

R E P O R T

on the use of Digital Mobile Control-Measuring Station

for monitoring of quality parameters of mobile electronic communications network service

Brief description of measurement system software configuration and preliminary observations

Measurements of quality parameters of mobile electronic communications network service in Montenegro were made in the period from 15 November 2017 - 19 January 2018, for the purpose of comparing the quality of services provided by the following mobile operators: Telenor, Crnogorski Telekom and m:tel.

Measurements were made as a drive test, and Digital Mobile Control-Measuring Station (DMCMS) was deployed. Three SAMSUNG Galaxy S3 measurement mobile terminals and three SAMSUNG NOTE 4 measurement mobile terminals were used.

Parameters of telephony service were measured so that three measurement terminals, each of them provided with one test SIM card of the mobile operators: Crnogorski Telekom, Telenor and m:tel, were set in a way to make calls to appropriate telephony machines installed in the networks of the mentioned operators. The calls lasted 60 sec, intervals between the calls were 15 sec, and the maximum time for setting-up a call from the moment of the call beginning was 15 sec. Above mentioned measurement terminals were in the automatic mode for choosing technology, depending on the operator network configuration, meaning that they had the approach to LTE/UMTS/GSM technologies of each of the operator individually. One call was used as a sample.

Parameters of data service were measured so that three measurement terminals, each with one test SIM card of the mobile operators: Crnogorski Telekom, Telenor and m:tel, were set in a way to provide connection to LTE/UMTS/GSM technologies. The terminals were connected to FTP servers installed in the operators' networks, performing uploads and downloads of the test files lasting 20 sec. and 15 sec, respectively. As a sample for FTP download was used a file of 10GB, and maximum time for setting-up, duration and termination of the session was limited to 15 sec. This way, approximately same number of samples per operator was provided. The operators had an obligation to keep FTP server in a good working order, as well as to work on their settings in a way that no restrictions neither in relation to setting-up connectins nor to their speed, were made; in other words, their obligation was to provide the best network performances from the server.

Also, user experience in using internet web pages, so called "web browsing" was tested in a way that measurement terminals were connected to http pages of some of the most visited dynamic web pages from the territory of Montenegro, as for example to: www.blic.rs, as well as static Kepler webpages uploaded in

the servers within the networks of operator.

Telephony Service:

For Telephony Service 4 parameters were measured: Radio Network Unavailability, Telephony Service Non-Accessibility, Telephony Setup Time and Telephony Cut-off Call. An appropriate number of samples is measured in the cities and on the roads, provided that for the confidence level of results of 99%, width of confidence interval of results is less than 3%.

During measurement campaign done in the cities and on the roads, the total miles driven were 2589,385 km, while regarding the hours, it was measured 85:02:31.

Data Service:

For Data Service 12 parameters were measured: Attach Success Ratio, PDP Context Activation Success Ratio, PDP Context Cut-off Ratio, EPS bearer allocation success ratio, FTP IP-Service Access Success Ratio, FTP {Download|Upload} Data Transfer Cut-off Ratio, HTTP browsing IP-Service Access Success Ratio, HTTP browsing Data Transfer Cut-off Ratio, FTP data rate download, FTP mean data rate download per session, FTP data rate upload, FTP mean data rate upload per session.

Depending on the group of parameters (referring to internet access and use of the service or referring to the speed measurement) and the type of the service (FTP or HTTP), the appropriate number of measurement samples was taken, provided that for the level of results confidence of 95%, the width of interval of results confidence is less than 3%.

The parameters were chosen in accordance with the Rules on the Quality of Public Communication Services ("Official Gazette of Montenegro", No: 02/18) and ETSI TS 102 250-2 standard. During the measurement, an optimal number of samples was taken in order to get an appropriate level of results confidence, in accordance with ETSI TS 102 250-6.

Test SIM cards were not limited in a speed and quantity of transferred data for download and upload, and they used maximum network capacities.

Parameters of Telephony Service: Radio Network Unavailability, Telephony Service Non-Accessibility and Telephony Cut-off Call Ratio are the parameters which refer to the accessibility and continued telephony

	<p>service performance, such being more important parameters than it is Telephony Setup Time. Further more, data service parameters, such as: Attach Success Ratio, PDP Context Activation Success Ratio, PDP Context Cut-off Ratio, EPS bearer allocation success ratio, FTP IP-Service Access Success Ratio, FTP {Download Upload} Data Transfer Cut-off Ratio, HTTP browsing IP-Service Access Success Ratio, HTTP browsing Data Transfer Cut-off Ratio represent parameters relating to the accessibility to the data service sessions and their continued performance, such being more important than the parameters relating to the realized speeds.</p> <p>In case of overlap of the confidence intervals, for certain parameters it is not possible to decide which network has a better value of the observed parameter.</p> <p>Obtained parameters of measurement refer to the time frame and territory in which the measurements were done, meaning that within some other time interval and/or some other measurement routs, these resluts could be different.</p>
<p>Measurement path/route</p>	<p>Travel routs: Podgorica – Danilovgrad – Nikšić – Plužine – Šćepan Polje Nikšić – Vilusi – Lipci Podgorica – Cetinje – Budva Podgorica – Virpazar – Petrovac (preko Paštrovačke gore i preko tunela Sozina) Ada Bojana – Ulcinj – Bar- Budva – Tivat – Kotor- Herceg Novi – Debeli Brijeg Nikšić – Žabljak – Pljevlja – Ranče Đurđevića Tara – Mojkovac Podgorica – Kolašin – Mojkovac – Bijelo Polje – Dobrakovo Ribarevine – Berane – Rožaje – Dračenovac Berane – Andrijevica – Plav – Gusinje Berane – Petnjica</p> <p>Cities (23 municipalities): Podgorica, Ulcinj, Bar, Budva, Tivat, Kotor, Kolašin, Mojkovac, Herceg Novi, Nikšić, Žabljak, Pljevlja, Plužine, Šavnik, Bijelo Polje, Berane, Rožaje, Andrijevica, Plav, Petnjica, Gusinje, Danilovgrad and Cetinje.</p> <p>In the attachments 1 and 2 are given the pictures of measurement routes.</p>

Measurement equipment:	<ul style="list-style-type: none">• Rohde&Schwarz mobile measurement terminals SAMSUNG Galaxy S3 (2G/3G/4G)• GPS receivers• Set of external GSM/UMTS/LTE antennnas• Softwares: Rohde&Schwarz ROMES v4.9, Rohde&Schwarz Network Problem Analyzer v4.9, Anite NEMO Outdoor, Anite NEMO Analyzer• Anite NEMO Walker II measurement system with 3 measurement terminals SAMSUNG NOTE 4• Network scanner Anite NEMO (GSM UMTS LTE) FSR 1
Report is made by:	<p style="text-align: center;">Ivan Vujović Manager for Control and Monitoring of RF Spectrum</p> <p style="text-align: center;">Miličko Kuč Officer for Control and Monitoring of FM Spectrum</p>

Measurements are done by:

Ivan Vujović

Manager for Control and Monitoring of RF Spectrum

Miličko Kuč

Manager for Control and Monitoring of RF Spectrum

Srđan Marković

Officer for Control and Monitoring of RF Spectrum

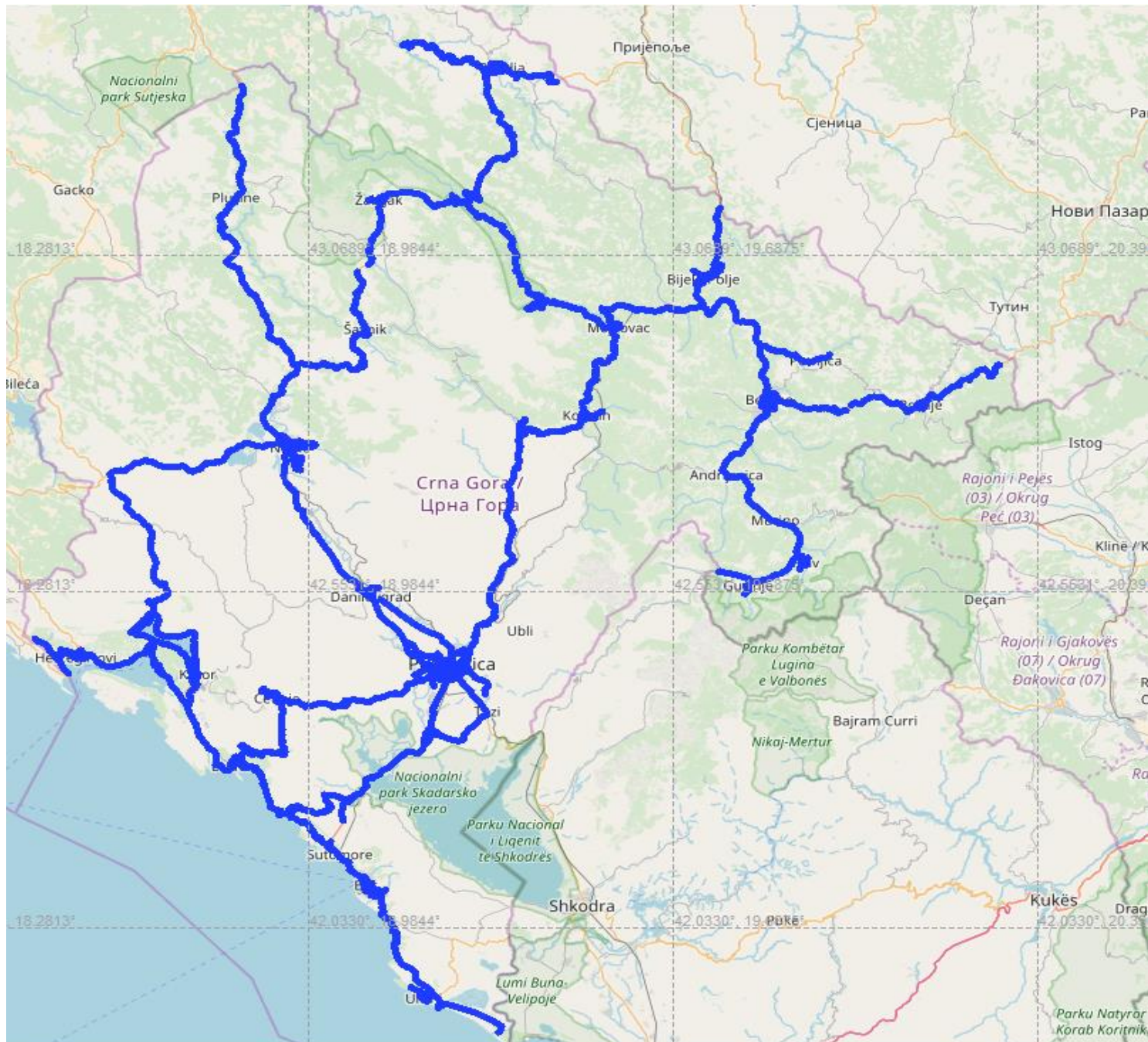
Nikola Miks

Officer for Control and Monitoring of RF Spectrum

Miljan Sekulić

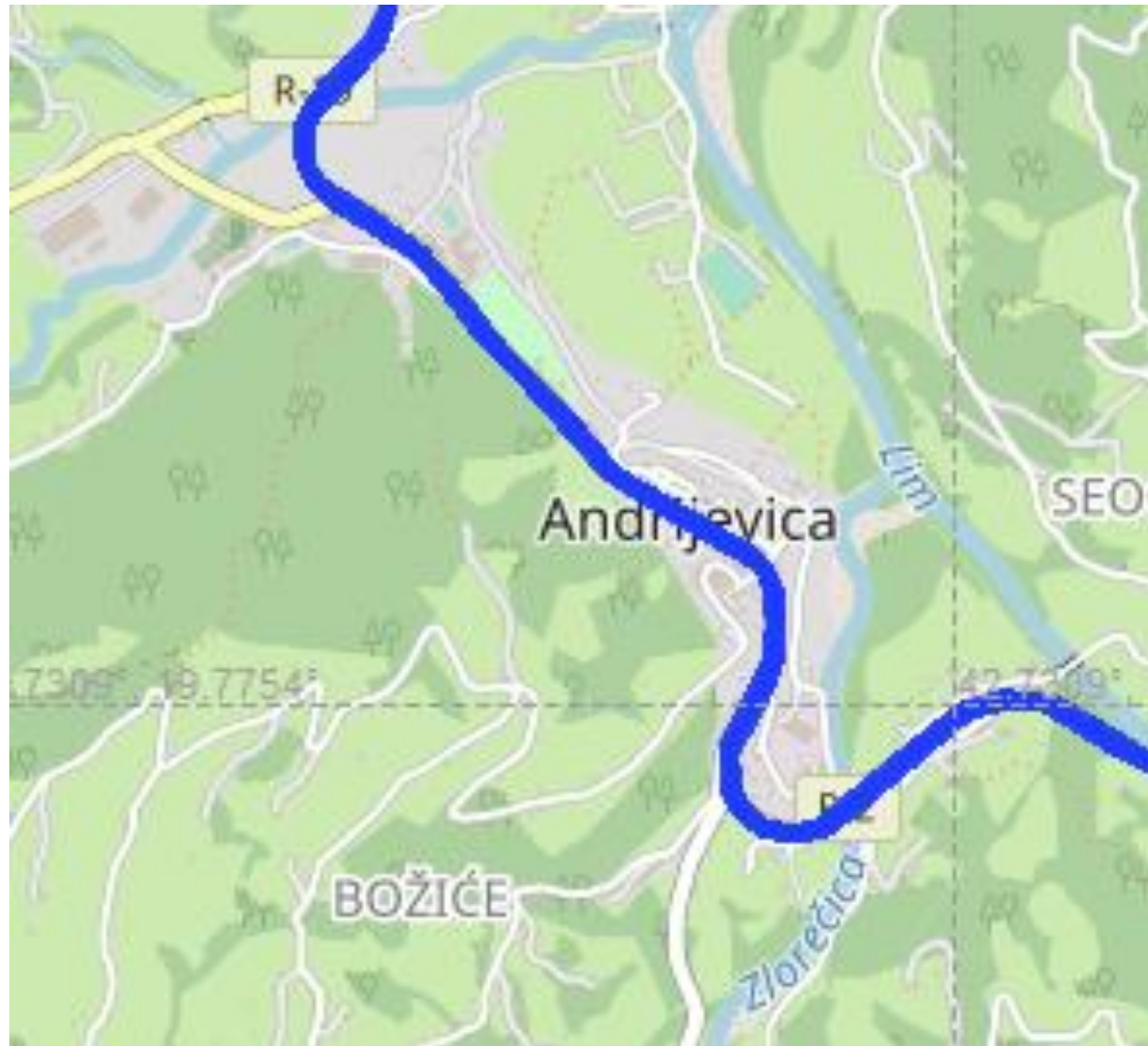
Officer for Control and Monitoring of FM Spectrum

Attachment 1: Measurement route for all measurements done in the territory of Montenegro

