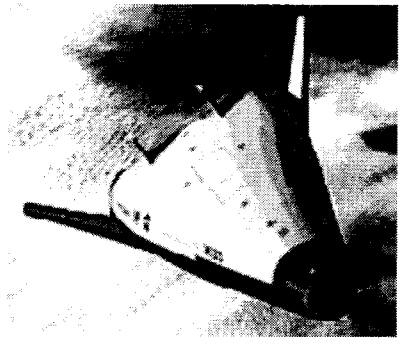
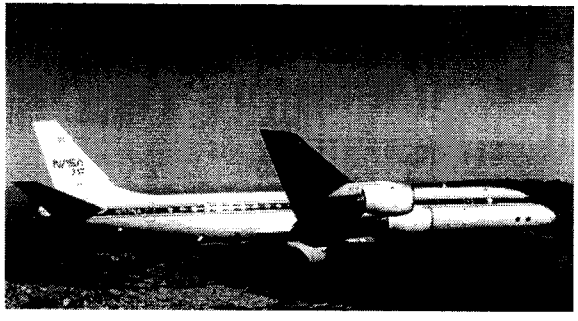
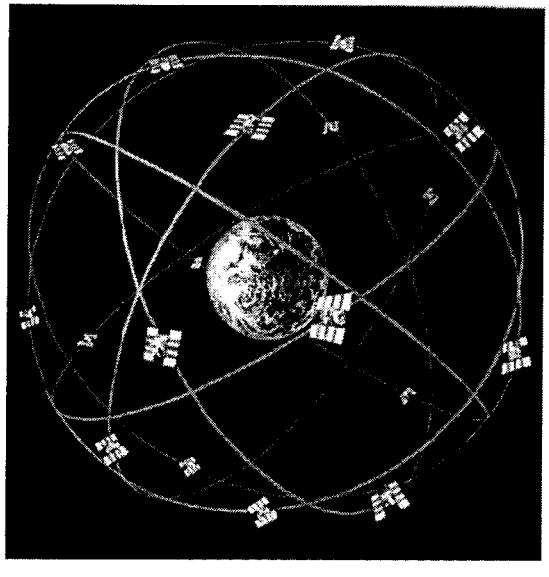


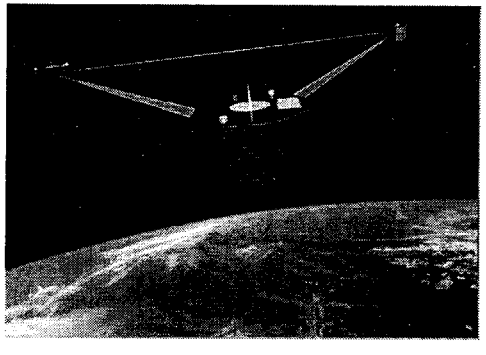


N ASA'sG lobalD ifferential GPSSy stem

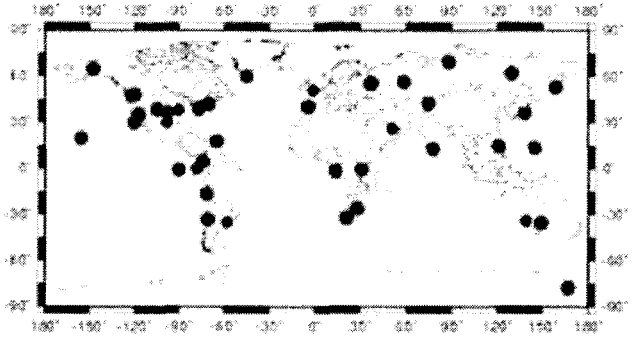
Yoaz Bar-Sever/JPL

Yoaz.Bar-Sever@jpl.nasa.gov



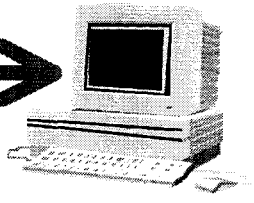


GDGPSSer viceNetwork Over view



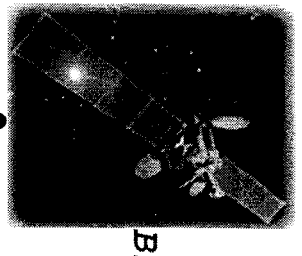
Network receiversrun ningIG DG

JPL processing center
runningI GDG



Internet

Broadcast



Internet 384 bps

Broadcast 256 bps

Remoteu ser
RunningIG DG

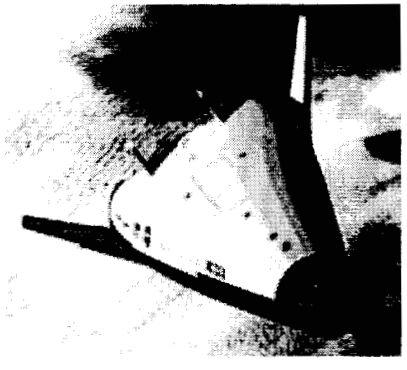
Revolutionary newca pability:
decimeter realtim epo sitioning,a nywhere,an ytime

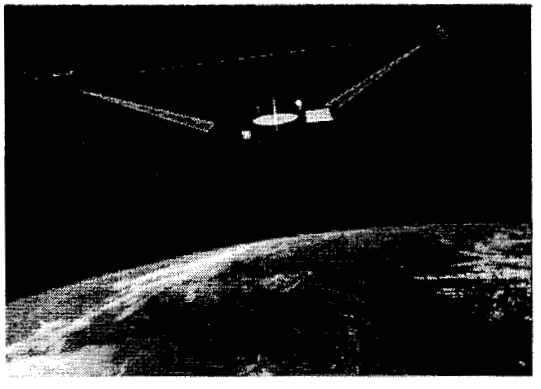
Capability		JPL's GDGPS	Un-augmented GPS
Coverage:	Global	Yes	Yes
	Seamless	Yes	Yes
	Usable in space	Yes	Yes
Accuracy:	Kinematic applications	**0.1 m horizontal** **0.2 m vertical**	5 m
	Orbit determination	**0.10 – 0.30 m 3D**	1 m
Dissemination method		Internet/broadcast	Broadcast
Targeted users		Dual-frequency	Dual-frequency

