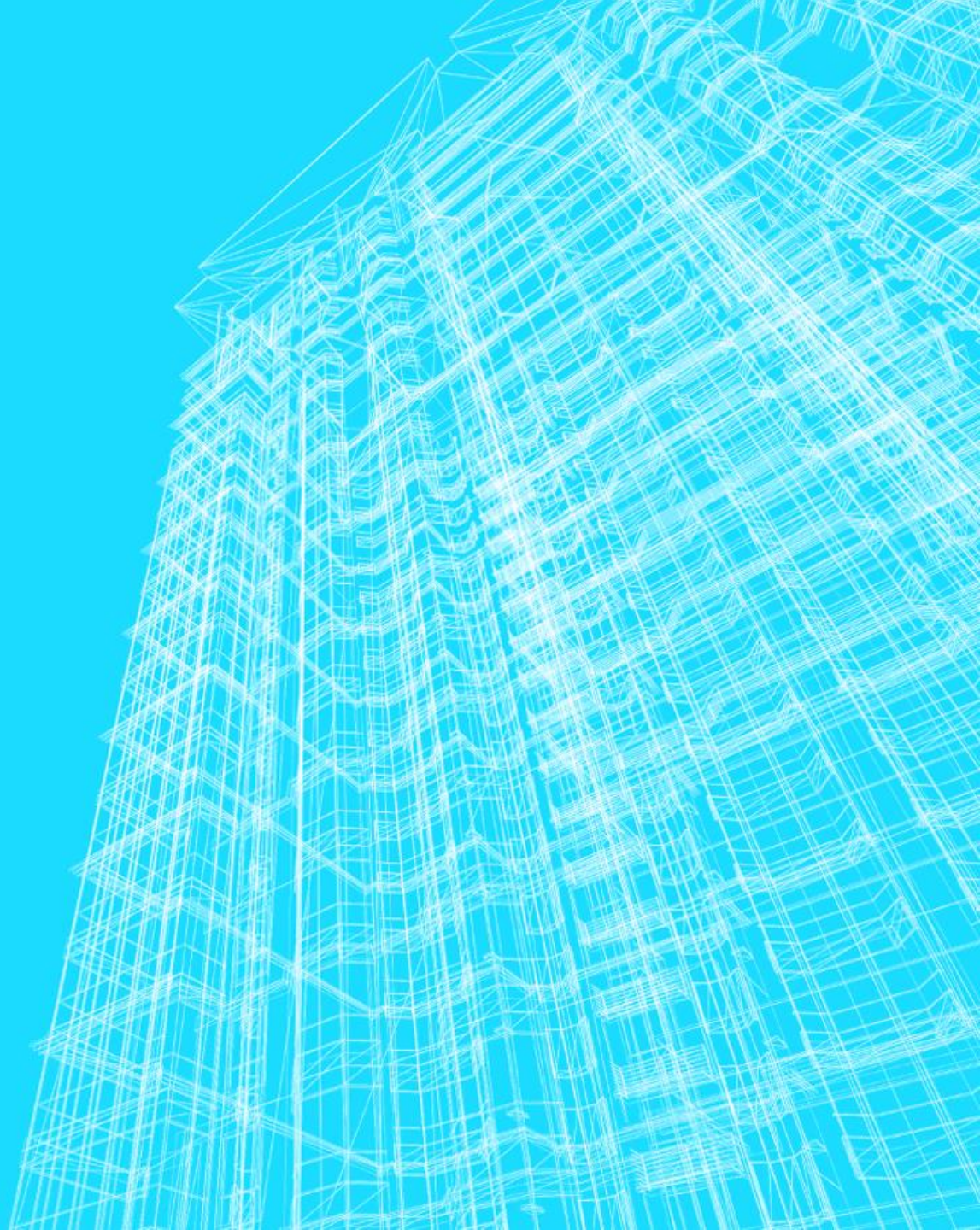
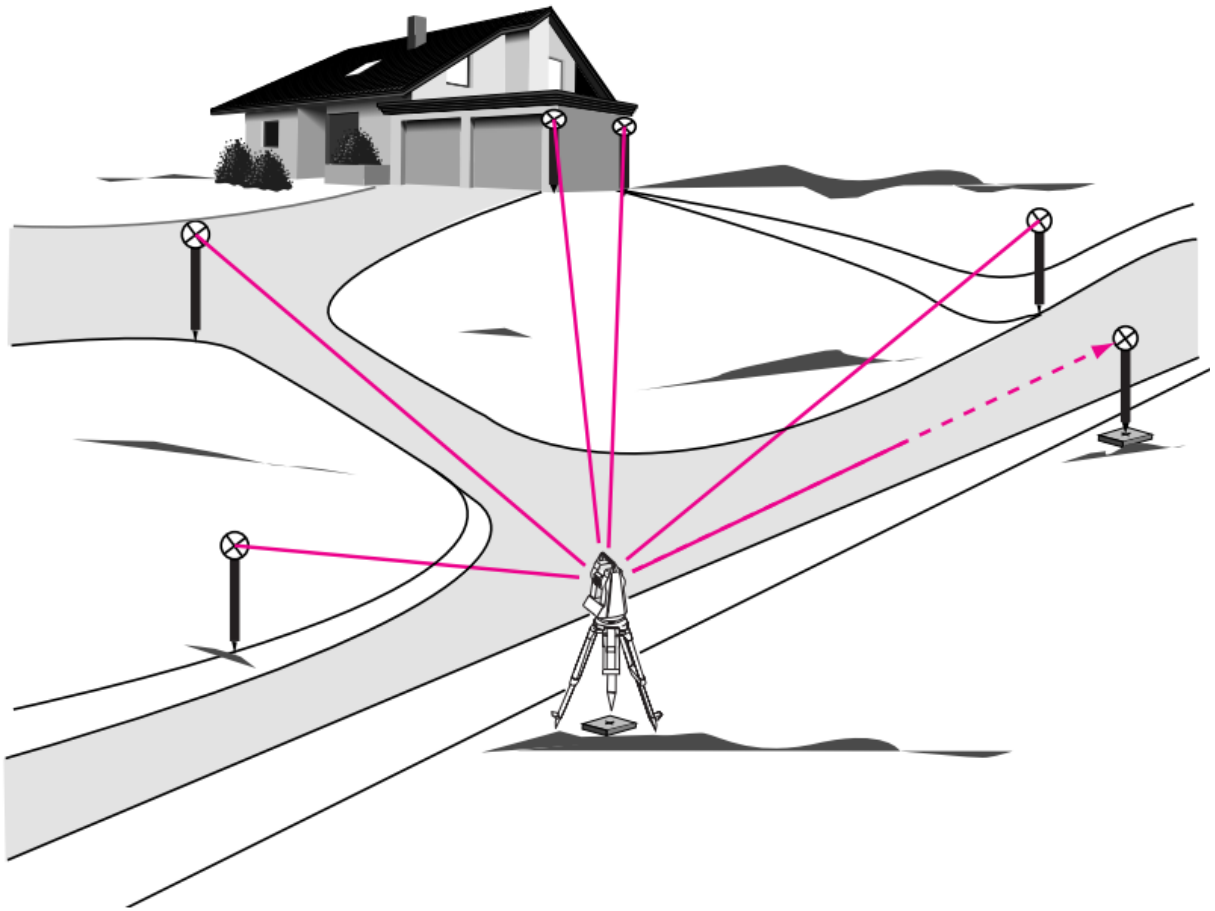
PROJEKTEERIMISE GEODEETILISED UURIMISTÖÖD

