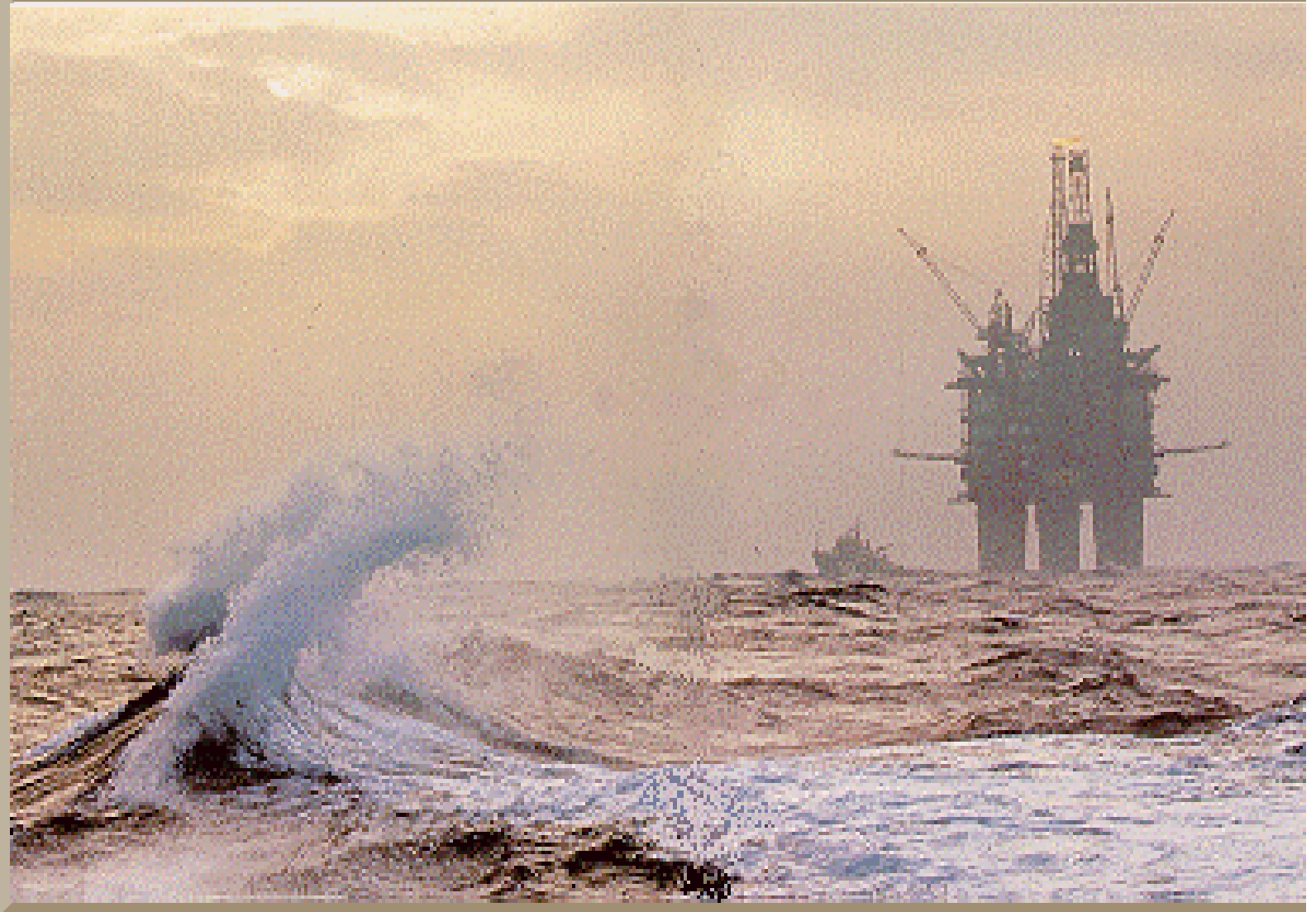




**Satellite Positioning
Dynamic Positioning Conference
October 13-14, 1998**



Satellite Positioning





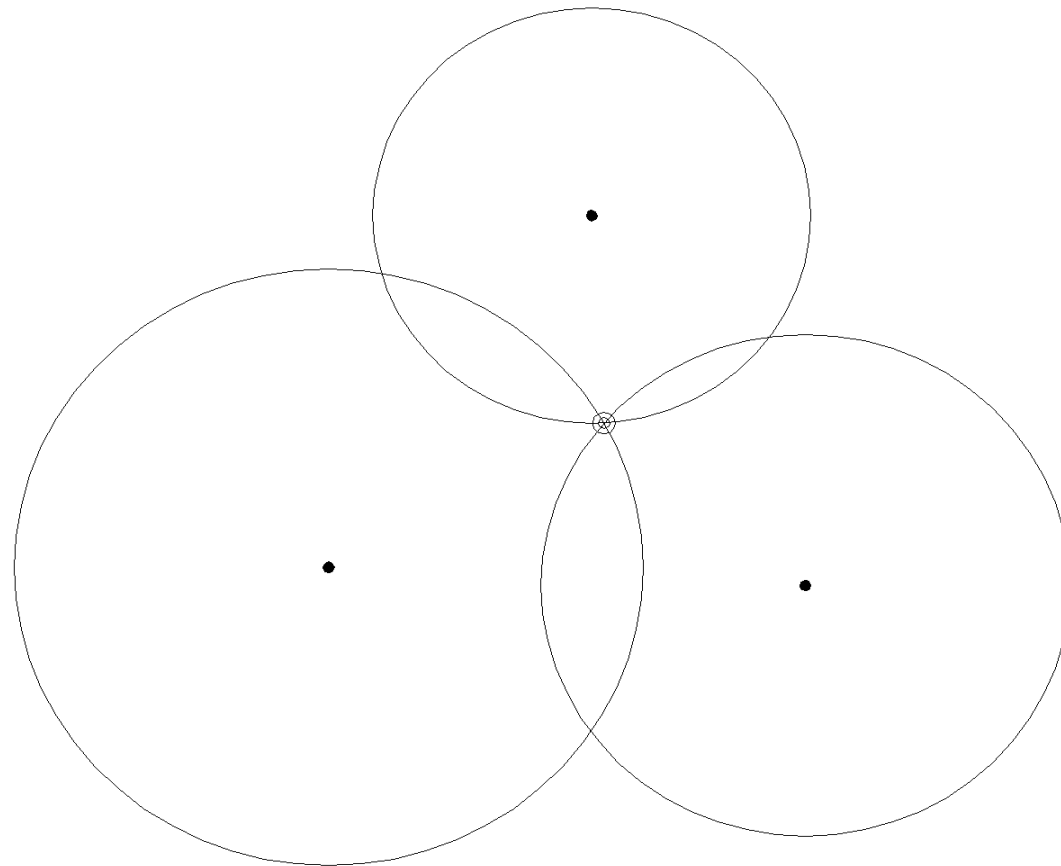
Radio Positioning Principles

- **GPS, GLONASS, Loran-C, Transit, Syledis...**
- **Reference Transmitters at “Known” Locations
(x,y,z)**
- **Mobile Receivers**
- **Range-Range System**
- **Timing derived distances**
- **Line of Sight**



Unique Position

RADIO POSITIONING
3 RANGE FIX





GPS

- **Global Positioning System**
- **Satellite-based Radio Positioning System**
- **Operated by US Department of Defense**
- **Position, Velocity and Time Service**
- **Replaces most older US-operated systems**
- **24 Operational Satellites**
- **3 Spare Satellites**



