Introduction to Total Station and GPS

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Overview

Not on the survey mathematics or detailed electronics, but to provide some background to **Modern Surveying** basics.

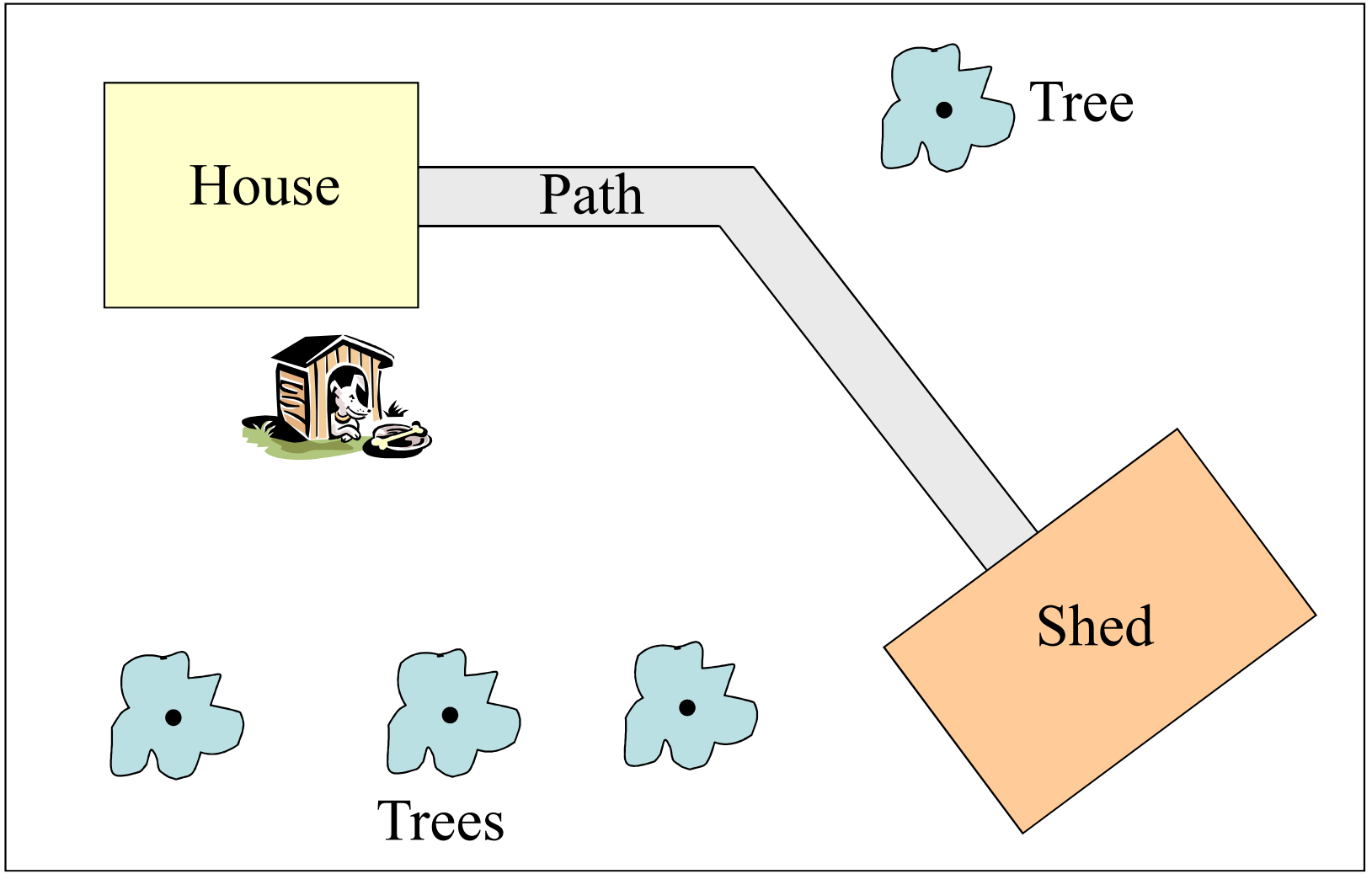
- Introduction
- History
- GPS
- Remote Sensing
- GIS

Introduction

We Measure – Why?

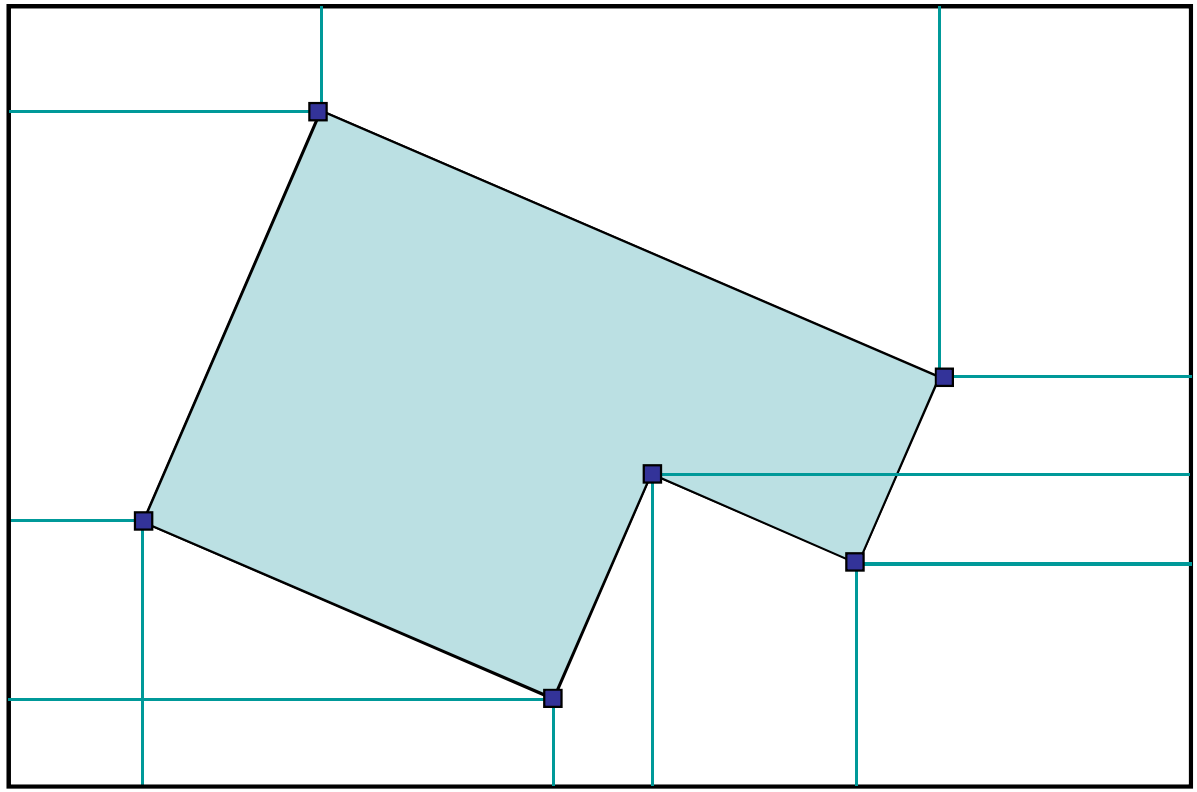
- ***Mapping*** - determining the location of existing features
- ***Setting-out*** - marking the location of new features

Application #1 - Mapping

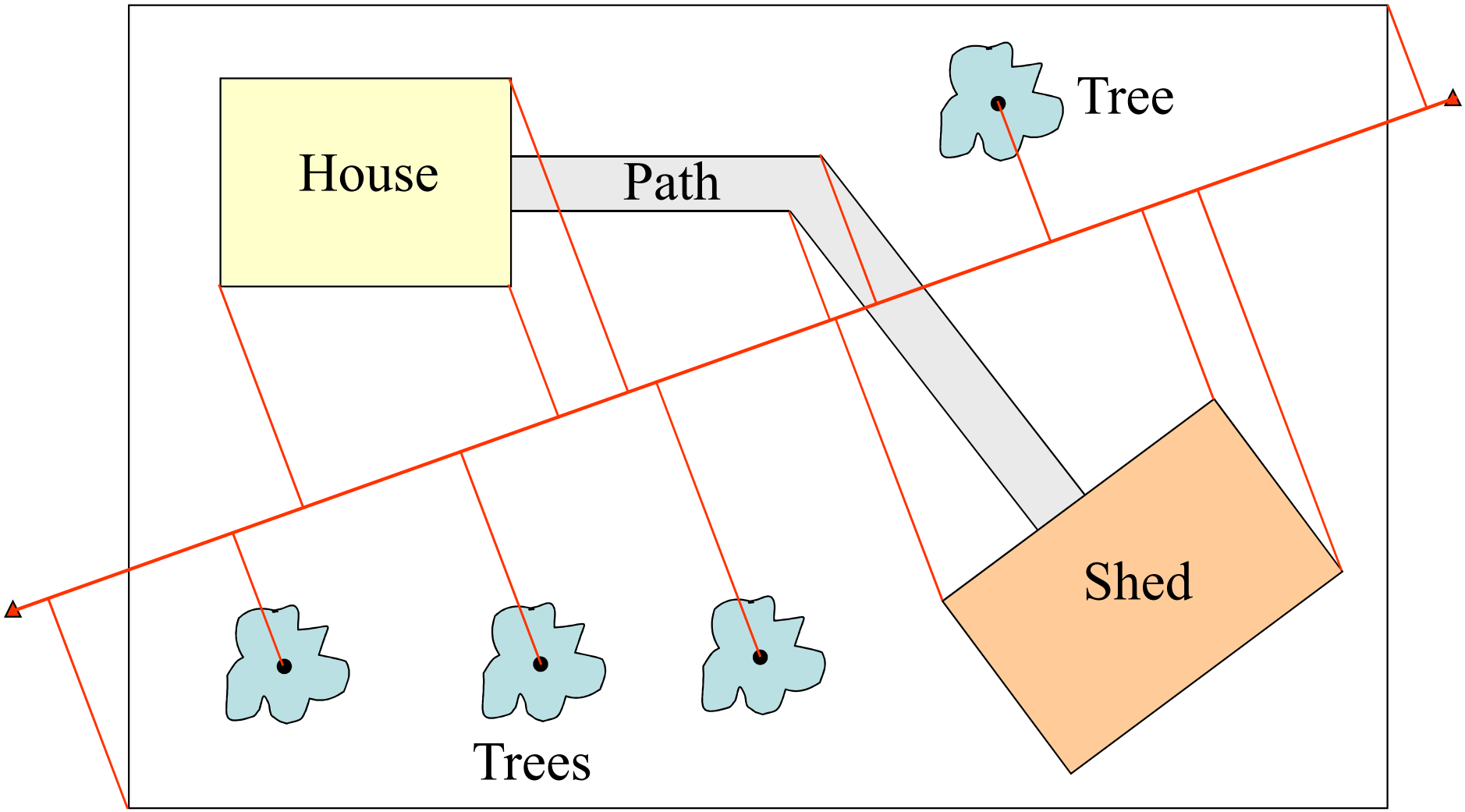


Application #2 - Setting out

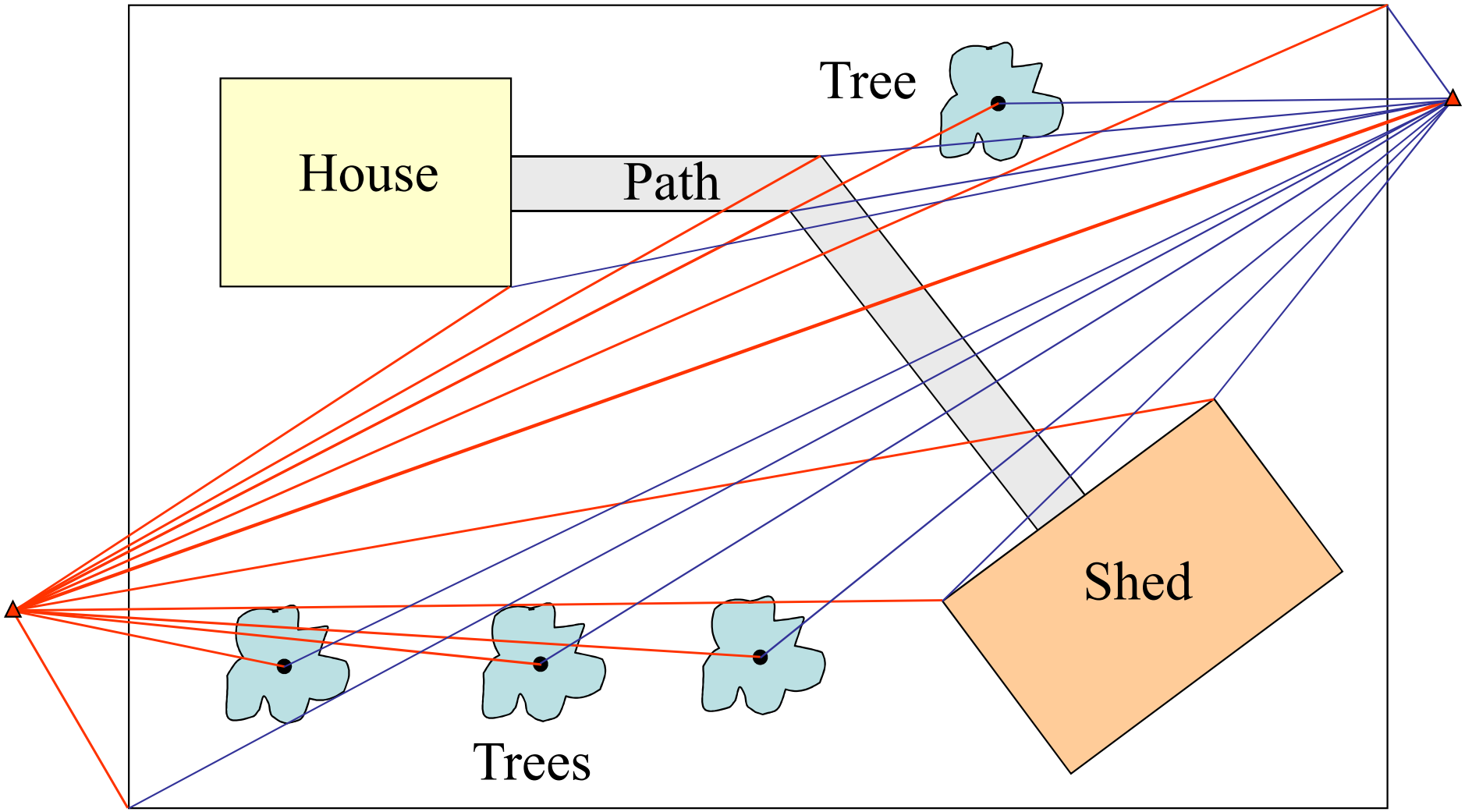
e.g. determining the location of a new construction on a site



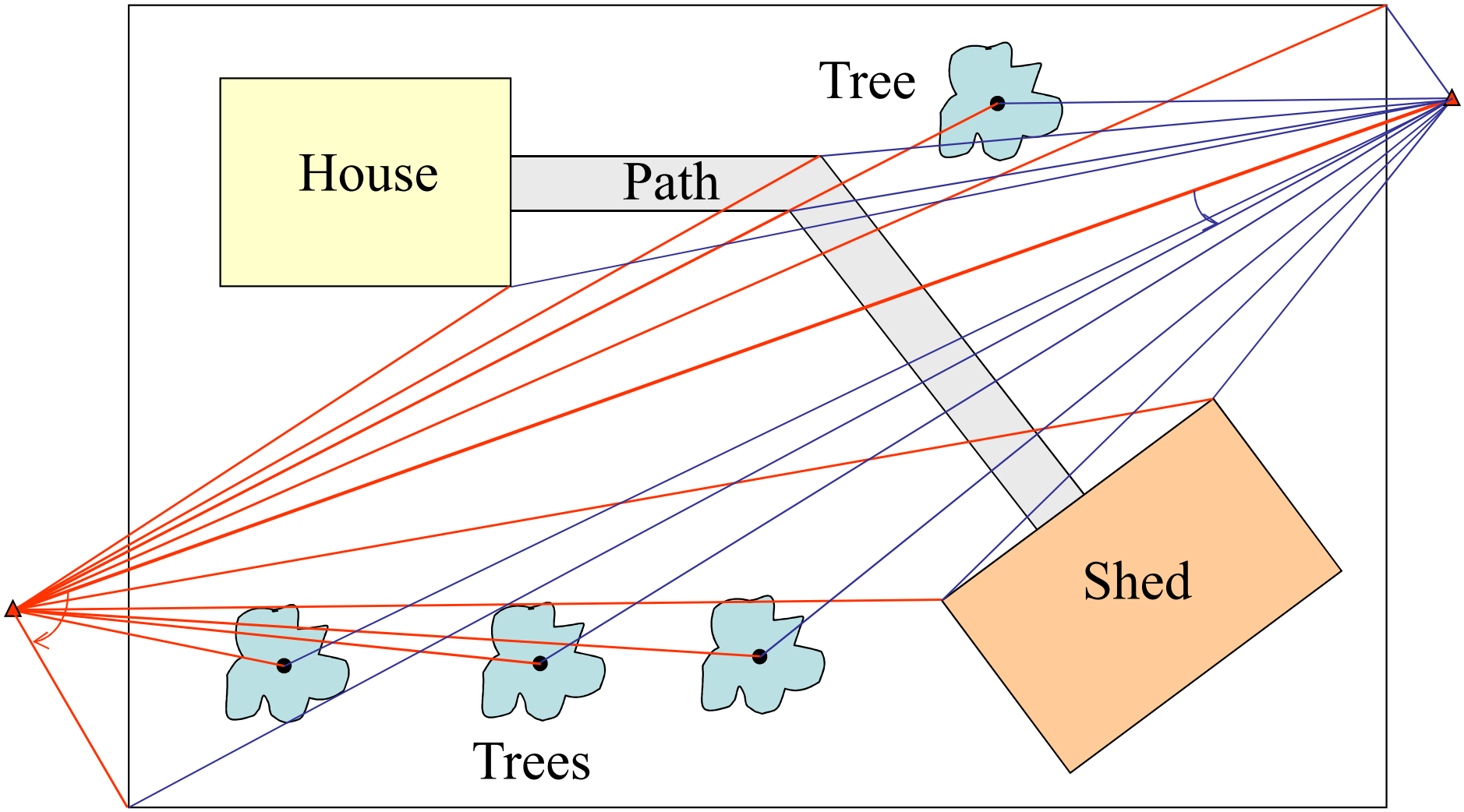
Chainage and offset



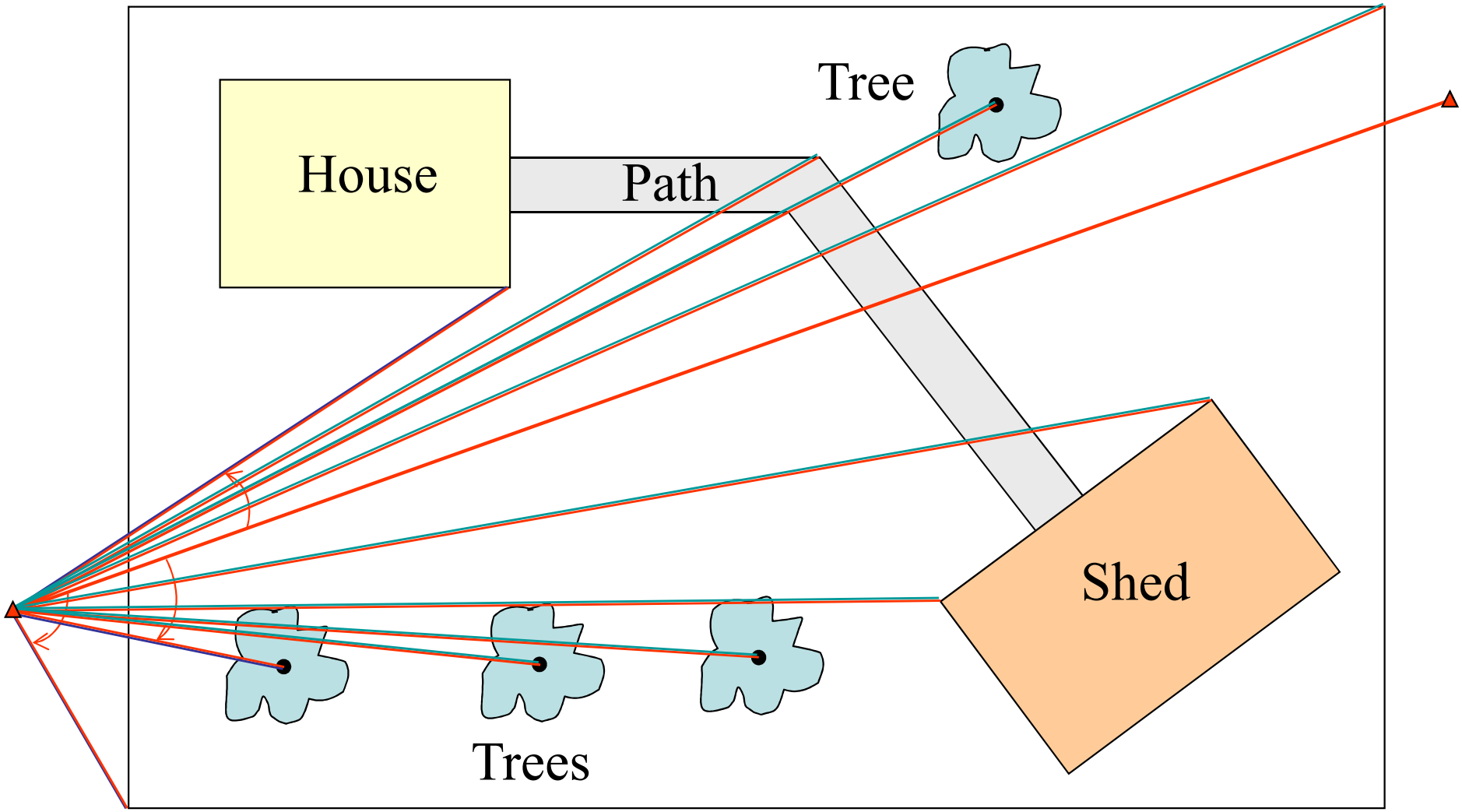
Distance-distance intersection



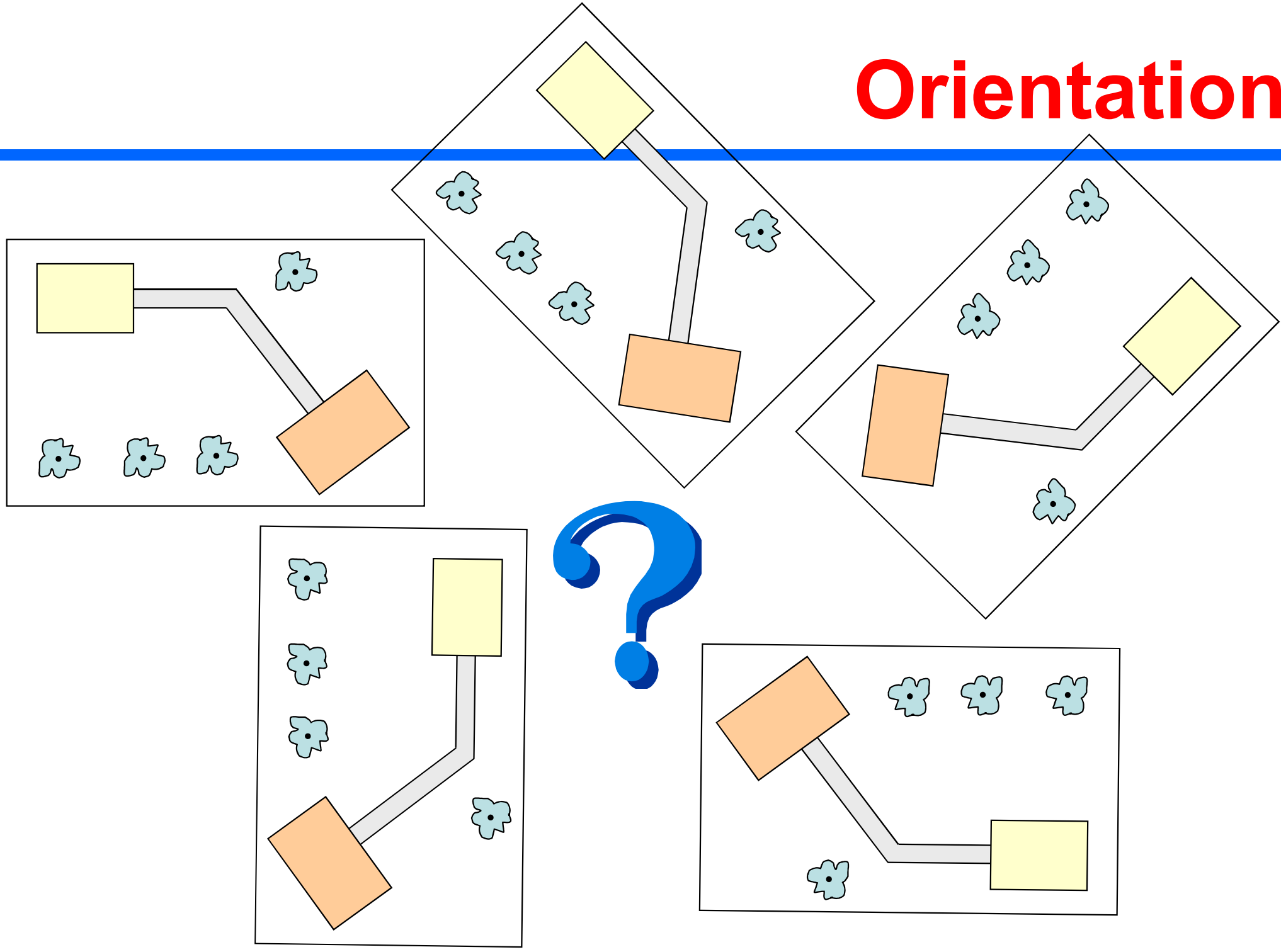
Angle-angle intersection



Distance-angle intersection



Orientation



Introduction Cont…

We Measure – What?

- Linear
- Angular

History

Tape & Compass

Stadia

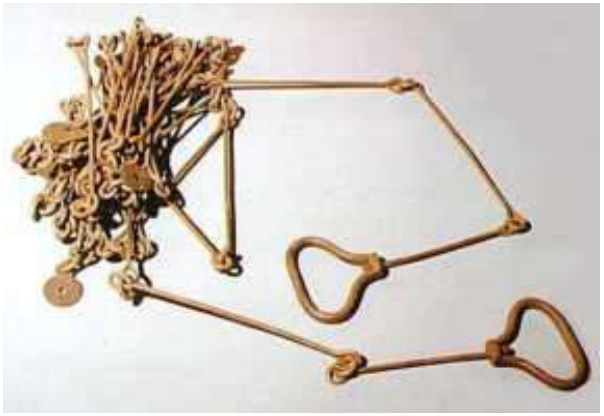
Self-Reducing Tacheometer

EDM

EDM with Data Collector . . . . .

Continuing Evolution of Measurement Technologies

History Cont…



Tapes & Chains

History Cont…

Compass & Levels

History Cont…

History Cont…

Hand held EDM

History Cont…

Digital Levels

Modern Equipments

Requirements

- Accuracy
- Functionality
- Integration
- Productivity
- Ease of Use

Field to Finish Operation

Modern Equipments . . .

