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“The visual reality of Struve Geodetic arc”

Master’s thesis with engineering project, 2019.

Struve Geodetic arc is a chain of survey triangulation (points of a survey), carried out between 1816 and 1855 by the great astronomer Friedrich Georg Wilhelm Struve and Carl Friedrich Tenner. From Hammerfest in Norway to the Black Sea, including 10 countries and over 2820 km long: Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Belarus, Ukraine and Moldova. Latvia is the only one of the ten countries in which the two excellent geodesists Struve and Tenner performed their measurements.

Struve Geodetic arc is an extraordinary example of scientific collaboration among scientists from different countries, and of collaboration between monarchs for a scientific cause. Project represented the first accurate measuring of a long segment of a meridian. Results helped to establish the exact size and shape of the planet and marked an important step in the development of earth sciences and topographic mapping.

The objective of master’s thesis with engineering project “The visual reality of Struve Geodetic arc” is to compile and analyze available cartographic material for Struve Geodetic arc, using ArcGIS Pro and ArcGIS Online possibilities, to popularize and show how historical events come together with geographical information systems. Also to create an application in ArcGIS Online platform, where all available cartographical material – historical and current are published. Developed a schemas how users will be able to supplement existing cartographical material application stocks for Struve Geodetic arc in Latvia.

To achieve this objective, available cartographic material had been gathered, processed and digitized using ArcGIS Pro. Cartographic material for Nowadays was processed according to location of the study area – Latvia.



Within this master's thesis applications were developed in order to help research Struve Geodetic arc, application for gathering field survey materials, created application for gathering all available cartographical material for Struve geodetic arc in Latvia.

In order to illustrate the visual reality for Struve geodetic arc, 3D models was created for Jekabpils and Krustpils, also for whole territory of Struve Geodetic arc in Latvia. Author has gathered work documentation for creating 3D model for Krustpils castle using an aircraft without a human pilot aboard (drone). Various schemes were added in order to show how other users of applications can add cartographic material for Struve Geodetic arc.

Main tasks:

- To gather all the available historical information about Struve Geodetic arc in Latvia;
- To gather and analyze available cartographic material for Struve Geodetic arc, using ArcGIS Pro and ArcGIS Online possibilities;
- Develop different Apps (using ArcGIS Online) in order to help users to get to know Struve Geodetic arc better;
- Develop schemes how all cartographic material (Web maps) was prepared for territory of Struve Geodetic arc;
- Develop schemes for users, if they want to prepare similar Web maps for Struve Geodetic arc and add to App "Cartographic material of Struve Geodetic arc";
- Using all available cartographic data, create two 3D models. One for Jekabpils city (between triangulation points Jacobstadt and Kreutzburg), one for common territory of Struve Geodetic arc.

Master's thesis with engineering project "The visual reality of Struve geodetic arc" consists of five sections from whom 4th and 5th are engineering project.

Theoretical part of thesis compiles information about history of Struve Geodetic arc, work of triangulation, usage of triangulation towers (signals), points in Latvia of Struve Geodetic arc, short descriptions about ESRI programs, emphasis on ArcGIS Pro and ArcGIS Online.

In first section author has compiled historical aspects of creation process of Struve Geodetic arc, for example, description of the main scientists and principals - F. G. Struve and C. Tenner, significance of measurements, the procedures for performing trigonometric work,

a brief information about signal tower or triangulation towers, summary of each point of Struve Geodetic arc in the UNESCO World Heritage and also list of State protected monuments (in Latvia), included author's photographs of Old Tartu Observatory.

Second section is dedicated for 16 points of Struve Geodetic arc - all points of Latvia. In each description are included coordinates (Nowadays and historical), historical description of place and usage of different survey instruments made by Struve himself, summary of field survey data and research descriptions made by Latvian Geospatial information agency, also photographs from different angles for each of points.

Third section is dedicated for all available cartographic material for Struve Geodetic arc in Latvia. Description of each material and what kind of information (layers) will be used for developing engineering part.

Engineering part is 4th and 5th section of master thesis.

4th section (engineering part) includes description of used programs, instructions how do prepare cartographic data are also included. From ArcGIS Pro un ArcGIS Online. Within this master's thesis with engineering project "The visual reality of Struve Geodetic arc" 4 Apps were developed, using ArcGIS Online tools.

"Points of Struve Geodetic arc" – developed using WebAppBuilder. This App contains a brief information about Struve Geodetic arc (basic facts), map, which shows all the triangulation points in Latvia. Statistical data section - facts about Struve Geodetic arc, shown in graphics/charts. User can get information about how much time did it took for Struve to observe all the necessary data/ measurements. Users can get information about which triangulations points are included in UNESCO World Heritage List or which are protected by State institution. Or, for example, get information in which county triangulation points are established, etc. There is included "Navigation" section where users can add points of interest or addresses and get the necessary route (includes information about roads, turns and timing). Last section is for measurements – user can measure distance and area between points.

