JPL Real-Time Analysis Software
Background

• Satloc's WADGPS services
  - State-spaced system using JPL's rtg s/w
    • In operation since Nov. 1996
  - Demonstrated dual-freq. DC-8 aircraft positions
    • < 50 cm vertical, 40 cm horizontal (rms.)
  - Sale of network to Fugro OmniSTAR
    • User services stopped in April of 2000.

• Prototype for FAA's WAAS
  - Software licensed by Raytheon
Enabling Software, part 1

- rtg (real-time GIPSY)
  - Contains precise models of GIPSY OASIS II
  - Can be embedded in real-time user equipment
    - X33 sub-orbital vehicle
    - NASA DC-8 SAR flights
Enabling Software, part 2

- rtnt (real-time Net Transfer)
  - Transfer GPS data from existing ground reference sites over the open Internet to JPL
    - Support LEO atmospheric occultations
      - Return 5 of the 6 data types at 1 Hertz, plus snr.
      - Phase resolution of 0.02 mm.
      - Range resolution of 1 mm.
    - Most LEO sites will have stable oscillators.
  - Provide users with global differential corrections over the open Internet from JPL
Why use the open Internet

• Reliability
  – Better short term reliability w/ VPNs, frame-relay
    • But not necessary to return 100% of the data
  – Better long term reliability w/ open Internet
    • Multiple world-wide sites provides data redundancy

• Costs
  – It’s FREE!
Overview of rtnt

Internet daemon
(monitor & distribution)

Internet daemon
(primary)

Internet daemon
(secondary)

1 sec traffic
remote clients
15 min traffic
local servers
Backup Server Operations

Internet daemon now primary

secondary daemon may requests re-routing of the entire network
Current network of ground receivers returning GPS data in real-time

- AOA Benchmarks
- Turbo-Rogues
- Ashtech Z-12s
Future Sites

• Bogoto, Columbia
• Vsat link to Easter Island
• UNAVCO installation in Uganda
• Other possibilities:
  cice, Mexico (TR)  iisc, Bangalore, India (TR)
6-Hour Test of GPS-like Data Transmission from the Philippines

- 98.08% total
- < 1 sec 93.44%
- < 2 sec 97.01%
- < 3 sec 97.67%
- < 4 sec 97.92%
- < 5 sec 98.03%
Typical Real-Time GPS Data Latencies

- **pimo (Philippines)**
- **tidb (Australia)**
Typical Real-Time GPS Data Latencies

- hrao (South Africa)
- okc1 (Oklahoma)
gdgps s/w overview

remote clients → new sites

560 bit/sec. → 1 sec. → 1 min.

rtnt → remote users → rtg
User Positioning Tests

- Stochastically position stationary GPS receiver at known location
  - Same s/w used on DC-8 flights
    - Replace Satloc CONUS corrections with gdgps corrections
  - JPL mesa Ashtech Z-12
    - Also running Z-12 in building 238
# Point-Positioning Results

Recent 6 hour test results from JPL mesa

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Sigma</th>
<th>RMS</th>
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<tr>
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<td>8</td>
<td>13</td>
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Units are in cms.
## Point-Positioning Results

RMS of test results from JPL mesa

<table>
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<th></th>
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<th>18-May 18:00</th>
<th>19-May 00:00</th>
<th>19-May 06:00</th>
<th>19-May 12:00</th>
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<tr>
<td>Vertical</td>
<td>20</td>
<td>13</td>
<td>14</td>
<td>23</td>
<td>10</td>
</tr>
</tbody>
</table>

Units are in cms.
15 hour time series of gdgps corrections applied to Satloc's Florida Site

- east (8 cms rms.)
- north (5 cms rms.)
- vertical (19 cms rms.)
Current Orbit Error

- 30 CMS over North Western Hemisphere
  - RMS of 3D RSS

- 35 CMS global orbit error
  - Tuning orbits should yield 30 CMS globally
Real-time and Post-processed Estimates of Goldstone's Wet Zenith Troposphere Delay

r.m.s. difference between truth and real-time solution: 0.95 cms

- precise wet zenith trop estimate
- rtg (slow) wet zenith trop estimate
Summary

- Open Internet is reliable choice to return GPS data for state-space dual-frequency global differential GPS corrections.
- Why is this better than WADGPS?
  - GPS satellites continuously observed.
  - Optimized for dual-frequency user.
- 10 CMS Rms. horizontal accuracy.
  - Anywhere, Anytime.
What's Next

- Commercial partnership to provide SIS.
- $1.4 M to implement NASA differential service (AIST NRA)
Acknowledgment

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