

GPS – Putting the *here* in “You are here”

RON BACKUS

BRN 13883

Agenda

- ▶ Global Positioning System (GPS) Segments 25 minutes
 - ▶ Space
 - ▶ Control
 - ▶ User
- ▶ Behind the Scenes Challenges 20 minutes
- ▶ GPS Augmentations 5 minutes
- ▶ Questions & Summary ? minutes

GPS Segments

1. Space Segment
 - ▶ Satellite constellation
2. Control Segment
 - ▶ Ground stations
 - ▶ System smarts
3. User Segment
 - ▶ Anyone with a GPS receiver
 - ▶ Anything with a GPS receiver



How GPS Works

Space Segment

- ▶ 32 GPS satellites orbit the earth
- ▶ GPS satellites broadcast where they are and what time it is

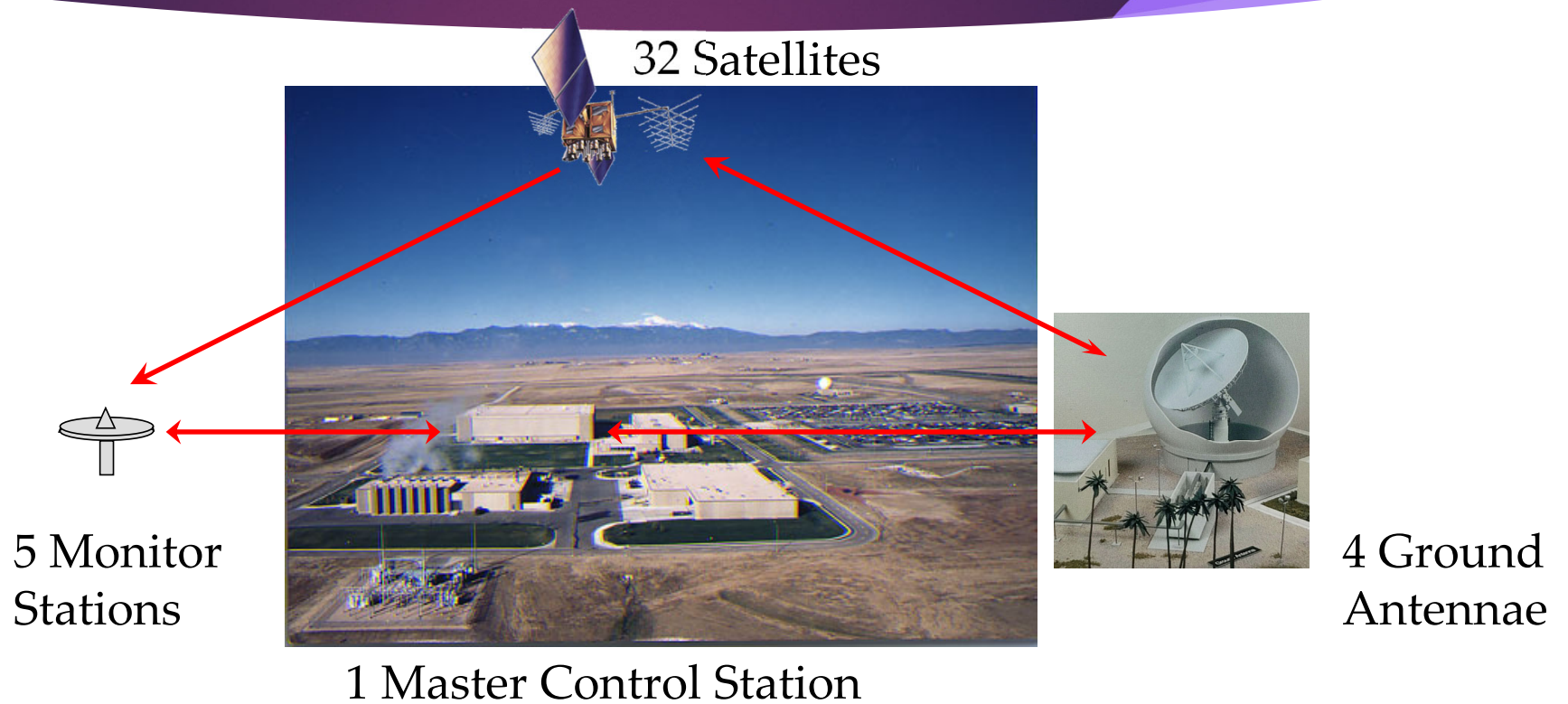
Control Segment

- ▶ Control segment ensures system operations by maintaining the space segment

User Segment

- ▶ Anyplace on earth can usually see/hear at least 6 satellites at one time
- ▶ A user unit calculates distance to satellites based on travel time of signals

