

## **CE-317 GIS/RS Application to Civil Engineering Spring 2011**

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- Lecture 07: GPS & GPS Errors

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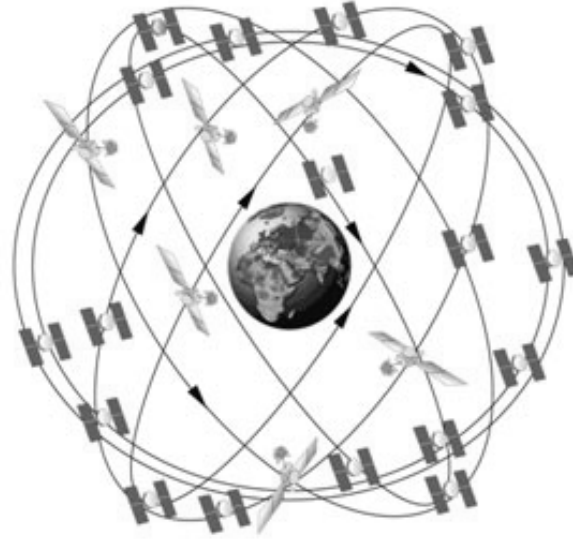
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## **Presentation Outline**

- GPS
- Components
- Services
- Orbit
- Uses
- Errors
- Other SAT-NAV System

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## GPS

- The Global Positioning System (GPS) is a U.S.-owned utility that provides users with **positioning, navigation, and timing (PNT)** services.
- This system consists of three segments:
  - 1.the space segment,
  - 2.the control segment,
  - 3.and the user segment.
- The U.S. Air Force develops, maintains, and operates the space and control segments.

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## 1. Space Segment

- The space segment consists of a nominal constellation of 24 operating satellites that transmit one-way signals that give the current GPS satellite position and time

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## 2. Control Segment

- The control segment consists of worldwide monitor and control stations
- It maintain the satellites in their proper orbits through occasional command maneuvers, and adjust the satellite clocks.
- It tracks the GPS satellites, uploads updated navigational data, and maintains health and status of the satellite constellation.

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### **3. User Segment**

- The user segment consists of the GPS receiver equipment, which receives the signals from the GPS satellites and uses the transmitted information to calculate the user's three-dimensional position and time.

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### **GPS Services**

- GPS satellites provide service to civilian and military users.
- The civilian service is freely available to all users on a continuous, worldwide basis.
- The military service is available to U.S. and allied armed forces as well as approved Government agencies.

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# GPS Services

## 1. Augmentations

- A variety of GPS **augmentation systems** and techniques are available to enhance system performance to meet specific user requirements.
- These improve signal availability, accuracy, and integrity, allowing even better performance than is possible using the basic GPS civilian service.

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# GPS Services

## 2. Performance

- The outstanding performance of GPS over many years has earned the confidence of millions of civil users worldwide.
- It has proven its dependability in the past and promises to be of benefit to users, throughout the world, far into the future.

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## Augmentations

- **Nationwide Differential GPS System (NDGPS)**
  - Map of NDGPS coverage NDGPS is a ground-based augmentation system that provides increased **accuracy and integrity of GPS information** to users on U.S. land and waterways.
- **Wide Area Augmentation System (WAAS)**
  - WAAS, a satellite-based augmentation system operated by the **Federal Aviation Administration (FAA)**, **supports aircraft navigation** across North America.

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## Augmentations

- **Continuously Operating Reference Stations (CORS)**
  - The U.S. CORS network, managed by the **National Oceanic and Atmospheric Administration**, archives and **distributes GPS data for precise positioning** tied to the National Spatial Reference System.
- **Global Differential GPS (GDGPS)**
  - GDGPS is a high accuracy GPS augmentation system, developed by the NASA Jet Propulsion Laboratory (JPL) to support the real-time positioning, timing, and determination requirements of **NASA** science missions

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## Augmentations

- **International GNSS Service (IGS)**

- IGS is a network of over 350 **GPS monitoring stations from 200 contributing organizations** in 80 countries.

- Its mission is to provide the highest quality data and products as the standard for global navigation satellite systems (GNSS) in support of Earth science research, multidisciplinary applications, and education, as well as to facilitate other applications benefiting society.

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## Augmentations

- **Other Augmentations**

- There are many other GPS augmentation systems available worldwide, both government and commercial.

- These systems use differential, static, or real-time techniques.

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## Satellite Orbits

- GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately **20,200 km**.
- Each satellite circles the Earth **twice a day**.
- The satellites in the GPS constellation are arranged into **six orbital planes**.
- Each containing **four primary satellites**.
- This **24-slot** arrangement **ensures** there are always **at least four satellites** in view from virtually any point on the planet.

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## Civilian Uses

- 1. Cellular telephony:** emergency calls and other applications.
- 2. Disaster relief/emergency services:** Depend upon GPS for location and timing capabilities.
- 3. Geofencing??:** Vehicle tracking systems, person tracking systems, and pet tracking systems use.
- 4. Geotagging:** Applying location coordinates to digital objects such as photographs and other documents for purposes such as creating map overlays.

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## Civilian Uses

**5.GPS Aircraft Tracking**

**6.GPS tours**

**7.Map-making**

**8.Navigation**

**9.Phasor measurement units:** GPS enables highly accurate timestamping of power system measurements, making it possible to compute phasors.

