Institut of Geodesy, Engeneering Research and Cadastr

Moldavian Surveyors Union

Struve Geodetic Arc in Republic of Moldova

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Subiects

Introduction

- History of geodetic arc measurements
- Destination of geodetic arc measurements
- History of Struve Geodetic Arc

Geodetic reference systems

- Reference ellipsoids parameters
- Coordinate transformations

Struve Arc points identification methods

- Points identification using GNSS methods
- Ppoints identification using ortophoto maps
- Transformation parameters errors modelling

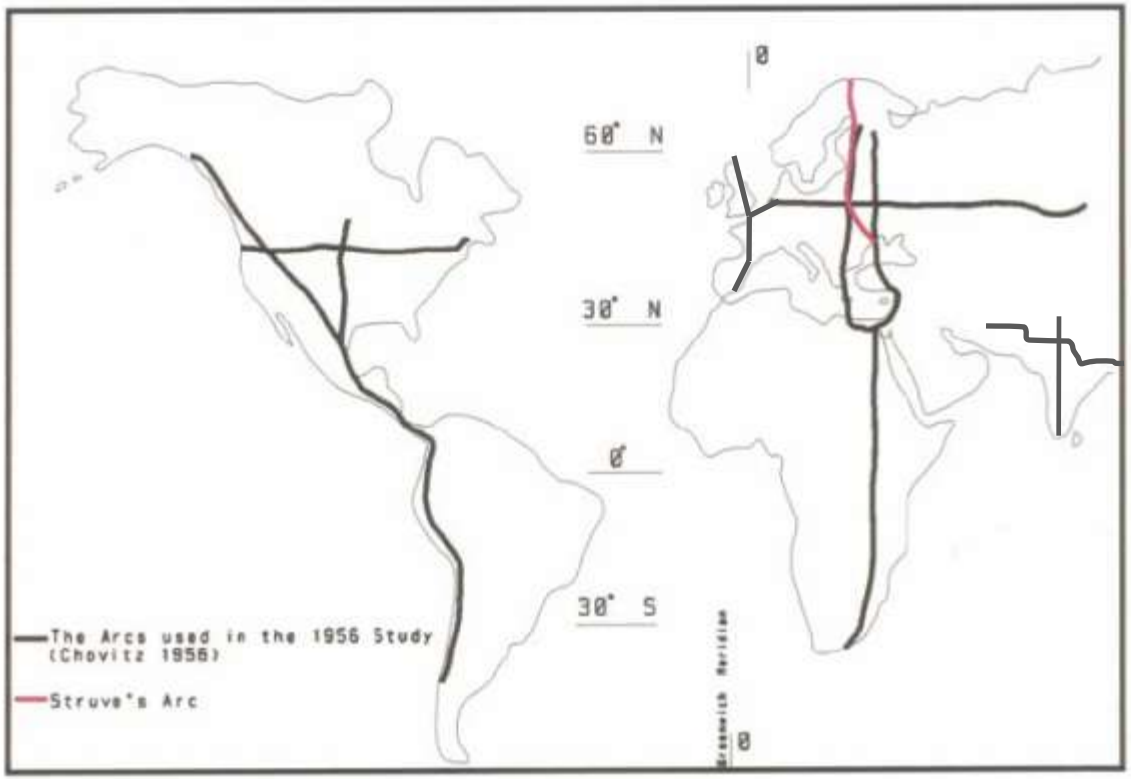
Conclusions and recommendations

Introduction

History of geodetic arcs measurements

Alexandria - Assuan (925 km), Egipt, Eratostene (276-195 BC)

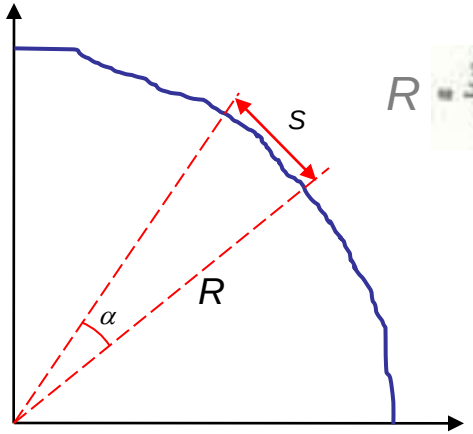
- **N-W from Bagdad (222 km), Arabia, Alimamun (827)**
- **Bergen op Zoom – Alkamaar (132 km), Holland, W. Snellius (1617)**
- **Malvoisine-Amiens (300 km), Franţa, J. Picard (1666)**
- **Peru (330 km), South America, Bouguer, Godin, La Condamine (1735-1744)**
- **Dunkerque-Barselona (1073 km), Paris, Delambre, Mechain (anii 1792-1798), meter definition**
- **Hammensfest (Norvegia) – r. Danube (2820 km), V. Struve (1816-1852)**