GPS

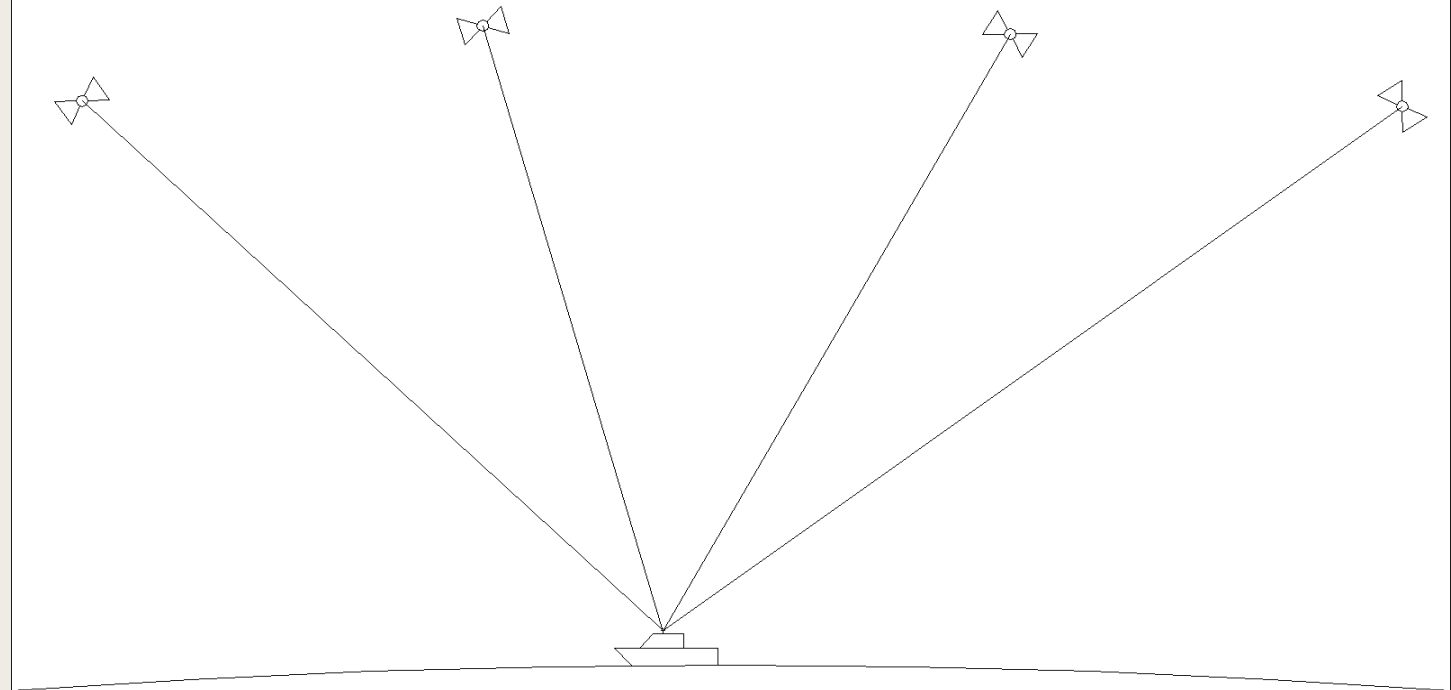
- **24 Hour Operations**
- **Master Control in Colorado Springs, CO**
- **5 Tracking Stations World-wide**
- **Selective Availability - intentional clock errors**
- **Accuracy 100m (~60m without SA)**
- **System Availability Assurance DOD/DOT/FAA**



GPS



GPS



EXPECTED ERROR ~ 100 m



GLONASS

- **Global Navigation Satellite System**
- **Satellite-based Radio Positioning System**
- **Under Development by Russian Ministry of Defense**
- **Position, Velocity and Time Service**
- **24 Satellites (14 currently)**
- **24 hr Operations (4 hr currently)**



GLONASS

- **Master Control in Moscow**
- **5 Tracking Stations in former Soviet Union**
- **Accuracy 60m (full constellation)**
- **System Availability???**
- **GPS+GLONASS Receivers**



GPS/GLONASS Comparison

	<u>GPS</u>	<u>GLONASS</u>
No. Satellites	24+3	14 (Full Constellation 24)
Orbiting Planes	6	3
Inclination	55°	65.8°
Orbit Radius (km)	26,560	25,510
Period (hr:min)	11:58	11:16
Signal L1 (MHz)	1575.42	1602 + 0.5625n
Signal L2 (MHz)	1227.60	1246 + 0.4375n
Spheroid	WGS 84	PZ 90



