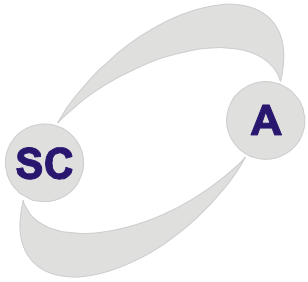
UN International Meeting on the Applications of GNSS, Vienna, 2011

Center for geoinformation technologies and systems
Faculty of technical sciences, Novi Sad, Serbia

GNSS TECHNOLOGY IN THEMATIC MAPS DEVELOPMENT

Milan Vrtunski, Miro Govedarica, Aleksandar Ristić, Dušan Petrovački

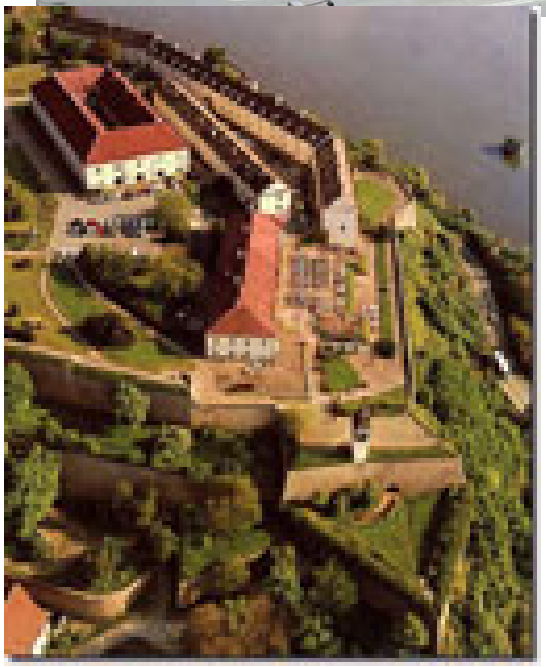


Serbia - AP Vojvodina

- Area of 21,506 km^2 (24.34 % of the area of the Republic of Serbia)
- Population of 2,024,487 (Census of 2002)
- Favorable geo-political position (pan European main road E-10, international river Danube)
- Belongs to middle European regions
- Multicultural, multinational, multiconfessional (27 nationalities)
- Most prosperous part of the Republic with great potential for developing many economic branches

Novi Sad

- Capital of Vojvodina
- 304519 inhabitants



University of Novi Sad (1)

- The University of Novi Sad was founded on June 28, 1960.
- Autonomous institution for education, science and arts.

