Agriculture
And Other High-Precision Applications
NavCom Technology, Inc.
November 6, 2008
Ron Hatch

Stanford’s PNT Challenges and Opportunities Symposium
Agenda

- NavCom Technology, Inc.
- StarFire, RTK and RTK Extend
- Agriculture Applications
- Other Applications
**First 80 Years**

1837  John Deere Makes Self Scouring Plow

**Second 80 Years**

1918  John Deere Buys Waterloo Boy Tractor

**The Next 80 Years...**

1999 John Deere buys NavCom Technology
Who We Are Today

- Acquired by Deere & Co. in November 1999
  - Member of IMET Division of Deere with Phoenix International and IVS

- Evolved from a provider of contract engineering services to a rapidly growing system integration company

- Major Business Areas
  - Contract Engineering
  - Proprietary Products
    - Wireless communication
    - Precise positioning
  - Product Services
    - Global GPS Corrections
    - *(StarFire™)*
NavCom’s Markets

Agriculture

• Precision Agriculture (AutoTrac)
  • 80,000+ deployed units
  • Growing at about 40% per year

Technologies

RTK
Nova
RTK-X
LRTK
StarFire

NavCom OEM
NavCom Charter

- NavCom is the GNSS technology steward of John Deere
  - The agricultural market – estimated growth rate of 40% per year
- NavCom owns and operates the StarFire Global DGPS network
- NavCom offers comprehensive Contract Engineering services for projects that need the above specialties
- NavCom also offers products & services for other applications:
  - Offshore market
  - Survey Applications
  - GIS
  - Machine Control and Asset Management
  - Military systems
What is StarFire?

- Worldwide GPS - Satellite Based Augmentation System (SBAS)
- Broadcasts GPS satellite clock and orbit corrections
- Utilizes six L-band satellites in geosynchronous orbits to provide duplicate global coverage

Provides 10 cm positioning anywhere on earth (or above it)
StarFire Global Differential GPS Overview

- Network of GPS Reference Sites
- User Equipment on Ag Machine
- Processing Hubs
- L-Band Communications Satellite
- DGPS Corrections
- GPS
- DGPS Corrections
- GPS
- GPS
- Land Earth Station
- GPS
- GPS

Network of GPS Reference Sites
StarFire System - User

User – Receivers and System

Ground Tracking - Global Network

Space – Signal Distribution

Control - Processing Center
StarFire Corrections via Communication Satellites

- **Worldwide Accuracy**
  - Dual Freq. = 10 cm**
  - Single Freq. = 50 cm**

- **No spatial de-correlation**
  - Distance to reference stations not relevant

- **RTK Extend**
  - RTK
  - With StarFire as backup

- **Reference Data**
  - StarFire Reference Station data for specialized applications
StarFire Receivers

**Worldwide decimeter accuracy in real-time**

- **StarFire iTC**
  - Dual frequency GPS receiver
  - Integrated Terrain Compensation (iTC)
    - Compensates for cab roll caused by uneven terrain
    - Improves vehicle guidance and row-following

- **StarFire SF-2050 Series:**
  - for Offshore, Survey, Government markets
Realtime kinematic GPS navigation techniques (RTK) offer superior performance in accuracy and repeatability for precise row crop operations.

However, RTK is dependent on maintaining a communication link with a local base station.

Often the most practical choice for this link is a radio modem operating in available, unlicensed bands with frequency and power restrictions that make them vulnerable to blockage.

Dual frequency, wide-area dGPS systems, if initialized properly can serve as a backup during RTK outages.
RTK Extend – Radio link blockage illustration

RTK Base Station with line of sight communications link
RTK-RTG Fallback Test, Deere Test Facility, Aguila, Arizona 10/24/03

- **Delta Northings and Eastings (meters)**

- **Gap #2 Statistics**

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<tr>
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<tr>
<td>Max (m.)</td>
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- **RTK gap #1**
  - 4 minutes stationary

- **RTK gap #2**
  - 17 minutes all dynamic

- **RTK gap #3**
  - 5 minutes stationary
Agricultural Applications

- Precision Farming
- Water Management
- Automatic Steering
- Control Traffic
GPS Guidance benefits

- Allows controlled traffic
- Reduces compaction, boost yields
- Greater machine utilization
- Less experienced operators achieve excellent results
- Significantly less operator stress and fatigue
- Night time operation
Benefits of GPS Guidance

- Virtually eliminates implement overlap
- Significant reduction of input costs – fuel, seed, fertilizer, herbicides
- More precise field operations
- Faster field speeds, more acres per day
“Driving” with GPS Guidance

- More focus on implement and tractor functions
- Able to work more hours, with less fatigue
- Less skilled operators achieve good results
- Ability to perform nighttime field operations
Current Developments in Ag

- Increased use of real time communications
- Leader / Follower (i.e. automated off-loading)
- Fleet operations—single operator
 Estimates are that there are somewhere in the vicinity of 300,000 to 400,000 agricultural GPS receivers currently employed.

 Estimated payback time is one to one and a half years on receiver equipment.

 Conservative estimate: 300,000 receivers at $7,500 per receiver with 600 days to payback is: $3,750,000 per day of economic worth
Other NavCom Applications

Offshore Operations

Machine Control

Aerial Survey

Surveying
Other NavCom Applications

- Aerial survey
- Unmanned aerial vehicles
- Military (AMSTE, CRISS)
- StarFire orbital data
- Commercial navigation scoring
- Unmanned ground vehicles (DARPA Grand Challenge)
- Irrigation Control

- Offshore Survey
  - Very high value
- Oceanographic
  - Coastal marrying of RTK and StarFire
- Near-Shore Vessels
- Land Survey
- GIS mapping
- Machine Control
- Container Tracking
- LNG Docking
Positioning and Navigation for UAVs

- Real-time 10 cm. positioning
- No post-processing required
AMSTE IIB Program

StarFire™ provides Affordable Moving Surface Target Engagement

Product: Contract Engineering, StarFire
GPS constellation data provided by StarFire allows modeling of GPS errors

Provides the most precise navigation software solution available to the SATNAV community
Boeing’s GPS/INS navigation systems
(Truth reference for scoring)

- Real-time 10 cm. positioning
- No post-processing required
- No communication range limitations

Product: VueStar
StarFire – DARPA Grand Challenge navigation solution to:

- 6 of the qualifying teams in 2004
- 13 of the qualifying teams in 2005
Offshore Survey

- C-Nav survey system
- 10cm accuracy globally

- StarFire C-Nav receiver
- Capable of decimeter positioning mid-ocean

Product: Custom Receiver Solution, StarFire Network
System Integration of RTK/StarFire GPS Receiver for NAVOCEANO

- Seamless navigation from inshore Hydrographic white ships (no guns) for the Navy to Oceanographic depths with shipboard and land-based stations.

Product: Contract Engineering, StarFire + RTK
LandCom - Chile

RTK replaces optical guidance technology for near shore vessels working as part of a local municipality

High degree of customer satisfaction from time savings
FLEX RTK Survey System

- SMI controller software
- GPS pole mount receiver with built in RTK radio link

Product: RT-3010S
GIS StarFire System

- Mapping software on an iPAQ controller
- 10 cm accuracy – No base station required
Machine Control

- Machine guidance and control
- Real-time earthmoving calculations

**Digmaster Pro:**
Graphical depth and profile monitoring for excavator solutions

Product: SF-2050M
Locating containers within a shipyard via RTK vehicle tracking

Product: NCT-2000D, OEM board
Portable system for docking of Liquid Natural Gas vessels

Product: SF-2050M
Thank you