DGPS

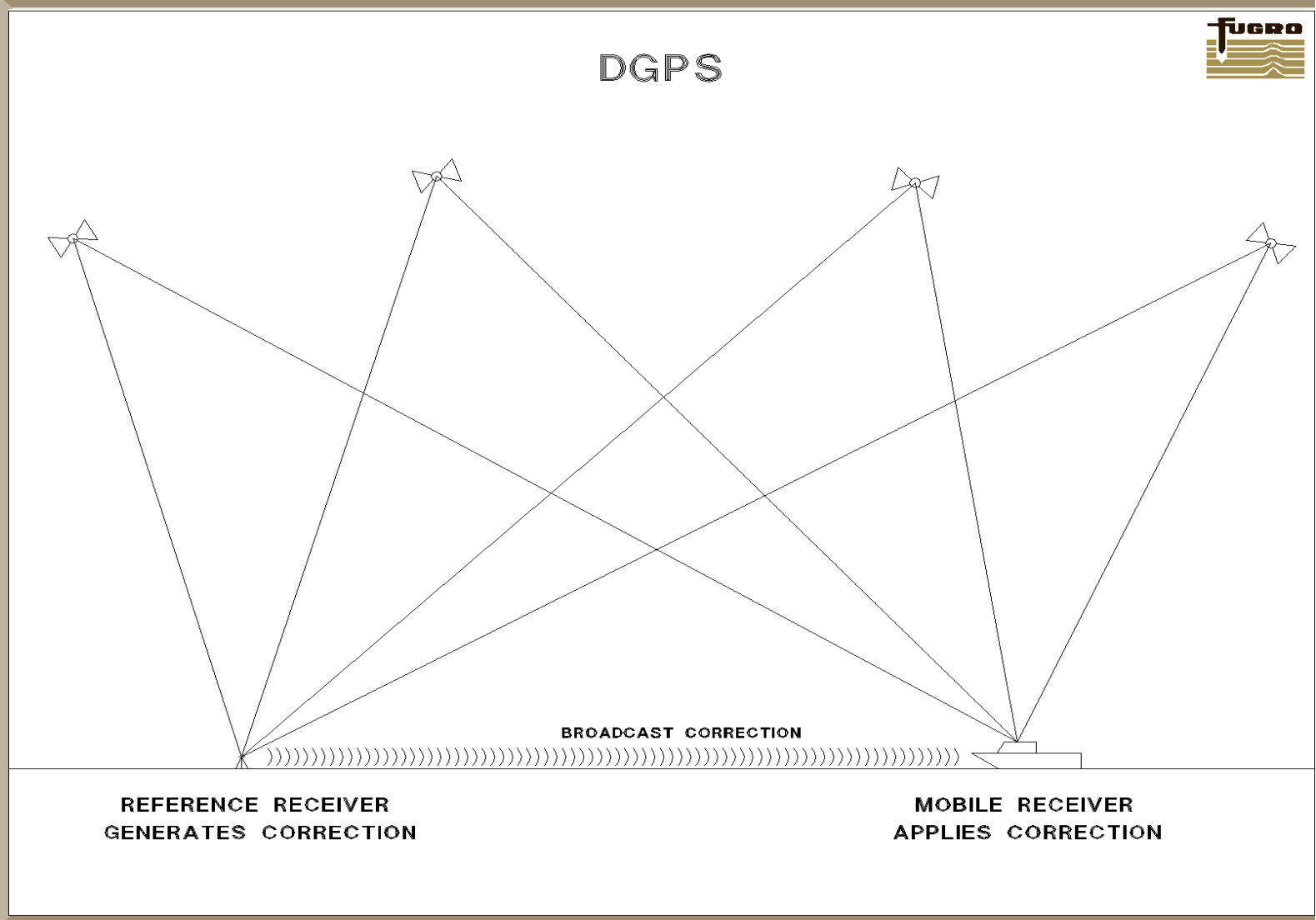
- **Differential GPS**
- **Implemented to Improve Real-time GPS Accuracy**
- **Minimize Errors due to SA, Atmosphere and Satellite Positions (Ephemeris)**
- **Range Corrections (C-O)**
- **Corrections Applied in Near Real-Time**
- **Single-Site v. Wide-Area**



