracy is inversely proportional to size of cluster
- Re-size cluster to an elliptical trajectory of 2.5 km to achieve approximately 10 m ground resolution
- Example application is to quickly locate a lost pilot (Time critical mission)



\* Figure courtesy of AFOSR Techsat21 Research Review (29 Feb - 1 Mar 2000)

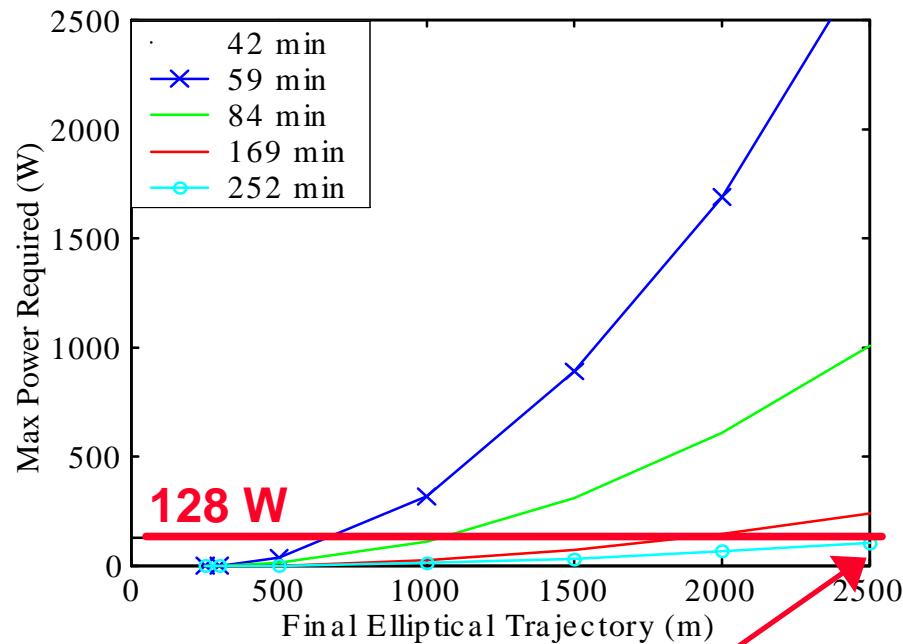


**Optimal Cluster Re-sizing**



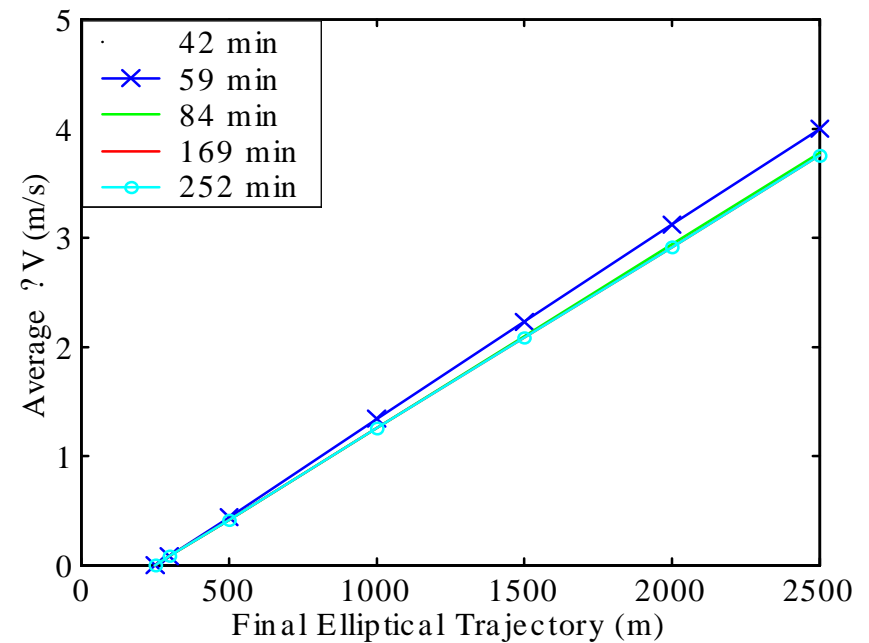
# Cluster Re-sizing (2)