EDM = **E**lectronic **D**istance **M**easuring

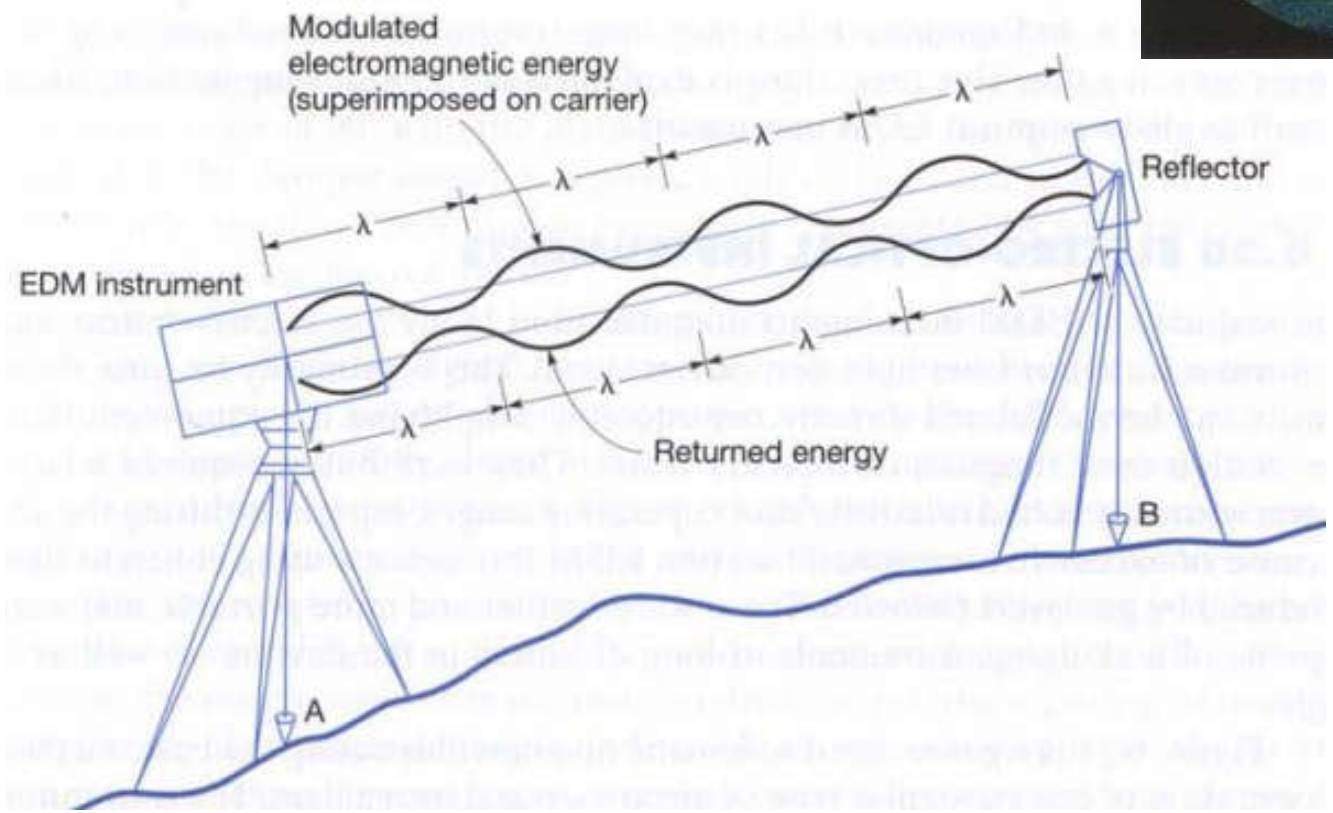
Two Types:

- IR or Light-wave (100 m – 7 km)
- Microwave (up to 100 km)

Modern Equipments . . .

EDM Operation:

A wave is transmitted and the returning wave is measured to find the distance traveled.



Modern Equipments . . .

EDM to Total Station

Advances In

- Computers
- Lasers
- Batteries

Total Station

Electronic Theodolite

with

Distance Meter

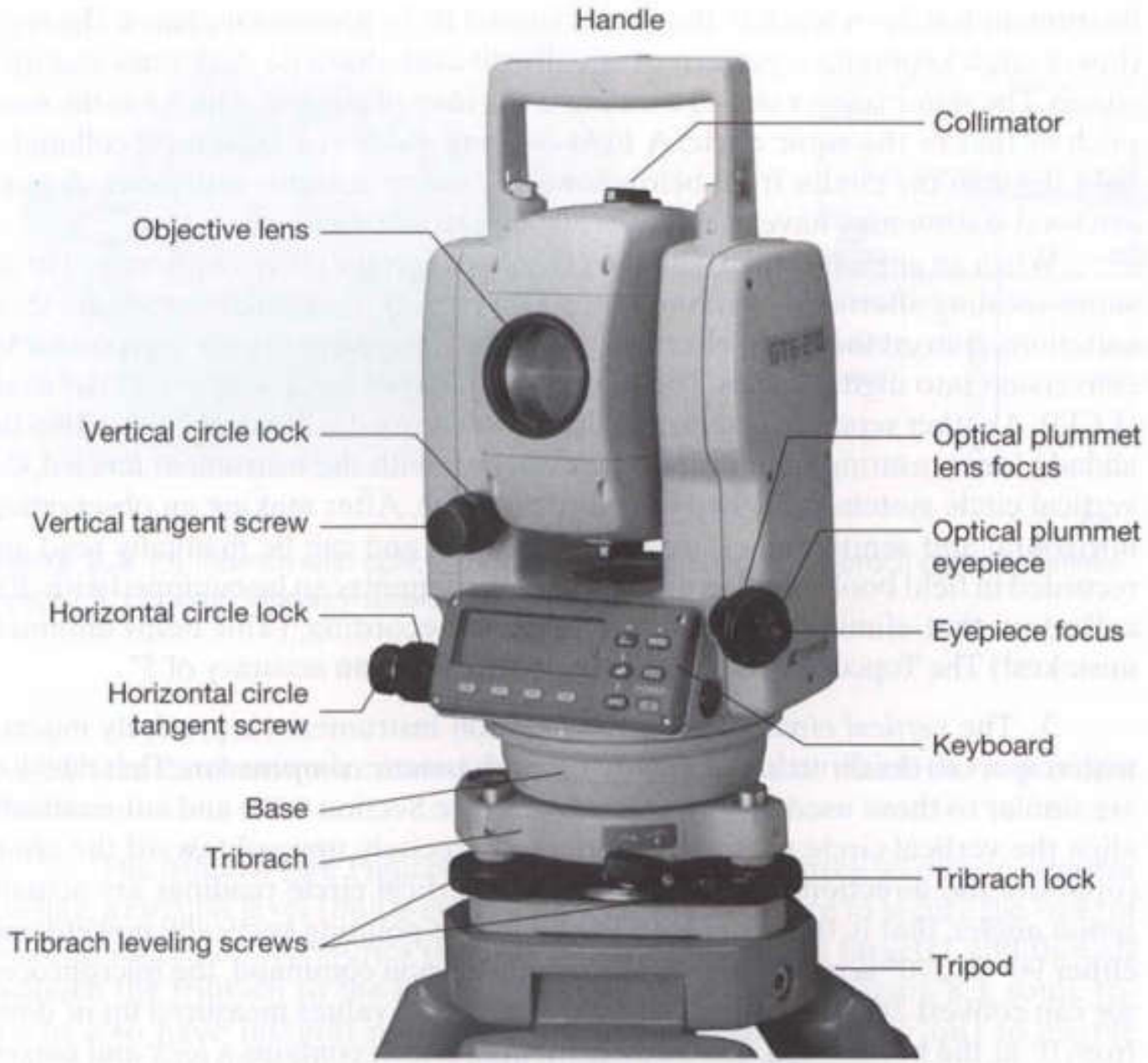
Total Station Cont…

Components of a Total Station

- EDM
- Electronic theodolite
- On-Board Micro-processor
- Data Collector (built in or separate unit)
- Data Storage (internal or memory card)
- Prisms

Total Station Cont…

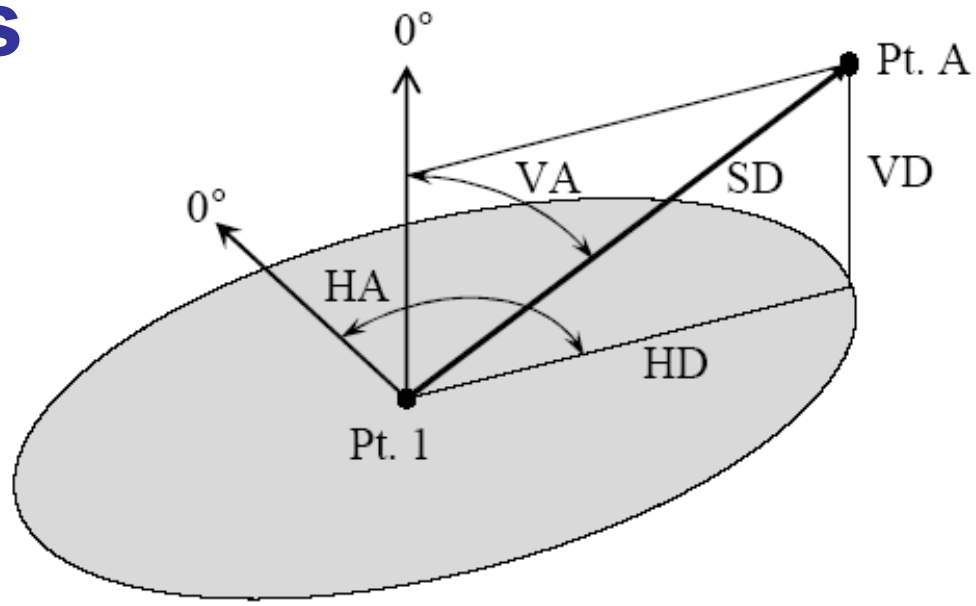
Total Station Cont…



Total Station Cont…

Measures and Records

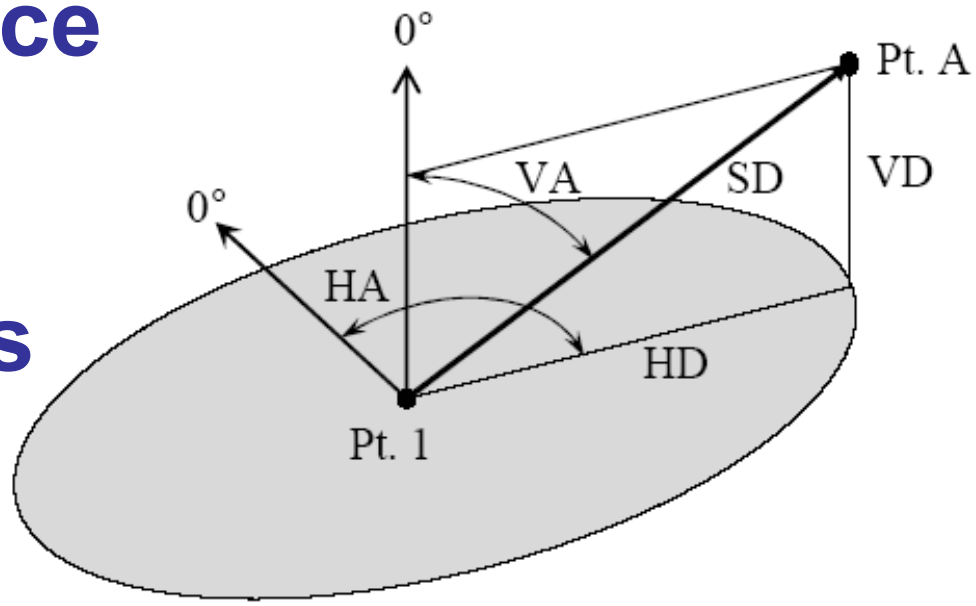
- Horizontal Angles
- Vertical Angles
- Slope Distances



Total Station Cont…

Calculates

- Horizontal Distance
- Vertical Distance
- X,Y,Z Coordinates
- Layout Etc.



Total Station Cont…

Technologies

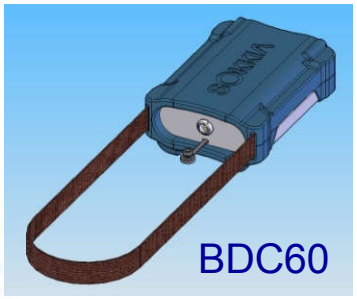
- Optical Total Station
- Servo Driven
- Auto Tracking
- Robotic
- Reflector less
- Software Integration

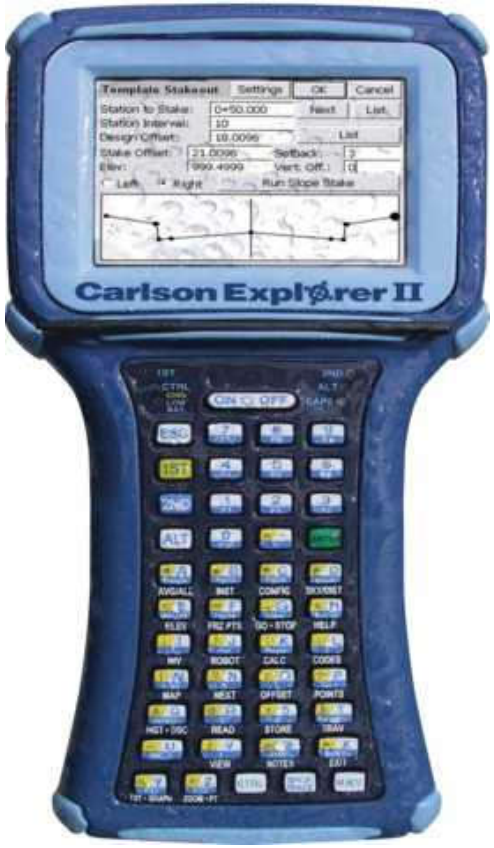
Total Station Cont…

Total Station Cont…

Total Station Cont…

Accessories

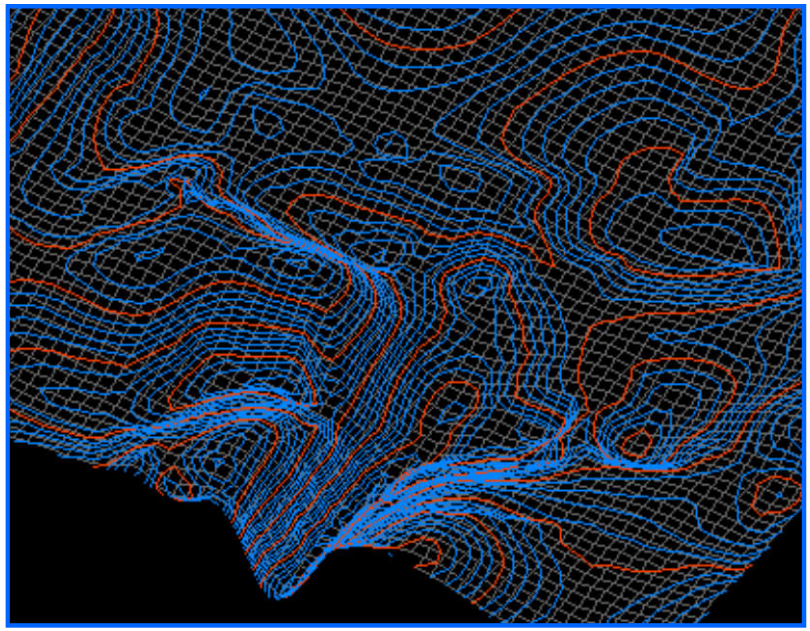


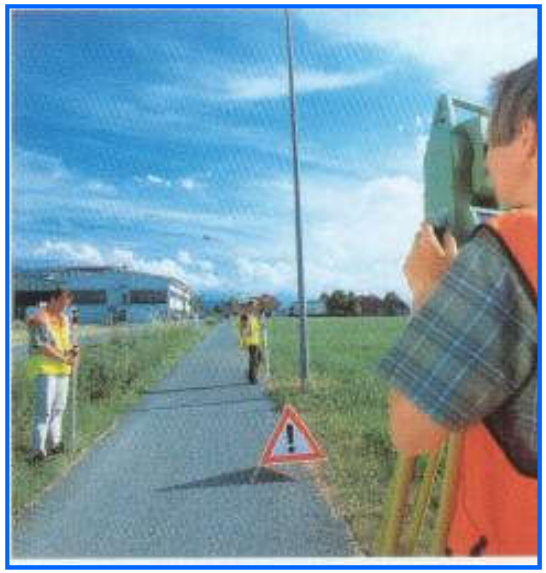


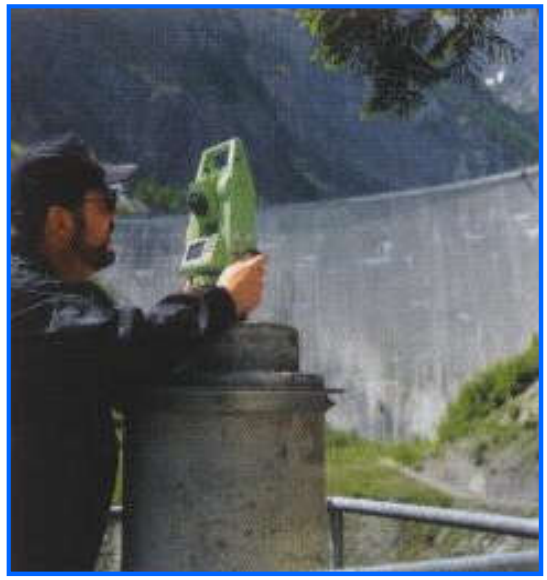
Total Station Cont…

Uses

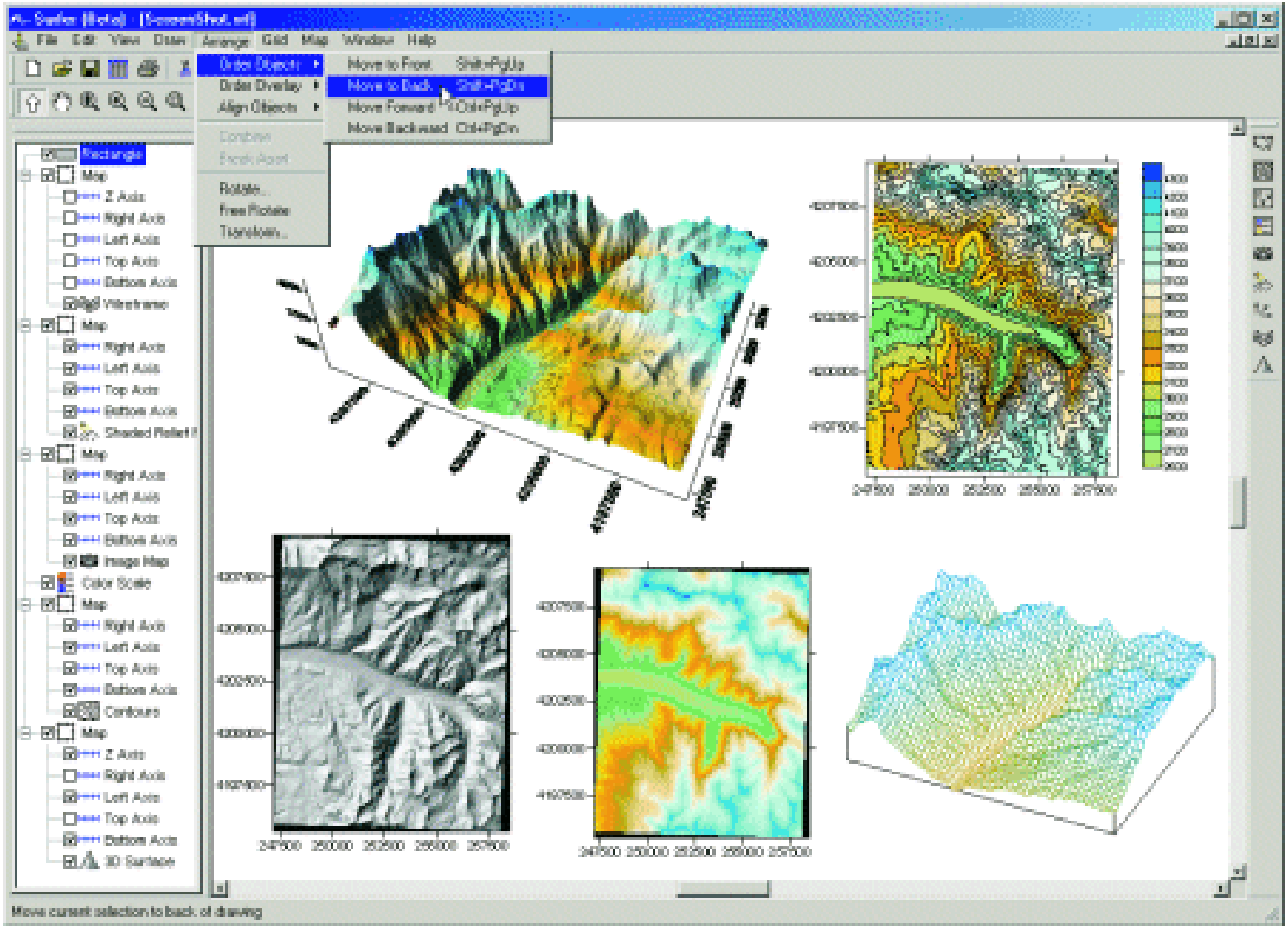
- Topo and As Builts
- Construction Layout
- Monitoring & Control



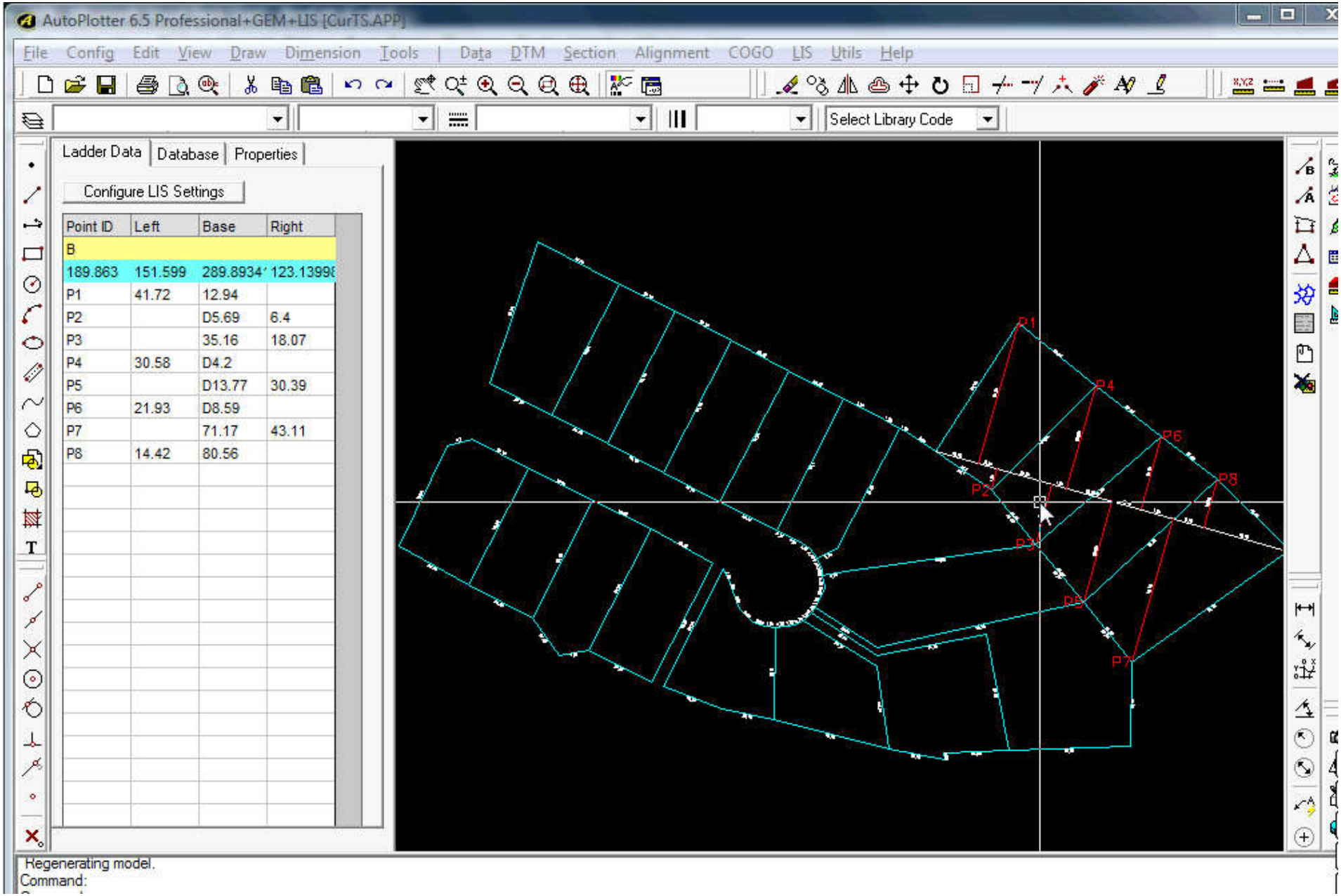




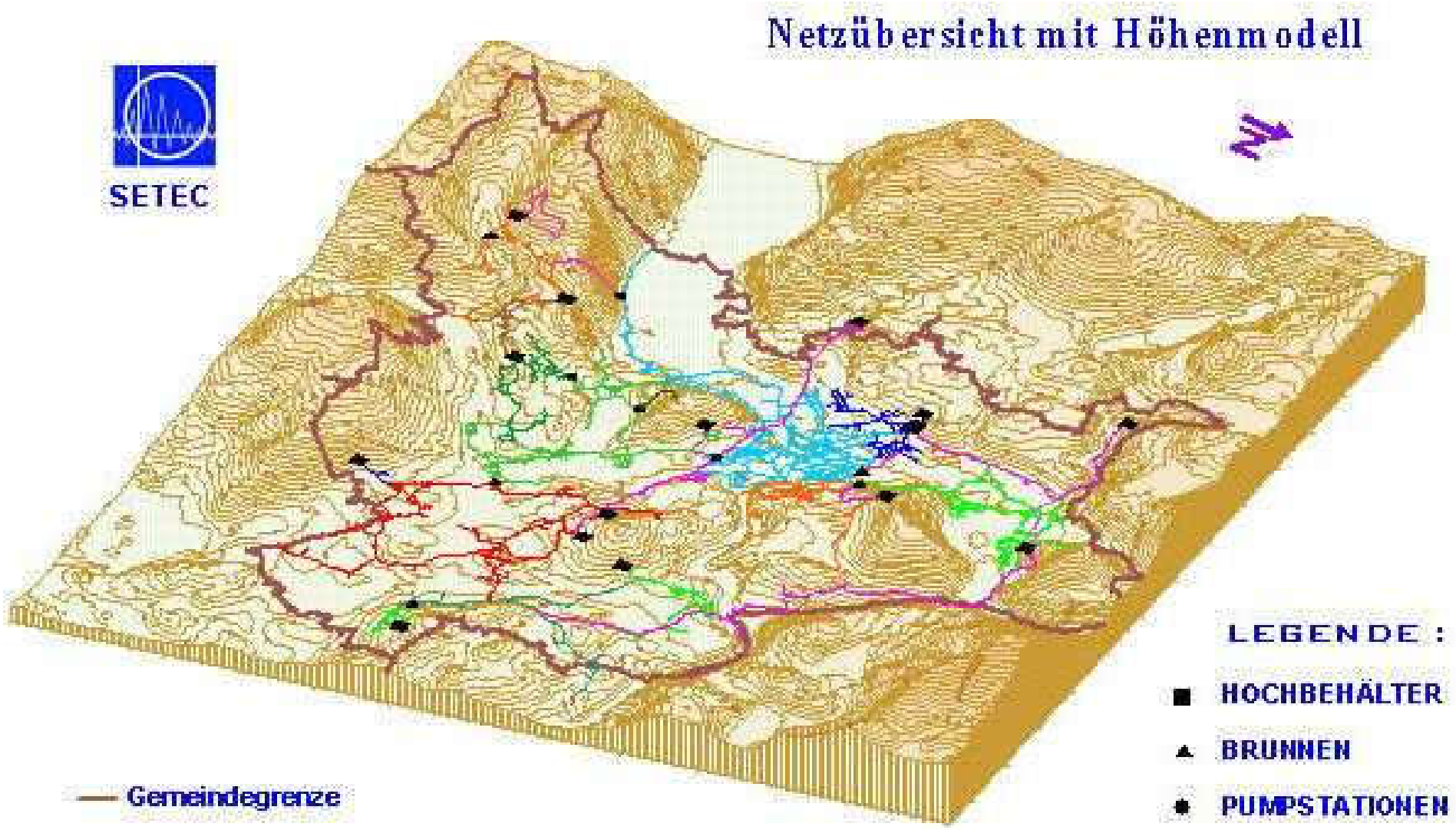
Examples


File Edit View Draw Arrange Grid Map Window Help
Order Objects
Order Overlay
Align Objects
Combine
Break Apart
Rotate...
Free Rotate
Translate...
Move to Front Shift+PgUp
Move to Back Shift+PgDn
Move Forward Ctrl+PgUp
Move Backward Ctrl+PgDn
Rectangle
Map
Z Axis
Right Axis
Left Axis
Top Axis
Bottom Axis
Wireframe
Shaded Relief
Image Map
Color Scale
Contours
3D Surface
Move current selection to back of drawing