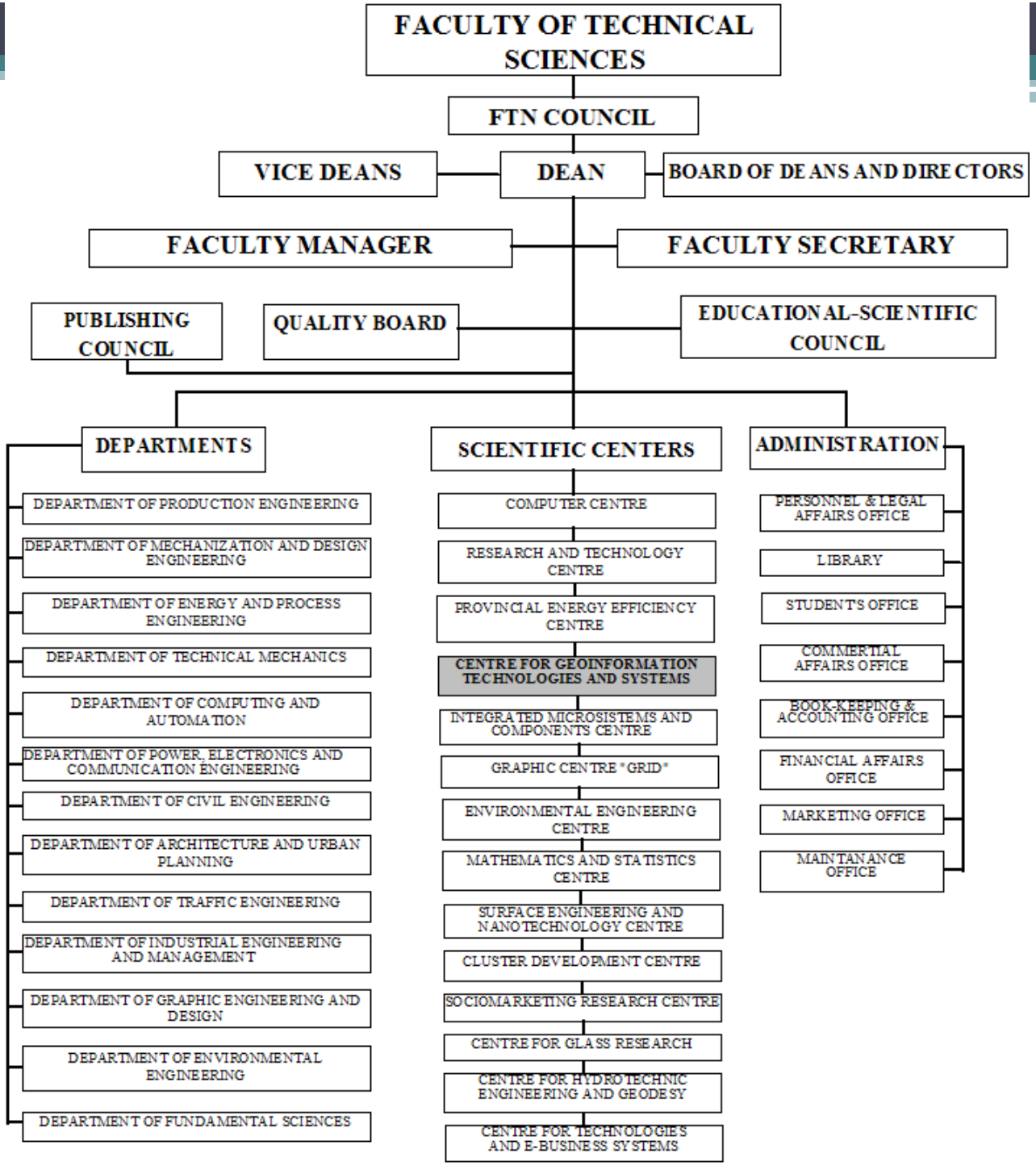
Faculty of Technical Sciences

- The Faculty of Technical Sciences was founded as the Faculty of Mechanical Engineering in Novi Sad on 18 May 1960.
- In 1974, when the Electrical and Civil Engineering Departments were established, the faculty changed its name into the Faculty of Technical Sciences

- Other departments:
  - Traffic Engineering (established in 1979)
  - Architecture (1996)
  - Industrial Engineering and Management (1999)
  - Environmental Engineering (1999)
  - Graphical Engineering and Design (1999)
  - Mechatronic (2002)
- Since the founding of the Faculty up to 2005, 7,500 students have completed the undergraduate program, 450 students have attained Master's degrees and 170 candidates have been awarded with the academic title of Ph.D.

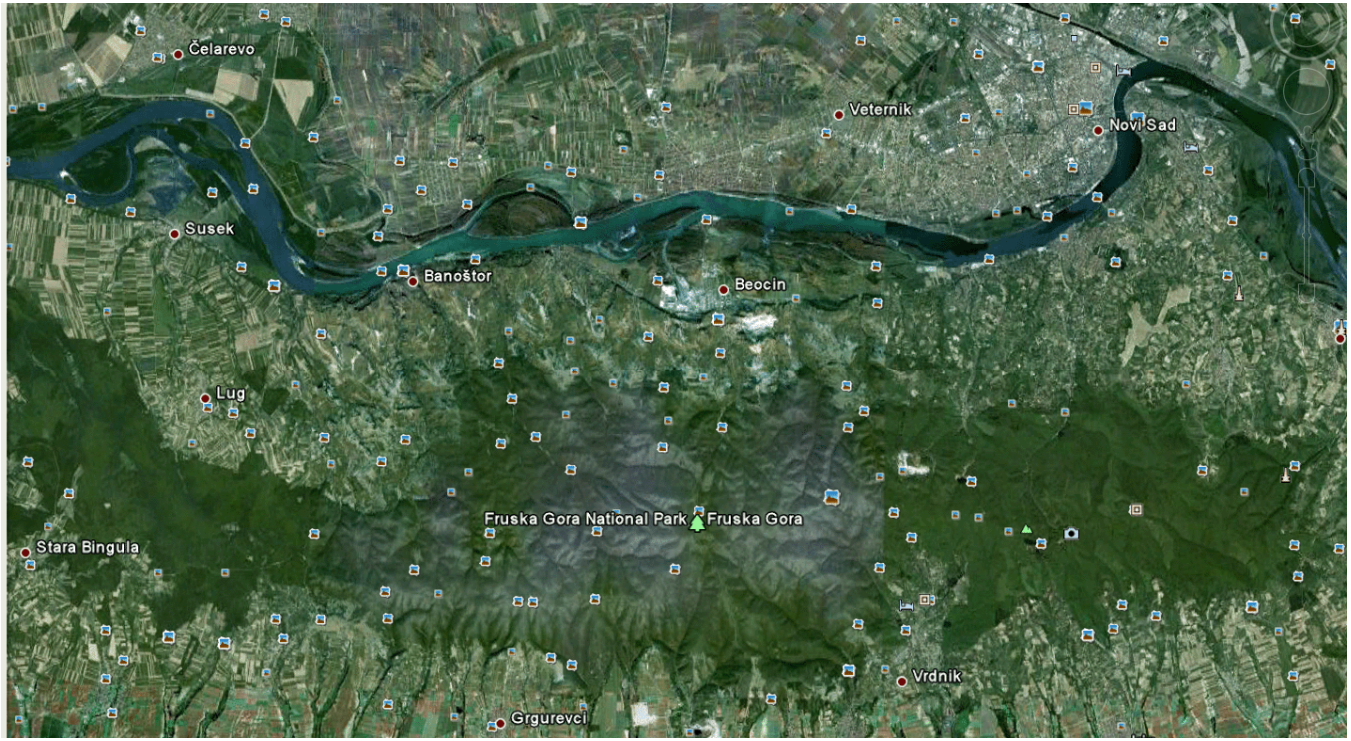
Faculty of Technical Sciences: facts and figures

