Precise astronomical positioning using motorized total station

Radovan Machotka, Richard Kratochvíl
*Brno University of Technology, Institute of Geodesy*

MAAS-1

Mobile Automated Astronomical System, spec. No. 1

MAAS-1 development

- department of Geodesy own development,

- 6 years of work (including testing),

- designed for vertical deflection determination based on astronomic and geodetic positioning measurements,

- based on CCD camera and Topcon GPT 9001 total station instrument.
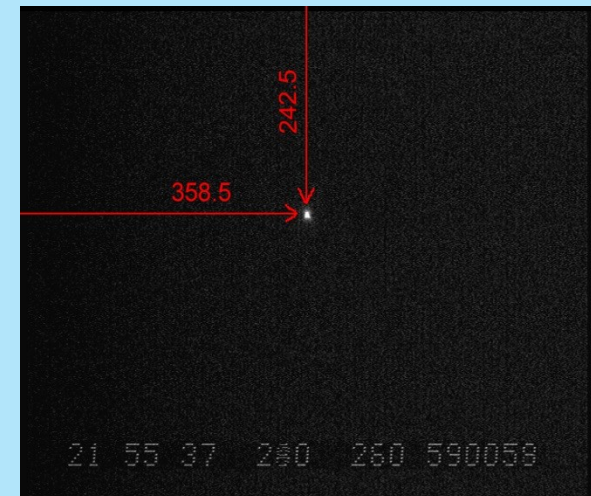
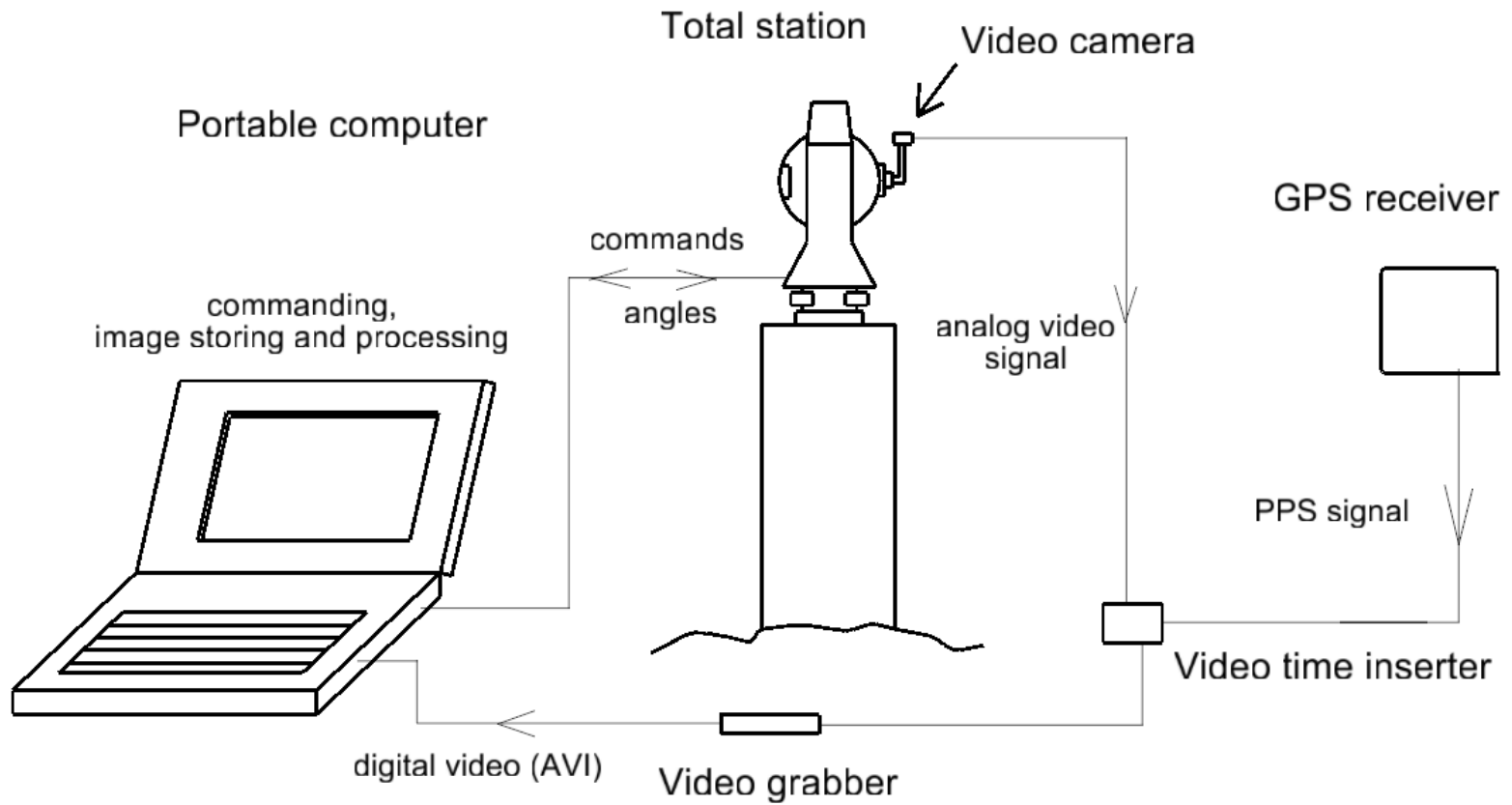# Measuring system demands