J R Smith, The Struve Geodetic Arc, 2005

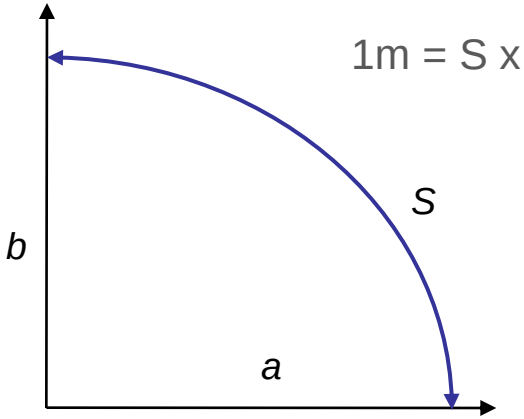
Introduction

Destination of geodetic arc measurements



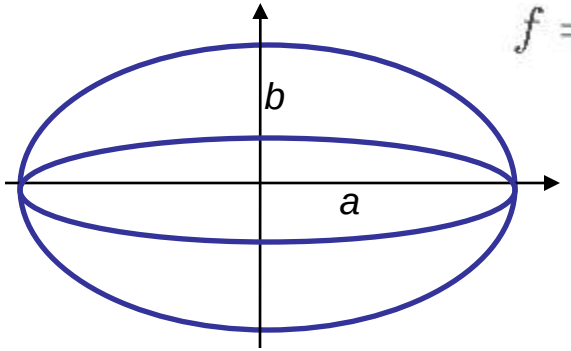
$$R = \frac{360 \cdot S}{2\pi\alpha}$$

Determination of shape and dimensions of the Earth



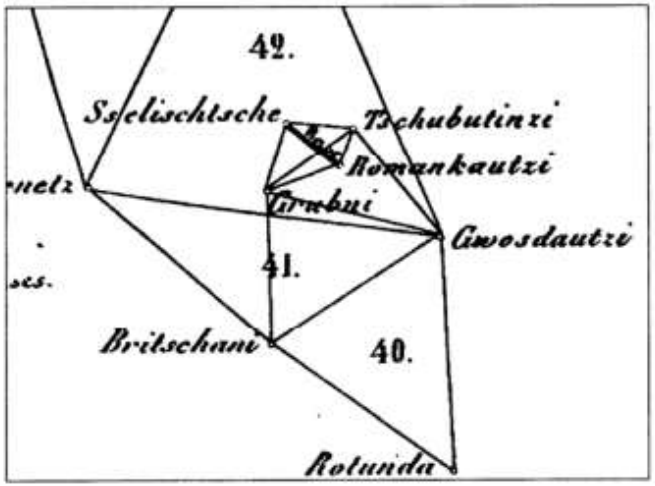
1m = S x 10^{-7}

Definition of length unit – meter



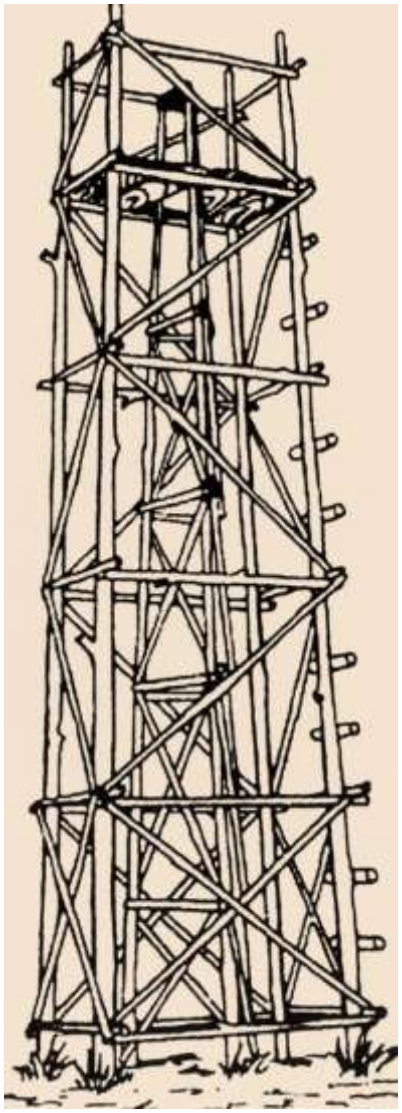
$$f = \frac{a-b}{a}$$

Calculation of reference ellipsoid parameters



Development of national geodetic networks

Introduction



History of Struve Geodetic Arc

- Measured between 1816-1855
- Hammerfest (Norway) – Staro-Nekrassowka (Ukraine)
- 10 countries: Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Belarus, Ukraine, Moldova
- 2820 km long
- 265 main points, 258 main triangles
- 27 Points in Moldova

Introduction

Persons in charge for The Arc

Friedrich Georg Wilhelm Struve:

- Professor of Mathematics and Astronomy at the University of Dorpat
- Director of Pulkovo Astronomical Observatory
- Overall coordination of the whole triangulation work
- Middle part of arc

Carl F. de Tenner:

–General of Russia

–Initial Triangulation work

–Southern part of arc including territory of Republic of Moldova

Introduction

Persons in charge for The Arc

Nils Haqvin Selander

- Professor of Geodesy at the Topographic Corps
- Director of the Royal Swedish Observatory
- Northen part of The arc between Tornea and Bäljatz-vaara in Norwegian Finnmark

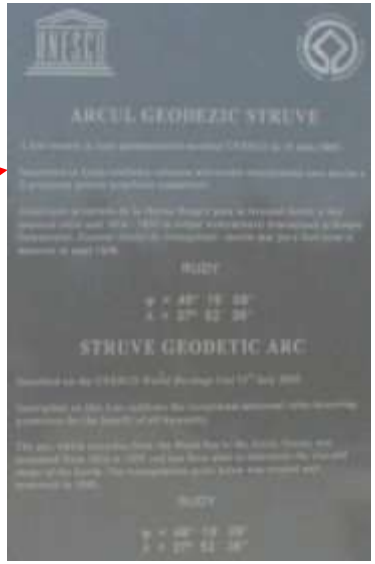
Christopher Hansteen

- Director of the Christiana Observatory
- Director of the Royal Norwegian Geographic Department
- Northen part of The arc between Atjik and Fuglenaes in the Arctic Ocean