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## Civilian Uses

**10.Recreation:** For example, geocaching, geodashing, GPS drawing and waymarking.

**11.Surveying:** Surveyors use absolute locations to make maps and determine property boundaries.

**12.Tectonics:** GPS enables direct fault motion measurement in earthquakes.

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## Military Uses

1. Navigation
2. Target tracking
3. Missile and projectile guidance
4. Search and Rescue
5. Reconnaissance
6. Nuclear detonation detectors

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## GPS Errors

- 1. Selective Availability (solved):** Selective availability is an artificial falsification of the time in the L1 signal transmitted by the satellite.
- 2. Satellite geometry:** Simplified, satellite geometry describes the position of the satellites to each other from the view of the receiver.
  1. If a receiver sees 4 satellites and all are arranged for example in the north-west, this leads to a “bad” geometry.
  2. In the worst case, no position determination is possible at all

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## GPS Errors

**3.Satellite Orbits:** Although the satellites are positioned in very precise orbits, slight shifts of the orbits are possible due to gravitation forces.

- Sun and moon have a weak influence on the orbits
- The resulting error being not more than 2 m.

**4.Multipath:** The multipath effect is caused by reflection of satellite signals (radio waves) on objects.

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## GPS Errors

**5.Atmospheric effects:** Another source of inaccuracy is the reduced speed of propagation in the troposphere and ionosphere.

**6.Clock inaccuracies and rounding errors:** Despite the synchronization of the receiver clock with the satellite time during the position determination

- the remaining inaccuracy of the time still leads to an error of about 2 m, rounding and calculation errors to 1 m.

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## GPS Errors

**7. Relativistic effects:** GPS navigation and must be accurate to 20 - 30 nanoseconds to ensure the necessary accuracy.

- Therefore the fast movement of the satellites themselves (nearly 12000 km/h) must be considered.

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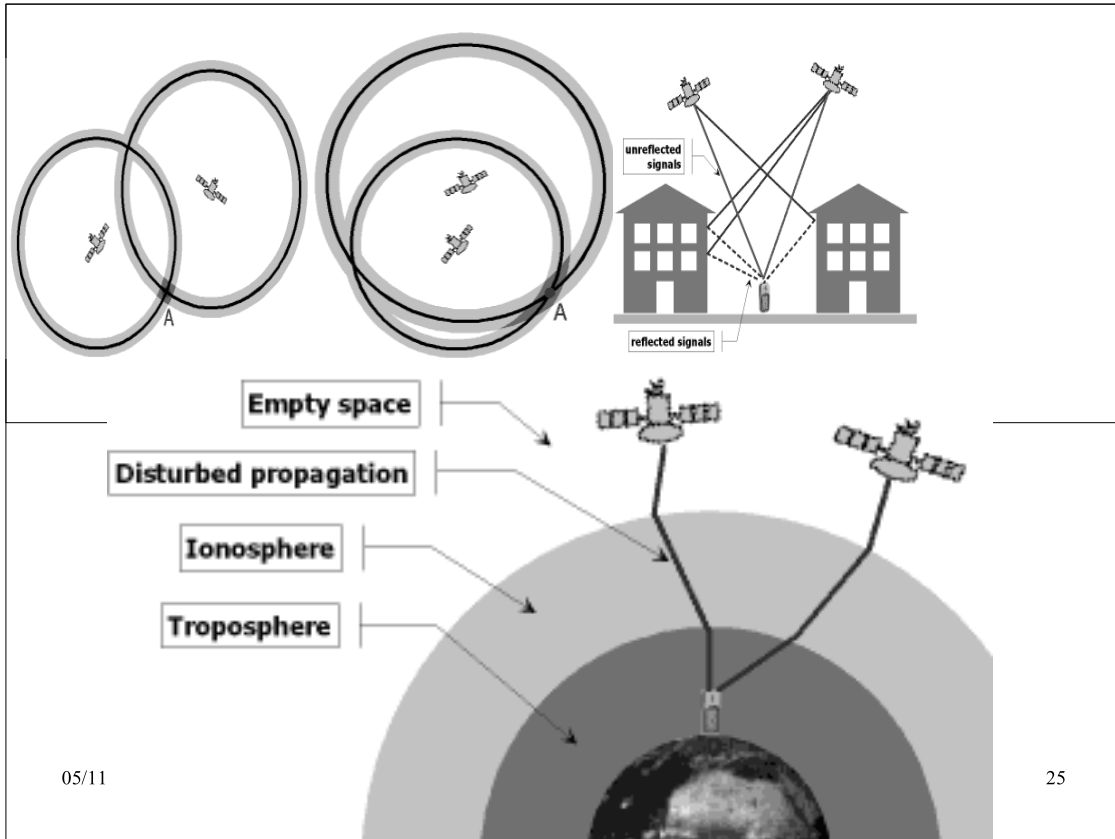
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## Other SAT-NAV Systems

- **GLONASS** is a radio-based satellite navigation system operated for the Russian government by the Russian Space Forces.
- Chinese **Compass** navigation system also **Beidou-2, BD2**
- **Galileo** positioning system of the European Union (EU) and
- Indian Regional Navigational Satellite System (**IRNSS**) of India.

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# Q n A

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