For more info see:
http://gipsy.jpl.nasa.gov/igdg

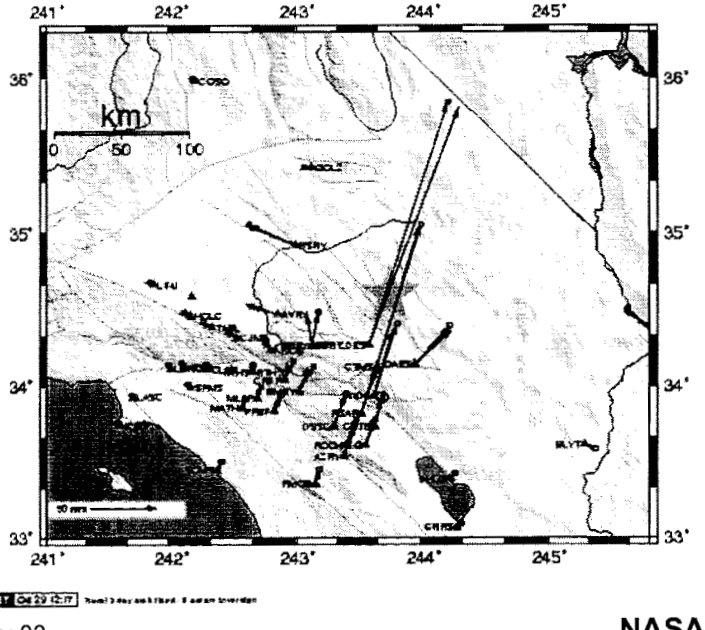
Special Value to NASA and Society

Autonomous operationsin Earth orbit to toenable smartsenso rw ebs andr educeoperatio nalcosts and communications bandwidth





Safe operations forN ASA missions



Aviation safety and efficiency

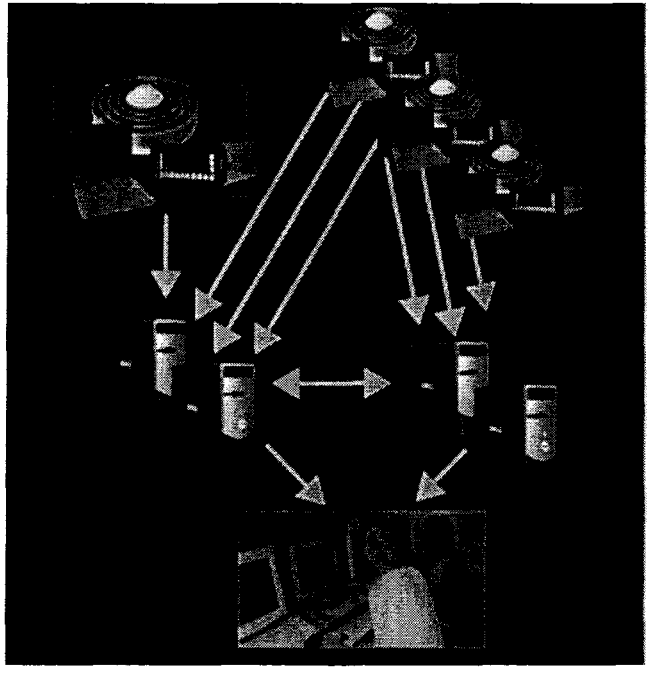
Timely monitoringa nd response tonat uralha zards

