Global Positioning System
GPS

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CLASS : VP10VT

CONTENT

- INTRODUCTION TO GPS
- GPS OPERATION
- GPS APPLICATION

Introduction to Global Positioning System

- The Global Positioning System was conceived in 1960 under the auspices of the U.S. Air Force, but in 1974 the other branches of the U.S. military joined the effort.
- The first satellites were launched into space in 1978. The System was declared fully operational in April 1995.
- The Global Positioning System consists of 24 satellites, that circle the globe once every 12 hours, to provide worldwide position, time and velocity information.

What is the Global Positioning System?

- GPS makes it possible to precisely identify locations on the earth by measuring distance from the satellites. GPS allows you to record or create locations from places on the earth and help you navigate to and from those places.
- Originally the System was designed only for military applications and it wasn't until the 1980's that it was made available for civilian use also.

The 3 segments of GPS

- The Global Position System has 3 segments:

  _ The Space segment.

  _ The Control segment.

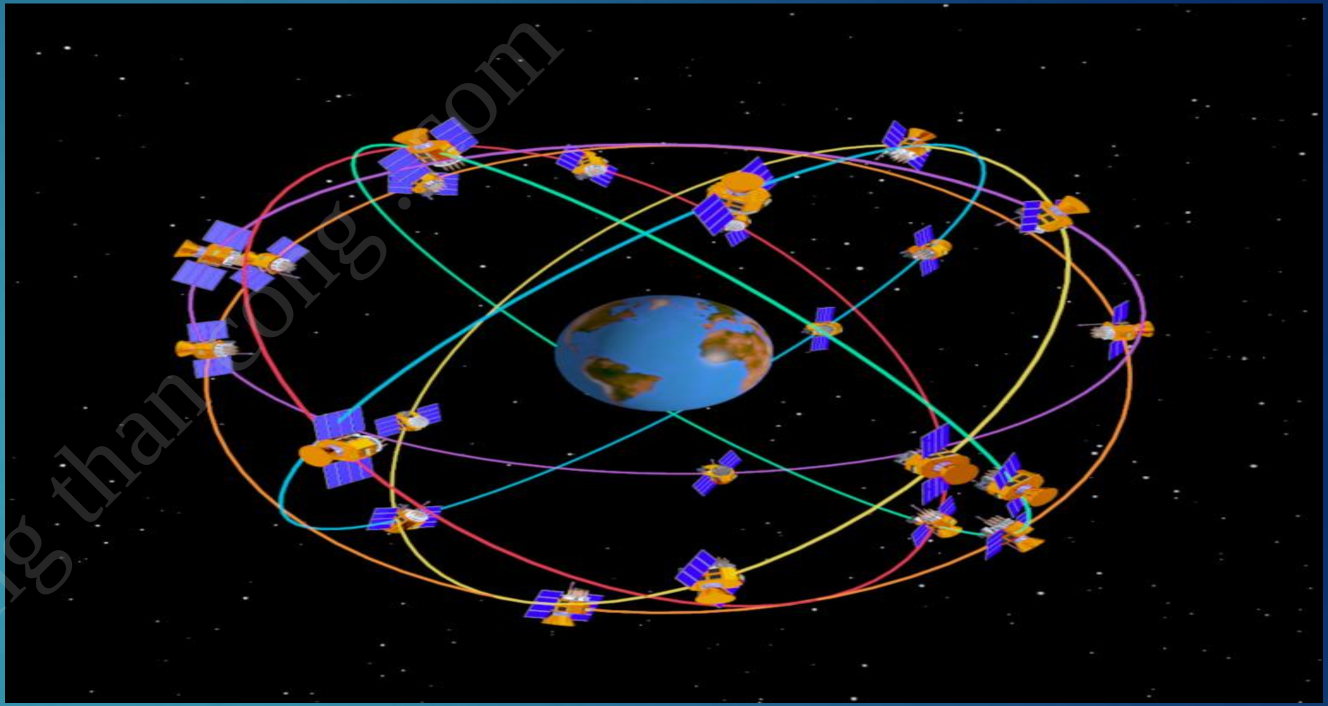
  _ The User segment.

The Space segment: The GPS Constellation

- The first GPS satellite was launched by the U.S. Air Force in early 1978. There are now at least 24 satellites orbiting the earth at an altitude of about 11,000 nautical miles. The high altitude insures that the satellite orbits are stable, precise and predictable, and that the satellites' motion through space is not affected by atmospheric drag. These 24 satellites make up a full GPS constellation.
- The GPS satellites are powered primarily by sun-seeking solar panels, with nicad batteries providing secondary power. On board each GPS satellite are four atomic clocks, only one of which is in use at a time. These highly accurate atomic clocks enable GPS to provide the most accurate timing system that exists.

The Space segment
Satellite Orbits

- There are four satellites in each of 6 orbital planes. Each plane is inclined 55 degrees relative to the equator, which means that satellites cross the equator tilted at a 55 degree angle. The system is designed to maintain full operational capability even if two of the 24 satellites fail.



GPS satellites complete an orbit in approximately 12 hours, which means that they pass over any point on the earth about twice a day. The satellites rise (and set) about four minutes earlier each day.

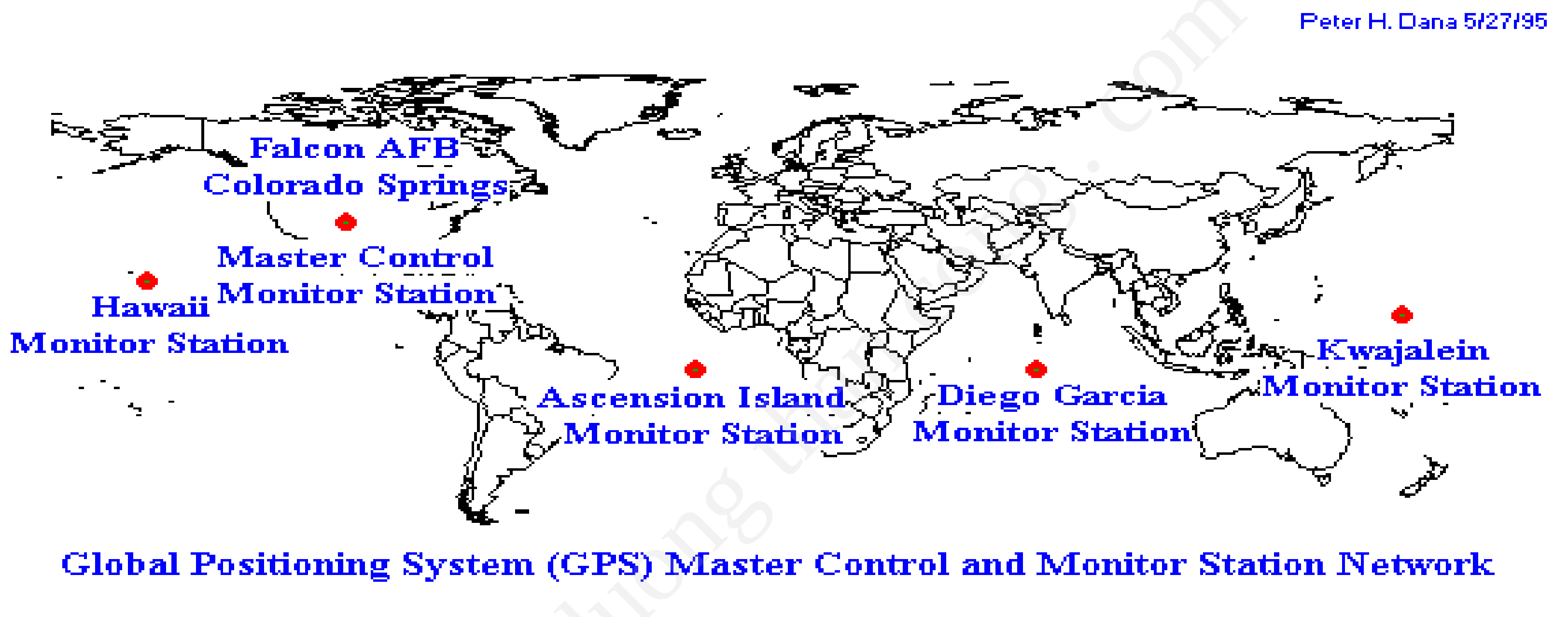
The Space segment
Satellite Signals

- GPS satellites continuously broadcast satellite position and timing data via radio signals on two frequencies (L1 and L2). The radio signals travel at the speed of light (186,000 miles per second) and take approximately 6/100ths of a second to reach the earth.
- The satellite signals require a direct line to GPS receivers and cannot penetrate water, soil, walls or other obstacles. For example, heavy forest canopy causes interference, making it difficult, if not impossible, to compute positions. In canyons (and "urban canyons" in cities) GPS signals are blocked by mountain ranges or buildings. If you place your hand over a GPS receiver antenna, it will stop computing positions.

The Space segment
Satellite Signals

- Two kinds of code are broadcast on the L1 frequency (C/A code and P code). C/A (Coarse Acquisition) code is available to civilian GPS users and provides Standard Positioning Service (SPS). Using the Standard Positioning Service one can achieve 15 meter horizontal accuracy 95% of the time. This means that 95% of the time, the coordinates you read from your GPS receiver display will be within 15 meters of your true position on the earth. P (Precise) code is broadcast on both the L1 and L2 frequencies. P code, used for the Precise Positioning Service (PPS) is available only to the military. Using P code on both frequencies, a military receiver can achieve better accuracy than civilian receivers. Additional techniques can increase the accuracy of both C/A code and P code GPS receivers.

Control Segment: U.S. DoD Monitoring



The U.S. Department of Defense maintains a master control station at Falcon Air Force Base in Colorado Springs, CO. There are four other monitor stations located in Hawaii, Ascension Island, Diego Garcia and Kwajalein. The DoD stations measure the satellite orbits precisely. Any discrepancies between predicted orbits and actual orbits are transmitted back to the satellites. The satellites can then broadcast these corrections, along with the other position and timing data, so that a GPS receiver on the earth can precisely establish the location of each satellite it is tracking.

User Segment: Military and Civilian GPS Users

- The U.S. military uses GPS for navigation, reconnaissance, and missile guidance systems. Civilian use of GPS developed at the same time as military uses were being established, and has expanded far beyond original expectations. There are civilian applications for GPS in almost every field, from surveying to transportation to natural resource management to agriculture. Most civilian uses of GPS, however, fall into one of four categories: navigation, surveying, mapping and timing.

