ASEN 5070
Statistical Orbit determination I
Fall 2012

Professor George H. Born
Professor Jeffrey S. Parker

Lecture 6: Launches and Spaceflight Ops

Announcements

- Homework 2 due Today
- Homework 3 due next week
- Atlas 5 Launch!

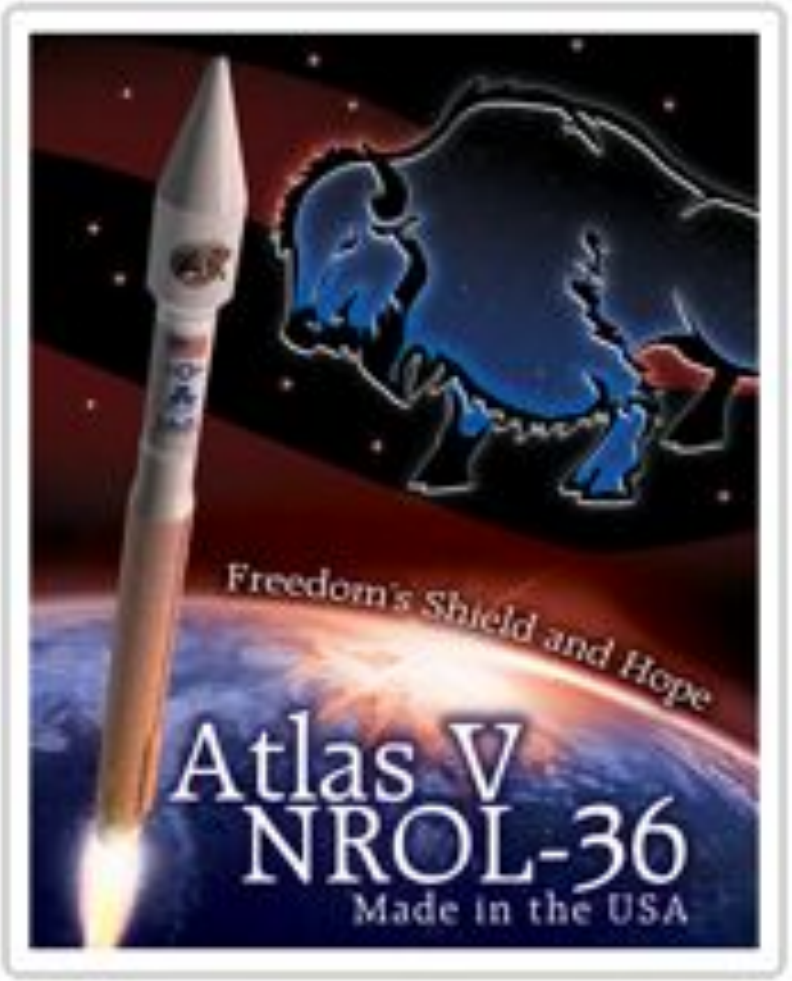
Quick Plan

- Plan: watch Atlas V launch
- Discuss where Stat OD comes in
- Talk about Spaceflight Ops

- Return to Quiz results, statistics, etc ☺

Atlas V launch

- Spaceflight Now
- 3:39pm launch time



Tracking a launch vehicle

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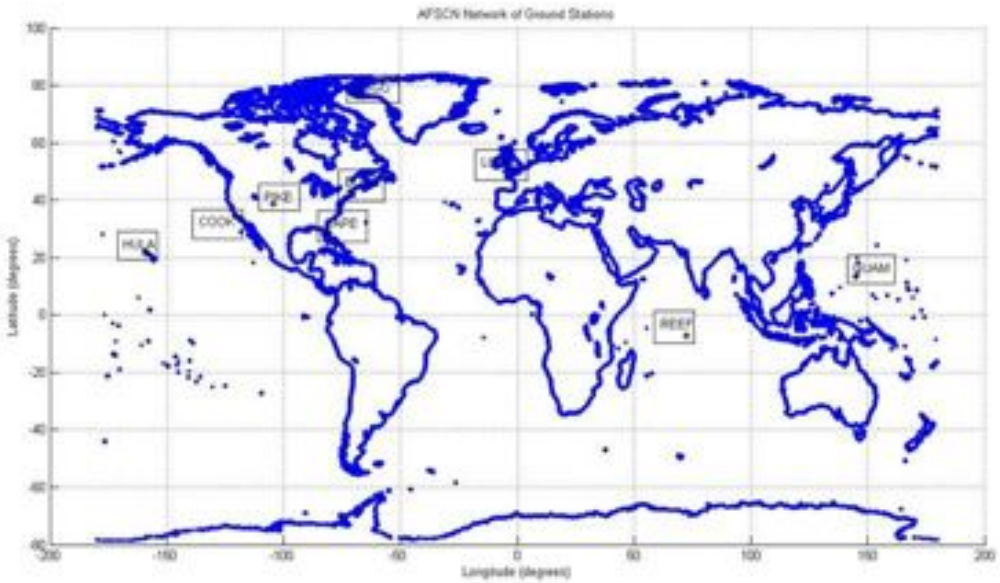
- Ground stations (including ships) track launches.
- In the past, people would use visual observations (compasses, protractors, etc)
- Now, mostly radar