Control Segment Operations

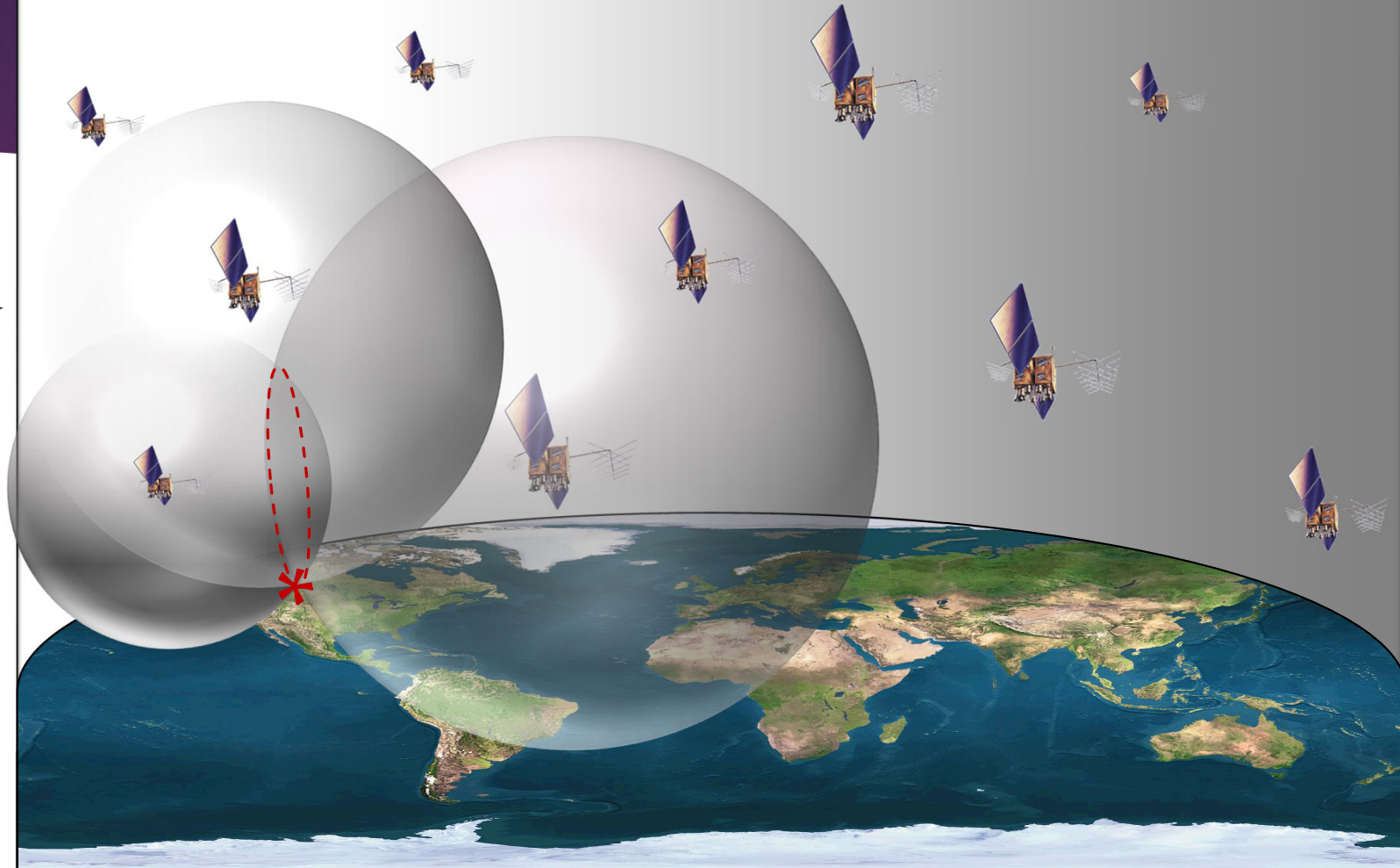


User Segment Trilateration

The user unit:

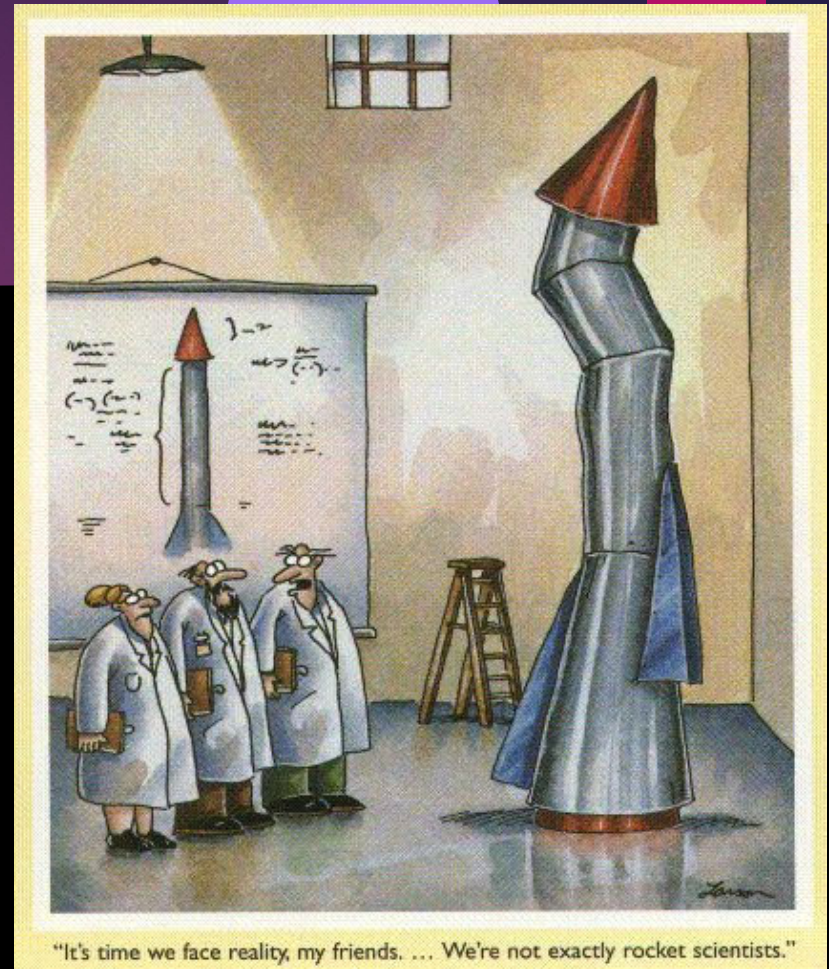
- ▶ Picks 3 satellites
- ▶ Determines how far it is from each of them
- ▶ Pinpoints a position based on the one place where all those distances meet
- ▶ Reports its position in latitude and longitude

Trilateration with Satellites



Behind the Scenes Challenges

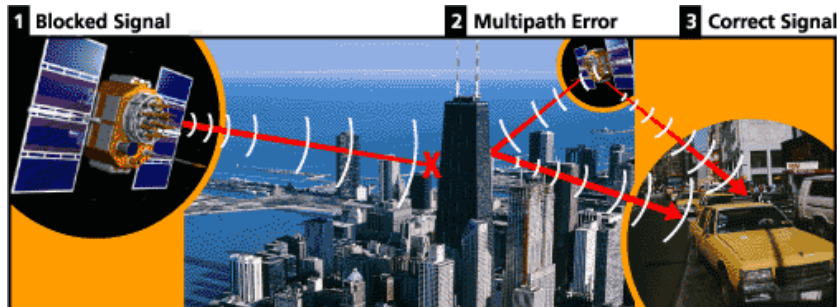
- ▶ Earth Solid Tide
- ▶ Precession & Nutation
- ▶ SV Eclipse Season (2/year)
 - ▶ Noon Turn Events
- ▶ SV Station Keeping
 - ▶ SVs don't stay in place
- ▶ Theory of Relativity



Errors and Augmentations – Even Better Accuracy

Sources of small errors

- ▶ Ionosphere and troposphere delays
- ▶ Signal multi-path
- ▶ Receiver Clock errors
- ▶ Orbital errors
- ▶ Number of SVs visible
- ▶ Satellite geometry

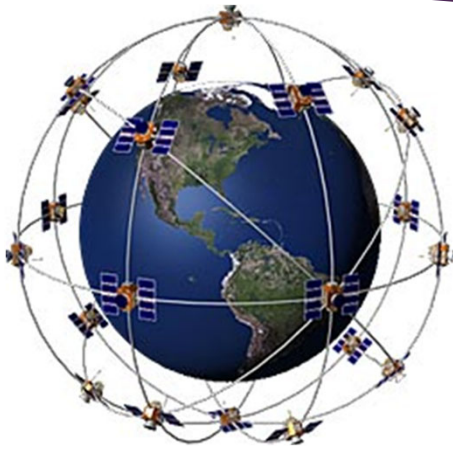


Augmentation Systems

- ▶ **WAAS - Wide Area Augmentation System in US**
 - ▶ 25 Additional precisely surveyed monitor stations
 - ▶ Wide-Area Master Station (WMS) calculates corrections
 - ▶ Real-time corrections broadcast from 2 geostationary satellites
 - ▶ WAAS Accuracy is less than 3 meters 95% of the time
- ▶ **MSAS – Multi-Function Satellite Augmentation System in Japan**
- ▶ **EGNOS – Euro Geostationary Navigation Overlay Service in Europe**



GPS – Putting the *here* in “You are here”



▶ Space Segment

- ▶ Each of 32 orbiting GPS SVs broadcast its time and position

▶ Control Segment

- ▶ Collects, analyzes, and corrects position and timing predictions sent by SVs

▶ User Segment

- ▶ Calculates distance to SVs based on travel time of signals using trilateration

