

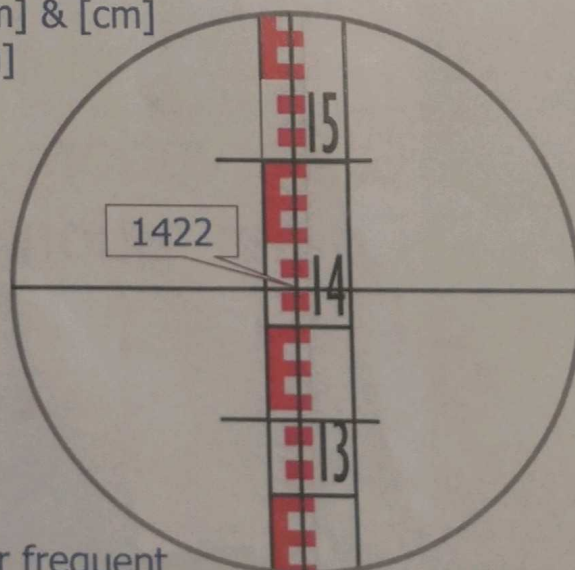
Definitions

- **Back sight (BS)**
 - The first reading from a new instrument stand point (i.e. take the height to the instrument)
- **Fore sight (FS)**
 - The last reading from the current instrument station (i.e. give the height to a benchmark)
- **Intermediate sight (IS)**
 - Any sighting that is not a back sight or fore sight

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Reading a Staff

- Read the [m], [dm] & [cm]
- Estimate the [mm]



- Check yourself for frequent used numbers (2/3) or (7/8)

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Basic Rules for Leveling

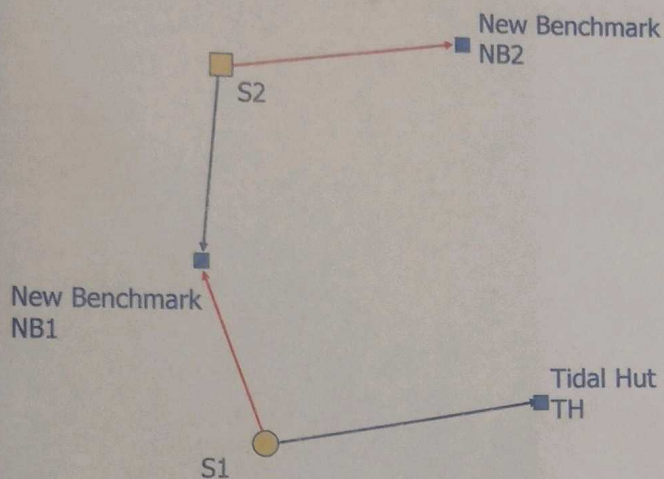
- Always start and finish a leveling run on a Benchmark (BM or TGBM) and close the loops
- Keep fore sight and back sight distances as equal as possible
- Keep *lines of sight* short (normally $< 50\text{m}$)
- Never read below 0.5m on a staff (refraction)
- Use stable, well defined change points
- Beware of shadowing effects and crossing waters

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Observation, Field Notes, and Computation

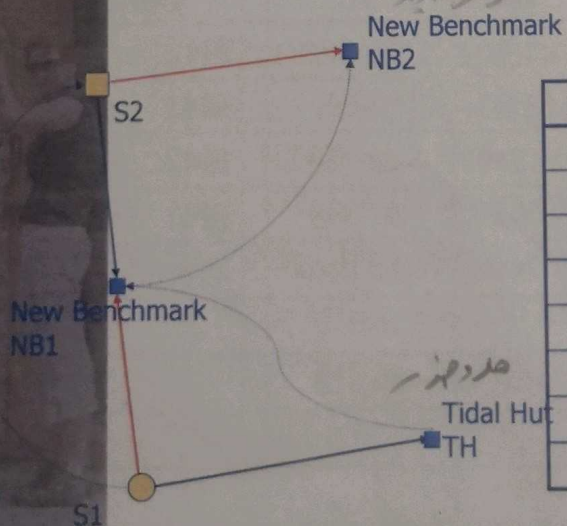
ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