Maa-ala geodeetiline mõõdistus kui projekteerimise alus

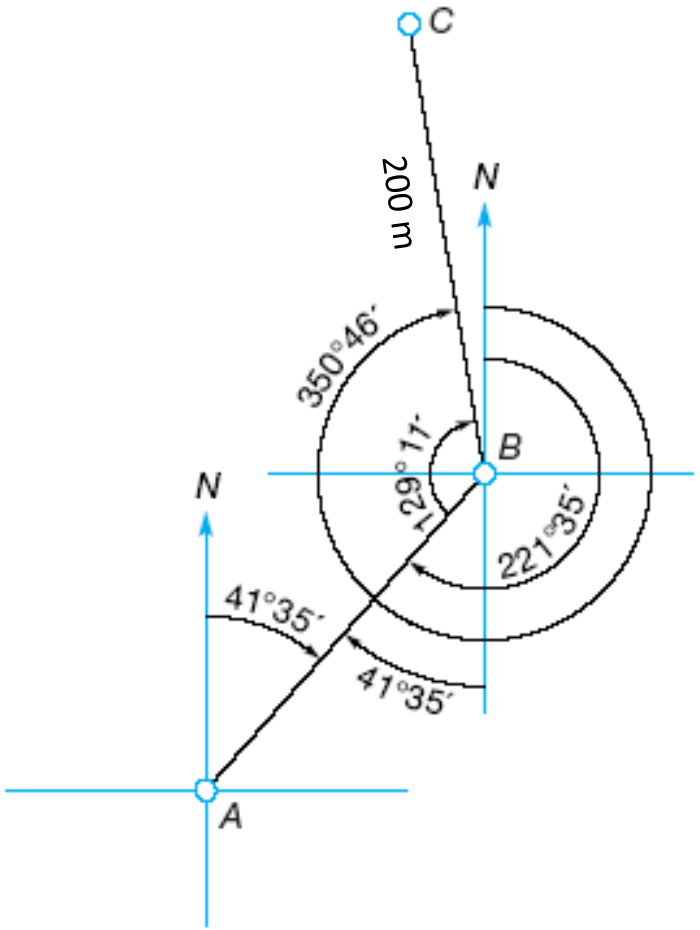


Lektor: Tarmo Kall, MSc, PhD
2023/24 õa

POLAARKOORDINAADID



RISTKOORDINAADID POLAARKOORDINAATIDEST



Olgu $X_A = 775{,}60\,\text{m}$ ja $Y_A = 2800{,}89\,\text{m}$ ning $X_B = 1000\,\text{m}$ *ja* $Y_B = 3000\,\text{m}$, siis

$$\tan R_{AB} = \frac{3000 - 2800{,}89}{1000 - 775{,}60} = \frac{199{,}11}{224{,}40}$$

$$R_{AB} = \arctan\frac{199{,}11}{224{,}40} = 41°35'$$

kuna 199,11 ja 224,40 on mõlemad positiivsed, siis $R_{AB} = \alpha_{AB}$

$$\alpha_{BC} = 41^\circ 35' - 180^\circ + 129^\circ 11' =$$

$$= -9^\circ 14' + 360^\circ = 350^\circ 46'$$

$$\alpha_{BA} = 41^\circ 35' + 180^\circ = 221^\circ 35'$$

$$\alpha_{BC} = 221^\circ 35' + 129^\circ 11' = 350^\circ 46'$$

$$X_C = 1000 + 200 \cdot \cos 350°46' = 1197{,}41\,\text{m}$$

$$Y_C = 3000 + 200 \cdot \sin 350°46' = 2999{,}84\,\text{m}$$

Ghilani, Charles D., and Paul R. Wolf. *Elementary surveying*. Pearson Higher Ed, 2012.

POLAARKOORDINAATIDE TÄPSUS

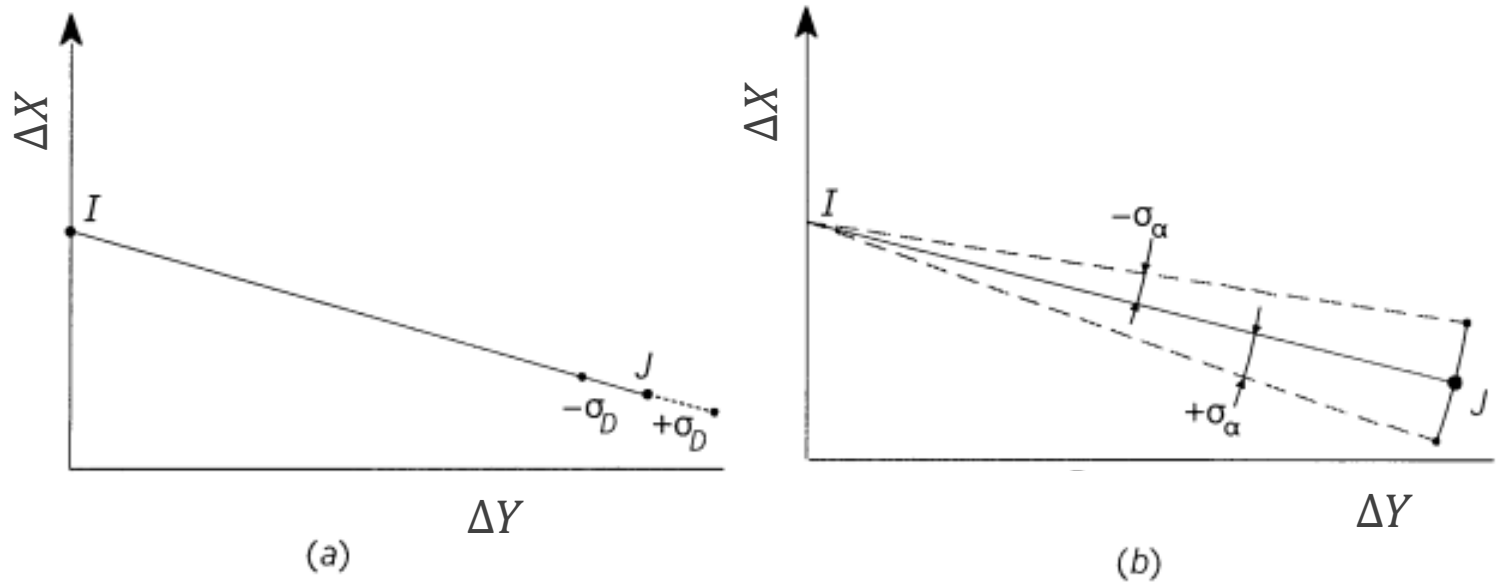


Figure 8.1 Latitude and departure uncertainties due to (*a*) the distance error (σ_D) and (*b*) the azimuth error σ_{Az}. Note that if either the distance or azimuth changes, both the latitude and departure of the course are affected.