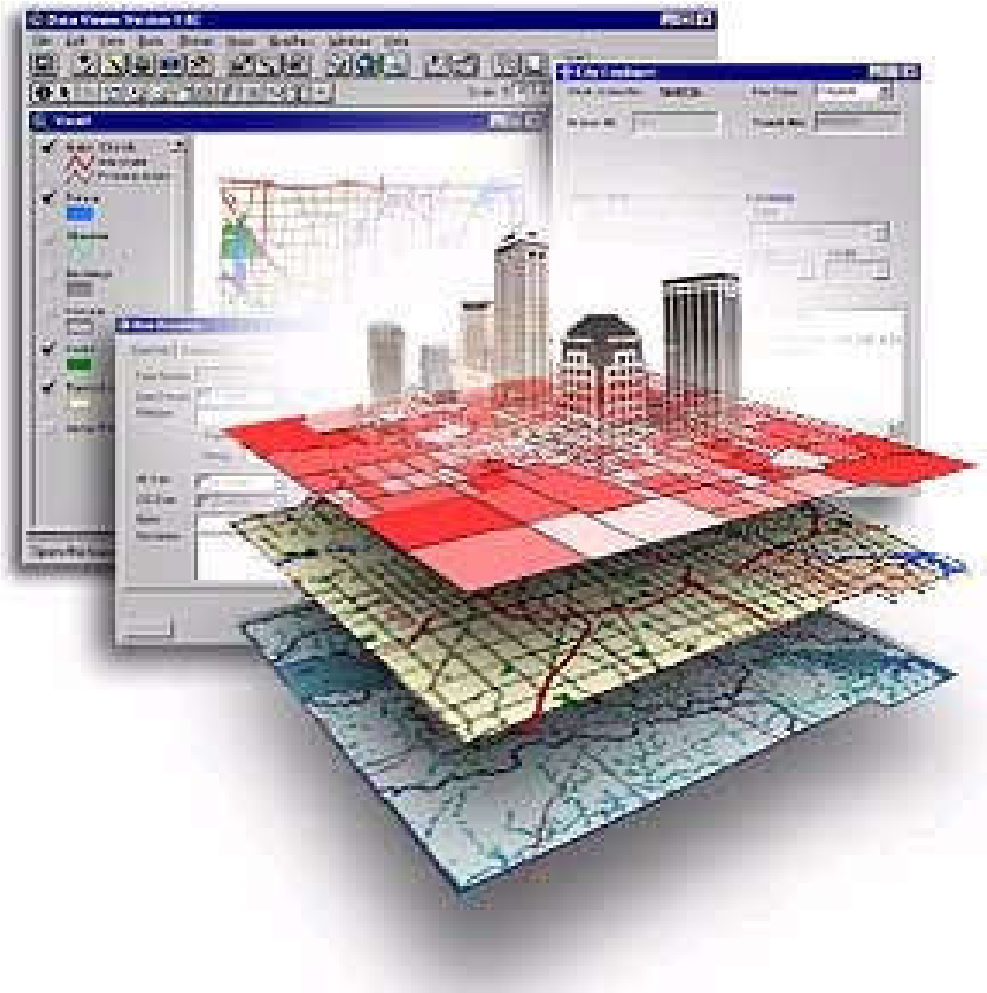
Examples….


AutoPlotter 6.5 Professional+GEM+LIS [CurTS.APP]
File Config Edit View Draw Dimension Tools Data DTM Section Alignment COGO LIS Utils Help
Select Library Code
Ladder Data
Database
Properties
Configure LIS Settings
Point ID Left Base Right
B
189.863 151.599 289.8934 123.1399
P1 41.72 12.94
P2 D5.69 6.4
P3 35.16 18.07
P4 30.58 D4.2
P5 D13.77 30.39
P6 21.93 D8.59
P7 71.17 43.11
P8 14.42 80.56
P1
P2
P3
P4
P5
P6
P7
P8
Regenerating model.
Command:

Examples….


Netzübersicht mit Höhenmodell
SETEC
N
LEGENDE :
HOCHBEHÄLTER
BRUNNEN
PUMPSTATIONEN
Gemeindegrenze

Examples….



Handling spatial data

Total Station Cont…

Downside

- Battery Dependant
  - Heavy
  - Temperature Dependant
  - ‘is it charged’
- Failures (Hard & Soft)
- Data Loss
- Durability
- Computer Dependant !!

G P S

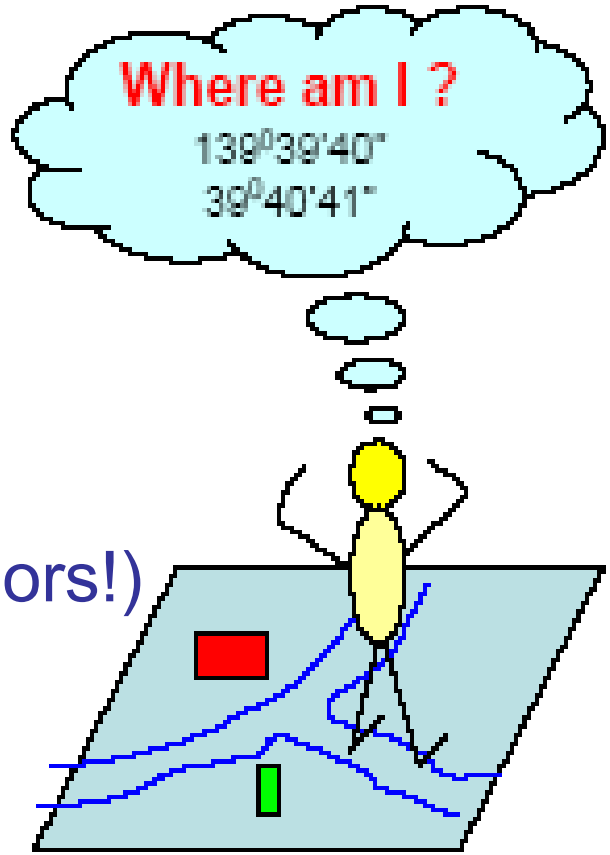
Since Earliest Times We' ve Been Trying to Figure Out Where We Are And Where We' re Going

GPS Cont…

Fundamental Problem

How to know my location precisely ?

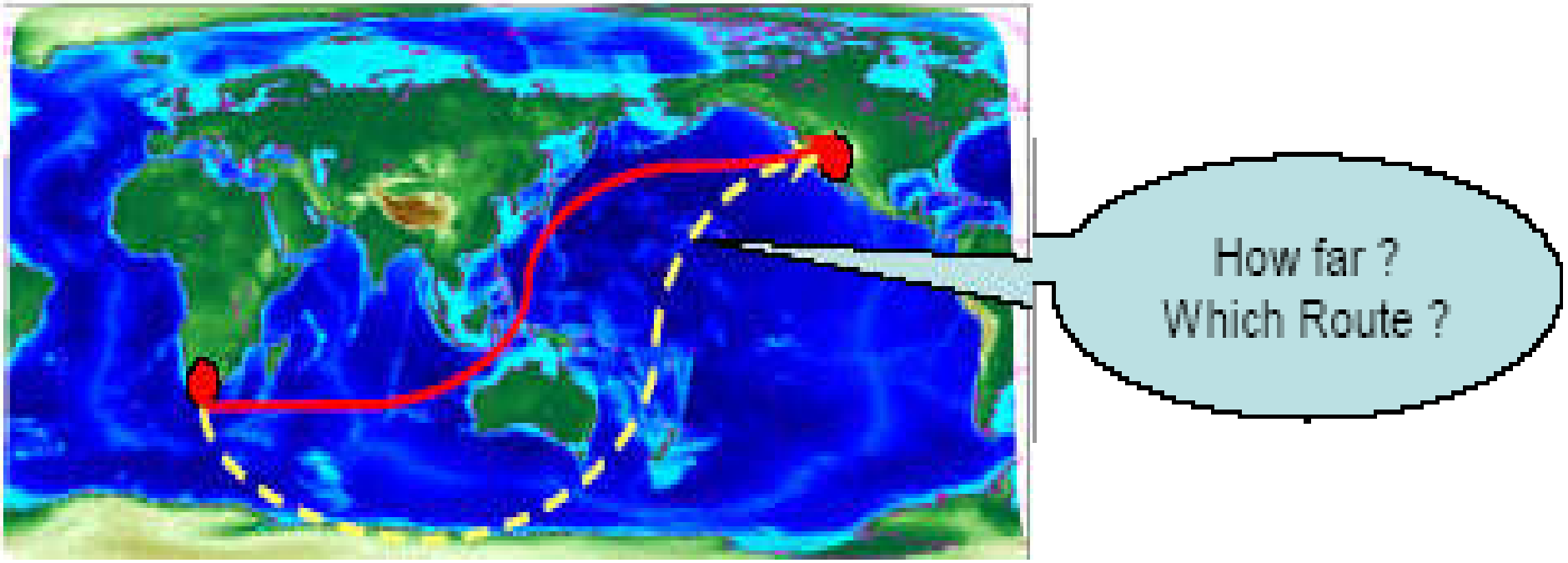
- In any condition
- At any time
- Everywhere on earth (at least outdoors!)



GPS Cont…

How to locate a landmark or target precisely ?

– Guidance or Navigation



GPS Cont…

Global **P**ositioning **S**ystem

A shortened term for NAVSTAR GPS
Navigation **S**atellite **T**iming **A**nd **R**anging

A system for locating ourselves on earth

GPS Cont…

- GPS is a satellite-based radio positioning, navigation, and time transfer system
- Designed to provide continuous, real-time, all-weather coverage worldwide
- A fundamental revolution in navigation!

What does GPS provide?

3D position

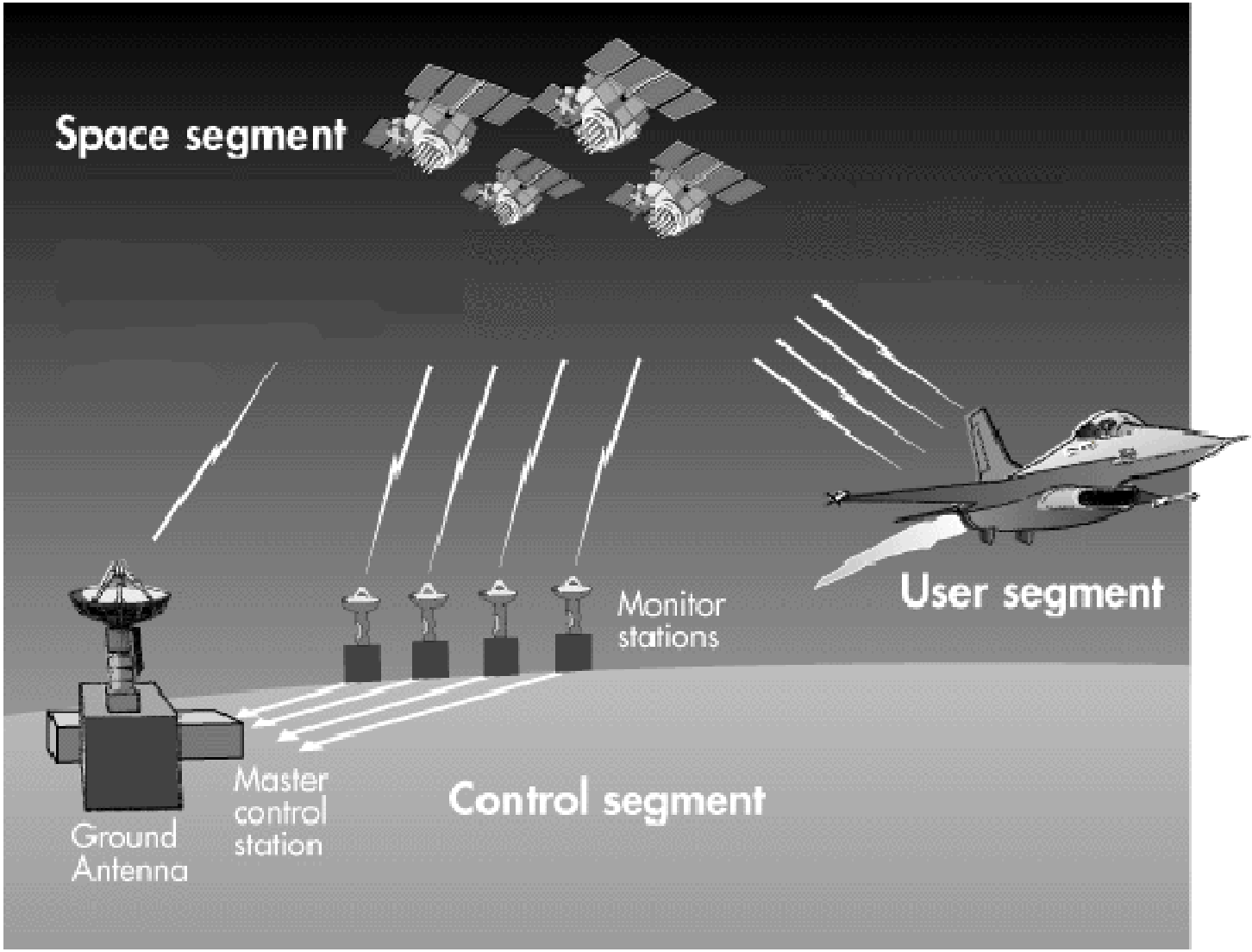
Navigation information

- position
- heading
- velocity

Time

GPS Cont…

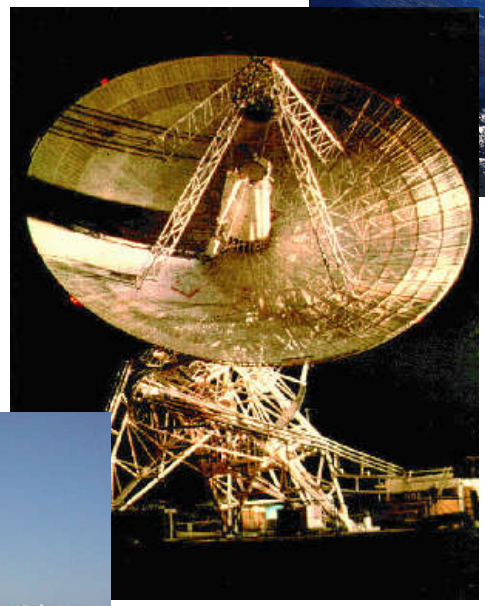
Three Basic Segments



GPS Cont…

Three Basic Segments

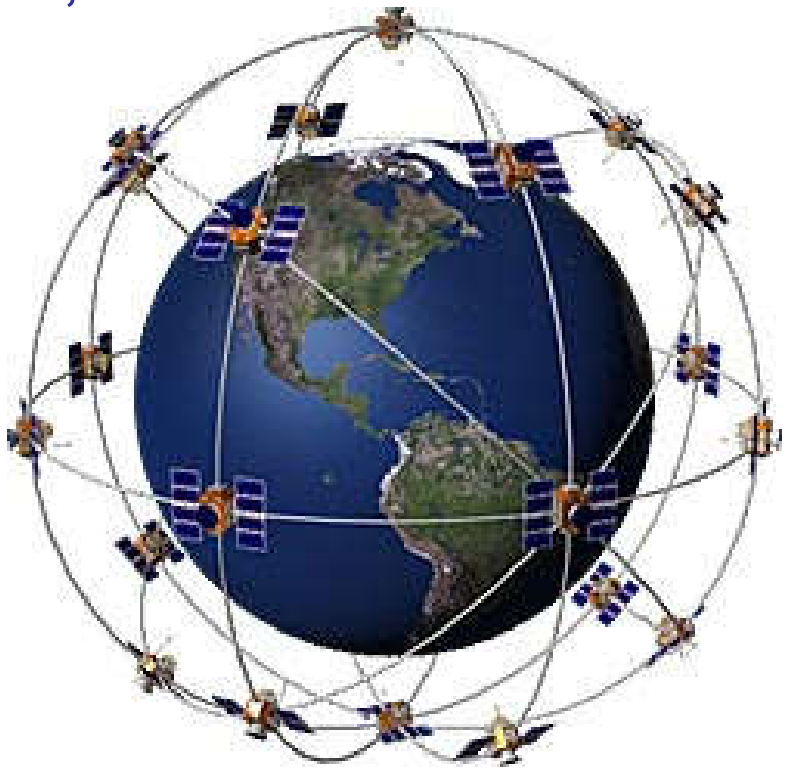
- Space Segment
- Control Segment
- User Segment



GPS Cont…

Space Segment

- 24 Satellites in 6 Orbital Planes inclined at 55^{o}
- Near Circular Orbits with Radius 26,560km
- Orbital Period : 11hr 58m
- Signals : L1 and L2 bands



GPS Cont…

Control Segment

- Monitor Satellite Orbits
- Maintain Satellite Health
- Maintain GPS Time
- Update Satellite Navigation Messages
- Command small maneuvers of satellites to maintain orbit and relocations to compensate and failures

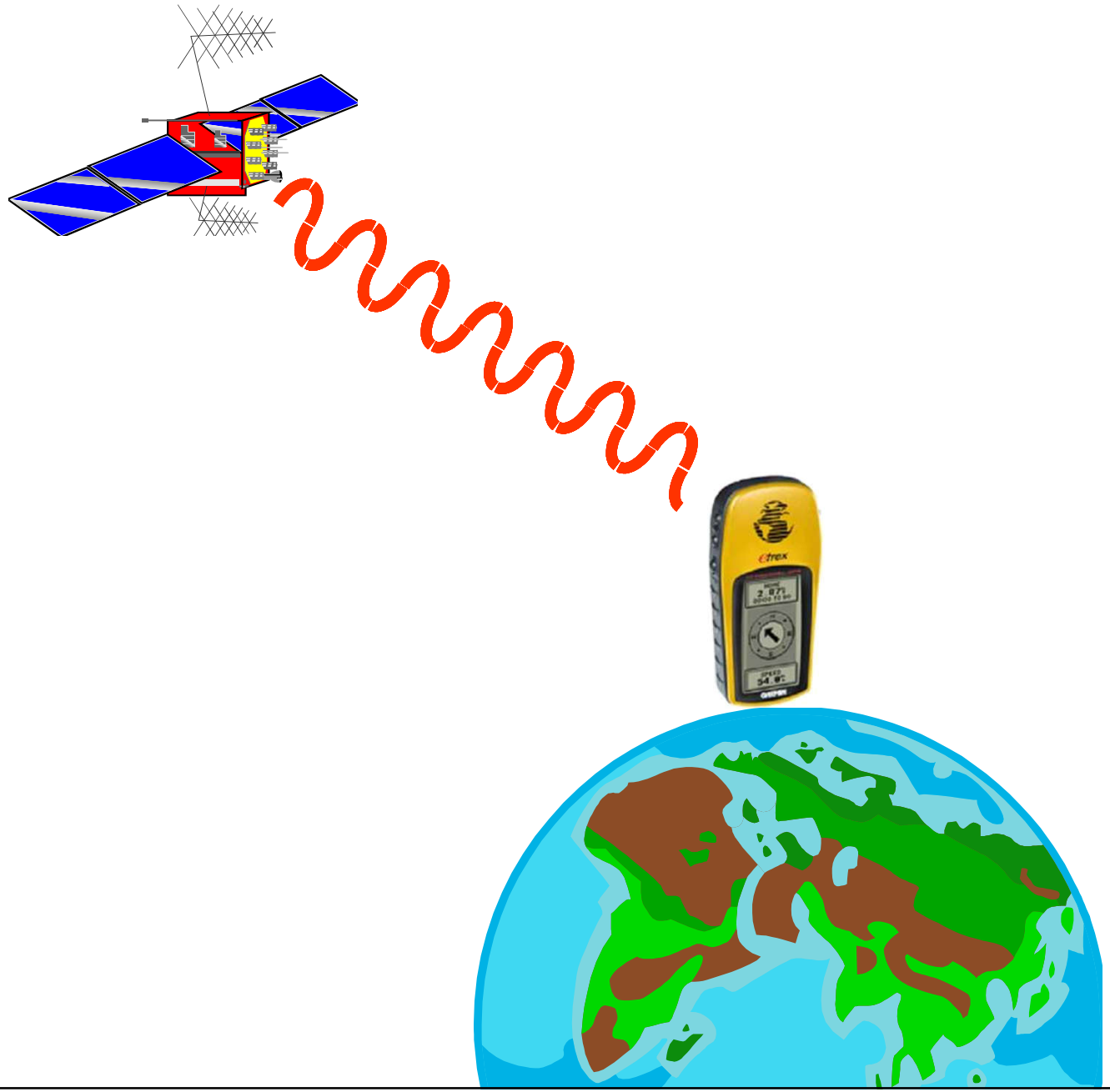
GPS Cont…

User Segment

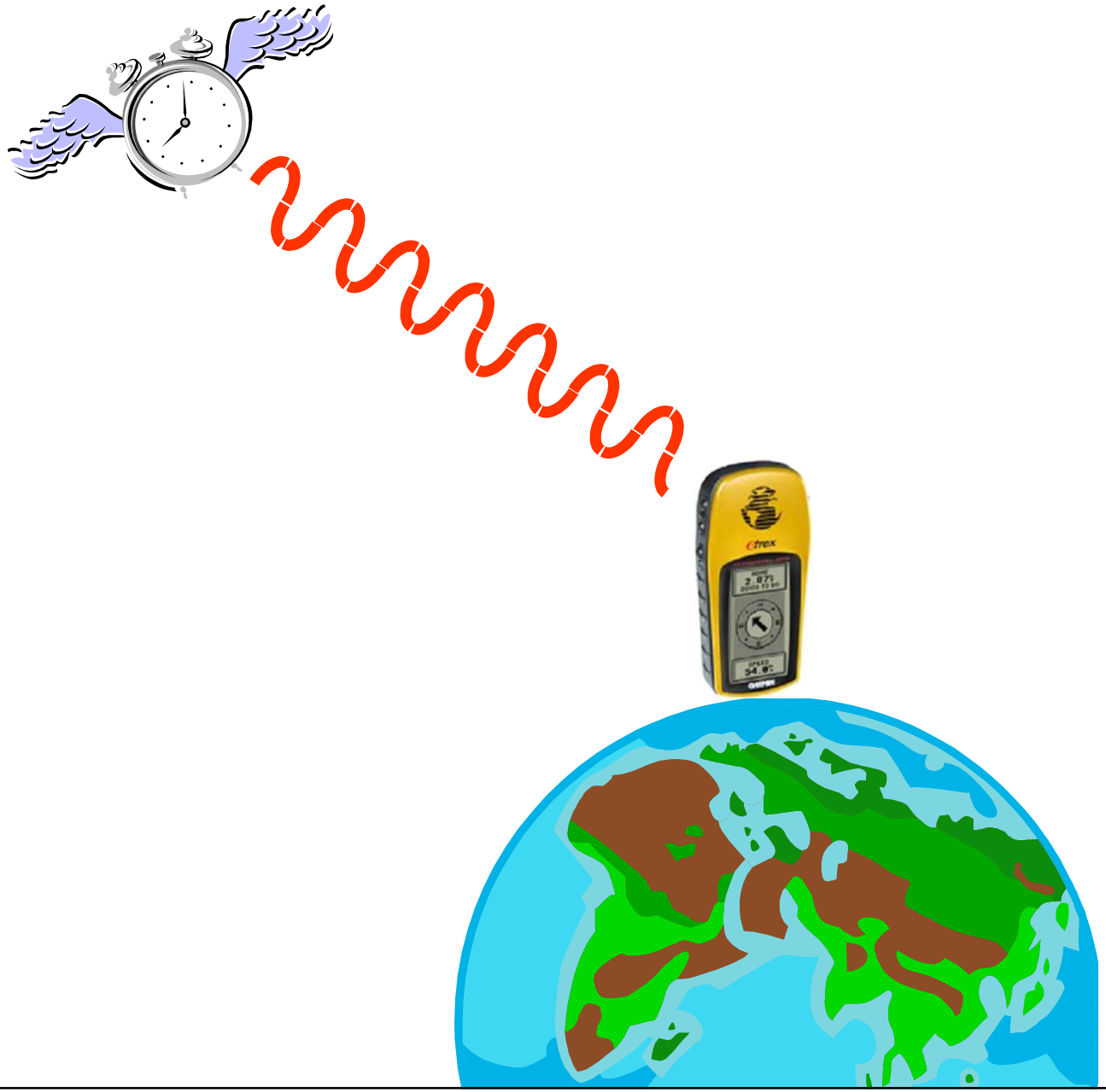
GPS Receivers and Users

- Civilian Users
  - Mapping, Surveying
  - Navigation
  - Search and Rescue (SAR)
  - Pleasure, Sports, Hiking
- Military Users
  - Navigation
  - Guidance
  - Artillery

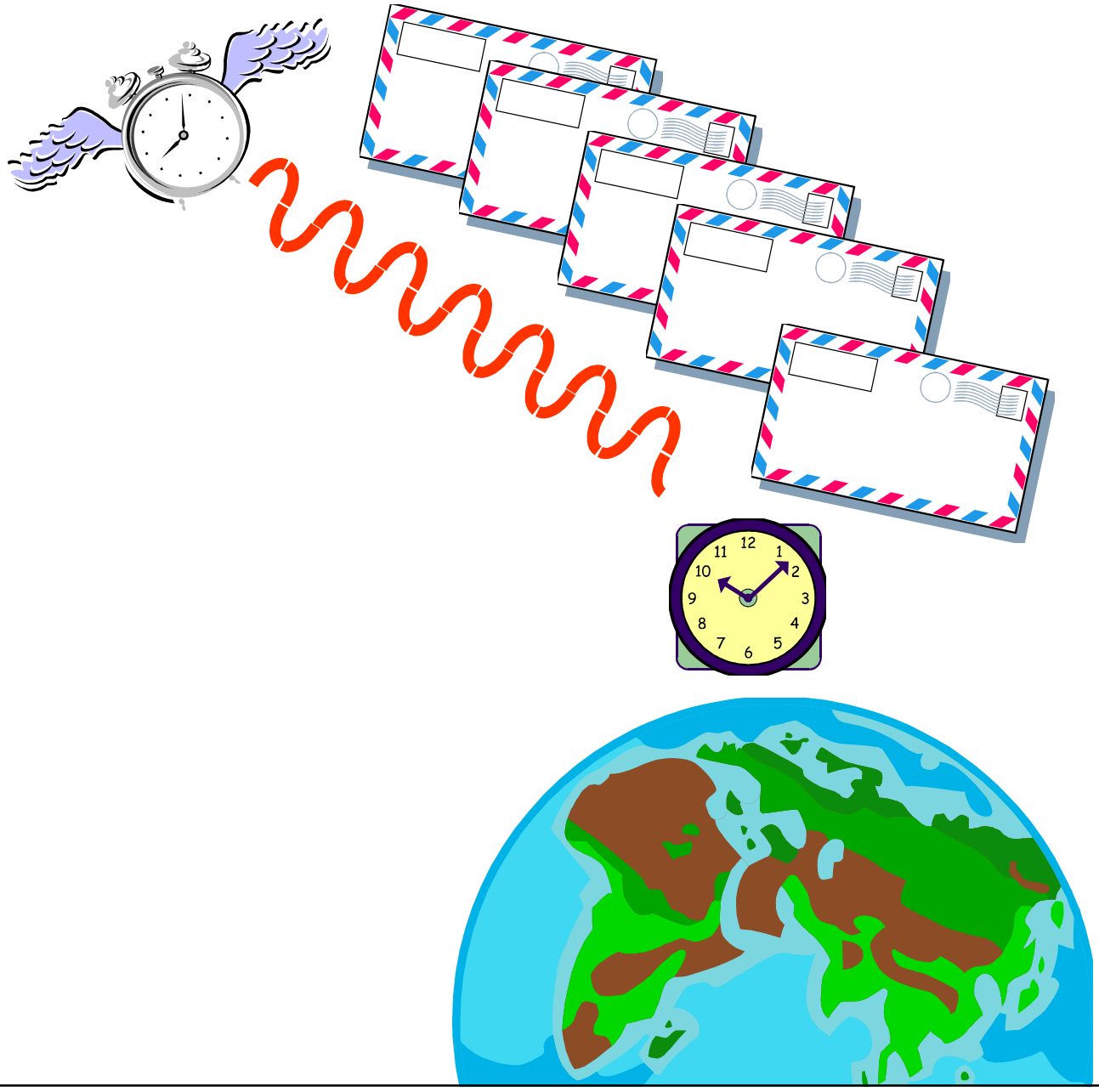
How GPS Works



How GPS Works….