DGPS



DGPS



REFERENCE RECEIVER
GENERATES CORRECTION

MOBILE RECEIVER
APPLIES CORRECTION

BROADCAST CORRECTION



Single-Site DGPS

- **Single Reference Station**
- **Range Corrections only**
- **Sub-meter Accuracy Possible near Reference Site**
- **Error increases with distance (1m/100km)**
- **Radio Telemetry**
- **USCG Differential GPS Navigation Service**



Single-Site DGPS



USCG SINGLE-SITE DGPS



EXPECTED RANGE ~ 260 km

EXPECTED ERROR ~ 3 m + (1 m / 100 km)



Wide-Area DGPS

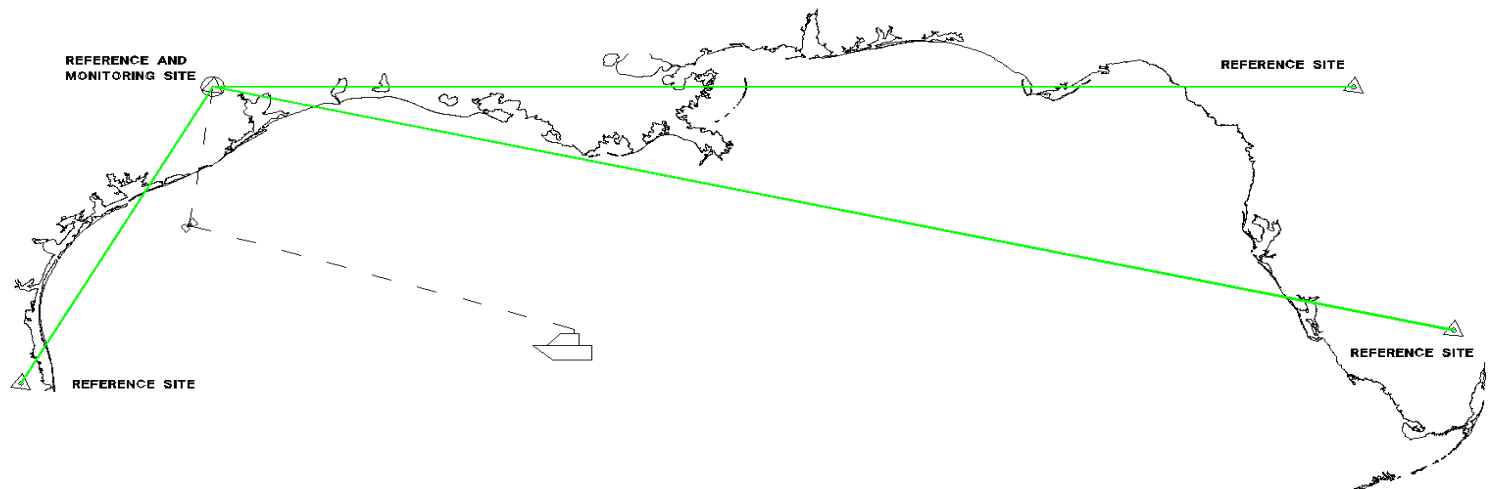
- **Multiple Reference Stations**
- **Optimized Solution**
- **Consistent, Sub-meter Accuracy**
- **Range, Range Rate and Atmospheric Corrections**
- **Satellite Telemetry**
- **Fugro Starfix**
- **Racal SkyFix**