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- GPS APPLICATION

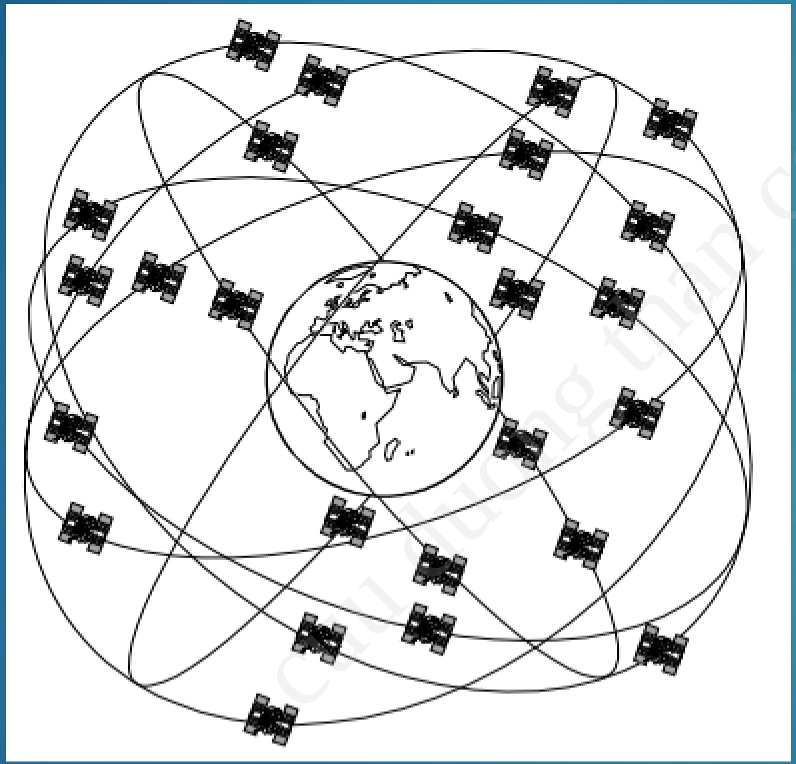
How does GPS work?

- GPS MADE SIMPLE
- GPS, THE TECHNOLOGY

GPS MADE SIMPLE

- Generating GPS signal transit time
- Determining a position on a plane
- The effect and correction of time error

Generating GPS signal transit time



28 Satellites inclined at 55° to the equator
Orbit the Earth every 11 hours and 58 minutes at a height of 20,180 km on 6 Different orbital planes

Figure : GPS satellites orbit the Earth on 6 orbital planes

Generating GPS signal transit time

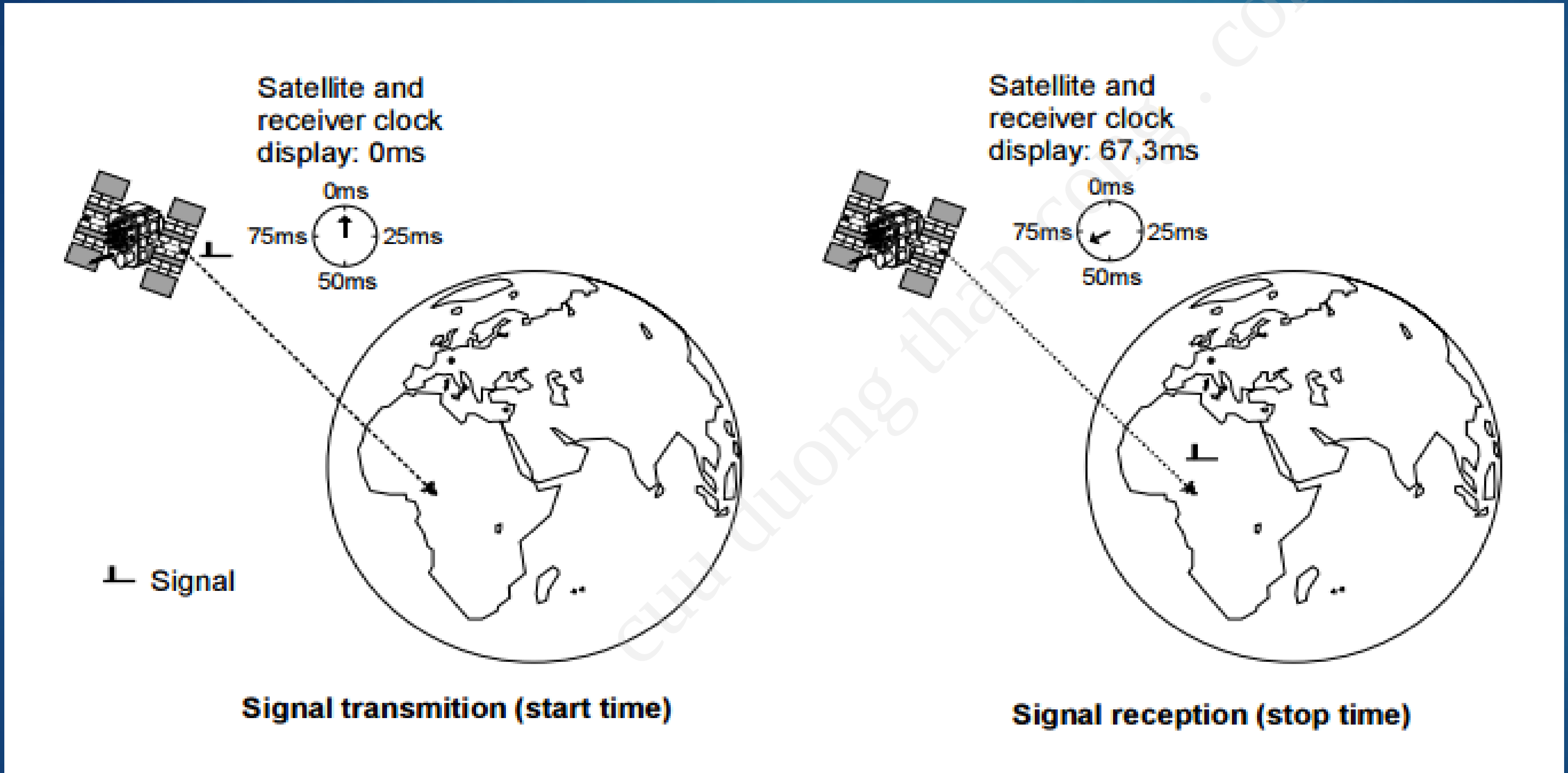


Figure :Determining the transit time

transit time (t) =stop time – start time (s)

Distance = t*c (m)