### Maximum Power Required For Geo-location



- **Minimum re-sizing time of 3 periods (252 mins) is required for Techsat 21 geo-location**

### Corresponding $\Delta V$ Required For Geo-location

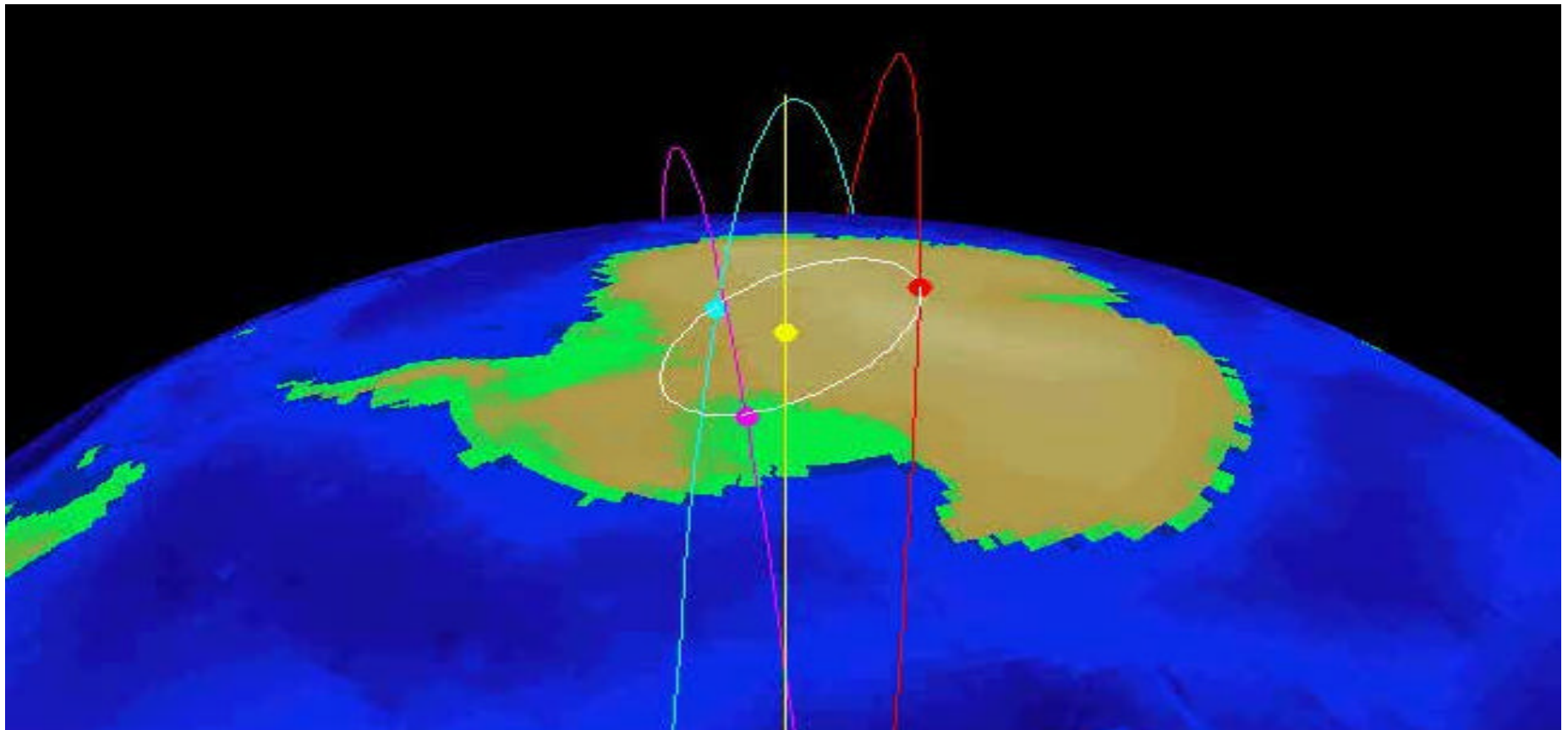


- **Minimal  $\Delta V$  savings in increasing re-sizing times beyond 1 period (84 mins)**

