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

- House
- Path
- Shed
- Tree
- Trees
Application #2 - Setting out

e.g. determining the location of a new construction on a site
Chainage and offset
Distance-distance intersection

- House
- Path
- Tree
- Trees
- Shed
Angle-angle intersection
Distance-angle intersection

House

Tree

Path

Trees

Shed
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 = **Electronic Distance Measuring**

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...
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

BDC60
Total Station Cont…

**Uses**

- **Topo and As Built**
- **Construction Layout**
- **Monitoring & Control**
Examples
Examples....
Examples....

Netzübersicht mit Höhenmodell

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 !!**
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
Global Positioning System

A shortened term for NAVSTAR GPS Navigation Satellite Timing And Ranging

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
Three Basic Segments

- **Space segment**
- **User segment**
- **Control segment**

- **Ground Antenna**
- **Master control station**
- **Monitor stations**
GPS Cont...

Three Basic Segments

- Space Segment
- Control Segment
- User Segment
GPS Cont...

Space Segment

◆ 24 Satellites in 6 Orbital Planes inclined at 55°
◆ 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
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....
The whole system revolves around time!!!

\[ \text{Distance} = \text{Rate} \times \text{Time} \]

- 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.

Could be anywhere along circle
How GPS Works….

**Triangulation in 2D**

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

(Circle diagram showing two possible locations between points A and B marked as 'Could Be Here' and 'Or Here')
How GPS Works….

**Triangulation in 2D**

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

![Diagram showing triangulation in 2D](image)
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....
Differential positioning

DGPS corrections

DGPS reference receiver

Differential transmitter
What is GPS used for? ...
Navigation
Navigation
Navigation
In-car navigation
In-car navigation

City Maps
Building/engineering set out
Mapping
Control Points

Ward Map - Mysore City

Legend
- Ground Control Point (GCP)
- Ward Boundary
- Ward Number
- GCP Number

Map Not to Scale

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<th>GCP</th>
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<th>Latitude</th>
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Total Population Distribution in Mysore

Legend
Mysore_Ward_PCA
- 4290 - 10480
- 10480 - 16670
- 16670 - 22860
- 22860 - 29050
- 29050 - 35240

Scale: 1 0 1 2 3 4 km
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

Moving Dirt 1905
Rose Creek Road, Hopkins County, Kentucky (outside Madisonville)
Machine guidance

GPS

Moving Dirt 2005
Machine guidance
Deformation monitoring
Missile guidance
How Accurate is GPS?

- 10 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

- Ambiguity
- Ionospheric and tropospheric delays
- Ephemeris and clock errors
- Clock errors, antenna-related errors, and receiver noises
- Multipath
GPS errors

28,000 km

200 km

50 km

Ionosphere

Troposphere

Foto de www.trimble.com
Future of GPS

![Bar Chart]

- **US $ Billions**
- **Years**: 1995, 2000, 2005
- **Categories**: US, Non US, Total

- **1995**
  - US: 2
  - Non US: 2
  - Total: 4

- **2000**
  - US: 4
  - Non US: 8
  - Total: 12

- **2005**
  - US: 10
  - Non US: 20
  - Total: 30
Future of GPS....

The Future?

Direction: East  Speed: 2.6 MPH  Distance To Destination: 0.8 Miles  Time To Destination: 18.5 Minutes

In 1998 Europe launch the implementation phase of GNSS-1, EGNOS.

In 2000 Chinese Beidou launched. 3 satellites currently in orbit. China has signed agreement with EU.

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.

Japanese QZSS....

Smart Station
Smart Station ....
Smart Station ....
Smart Station ....
Smart Station ....

Topographic Survey in a remote area
Stakeout on a large construction site
Smart Station ....

Property surveys in a rural locality
Smart Station ....

Surveying utilities in an urban environment
The digital flow

Survey

Calculation Traverse
Net adjustment

Communication

Stake out

Mapping, CAD

Design

Plans & drawings

ArcGIS
The digital flow

Survey

Communication

Calculation Traverse
Net adjustment

Software

Stake out

Mapping, CAD

Design

Plans & drawings

ArcGIS
Survey and 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.
Mapping and CAD

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

for sketches, situation plans, as-built drawings, 3D pictures, etc.
Software is also a design application.

- Use it for road and railway design, sewer, pipes, excavations, concrete and asphalt calculations.
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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
“The great success of Electronic gadgets is not technical, but its human impact”
Thank You

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