Introduction

UNESCO World Heritage

- 34 points of Struve Arc are inscribed on UNESCO List of World Heritage
- 1 point in Moldova (Rudy)
- Points were monumented, reachable for tourists, example for the future generations of surveyors



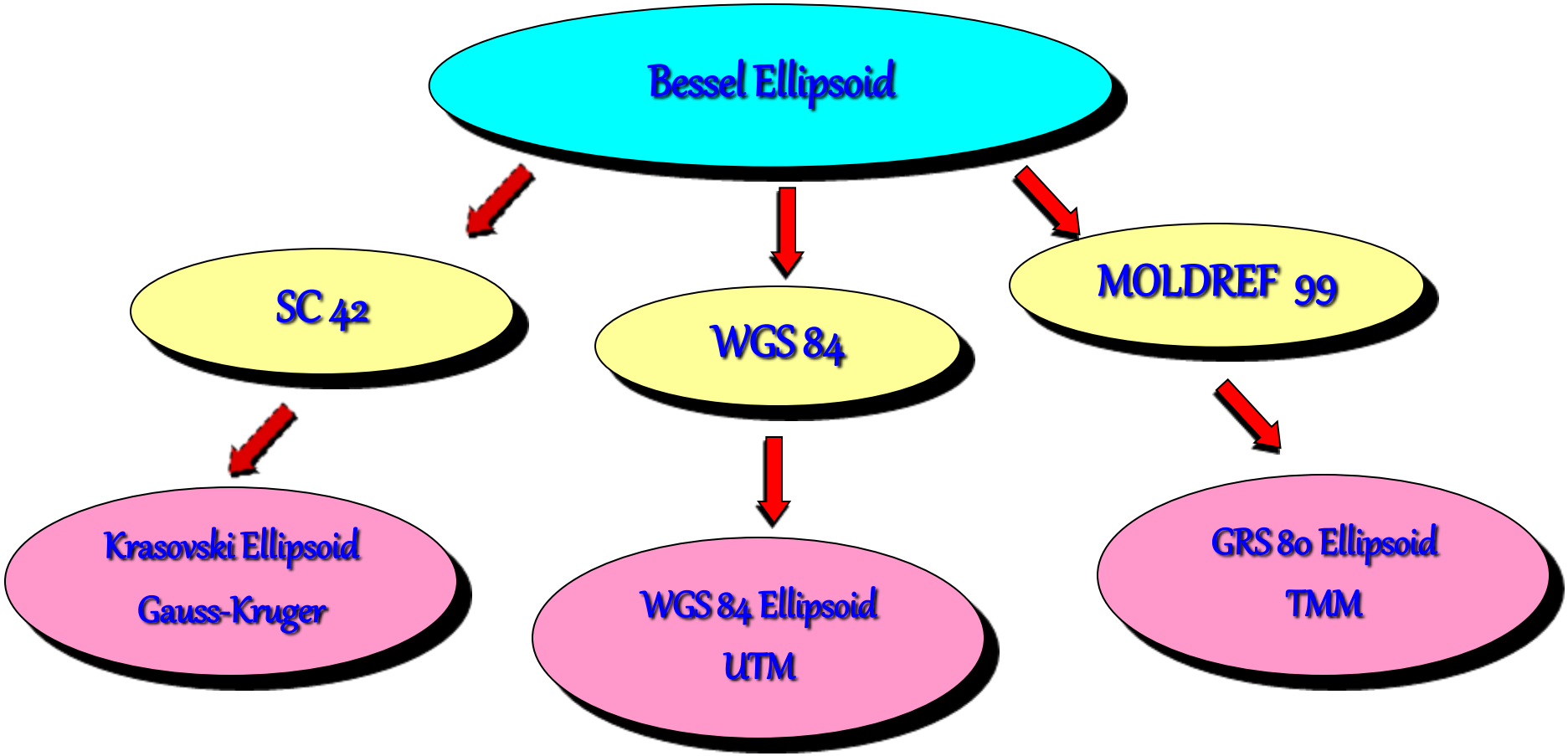
Introduction

Moldavian investigations

- Struve Arc investigations were organised by Land Relations and Cadastre Agency
- Site Rudy was found by the Moldavian Military Topography Service of National Army using satellite images and PLGR
- Optical check of aerial images to see the surface around the estimated points (field/forest/..)
- Transformation calculated with the help of some Ukrainian point coordinates
- Boreholes on and around calculated coordinates to see if something could be found
- Site Geamana was found by Institute of Geodesy, research and Cadastre INGEOCAD using GNSS RTK measurements
- Another calculation (including Geamana) of the transformation parameters was done by INGEOCAD

