Advantages & Limitations of GPS in Disaster Management

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What is this instrument?
What is this instrument?
What is this instrument?

https://www.youtube.com/watch?v=OG8gDXeTDHM

https://www.youtube.com/watch?v=q20-DBAmm2E

Robotic ETS
What is this instrument?
What is this instrument?
What is this instrument?
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NAVSTAR GPS

NAVSTARGPS (NAVigation System with Time And Ranging Global Positioning System)

• Satellite based Positioning and Time transfer System
• Designed, financed, deployed and operated by US DoD
• Development work of GPS commenced within the DoD in 1973
• The objective was to design and deploy an all weather, 24 hour, global, satellite based navigation system to support the positioning requirement of US armed forces and its allies
What is GPS?

The Global Positioning System (GPS) is a Constellation of Earth-Orbiting Satellites Maintained by the United States Government for the Purpose of Defining Geographic Positions On and Above the Surface of the Earth. It consists of Three Segments:

- Space Segment
- Control Segment
- User Segment
Space Segment Description

28 satellites

- 6 planes with 55° Inclination
- Each plane has 4-5 satellites
- Broadcasting position and time information on 2 frequencies
- 1 revolution in approximately 12 hrs
How the system works

Space Segment
24+ Satellites

Monitor Stations
- Diego Garcia
- Ascension Island
- Kwajalein
- Hawaii
- Colorado Springs

GPS Control
Colorado Springs

The Current Ephemeris is Transmitted to Users

User
Control Segment

1. Correct Orbit and clock errors
2. Create new navigation message
3. Observe ephemeris and clock

(5) Monitor Stations

Upload Station
Distance Measuring

The whole system revolves around time!!!

Signal Transmitted time from satellite \(- T_t\)

Signal receiving time by receiver \(- T_r\)

Synchronization error in satellite and receiver clock \(- T_o\)

Satellite position \((X_i, Y_i, Z_i)\) - Known

Receiver Position \((X_o, Y_o, Z_o)\) – Unknown

Speed of signals \(- c \) (velocity of light)

Signal Travel Time \(= (T_r - T_t) + T_o\)

Range \(R = c \{(T_r - T_t) + T_o\} = \sqrt{(X_i - X_o)^2 + (Y_i - Y_o)^2 + (Z_i - Z_o)^2}\)

Or \(c (T_r - T_t) = \sqrt{(X_i - X_o)^2 + (Y_i - Y_o)^2 + (Z_i - Z_o)^2} - c T_o\)
Triangulation

Satellite 1

Satellite 2

Satellite 3

Satellite 4

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GPS Signal Structure

The satellite signals basically consists of:

- The two L band carrier waves
- The ranging codes modulated on carrier waves
  - **C/A code** ("clear/access" or "coarse/acquisition" code)
  - **P - code** ("private" or "precise“ or “protected” code)
- The Navigation Message
Each NAVSTAR satellite transmits ranging signals on two L-band frequencies, designated as L1 and L2 carrier waves.

- L1 is the principal GPS carrier signal
- The frequency of L1 carrier wave is 1575.45 MHz
- The wavelength of L1 carrier wave is approximate 19cm
- L1 Carrier wave is modulated with P(Y) code, C/A code and Navigation message.
The Carrier Waves [2]

- L2 carrier is transmitted at a frequency of 1227.60 MHz
- It has a wavelength approximate 24cm
- L2 carrier wave is modulated only with P (Y) code & Navigation message
- This signal provide a means of estimating the ionosphere delay to GPS measurement.

As the name implies the carrier waves means by which the ranging codes and navigation message is transmitted to earth (and hence to the user).
Other Carrier Waves

- **L3 carrier** is transmitted at a frequency of **1381.05 MHz**
  - Used by defense support program to signal detection of missile launches
  - Nuclear detonations and other high energy infrared events

- **L4 (1379.913MHz)** carrier is being studies for additional ionosphere correction.

- **L5 (1176.45MHz)** carrier proposed for the use as a civilian safety of life (SoL)
The Ranging Codes

Two ranging codes are used:

• The C/A code, the "clear/access" or "coarse/acquisition" code (sometimes also referred to as the "S code")

• The P code, the "private" or "precise" or “protected” code

• The primary function of the ranging codes is to determine the signal transit time from satellite to the receiver.

• The transit time when multiplied by the speed of electromagnetic radiation (=299792458m/s in a vacuum) gives the receiver – satellite range.
Navigation Message

• GPS signals are also modulated with navigation message
• This contain the information such as:
  o The satellite orbital data (broadcast ephemeris)
  o Satellite almanac data for the entire constellation
  o Satellite clock correction parameters
  o Satellite health and constellation status
  o Ionosphere model parameters for single frequency users
Uncertainties Associated with GPS

• Satellite:
  o Satellite Clock Error
  o Satellite Position (Ephemeris) Error

• Signal Propagation:
  o Atmospheric Interference (ionosphere and troposphere)

• Receiver:
  o Receiver Clock Errors
  o Receiver Environment Errors (Multipath)
  o Signal Noise
Common Problems – Errors [1]

- Direct Signal
- Reflected Signal
- GPS Antenna
- Satellite
- Reflected Signal
- Hard Surface

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Common Problems – Errors [2]

• Errors Caused By GPS Multipath Reflections
  o Use Ground Plane On Antenna
  o Move Away From Reflective Surfaces

• Influences on the GPS Signal
  o Radar
  o Microwave
  o ILS or Radio NDB Equipment
  o ATC Radio Traffic
GPS Multipath Errors

Effects of Multipath on the GPS Signal

- Avoid Reflective Surfaces
- Use A Ground Plane Antenna
- Use Multipath Rejection Receiver
GPS Antenna

- Antenna height in relation to unknown point
  - Follow manufacturer’s instructions
  - Take more than one measurement (cm and in)
  - Most common error!!!
Dilution Of Precision [1]

A Measure of The Geometry Of The Visible GPS Constellation

Good DOP

Poor DOP

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Dilution Of Precision [2]

- PDOP = Position Dilution Of Precision (*Most Commonly Used*)
- VDOP = Vertical Dilution Of Precision
- GDOP = Geometric Dilution Of Precision
- HDOP = Horizontal Dilution Of Precision
- TDOP = Time Dilution Of Precision

<table>
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<th>QUALITY</th>
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<tr>
<td>Very Good</td>
<td>1-3</td>
</tr>
<tr>
<td>Good</td>
<td>4-5</td>
</tr>
<tr>
<td>Fair</td>
<td>6</td>
</tr>
<tr>
<td>Suspect</td>
<td>&gt;6</td>
</tr>
</tbody>
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Survey planning is critical to obtain GOOD data.
Advantage of GPS in Disaster Management

• Easy to use

• Greatest advantage is, its ability to be used at any time of the day under any weather condition.

• It has 100% coverage of the planet

• GPS is free for all users, as such it can be used to manage disaster from anywhere in the world.

• GPS is used at every stage of a disaster event, right from the pre-disaster, during disaster and post-disaster events.

• Easy integration with other geospatial technologies that aid in disaster management
Limitations of GPS In Disaster Management

• Since GPS is mainly concerned with precise positioning, most of its limitation are related to accuracy

• Since GPS satellite signals are weak, we cannot work inside the house or under water
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