How GPS Works….



How GPS Works….

The whole system revolves around time!!!

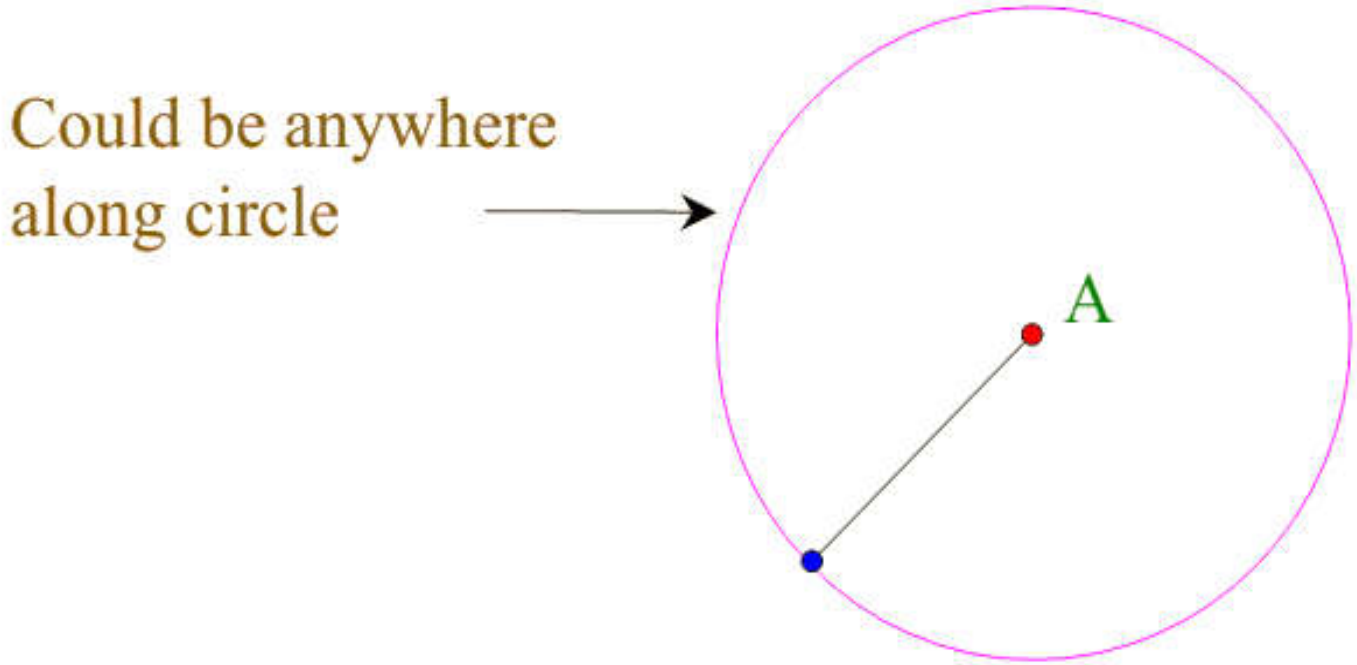
Distance = Rate x Time

- Rate = 186,000 miles per second (Speed of Light)
- Time = time it takes signal to travel from the SV to GPS receiver

How GPS Works….

Triangulation in 2D

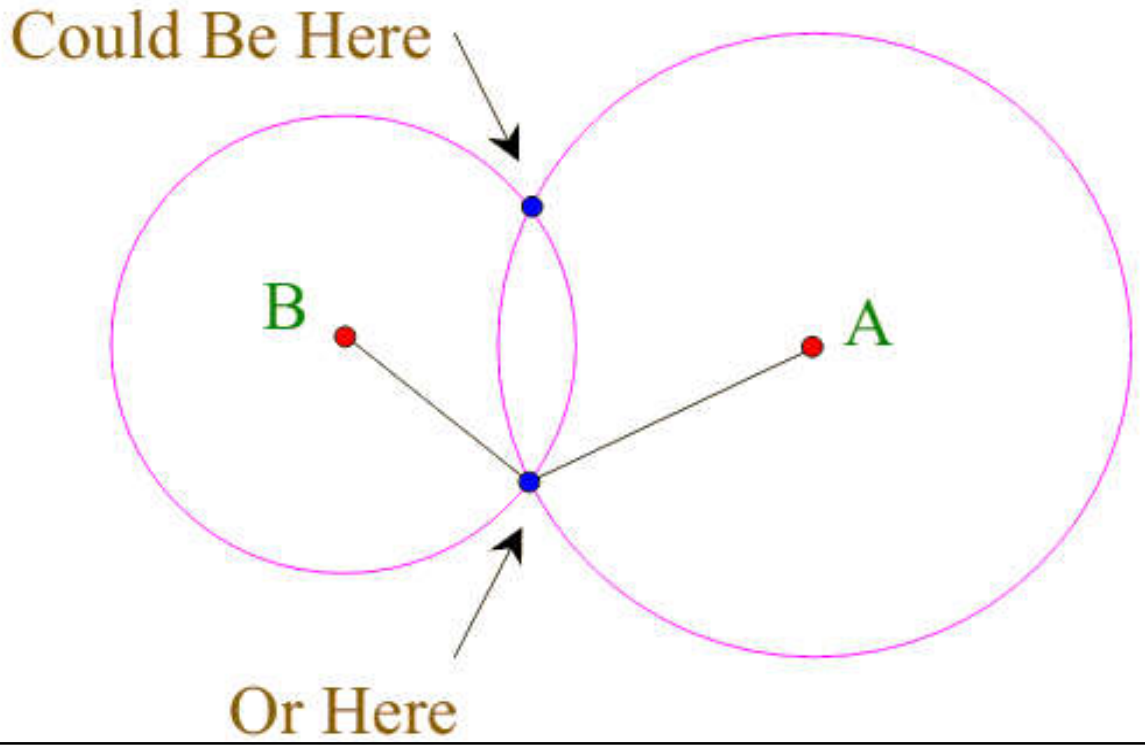
- If location of point A is known, and the distance to point A is known, desired position lies somewhere on a circle.



How GPS Works….

Triangulation in 2D

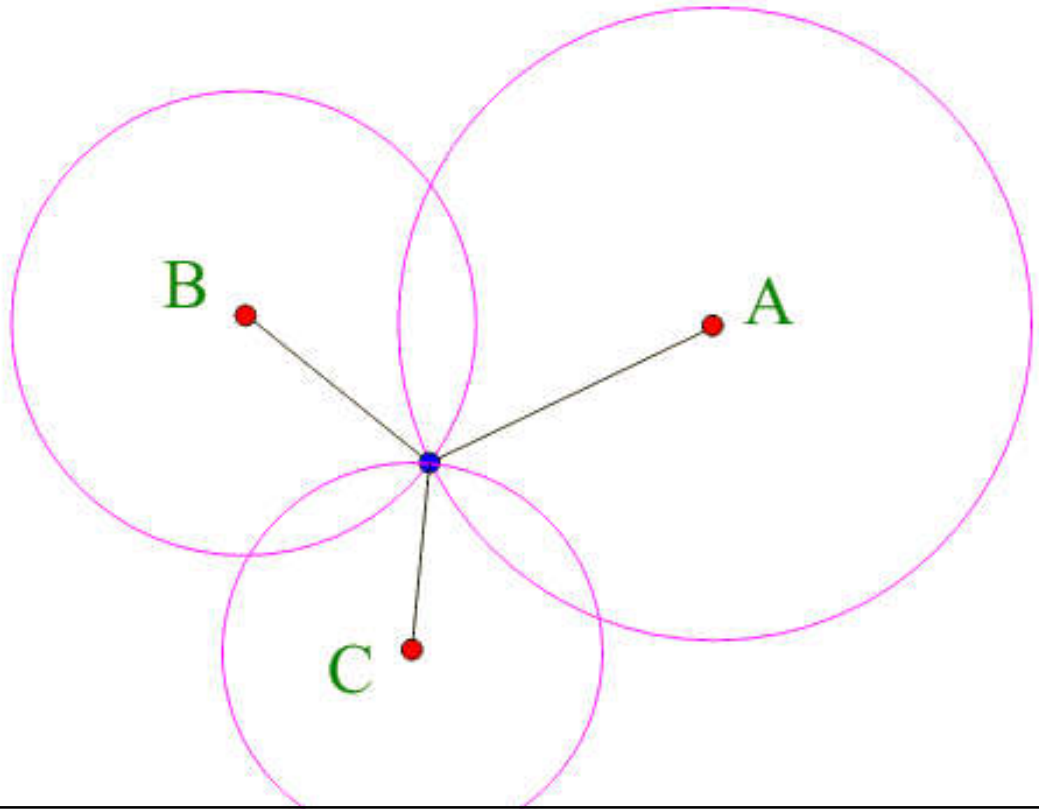
- Distance to two points are known.
- Desired position is in one of two locations.



How GPS Works….

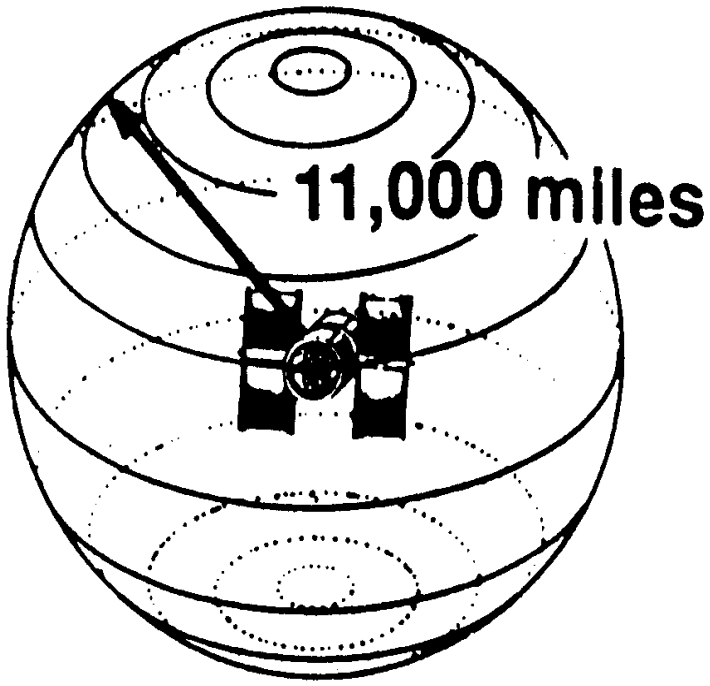
Triangulation in 2D

- Distance to three points are known.
- Position is known!



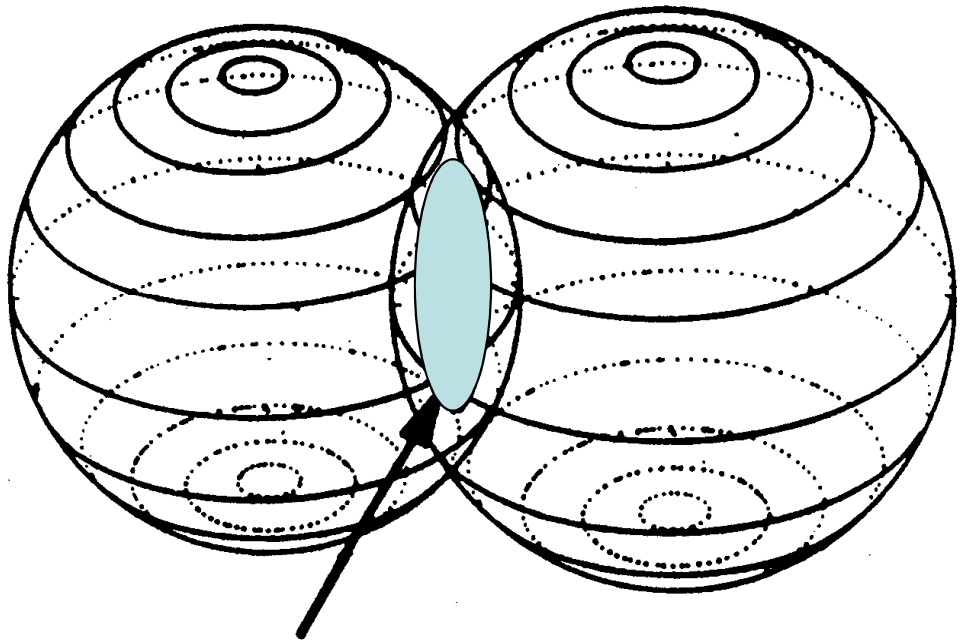
How GPS Works….

A measurement from one satellite locates a point somewhere on a sphere with the satellite in the center.



How GPS Works….

A second measurement from another satellite narrows the location of the point to any point on the circle where the two spheres intersect.

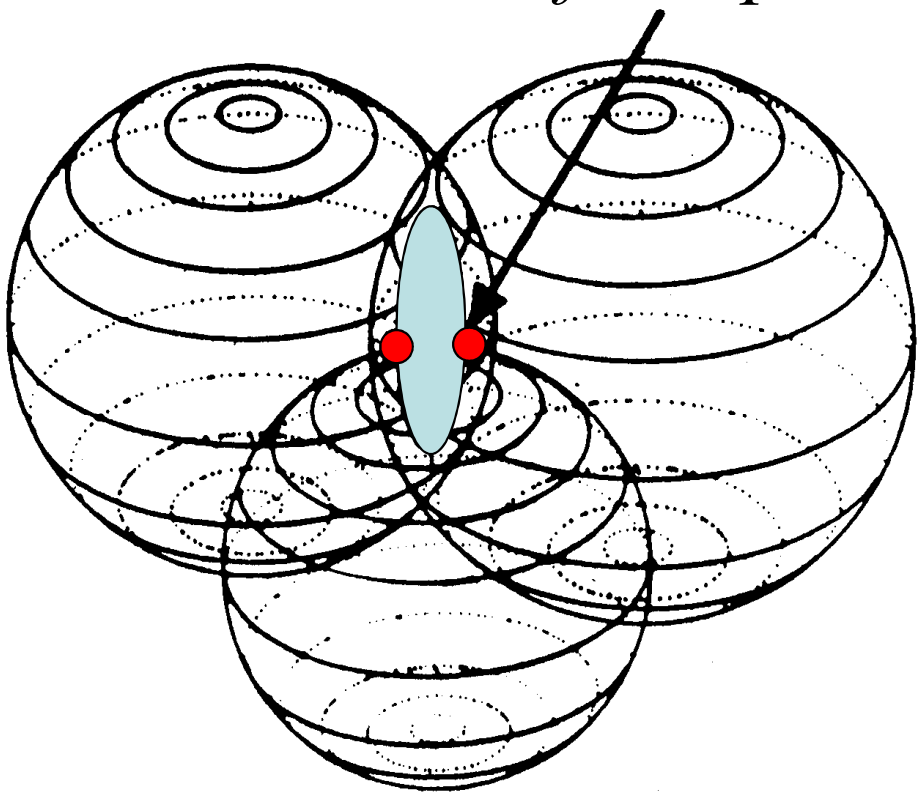


Two measurements puts us somewhere on this circle

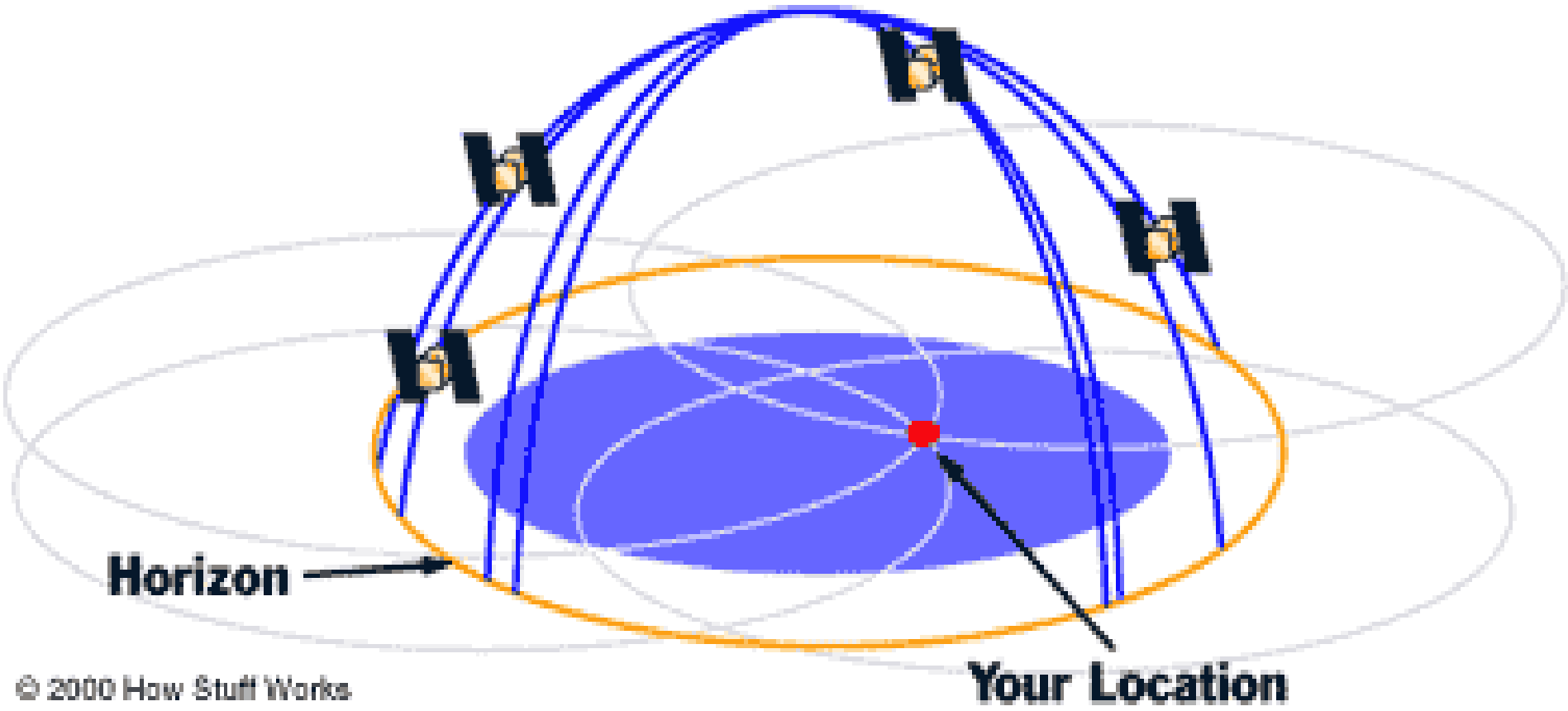
How GPS Works….

A third measurement from yet another satellite puts the location of the point at one of the two points where the third sphere intersects the circle

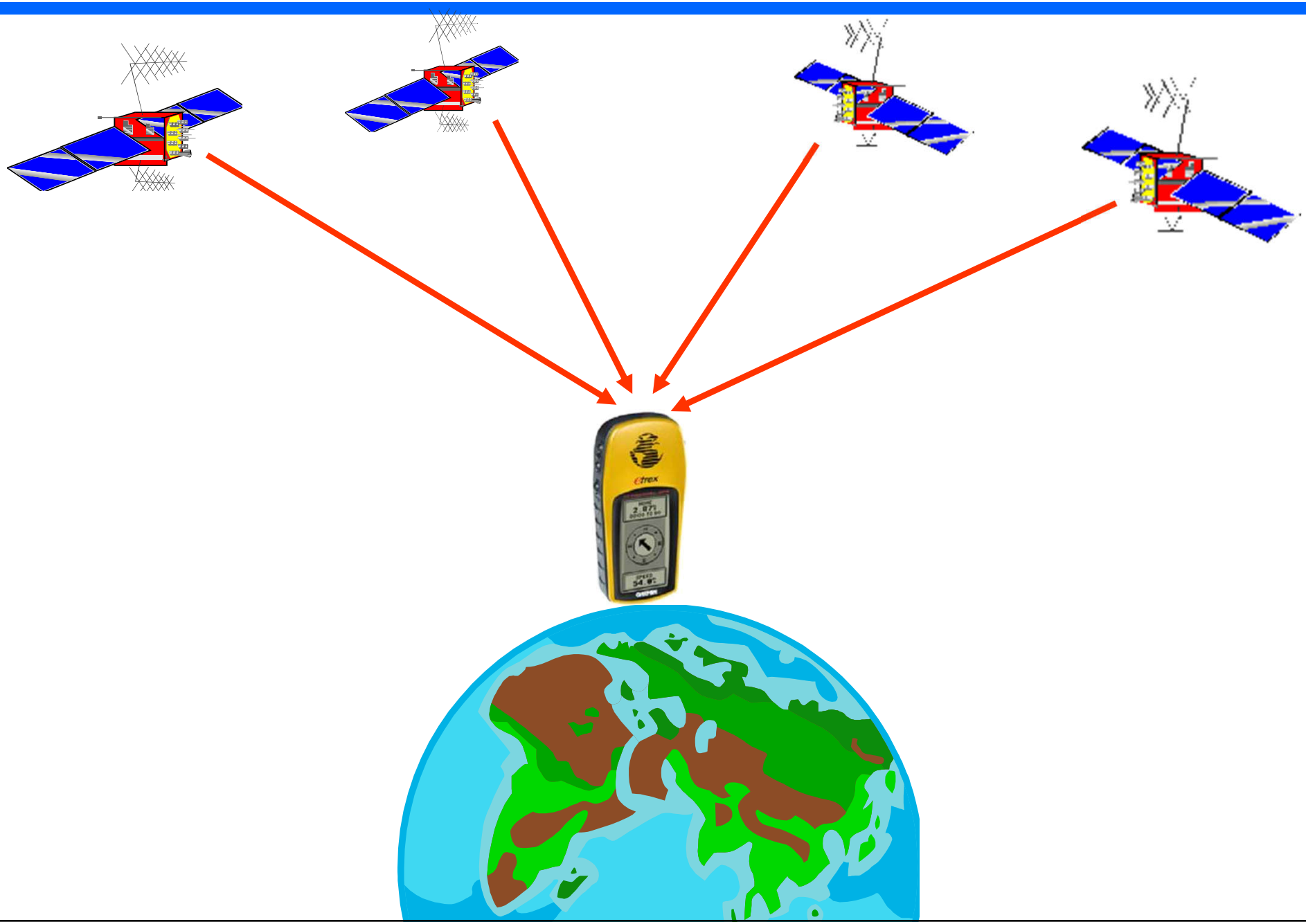
Three measurements puts us at one of two points



How GPS Works….

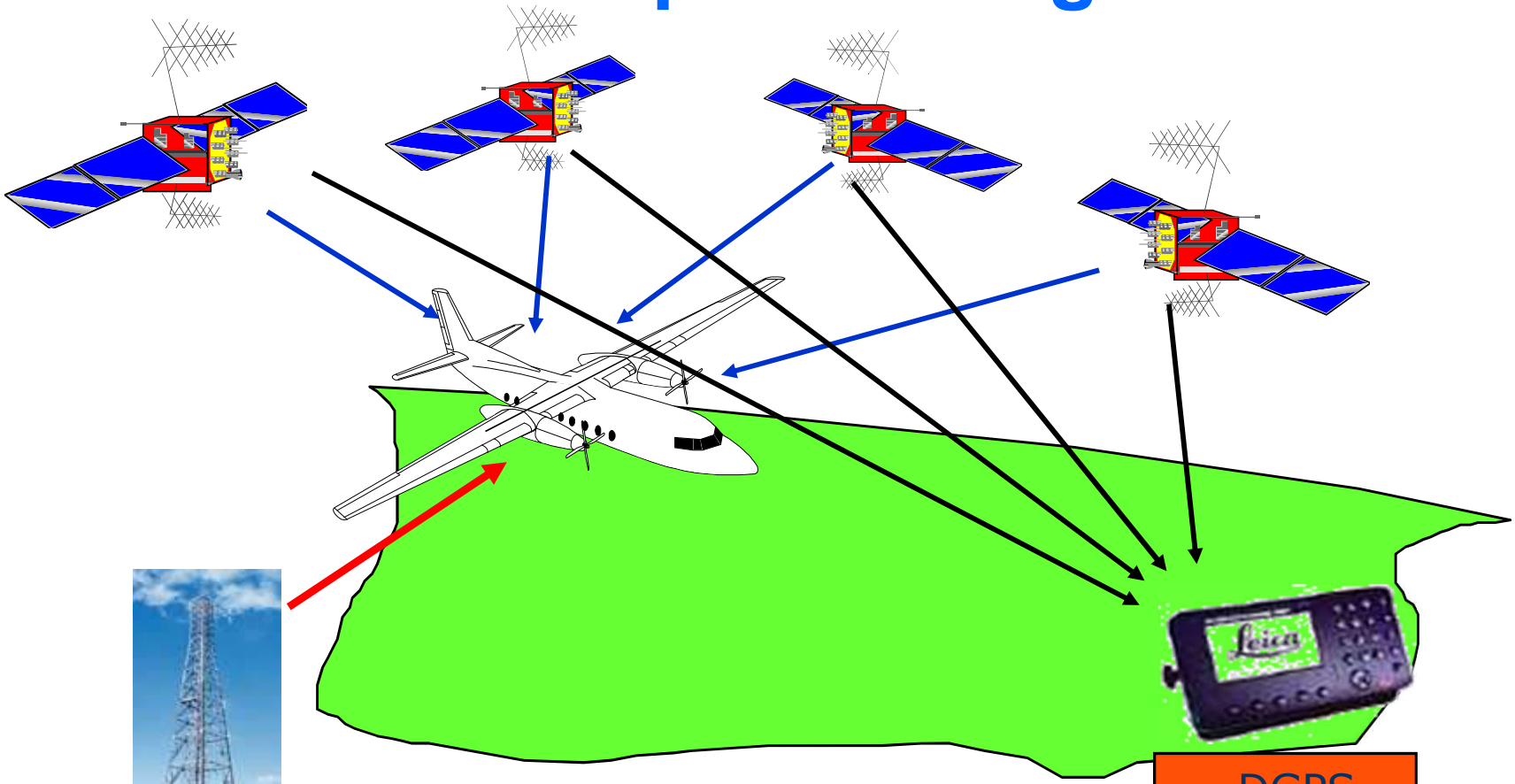


How GPS Works….