- About 12000 students
- 14 departments
- About 850 staff
- graduate studies
- master studies
- PHD studies


FACULTY OF TECHNICAL SCIENCES
FTN COUNCIL
VICE DEANS
DEAN
BOARD OF DEANS AND DIRECTORS
FACULTY MANAGER
FACULTY SECRETARY
PUBLISHING COUNCIL
QUALITY BOARD
EDUCATIONAL-SCIENTIFIC COUNCIL
DEPARTMENTS
SCIENTIFIC CENTERS
ADMINISTRATION
DEPARTMENT OF PRODUCTION ENGINEERING
DEPARTMENT OF MECHANIZATION AND DESIGN ENGINEERING
DEPARTMENT OF ENERGY AND PROCESS ENGINEERING
DEPARTMENT OF TECHNICAL MECHANICS
DEPARTMENT OF COMPUTING AND AUTOMATION
DEPARTMENT OF POWER, ELECTRONICS AND COMMUNICATION ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
DEPARTMENT OF ARCHITECTURE AND URBAN PLANNING
DEPARTMENT OF TRAFFIC ENGINEERING
DEPARTMENT OF INDUSTRIAL ENGINEERING AND MANAGEMENT
DEPARTMENT OF GRAPHIC ENGINEERING AND DESIGN
DEPARTMENT OF ENVIRONMENTAL ENGINEERING
DEPARTMENT OF FUNDAMENTAL SCIENCES
COMPUTER CENTRE
RESEARCH AND TECHNOLOGY CENTRE
PROVINCIAL ENERGY EFFICIENCY CENTRE
CENTRE FOR GEOINFORMATION TECHNOLOGIES AND SYSTEMS
INTEGRATED MICROSISTEMS AND COMPONENTS CENTRE
GRAPHIC CENTRE "GRID"
ENVIRONMENTAL ENGINEERING CENTRE
MATHEMATICS AND STATISTICS CENTRE
SURFACE ENGINEERING AND NANOTECHNOLOGY CENTRE
CLUSTER DEVELOPMENT CENTRE
SOCIOMARKETING RESEARCH CENTRE
CENTRE FOR GLASS RESEARCH
CENTRE FOR HYDROTECHNIC ENGINEERING AND GEODESY
CENTRE FOR TECHNOLOGIES AND E-BUSINESS SYSTEMS
PERSONNEL & LEGAL AFFAIRS OFFICE
LIBRARY
STUDENTS OFFICE
COMMERTIAL AFFAIRS OFFICE
BOOK-KEEPING & ACCOUNTING OFFICE
FINANCIAL AFFAIRS OFFICE
MARKETING OFFICE
MAINTANANCE OFFICE

Introduction

- Task: development of thematic maps of hiking tracks in the mountain Fruška gora.
- It covers area of 70x30km containing natural protected area.
- Total length of tracks was approximately 140km. Required accuracy of the maps was 10m. Time frame was one month.
- Choosing adequate acquisition method was essential.