- $Lat = \Delta X = S * cos\alpha$
- $Dep = \Delta Y = S * sin\alpha$

Wolf, P. R., & Ghilani, C. D. (2006). Adjustment Computations Spatial Data Analysis, John Wiley & Sons, Inc.

POLAARKOORDINAATIDE TÄPSUS

1

$$\frac{\partial \text{Lat}}{\partial D} = \cos \text{Az} \qquad \frac{\partial \text{Lat}}{\partial \text{Az}} = -D \sin \text{Az}$$

$$\frac{\partial \text{Dep}}{\partial D} = \sin \text{Az} \qquad \frac{\partial \text{Dep}}{\partial \text{Az}} = D \cos \text{Az}$$

2

Example 8.1 A traverse course has a length of 456.87 ± 0.02 ft and an azimuth of 23°35′26″ ± 9″. What are the latitude and departure and their estimated errors?

SOLUTION Using Equation (8.1), the latitude and departure of the course are

$$\text{Lat} = 456.87 \cos(23°35'26'') = 418.69 \text{ ft}$$

$$\text{Dep} = 456.87 \sin(23°35'26'') = 182.84 \text{ ft}$$

3

$$\Sigma_{\text{Lat,Dep}} = \begin{bmatrix} \frac{\partial \text{Lat}}{\partial D} & \frac{\partial \text{Lat}}{\partial \text{Az}} \\ \frac{\partial \text{Dep}}{\partial D} & \frac{\partial \text{Dep}}{\partial \text{Az}} \end{bmatrix} \begin{bmatrix} \sigma_D^2 & 0 \\ 0 & \sigma_{\text{Az}}^2 \end{bmatrix} \begin{bmatrix} \frac{\partial \text{Lat}}{\partial D} & \frac{\partial \text{Dep}}{\partial D} \\ \frac{\partial \text{Lat}}{\partial \text{Az}} & \frac{\partial \text{Dep}}{\partial \text{Az}} \end{bmatrix} = \begin{bmatrix} \sigma_{\text{Lat}}^2 & \sigma_{\text{Lat,Dep}} \\ \sigma_{\text{Lat,Dep}} & \sigma_{\text{Dep}}^2 \end{bmatrix}$$

4

Substituting partial derivatives into the above yields

$$\Sigma_{\text{Lat,Dep}} = \begin{bmatrix} \cos \text{Az} & -D \sin \text{Az} \\ \sin \text{Az} & D \cos \text{Az} \end{bmatrix} \begin{bmatrix} 0.02^2 & 0 \\ 0 & (9''/\rho)^2 \end{bmatrix} \begin{bmatrix} \cos \text{Az} & \sin \text{Az} \\ -D \sin \text{Az} & D \cos \text{Az} \end{bmatrix} \quad (8.3)$$

Wolf, P. R., & Ghilani, C. D. (2006). Adjustment Computations Spatial Data Analysis, John Wiley & Sons, Inc.

POLAARKOORDINAATIDE TÄPSUS

5

Entering in the appropriate numerical values into Equation (8.3), the *covariance matrix* is

$$\Sigma_{\text{Lat,Dep}} = \begin{bmatrix} 0.9167 & -456.87(0.4002) \\ 0.4002 & 456.87(0.9164) \end{bmatrix} \begin{bmatrix} 0.0004 & 0 \\ 0 & (9''/\rho)^2 \end{bmatrix} \begin{bmatrix} 0.9167 & 0.4002 \\ -456.87(0.4002) & 456.87(0.9164) \end{bmatrix}$$

from which

$$\Sigma_{\text{Lat,Dep}} = \begin{bmatrix} 0.00039958 & 0.00000096 \\ 0.00000096 & 0.00039781 \end{bmatrix} \qquad (8.4)$$