Geodetic Reference Systems

Coordinate transformations



Geodetic Reference Systems

Reference ellipsoids parameters

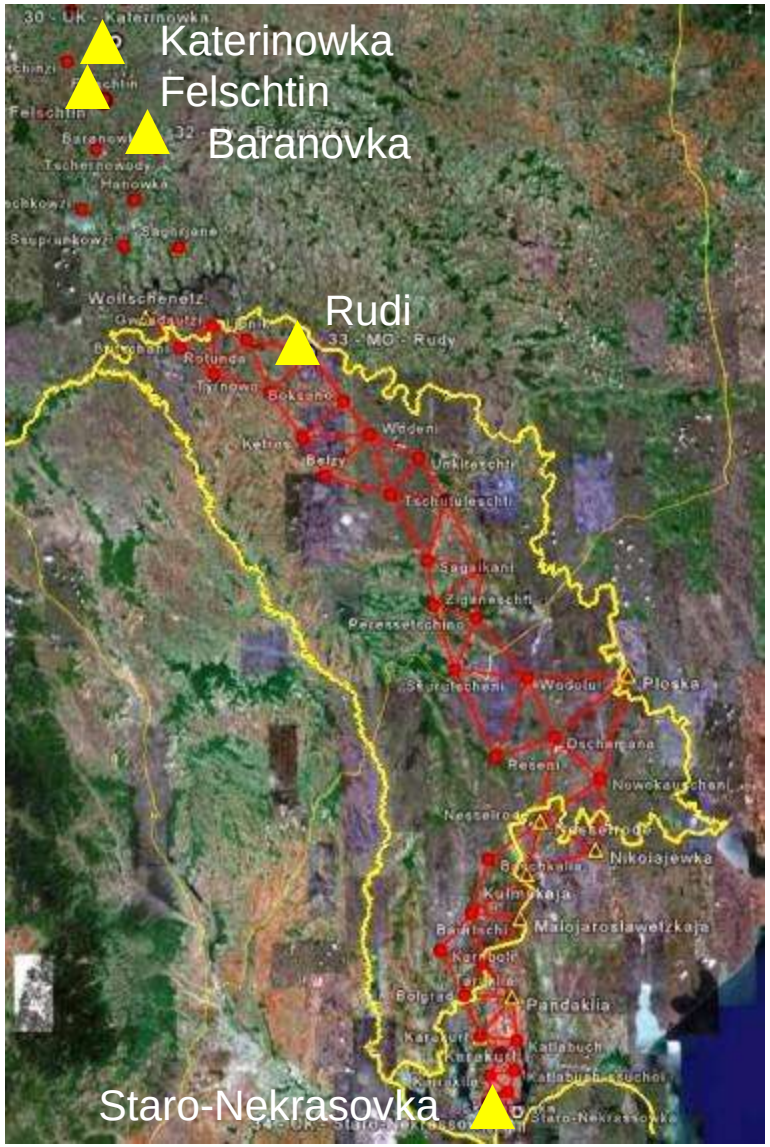
Ellipsoid name	Year	Major semi-axe *a* (m)	Ellipsoid flattening 1/f	Application
Bessel	1841	6 377 397.155	299.152 812 8	Europa
Krasovski	1939	6 378 245. 0	298.3	USSR
GRS 80	1980	6 378 137. 0	298.257 222 101	Internaţional
WGS 84	1984	6 378 137.0	298.257 223 563	GPS

Geodetic Reference Systems

Coordinates transformations

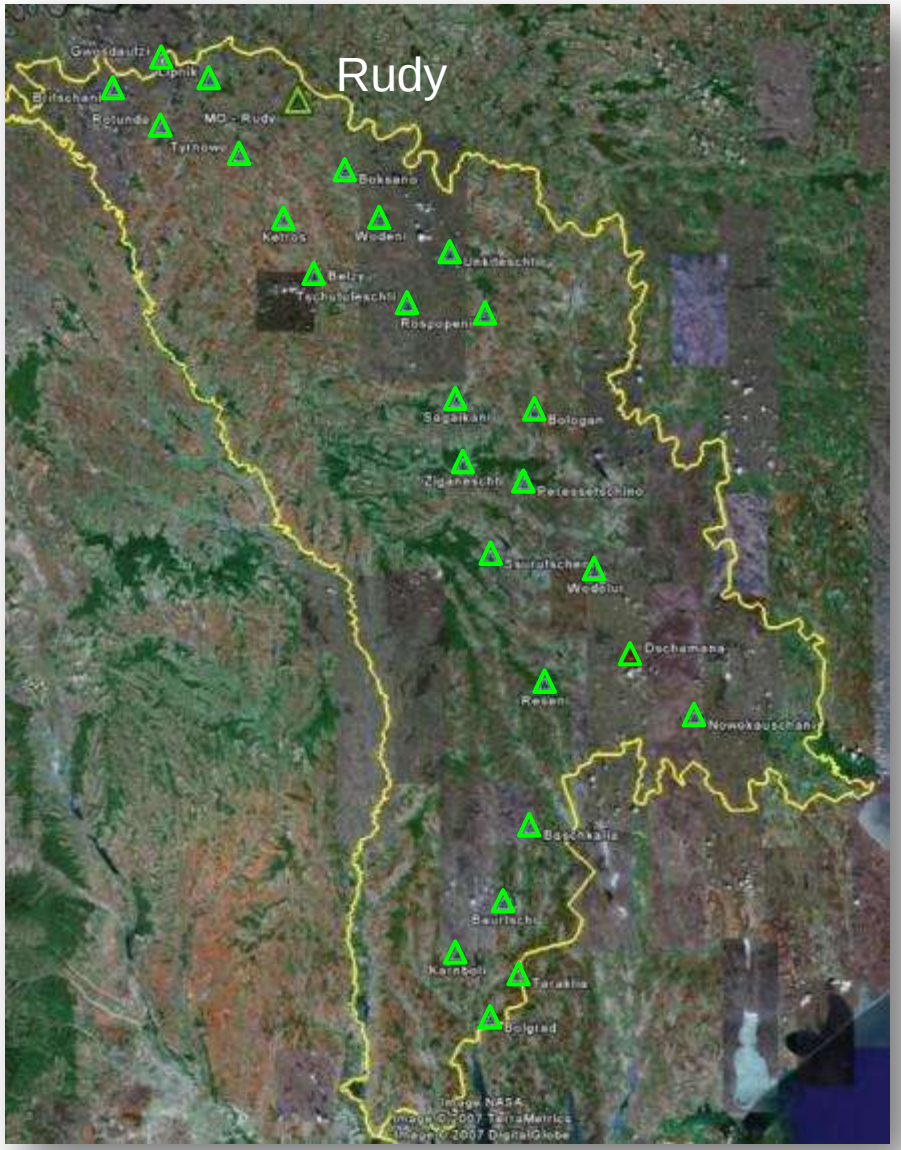
Struve Arc site name	Geodetic coordinates on Bessel ellipsoid	
	ϕ ° ‘ “	λ ° ‘ “
Katerinovka	49 33 56.97	26 45 22.01
Felschtin	49 19 48.14	26 40 55.41
Baranovka	49 08 55.41	26 59 29.75
Rudy	48 19 07.51	27 52 36.84
Staro- Nekrasovka	45 19 57.14	28 55 40.28