Determining a position on a plane

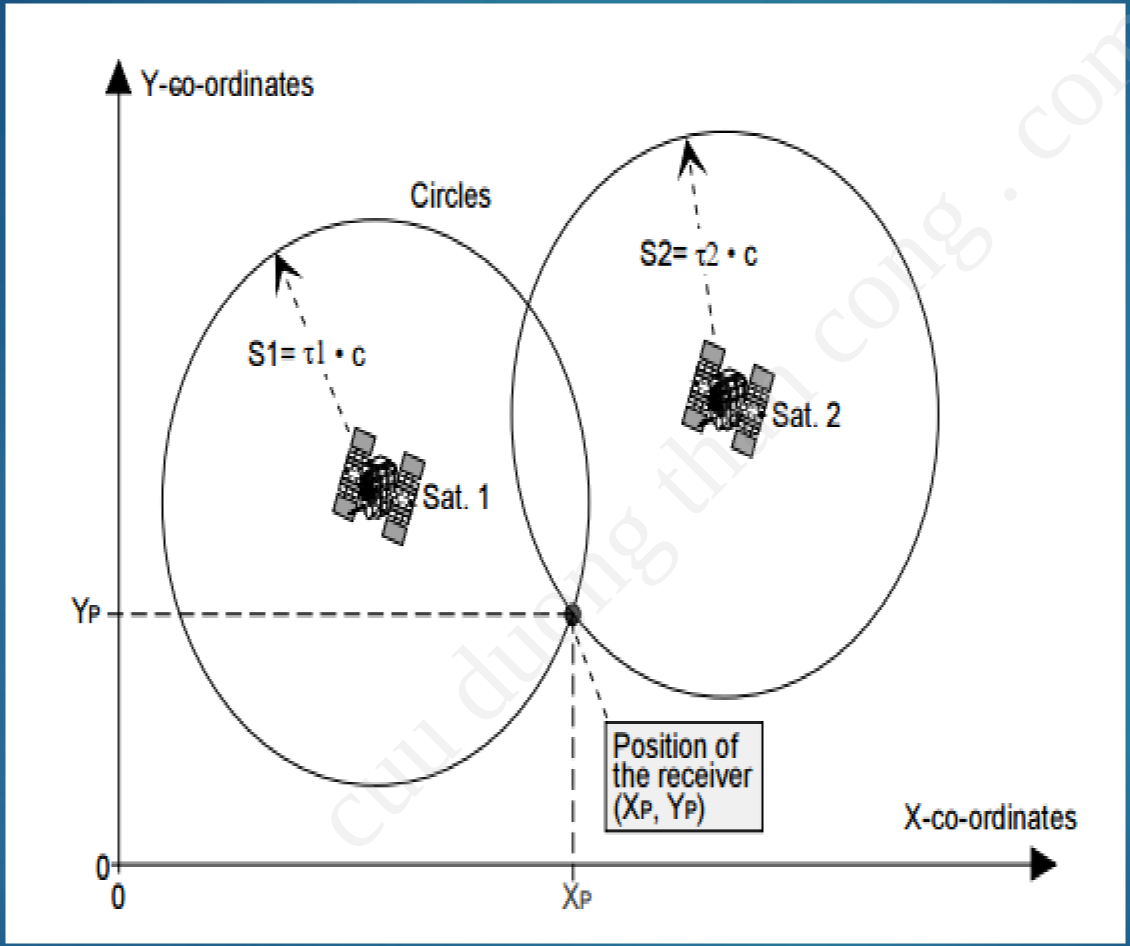


Figure : The position of the receiver at the intersection of the two circles

Determining a position on a plane

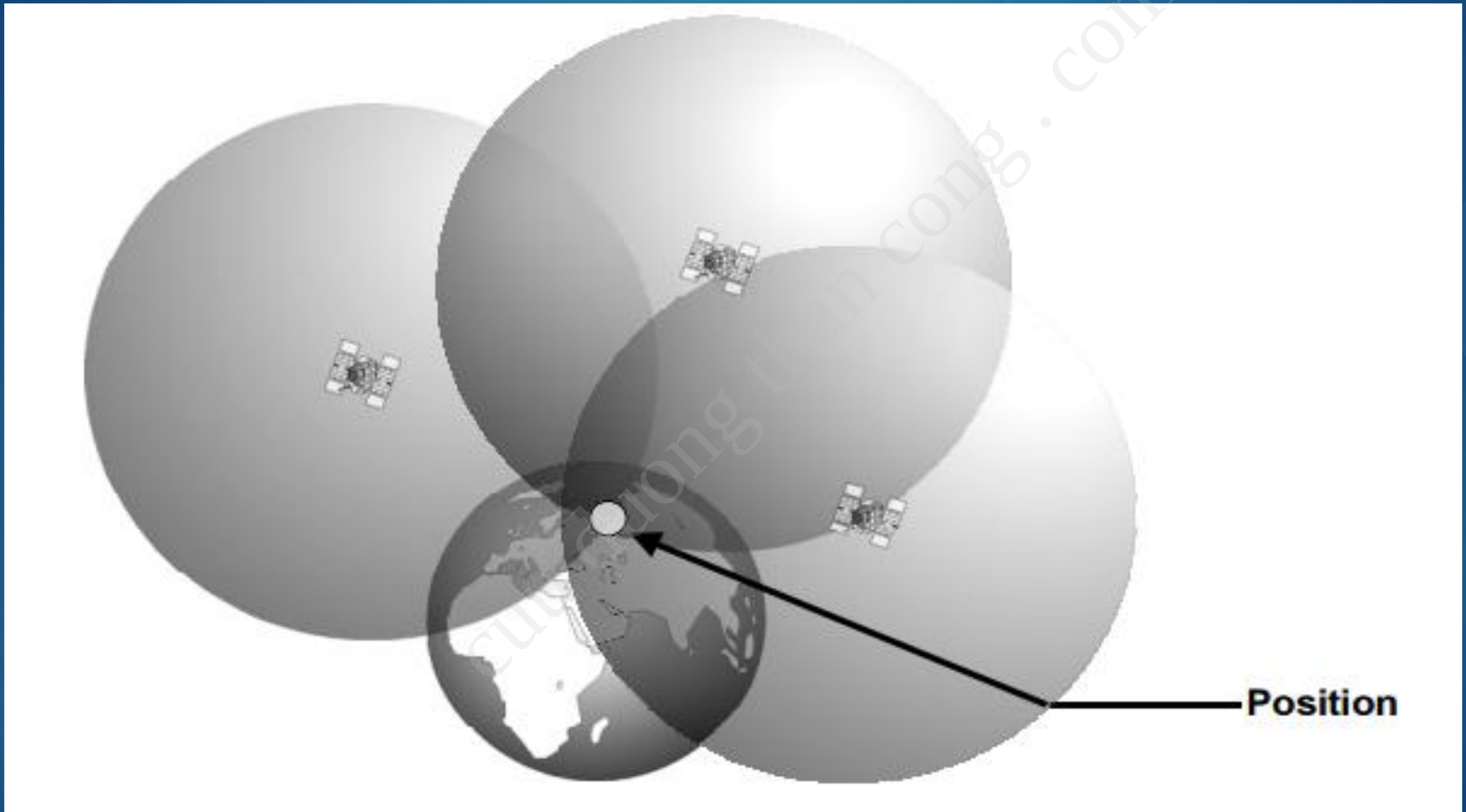


Figure 6: The position is determined at the point where all three spheres interse

The effect and correction of time error

- If the transit time is out by just $1\mu s$ this produces a positional error of 300m
- If the the time measurement is accompanied by a constant unknown error, we will have four un know variable in 3-D space :

  _Longtitude (X)

  _Latitude (Y)

  _Height(Z)

  _Time error(Δt)

=>It therefore follows that in three-dimensional space four satellites are needed to determine a position

Determining a position in 3-D space

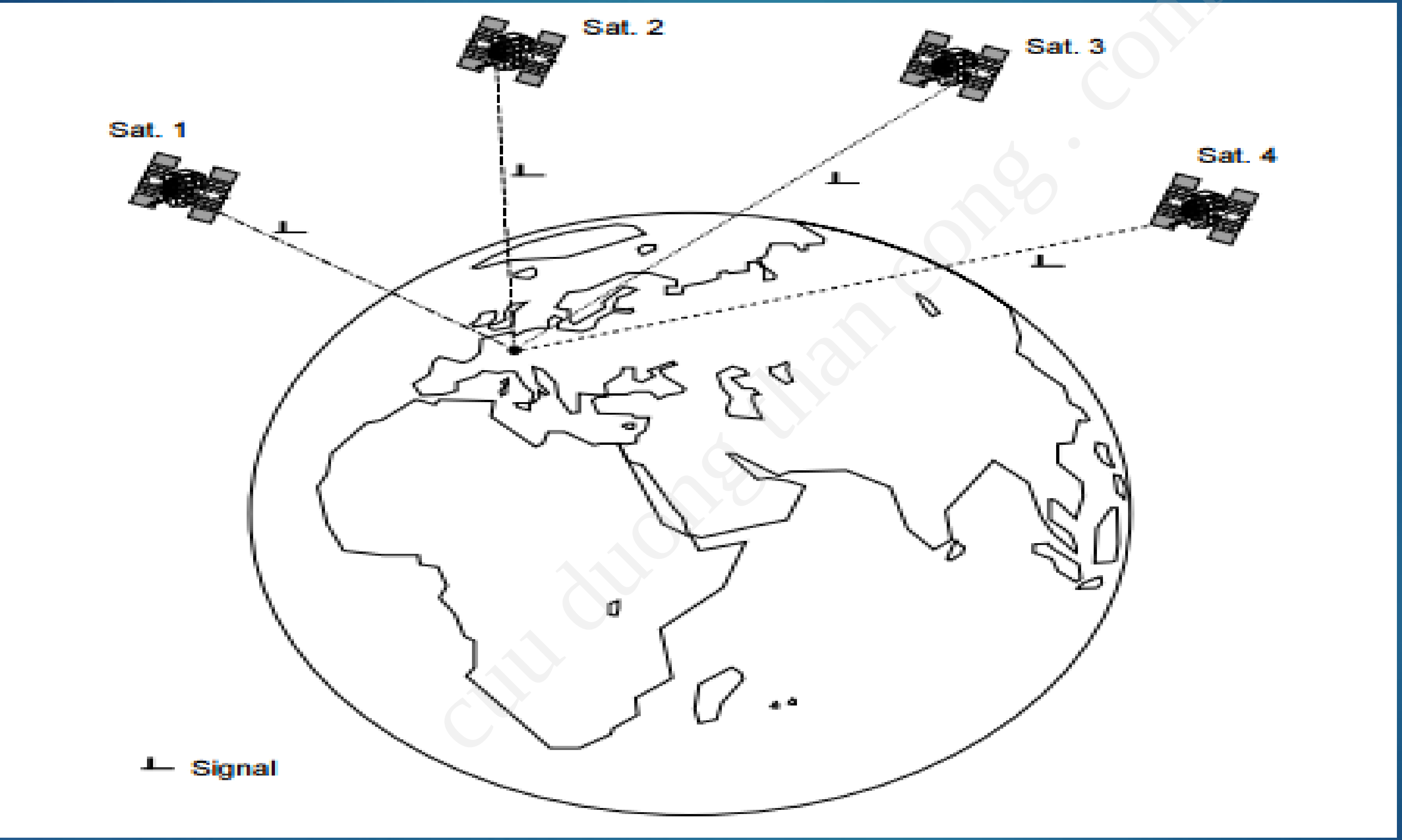


Figure: Four satellites are required to determine a position in 3-D space

How does GPS work?

- GPS MADE SIMPLE
- GPS, THE TECHNOLOGY

Description of the entire system

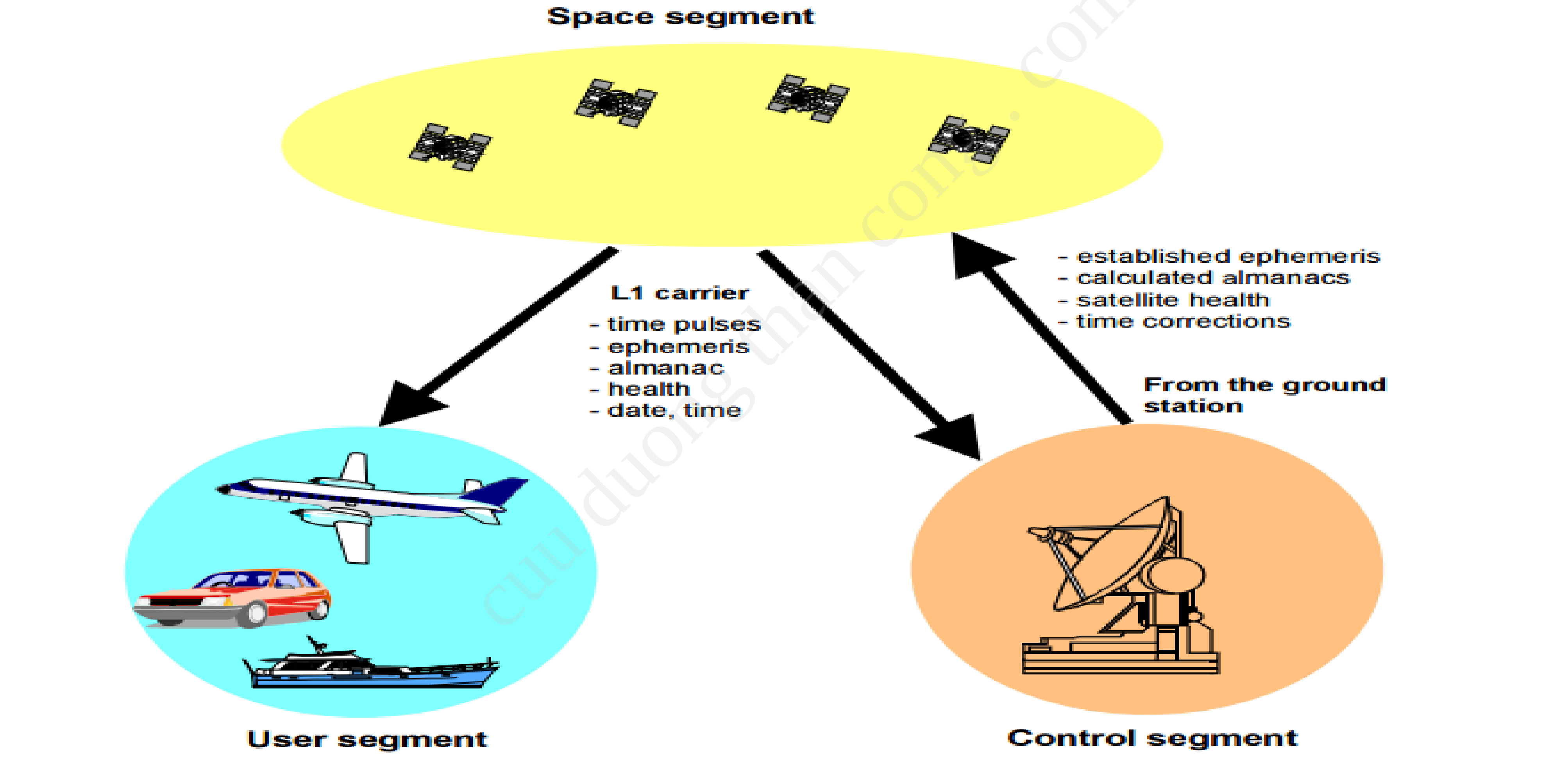
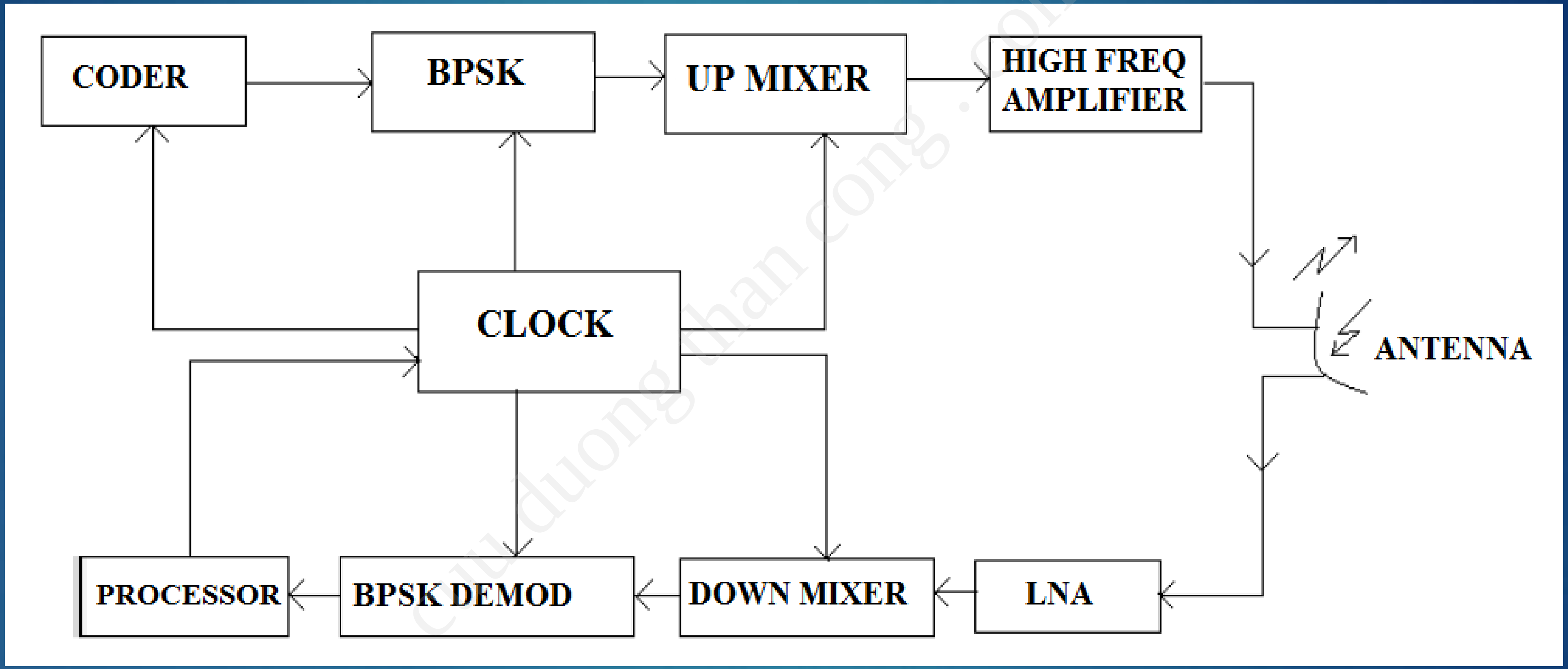