"Field survey data of Struve Geodetic arc", developed using ArcGIS Online, GeoForm. In the begging geodatabase was created, imported feature classes (enabled attachments). ArcGIS Online – Create Web App – Using template - Collect/Edit data – GeoForm. In the end, an App was developed, which will be handy when it comes to collecting field survey data – photos. User can add pictures and add additional information/

field notes about specific triangulation point. Data can be added directly from mobile device (internet and location services needed) or upload them latter using desktop computer.

“Comparison of topographic maps in scale 1: 50 000”, developed using ArcGIS Online, Story Map Swipe and Spyglass, where users can compare two different maps – 2nd edition topographic map, produced by Latvian Geospatial information agency (2005-2012), other – topographic map implemented by The State Land Service (1994-1998). All cartographic data was prepared for Struve Geodetic arc in Latvia (by author, data preparation is shown in engineering part of master’s thesis and every data preparation is shown step by step in instructions). Users can compare and detect changes in the landscape – changes of forest and agricultural land areas, density of population, development of infrastructure, etc.

“Cartographic material of Struve Geodetic arc”, developed using ArcGIS Online, Map Series Builder. An App where all available cartographic material is compiled. App includes nine historical maps which were georeferenced and digitized by author. For instance – historical city plans of Jēkabpils from 1820 and 1848, which originally are drawn by hand. An overview maps which defines the boundaries of an administrative territories throughout time. App contains available cartographic material – topographical maps in scale 1: 50 000, topographic map in scale 1: 10 000, topographic map in scale 1:2 000. All cartographic material was prepared for territory of Struve Geodetic arc in Latvia. Description of all maps is also added – information about maps author, year of issue and how data for Web map was created.

Cartographic data preparation is time consuming process, in the end author digitized different scale of maps: “Jēkabpils historical plans” year 1820 and 1848, “Specialcharte von livland in VI Blattern 1839”, “General-Karte von Livland” year 1889, “Latweesch Semes” year 1901, “Latwijas map” year 1919, “Krustpils historical plan” year 1929, Topographic map year 1942 in scale 1: 25 000, Topographic map (1921-1940) in scale 1: 75 000.

Data collected from other institutions but processed by author: Topographic map in scale 1: 50 000 (1994-1998) The State Land Service, 2nd edition Topographic map in scale 1: 10 000 (Latvian Geospatial information agency), 3rd edition Topographic map in scale 1: 50 000 (2005-2012), Topographic map in scale 1: 2 000.

5th section - The visual reality of Struve Geodetic arc is shown in 3D models. One is 3D model for city of Jēkabpils, where are two triangulation points of Struve Geodetic arc. Jacobstadt (Nowadays included in UNESCO World Heritage List, other – Kreutzburg (Nowadays Jekabpils History Museum), tower of Krustpils castle, which was the place from

where Struve measured distances and angles between other triangulation points. For that purposes author used topographic map in scale 1:2 000, digital elevation model and LAS data for object heights (buildings and trees), originally developed by Latvian Geospatial information agency. When 3D model was created, author used exploratory analysis tool between triangulation points. The interactive tool helps to create analytical objects, in this case, by using source layers, two triangulation points. Users can investigate if triangulation points are visible from a given location and height.

For creating 3D model for all territory of Struve Geodetic arc, author prepared data of 2nd edition topographic map in scale 1: 50 000 and digital elevation model. Layers: forests, lakes, rivers, roads, agricultural land territories. To show how and where triangulation points were established, author made specific 3D symbols using Sketchup Pro. Created 3D triangulation tower models – models of triangulation towers which used Struve and Tenners. Also created 3D model for Opekālns church and Krustpils castle. 3D objects were imported in ArcGIS Pro.

Author has gathered work documentation for creating 3D model for Krustpils castle using an aircraft without a human pilot aboard (drone). Link is added in the attachment.

For visualization of historical (hand drawn) city plans, author chose .stylx extension called “Watercolor” (created by John Nelson). All plans were georeferenced and digitized in ArcGIS Pro.

One of the aims is to popularize Struve Geodetic arc and possibilities of geographical information systems. All Apps, Web maps and 3D models will be used as part of presentation about Struve Geodetic arc in schools (Jelgavas 4th High School, Aknīste Secondary School, Vecumnieku High School) in geography lessons. Students will be able to find out what is GIS and how we can create projects using ArcGIS Pro and ArcGIS Online.

Author developed Master’s thesis with engineering project “The visual reality of Struve Geodetic arc” between July 2018 – January 2019.

In the attachment of e-mail is summarize of “The visual reality of Struve Geodetic arc” -poster with illustrations and descriptions, also projects future vision.

In the attachment is added list of all Web Maps, Applications and link to 3D model of Krustpils castle.