6

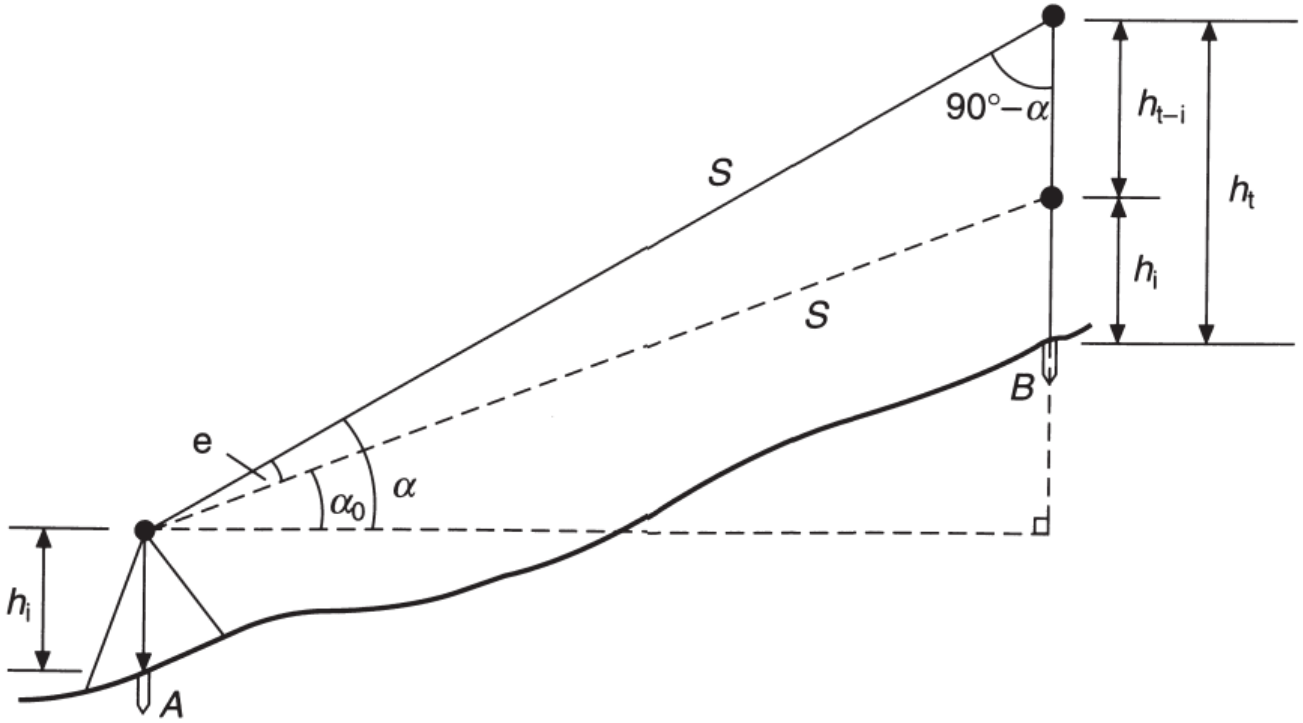
In Equation (8.4), σ_{11}^2 is the variance of the latitude, σ_{22}^2 the variance of the departure, and σ_{12} and σ_{21} their covariances. Thus, the standard errors are

$$\sigma_{\text{Lat}} = \sqrt{\sigma_{11}^2} = \sqrt{0.00039958} = \pm 0.020 \text{ ft} \quad \text{and}$$

$$\sigma_{\text{Dep}} = \sqrt{\sigma_{22}^2} = \sqrt{0.00039781} = \pm 0.020 \text{ ft}$$

Wolf, P. R., & Ghilani, C. D. (2006). Adjustment Computations Spatial Data Analysis, John Wiley & Sons, Inc.

TRIGONOMEETRILINE NIVELLEERIMINE



When measuring the vertical angle α

$$\Delta h = S \sin \alpha$$

When using the zenith angle z

$$\Delta h = S \cos z$$

If the horizontal distance is used

$$\Delta h = D \tan \alpha = D \cot z$$

The difference in elevation (ΔH) between ground points A and B is therefore

$$\Delta H = h_i + \Delta h - h_t$$

$$= \Delta h + h_i - h_t$$

where h_i = vertical height of the measuring centre of the instrument above A
h_t = vertical height of the centre of the target above B

Schofield, W., & Breach, M. (2007). Engineering Surveying", 6th ed, Elsevier Ltd

TRIGONOMEETRILISE NIVELLEERIMISE KÕRGUSE TÄPSUS

What constitutes a short line may be derived by considering the effect of curvature and refraction compared with the accuracy expected. The combined effect of curvature and refraction over 100 m = 0.7 mm, over 200 m = 3 mm, over 300 m = 6 mm, over 400 m = 11 mm and over 500 m = 17 mm.