Figure : The three GPS segment

Description of the entire system

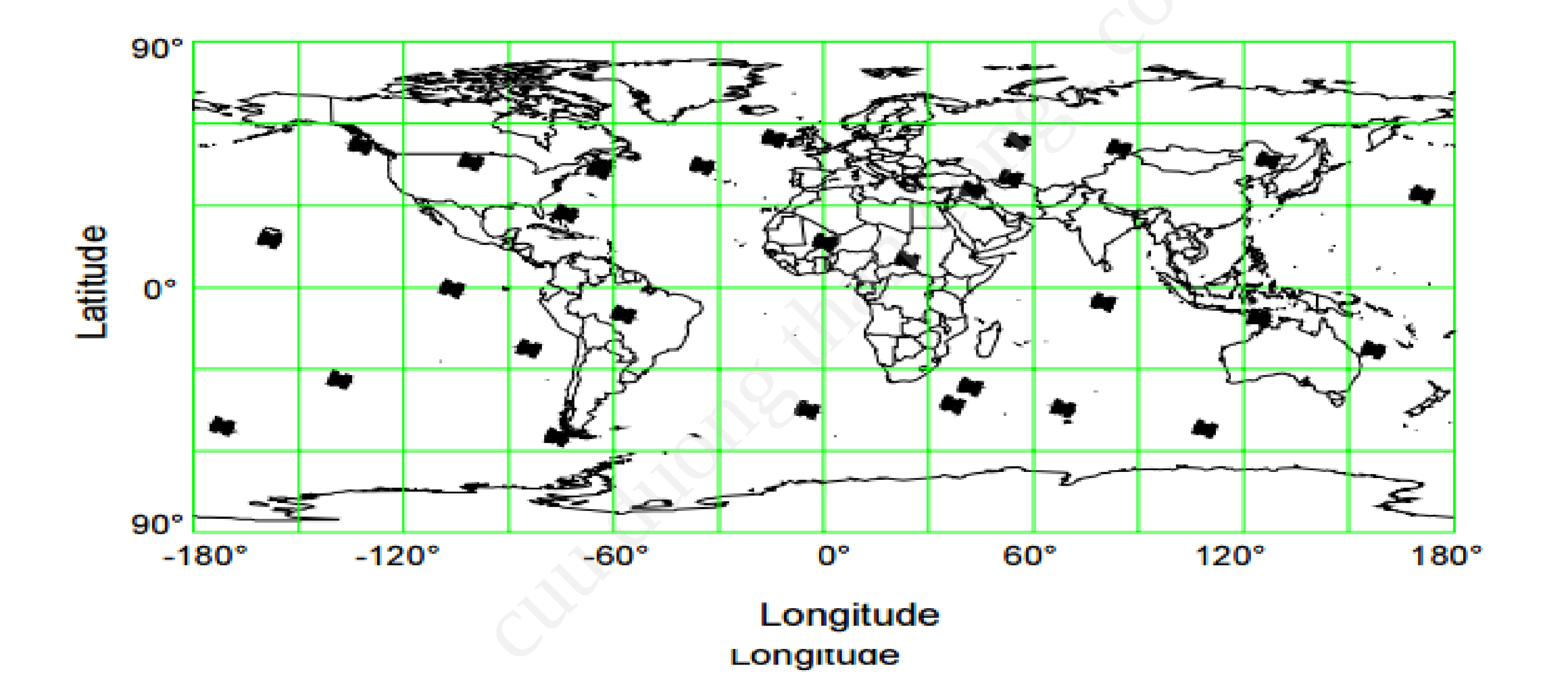
- Space segment
- Control segment
- User segment

