WAAS for Sub-meter Mapping

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WAAS – What is it?

- Wide Area Augmentation System
  - An Federal Aviation Administration (FAA) program that provides GPS integrity monitoring and improves GPS accuracy.
  - ~$90M-100M annual budget.
WAAS – What is it?

• **What does WAAS do?**
  - Provides position integrity. GPS alone isn’t reliable enough for aviation navigation.
  - The specification when using WAAS is that GPS shouldn’t provide an “out of tolerance” position more than 1 in 100,000,000 times.
  - Provides user notification within six seconds if a position is “out of tolerance”.
  - Ionospheric modeling.
  - Position corrections.
WAAS – What is it?

- WAAS addresses three GPS error sources; ionospheric error, satellite clock error, satellite ephemeris error.
- Error from the ionosphere is the largest and most dynamic.
- WAAS models the effect of the ionosphere that it has on GPS signals passing through it.
WAAS – What is it?

WAAS consists of:

- A network of 38 WAAS Reference Stations (WRS) that are dual frequency (L1/L2) GPS receivers.
- Processing facilities.
- Geostationary satellites.
- Control facilities.
WAAS – What is it?

WAAS
wide area augmentation system

Wide-area Reference Station (WRS)
Wide-area Master Station (WMS)
New WRS’s
Ground Uplink Station

GEO Satellite

GEO Satellite
WAAS – What is it?

PanAmSat 133°W  
Telesat 107°W
WAAS performance

- Elevation of WAAS PRN 138/ SV 51
WAAS performance

- Elevation of WAAS PRN 135/ SV 48
World-wide compatibility
It seems that WAAS is all about aviation.

How does the surveying/mapping community benefit from WAAS?
Trends in GPS mapping

• The survey/mapping community expects smaller, simpler, cheaper GPS sub-meter mapping equipment.
• The user community is moving away from post-process differential correction and towards real-time corrections.
• What are the choices for real-time DGPS corrections?...
Real-time Correction Sources

• **WAAS (SBAS)**
  - free, accurate, North American coverage (US/Alaska, Hawaii, Canada, Mexico), Western Europe (EGNOS), MSAS (Japan).

• **Radio-beacon DGPS/NDGPS**
  - free, accurate, US coverage (parts of Canada), coastlines of 40+ other countries.

• **Commercial DGPS services**
  - subscription-based, accurate, world-wide coverage.

• **RTK networks**
  - subscription-based, very accurate, very limited coverage.
WAAS

- All WAAS-enabled receivers aren’t created equal.
- WAAS was designed for aviation. GPS receivers can be designed to optimize WAAS for ground users.
- Some companies have introduced high performance GPS L1 mapping receivers that exploit WAAS for ground users.
WAAS

- The position integrity bounds (horizontal and vertical) required by the FAA is 99.99999%. Therefore, integrity trumps accuracy.
- If that level of integrity is not required, then integrity can be traded for accuracy.
WAAS performance

Examples of WAAS Mapping users

Examples of WAAS users around North America...
WAAS Mapping users

- J.D. Irving Ltd.
- 15,000 employees
- Industry: Forest Products
- Location: Eastern Canada
- Application: Harvesting timber.
- 300+ high performance WAAS receivers

"Initially, a number of DGPS options were tested, and WAAS proved to penetrate our forest canopy type the best."
“We tested against post-processing units in some of the toughest forestry environments we know of. We are extremely pleased with WAAS performance.”
WAAS Mapping users

- US Nat’l Park Service
- Industry: Gov’t
- Location: Sub-Arctic Alaska
- Application: Map archaeological sites
- 45 high performance WAAS receivers

"Many mapping grade GPS users still do not feel good about relying on WAAS. You can always post-process, but after reading these numbers, some may ask *why bother?*"
WAAS Mapping users

- American Forest Mgt
- 250 employees
- Industry: Forestry
- Location: VA to TX, ME to MI.
- Application: Area calcs, road work, land owner mapping.
- 25 hi-performance WAAS receivers.

“Our field efficiency has drastically increased due to reliable reception and ease of use...office productivity also increased because of real-time correction.”
WAAS Mapping users

- Portland General Electric
- 2,600 employees
- Industry: Utility
- Location: Oregon
- Application: Utility pole mapping
- 15 hi-performance WAAS receivers.

“Four years ago, we started out using low-end WAAS receivers, but switched to mapping-grade WAAS receivers after 60 days due to accuracy problems. 225,000 poles and four years later, we are still using the same WAAS receivers.”
WAAS Mapping users

- State of Minnesota
- Industry: Gov’t
- Location: Minnesota
- Application: Mapping abandoned chem bldgs.
- 5 hi-performance WAAS receivers.

Approximately 500 facilities were mapped using a bluetooth, submeter WAAS GPS and a windows mobile data collector. Wireless technology eliminated connectivity problems and the receivers had Coast technology, consistently giving us submeter, real-time results, even in areas that had poor visibility.
“Signal reliability is probably 95%. Great reception along a forest road. A differentially-corrected file with no post-processing. That is a HUGE timesaver.”
Watch the manufactures

• Both mapping and survey GPS receivers have been introduced that exploit WAAS and the WAAS GEO observables.
Take away messages

• WAAS, when exploited for ground users, is an effective source of GPS corrections throughout North America, Europe and Japan (soon India).
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- The survey/mapping user community clearly prefers a low overhead solution such as WAAS that requires no additional receiver and antenna hardware.

- WAAS, when exploited for ground users, meets the sub-meter accuracy requirements expected of today’s high performance mapping systems.
QUESTIONS?

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WAAS performance report

75cm

- Ave. horizontal accuracy with 95% confidence throughout North America based on more than 7 million measurements per site over a 3 month period.

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