If we apply the standard treatment for small errors to the basic equation we have

$$\Delta H = S \sin\alpha + h_\mathrm{i} - h_\mathrm{t} \tag{3.11}$$

and then

$$\delta(\Delta H) = \sin\alpha \cdot \delta S + S \cos\alpha \, \delta\alpha + \delta h_\mathrm{i} - h_\mathrm{t} \tag{3.12}$$

and taking standard errors:

$$\sigma^2_{\Delta H} = (\sin\alpha \cdot \sigma_s)^2 + (S \cos\alpha \cdot \sigma_\alpha)^2 + \sigma^2_\mathrm{i} + \sigma^2_\mathrm{t}$$

Consider a vertical angle of $\alpha = 5°$, with $\sigma_\alpha = 5''$ (= 0.000024 radians), $S = 300$ m with $\sigma_s = 10$ mm and $\sigma_\mathrm{i} = \sigma_\mathrm{t} = 2$ mm. Substituting in the above equation gives:

$$\sigma^2_{\Delta H} = 0.9^2 \text{ mm}^2 + 7.2^2 \text{ mm}^2 + 2^2 \text{ mm}^2 + 2^2 \text{ mm}^2$$

$$\sigma_{\Delta H} = 7.8 \text{ mm}$$

This value is similar in size to the effect of curvature and refraction over this distance and indicates that short sights should never be greater than 300 m. It also indicates that the accuracy of distance S is not critical when the vertical angle is small. However, the accuracy of measuring the vertical angle is very critical and requires the use of a theodolite, with more than one measurement on each face.