SPACE SEGMENT



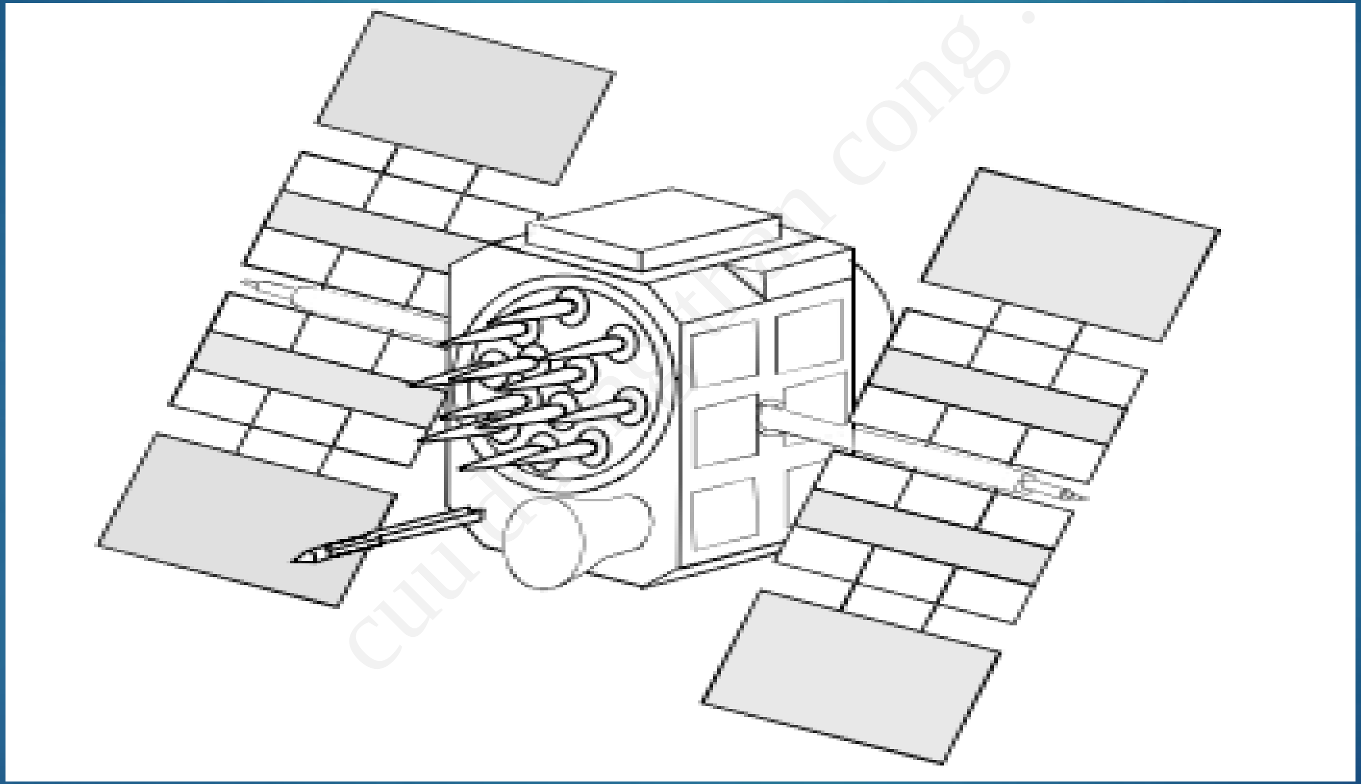
GPS satellite block diagram

Satellite movement



Position of the 28 GPS satellites at 12.00 hrs UTC on 14th April 2001

The GPS satellites
Construction of a satellite



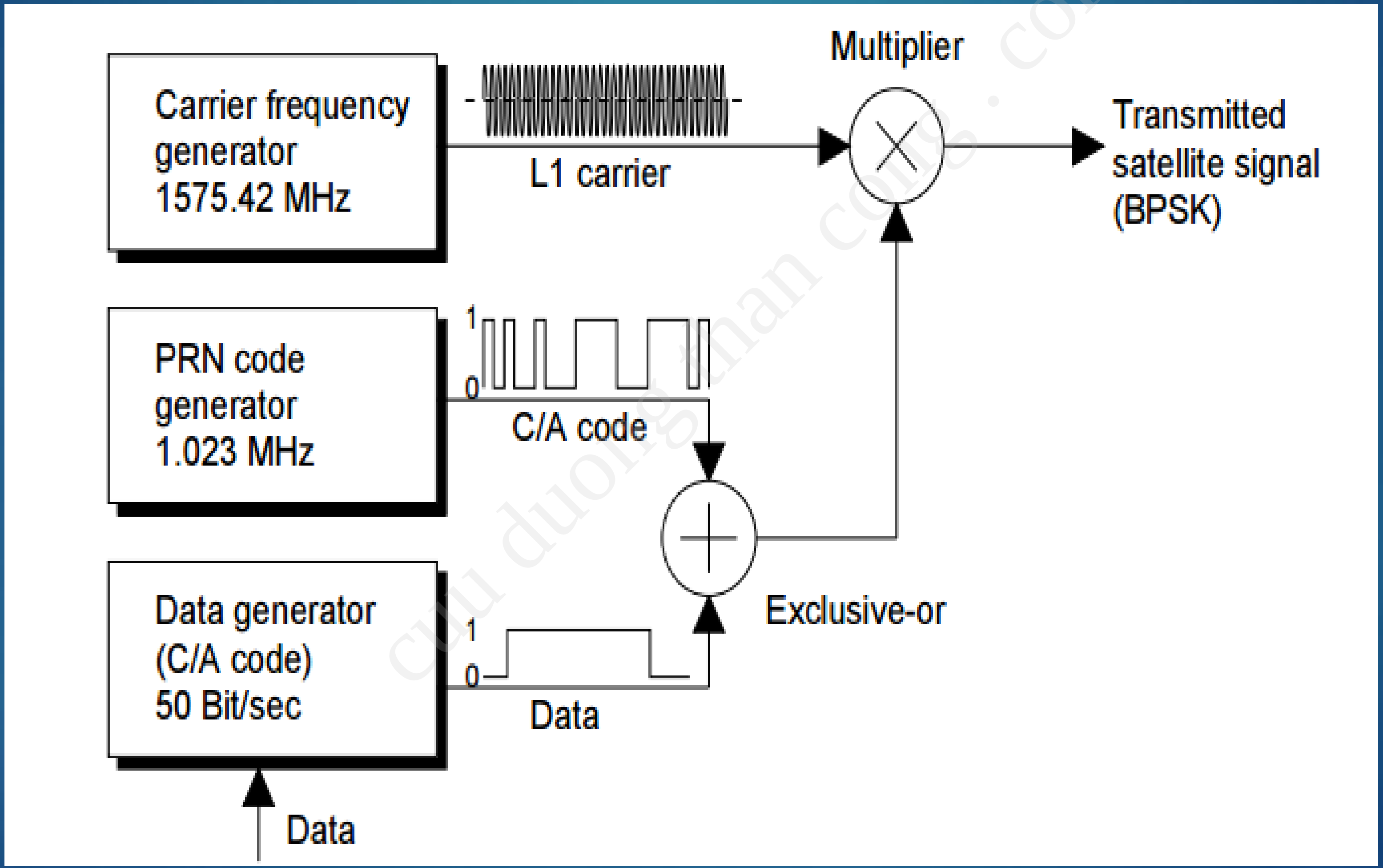
A GPS satellite

The communication link budget analysis

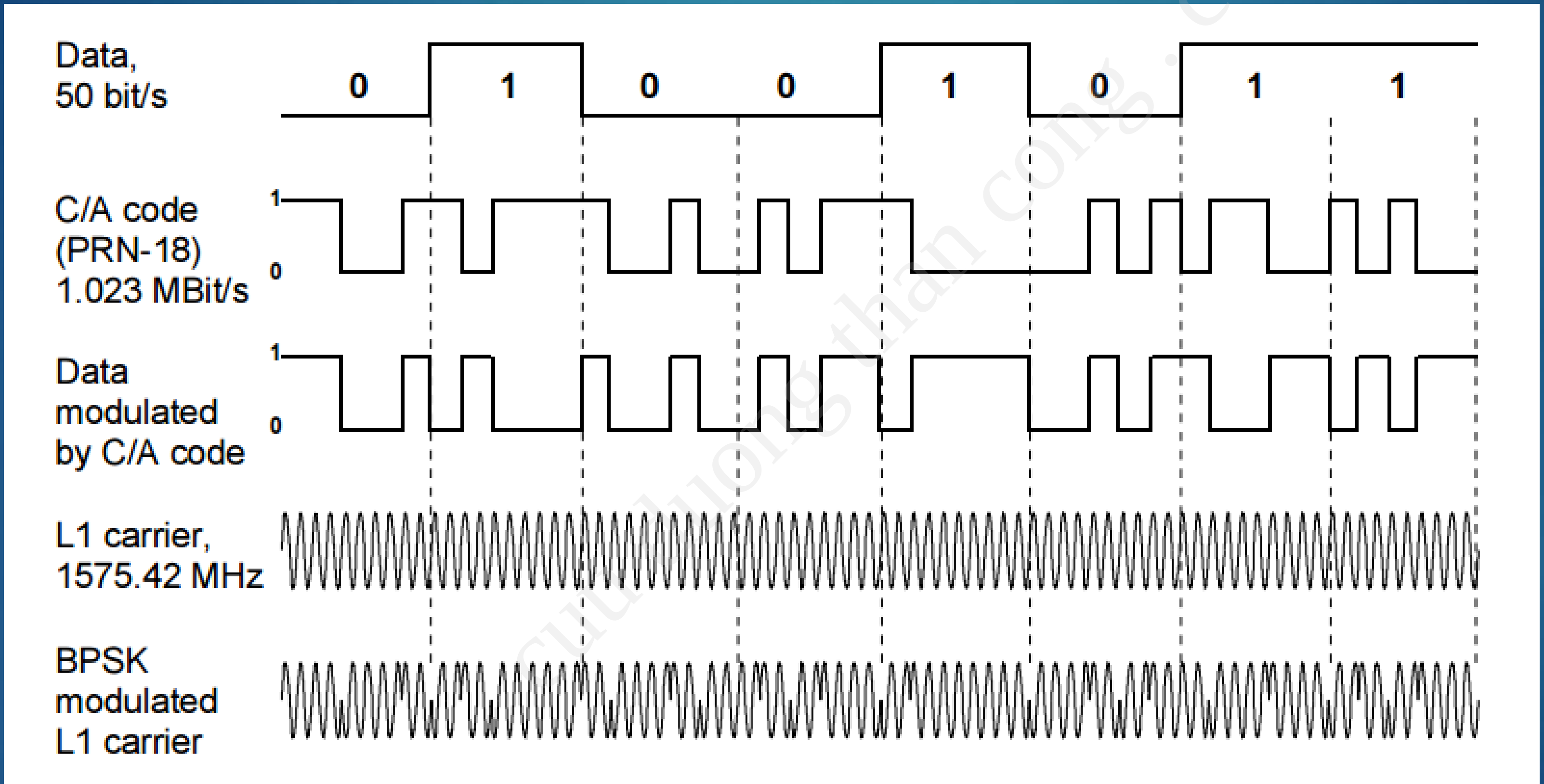
	Gain (+) /loss (-)	Absolute value
Power at the satellite transmitter		13.4dBW (43.4dBm=21.9W)
Satellite antenna gain (due to concentration of the signal at 14.3°)	+13.4dB	
Radiate power EIRP (Effective Integrated Radiate Power)		26.8dBW (56.8dBm)
Loss due to polarisation mismatch	-3.4dB	
Signal attenuation in space	-184.4dB	
Signal attenuation in the atmosphere	-2.0dB	
Gain from the reception antenna	+3.0dB	
Power at receiver input		-160dBW (-130dBm=100.0*10^{-15}W)

The link budget analysis (Table) between a satellite and a user is suitable for establishing the required level of Satellite transmission power