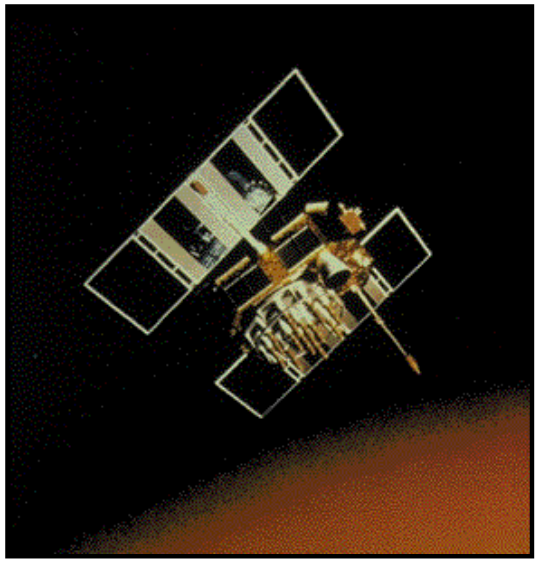


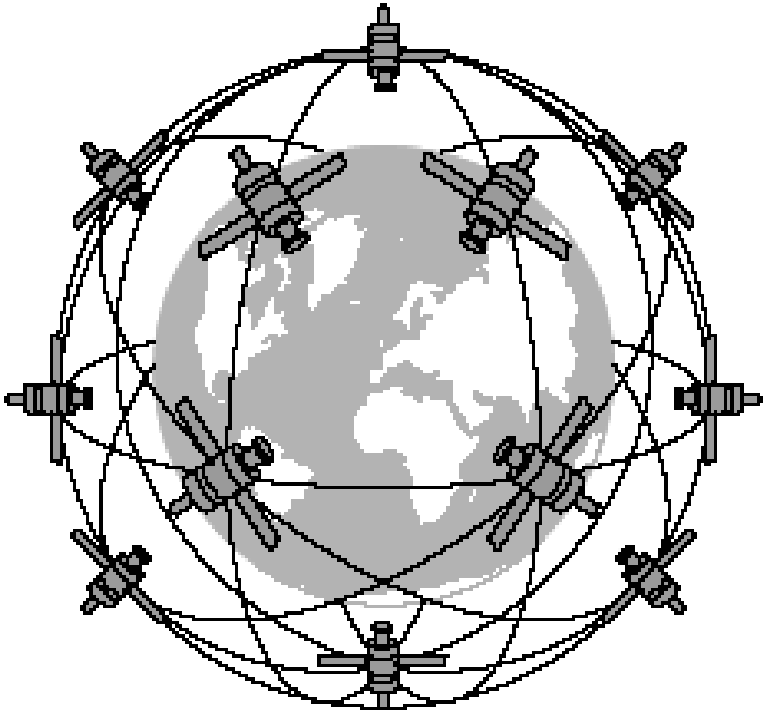
GPS Cont…

Differential positioning



What is GPS used for? ...



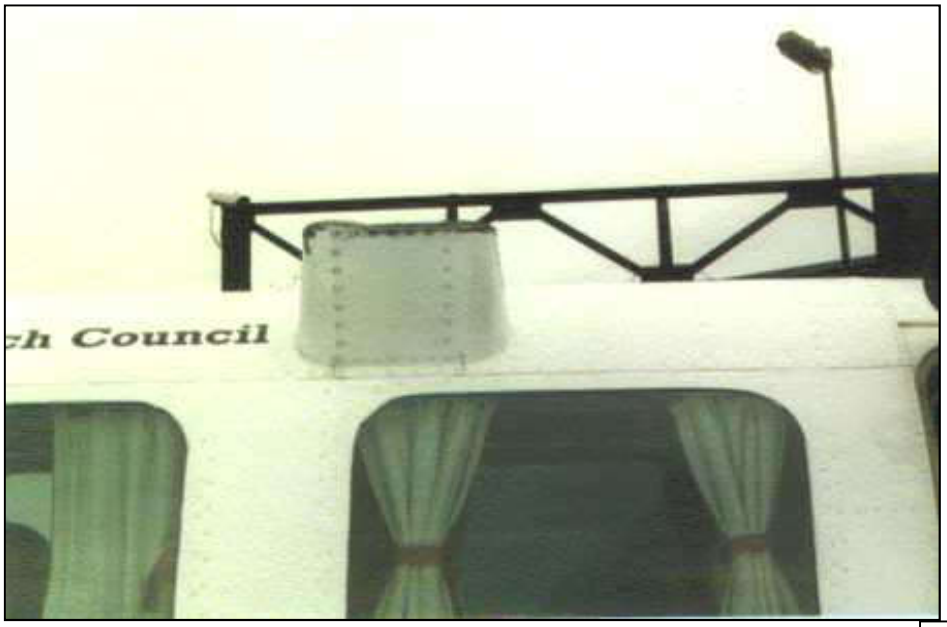


HiPer Lite+ Series

Navigation

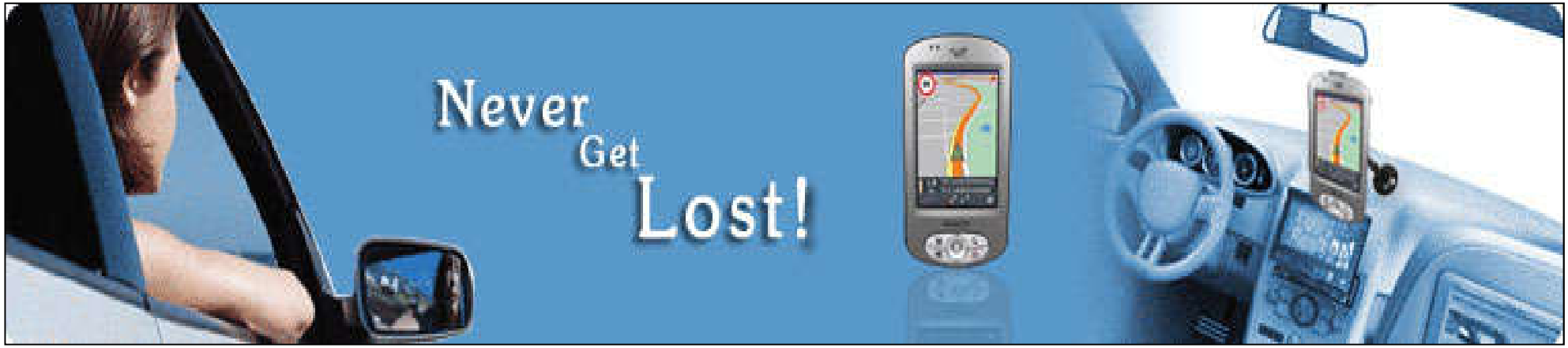
Navigation

Navigation



In-car navigation

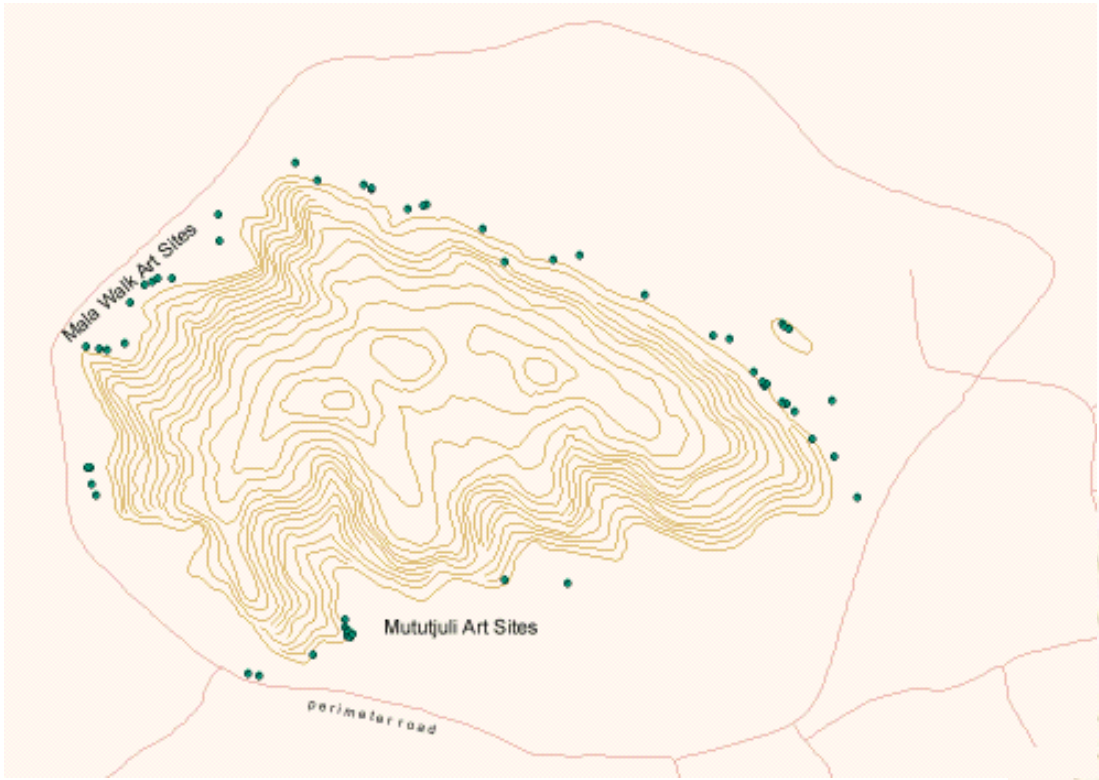
In-car navigation



City Maps

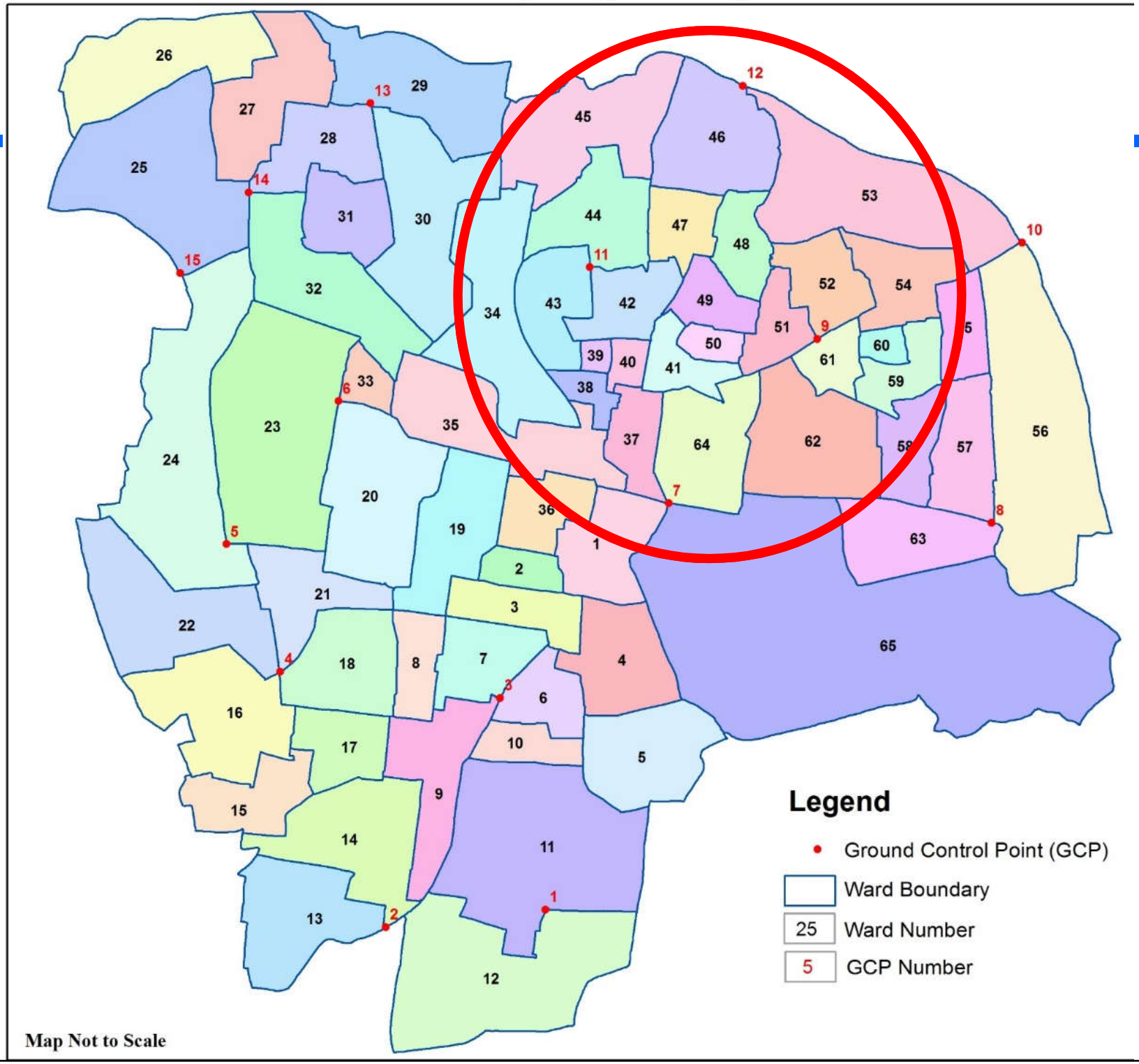
Building/engineering set out

Mapping

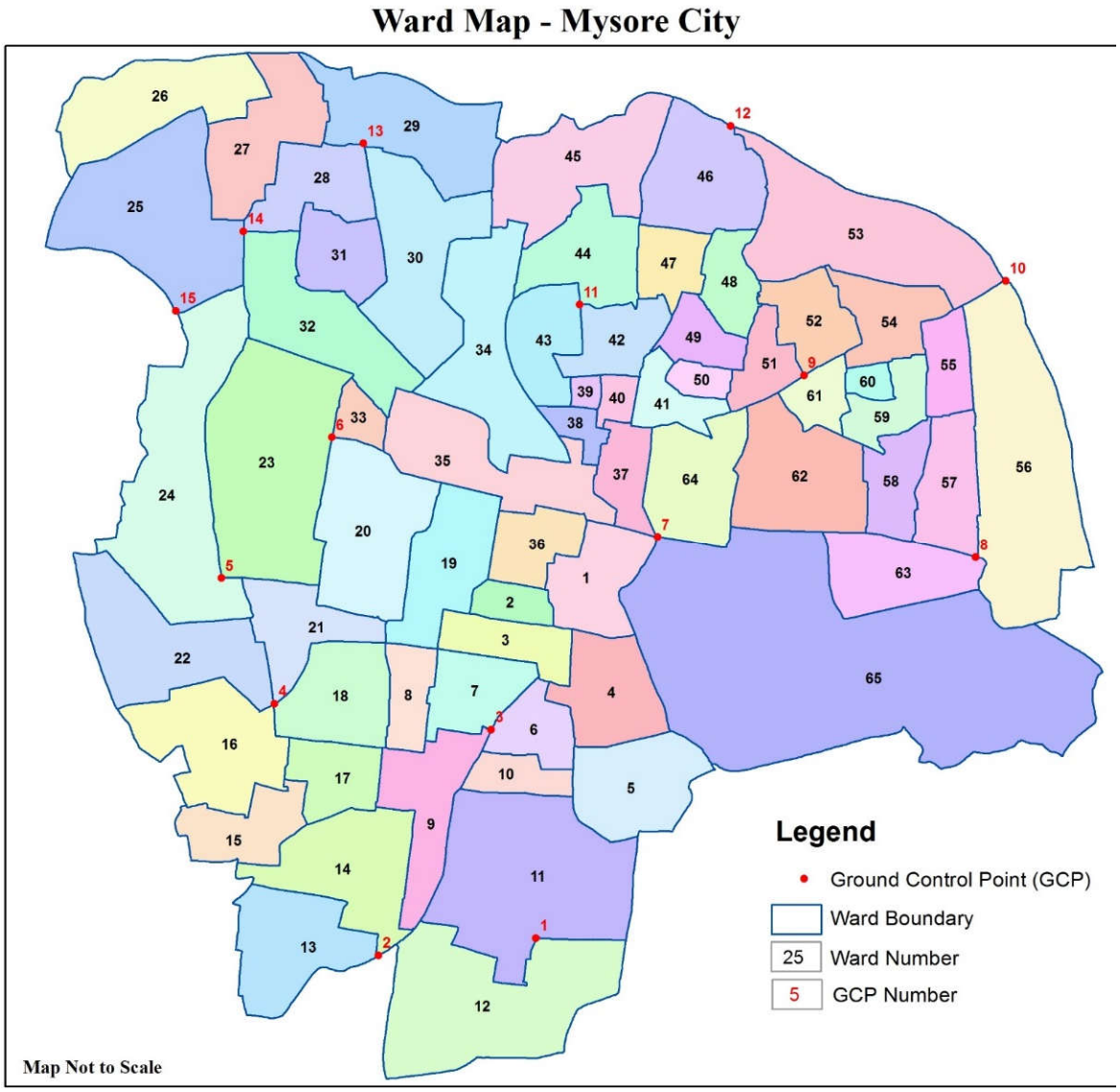

Mala Walk Art Sites
Mututjuli Art Sites
perimeter road


Mututjuli Art Sites
perimeter road

Ward Map - Mysore City



Control Points



Mysore City		
GCP	Longitude	Latitude
1	76.648849050	12.267386148
2	76.633172162	12.265418473
3	76.644052212	12.287837785
4	76.622385724	12.290051312
5	76.616882196	12.302348407
6	76.627669375	12.316490605
7	76.660330959	12.307149110
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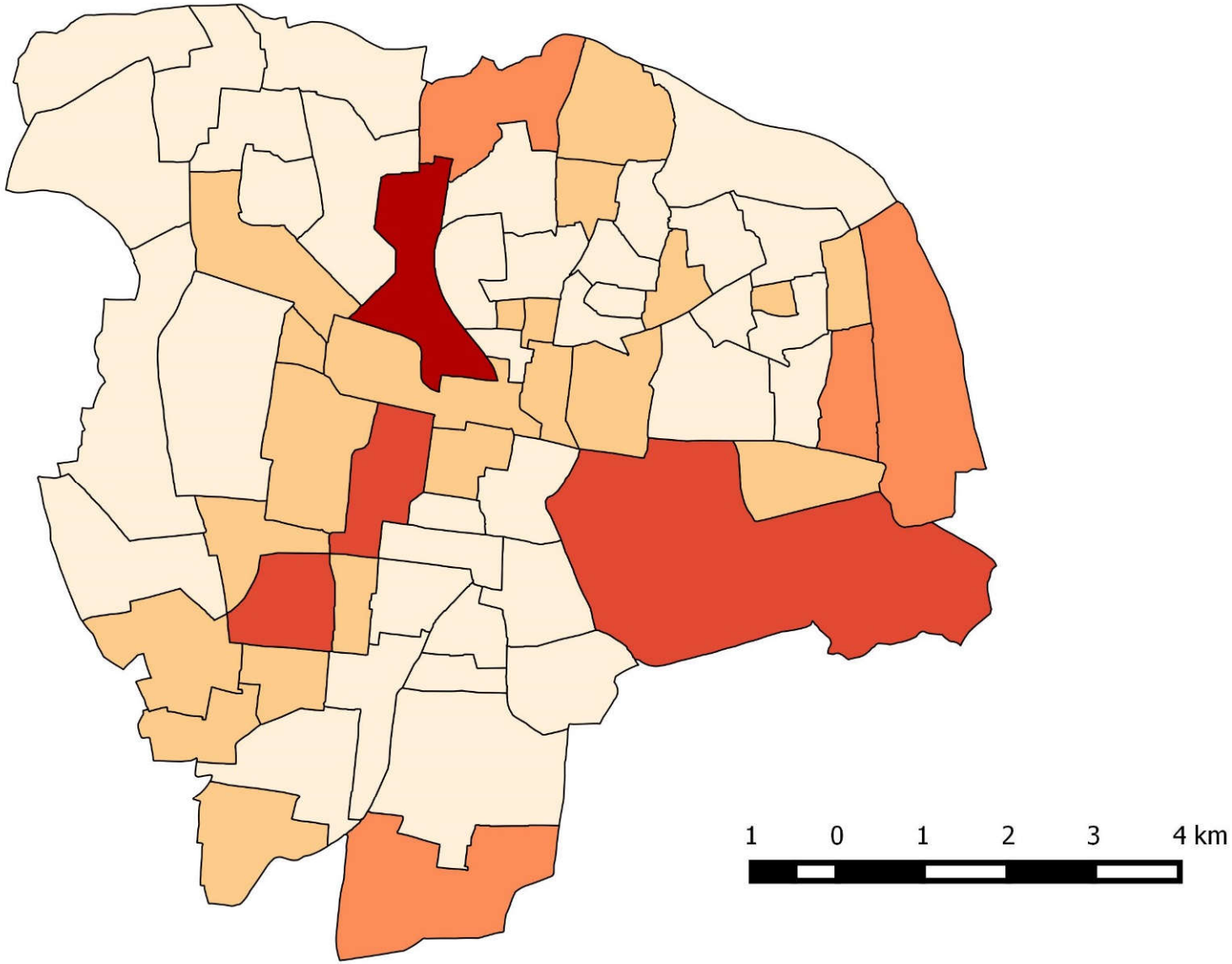
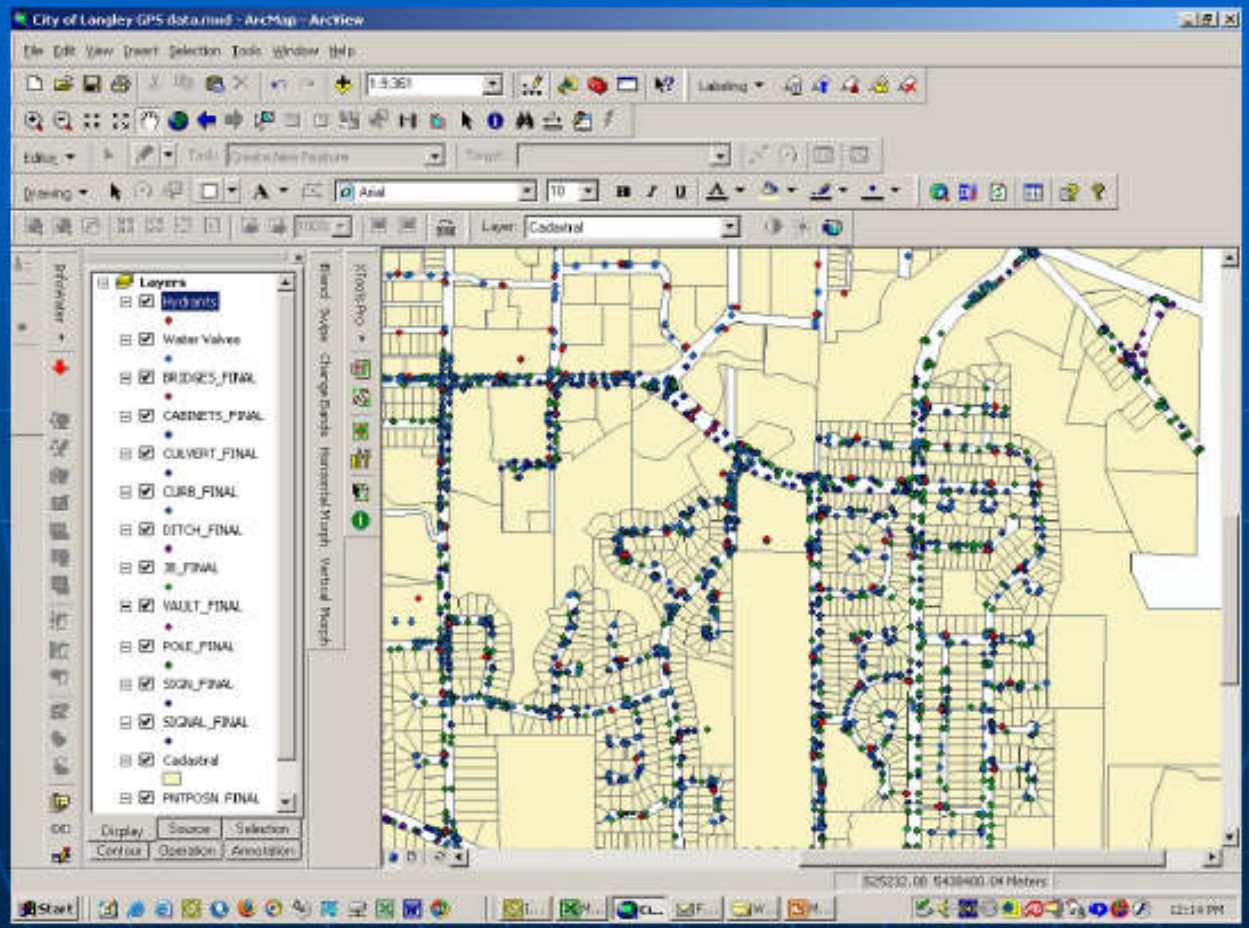
9	76.674680285	12.323340105
10	76.694648762	12.332985015
11	76.652195657	12.329953224
12	76.666959208	12.347802326
13	76.630331570	12.345493168
14	76.618523934	12.336633462
15	76.611912984	12.328705243

Total Population Distribution in Mysore



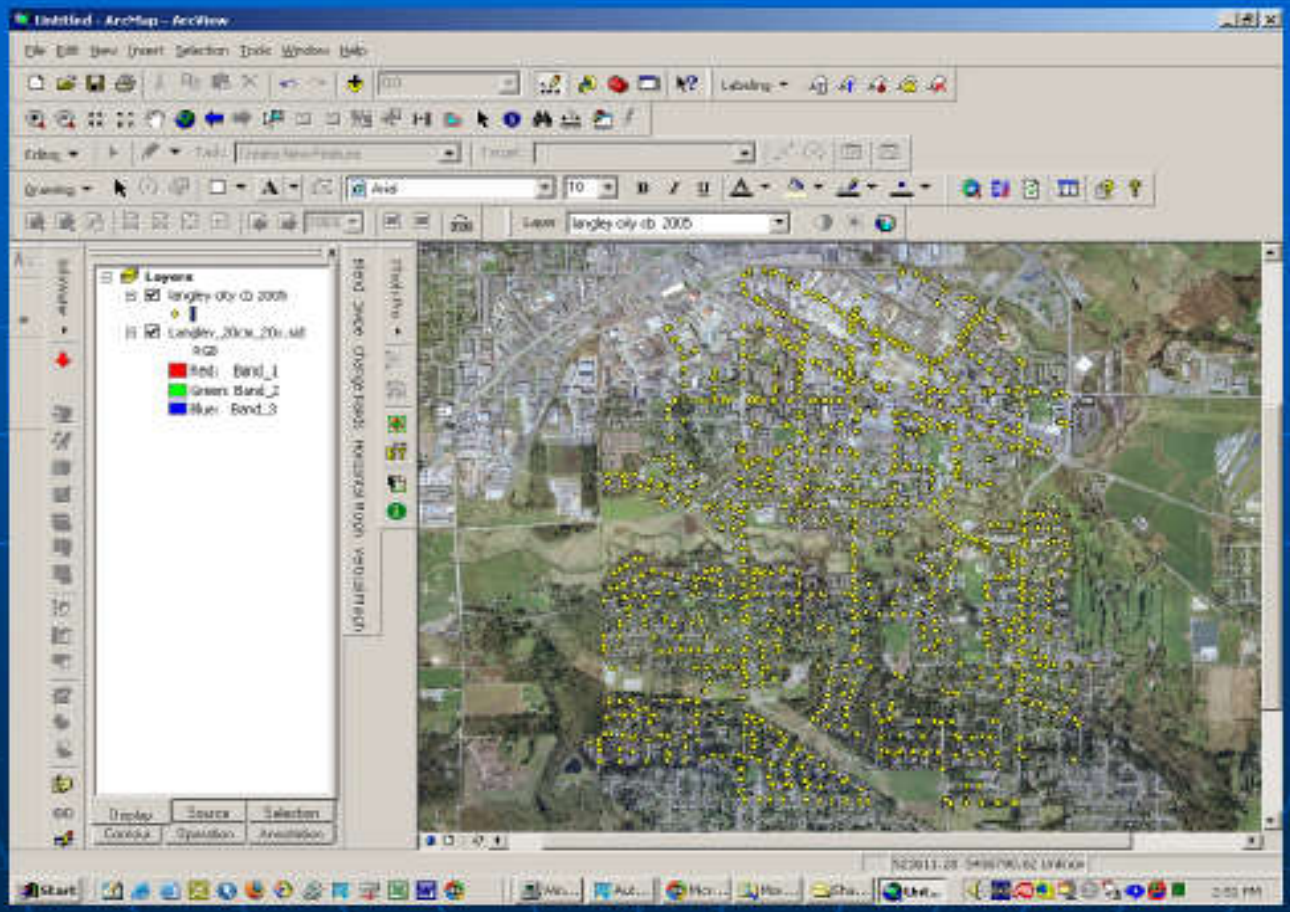
Mapping

In 3 months, entire water system (100km) City mapped with Centimeter Accurate GPS (Average 200+ points/day)