Data acquisition – method

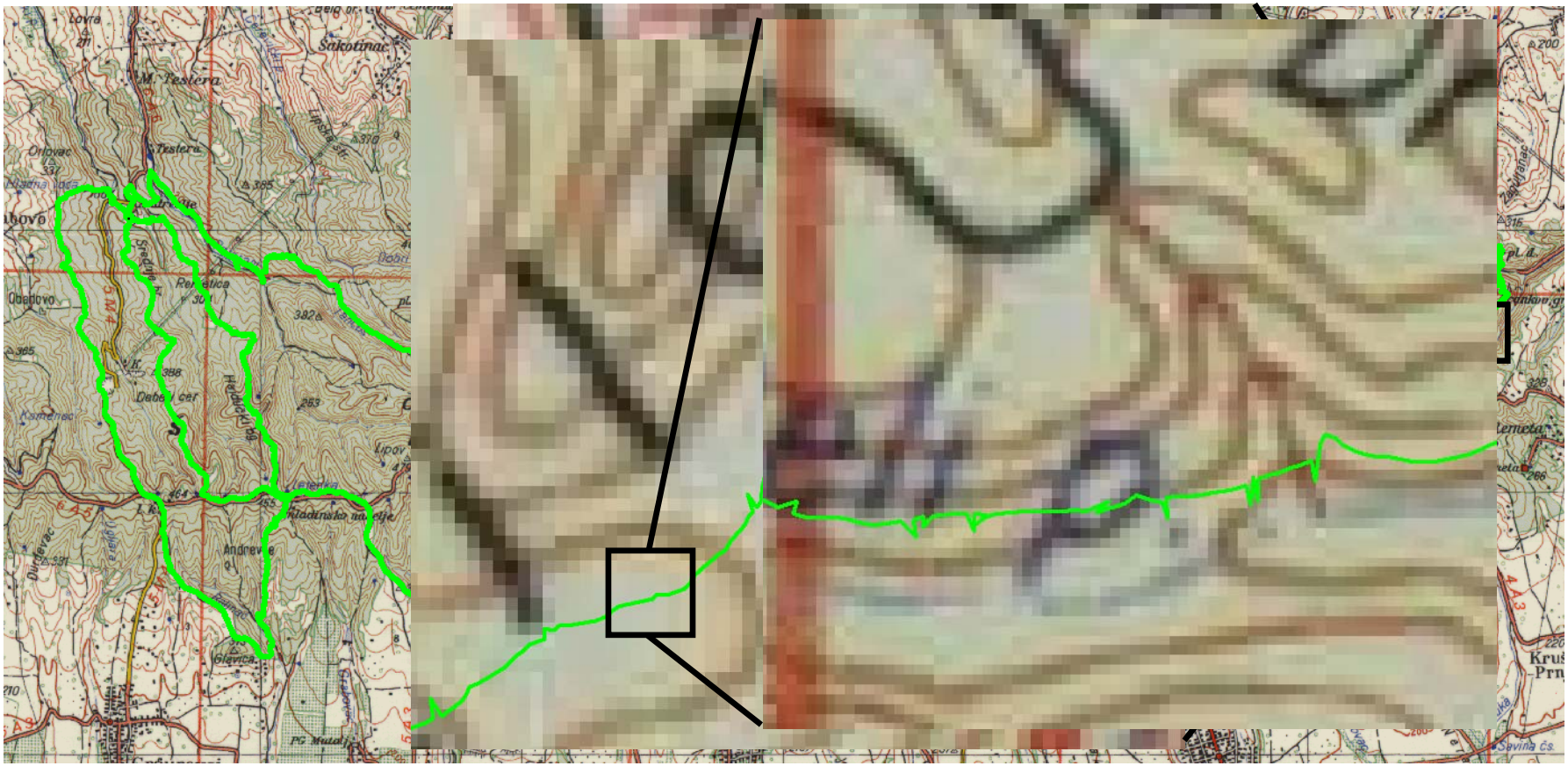
- Different methods were discussed:
  - **Vectorization** – fast, unreliable: source dependent
  - **Geodetic survey using total station** – high accuracy, slow
  - **Survey using GNSS/INS equipped vehicle** – not applicable on entire route
- Method of choice – GNSS survey using hand-held receiver
  - **Fast** – estimated time to survey 140km - 10 days
  - **Accurate** – sub-meter accuracy in DGPS mode
- Survey was done using hand-held device. Differential correction was done in post processing.