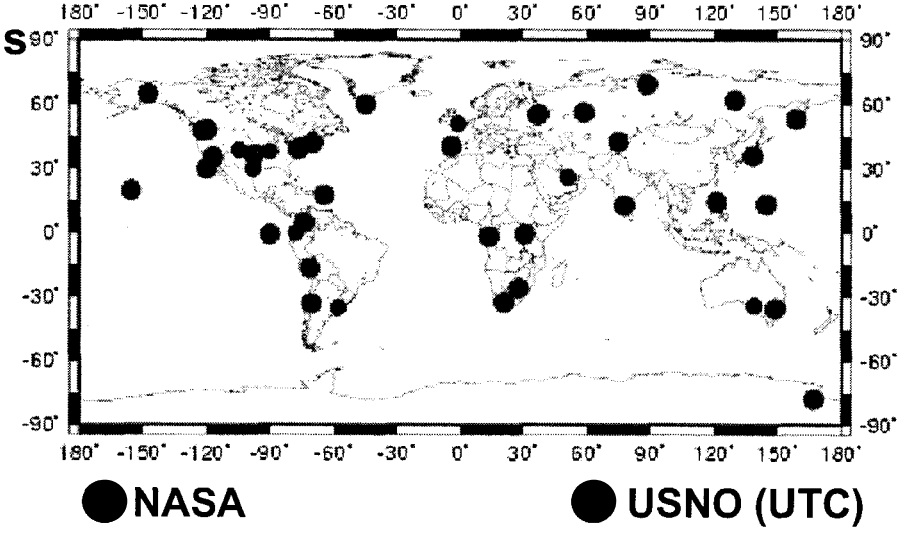
Many commercial applications

ReliabilityThrou ghRedun dancy

Multiply redundant Network and data paths

- Sitess treamd atatot wo datahu bsi n parallel
- TwoU TC referenceso urces



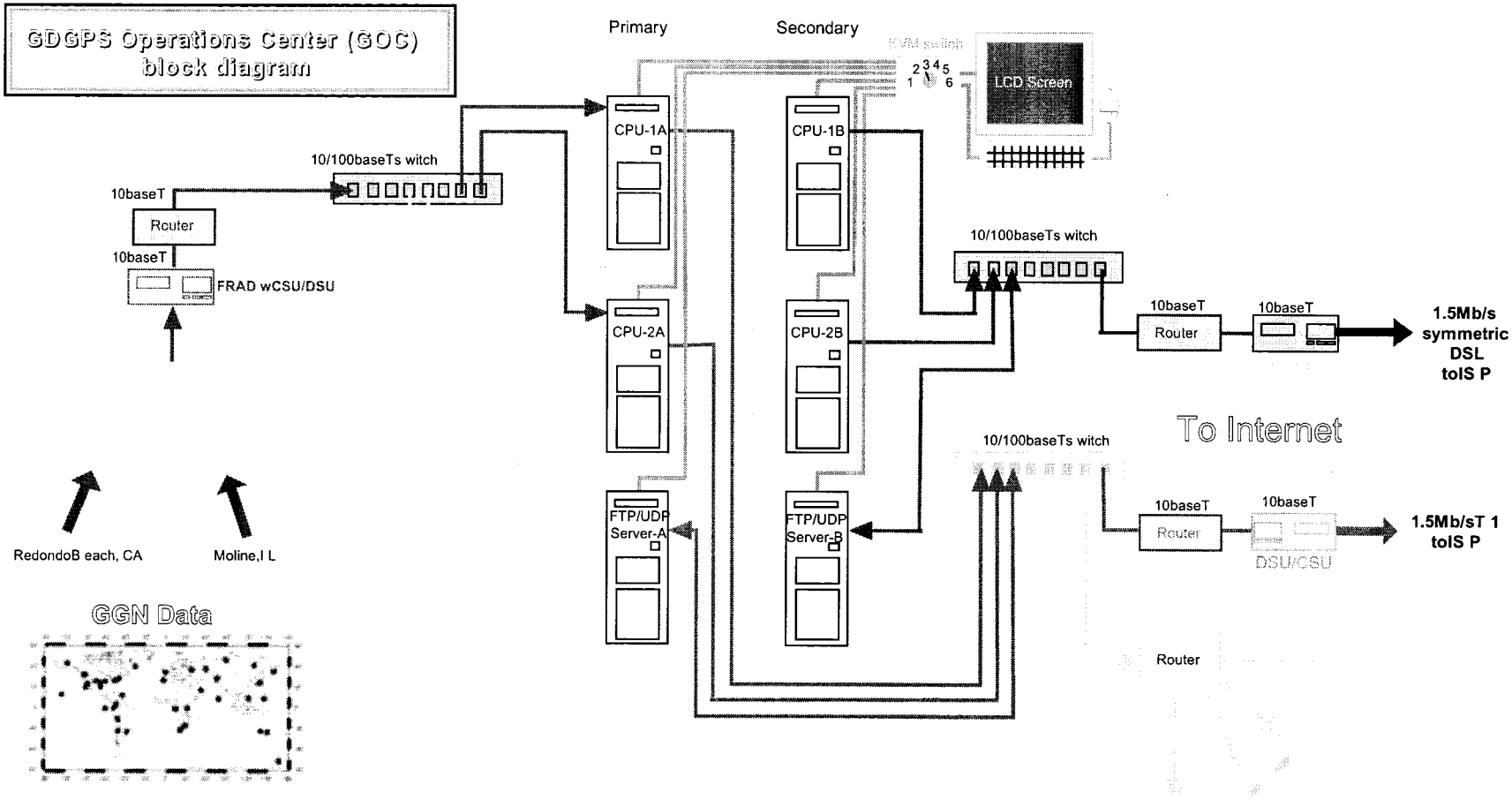


Flexiblel nternetarc hitecture

- Anyn umbero fda tah ubsand op eration centers
- Automatic fault detection and data rerouting
- Multiple datafor mats

No single points of failure

GDGPSOp erationsCe nter(GOC)



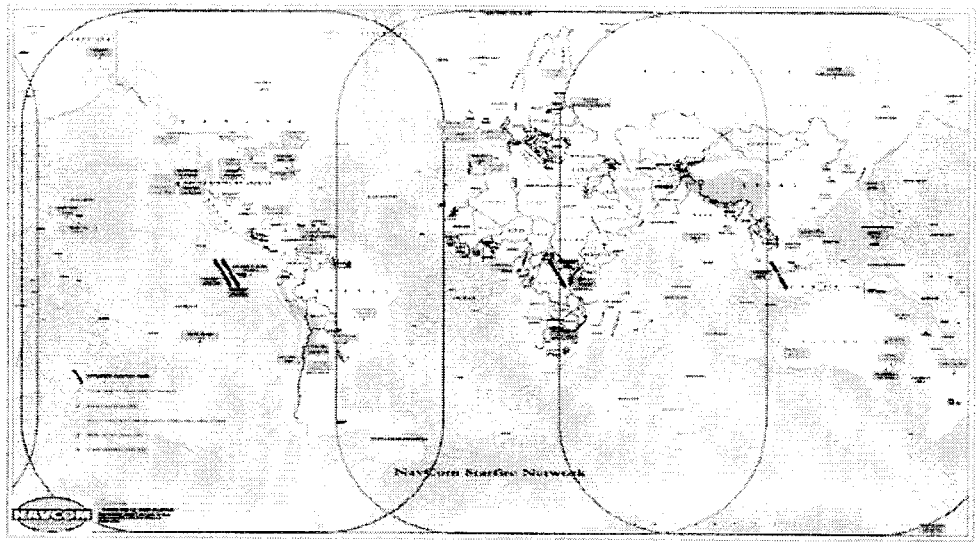
Track record of 99.99% reliability Since 2000

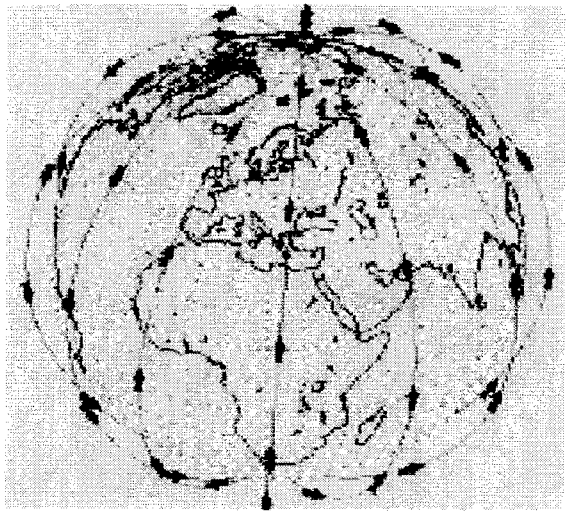
Customer Dedicated Frame-Relay Lines

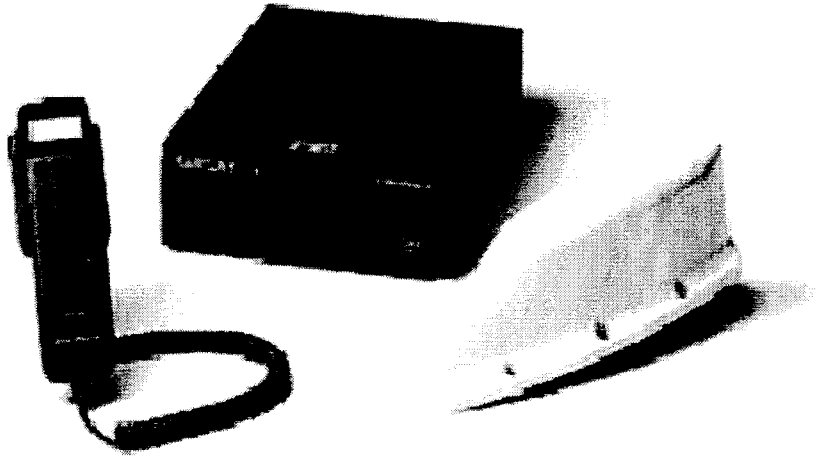
CommunicationRel ay Systems

True globalre ach:

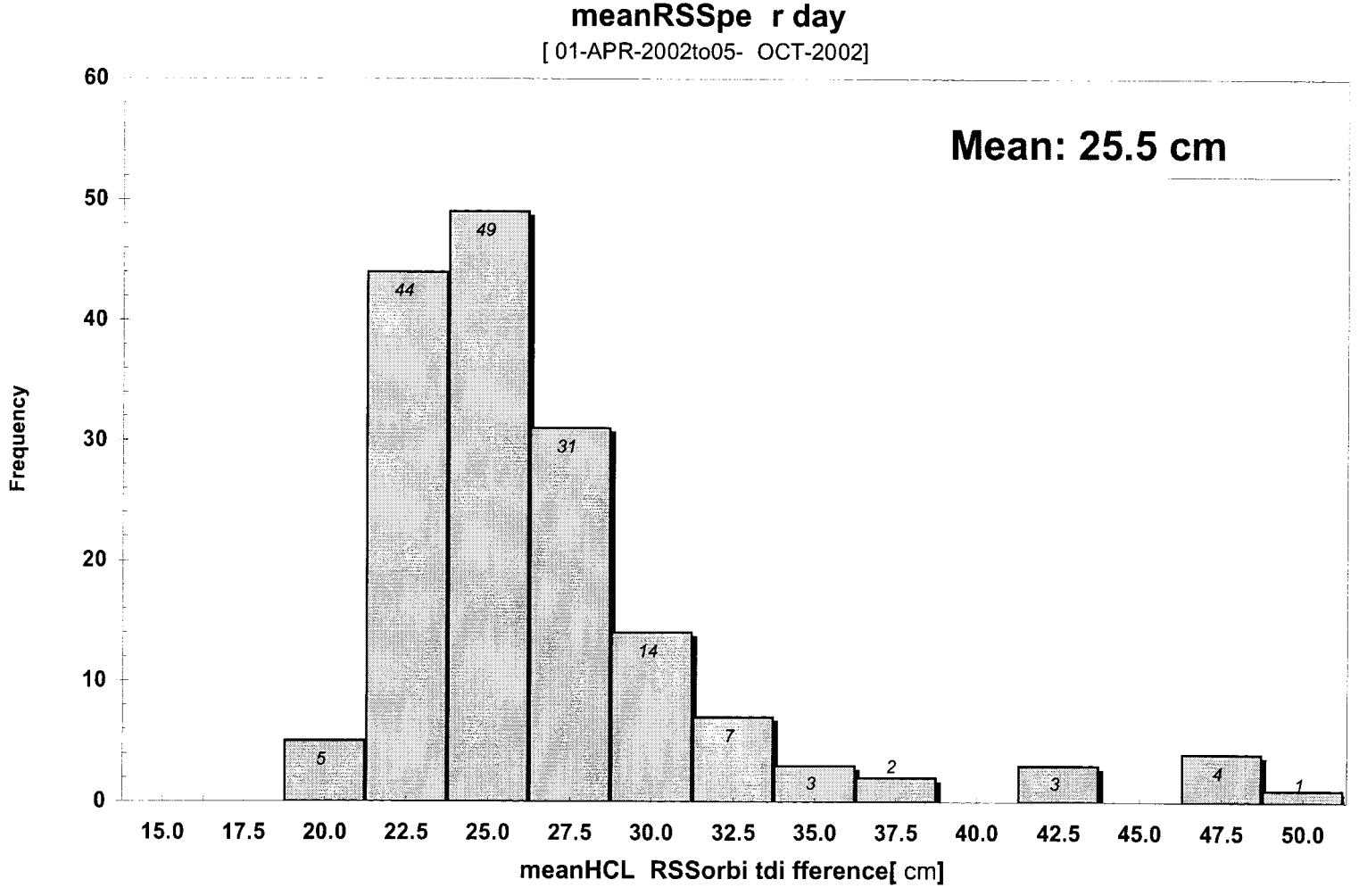
- Theo peninte rnet
- 3In marsatsa tellitesw ithglo bal coverageup to lat itude ±75º(operated byN avcom
- Iridiumt elephonem odems provide internet access globally (including the polar regions)



