GGE2012 Advanced Surveying (Course Note)

Surveying Basics

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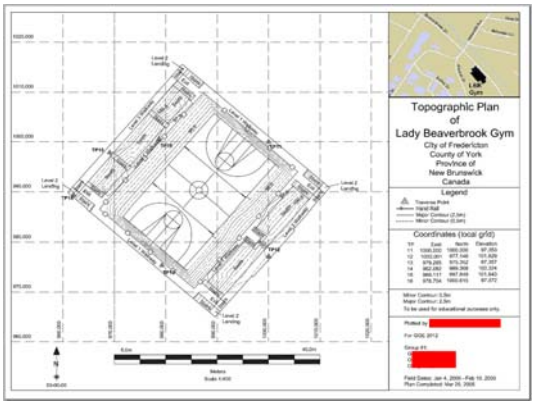
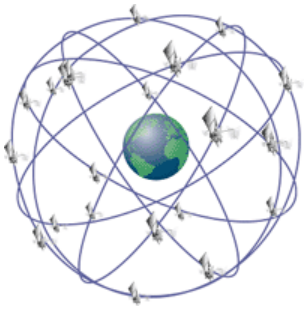




History of Surveying

Brief History

- Origin of Surveying: B.C 3000 (from Egypt) due to the overflowed Nile River. Try to re-established the boundaries.
- around 14C: invent of Compass in medieval Europe

- early 17C: modern triangulation (Willebrord Snell, Netherland)
- 17C: invent of Vernier (in 1613, Pierre Vernier, France)
- 18C: invent of "true" Transit (in 1576, Joshua Habermel, Germany), completed with compass and tripod
- 19C: Carl Friedrich Gauss (Germany), numerous contributions in mathematics including error statistics.
- 19C: Photogrammetry (in 1851, Aime Laussedat, French officer)
→ Aerial Photo (by Th. Scheimpflug, Austria)

- Recent Development (late 20C): Satellite Surveying, GNSS (Global navigation satellite systems)

Survey?

Definition

• "*the art of measuring distances, angles, and positions on or near the surface of the earth. It is an art because only a surveyor who possesses a thorough understanding of surveying techniques can determine the most efficient methods required to obtain optimal results over a wide variety of surveying problems ...*" (Kavanagh, 2006)

• "*The orderly process of determining data relating to any physical, chemical or geometric characteristic of the Earth.*
The list of orderly processes which may properly be called "surveys" is long. It may be divided into classes according to the type of data obtained, the methods and instruments used, the purposes to be served, etc. For example, there are geodetic, topographic, hydrographic, land, geologic, geophysical, soil, mine, and engineering surveys. ..." (Glossary from National Geodetic Service (NGS))

Classifications

Survey Types

• Plane Surveying-

- referenced to a flat plane without considering curvature.
- ignored actual shape of the Earth and allow use of plane geometry and trigonometry
- performed on the surface of the Earth
- assumed all lines are straight like a plane for all x and y dimensions. All z axis (height) are referenced to the surface of the Earth's reference ellipsoid (GRS80) or MSL
- limited extent (for 1ppm (part per million) accuracy, within radius 11km, or area of less than 380 square kilometres)
- localized projects such as highway and railroads only

• Geodetic Surveying-

- performed on the surface of the Earth
- consider the size & shape of Earth, behavior of its gravity field
- require principles of geodesy

Classifications

Survey Methods

- Conventional Surveying

- Levels, theodolites, electronic distance measurement unit (EDM), or Total stations