Designed for

- field measurements,

- maximal positioning accuracy,

- high measuring productivity.

Other requirements:

- easy to transport design,

- easy to replicate design,

- full automation of measurements,

- elimination of personal errors,

- accuracy of results at least 0,5 arc seconds.

Hardware configuration of MAAS-1

Special techniques (I)

Special sofisticated method of selection of stars for observation.
*The method of pairs of equal heights* is designed for:

- use of motorized total stations,
- minimization of influence of atmospheric refraction using pairs of stars,
- minimization of idle times in observations,
- determination of both geographical coordinates (latitude and longitude) at the same time.
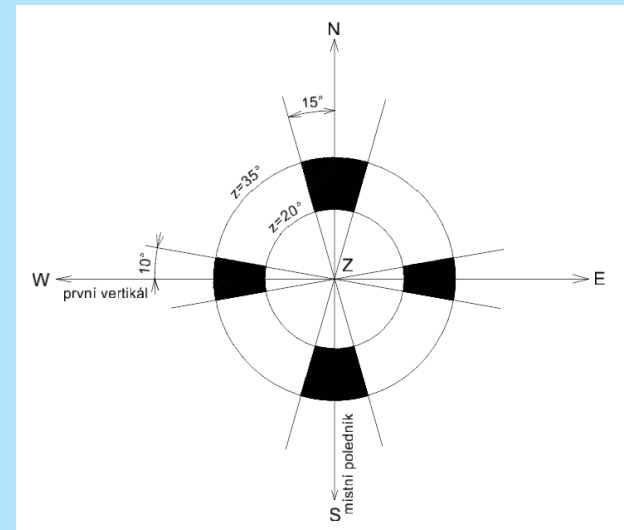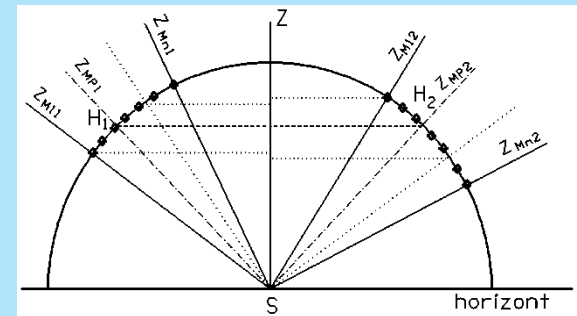
Special techniques (II)

Numerical composition of final „long exposure" image from partial short exposure images:

- single image (exposition 0.02 [s]),

- composition of 9 partial images (without compensation of motion),

- composition of 9 partial images (with compensation of motion).
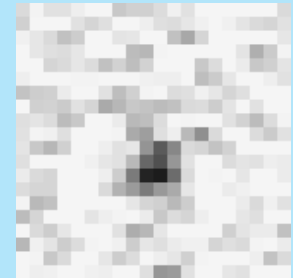
Special techniques (III)

Telescope camera calibration using "Polaris imaging calibration".