Data acquisition – parameters

- Entire route was divided in 35 stages (1.5 – 10km long).
- Each stage was represented as a line feature.
- Since large amount of data had to be collected, parameters had to enable memory efficient acquisition.
- Regarding demanded accuracy (10m), distance between points within the line was set to 5 meters.
- Acquisition was done by mountineers, not familiar with the field software, therefore setup was as simple as possible.

Data acquisition – realization results

- The survey of entire route (140km) was completed in 7 days during February 2011.
- Distance between points varied depending on local measuring conditions (sections: field, **deciduous** and evergreen forest).

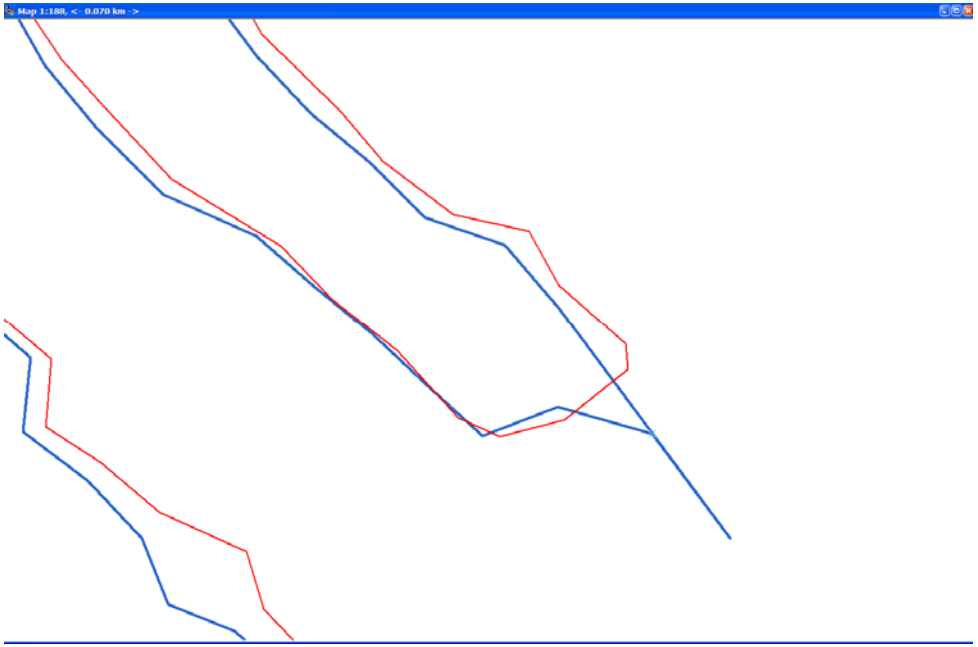


Data processing

- Processing was done in three steps:
  1. Differential correction
  2. Point filtering
  3. Final processing
- Differential correction was performed using RINEX data from academic permanent stations network (Academic Positioning System - APOS-NS).

1. Differential correction

- A number of point coordinates was significantly corrected which increased the data accuracy.
- Length of line is used to assess error. Since raw data contain errors from different sources, line before processing is longer than line after processing (**blue** line longer than **red** line).
- To represent accuracy increment ratio of line lengths before and after differential correction was calculated.