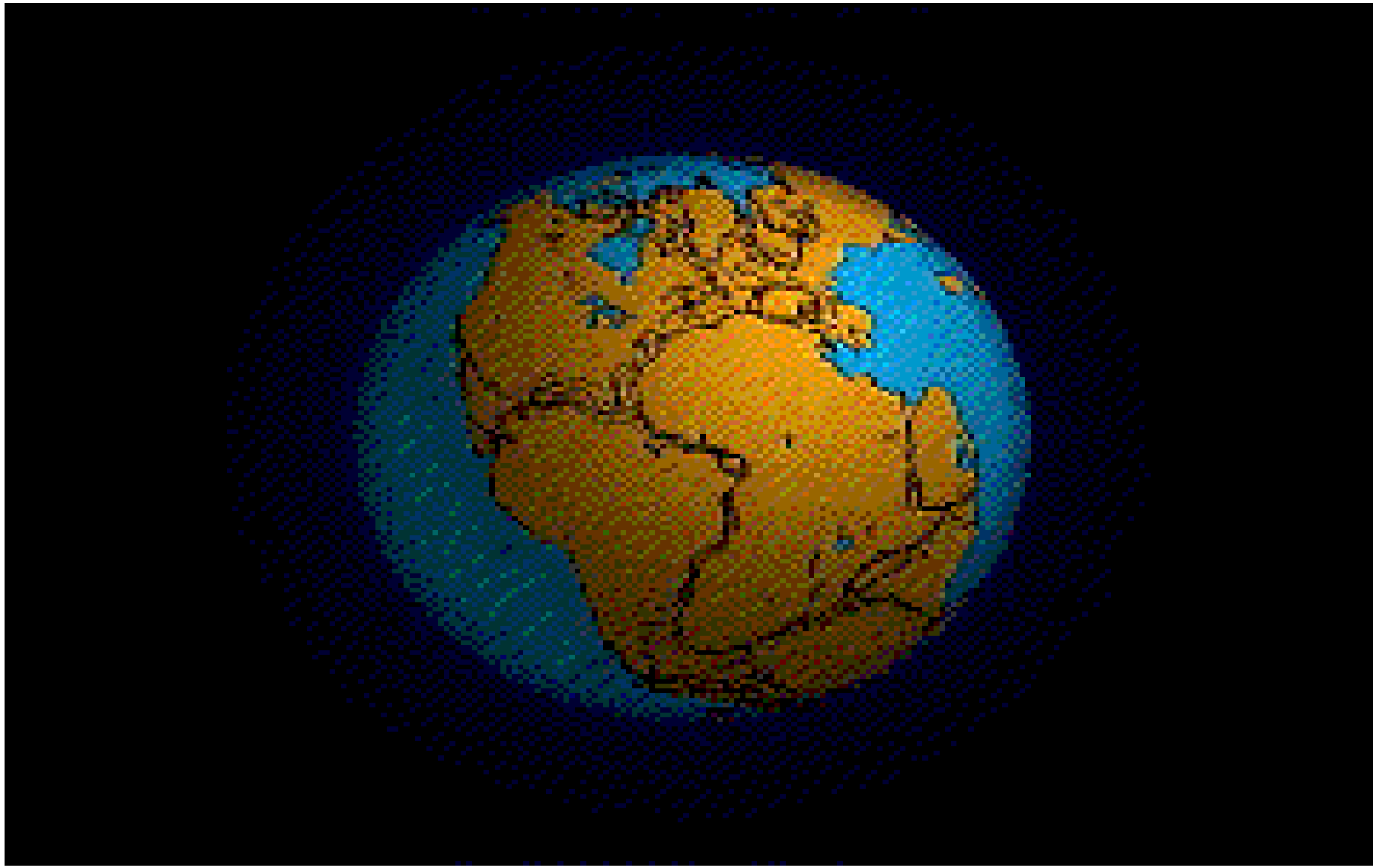


Mapping

1600 Catch Basins - GPS mapped in 4 days,
using Hand-held GPS (400+ points/day)



Crustal Dynamics
Pangea to the Present Day

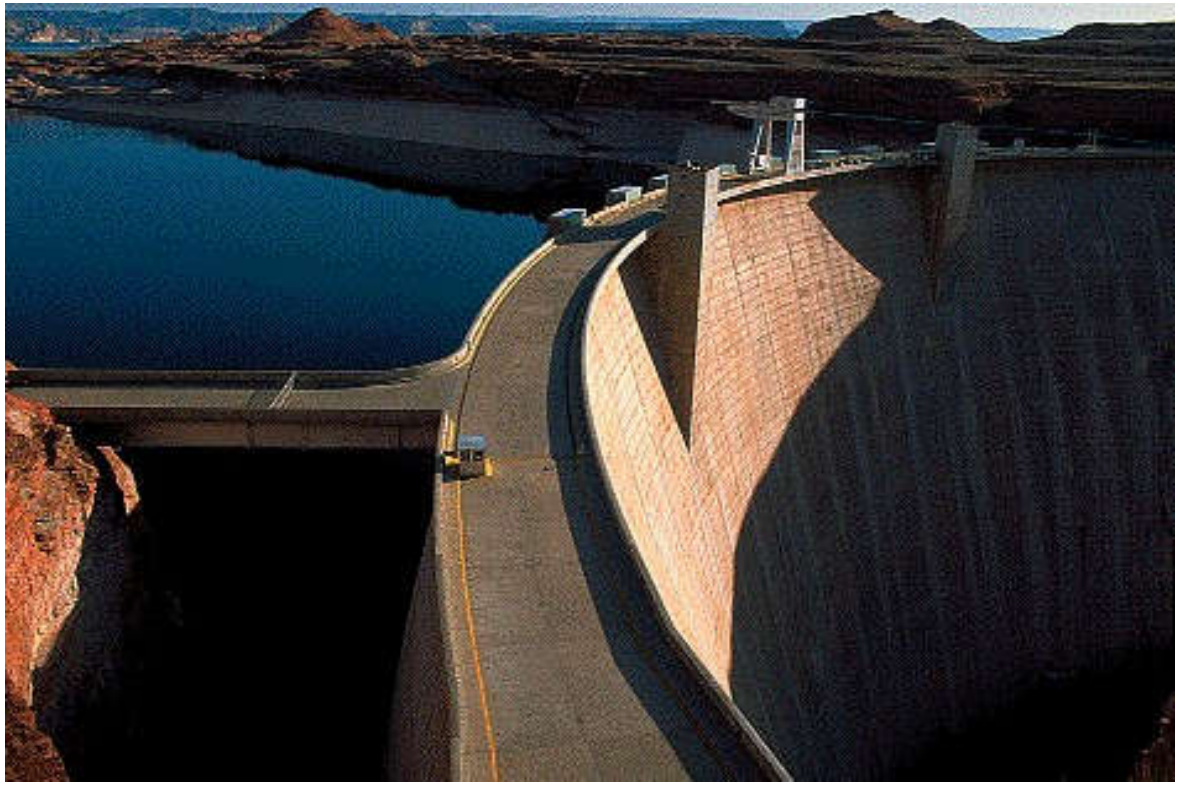


Machine guidance

Machine guidance

Machine guidance

Deformation monitoring



Missile guidance

How Accurate is GPS?

10 m

1 m

1 cm

1 mm

GPS Cont…

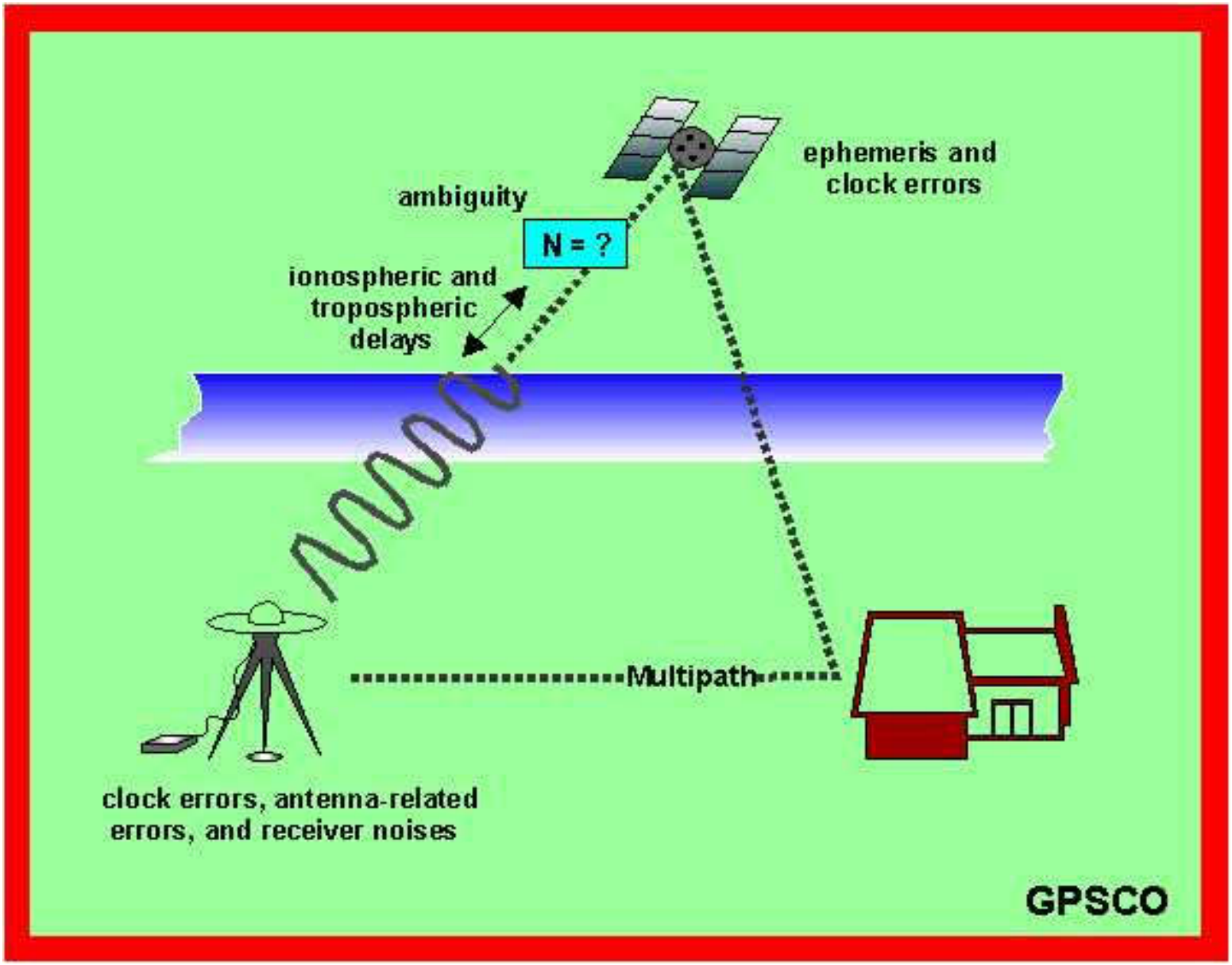
Upside

- No control needed
- Fast
- Large Areas / Intervisibility
- Minimum disturbance at site

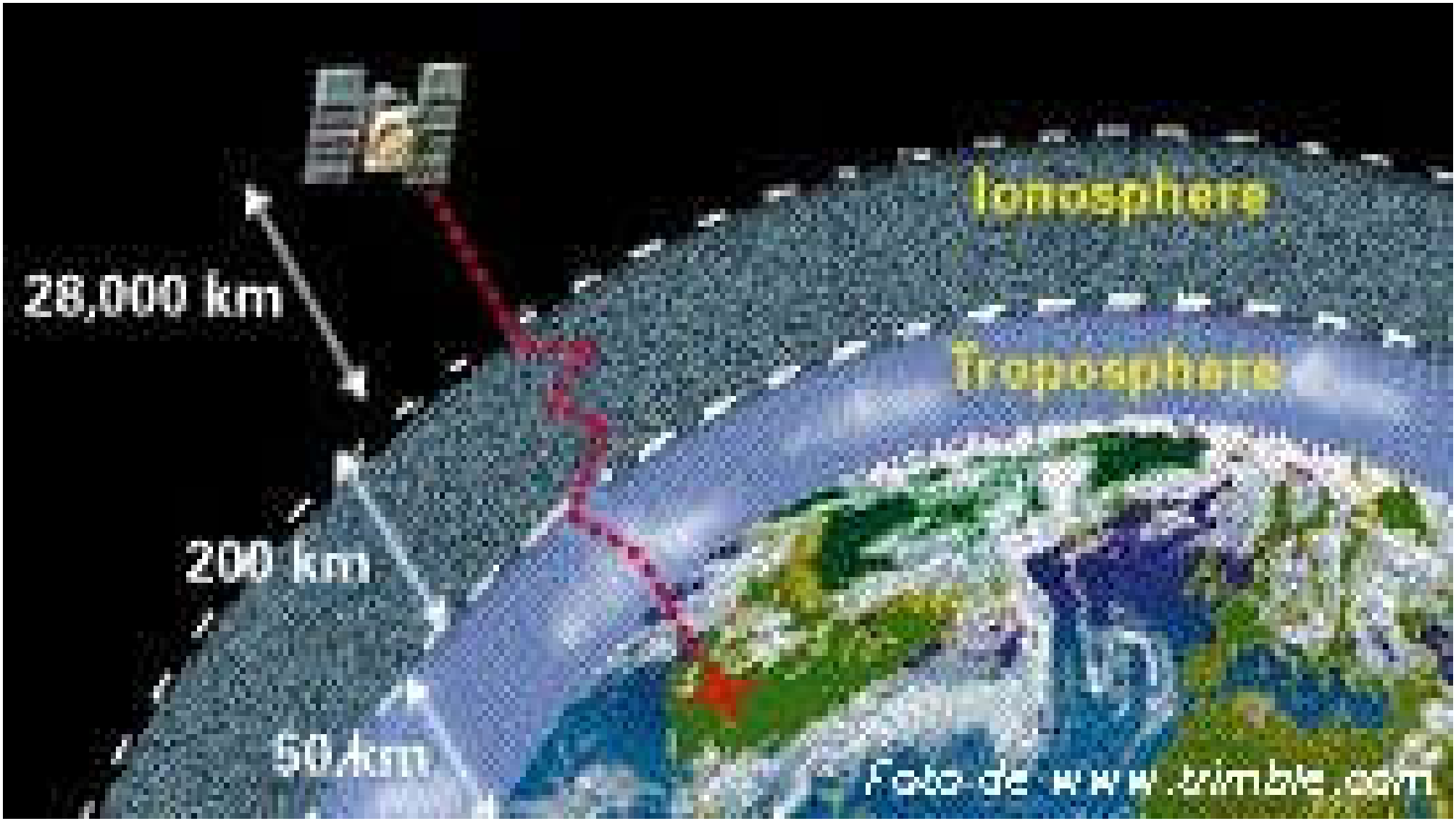
Downside:

- Highly Trained Personnel
- Expensive Equipment
- Multipath & Horizon
- Vegetation & Horizon
- Post processing required?

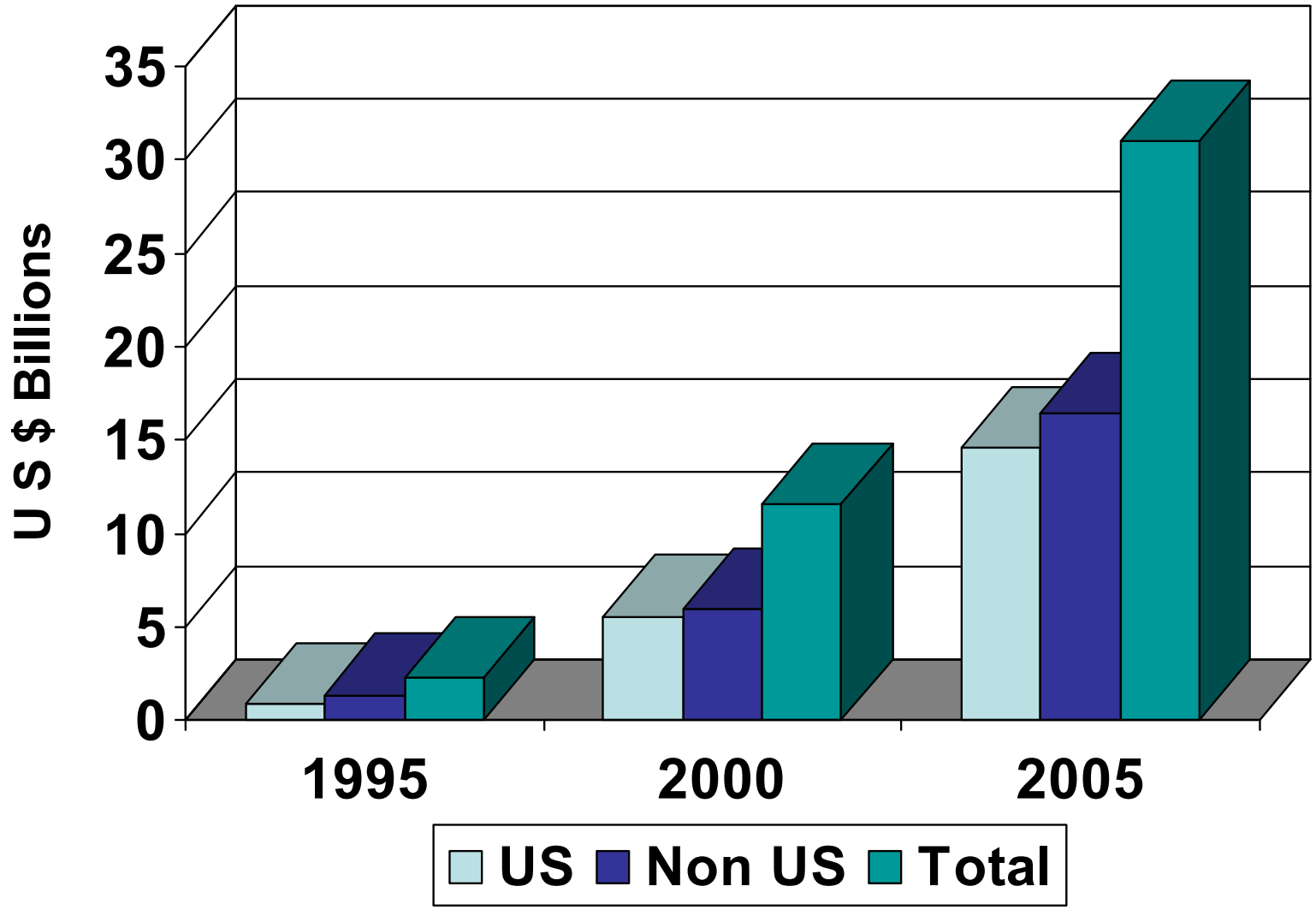
GPS errors


ephemeris and
clock errors
ambiguity
N = ?
ionospheric and
tropospheric
delays
Multipath
clock errors, antenna-related
errors, and receiver noises
GPSCO

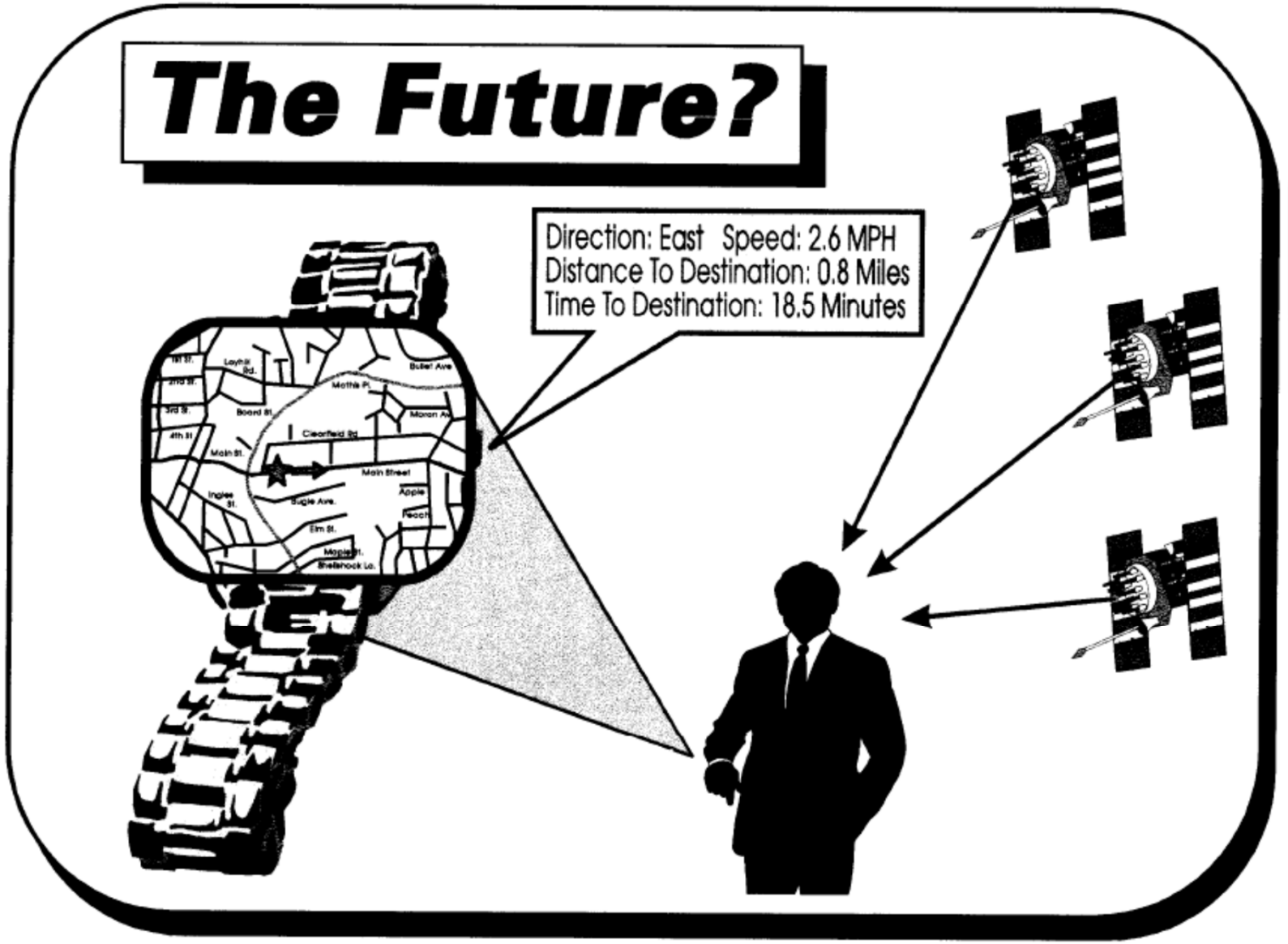
GPS errors

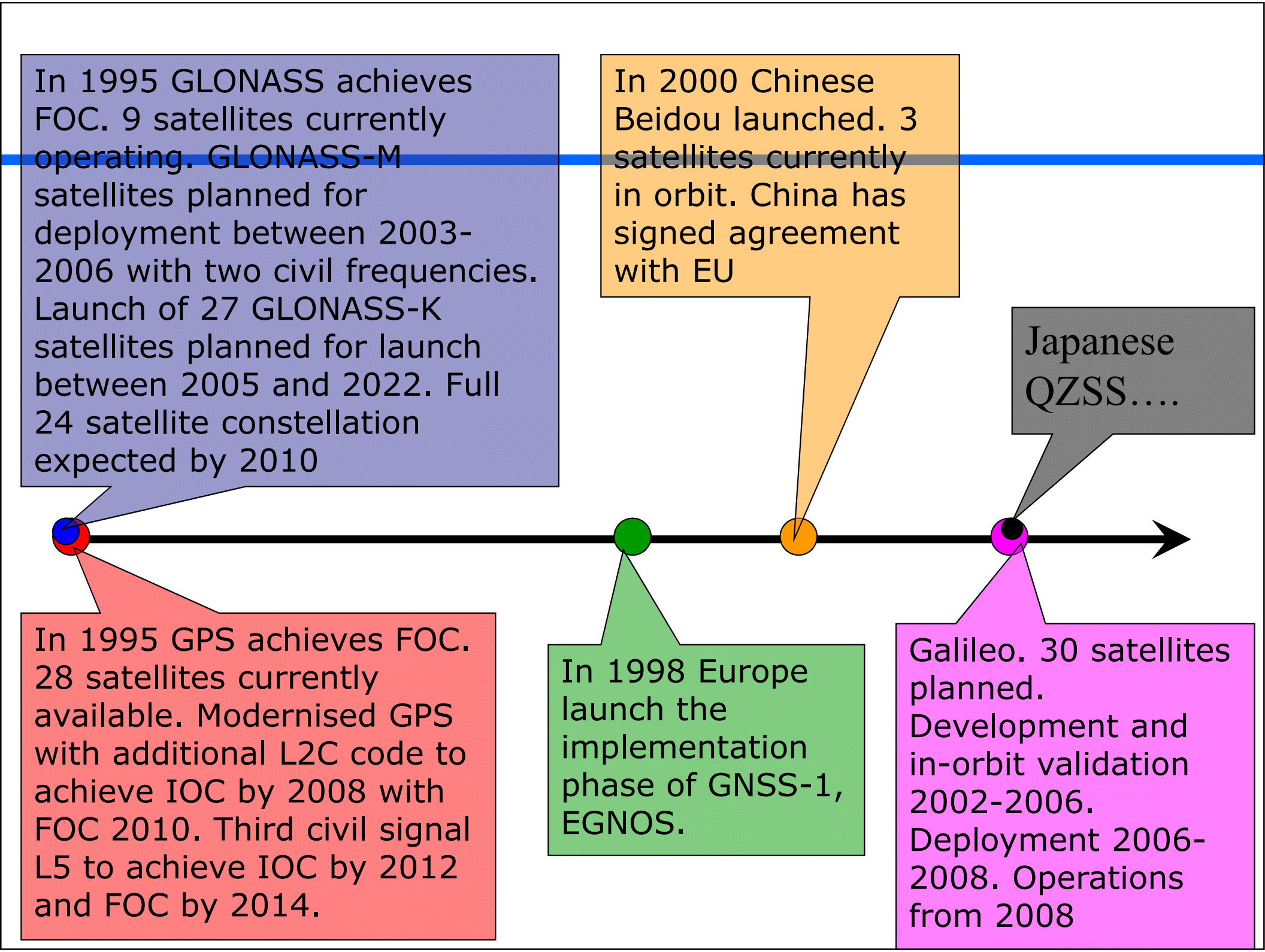

Ionosphere
Troposphere
28,000 km
200 km
50 km
Foto de www.trimble.com

Future of GPS

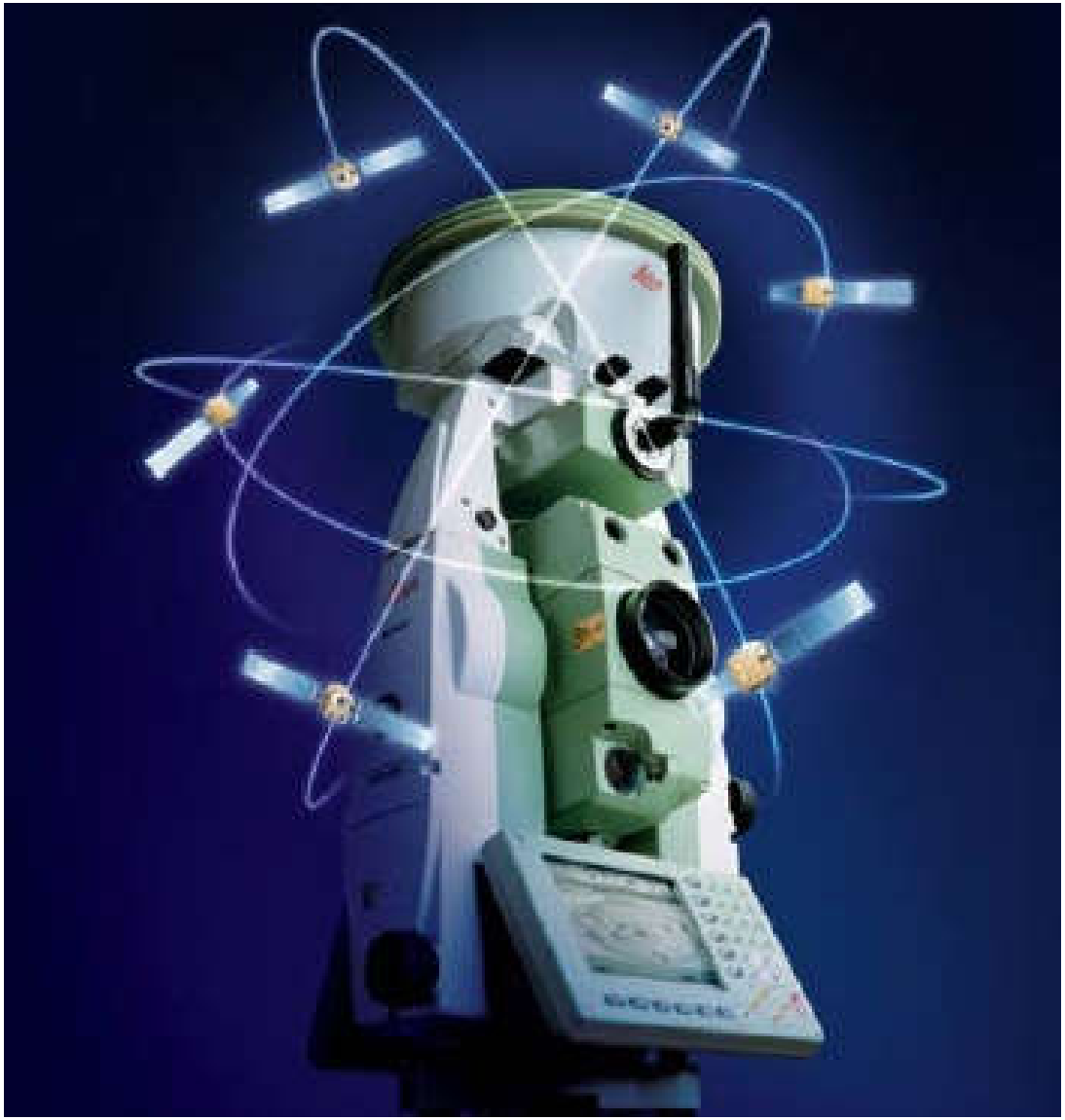


Future of GPS….