- Computation of pixel angular dimensions and image rotation from calibration image,
- repeated exposition of Polaris in different camera image locations,
- numeric compensation of Polaris movement between expositions,
- composition of Polaris calibration image using total station circle readings (see picture).
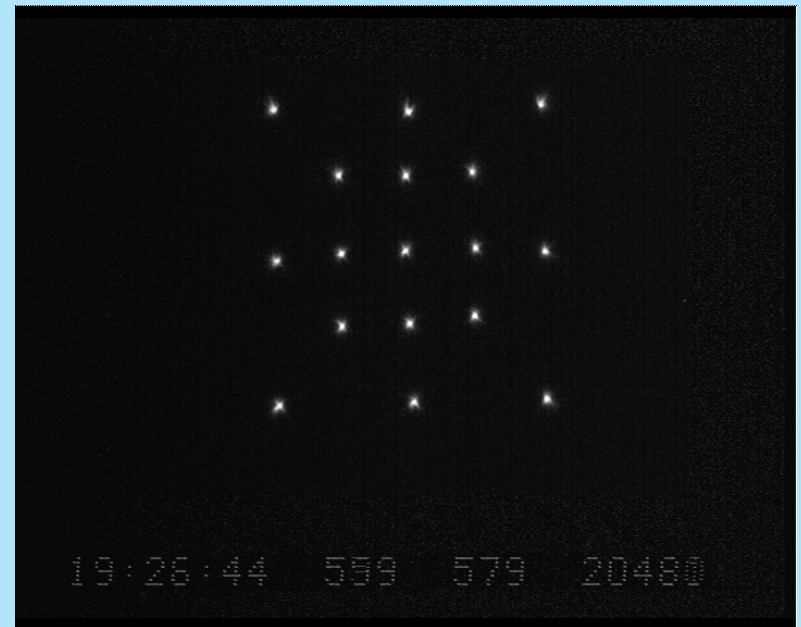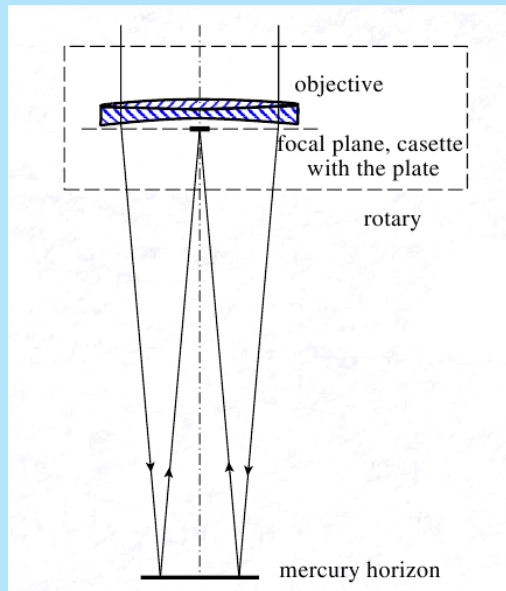
MAAS-1 Testing (I)

Cooperation with Astronomical Institut of Academy of Science CR in Ondřejov:

- simultaneous measurement of digital PZT and MAAS-1 (2009).

MAAS-1 Testing (II)

Cooperation with Reasearch Institut of Geodesy, Topography and Cartography:

• comparative measurements on astrogeodetic points determined by cirkumzenithal instrument (2010).