Struve Arc site name	Plane coordinates (MOLDREF99)	
	X (m)	Y (m)
Katerinovka	493524.607	081091.637
Felschtin	467425.426	075122.766
Baranovka	446795.243	097260.157
Rudi	353692.930	161168.744
Staro-Nekrasovka	021743.396	241378.321



Struve Arc points identification methods

Struve arc points field identification using RTK GNSS technology



Struve Arc points identification methods

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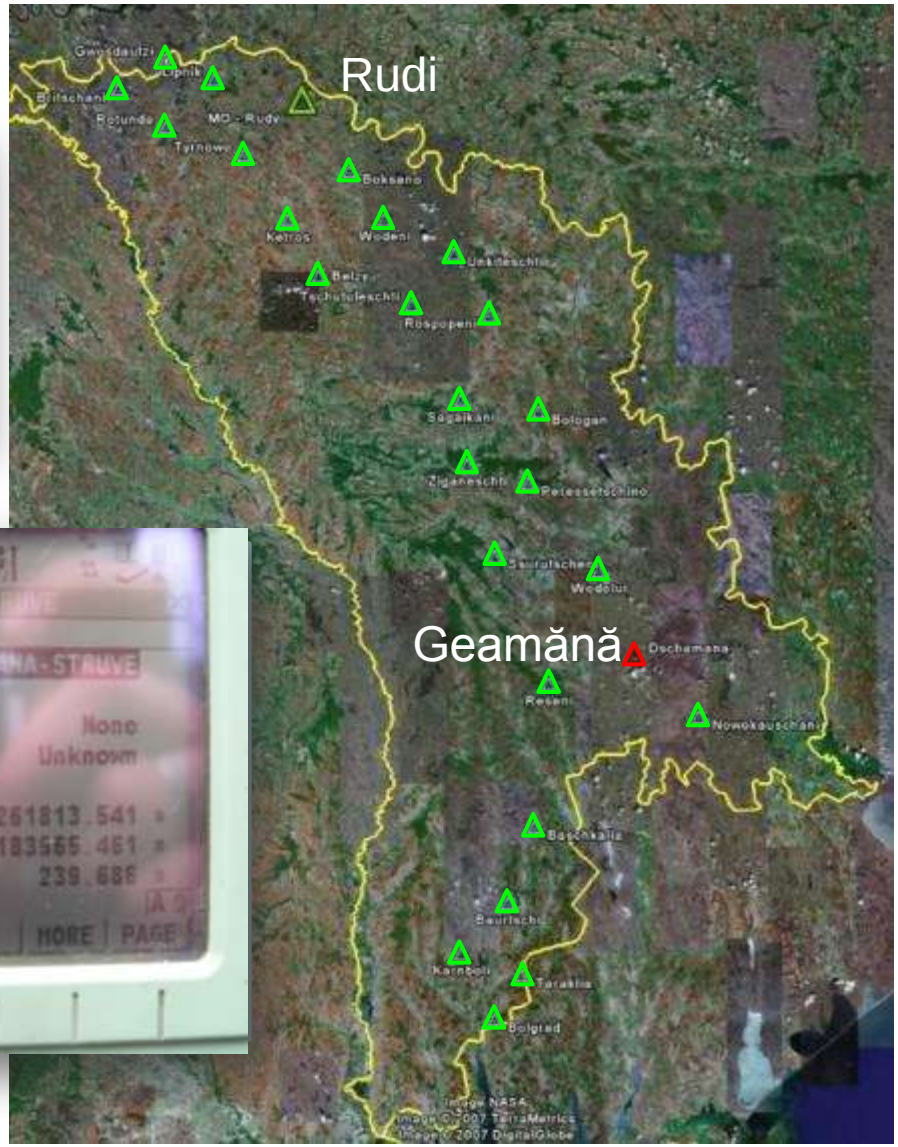
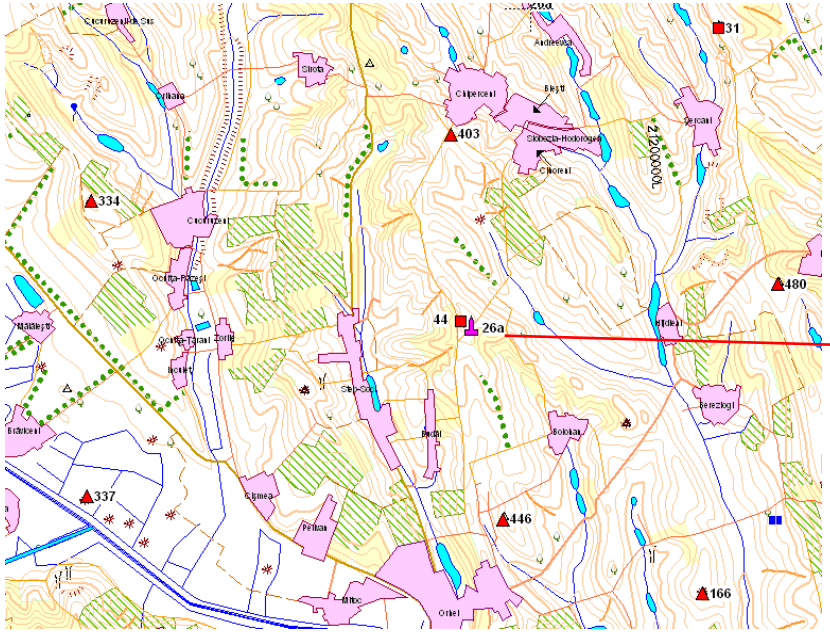
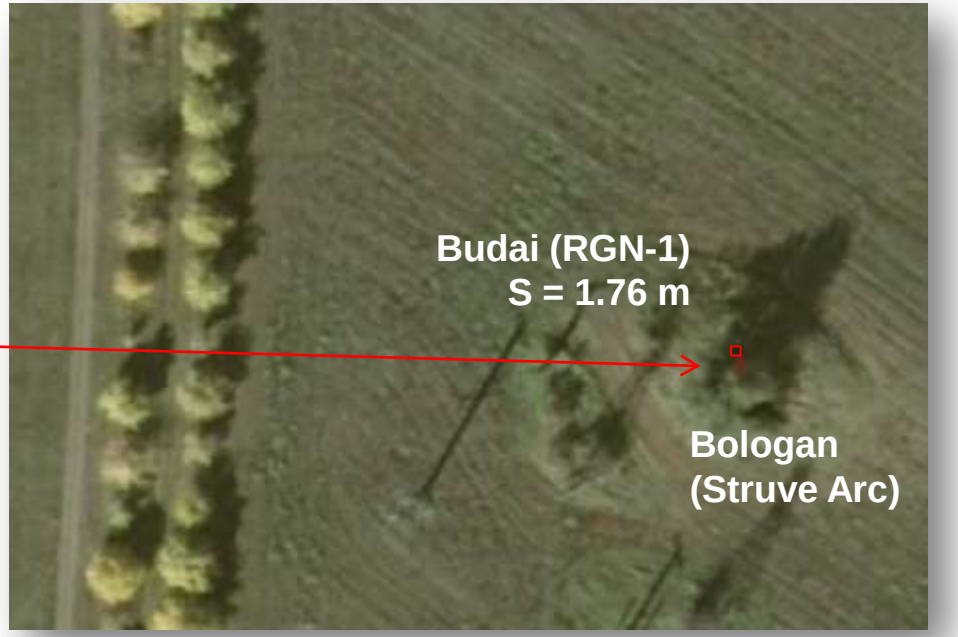