- **Blue line:** raw (GPS) data
- **Red line:** corrected (DGPS) data

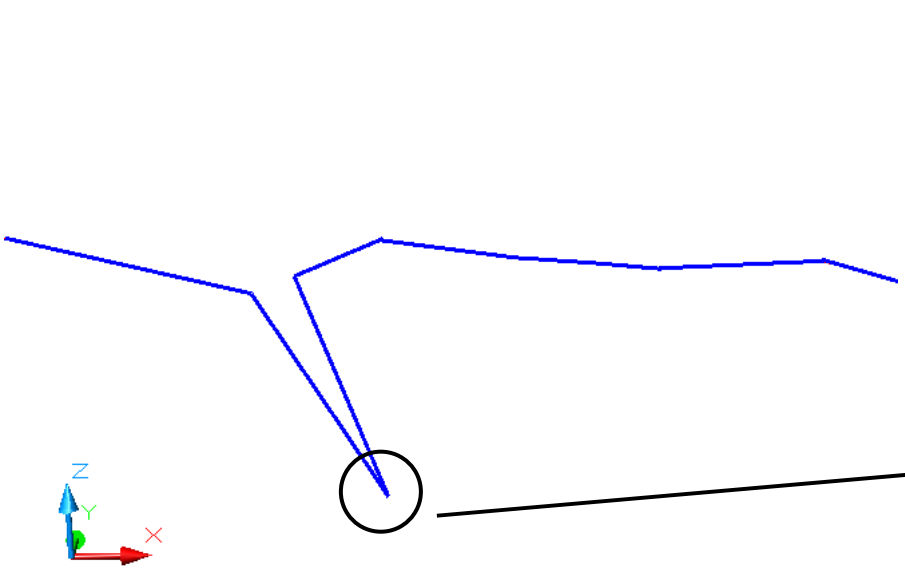
1. Differential correction

Stage	L_{GPS} [m]	L_{DGPS} [m]	Δ [m] (L_{GPS}-L_{DGPS})	$\frac{\Delta}{L_{GPS}} \cdot 100\%$
Start – KT1	4067	3744	323	7.94
KT1 – KT2	6108	5603	505	8.27
KT2 – KT3	3607	3382	225	6.24
KT3 – KT4	4007	3601	406	10.13
KT4 – KT5	2603	2331	272	10.45
KT5 – KT6	8554	8071	483	5.65
KT6 – KT7	12440	7604	4836	38.87

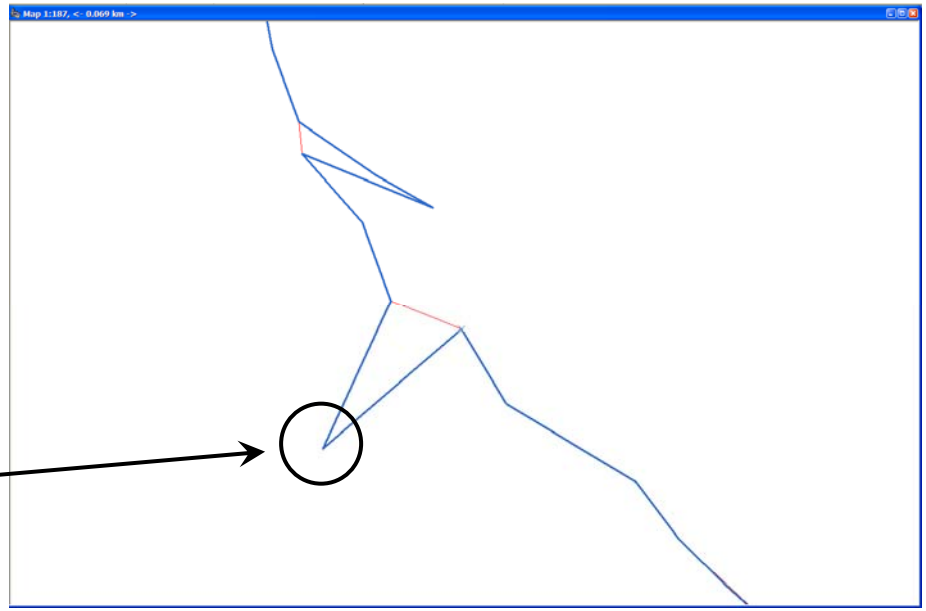
2. Point filtering

- Having in mind non-ideal conditions in the field, random errors have the biggest impact on accuracy.
- Some method had to be applied to filter out points that do not meet some criterion.
- Adopted criterion, based on expert knowledge, was that the slope between two consecutive points cannot be bigger than 45 or lower than -45 degrees.
- This method was implemented as MATLAB function.

2. Point filtering



Vertical plane



Horizontal plane

- The majority of points that did not meet this criterion (V plane) had big offsets of x and y coordinate (H plane).
- Line lengths decreased 20% in average.