MAAS-1 Testing (III)

Cooperation with IfE Leibniz Universität Hannover:

- comparative measurements on astrogeodetic points determined by digital zenith camera TZK2-D (2011).

Accuracy

Combination of MAAS-1 and GNSS-RTK measurement provide:

- accuracy of 0,2 – 0,3 arc seconds in both vertical deflections components (meridian ξ and prime vertical η),

- this accuracy is achieved in one „standard" measurement comprising of 4 latitude and 4 longitude star pairs,

- duration of such „standard" observation is approximately 1 hour.

MAAS-1 Pilot projects (I)

Determination of vertical deflections and quasigeoid model in AGNES network, Brno (34 astrogeodetic points, 2010).

LOKÁLNÍ ASTRONOMICKÝ KVAZIGEOID
NA ÚZEMÍ MĚSTA BRNA
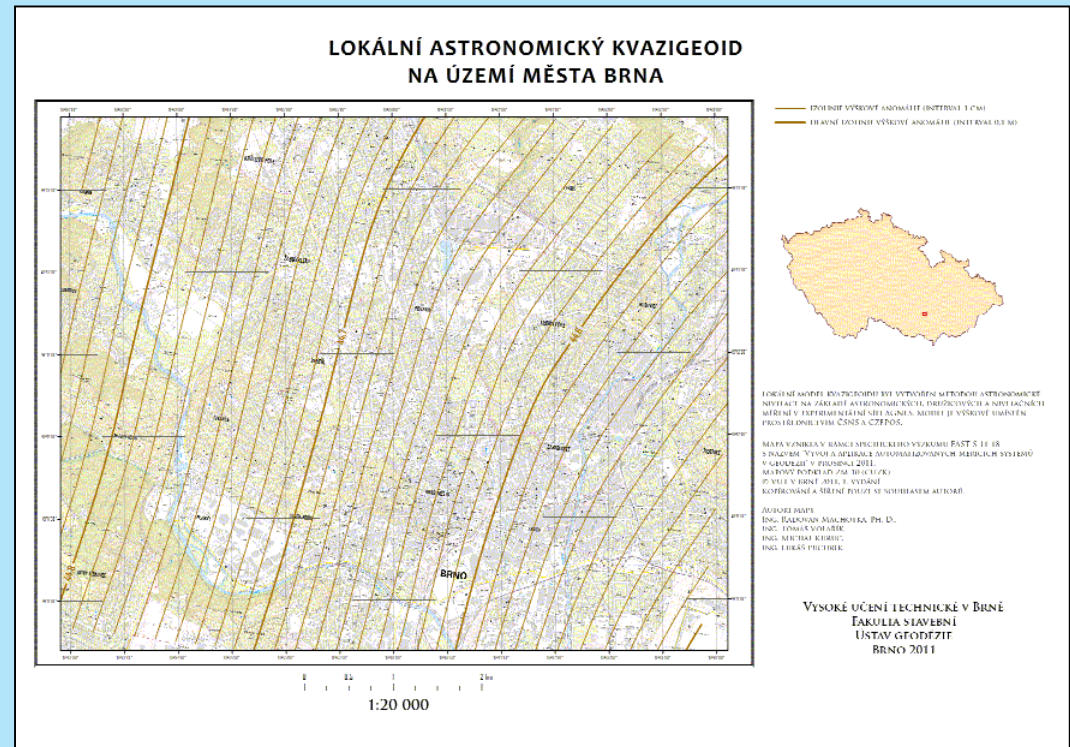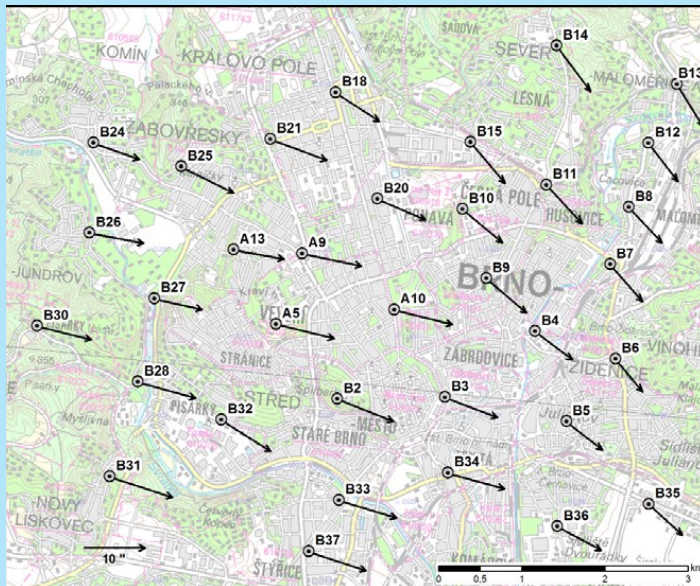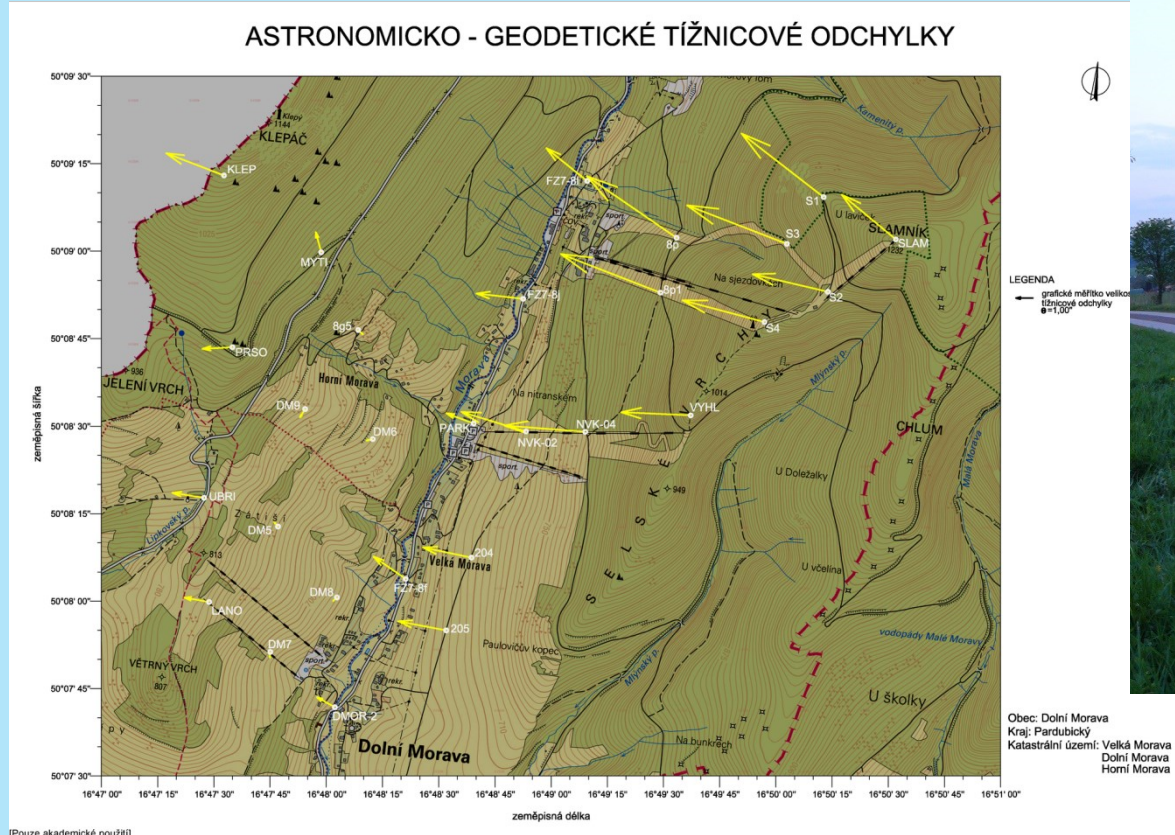
MAAS-1 Pilot projects (II)