Nr.	Web maps
	General-karte von Livland, Rucker, 1889
1	https://rtu-lv.maps.arcgis.com/home/item.html?id=9bc439495c2f476bb451d1066efaabbb
	Jekabpils pilsetas plans_1820
2	https://rtu-lv.maps.arcgis.com/home/item.html?id=2b343e325b7a49b6883481efb37c0aad
	Jekabpils pilsetas plans_1848
3	https://rtu-lv.maps.arcgis.com/home/item.html?id=6af14c804a03403eb125cdacc3e6b4fb
	Krustpils pils situācijas plāns_1929
4	https://rtu-lv.maps.arcgis.com/home/item.html?id=500b4dd559a246c6a6d1f069c043f859
	Latvijas Karte, H.Laakmann'a, 1919
5	https://rtu-lv.maps.arcgis.com/home/item.html?id=1f0094d3db8c4e998557946e0c2f6718
	Latweeschu Semes karte, M.Silins, 1901
6	https://rtu-lv.maps.arcgis.com/home/item.html?id=c51299566b3f438f872995c000f38496
	Specialcharte von Livland in 6 Blättern. 1839 Carl Gottlieb Rücker
7	https://rtu-lv.maps.arcgis.com/home/item.html?id=b817ab43d8eb402abdd27160d8d15142
	Topogrāfiskā karte mērogā 1: 10 000, LĢIA
8	https://rtu-lv.maps.arcgis.com/home/item.html?id=580f1469f51646e2a96ba2f175678237
	Topogrāfiskā karte mērogā 1: 25 000,1942
9	https://rtu-lv.maps.arcgis.com/home/item.html?id=caabe81e820e46dc88317d0de3dd954d
	Topogrāfiskais pilsētas plāns M 1: 2 000, LĢIA
10	https://rtu-lv.maps.arcgis.com/home/item.html?id=aec58f5c26734f80b4819bd1c1cfae0a
	Latvijas armijas Ģenerālštāba karte mērogā 1: 75 000
11	https://rtu-lv.maps.arcgis.com/home/item.html?id=3beacd62fc2c48aeb7a7cdeb09be710a
	Ortofoto, 1.cikla, LĢIA
12	https://rtu-lv.maps.arcgis.com/home/item.html?id=510bf662790640b78ff2003de9854aa5
	OPEN LĢIA Satelītkarte

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13	https://rtu-lv.maps.arcgis.com/home/item.html?id=0b8c7438d5e84705aeb3d148607dc3e4
	T50_2_izdevuma_karte_LGIA
14	https://rtu-lv.maps.arcgis.com/home/item.html?id=8d9006e748c047e6986c6017f708f729
	Apps
	Topogrāfisko karšu mērogā 1: 50 000 izmaiņu salīdzināšana
1	https://rtu-lv.maps.arcgis.com/home/item.html?id=c0c976b7fdd242d78f120fa1f068d1c0
	Strūves ģeodēziskā loka lauka apsekošanas dati
2	https://rtu-lv.maps.arcgis.com/home/item.html?id=d47a5cbc33b14ac2a8729c57163df20c
	Strūves ģeodēziskā loka punkti
3	https://rtu-lv.maps.arcgis.com/home/item.html?id=3af51396d1cb49a38d79757d7d426f22
	Strūves ģeodēziskā loka kartogrāfiskais materiāls
4	https://rtu-lv.maps.arcgis.com/home/item.html?id=a9761291914b4fc7a277f3f121535bac
	Historic city plans, visualization
	Jēkabpils pilsētas plāns, 1848, digitalizēts
1	https://rtu-lv.maps.arcgis.com/home/item.html?id=211256f3a08049f381ce4bbf1d13d2b4
	Jēkabpils pilsētas plāns, 1848, digitalizēts
2	https://rtu-lv.maps.arcgis.com/home/item.html?id=8a6aef860f404d82a03c1ce1b254b654
	Krustpils kazarmu situācijas plāns, 1929
3	https://rtu-lv.maps.arcgis.com/home/item.html?id=75ba84660d2d4e23a565ec128b843fa6

3D model for Krustpils castle

http://realitymodels.northeurope.cloudapp.azure.com/rm/Krustpils_pils_3dtiles/App_CCWebViewer2/index.html?viewId=1&extents=454.87920681203644,218.38463090478683,763.4461369601504&origin=3174138.5638999897,1538185.353558404,5296061.813851277&rotation=-0.5110077685672494,0.13041968454536976,0.8496244854916829,0.8577017612913846,0.01212569520366455,0.5140045293511375,0.056734021024224146,0.9913847252196869,-0.11805751758998165&eyePoint=3174747.379100812,1538811.770298334,5296084.201820337&focusDistance=454.87920681248875&lensAngle=0.9272952180008168

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