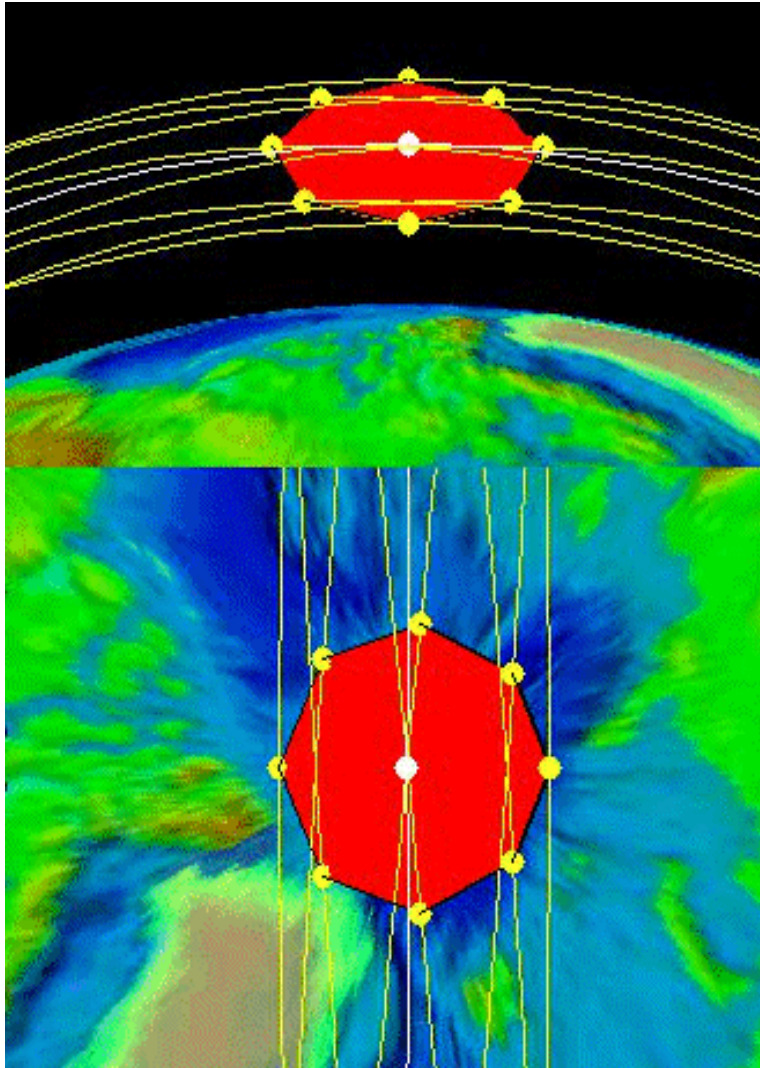
# ***Formation Flying and $J_2$ disturbances***



Currently, SSL is deriving new linearized equations of motion that accurately describe the motion of satellites in a cluster.



# Modeling the Dynamics



- Linearized equations of motion are needed to develop optimal control routines.
- Current linearized equations (Hill's equations) do not capture the effect of the  $J_2$  disturbance.
- New equations developed here in the Space Systems Lab, capture the effects of the  $J_2$  disturbance including:
  - Tumbling of the cluster
  - Differential drift in the longitude of the ascending node
  - New initial starting conditions