Struve Arc points identification methods

Arc Struve points identification using ortophoto maps

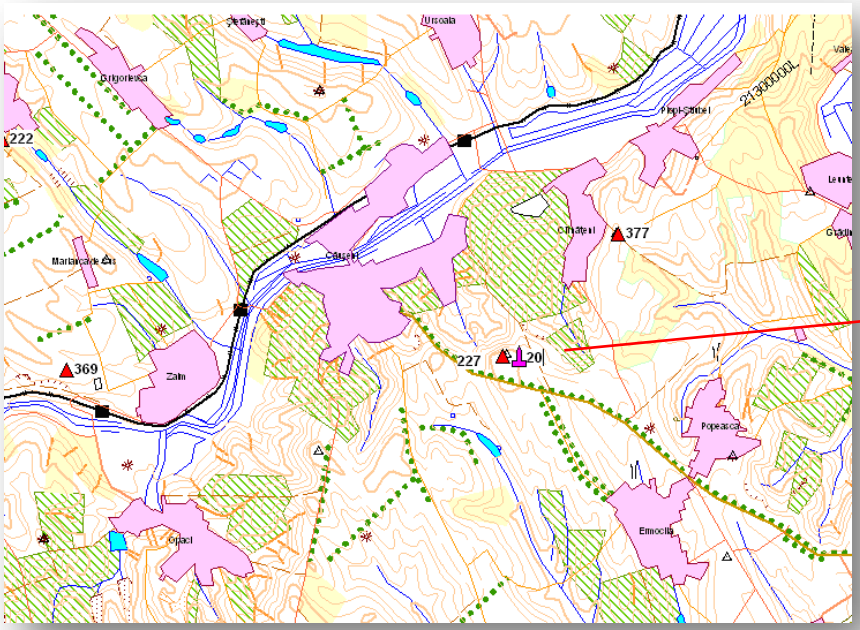




MOLDREF99:	X = 258257.129	Y = 232682.833

Struve Arc points identification methods

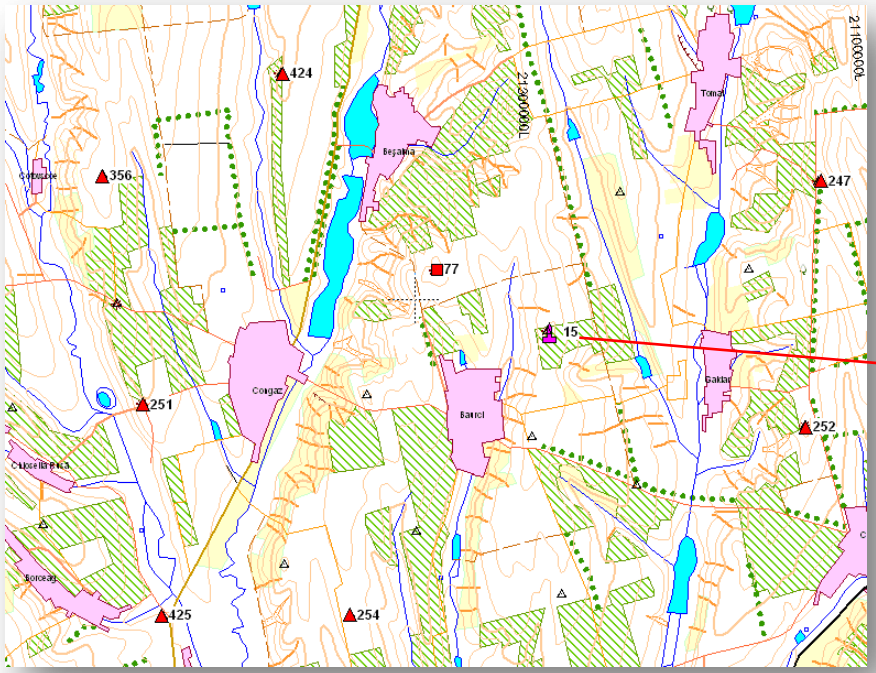
Arc Struve points identification using ortophoto maps