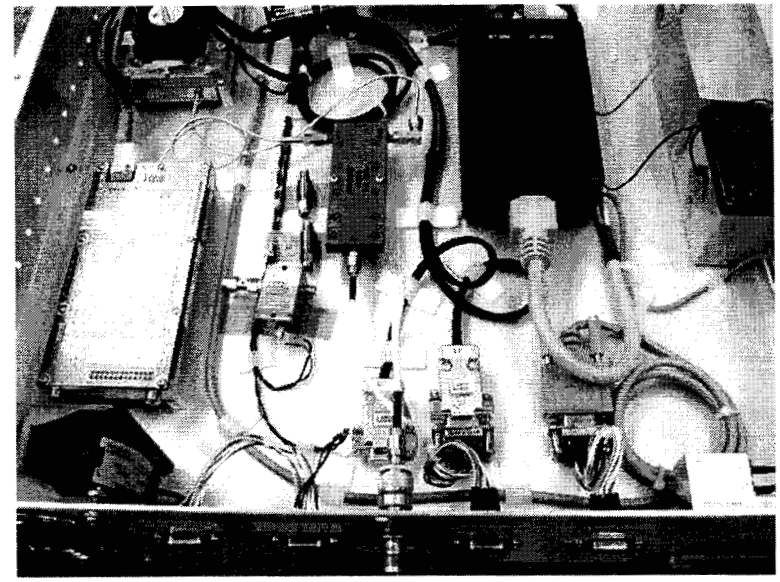




MeasuredP erformance-GP SOrbits



MeasuredPer formance-Air borneU sers



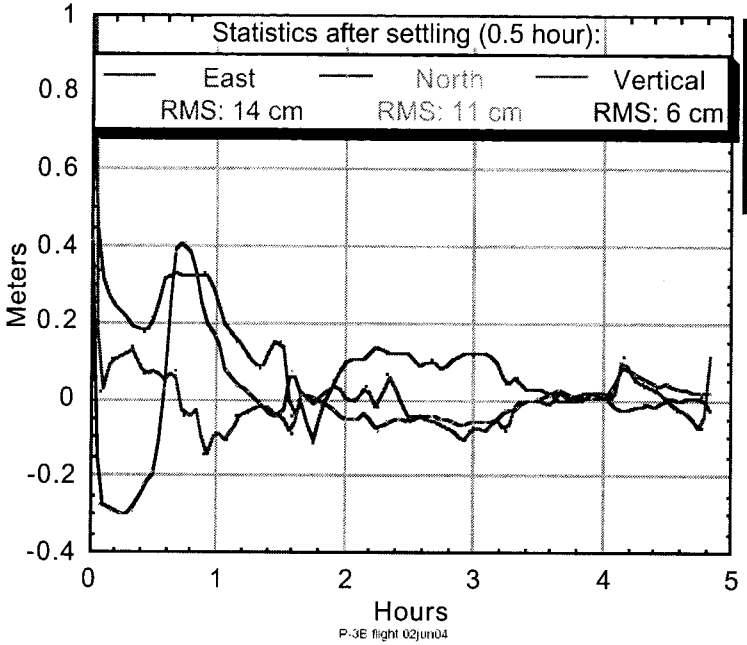
Extensivefl ightt ests

- North America,Fe bruary- Sep tember2 002: NASADC -8Ai rSAR
- Greenland,M ay2 002:NA SA P-3 LIDAR
- Sweden,po larregi on, February03 :NA SA DC-8

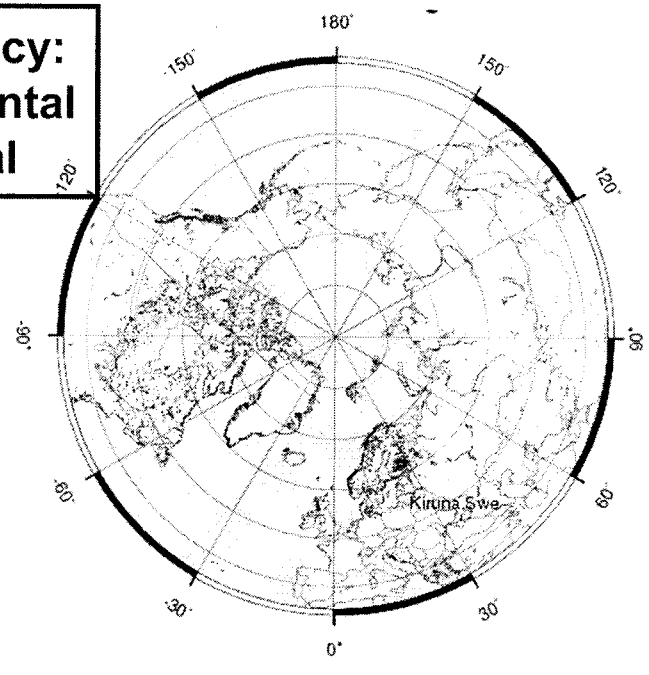
Performancev alidationby co mparisonsw ith:

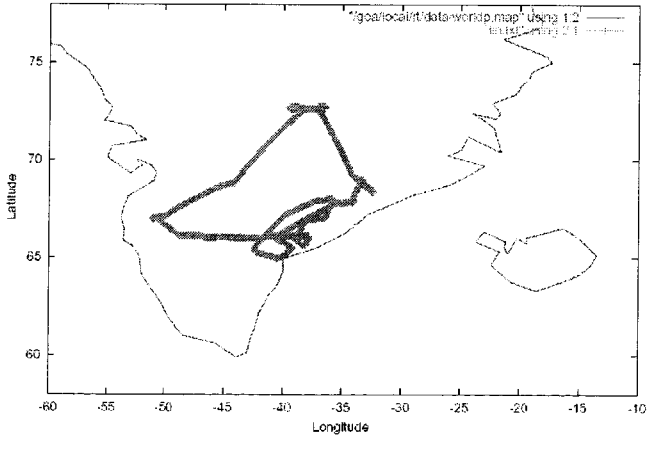
- Postp rocessing(preciseorb its +sm oothing)
- Independentloc ala rea differential techniques
- Laser ranging

MeasuredPer formance-Air borneU sers



Consistent Accuracy:
10 cm RMS Horizontal
20 cm RMS Vertical





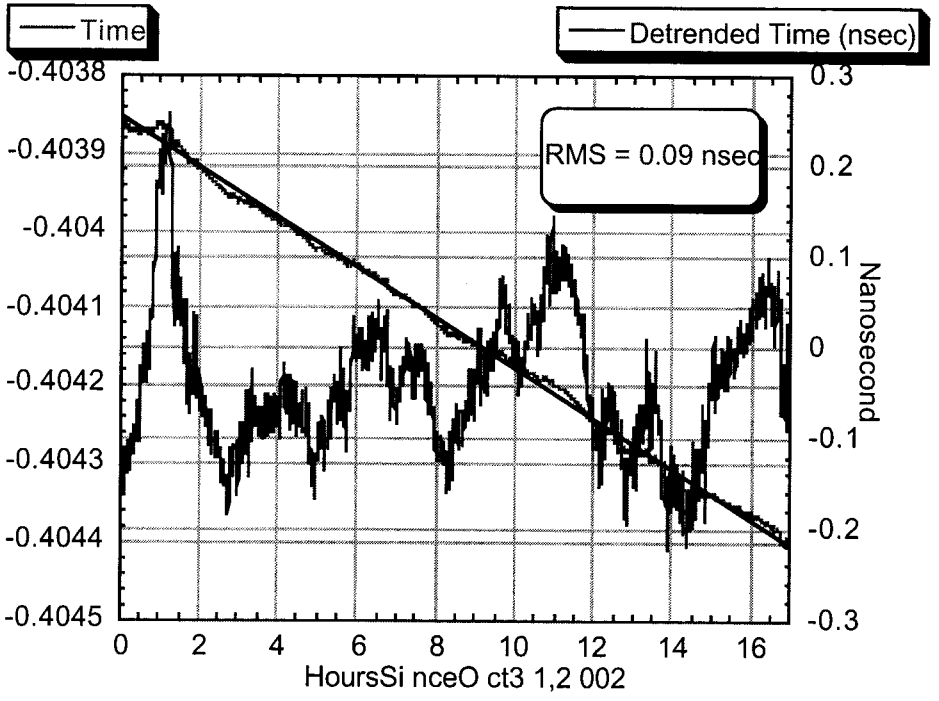
Differencebet weenG DGPSan dL ADGPS(cm)