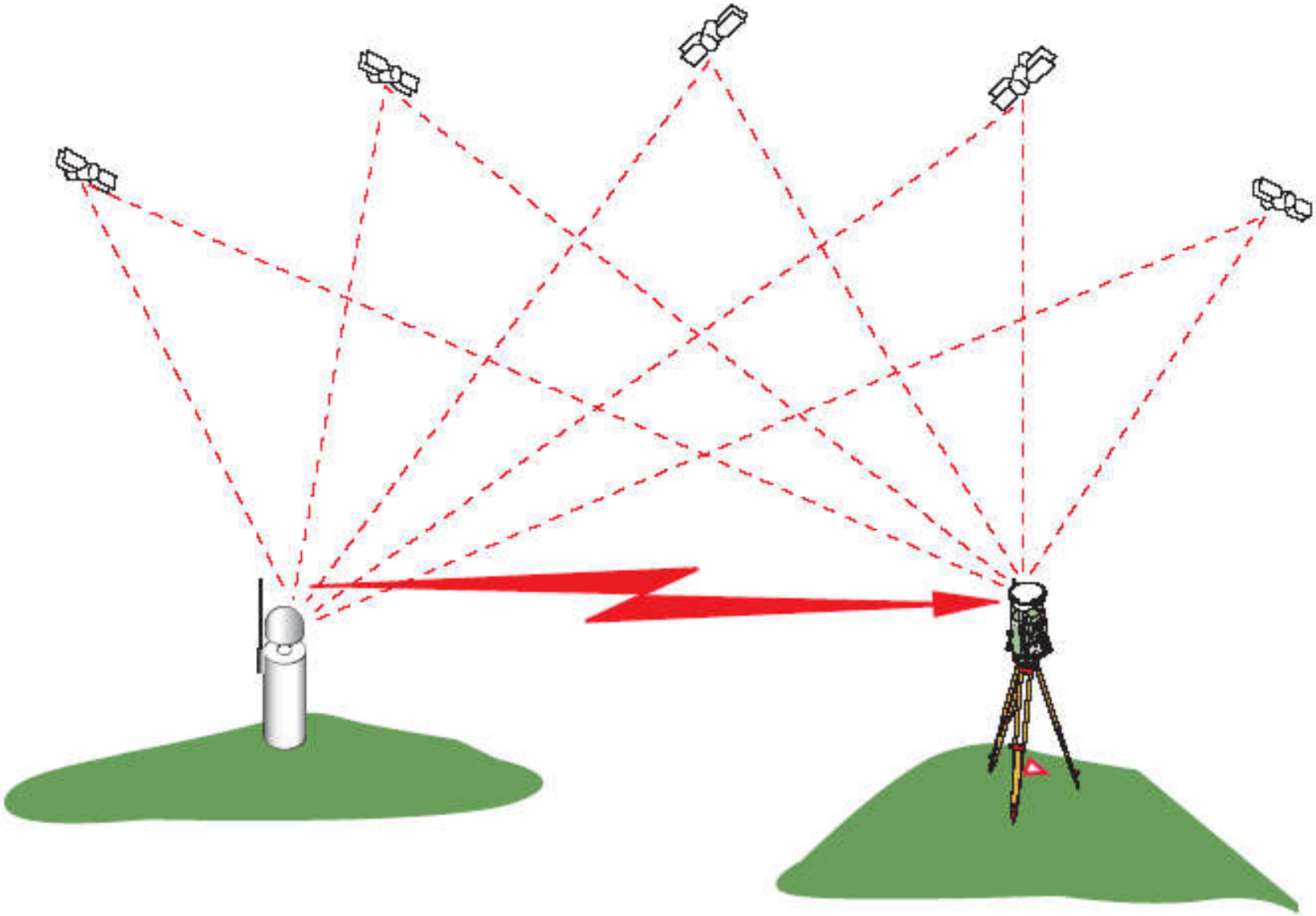



In 1995 GLONASS achieves FOC. 9 satellites currently operating. GLONASS-M satellites planned for deployment between 2003-2006 with two civil frequencies. Launch of 27 GLONASS-K satellites planned for launch between 2005 and 2022. Full 24 satellite constellation expected by 2010
In 2000 Chinese Beidou launched. 3 satellites currently in orbit. China has signed agreement with EU
Japanese QZSS….
In 1995 GPS achieves FOC. 28 satellites currently available. Modernised GPS with additional L2C code to achieve IOC by 2008 with FOC 2010. Third civil signal L5 to achieve IOC by 2012 and FOC by 2014.
In 1998 Europe launch the implementation phase of GNSS-1, EGNOS.
Galileo. 30 satellites planned. Development and in-orbit validation 2002-2006. Deployment 2006-2008. Operations from 2008

Smart Station

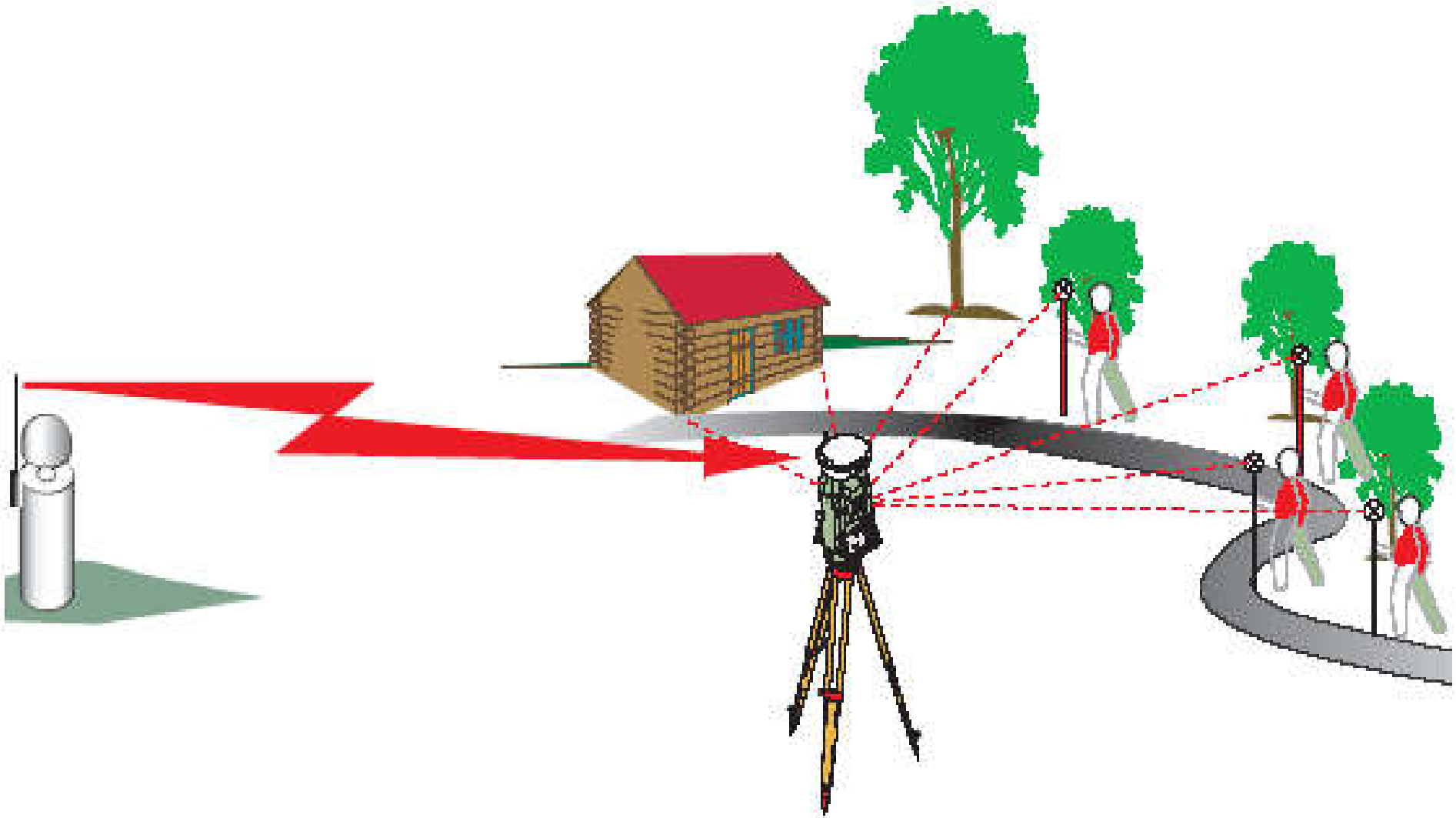


Smart Station ….



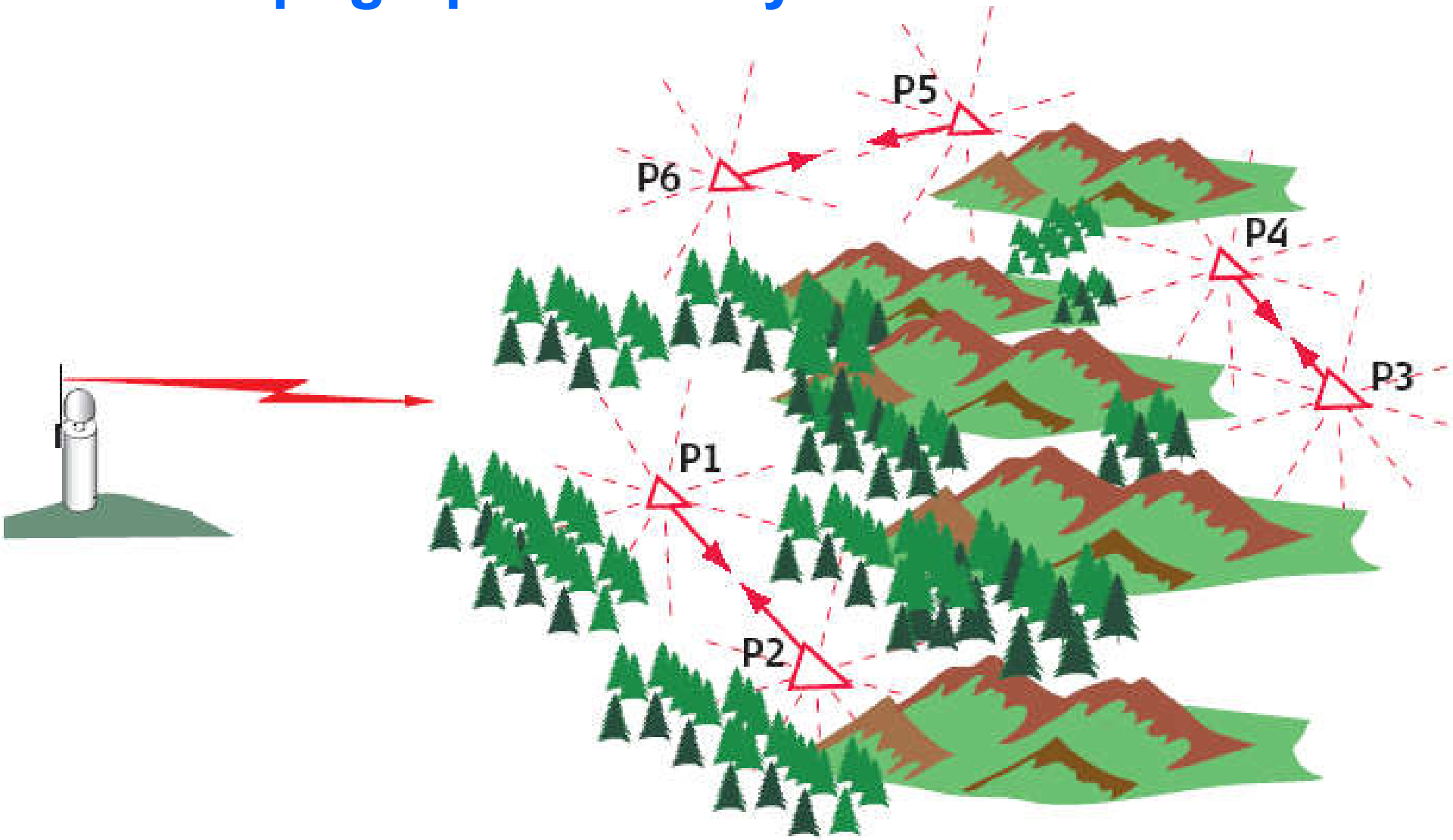
Smart Station ….

Smart Station ….



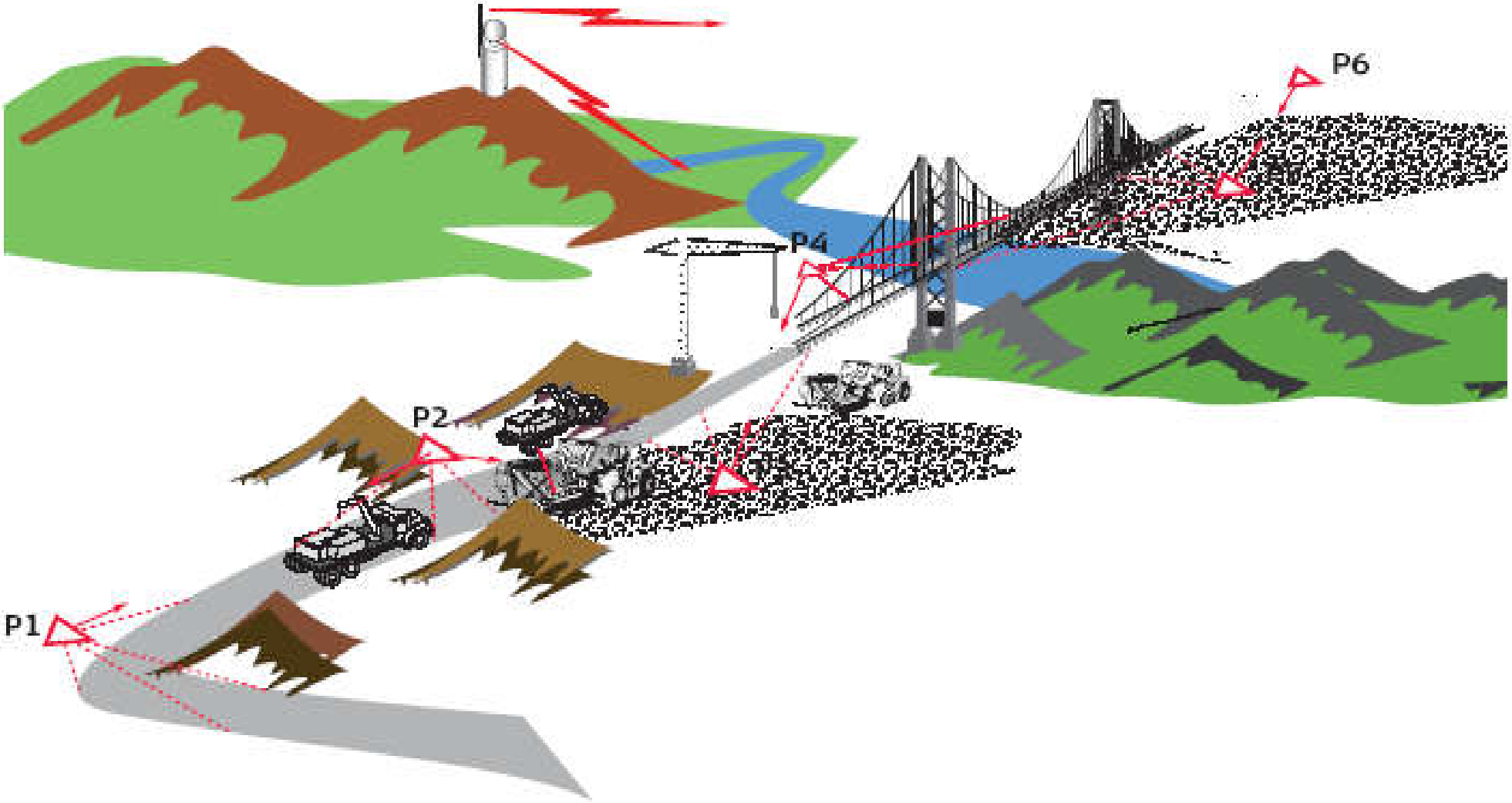
Smart Station ….

Topographic Survey in a remote area



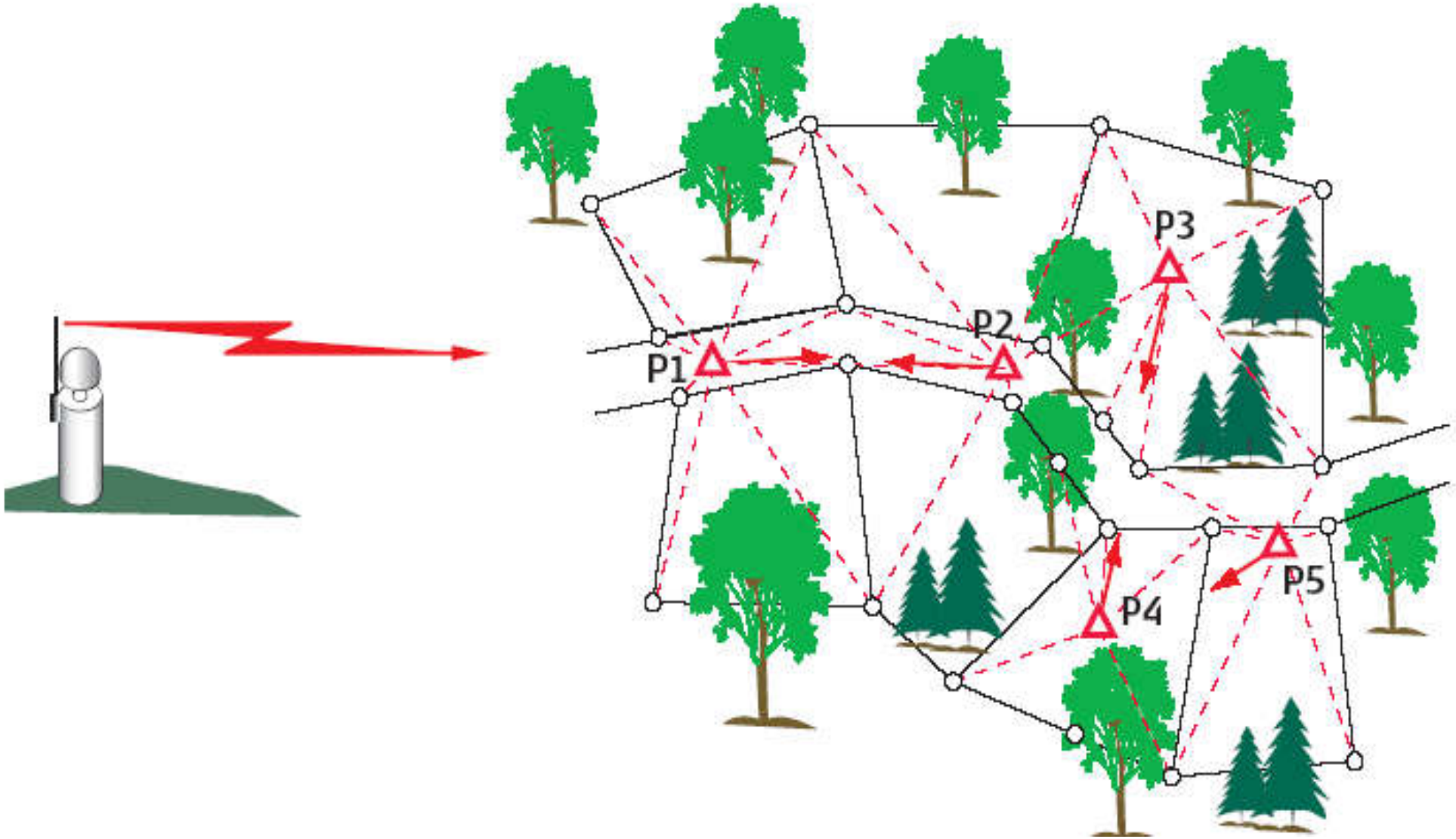
Smart Station ….

Stakeout on a large construction site



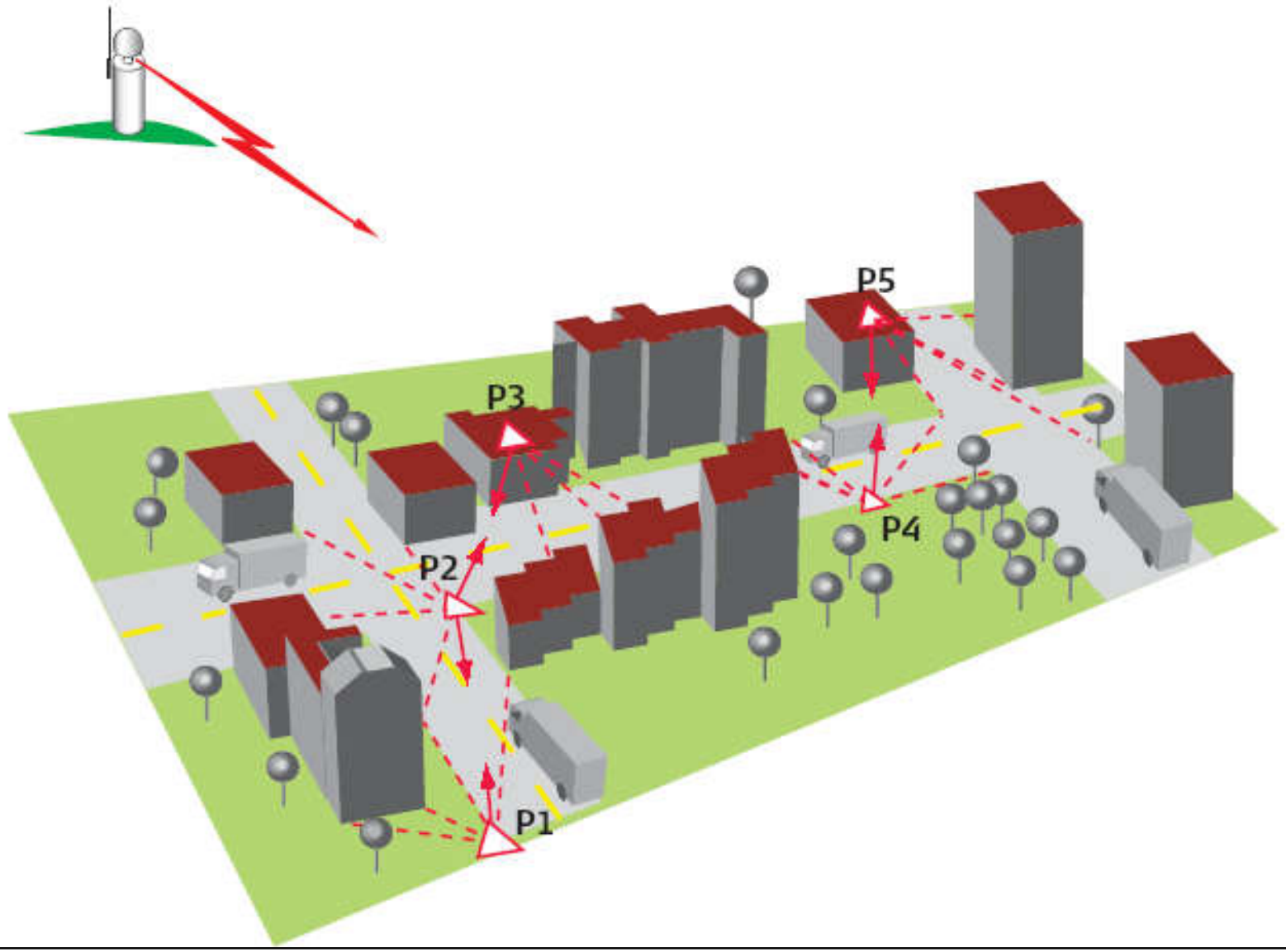
Smart Station ….

Property surveys in a rurl locality



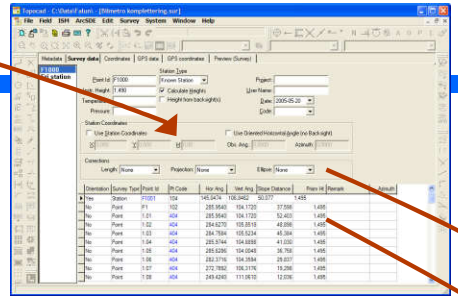
Smart Station ….