Determination of vertical deflections on 100 km quasigeoid profile Velká Bíteš – Brno – Uherské Hradiště (30 astrogeodetic points, 2011).
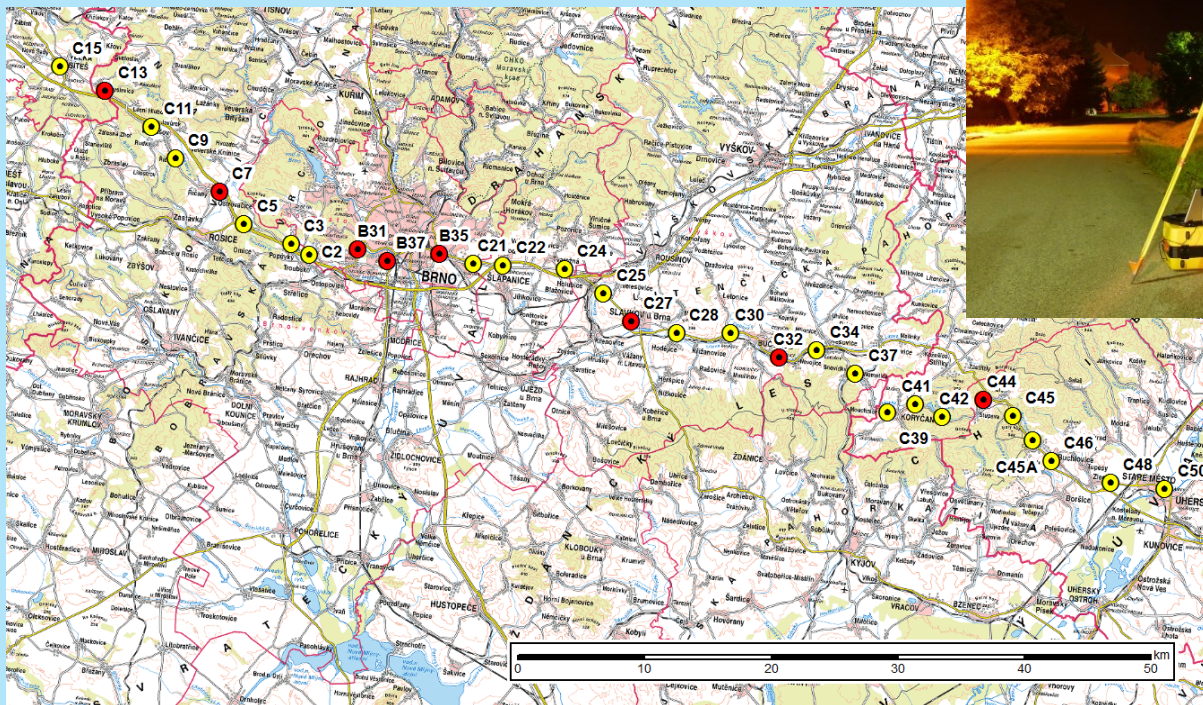
MAAS-1 Pilot projects (III)