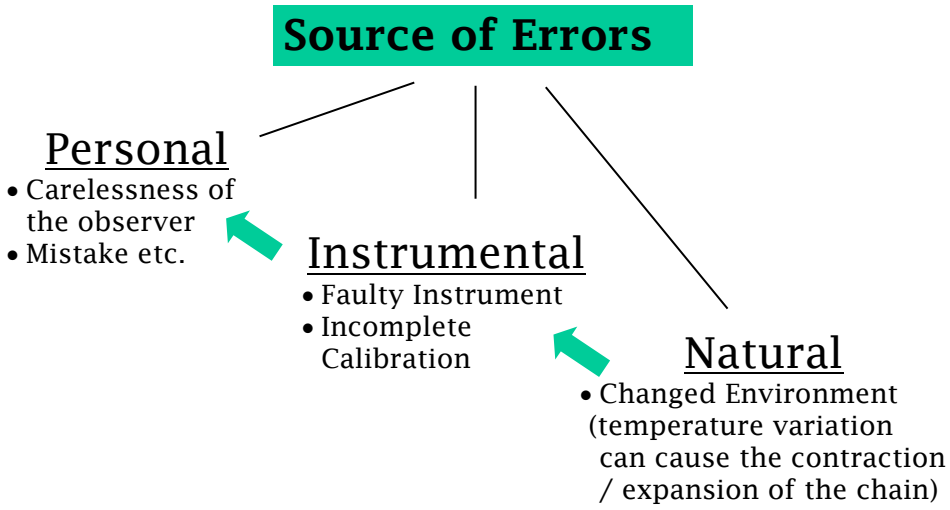
- NAVSTAR GPS Surveying → GNSS
- satellite-based surveying method
- determining accurate position, velocity, and timing information
- has to carefully select the proper method

Classifications

Survey Purposes

- Topographic surveys: preliminary surveys used to tie in the natural and constructed surface feature of an area.
- Hydrographic surveys: preliminary surveys used to tie in the underwater features to a surface control line.
- Route surveys: preliminary, layout, and control surveys that range over a narrow but long strip of land.
- Property surveys: preliminary, layout, and control surveys that determines the boundary locations.
- Aerial surveys: preliminary and final surveys using traditional aerial photography and aerial imagery. Digital camera, multispectral scanners, lidar, and radar
- Construction, Cadastral, Mine, Astrnomical, Artillery, Satellite, Land, Inertial Surveys etc.

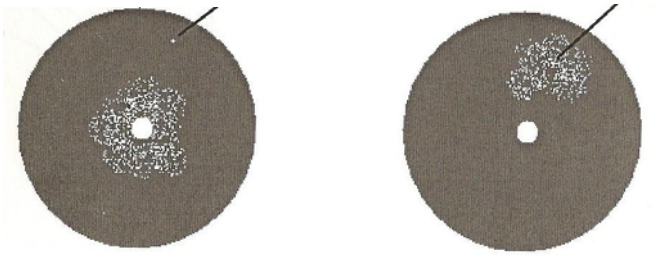
Error Sources



Types of Errors

- **Gross Errors (blunders or mistakes)**

  - **Characteristics**: Its magnitude is significantly large or different when compared to the measured values
  - **Sources**: Personal errors (carelessness of the observer)
  - **Effect**: Inhomogeneous observables
  - **Solution**: Eliminated from the measurements by carefully checking them.



Types of Errors

Systematic Errors

- **Characteristics**: Can identify in a deterministic system. When known, it follows some functional relationship
- **Sources**: Instrumental, Natural, Personal
- **Effect**: Shifted all observation. Remains as a constant if its magnitude and sign are the same throughout the process.
- **Solution**: Must be corrected by, e.g. calibrating the instrument before use., Adjusting the instrument, Certain procedures before survey work. e.g. Peg test for detecting collimation errors.

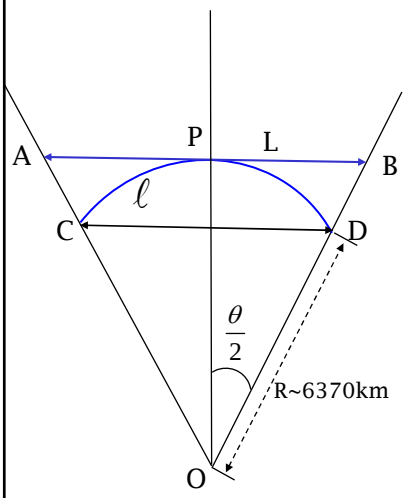
Types of Errors

Random Errors

- **Characteristics**: The remaining errors after gross and systematic errors have been removed. No functional relationship based on a deterministic system. Usually modelled by stochastic parameters using probability theory
- **Sources**: Instrumental, Natural, Personal
- **Solution**: Can be minimized by applying, “Least-square adjustment” in the redundant observables.