Wide-Area DGPS



WIDE-AREA DGPS



EXPECTED RANGE ~ UNLIMITED

EXPECTED ERROR ~ 1-2 m

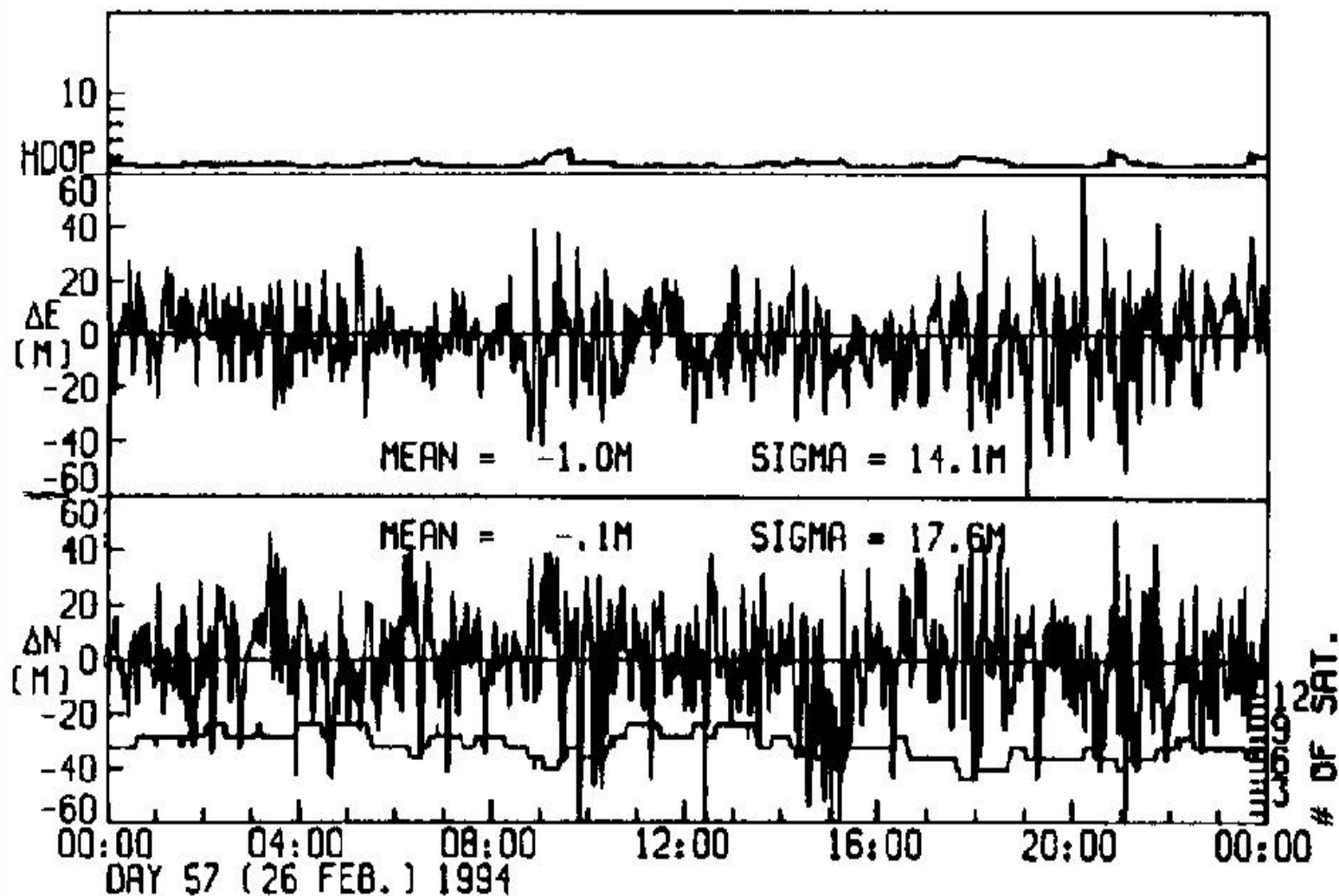


DGPS Accuracy

- **Navigation, GIS, Surveying, Recreation...**
- **Accuracy is measured over a known point**
- **Stand-alone GPS averages ~ 0 m**
- **Standard Deviation over time**
- **1m Accuracy = 1m Std. Deviation (1 ?)**
- **Function of receiver quality AND corrections**
- **Accuracy degraded in dynamic environment**