Determination of vertical deflections in mountainous terrain of Sneznik Massif (28 astrogeodetic points, 2014-2016).
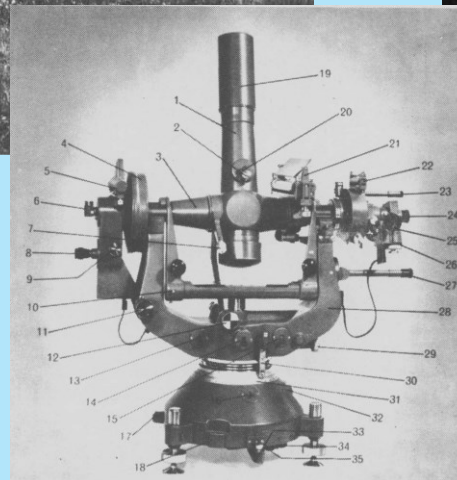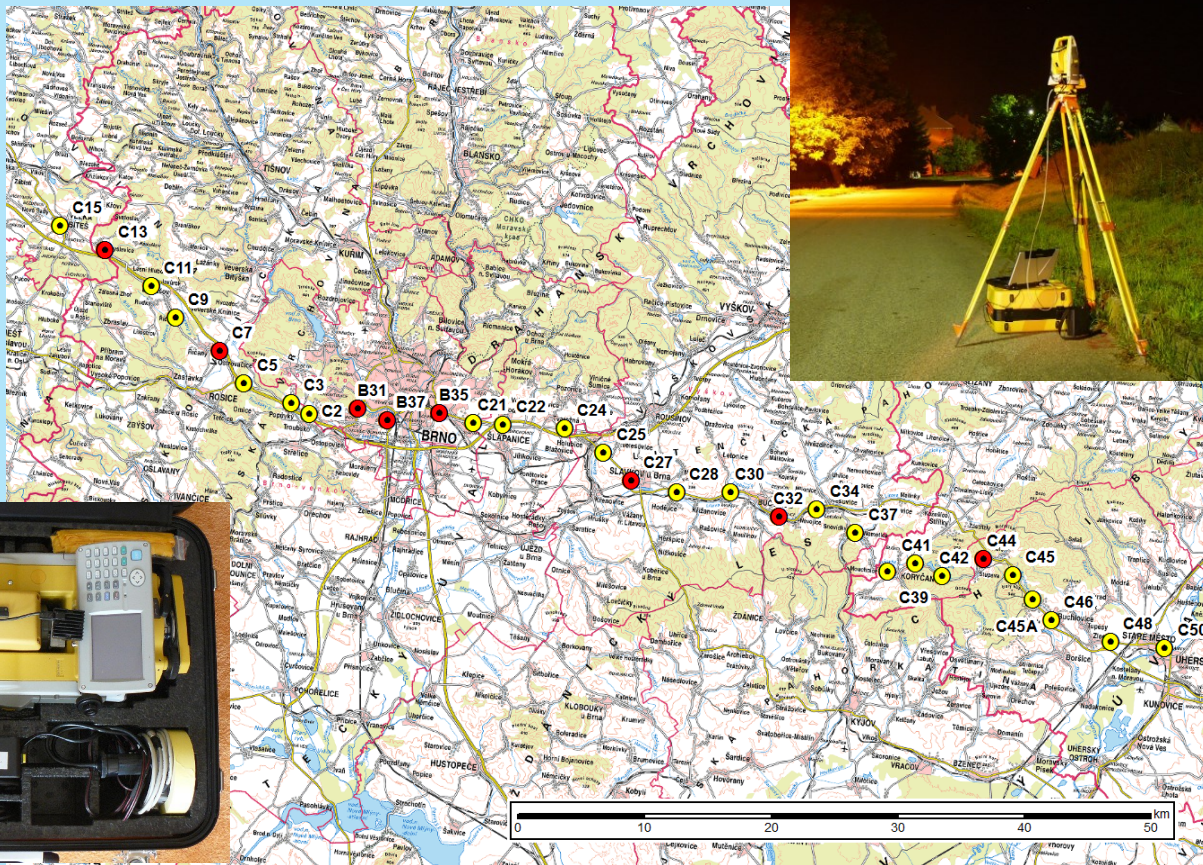
History

- Astronomical observation on trigonometric point Sneznik in 1956

≈120 kg
1 point a week

Today!

≈20 kg
6 point a night

Quasigeoid profile V. Bíteš – Brno – U. Hradiště (2011)

Future?

- MAAS-1 is composed of standard components: CCD camera, portable computer, geodetic total station... The heart of the system is software - It is easy to replicate!

- It is posssible to fabricate MAAS-2, MAAS-3, ...

- If you want one, contact me!

Thank you for your attention