GPS Update

Radio Technical Commission for Maritime Services

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NMEA Convention & Expo 2010
What is RTCM?

• International non-profit scientific, professional and membership organization.

• RTCM has over 120 member organizations, including
  Manufacturers
  Government agencies
  Associations
  Ship owners and operators
  Educational institutions
  Sales and service providers

• Special Committees develop reports and standards for maritime radiocommunication and electronic navigation systems.
  12 active Special Committees maintain 13 current standards
  Several new standards and reports under development
What is RTCM?

• RTCM supports development of international standards
  International Maritime Organization (IMO)
  International Telecommunications Union (ITU)
  International Electrotechnical Commission (IEC)
  International Hydrographic Office (IHO)
  International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA)

• RTCM’s most widely used standards globally concern Differential GPS services
What is RTCM?

- Current active Special Committees:

  SC 101 on Digital Selective Calling (w/SC110 on GPS-equipped VHF handheld radios)
  SC 104 on Differential Global Navigation Satellite Systems
  SC 109 on Electronic Charts
  SC 110 on Emergency Beacons
  SC 112 on Ship Radar
  SC 119 on Maritime Survivor Locating Devices
  SC 121 on Automatic Identification Systems and Digital Messaging
  SC 123 on Digital Message Services over Maritime Frequencies
  SC 127 on eLoran
  SC 128 on Satellite Emergency Notification and Location Devices
  SC 129 on Portrayal of Navigation-Related Information on Shipboard Displays

ProTECTS Alliance - a forum on satellite personal location devices

RTCM also maintains the distribution list for the U.S. Coast Guard's Global Maritime Distress and Safety System (GMDSS) Task Force
Global Navigation Satellite Systems (GNSS)
- GPS (USA)
- GLONASS (Russia)
- Galileo (Europe)
- Compass/Beidou (China – regional)
- QZSS (Japan – regional)
- IRNSS (India – regional)
How it works

Minimum 24 satellites (32 currently)
6 orbital planes
Medium Earth Orbit (12,550 miles)
2 orbits / day (8600 mph)
Typically 8 satellites in view of any point
4 necessary for a 3D position
Civilian signal at 1575.42 MHz (L1)
Different code for each satellite
Receiver separates codes and calculates position
Satellite position and time are precisely known

Receiver calculates distance to each satellite

Distances resolve to only one point in space and time
Each satellite broadcasts unique Coarse Acquisition (C/A) Code at precise times.

Receiver uses C/A Code and time of arrival to calculate distance to each satellite.

Requires –
- Satellite with precise atomic clock
- Precise time as part of receiver solution
- Compensation for slowdown and speedup of time due to Einstein’s general and special theories of relativity
- Frequency change due to Doppler shift
- Satellite broadcast of almanac
How it works

Better positioning through carrier phase measurement

Receiver compares known waveform with actual received waveform to calculate more precise position.

Positioning within a few meters possible
## Sources of error

<table>
<thead>
<tr>
<th>Source</th>
<th>Effect (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal arrival C/A</td>
<td>±3</td>
</tr>
<tr>
<td>Ionospheric effects</td>
<td>±5</td>
</tr>
<tr>
<td>Ephemeris errors</td>
<td>±2.5</td>
</tr>
<tr>
<td>Satellite clock errors</td>
<td>±2</td>
</tr>
<tr>
<td>Multipath distortion</td>
<td>±1</td>
</tr>
<tr>
<td>Tropospheric effects</td>
<td>±0.5</td>
</tr>
<tr>
<td>Numerical/Geometrical</td>
<td>±6.7</td>
</tr>
</tbody>
</table>

Total ~ 15 m
Correcting for errors

Differential GPS (DGPS – now DGNSS)
- Uses reference station at precisely known location
- Corrections broadcast by station and used by receiver
- Can be relayed by satellite (Satellite Based Augmentation System – SBAS) such as FAA’s Wide Area Augmentation System (WAAS)
What’s new?

Additional satellite systems

- GLONASS (Russia)
- Galileo (Europe)
- Compass/Beidou (China – regional)
- QZSS (Japan – regional)
- IRNSS (India – regional)

All have or will have characteristics similar to GPS – Added satellites = added precision
New frequencies

In addition to present “L1 C/A” frequency, new GPS satellites have:

• L2C - 1227.60 MHz (GPS launches after 2005) - When combined with L1 C/A in a dual-frequency receiver, L2C enables ionospheric correction

• L5 - 1176.45 MHz (GPS launches after 2010) – When used in combination with L1 C/A and L2C, L5 will provide a highly robust service that may enable sub-meter accuracy without augmentations, and very long range operations with augmentations.

• L1C - 1575.42 MHz (GPS launches after 2016) – Future standard for international interoperability (Galileo, etc.).
New GNSS Satellites will carry Cospas-Sarsat Search and Rescue processors
• Will replace current Low Earth Orbit weather satellites
• “MEOSAR” system will give rise to Next Generation EPIRBs and PLBs
• GPS-like position determination
• Return link service
• Lower power requirement?
• Existing beacons compatible
• New beacons available 2016?
“Volpe Study” released Sep 10, 2001

- GPS susceptible to intentional and unintentional interference
  - Ionospheric disruptions
  - Jamming / Spoofing
  - Satellite destruction by adversary
- GPS used for critical timing applications as well as navigation
- Serious disruption could be mitigated by backup system
  - Safety and economic implications
- Continue Loran-C (eLoran) modernization program
eLoran
• Precise timing enables unified Loran network
• Data channel enables improved performance

Receiver standard for eLoran required
• Receive and use data channel
  • US signal specification
  • Eurofix
  • Others?
• GNSS backup
• GNSS receiver integration / automatic fail-over

U.S. Coast Guard discontinuing Loran-C signal
No decision on eLoran – but not encouraging

Committee adopting a more European focus
Coast Guard Response

Loran-C is no longer required by the armed forces, the transportation sector, or the nation’s security interests.

Backups to GPS for safety-of-life navigation applications, or other critical applications can be:
- other radionavigation systems,
- operational procedures,
- a combination of these systems and procedures.
GPS and other GNSS Systems will provide increasing accuracy and reliability

- Additional frequencies
- Redundant systems

All GNSS Systems have the same vulnerabilities

- Ionospheric disruptions
- Jamming / Spoofing
- Satellite destruction by adversary

- Backup systems not yet adequately addressed
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www.rtcm.org