The BOW GNSS Receiver Project

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INTRODUCTION TO GNSS CONCEPTS
GNSS: Global Navigation Satellite System

• A system employing satellites to provide global navigation information to users
• There are four GNSS systems
  • Galileo European Union (fully deployed 2020)
  • BEI-DOU China
  • GLONASS Russia
  • GPS US
• We’ll describe GPS as an example of how GNSSs work

• The GPS system is divided into three segments
  • GPS Space Segment (SS): 24+ Satellites
  • GPS Control Segment (CS): 16 sites
  • GPS User Segment (US): Half the world’s population?
**GPS Technology Basics**

**Six orbits, four satellites in each**

Each satellite has a schedule for broadcasting messages containing:

- Satellite identity,
- Time message transmitted (T\textsubscript{tx})
- Satellite’s precise location at T\textsubscript{tx}

1. **GPS Receiver**
   - Determines time it received message (T\textsubscript{rx})

2. Uses satellite’s T\textsubscript{tx} to determine distance \(d\) from receiver to satellite

3. Combines \(d\) from at least 4 satellites to determine:
   - Latitude
   - Longitude
   - Altitude

As a first approximation, \(d\) is \((T_{rx} - T_{tx})c\)

- GPS Satellite orbit: 22,000 kilometers (14,000 miles)
- Hubble and ISS orbits: \~400 kilometers (250 miles)

*10/28/2015* Presentation to Wellesley College GIS Summit
## Existing GNSS Receiver Types in 2014

<table>
<thead>
<tr>
<th>Surveying</th>
<th>Self-driving tractors</th>
<th>Undergraduate Research</th>
<th>Find way home</th>
</tr>
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<tbody>
<tr>
<td>$20K+</td>
<td>$2K</td>
<td>$20</td>
<td></td>
</tr>
<tr>
<td>Centimeter ½ inch</td>
<td>Decimeter 6 inches</td>
<td>Accuracy</td>
<td>Ten meters 30 feet</td>
</tr>
</tbody>
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- **Missing Link!**
- **Opportunity**
- **For BOW President’s Fund Project**

- Way too expensive
- Too expensive
- Inadequate Technology

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Way too expensive               Too expensive               Just right               Inadequate Technology

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BOW GPSS Receiver Goals

• Primary goal:
  • Actual shared technology between BOW colleges
  • Education about shared technology (here you are!)

• GPSS Receiver Objectives:
  • Low Price (about $200 for whole receiver)
  • High Accuracy (looking for 1M accuracy)
  • Useful on all BOW campuses
    • Easy to adapt to different project types
    • Makes new technology available as soon as possible
  • Architectural design
    • Projects independent of GNSS technology changes
BOW GNSS Receiver technology search

Chosen for initial technology testing
u-blox GNSS chip

informal sanity testing

Upward compatible programming interface

Informal accuracy measurements

Quantity 1 prices

4 constellation

iPhone6

Ublox6

Ublox6P

Ublox7P

Ublox m8n

15m

15m

3m

1.8m

1.2m

0.6m

3DR

$89

$214

$119

$69

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GNSS Receiver Application

Olin College Team Sailing Project

*Navigation system to let competitive blind sailors be more autonomous.*

First on-water BOW GNSS Receiver Test

Olin College Research Boat Sailing in Charles River Basin

August 14, 2015
Cooperation with Wellesley

• Working with Prof. Katrin Monecke, Wellesley Department of Geosciences
  GNSS Receiver appropriate for Bathymetric research
  (How deep is the ocean?)
• Focus is for altitude (Z) accuracy
  • Harder than X/Y
Nice to talk to you!

Jason and Alex
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