3. Final processing step

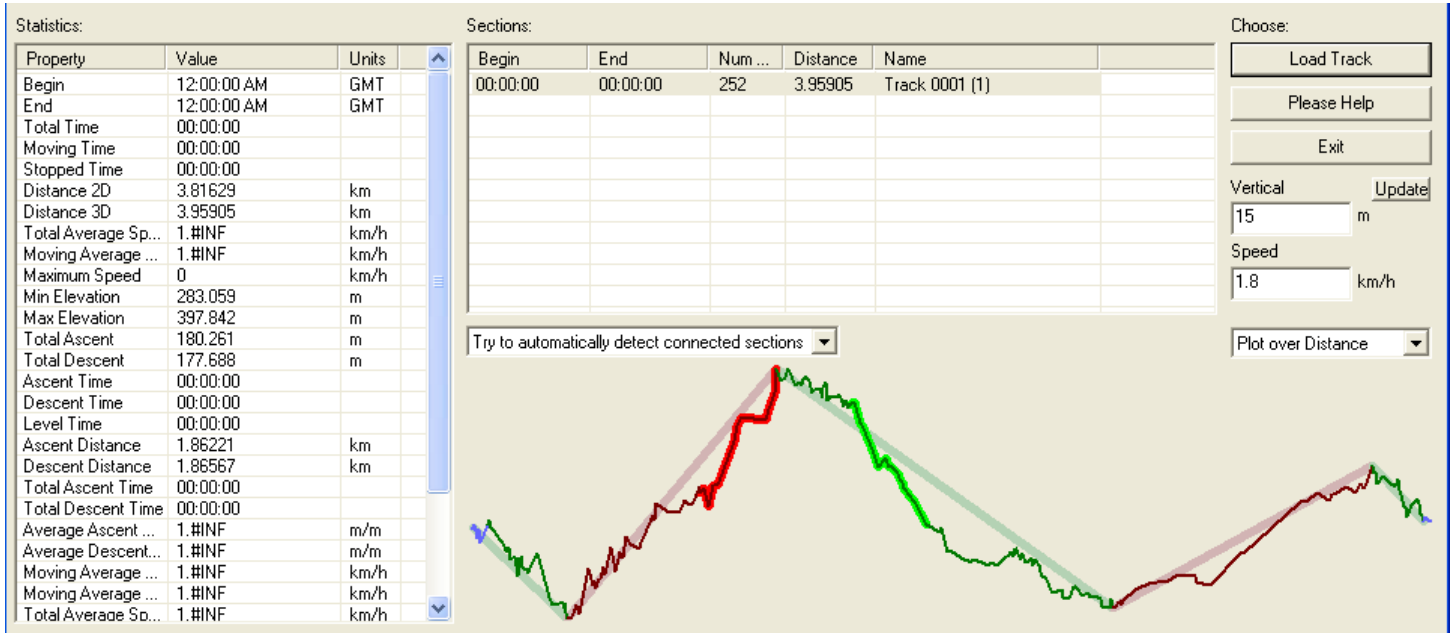
- Point filtering removes the data so that step was performed only once. Therefore, further processing had to be done.
- Final step involved manual correction of the data.
- Other data sources were used in this step (raster data, such as topographic maps, DEM, orthophoto, etc).
- On locations where visually or based on the expert knowledge the route did not correspond to real state in the field, the points were corrected according to raster data.

3. Final processing step

- These raster data were used for final data check.
- On locations where it was previously known that the route was not changed, the surveyed routes and raster data were compared. The heights were compared with DEM.
- The offsets were lower than maximum allowed (10m).

Data representation (1)

- Resulting data were used to create maps of hiking tracks.
- Various numeric data, based on this results, were noted on maps: lengths of stages and tracks, slopes, heights and height differences.
- Maps were made in electronic form and as hardcopy. Raster data (scanned touristic maps, satellite images and orthophoto) were used as a background.



Data representation (2)