Limitation of Plane Surveying

- **Geometry due to the Earth's curvature**



$$BP = AP = R\tan\left(\frac{\theta}{2}\right)$$

$$L = (BP + AP) = 2R\tan\left(\frac{\theta}{2}\right) = 2R\left(\frac{\theta}{2} + \frac{1}{3}\frac{\theta^3}{2^3} + \frac{2}{15}\frac{\theta^5}{2^5} + \ldots\ldots\right)$$

$$from\ Maclaurin\ Series,\ \tan(x) = \left(x + \frac{1}{3}x^3 + \frac{2}{15}x^5 + \frac{17}{315}x^7 \ldots\ldots\right)$$

$$= 2R\left(\frac{\theta}{2} + \frac{1}{3}\frac{\theta^3}{2^3} + \frac{2}{15}\frac{\theta^5}{2^5} + \ldots\ldots\right) \cong 2R\left(\frac{\theta}{2} + \frac{\theta^3}{24}\right) = R\theta\left(1 + \frac{\theta^2}{12}\right)$$

$$= \ell\left(1 + \frac{\ell^2}{12R^2}\right)$$

$$\therefore L = \ell + \frac{\ell^3}{12R^2} \rightarrow L - \ell = \frac{\ell^3}{12R^2} \rightarrow \frac{L-\ell}{\ell} = \frac{\ell^2}{12R^2}$$

Limitation of Plane Surveying

- **Relationship btw Precision and Range due to the Earth's curvature**

Precision $\left(\frac{L-\ell}{\ell}\right)$	Radius $\left(\frac{\ell}{2}\right)$	Diameter (ℓ)
$1/10^6$	11 km	22 km
$1/10^5$	35 km	70 km
$1/10^4$	110 km	220 km

[**5min. Quiz**] The Earth's radius is assumed as 6,378 km (=R), and you are supposed to determine the distance between two points, 50km apart on Earth. When your survey is assumed as the plane surveying, what is your overall expected distance error?

Field Notes

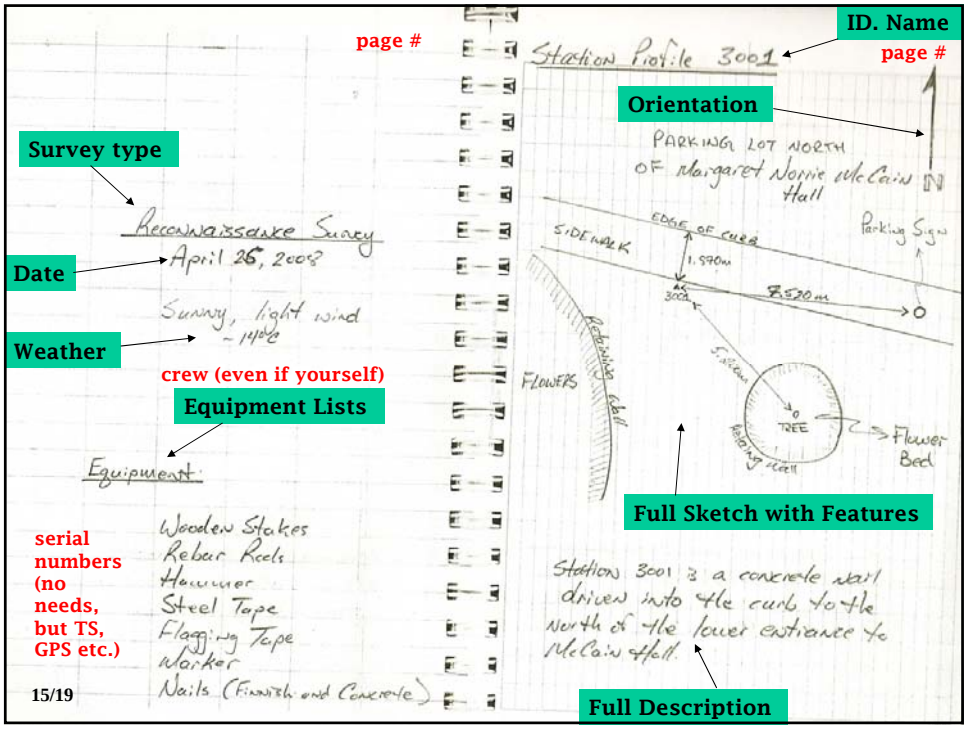
- title page of each day
- names and duties of your crew member
- instruments used and the serial number of each
- location of your survey area, and detailed sketches
- page number on upper right corner
- weather condition, e.g. pressure, temperature, and setting on the instrument
- data values (should be original values, never manipulated or corrected)
- any comments which can affect the result of your survey and accuracy