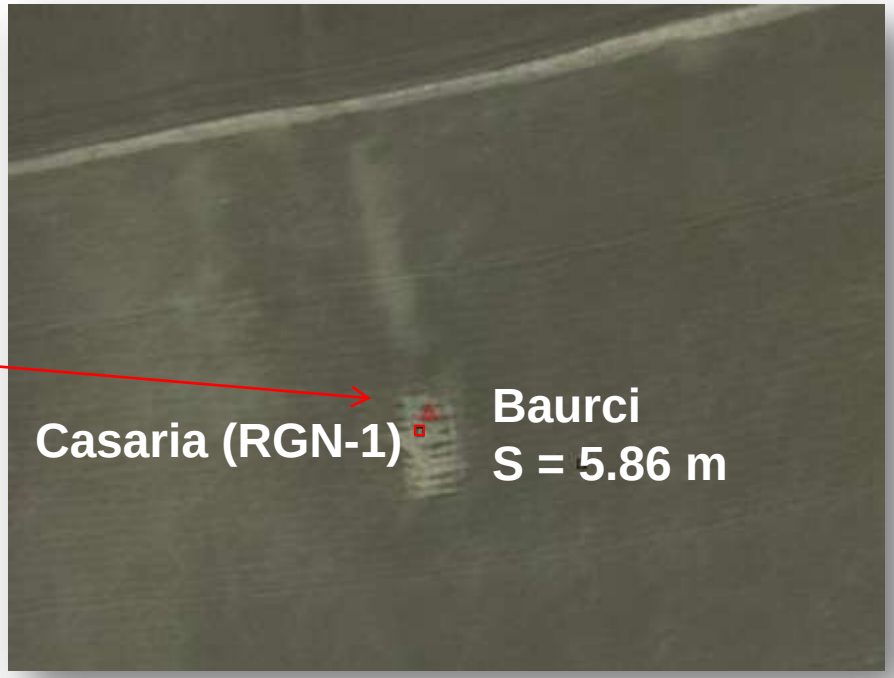


MOLDREF99:	X = 165470.719	Y = 281218.215

Struve Arc points identification methods

Arc Struve points identification using ortophoto maps

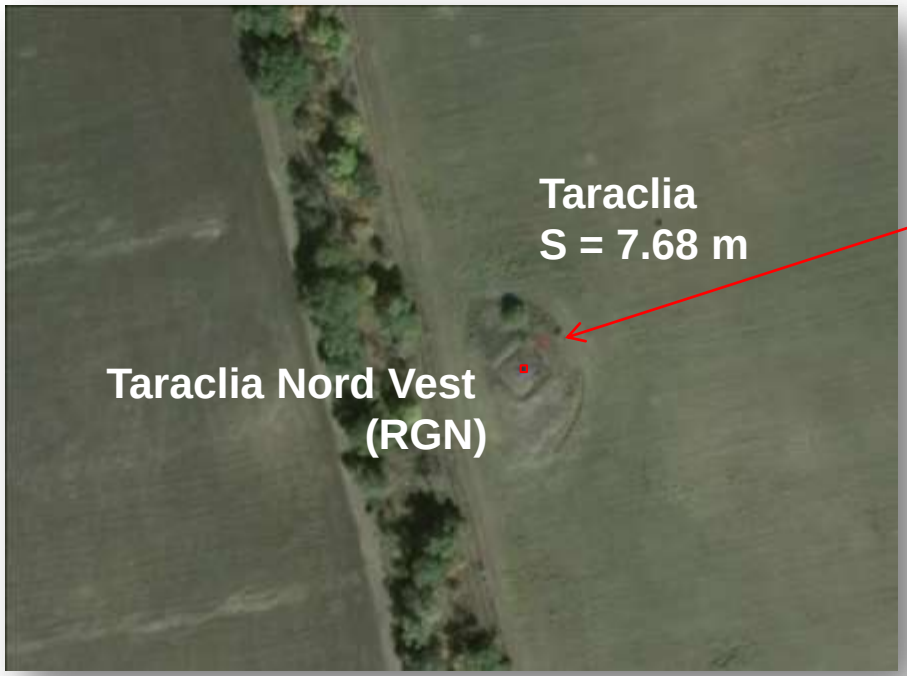


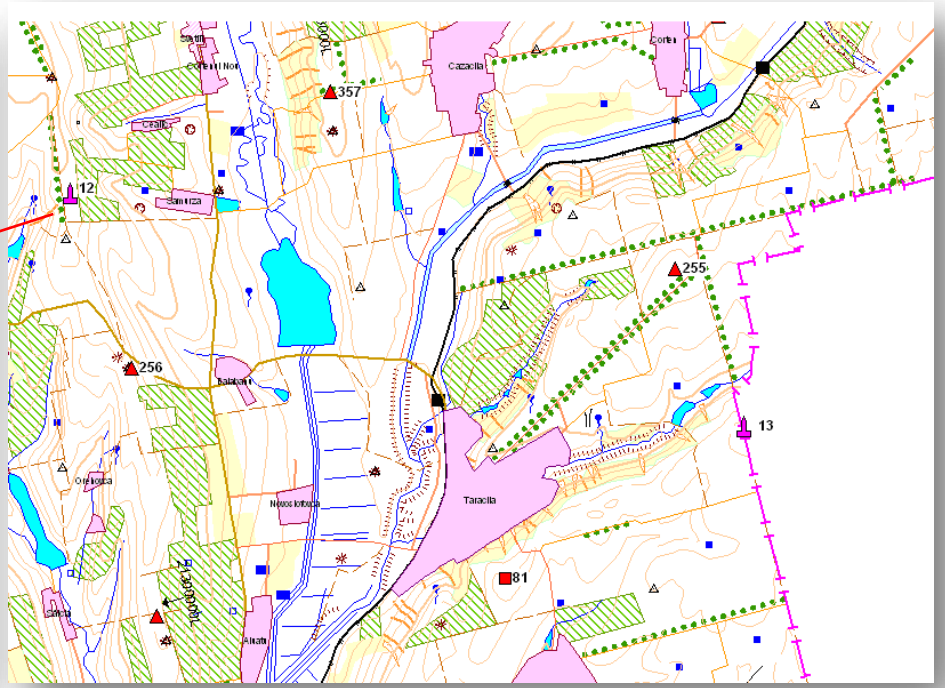


MOLDREF99:	X = 108924.46	Y = 223418.635

Struve Arc points identification methods

Arc Struve points identification using ortophoto maps

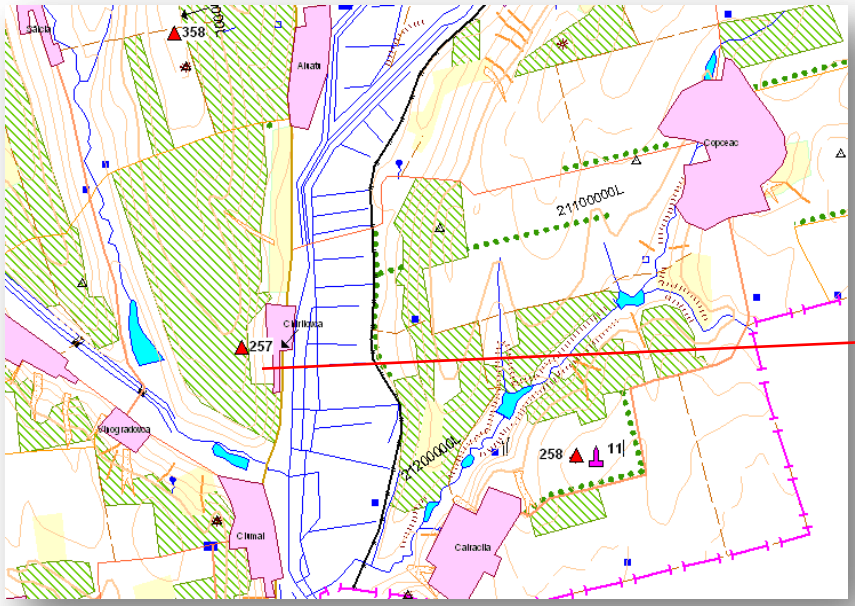




MOLDREF99:	X = 86604.902	Y = 227839.553

Struve Arc sites identification methods

Arc Struve sites identification using ortophoto maps



MOLDREF99:	X = 73007.975	Y = 219487.842

Struve Arc points identification methods

Modeling of transformation parameters errors:

- **Identification of Struve Arc points close to control points of 1st and 2nd order National Geodetic Networks**

- **Calculation of differences between coordinates of National Geodetic Networks control points and coordinates of Struve Arc points using transformations parameters**

- **Generation of position error vector of Struve Arc points relative National Geodetic Networks control points**

- **Analyses of orientation and dimensions of Struve Arc points error**

Conclusions

- On the first stage, RUDY point was found by the Moldavian Military Topography Service of National Army and monumented by Land Relation and Cadastre Agency

- On the second stage, as result of coordinate transformation and field identification GEAMANA point was found by Institute of Geodesy, Engineering Research and Cadastre

- Analyses of Struve Arc points position on the Ortofoto-2007 shows low probability to found points in the field due to intensive agricultural works

- Analyses of Struve Arc points position relative to control points of 1st and 2nd order National Geodetic Network shows high probability of overlays

Recommendations

- Creation of CLGE WG to analyze existing data and calculate transformation parameters from Bessel ellipsoid to GRS80 ellipsoid using GNSS measurements on all detected Struve Arc points and to calculate coordinates of not detected points in ETRS89

- To define a special map projection for Struve Geodetic Arc zone with central meridian Tartu 26°43′ based on Transverse Mercator Projection and ETRS89

- To identify all control points from national geodetic networks close to calculated Struve Geodetic Arc points and in case of coincidence with accuracy of transformation parameters control points to be considered Struve Geodetic Arc points

Thank you for attention