Uncertainty and guidance

- Every launch system works differently
- Solid vs. Liquid systems
- Active vs. Passive guidance systems
- Feedback vs. Seat-of-the-Pants systems
- Measurements: IMUs, accelerometers, gyros, GPS, etc.

Launch vehicle performance

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- Delta and Atlas launch vehicles are historically very accurate
  - Liquid core and upper stages
  - Well-characterized systems
  - Good feedback with measurements
  - Expensive

- Pegasus, Minotaur IV less accurate, but not bad
  - Pegasus accuracy:
    - Injection apse: +/- 10 km (3-sigma)
    - Opposite apse: +/- 80 km
  - Minotaur accuracy:
    - Injection apse: +/- 5 km (3-sigma)
    - Opposite apse: +/- 25 km

Configuration	Insertion Apse Altitude	Non-Insertion Apse Altitude	Semi-Major Axis	Inclination
Pegasus XL	±10 km	±80 km	±45 km	±0.15°
Pegasus XL with HAPS	±15 km	±15 km	±15 km	±0.08°

PMD-070

Figure 3-5. 3-sigma Injection Accuracies Typical of Pegasus XL Missions

  - Minotaur IV is essentially three Peacekeeper ICBMs stacked on top of each other.
  - Orion 38 4th stage may be used to improve injection accuracy. Optional Star 48 not-so-much.
  - http://www.orbital.com/video/SBSS/video.html

Spacecraft Separation

- Launch services provide an estimate of the spacecraft's trajectory and a corresponding covariance matrix.

$$P = \begin{bmatrix} \sigma_1^2 & \rho_{12}\sigma_1\sigma_2 & \cdots & \rho_{1n}\sigma_1\sigma_n \\ \rho_{12}\sigma_1\sigma_2 & \sigma_2^2 & \cdots & \rho_{2n}\sigma_2\sigma_n \\ \vdots & & \ddots & \vdots \\ \rho_{1n}\sigma_1\sigma_n & \rho_{2n}\sigma_2\sigma_n & \cdots & \sigma_n^2 \end{bmatrix}$$

Spacecraft Stat OD

- The Stat OD process then takes the estimate of the spacecraft trajectory: $\bar{X}$
- And the covariance $\bar{P}$
- And uses those to initialize the Stat OD process.

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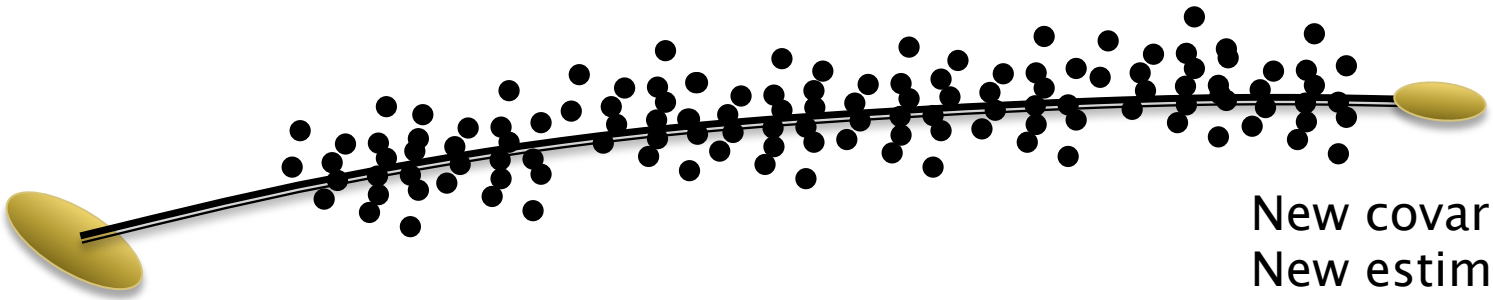
- Observations update these



Mars Odyssey

- Brief Switch to Mars Odyssey Example

Homework 1

- Some popular questions and answers

- Grading, code, etc
- Comments may be audio files

Homework 2

- Some popular questions and answers
- Energy tolerance, compared to solutions

Homework 3

- Questions yet?