Date	East	North	Vert
31M ay	17.2	10.1	13.0
02 Jun	4.5	4.6	5.9
04 Jun	8.0	6.1	12.6

TimeTr ansferCa pabilities

Real-Timetimetransfe r accuracy isconsis tent with that of positioning:
nanosec levelf or dynamicp latforms;0. 1 nanoseclev el forsta ticpla tforms

TimeT ransfer fromUS NOt oJP LMa ser
Positionh eldfi xed



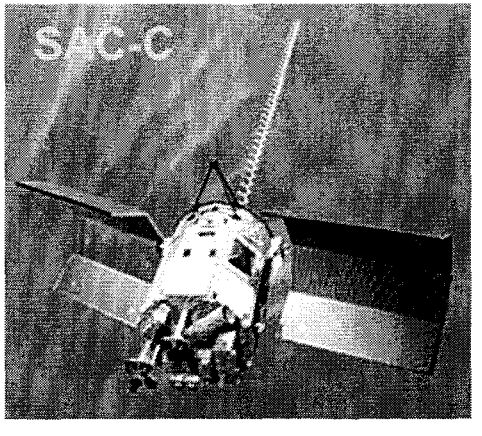
Anord ero fm agnitudeim provementc omparedto una idedGP S

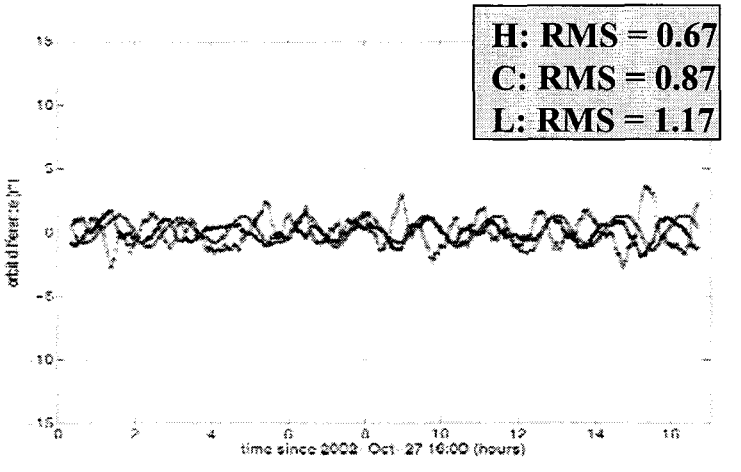
OrbitDete rminationPerforma nce

Assessend -to-endsys temperf ormanceof pre cise realt imeorb itd etermination

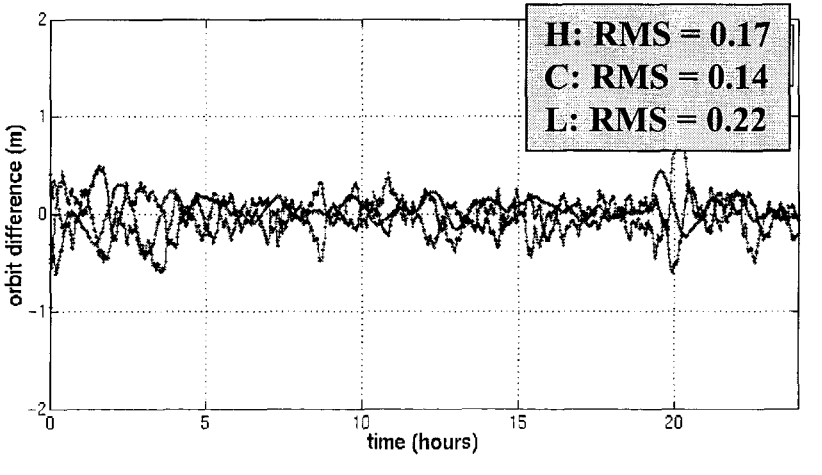
- SA C-Cte stbedf ors oftwarebu twi thoutG DGPSc orrectiond atastr eam
- G DGPSper formance "simulated"w ith ***realda ta,r eal orbits,r eal timefilt er***

A ltitude:650 km





This is how well we currently perform onboardSA C-C (w/o GDGPS corrections)

