GNSS Interoperability Comments

ICG Interoperability Workshop

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JOHN DEERE

Topics

Deere and Company

High Precision GNSS and Agriculture at Deere

GNSS Interoperability Comments

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Agriculture

A world leader in providing advanced products and services for agriculture and construction

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Critical Role of GNSS Technology in Agriculture

Improved Agricultural Productivity

Input Cost Management and Sustainability

Improved Environmental Impact

Summary of Economic Benefit of GNSS in Ag

Minimum of $8.2 billion annual input savings

Minimum of $6 billion annually in improved yield

Total of savings and yield improvement of over 14 billion annually

Also saves over-application of pesticides and fertilizer on 17.5 to 25 million acres of land per year.

Deere and Precision Agriculture

Deere has been using satellite navigation on its platforms for 16 years – pioneer in precision agriculture

Deere designs and manufactures its own GNSS receivers

Many Deere applications require accuracies of a few centimeters

GNSS alone can't provide the necessary accuracy – differential GNSS augmentation is needed:

- StarFire – global network – 4-10 centimeter accuracy
- RTK (Real Time Kinematic) – dealer and customer networks - 1-2 centimeter accuracy

RTK

RTK is a form of differential GNSS

- A stationary GNSS receiver sends corrections to local mobile GNSS receivers
- Accuracies of two centimeters over ranges of 15 miles are normal
- Deere dealers operate many RTK networks in the US

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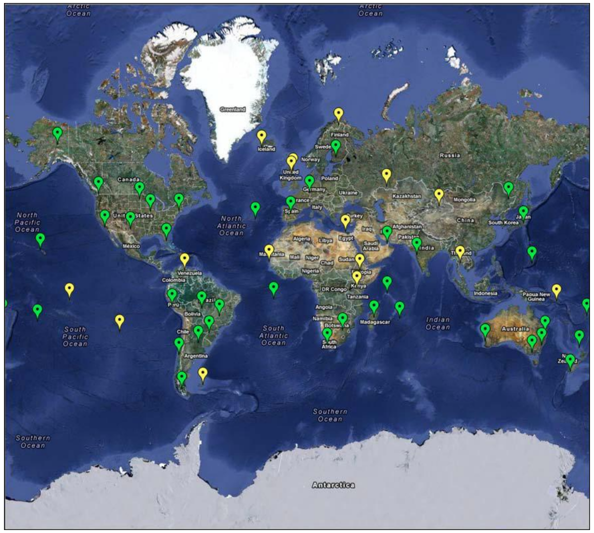
Deere StarFire Network

Distributes differential GNSS corrections via seven Inmarsat L-band satellites to Deere customers worldwide

- Owned and operated by Deere
- Corrections derived from real time data collected at over 50 worldwide GNSS reference stations
- Computations at two Deere Processing Centers are sent to Uplink sites for the satellites
- Deere GNSS receivers use the corrections to achieve high accuracy real time navigation



All seven satellite downlinks are in the Mobile Satellite Service (MSS) L-band (1525-1559 MHz)

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GNSS Receivers

We are delivering our 4th generation GNSS receiver: SF3000

Deere receivers are specifically designed for our customers:

- Very high accuracy
- StarFire and RTK are integral capabilities
- Extremely rugged/reliable (required for Ag and Construction)
- Uses GPS and GLONASS (Russian GNSS), will use Galileo (EU GNSS) and BEIDOU (China) when they are available

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Representative Applications

Yield mapping

Seeding

Precision planting

Precision spraying

Water optimization

Overlap minimization

Production efficiency

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Interoperability Issues – Signal Structure

CDMA signals are preferred over FDMA signals.

Using an offset to the GPS center frequencies for the CDMA signals should be considered to avoid increasing the noise floor while still offering interoperability.

The legacy receivers will continue to use the current signals for many years.

Satellite bandwidth should at least take advantage of all the bandwidth authorized for optimum measurement accuracy, i.e. for improved code recovery accuracy and multipath reduction

Signal quality indicators are preferred to removing or limiting signal power when signals do not meet their intended specification. This can allow continued use in augmentation systems which provide their own quality.

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Interoperability Issues – System Geodesy and Time

Differences in the geodesy and time references should be made available from external sources.

Deere's StarFire and RTK corrections adjust for geodesy and time differences present in the separate constellations.

In general, GNSS and SBAS systems should strive for common geodesy and time standards. However, the use of separate tracking sites will always leave room for some differences.

Interoperability Issues – Three Frequency Carrier Phase Use

Deere expects to take advantage of satellites broadcasting on three frequencies to improve the ability to resolve carrier-phase ambiguities.

The optimum separation of the frequencies is to have them approximately equally separated, but they will be used whatever the separation.

An ideal triple frequency set would be L2, L1 and 1810 MHz which would yield easy to resolve wide-lane ambiguities and result in narrow-lane whole-cycle ambiguities in the refraction corrected combination.

Precise phase coherence between the three frequencies is highly desirable.

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Interoperability Issues – Interference

Vigorous coordinated efforts need to be made to protect the spectrum of the various satellite constellations from encroachment by other systems or from local intentional jamming.

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