RTK GPS

- Täpsus:
  - H: ± 1..2 cm
  - V: ± 3..5 cm

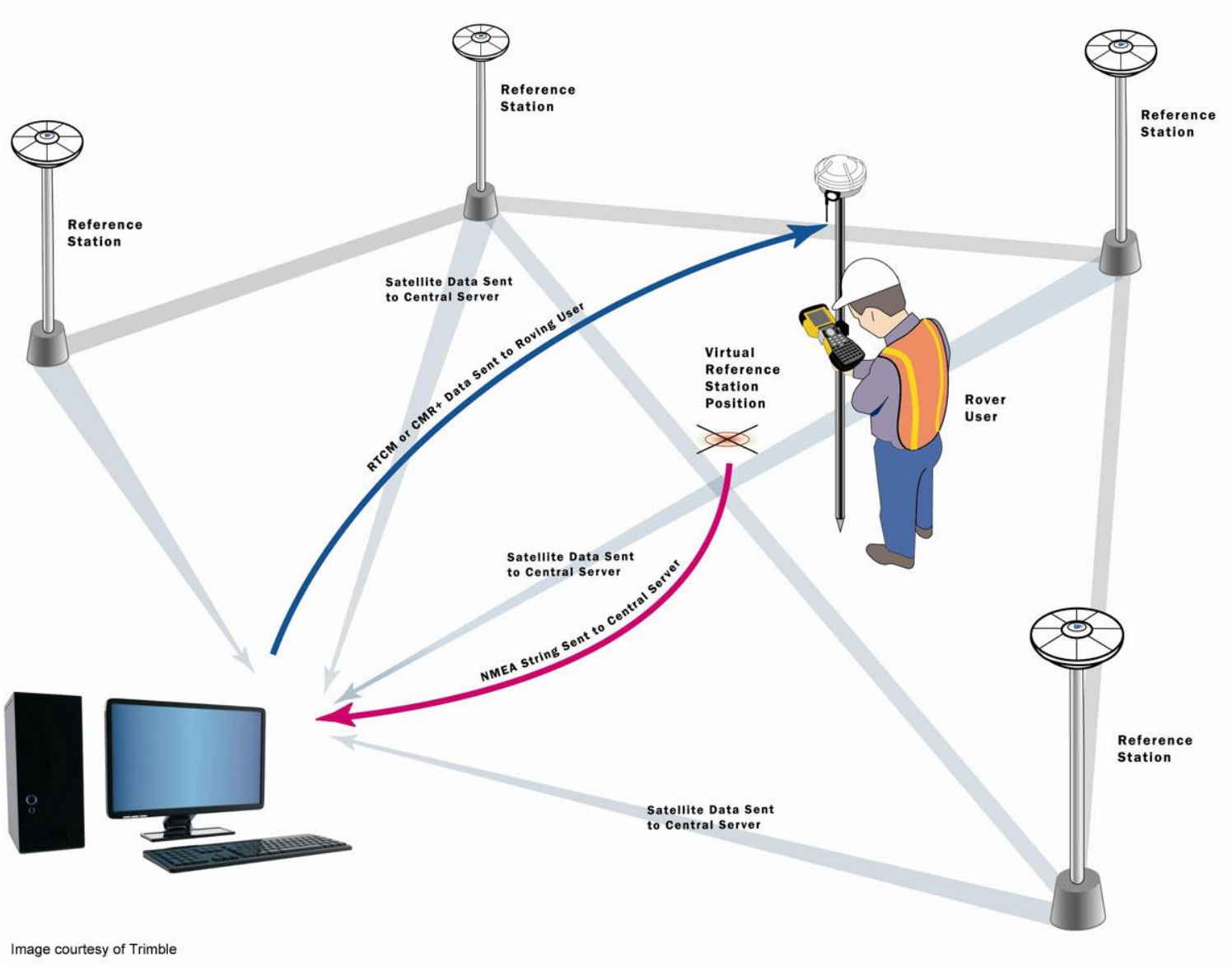


Image courtesy of Trimble

GEODEETILINE ALUSPLAAN

- Maapealne situatsioon (kohtkindlad punkt-, joon- ja pindobjektid, nagu ehitised, kõlvikud jne)
- Reljeef
- Mõõdistusalasse jäävad maakatastris registreeritud katastriüksuste piirid, nende katastritunnused ja lähiaadressid
- Maapealne tehnovõrk
- Maa-alune tehnovõrk
- Kaevude andmestik

MAA-ALUSE TEHNOVÕRGU UURIMINE

- **§ 28. Maa-aluse tehnovõrgu mõõdistamine ja kujutamine plaanil**
- (1) Maa-alune tehnovõrk kantakse maa-ala plaanile, eelistades andmeallikaid järgmiselt:
  - 1) välimõõdistamine;