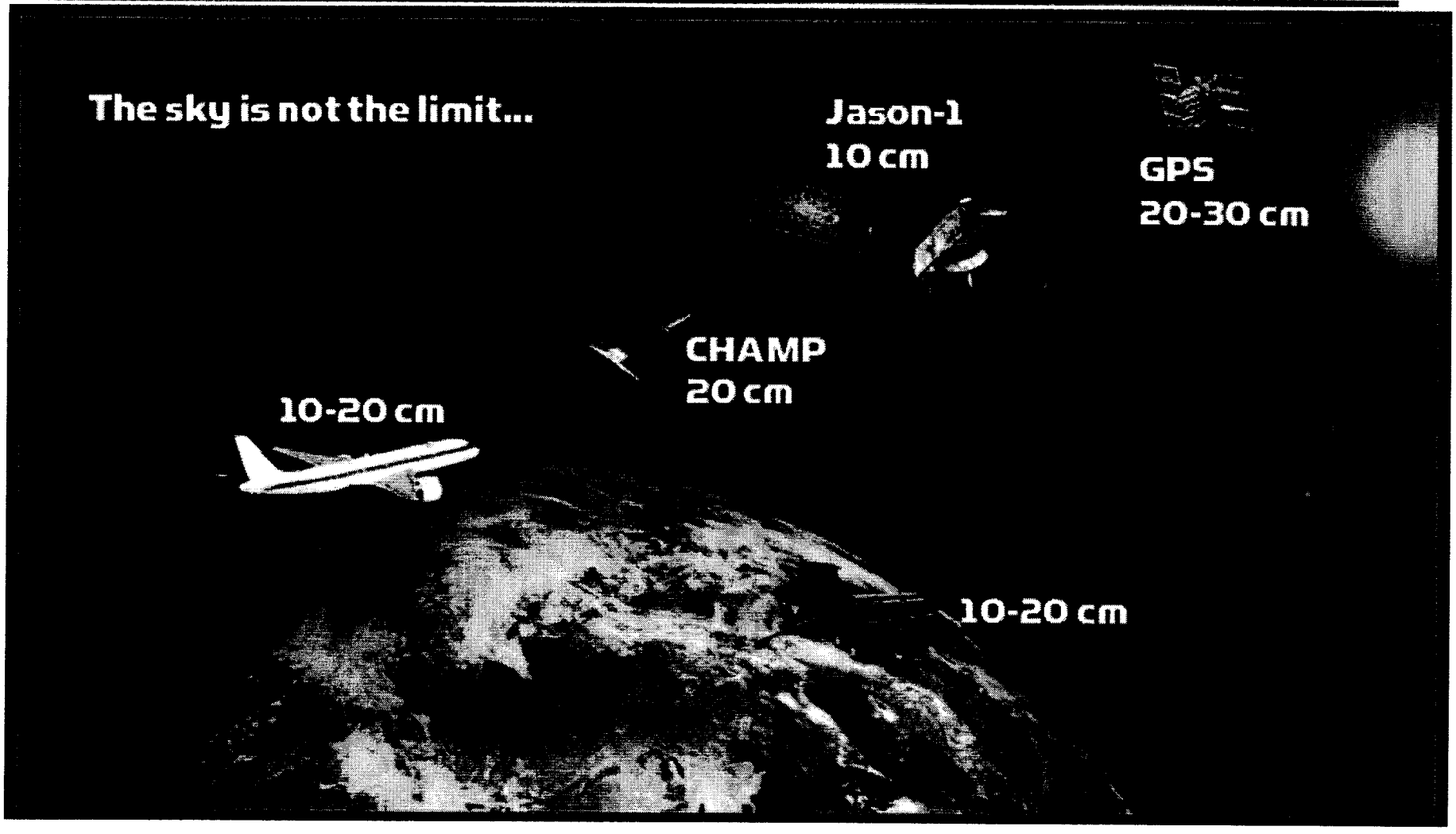


This is how well we expect to perform when the complete differential GPS receiver is deployed on af uture SAC-C-like s/c

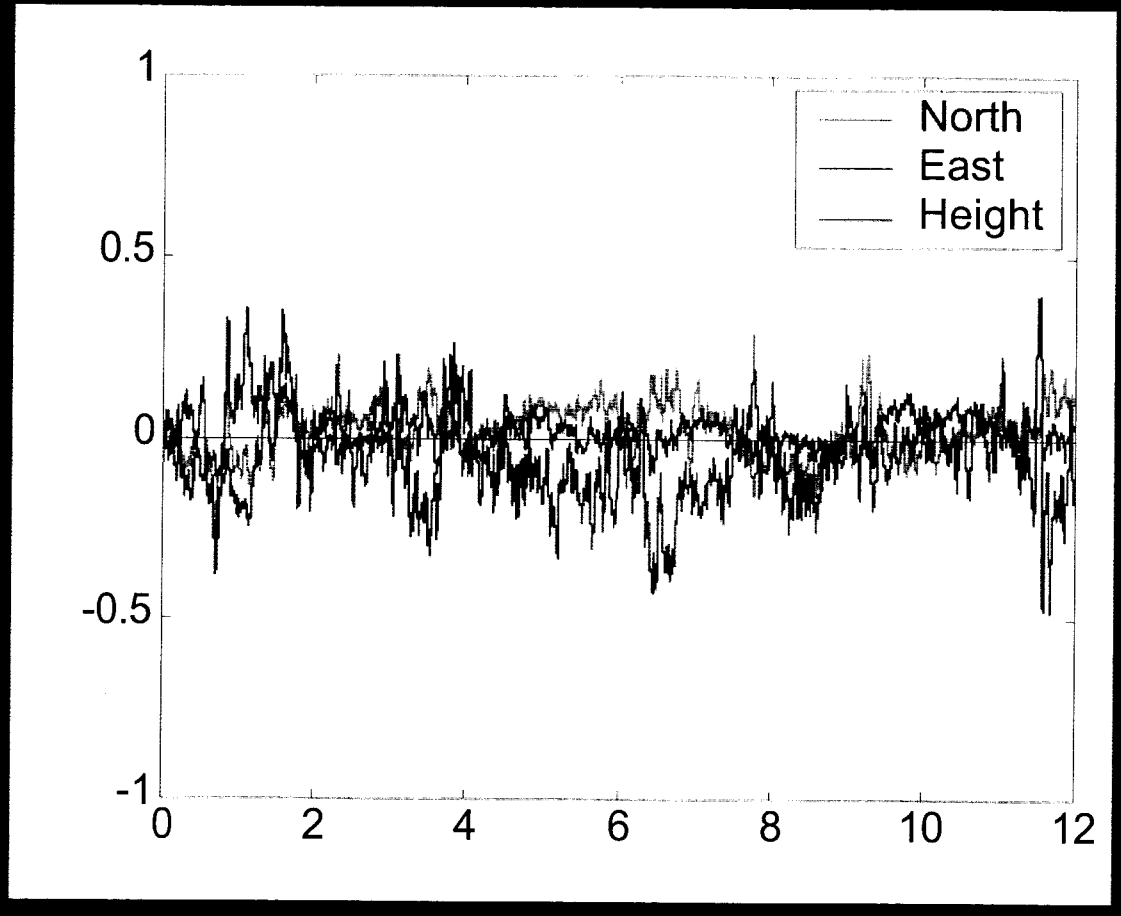
Resultsf or better modeledsa tellites CHAMP(4 50 km), Jason-1 (1300k m):

15 - 25 cm 3D RMS

Demonstrated Performance



Global Differential GPS



- single GPS receiver !
- using Real Time JPL satellite orbits & clocks
- filtered positions
- difference with precisely known reference
- low dynamics