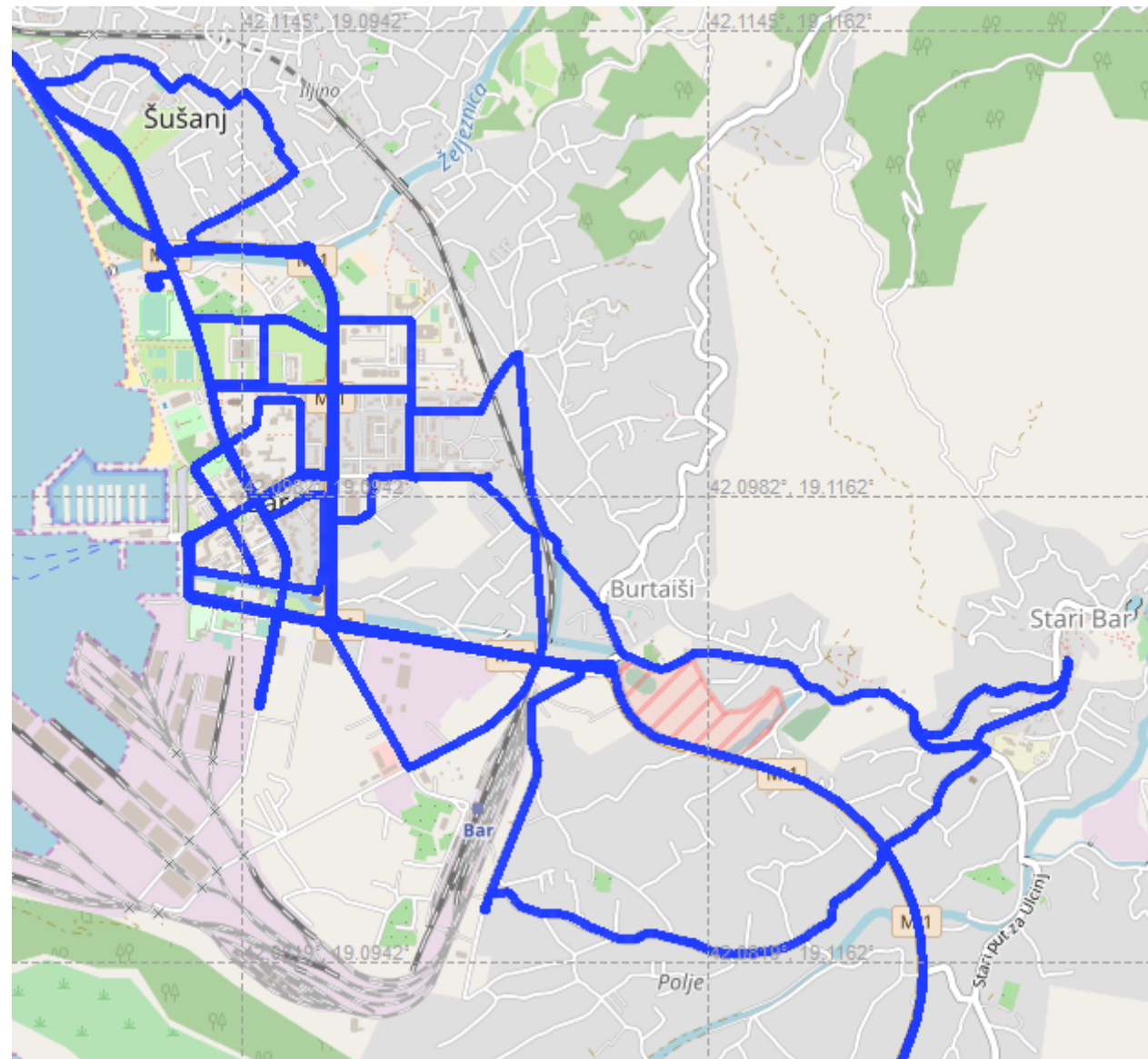


Attachment 2: Measurement routes in the cities

1) Andrijevica



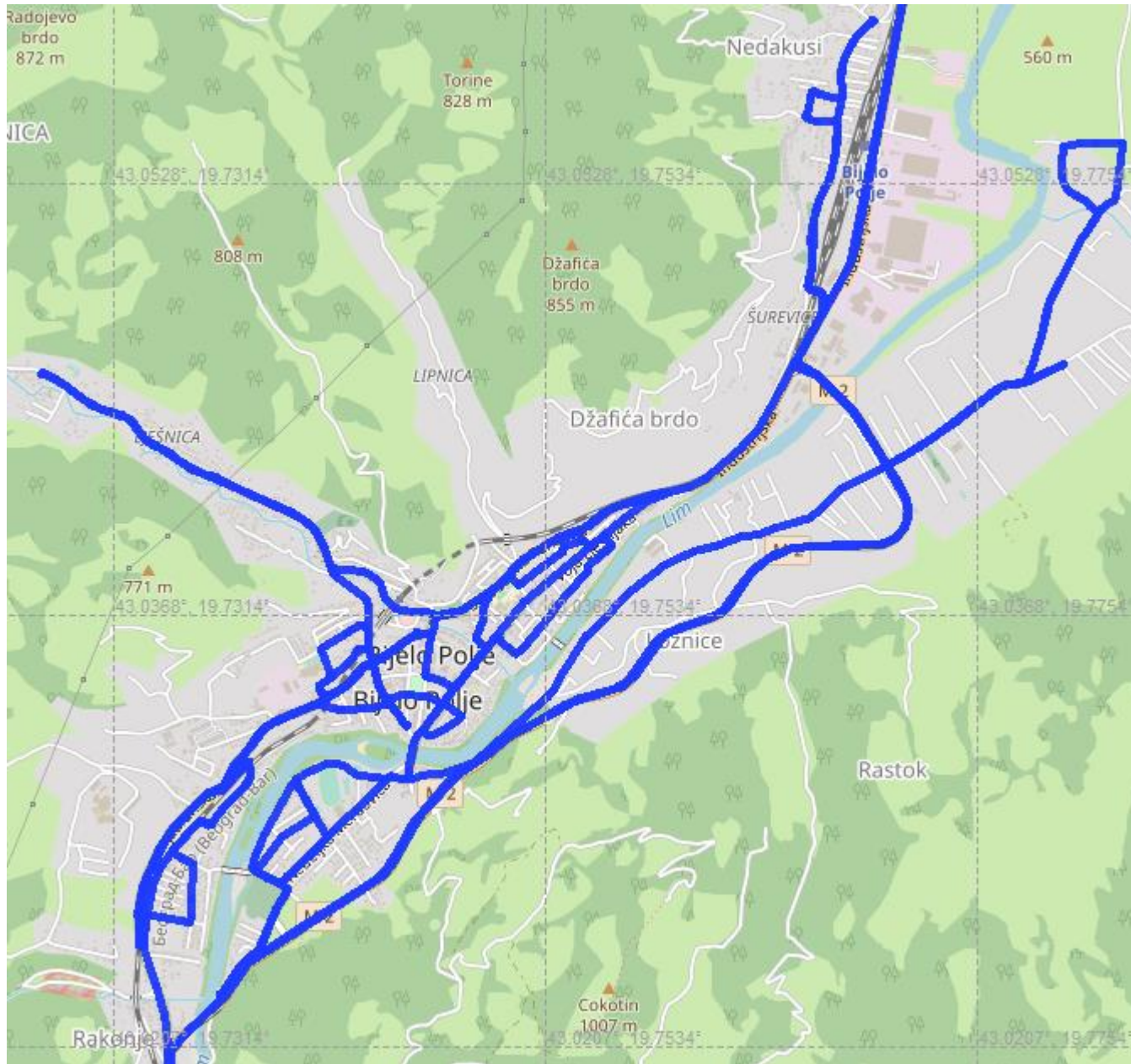
2) Bar



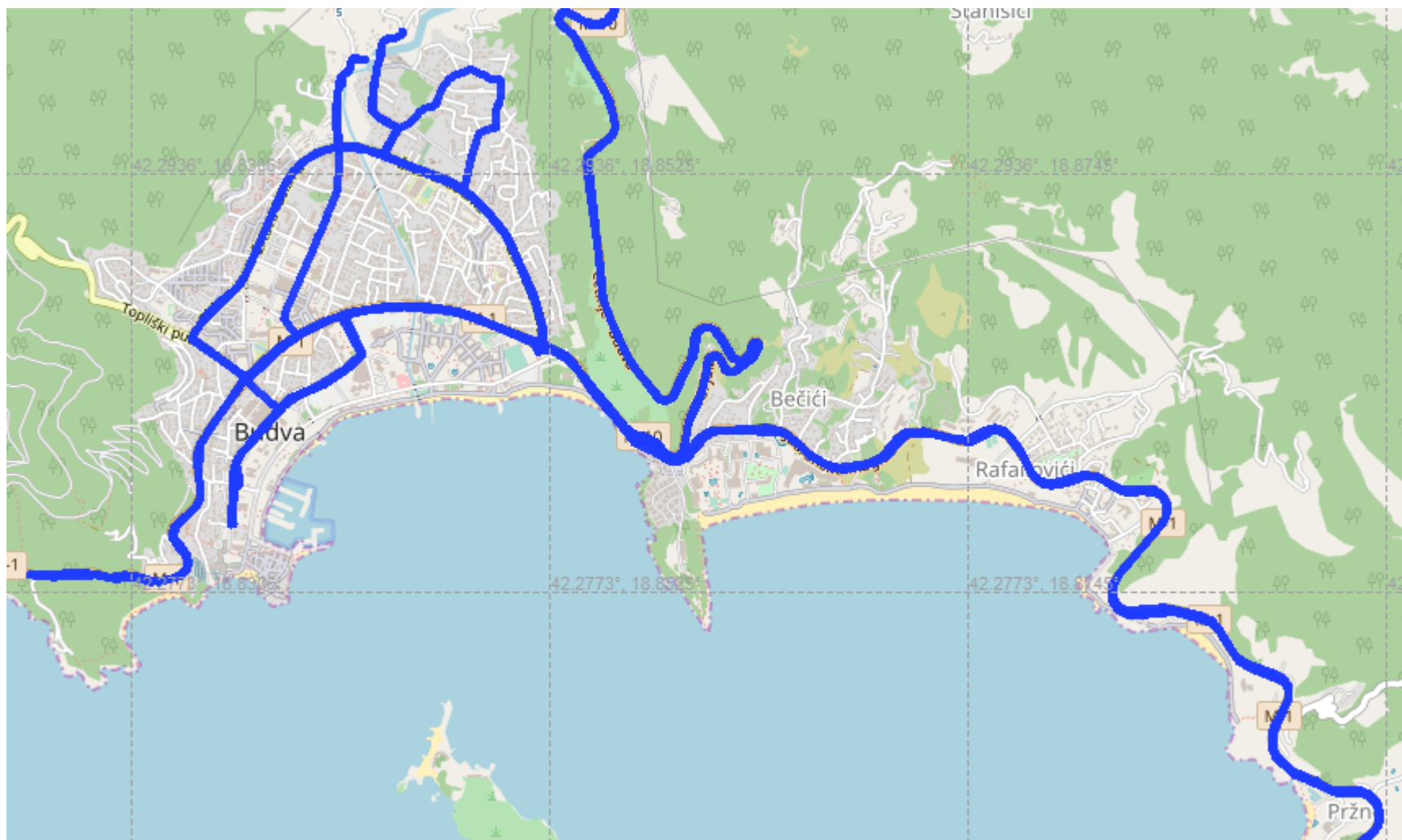
3) Berane



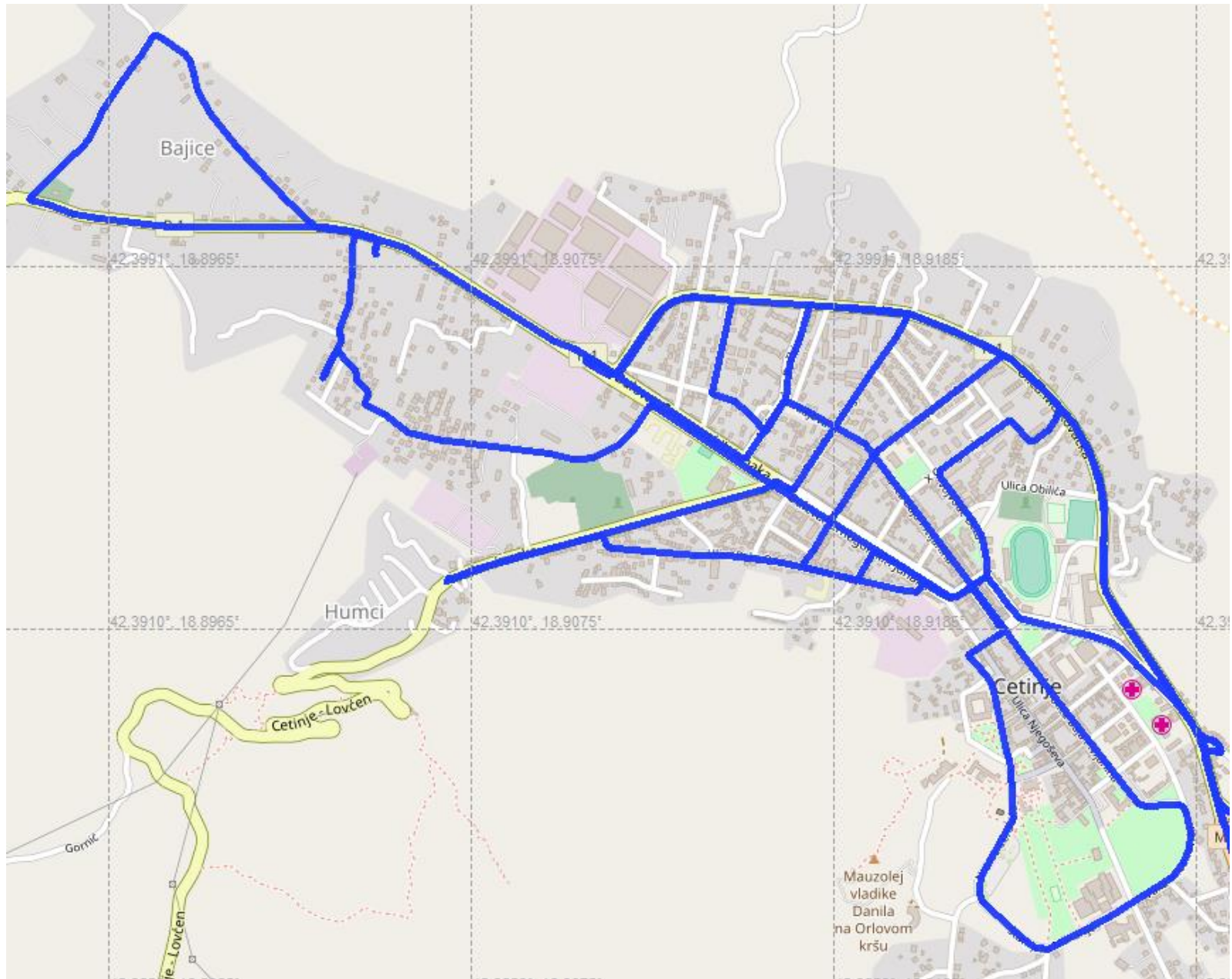
4) Bijelo Polje