How to: A sample loop



ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

How To: Field Notes



Back	Inter	Fore	Point
1327			TH
2365		3982	NB1
2347		0986	NB2
3753		3724	NB1
		1101	TH

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Date, Observer,
Instrument

Instrument Check

Back Fore $\Sigma \Delta$

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Compute levels

Back	Inter	Fore	dh	H	Comment
1327				100 000	TH
2365		3982	'7345	97 345	BM1
2347 ⁺¹		0986	1379	98 724	BM2 ?
3753		3724	'8624	97 348	BM1
		1101	2652	100 000	TH
9792		9793	0	0	
IST	-0001				
SOLL	0000				
	0001	(SOLL - IST)			

Loop misclosure

- **Misclosure Error**

- The difference of the *measured* height difference (ΔH_{meas}) to the *known* height (closed loops = 0, known benchmarks = height difference)

$$\text{Misclosure} = \Delta H_{\text{SOLL}} - \Delta H_{\text{IST}}$$

- **Point errors** at double observed points

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Achievable Accuracy

- **Instrument dependent**

- Roughly from the instrument
 - ♦ NI002 = 0,2mm/km (doubled line)
 - ♦ NI025 = 2.5mm/km (doubled line)

- **Survey line length dependent**

- $m_s = m_{1\text{km}} \sqrt{s}$, s in km
- $m_H = (m_{1\text{km}}/2) \sqrt{s}$, s in km # (middle of the line)

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

An acceptable misclose?

- *Small* misclosures in closed level loops are expected because of the accumulation of random errors and can be adjusted
- If the misclosure is *large*, the loop (or part of it) must be repeated
- *Misclosures can also result from errors in published BM levels and from BM instability*

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Testing the misclose

- The amount of misclosure acceptable using a specific instrument and survey line length
- For our example, a *second order* leveling standard is adopted*...

$\text{misclosure} \leq 2,5\sqrt{s} \text{ mm}$

- where **s** is the length of the line in km

*Dependent on your contry's rules and the instrument used

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Our example

- The misclosure is +1 mm
- The length of the loop is 0.4 km
- Acceptable error is
 $2.5\sqrt{(0.4)} = \pm 1.6 \text{ mm}$
- The misclosure of +1 mm is within the limit
- Mean error for NB1 = $2.5/2 * \sqrt{(0.4)}$

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Errors and their effects

(many, but only a few addressed)

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Errors in leveling, e.g.

- Collimation, Parallax ^{انحراف البصر}
- Change point / staff instability ^{عدم استقرار}
- Instrument or Benchmark instability
- Refraction ^{انكسار}
- Uncalibrated staff or levels ^{عدم تصحيح المسطرة}
- Reading, booking, or computation errors ^{خطأ في القراءة}
- Fore- and backsight distances different ^{اختلاف المسافات}

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Systematic and Random Errors

- Earth curvature ^{انحناء الأرض}
- Refraction ^{انكسار}
- Collimation errors

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Summary

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Procedure of leveling

1. The instrument must be checked before use! (see lecture) ✓
2. The instrument and level must be stable settled-up ✓
3. The bubble tube must be leveled before the reading ✓
 - Beware of sun exposure (will wander) ✓
 - Ensure the instrument's pendulum is in-limit ✓
4. The instrument must be set up in the middle between two staffs (مابين) ✓
 - Prevents curvature effects
 - If impossible, use the same distances, but opposite for the next readings (اختلاف المسافات)
5. You must not use the parallax screw between the backsight and foresight readings

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

Procedure of Leveling

6. Readings must be taken 30-50 cm above the ground
 - Surface refractions
 - Beware also of temperature gradients (inside/outside buildings) !!!!
7. Staff should be set up vertically ✓
8. A change plate should be used ✓
9. Leveling must be done in two opposite directions but the same line (beware of gravity gradients) ✓
10. Staff should be calibrated, especially if INVAR
11. Be careful when crossing rivers (large water surfaces)
 - Use "same-time" (mutual) observations *متبادل*
 - Repeat it during different times of the day *بم الزمانه فلك اوقات مختلفه*

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006

An Unhappy Surveyor



... having a 2 centimeter difference

ODINAFRICA/GLOSS Sea Level Training Course - Oostende, Belgium - 13-24 Nov. 2006