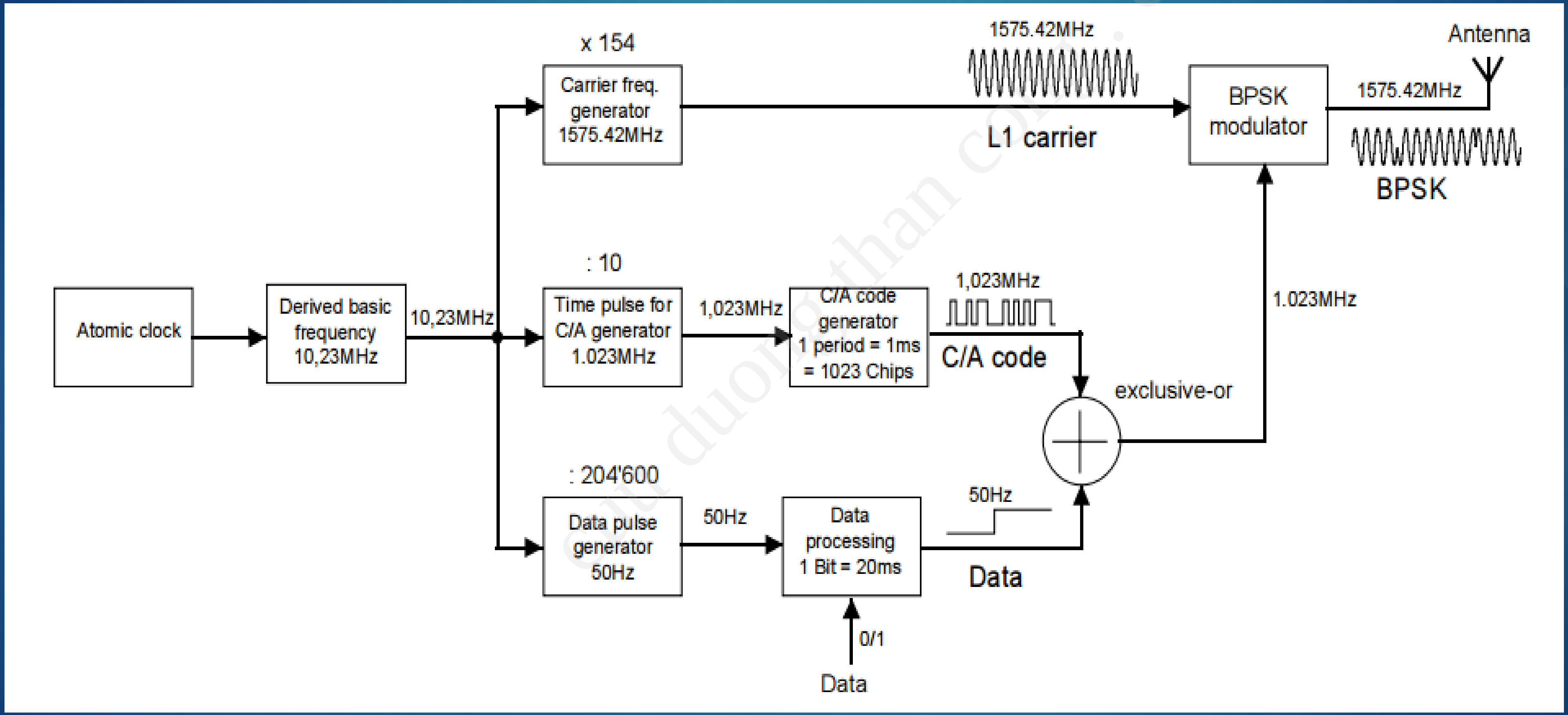
Simplified satellite block diagram



Data structure of a GPS satellite



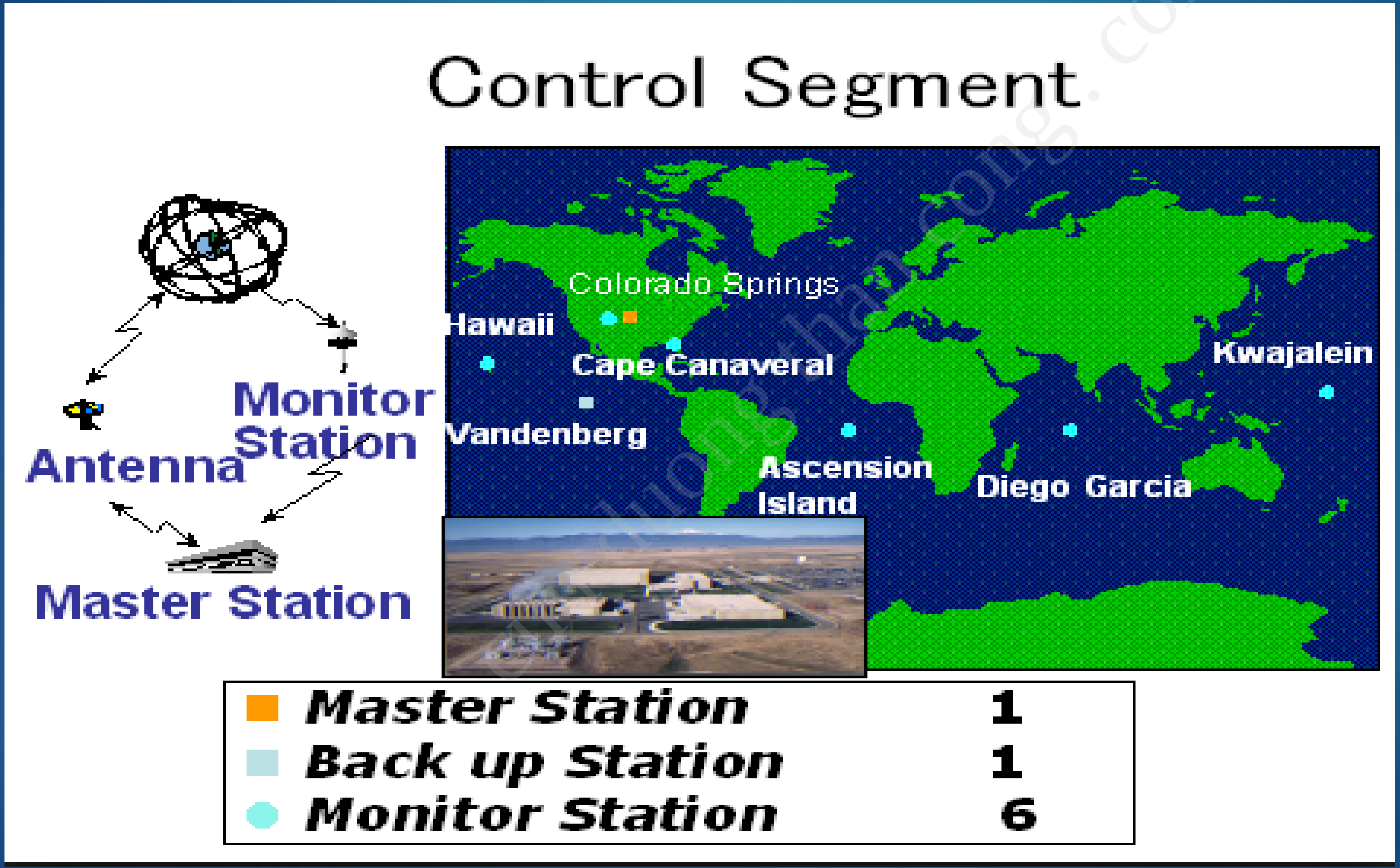
Detailed block system of a GPS satellite



Description of the entire system

- Space segment
- Control segment
- User segment

Control segment



Control segment

- The most important tasks of the control segment are:

•Observing the movement of the satellites and computing orbital data (ephemeris)

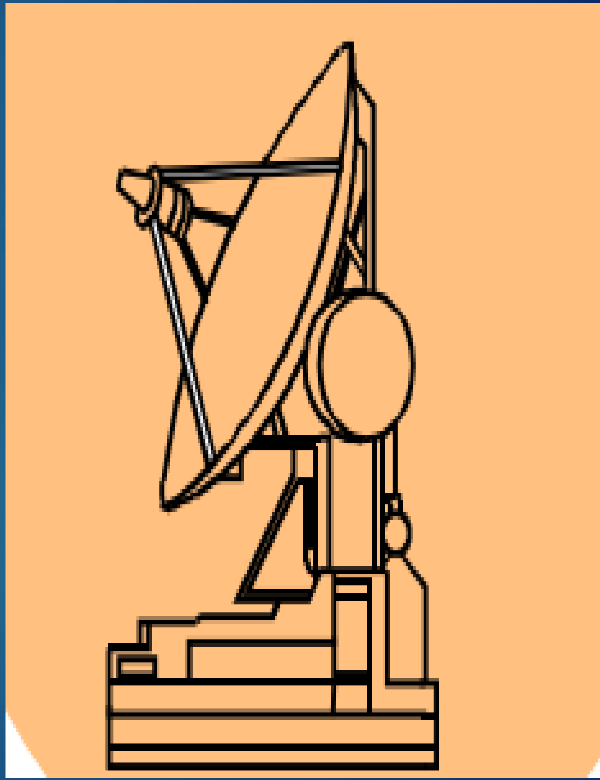
• Monitoring the satellite clocks and predicting their behaviour

• Synchronising on board satellite time

•Relaying precise orbital data received from satellites in communication

•Relaying the approximate orbital data of all satellites (almanac)

•Relaying further information, including satellite health, clock errors



Description of the entire system

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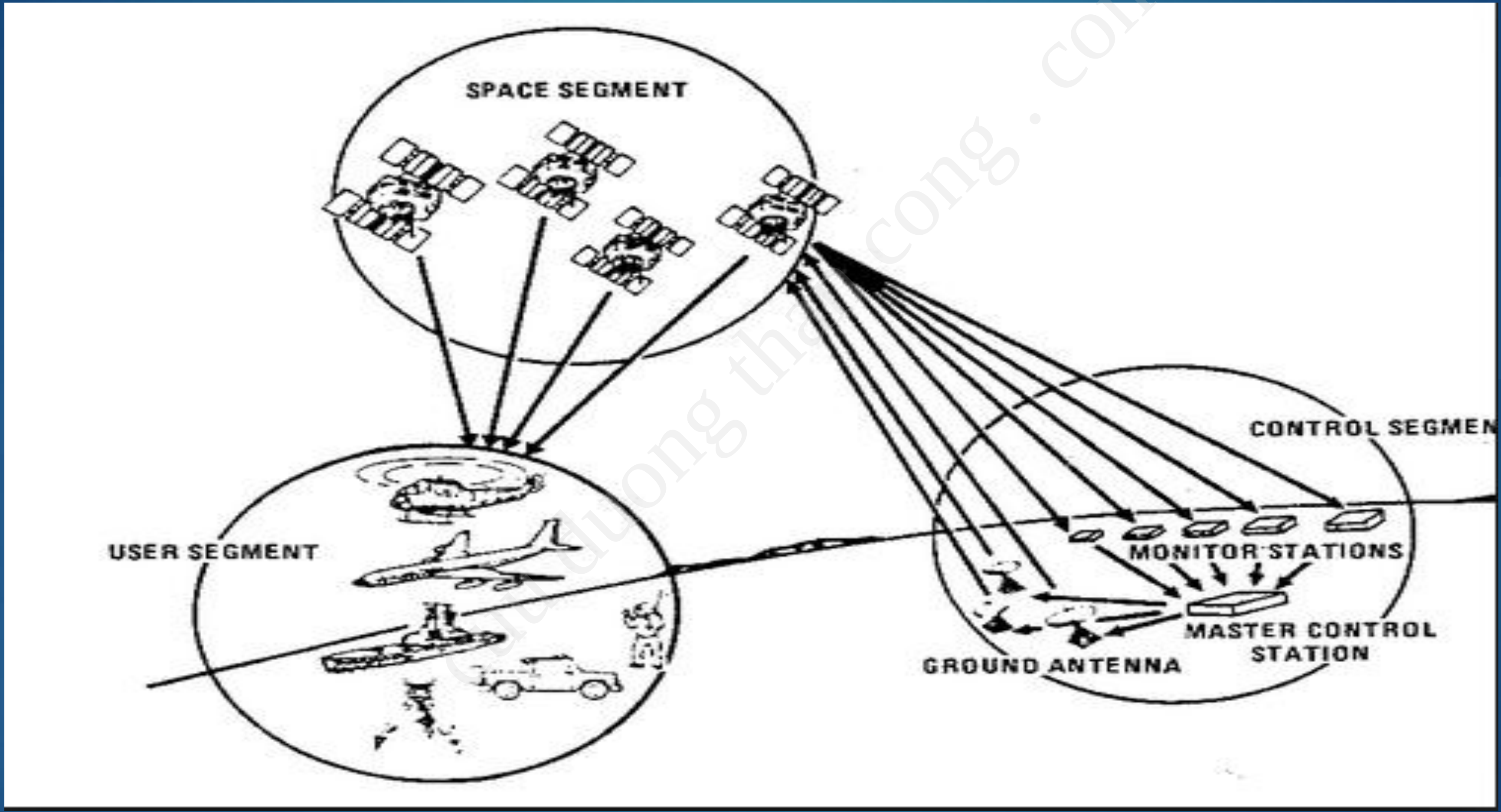
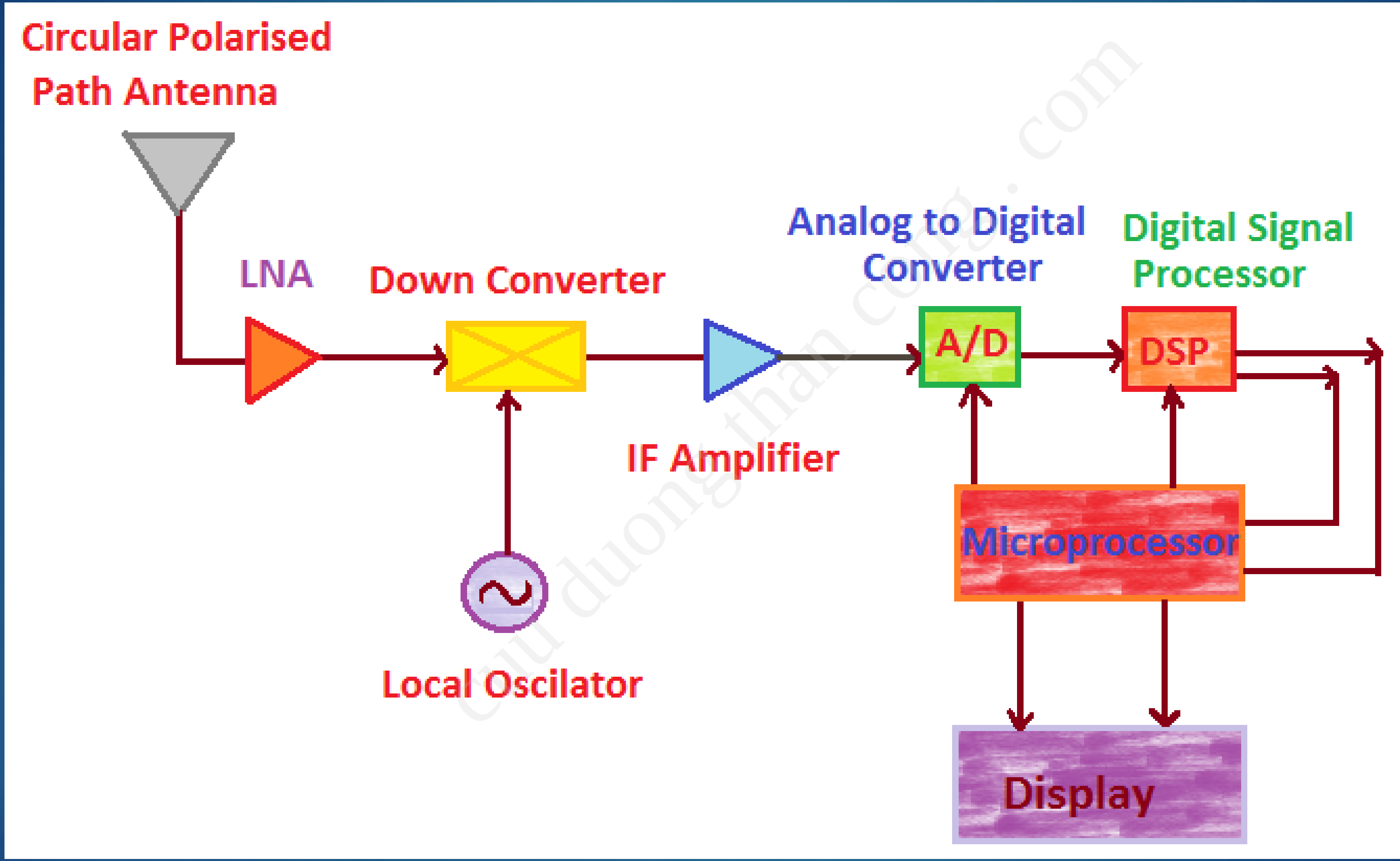
User segment