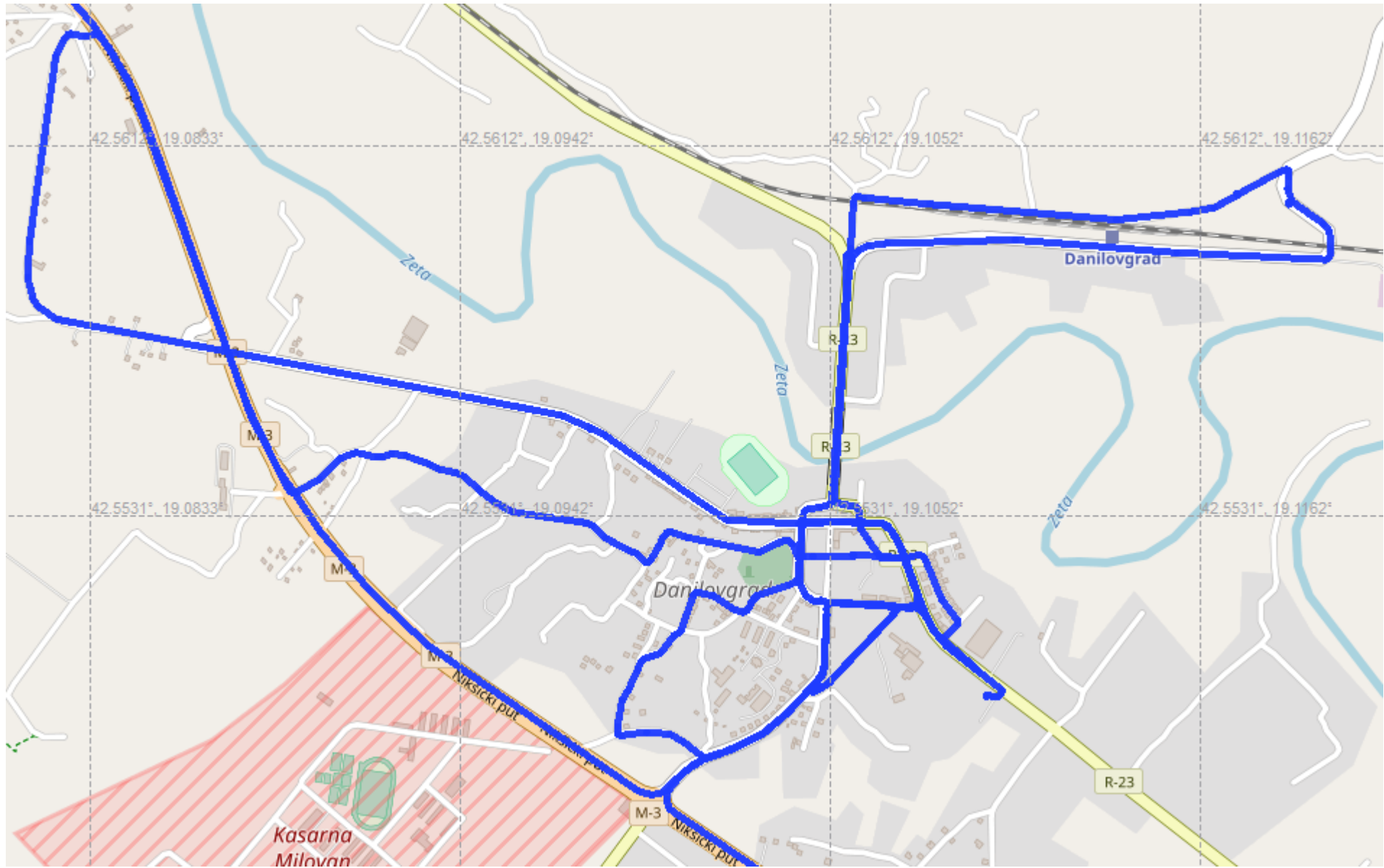
5) Budva



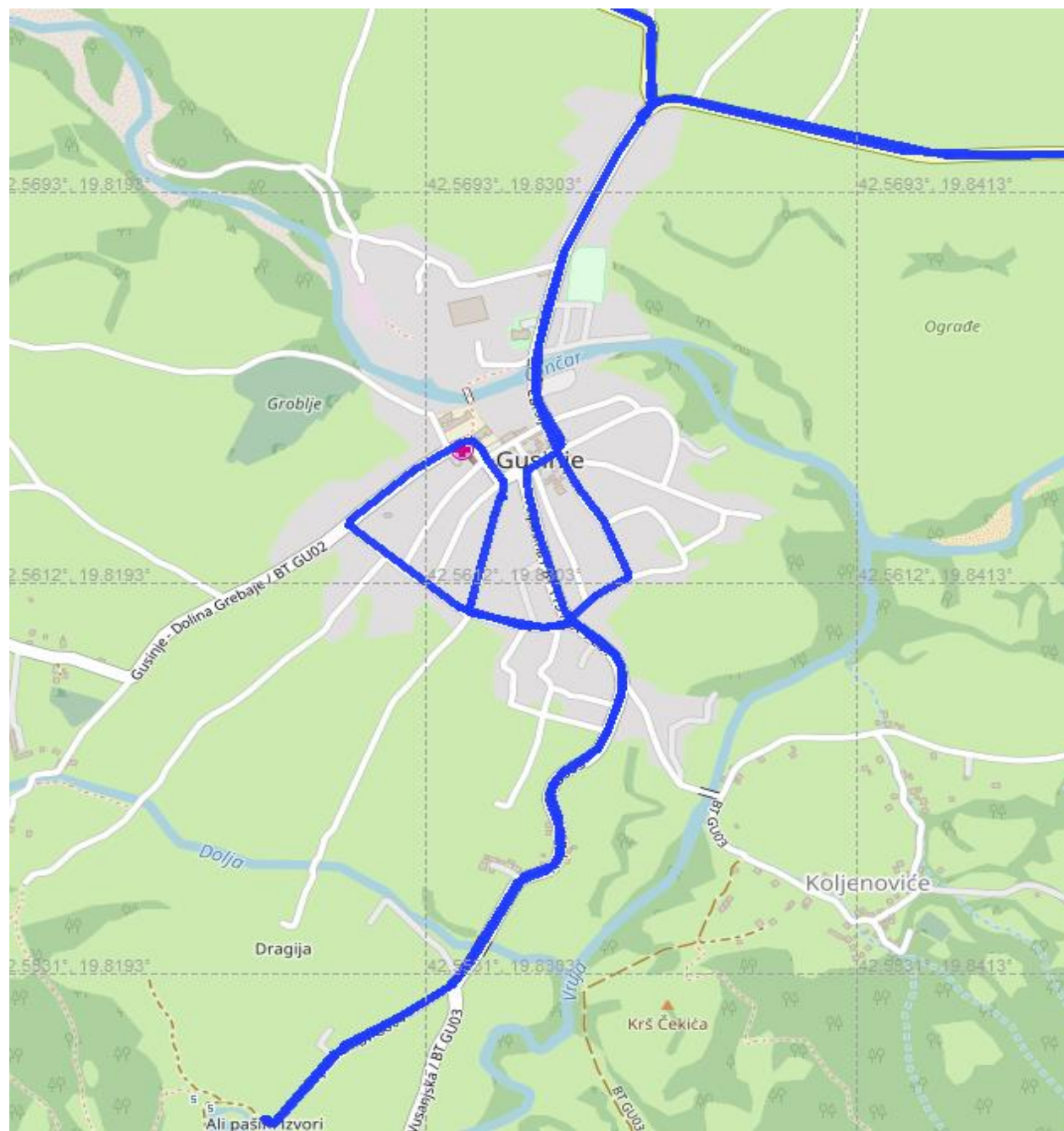
6) Cetinje



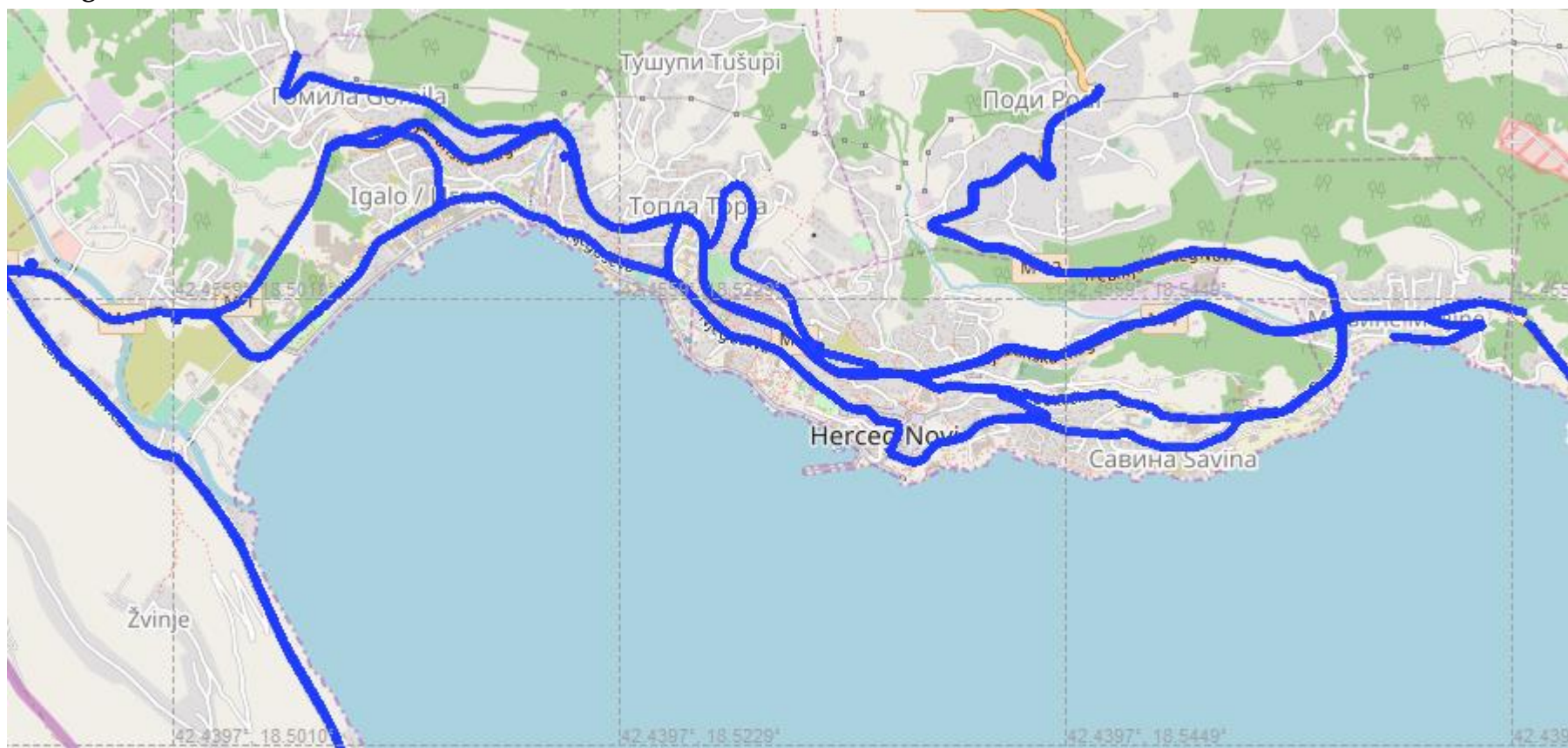
7) Danilovgrad



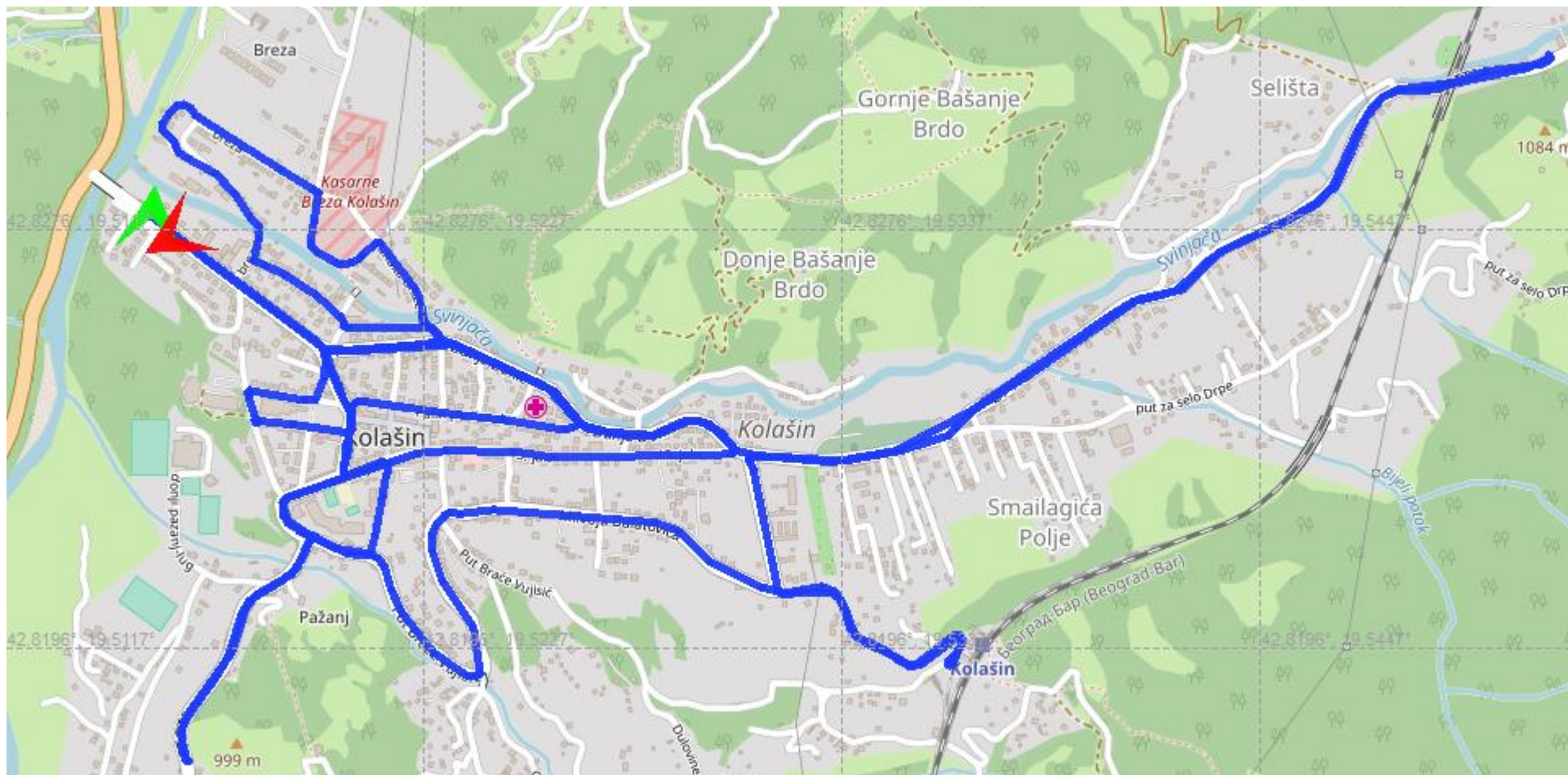
8) Gusinje



9) Herceg Novi



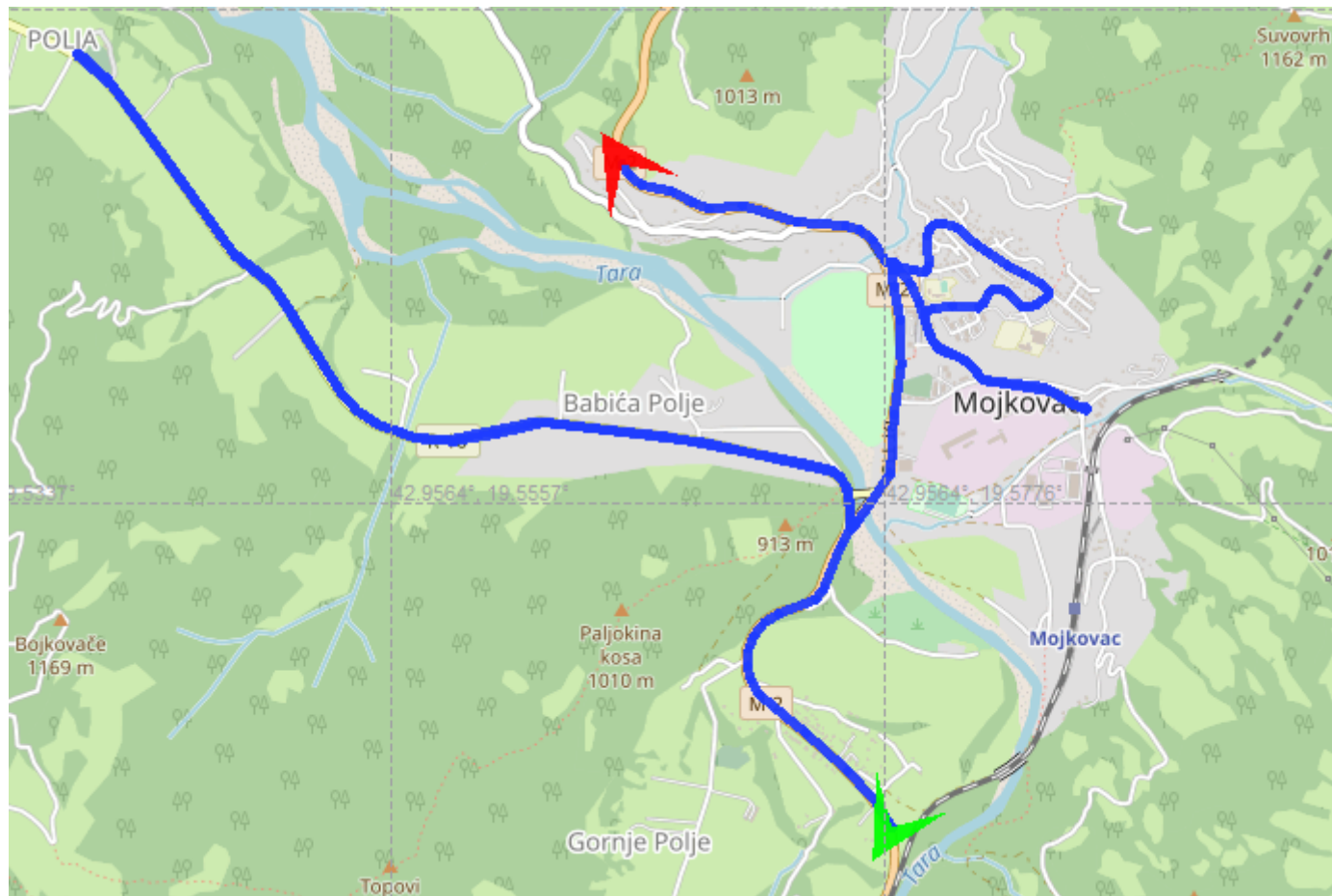
10) Kolašin