- Isometric 3D representation

СТАЗА ПЛАНИНАРСКОГ МАРАТОНА НА ФРУШКОЈ ГОРИ

Ултра плус маратон

Дужина: 111,151 км

Успони: 4119 м

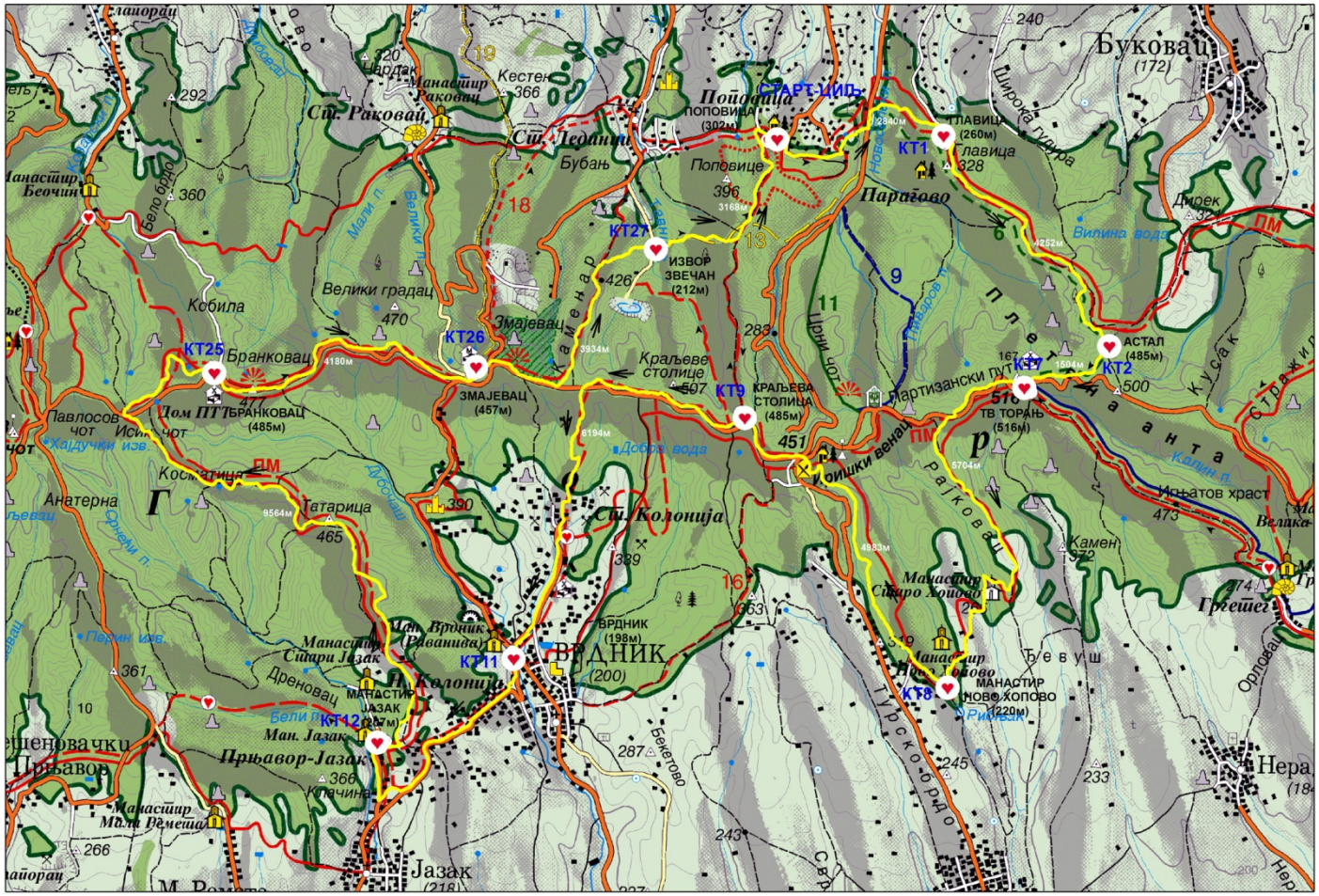
Силасци: 4119 м

ИЗДАВАЧ: ПСД Железничар, Трг Галерија 4, Нови Сад
МЕРЕЊЕ ТРАСЕ НА ТЕРЕНУ: Миливој Настасић
ОБРАДА ПОДАТАКА: Милан Вртунски, Горан Ницић, Иван Аларгић, Владимир Пајић (Центар за геоинформационе технологије и системе, ФТН Нови Сад) Борислав Станковић (ПСД Железничар, Нови Сад)
ОСНОВА: ЈП Национални парк Фрушка гора
ИЗРАДА И ШТАМПА:

Нови Сад, 2011. године

Data representation (3)

- Print-ready map



Conclusions

- Efficient procedure for mapping hiking tracks is implemented. Survey using GNSS device was done in very short time interval. Three steps of processing resulted in data which meet the provided purpose in terms of precision and reliability.
- Not only it is possible to apply GNSS technology in non-ideal conditions but also that it is a very efficient survey method.
- Using various raster data as a background, the resulting data were used to make maps in different forms.
- Maps for other purposes: touristic maps, environmental protection, mapping infrastructure objects in unreachable areas, etc.

Thank you for your attention!

Milan Vrtunski, Miro Govedarica, Aleksandar Ristić, Dušan Petrovački

milanv@uns.ac.rs, miro@uns.ac.rs,
aristic@uns.ac.rs, petrovacki@uns.ac.rs