User segment



User block diagram

User segment

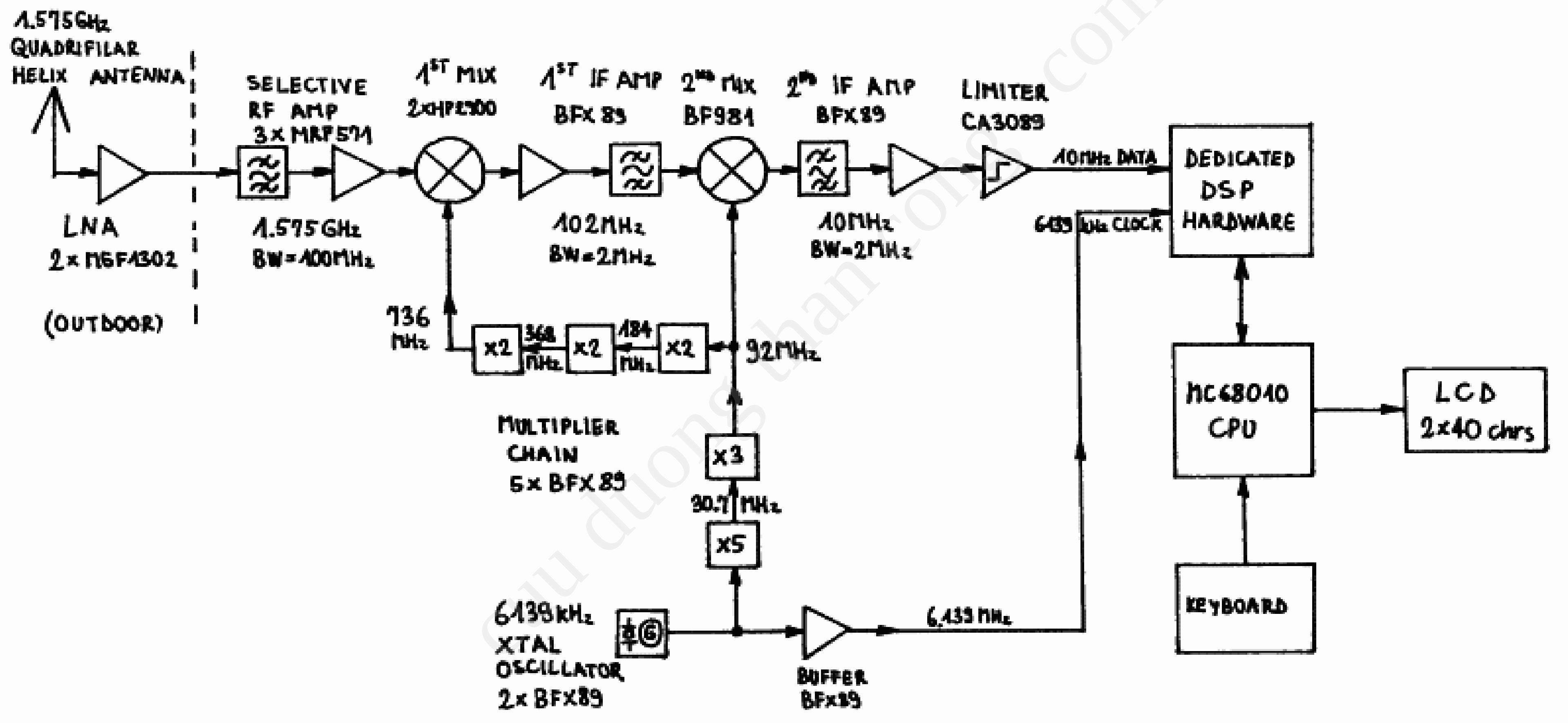


Fig. 13 - GPS receiver block diagram.

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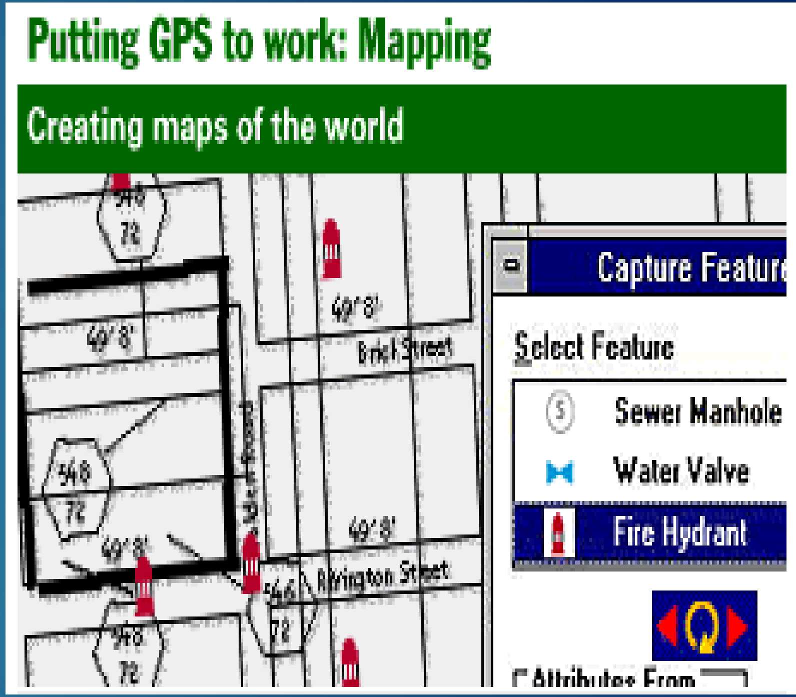
GPS Applications

GPS Tracking

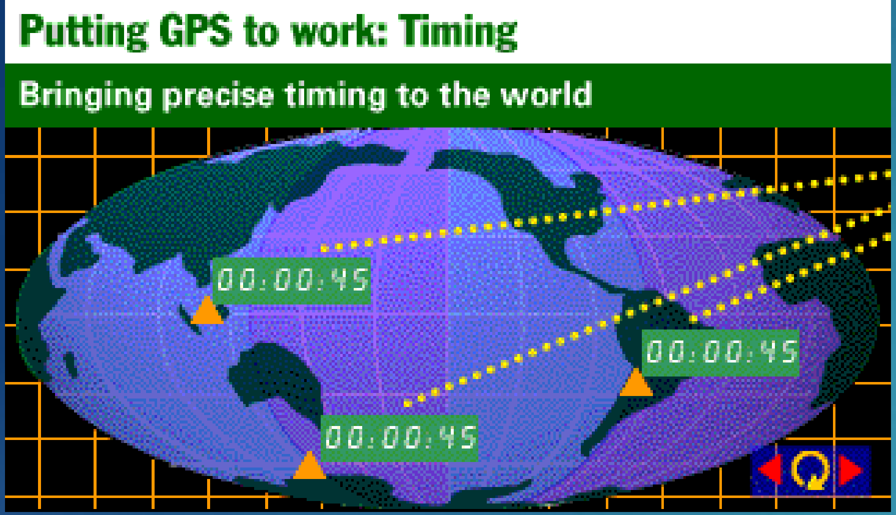
- Based on:
  - GPS
  - GSM/GPRS
  - GIS
- Function:
  - Current position (latitude, longitude, elevation).
  - Direction and distance to specified waypoints.
  - Vehicle information: speed, ignition (on/off), fuel, door open, air conditioner.
  - Black-box.

GPS Mapping

- Precision positioning minerals, assets and identify changes.
- Mapping the facilities such as telephone poles, sewer lines, fire hydrant...