Surveying utilities in an urban environment



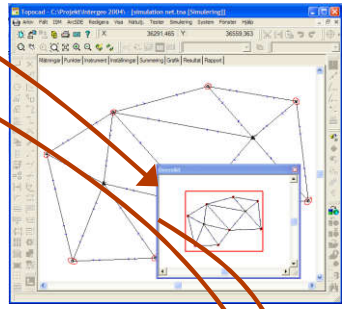
The digital flow

Survey

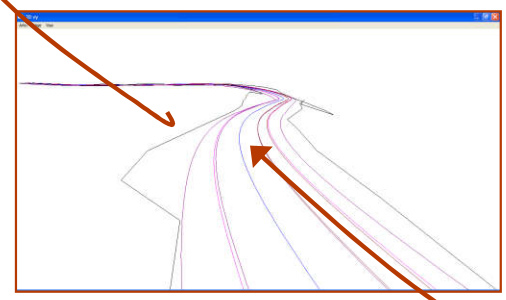


Communication

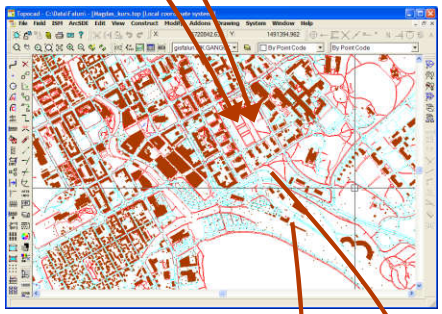
Calculation Traverse
Net adjustment



Stake out

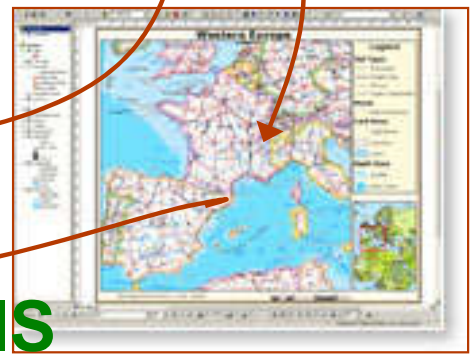


Design



Mapping, CAD

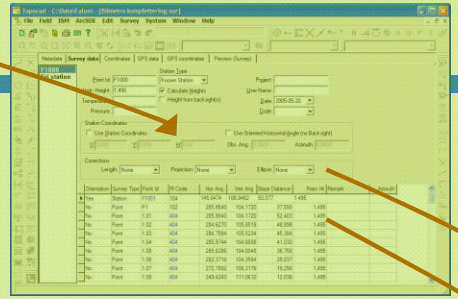
Plans & drawings



ArcGIS

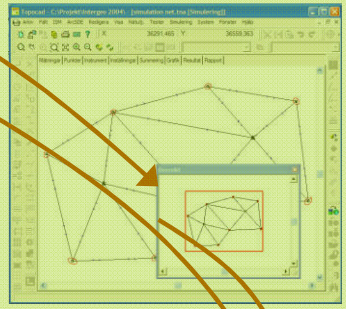
The digital flow

Survey

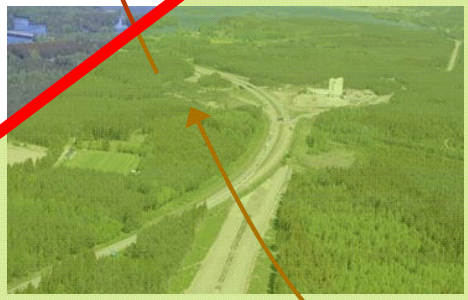


Communication

Calculation Traverse
Net adjustment

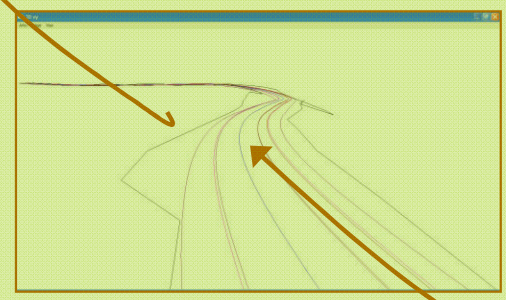


Software



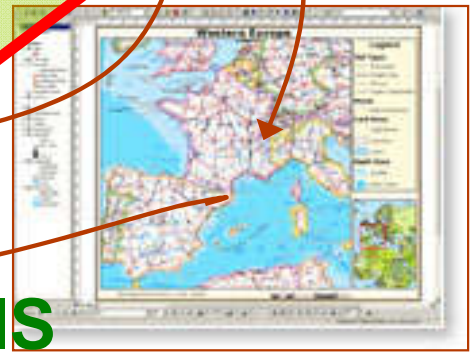
Stake out

Mapping, CAD



Design

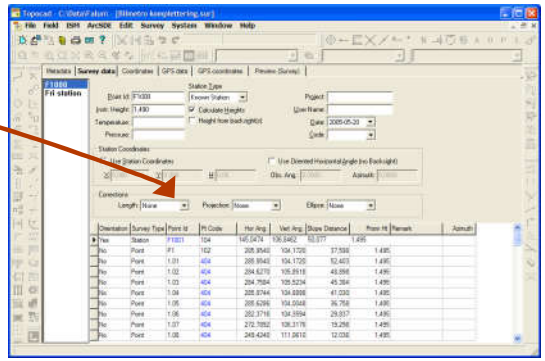
Plans & drawings



ArcGIS

Survey and communication

Survey



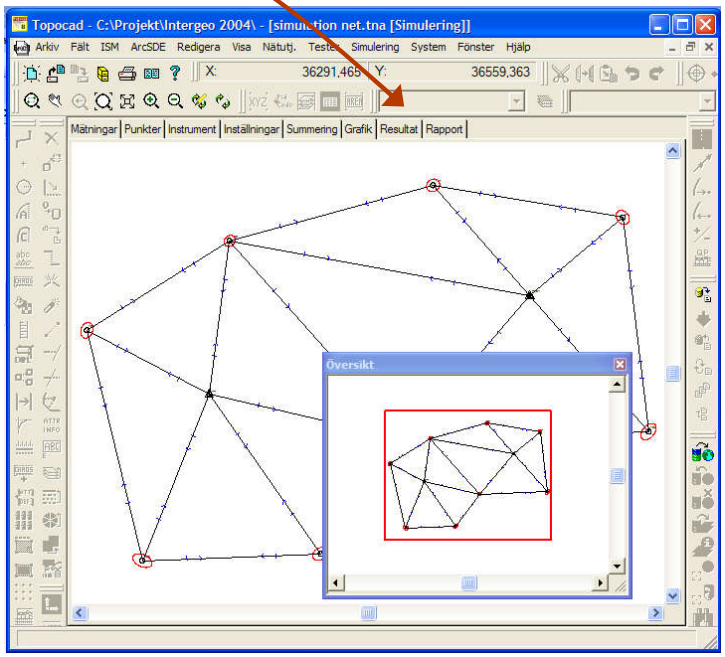
Communication

- Software communicates with total stations and GPS receivers.
- Input and output.
  - +Manual input
- *Field module* for direct communication from GPS to the map.

Calculation

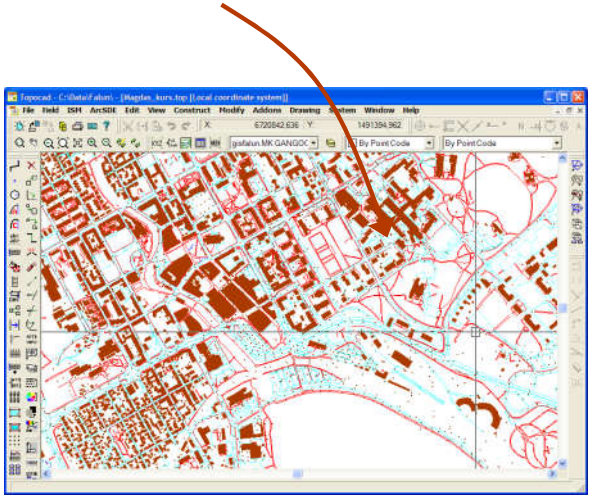
- Least square calculation within survey calculation.
- Base package with built-in traverse calculation
- Net adjustment module
  - Plan and height
  - Error tests
  - Reports
  - Simulation
  - Add new known points to database.
  - Add graphic to drawing and GIS database.

Calculation
Traverse
Net adjustment



Mapping and CAD

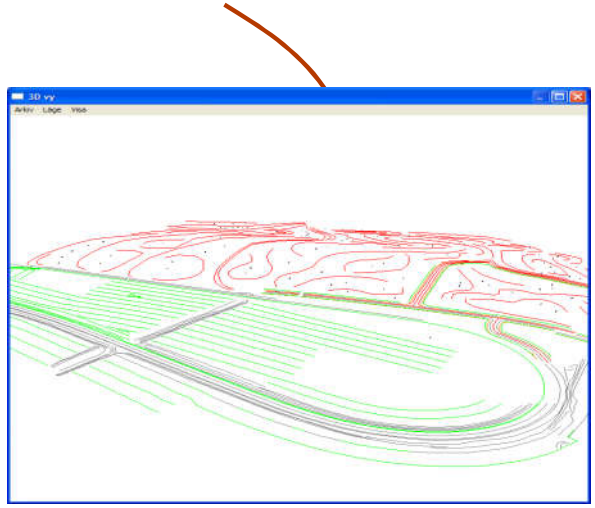
- Built-in CAD engine
- 3D system
- Settings for maps – projections and transformations.



Mapping, CAD

Mapping and CAD

- Built-in CAD engine
- drawing contains more data than other file formats – made for GIS solutions.
- 3D system
- Settings for maps – projections and transformations.



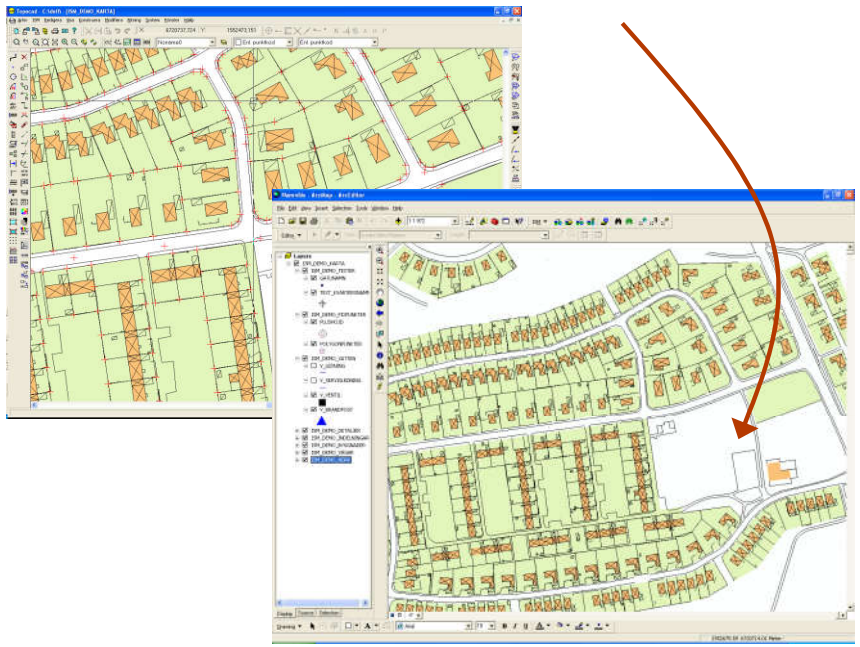
Mapping, CAD in 3 dimensions

GIS adaptations

- GIS/database storage possibility:
  - ArcGIS adapter for personal geodatabase or ArcSDE database.

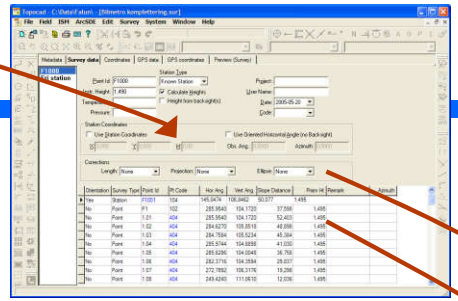
Seamless connection to ArcGIS:

Open, save, add, version management



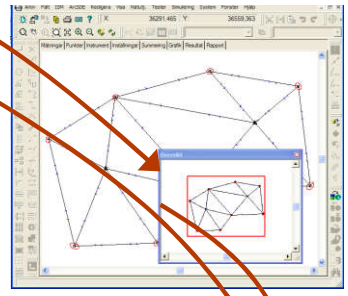
ArcGIS

Survey



Communication

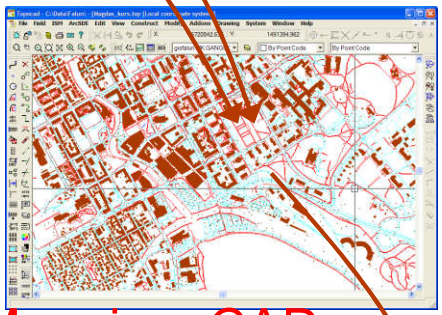
Calculation
Traverse
Net adjustment



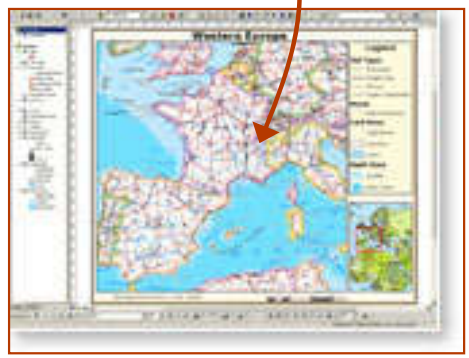
Remember this!

It should work from the surveyor to ready GIS without too much of editing!

Code tables, layers, attributes, map setup, geo database makes this happen!

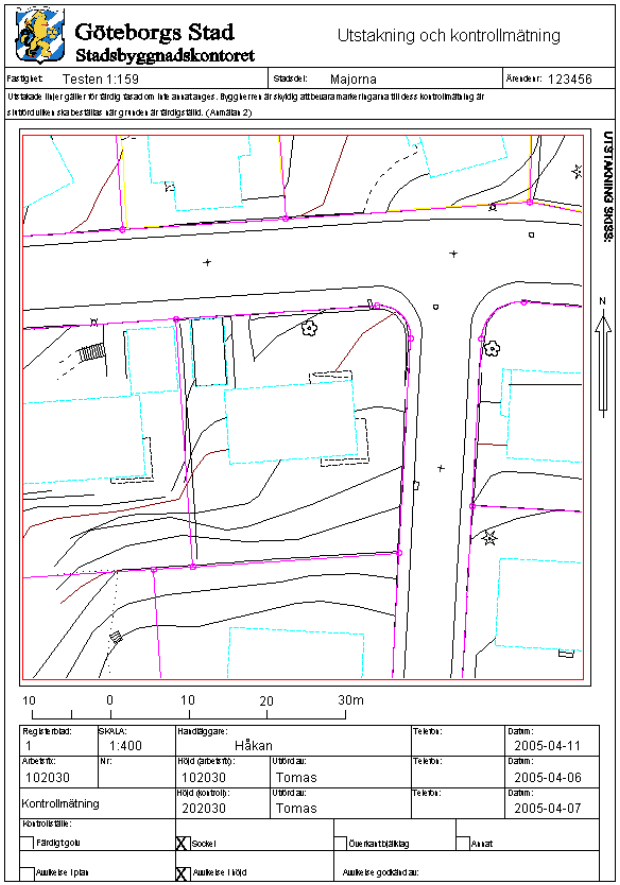


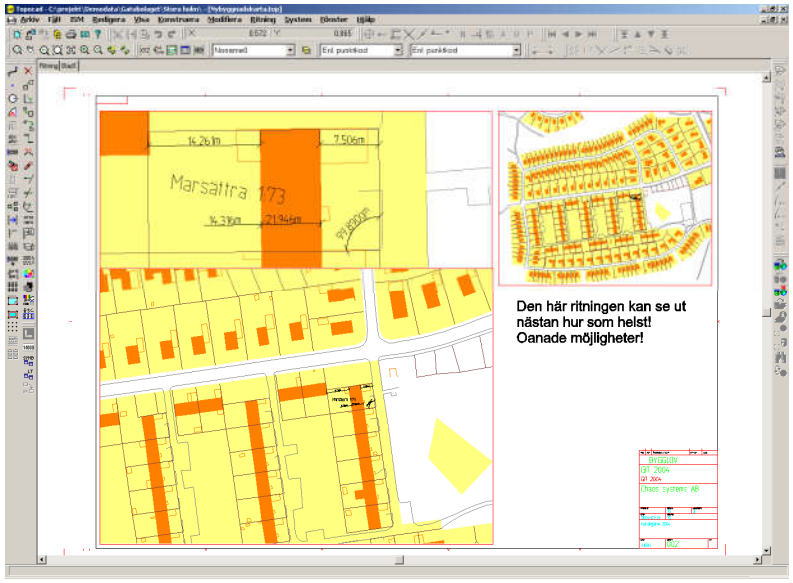
Mapping, CAD



Plans and drawings

for sketches, situation plans, as-built drawings, 3D pictures, etc.



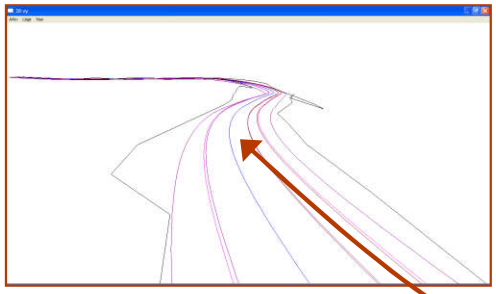


Plans & drawings

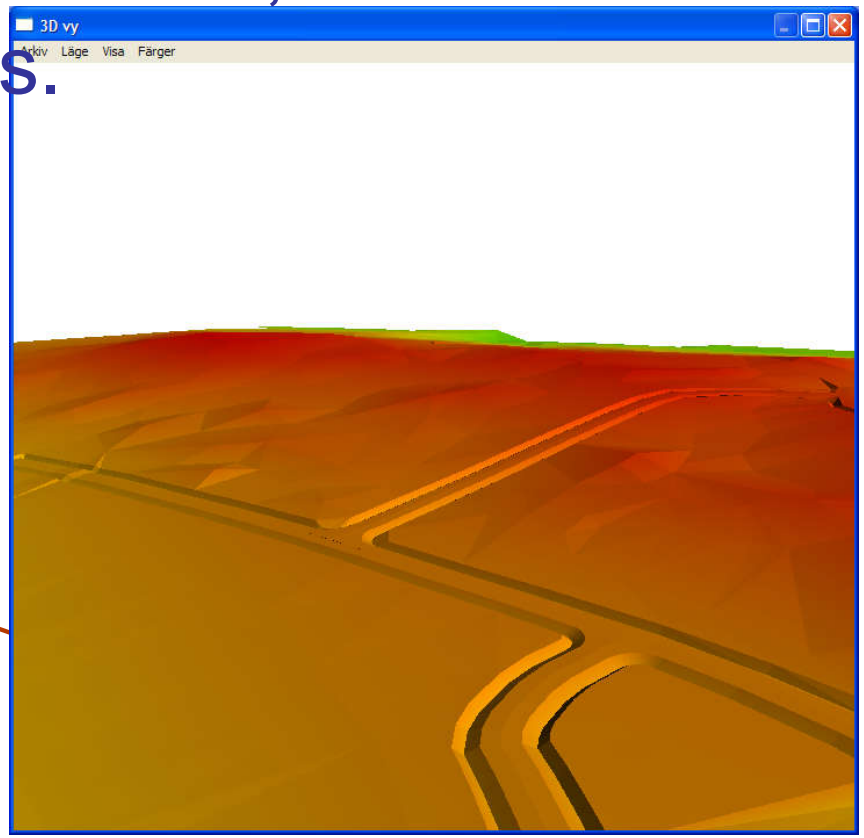
Design

Software is also a design application.

- Use it for road and railway design, sewer, pipes, excavations, concrete and asphalt calculations.



Design

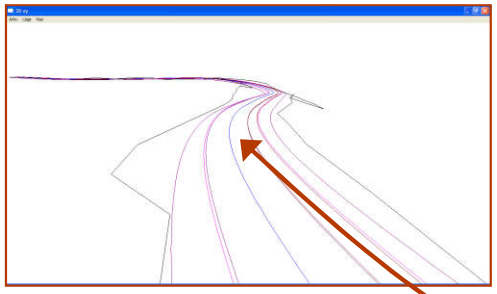


Digital terrain model

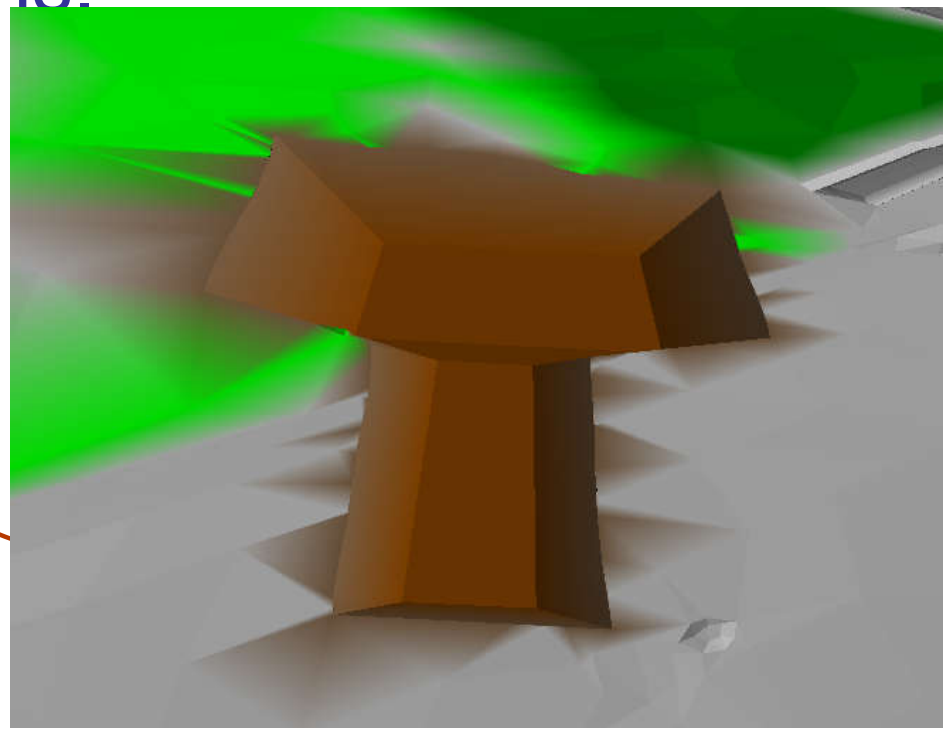
Design

Software is also a design application.

- Use it for road and railway design, sewer, pipes, excavations, concrete and asphalt calculations.



Design

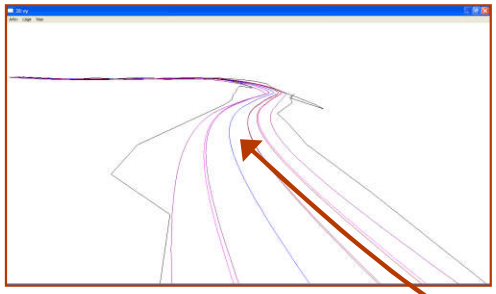


Volume calculation

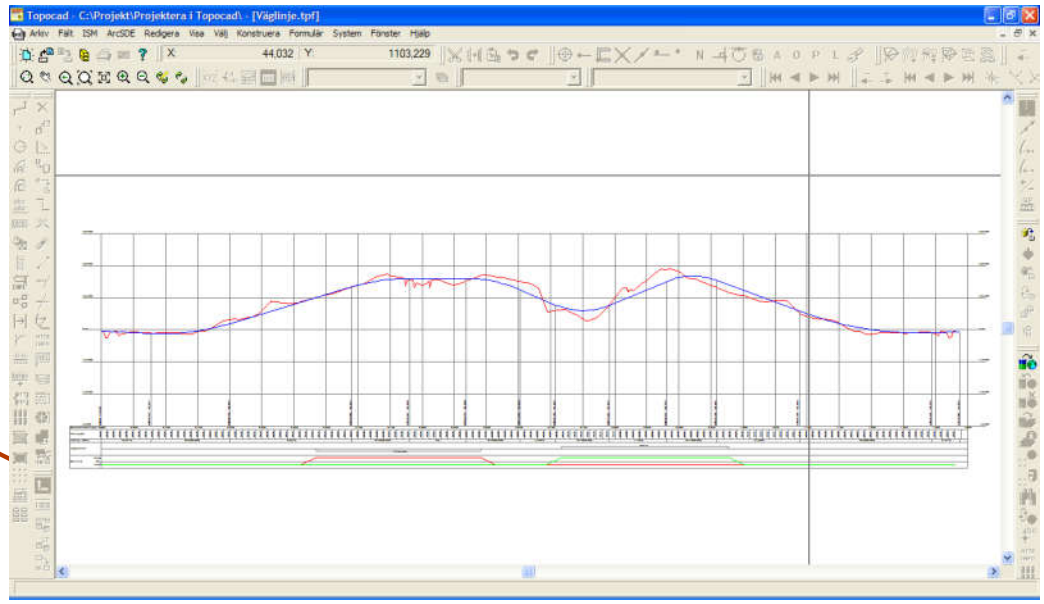
Design

Software is also a design application.

- Use it for road and railway design, sewer, pipes, excavations, concrete and asphalt calculations.



Design

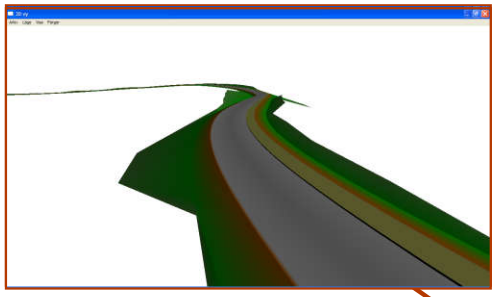


Profiles

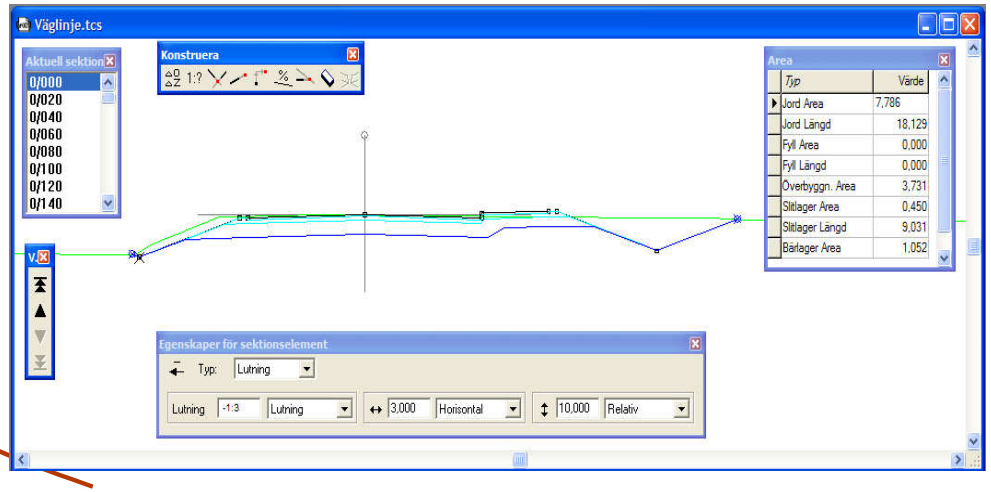
Design

Software is also a design application.

- Use it for road and railway design, sewer, pipes, excavations, concrete and asphalt calculations.



Design



Sections

Stake out and output

- Export to instruments and GPS.
- Export to co-ordinate files
- Export to drawing files.
- Export to databases.

Software

- Autodesk Civil 3D
- Carlson
- LisCAD
- Microsurvey
- TopoCAD
- Trimble Model
- Golden Software Surfer
- CivilCAD.....

Having the technology is not enough

It has to be applied

Using

- Right tool
- Right time
- Right place

Last Word

"The great success of Electronic gadgets is not technical, but its human impact"

Thank You

pnswamy@sjce.ac.in

94492 64365