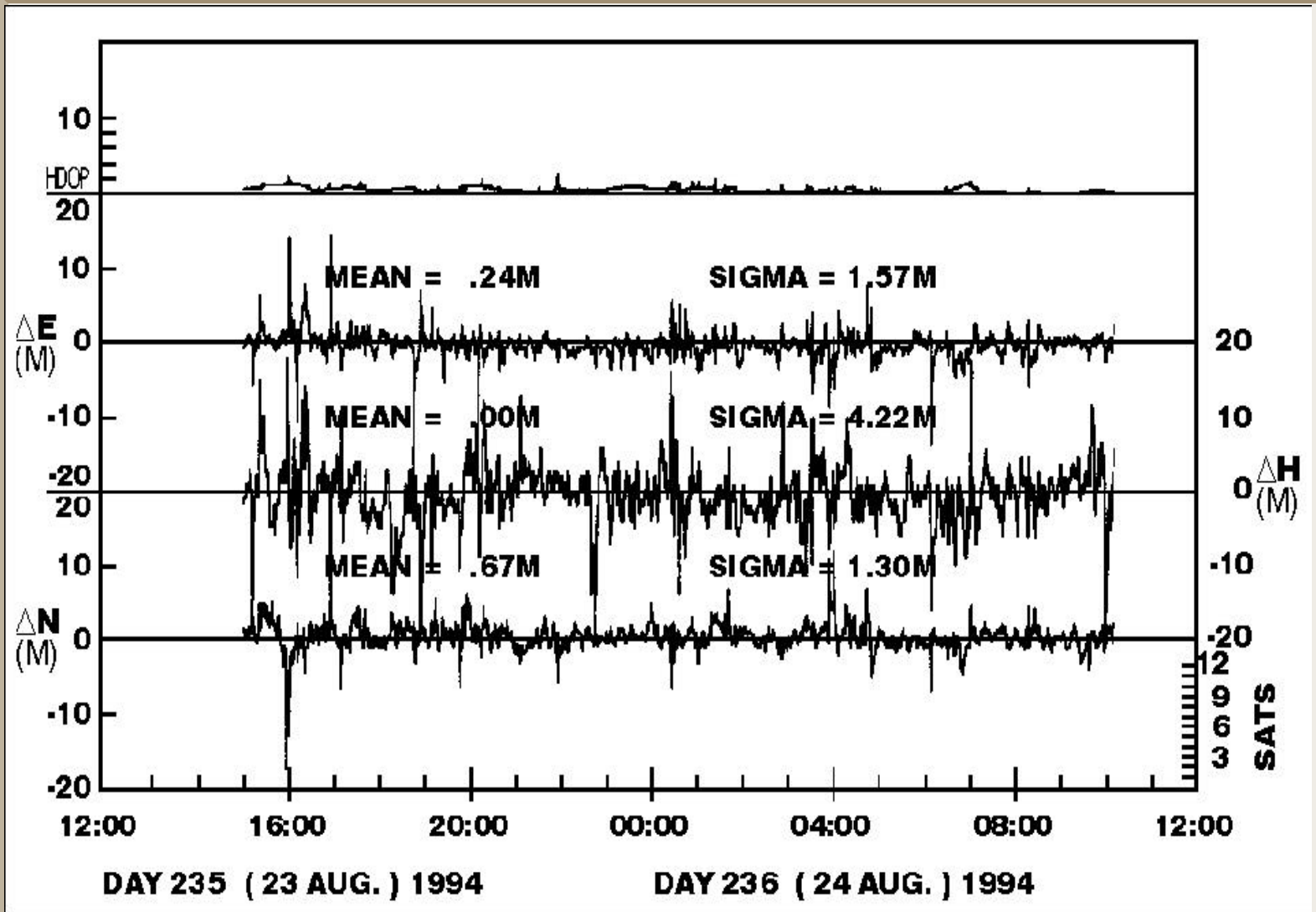


Stand-alone GPS





DGPS





Sub-meter DGPS