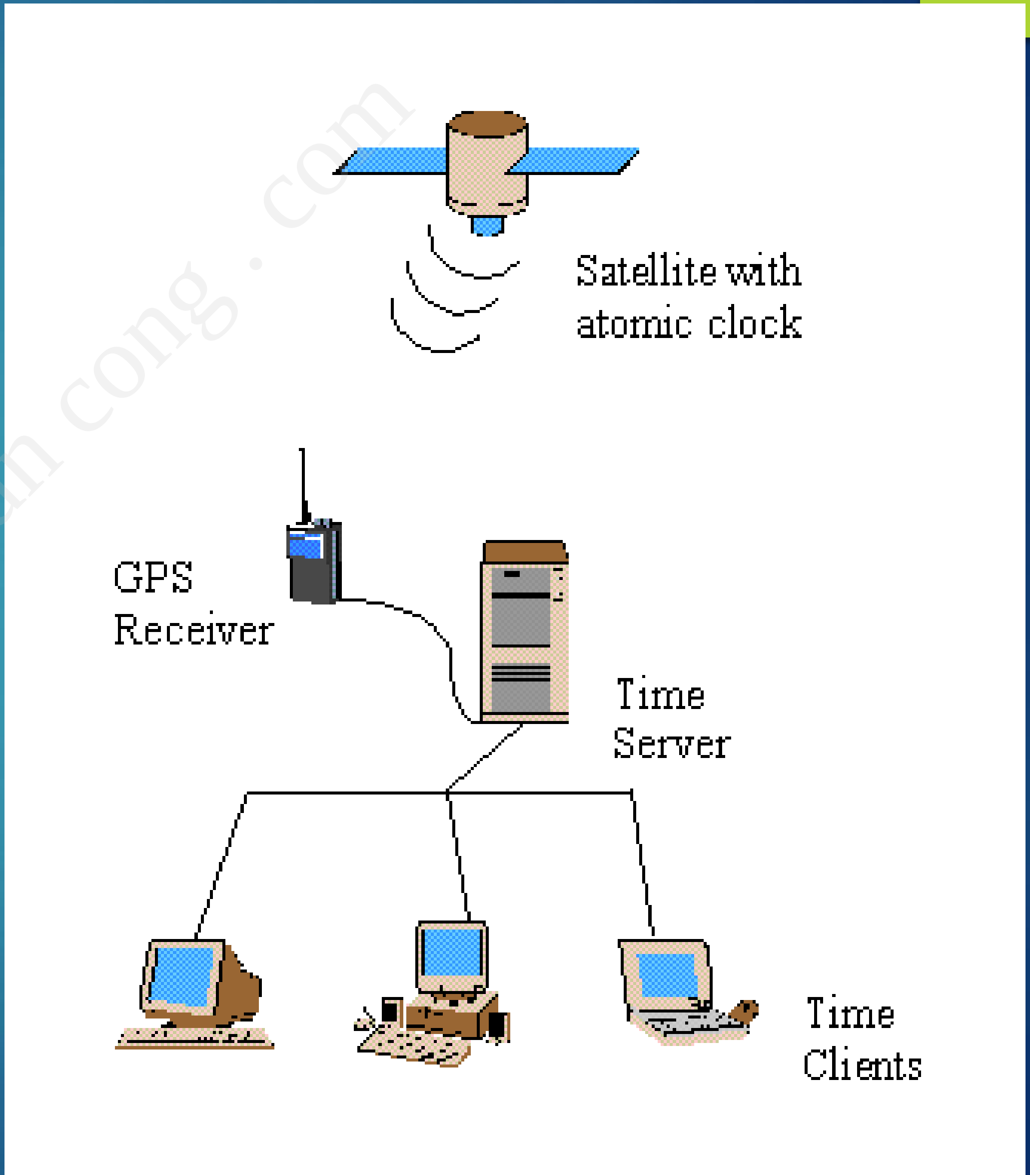


GPS Timming



Putting GPS to work: Timing
Bringing precise timing to the world
00:00:45
00:00:45
00:00:45

Step 3: Getting perfect timing

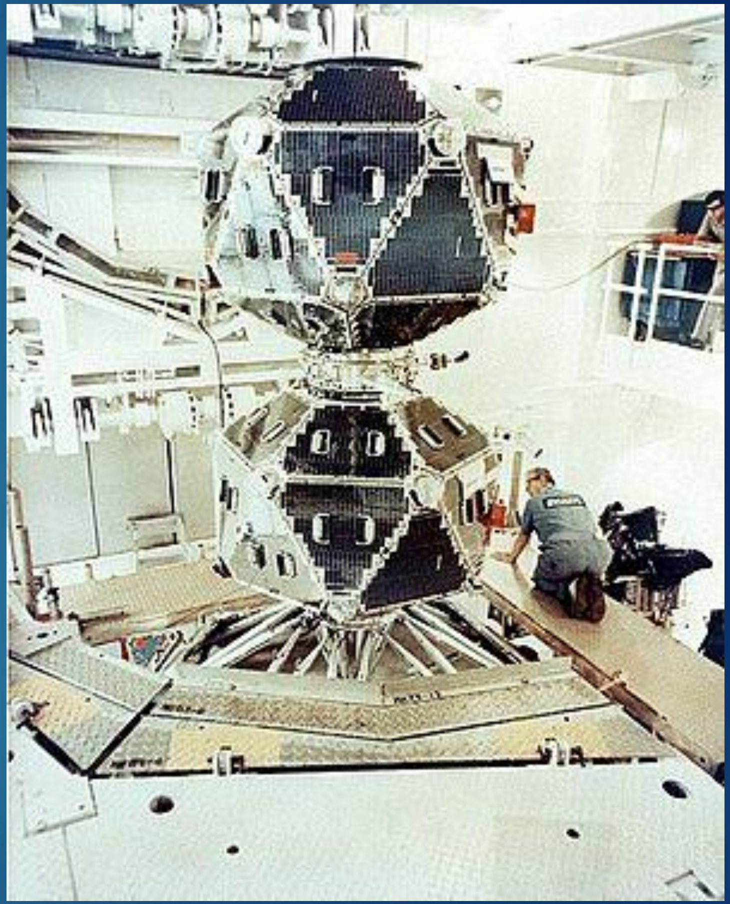


Satellite with atomic clock
GPS Receiver
Time Server
Time Clients

Military Applications

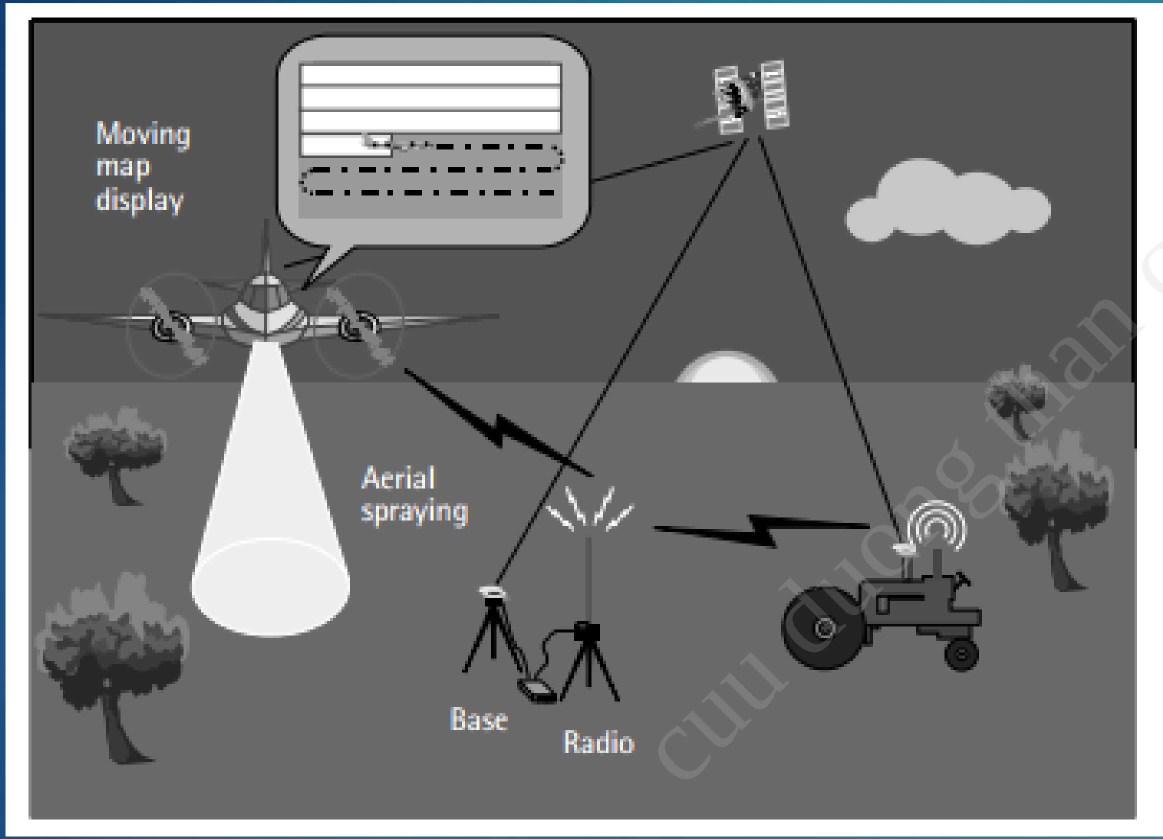
- Navigation (marine, aviation)
- Target tracking
- Missile and projectile guidance
- Reconnaissance
- Nuclear detonation detectors

PLGR (Precision Lightweight GPS *Receiver*) – "Plugger"

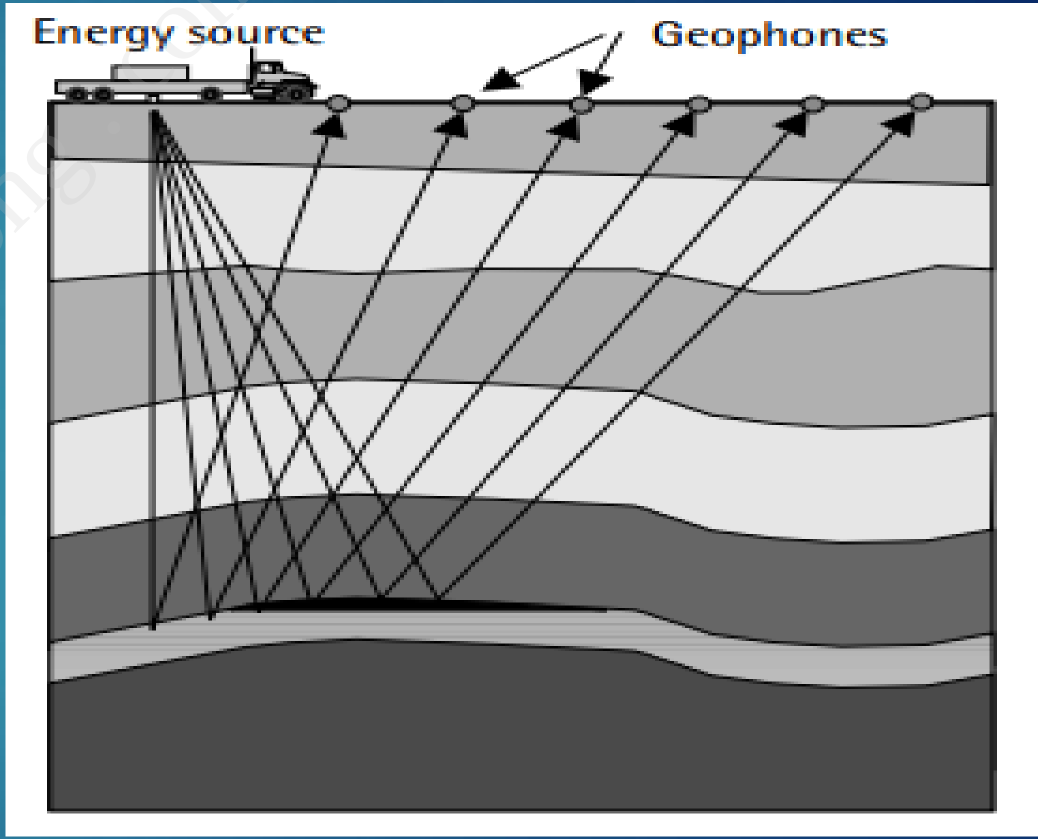


The Vela-5A/B Satellite

Other Applications



GPS for precision farming.



GPS for land seismic surveying.

References

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Thanks For Your Attention