    2) kaevu uurimine;
    3) varasem teostusmõõdistus;
    4) tehnovõrgu omanik või valdaja.
- (3) Varasema uuringu andmeid kasutatakse juhul, kui käesoleva paragrahvi lõikes 1 loetletud tegevuste tulemusel ei õnnestu tehnovõrgu olemasolu ja asukohta tuvastada.

MAA-ALUSE TEHNOVÕRGU UURIMINE

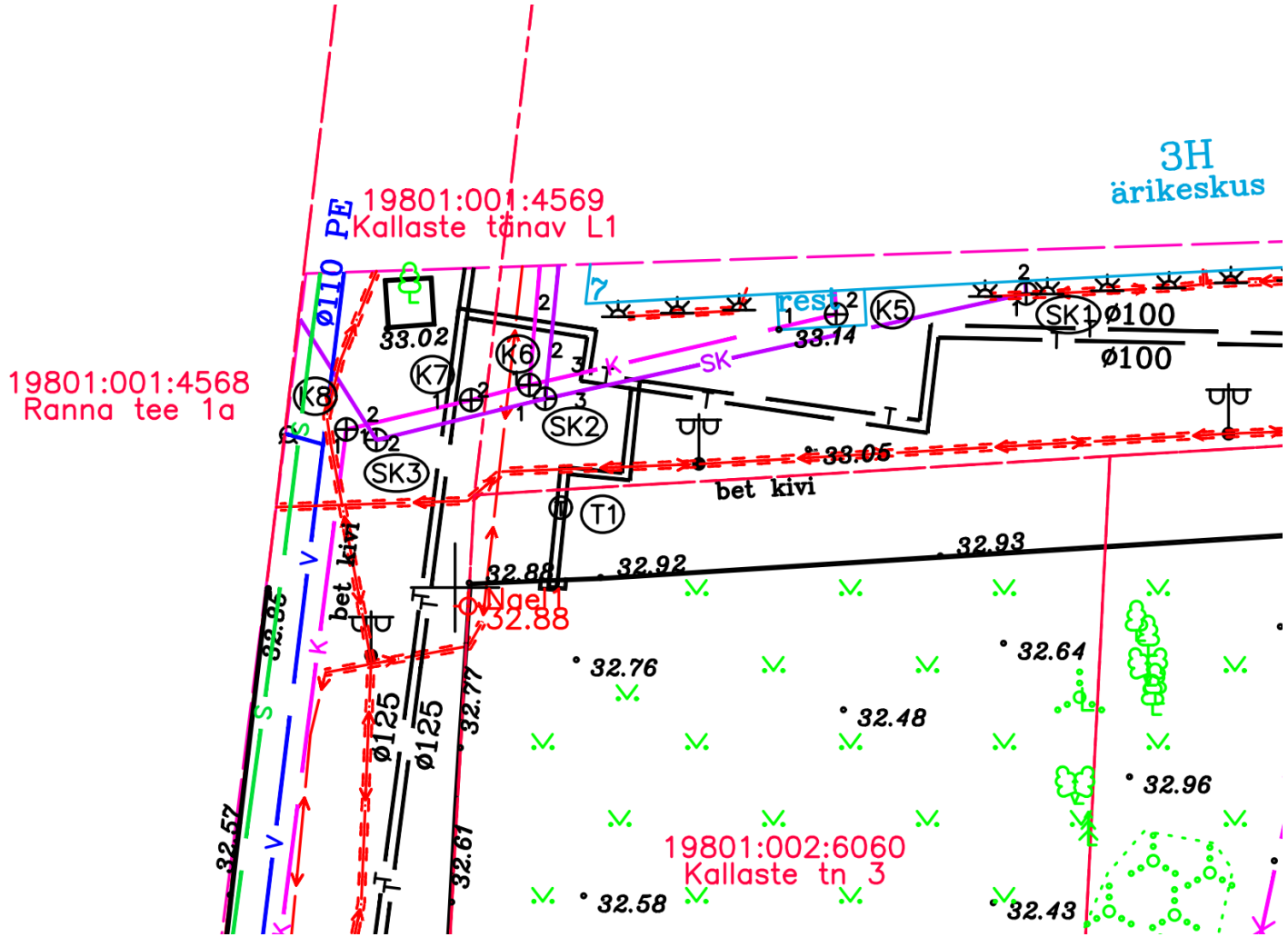
- (4) Varasema uuringu ja teostusjoonise andmete tõepärasust kindlustatakse pistelise kontrolliga.
- (5) Lähteülesandes sätestatud juhul määratakse tehnovõrgu asukoht trassiotsijaga.
- (6) Omaniku või valdaja andmete alusel plaanile kantud tehnovõrgu kohta tehakse vastav märge uuringu aruandesse.
- Printsiip – USALDA, AGA KONTROLLI!