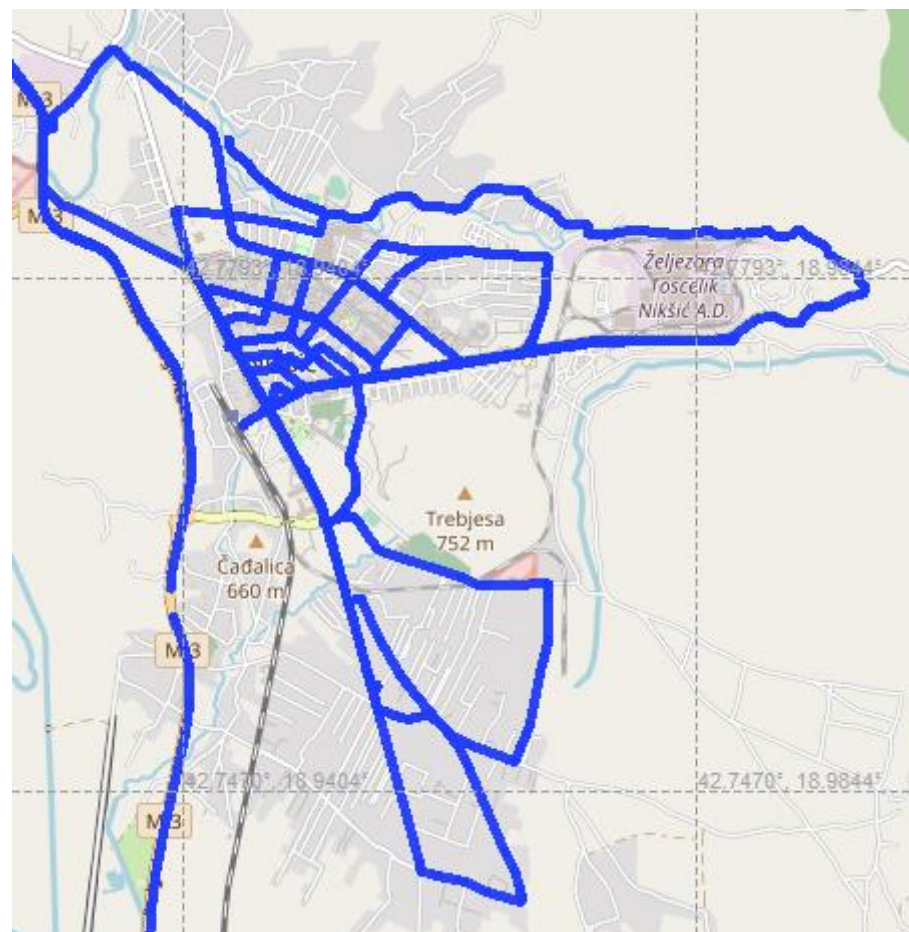
11) Kotor



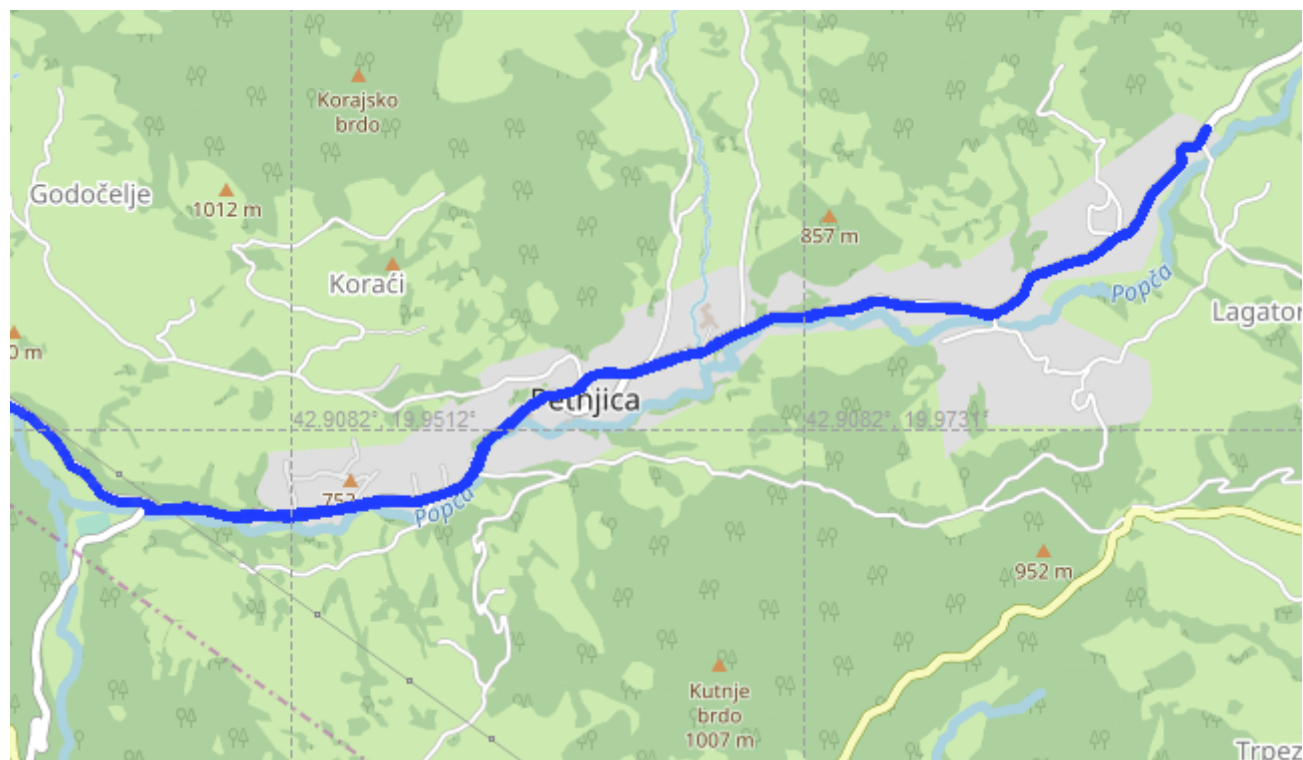
12) Mojkovac



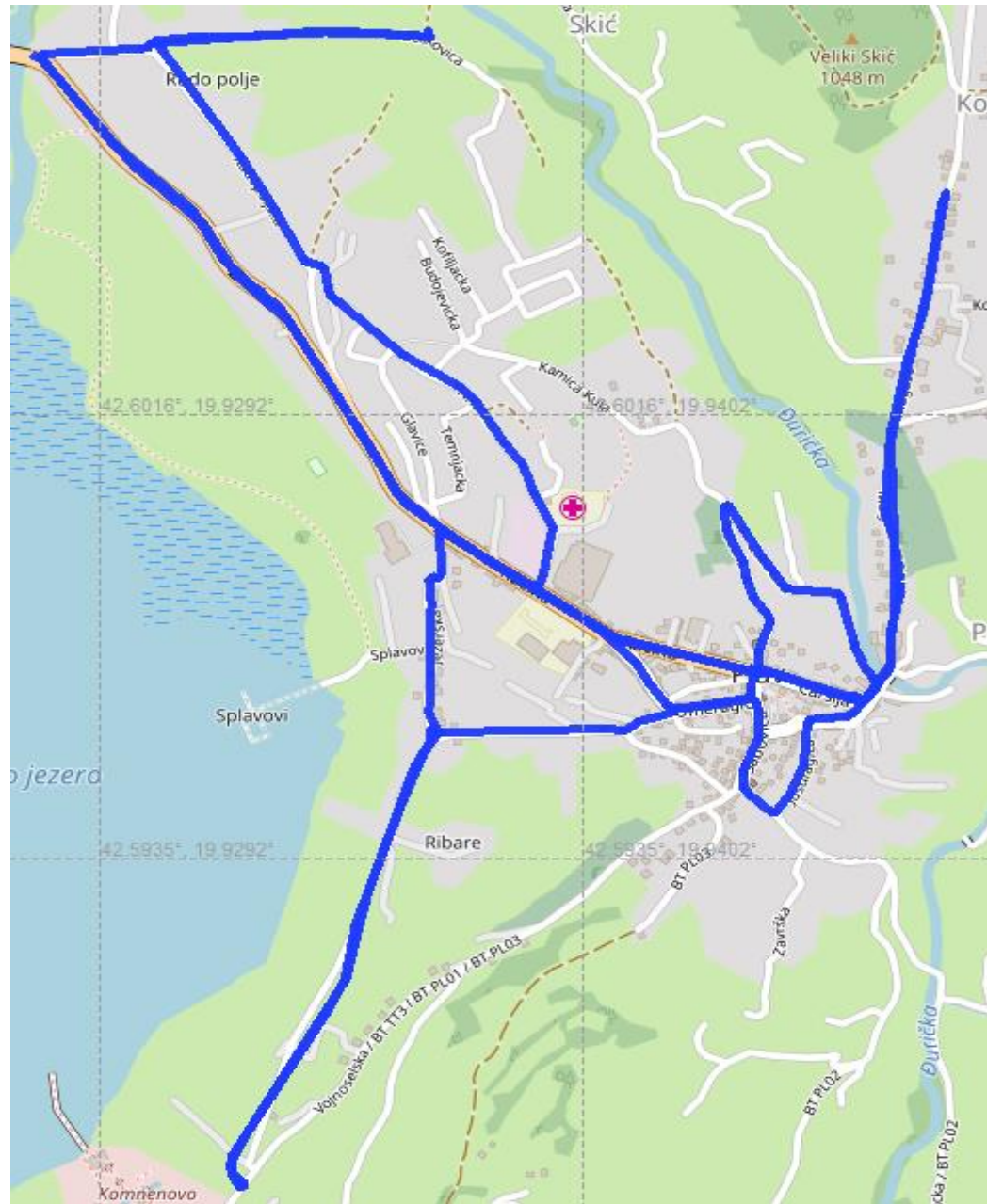
13) Nikšić



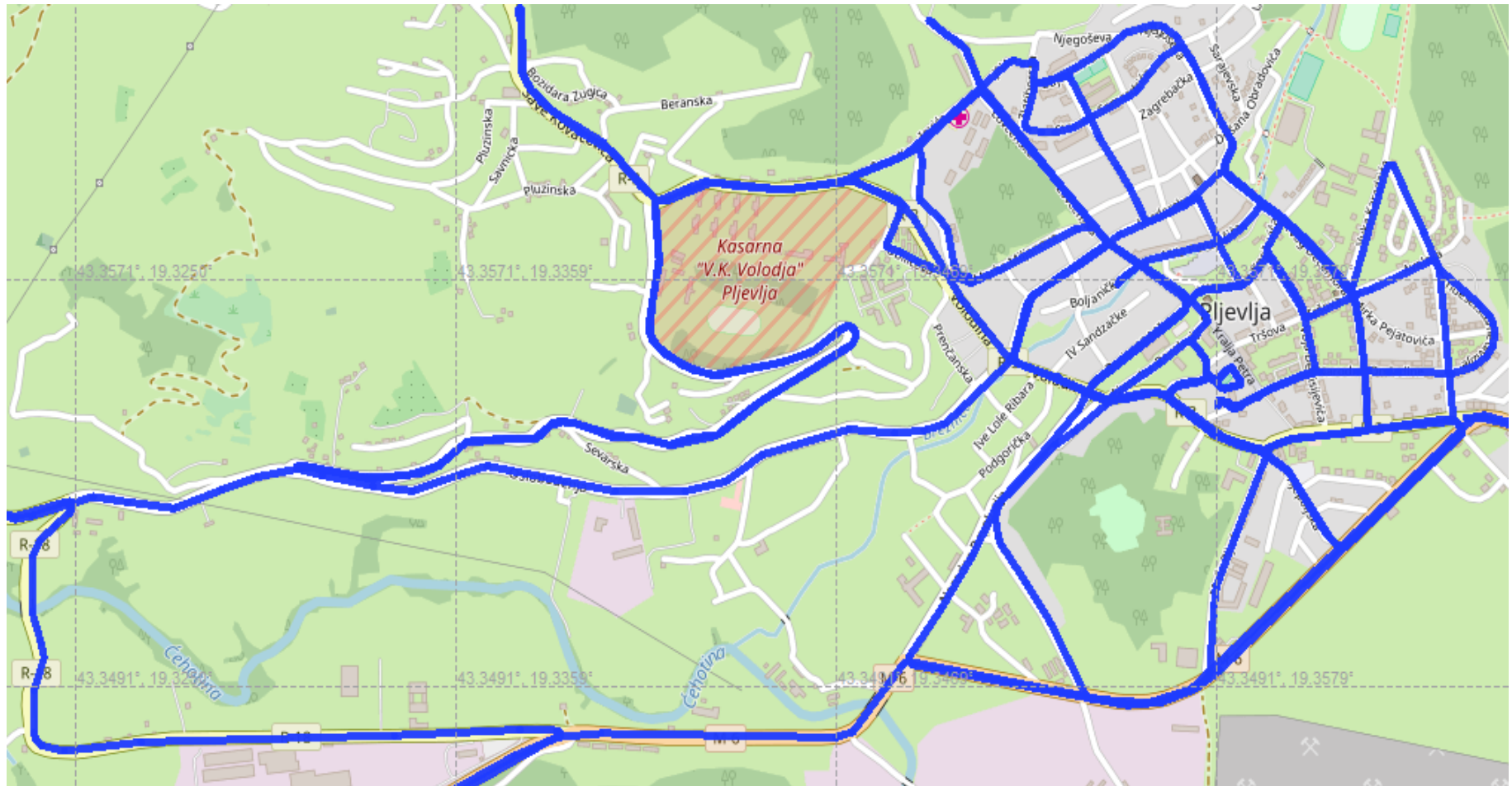
14) Petnjica



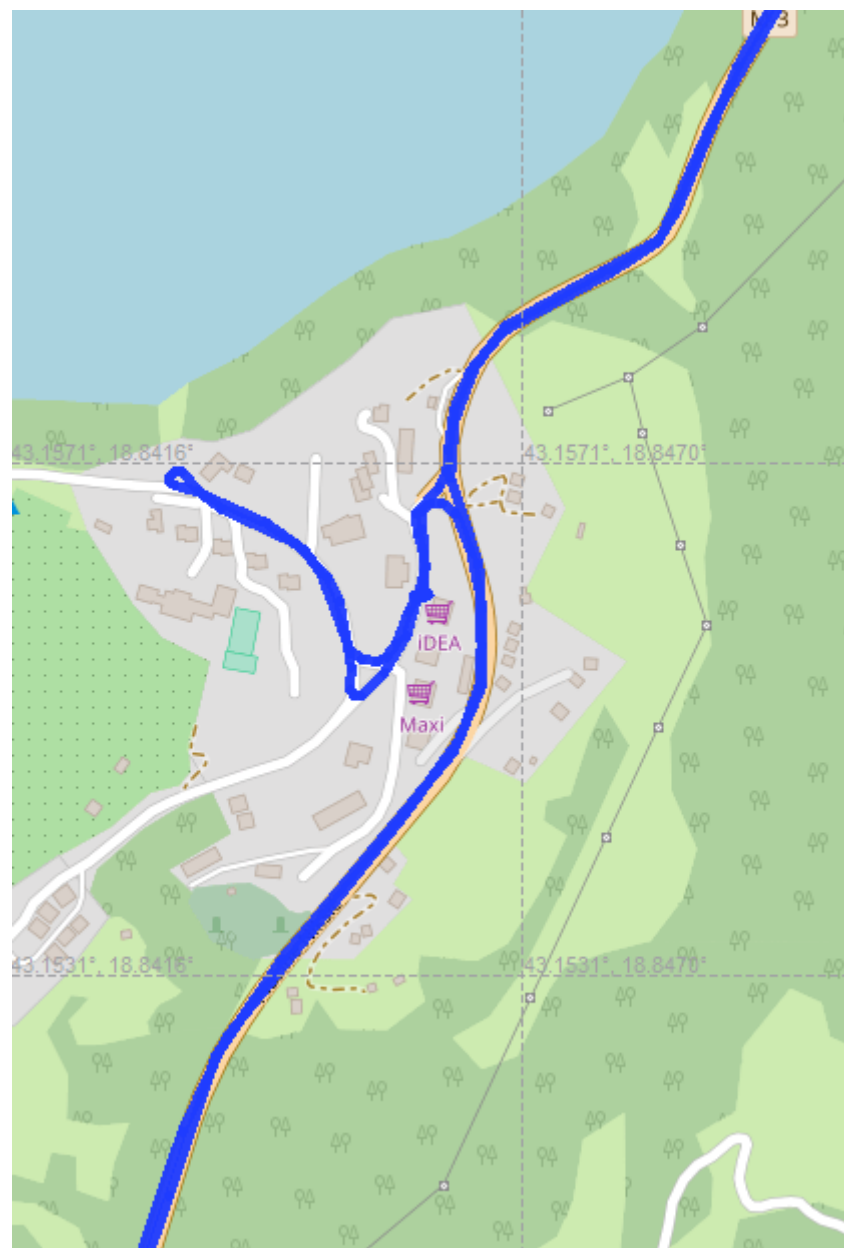
15) Plav



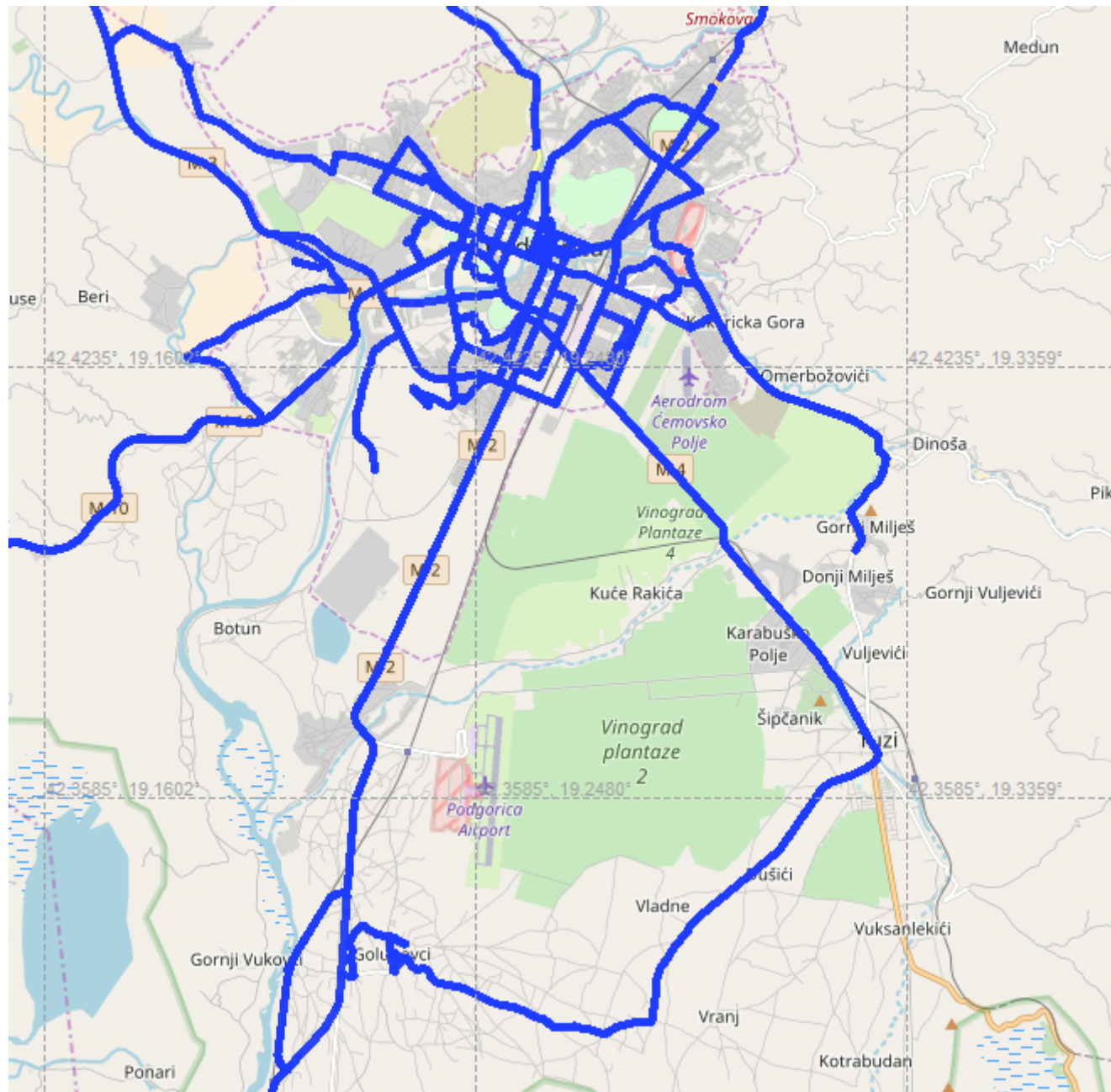