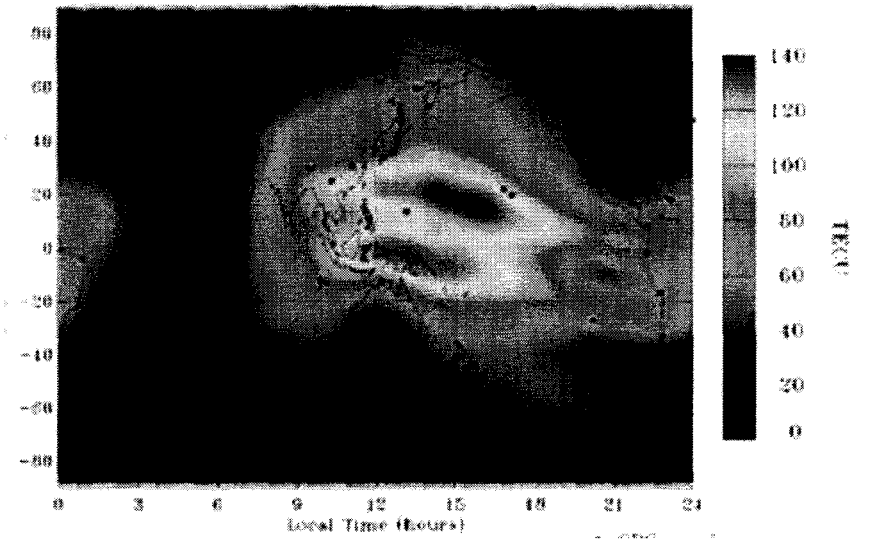
Nov. 17th, 2002
00:00 – 12:00 (GPS)

[m]	North	East	Height
mean	0.02	0.00	-0.05
st.dev	0.07	0.06	0.13

By-ProductsandCr oss-CuttingBene fits

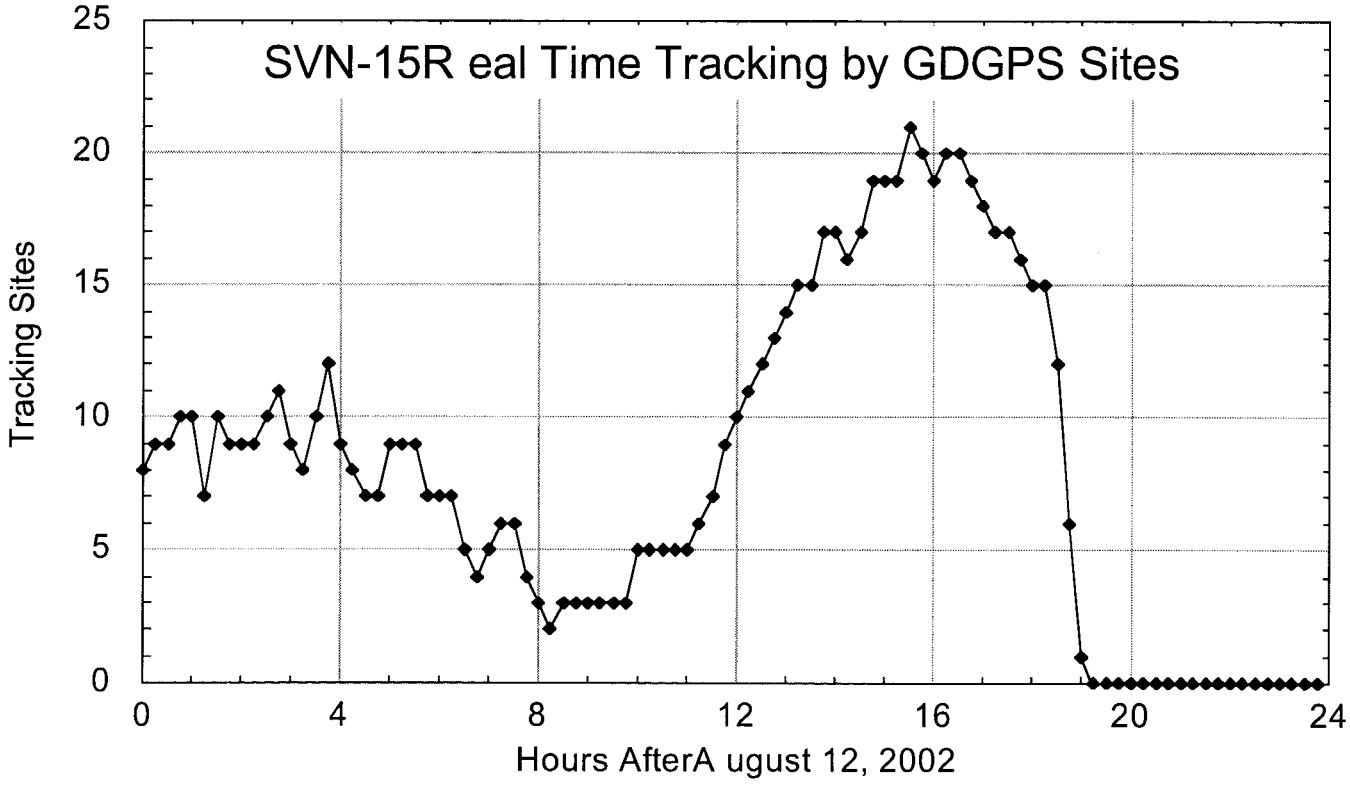
Core realtim eG DGPSpro ducts:
- RawG PSdata fro mg lobalne twork
- DifferentialC orrections
- Preciseo rbits
- Broadcast navigation message

Environmentalb y-products:
- Tropospheric delays
- Totalele ctronc ontent



Enabledpr oducts: near-real-time(N RT)orb itde termination ofsp ace sensors
- Demonstrated2 .5c mR MS radialac curacy forJ ason-1w ith threehou rla tency

Synergyw ith NRTsci encedat afr om spacese nsors
- Seasu rfaceh eightus ing NRTJa son-1s cience data
- Spacewe ather(g lobal ionospheric maps) usingN RTJas on-1,G RACE,CH AMP scienceda ta
- Improved globals calewe atherfo recasting

GPSInt egrityM onitoring

GDGPS is the only redundant real time network observing all GPS satellites all the time