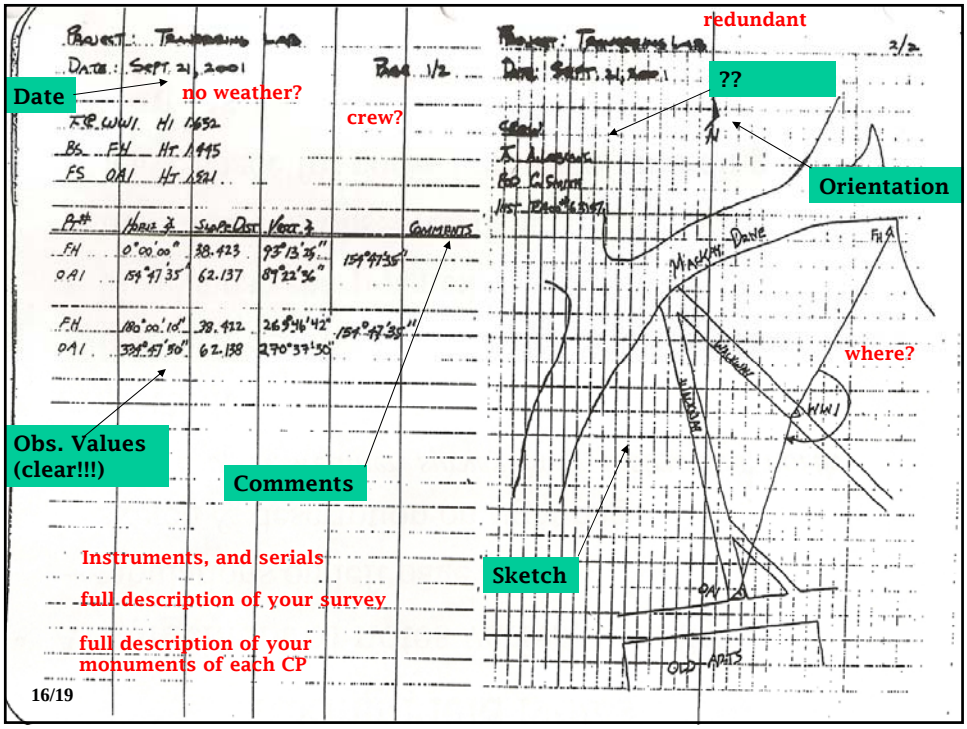
Taking Field Notes

- Arrangement of notes varies, usually:
  -tabulations on left page
  -sketch & description on right page
  e.g. project, weather, survey party, instrument, north

- Important
- bad or illegal practice for transferring notes
- always use sharp pencil
- *no erasure of observed data*
- leave space for correction when recording

- Examples


page #
ID. Name
page #
Station Profile 3001
Orientation
Survey type
PARKING LOT NORTH
OF Margaret Norrie McCain
Hall
Reconnaissance Survey
Date
April 25, 2008
Sunny, light wind
-14°C
Weather
crew (even if yourself)
Equipment Lists
Equipment:
serial numbers (no needs, but TS, GPS etc.)
Wooden Stakes
Rebar Rods
Hammer
Steel Tape
Flagging Tape
Marker
Nails (Finish and Concrete)
15/19
Full Sketch with Features
Station 3001 is a concrete wall driven into the curb to the north of the lower entrance to McCain Hall.
Full Description


redundant
Date
no weather?
crew?
??
Orientation
where?
Obs. Values (clear!!!)
Comments
Sketch
Instruments, and serials
full description of your survey
full description of your monuments of each CP
16/19