MAA-ALUSTE TORUSTIKE UURIMINE JA KOGUTAVAD ANDMED

- § 29. Maa-aluse torustiku kaevu uurimine, mõõdistamine ja kujutamine plaanil
- § 30. Kaevude andmestik

https://www.riigiteataja.ee/akt/119042016003#para29

FRAGMENT GEODEETILISEST ALUSPLAANIST



KAEVUDE UURIMISE TABELID

Kanalikaevude tehnilised andmed

TT-6558.xls

Kaevu nr.	Andmed saadud	Kõrgused (m)			Kaevu andmed			Torude andmed					Märkused
		Kaas	Maap.	Põhi	ø (mm)	Sein	Kaas	Nr.	Põhi	ø (mm)	Mat.	Suub.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
K1	21_024_10	32.76	32.76	31.16	560/500	Plast	Malm	1	31.16	160	PVC	K2	
								2	31.16	160	PVC		
K2	21_024_10	32.53	32.5	30.96	560/500	Plast	Malm	1	30.96	160	PVC	K3	

Sadekanali kaevude tehnilised andmed

TT-6558.xls

Kaevu nr.	Andmed saadud	Kõrgused (m)			Kaevu andmed			Torude andmed					Märkused
		Kaas	Maap.	Põhi	ø (mm)	Sein	Kaas	Nr.	Põhi	ø (mm)	Mat.	Suub.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
SK1	21_024_8	32.84	32.84	31.60	400/315	Plast	Malm	1	31.63	160	PP	SK2	
								2	31.77	160	PP		
SK2	21_024_8	32.88	32.88	31.56	560/500	Plast	Malm	1	31.55	160	PP	SK3	

Sidekaevude tehnilised andmed

TT-6558.xls

Kaevu nr.	Andmed saadud	Kõrgused (m)			Kaevu andmed			Torude andmed					Märkused
		Kaas	Maap.	Põhi	ø (mm)	Sein	Kaas	Nr.	Lagi/Põhi	ø (mm)	Mat.	Suub.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
SI1	TJ-389/03-22	32.72	32.72	31.53	1800x1000	Bet	Malm	1	31.78/31.58	2x2x100	PL		

Soojakaevude tehnilised andmed

TT-6558.xls

Kaevu nr.	Andmed saadud	Kõrgused (m)			Kaevu andmed			Torude andmed					Märkused
		Kaas	Maap.	Põhi	ø (mm)	Sein	Kaas	Nr.	Põhi	ø (mm)	Mat.	Suub.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
T1	Uuritud	32.88	32.88	32.28	700	Plast	Malm						Ventiilide peale 32.74
T2	Uuritud	32.74	32.74	32.08	500	Plast	Malm						Ventiilide peale 32.18
T3	Uuritud	32.73	32.73	32.03	500	Plast	Malm						Ventiilide peale 32.14

KAEVU MÕÕTMINE TÄNAPÄEVAL ☺