16) Pljevlja



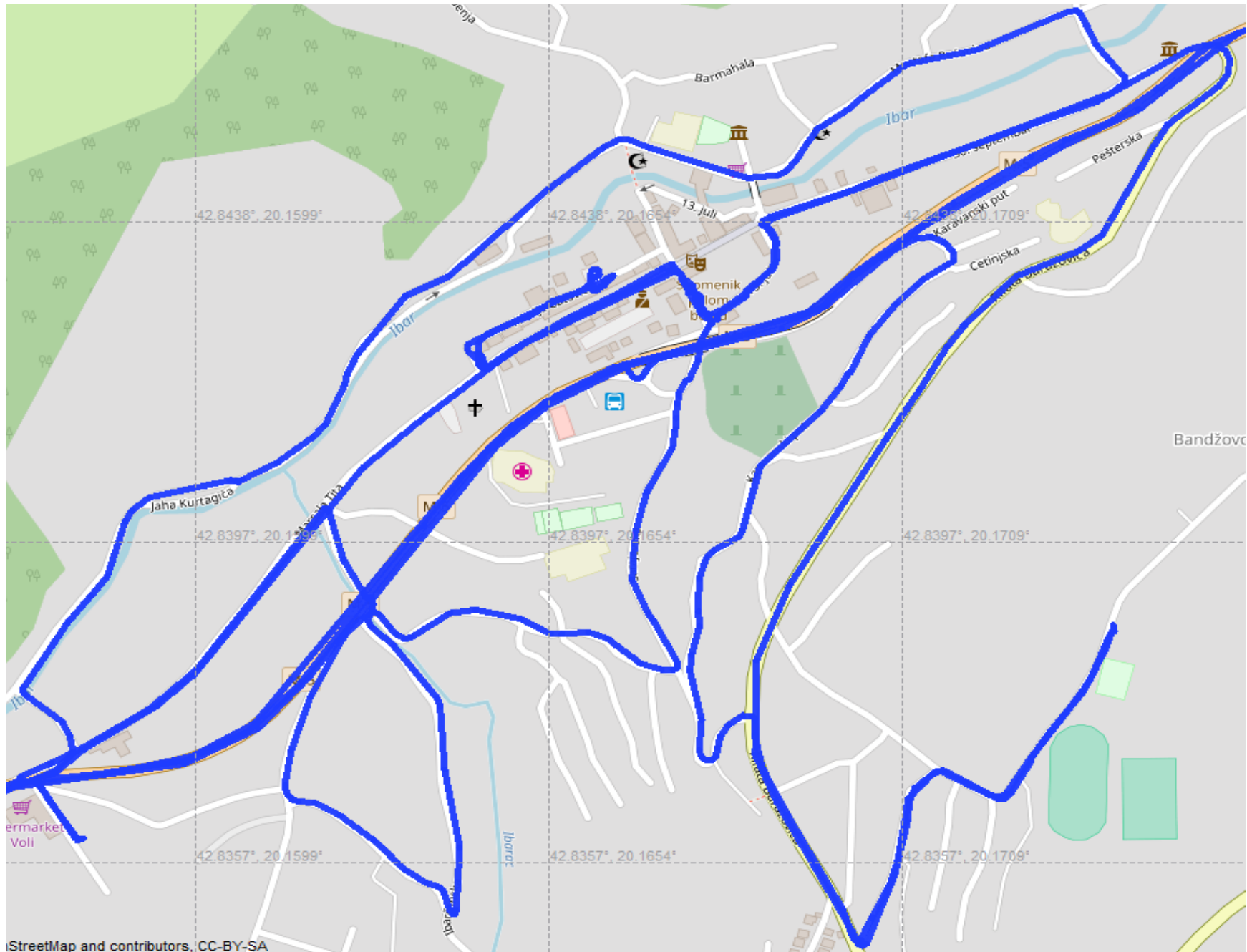
17) Plužine



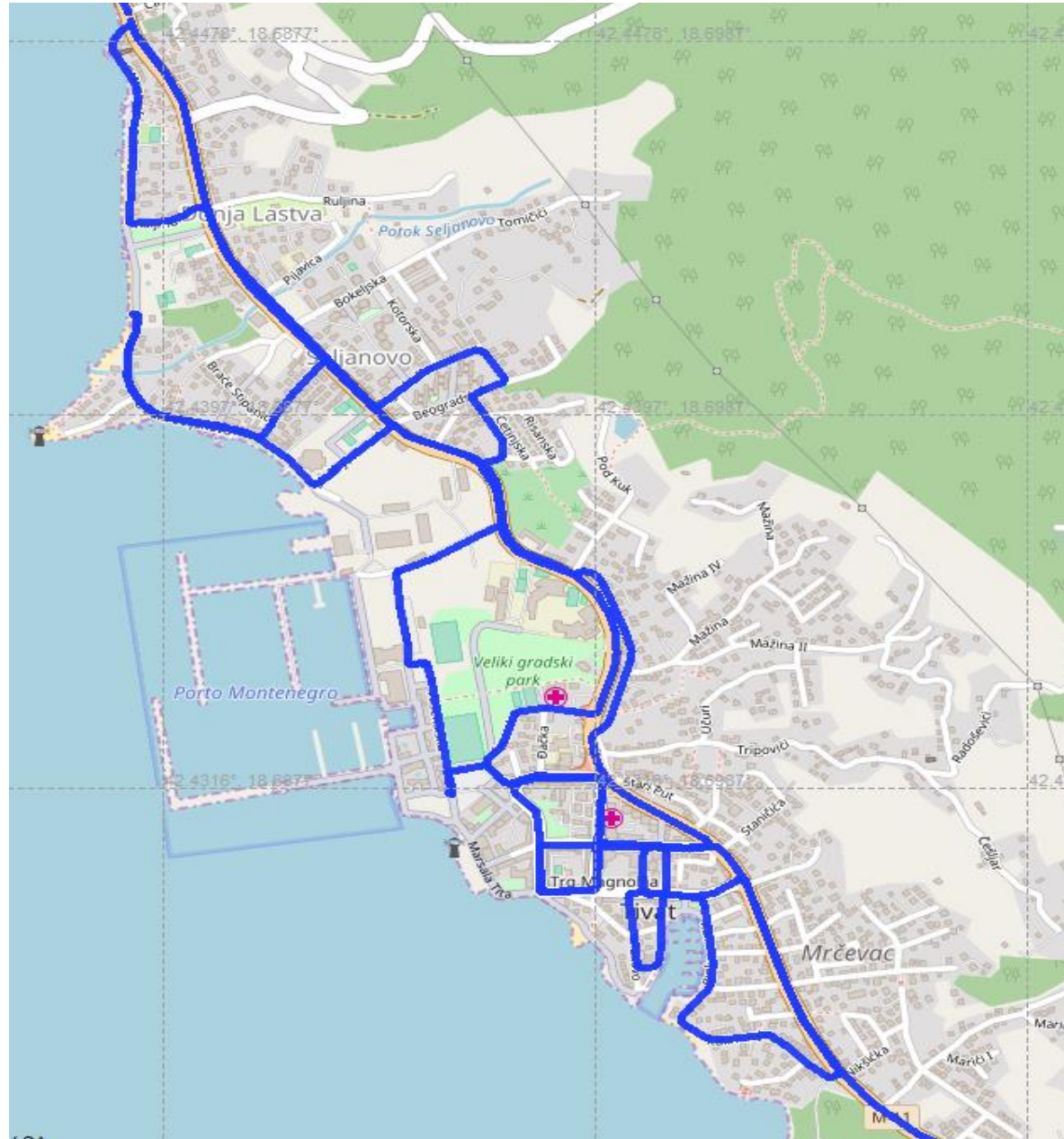
18) Podgorica



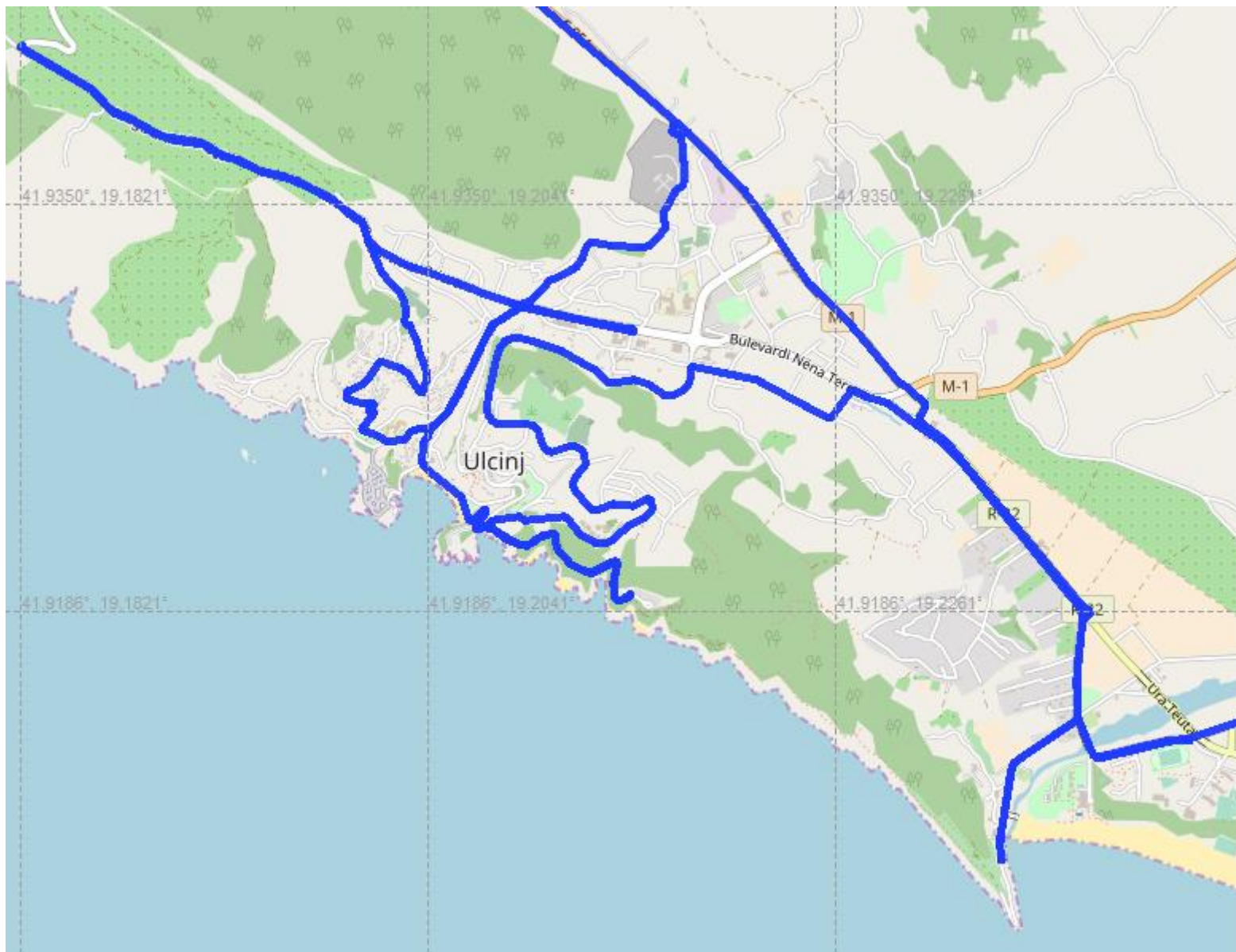
19) Rožaje



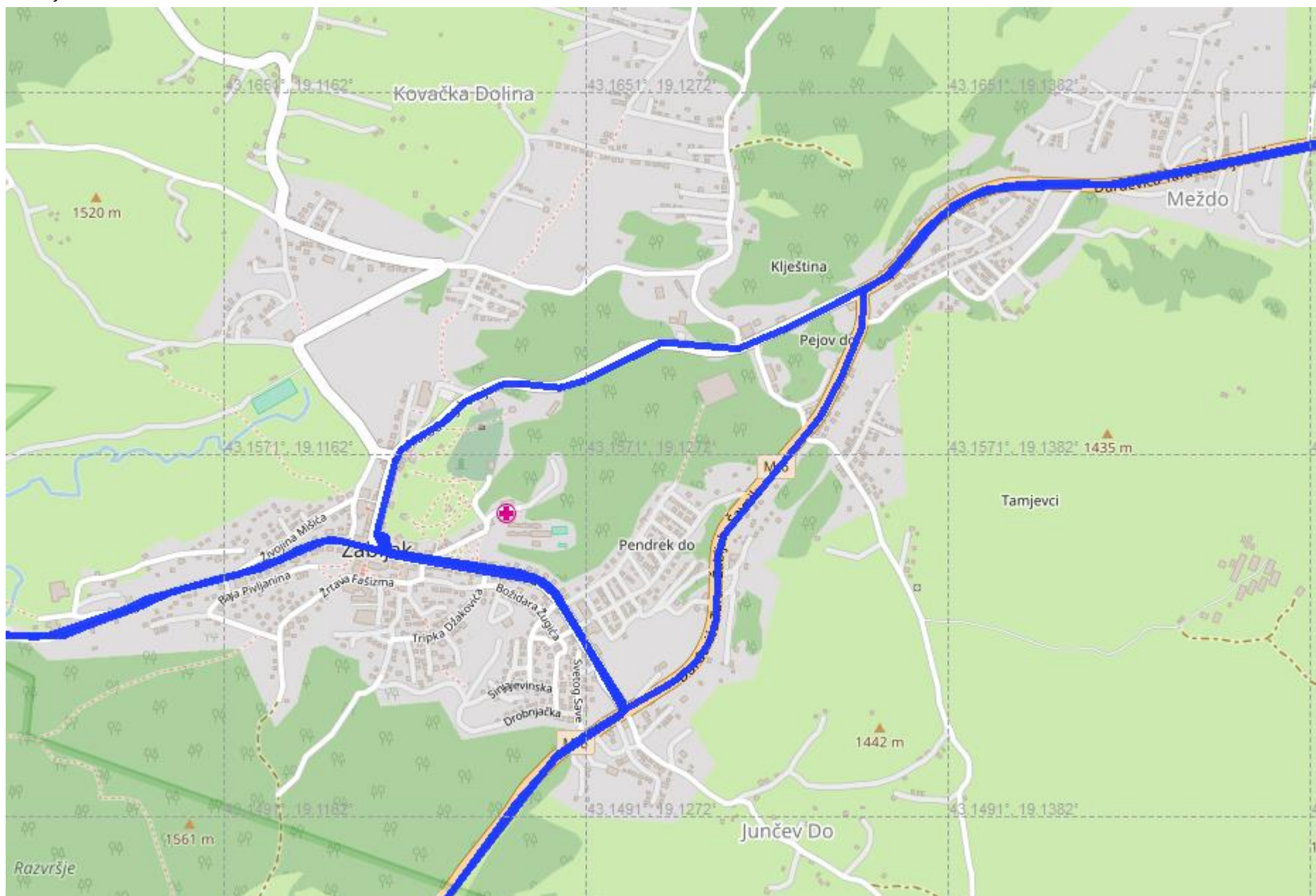
20) Tivat



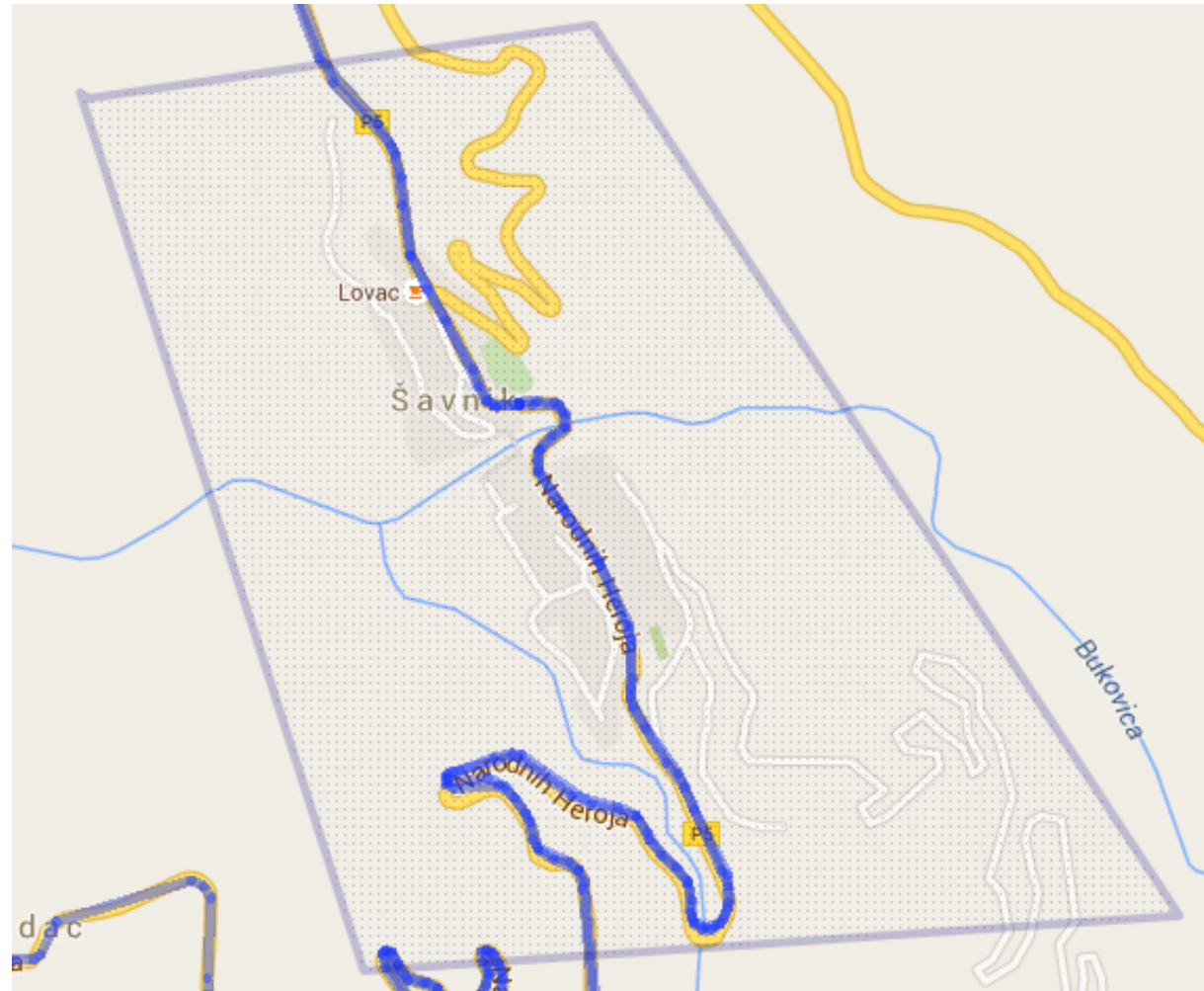
21) Ulcinj



22) Žabljak



23) Šavnik



Number of samples (calls) in the cities for telephony service

Municipality	Operator		
	Telenor	Telekom	MTEL
Andrijevica	3	3	3
Bar	120	120	120
Berane	87	87	87
Bijelo Polje	93	93	92
Budva	58	57	57
Cetinje	49	49	48
Danilovgrad	50	50	48
Gusinje	18	18	18
Herceg Novi	78	79	78
Kolašin	36	36	36
Kotor	65	63	64
Mojkovac	32	33	33
Nikšić	143	142	143
Petnjica	9	9	9
Plav	31	31	31
Pljevlja	82	82	82
Plužine	39	39	39
Podgorica	680	676	674
Rožaje	47	47	47
Šavnik	6	6	6
Tivat	39	39	39
Ulcinj	48	48	48
Žabljak	20	20	20
TOTAL	1833	1827	1822

Samples per cities