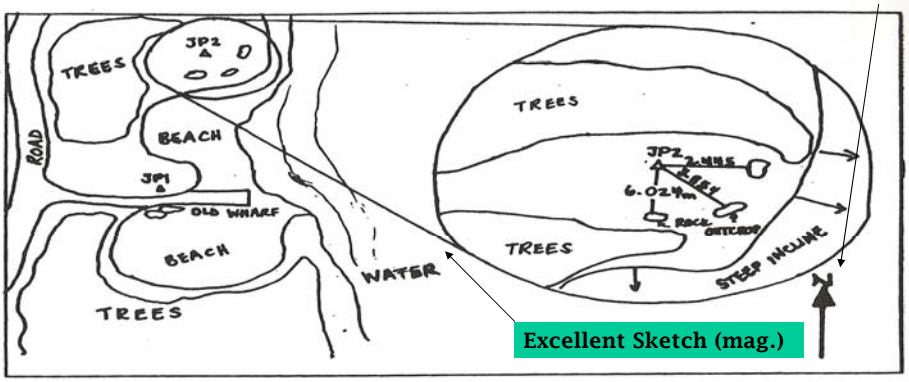
GPS STATION DESCRIPTION
GGE 2013
GROUP: Katie Munroe, Bronwyn Cox, and Michelle Weirathmueller

Titles and Group members

Station Name: JP2

ID. Name

Orientation



Excellent Sketch (mag.)

Station: Metal pin, approximately 60 cm long, in grassy area. The point is flush with the ground.

Access: Travelling west from Saint John on Highway 1, take the South Musquash exit. Turn left onto highway 790. A sharp right turn on this highway leads to South Musquash. Turn right onto Gooseberry Road. The point is located at a clearing to the left which overlooks the water and an old wharf. The point is on the side of the hill on the north-west side of the beach.

Full Description

17/19

Site Owner: private ownership

GGE 2013 STU (C) Survey Control Network

Station Details

Reference - NAD83 (CSRS)

Station Number: 3001

General:

Established By:	GGE 2103 Group Three
Owner:	GGE 2103 Group Three
Name:	STU_C_3001
Method:	Traverse (Total Station)
Published:	05/09/2008

General:

Province:	New Brunswick
County:	York
City:	Fredericton
Location:	STU Campus (C)

North of Lower Entrance to McCain Hall, in sidewalk adjacent to parking lot. In a direction of South from the edge of the parking lot a distance of 1.87 m. In a direction West from a parking sign post a distance of 7.52 m. In a direction of North/West of a tree in the centre of a flower bed a distance of 5.20 m.

N.B. Stereographic Projection:

Easting:	2488698.440 m
Northing:	7438170.262 m

Geodetic Coordinates:

Latitude (N):	45°56'37.02247"
Longitude (W):	66°38'44.72574"

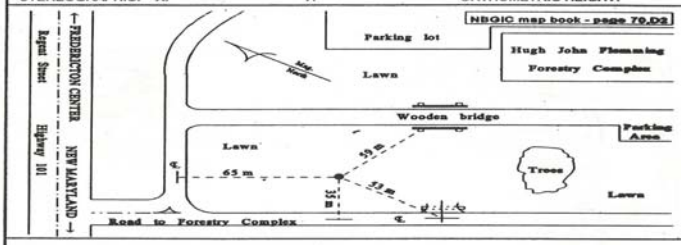
18/19

Heights:

RGHPNB NAD83 (CSRS) P-13

STATION NO: **941007** STATION NAME: **Fredericton**

GEOGRAPHIC COORDINATES	CARTESIAN COORDINATES
LATITUDE: LONGITUDE: ELLIPSOIDAL HEIGHT:	X: Y: Z:
PUBLICATION:	CLASSIFICATION:
STEREOGRAPHIC: X: Y:	ORTHOMETRIC HEIGHT:



STATION: Concrete pillar, 40 cm in diameter, 1.5 m above ground, with a forced centering brass plate.

ACCESS: This site is reached by driving to the street lights at the Regent Street Mall and taking the exit to the east. The pillar is on a large lawn on the north side of the entrance road to the Hugh John Flemming Forestry Complex.

SITE OWNER: Department of Natural Resources.

NOTES: Contact Cecil Freeman, Complex Administration, at 452-6950 to advise of use.

SURVEY CONTROL SECTION
DIVISION DE LA GÉODÉSIE

NEW BRUNSWICK
NOUVEAU-BRUNSWICK