The integration of GIS and GPS technology in the EDB

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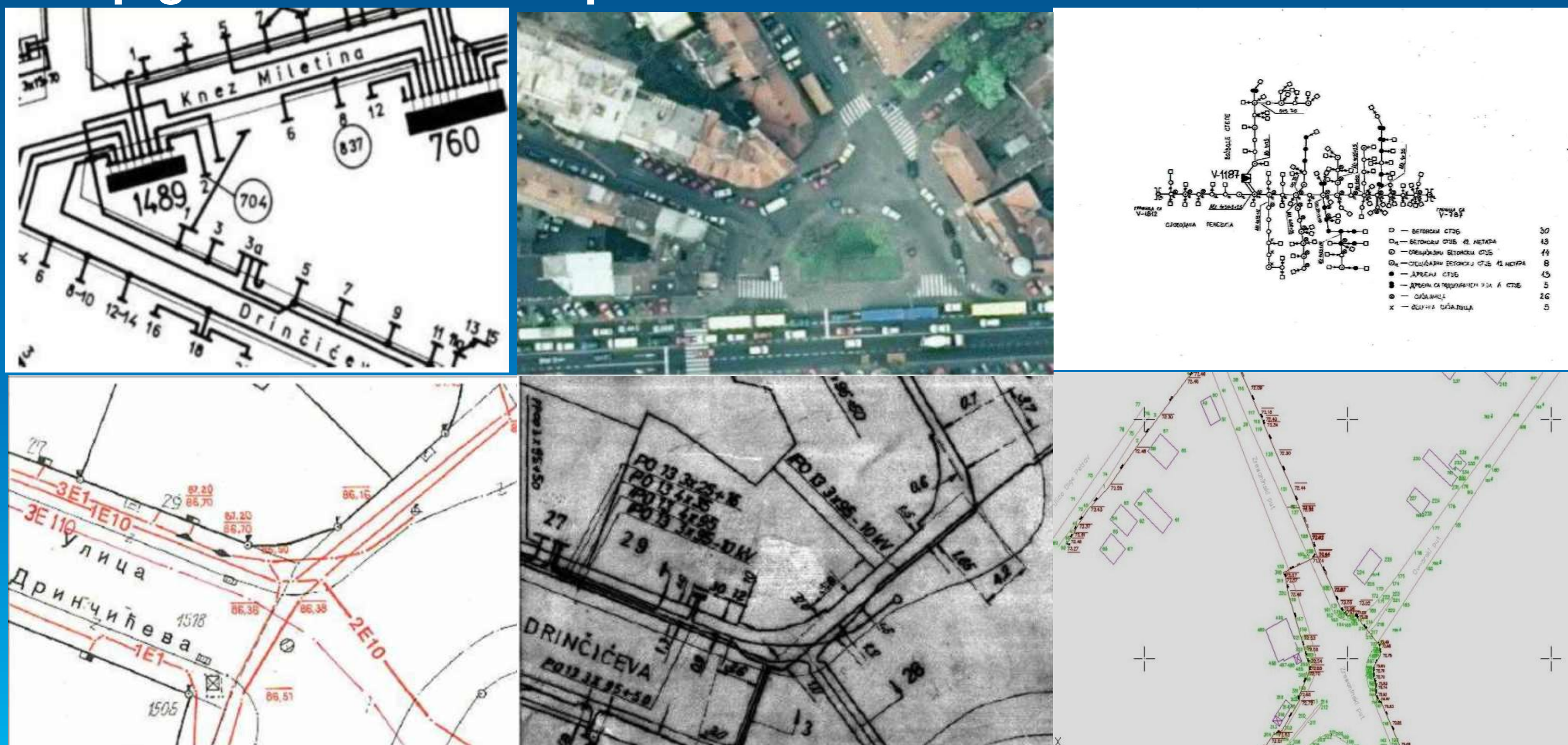
EDB’s network

- EDB’s network is comprised of 6,500km of underground power lines and spans 9,500 km of overhead lines

- Service points 830.000
- Underground lines 6.500 km
- Overhead lines 9.500 km
- Transformer substations
  - HV/MV 100
  - MV/LV 7000
- Total employed 1800

Scanning, digitizing, rasterization,vectorization Existing graphic documentation

- **The organization’s mapping system included a mix of paper-based survey and cable plans, CAD files that were somewhat incomplete, and an array of aerial photos.**
- **Map guide - The exact positions of trench axes.**



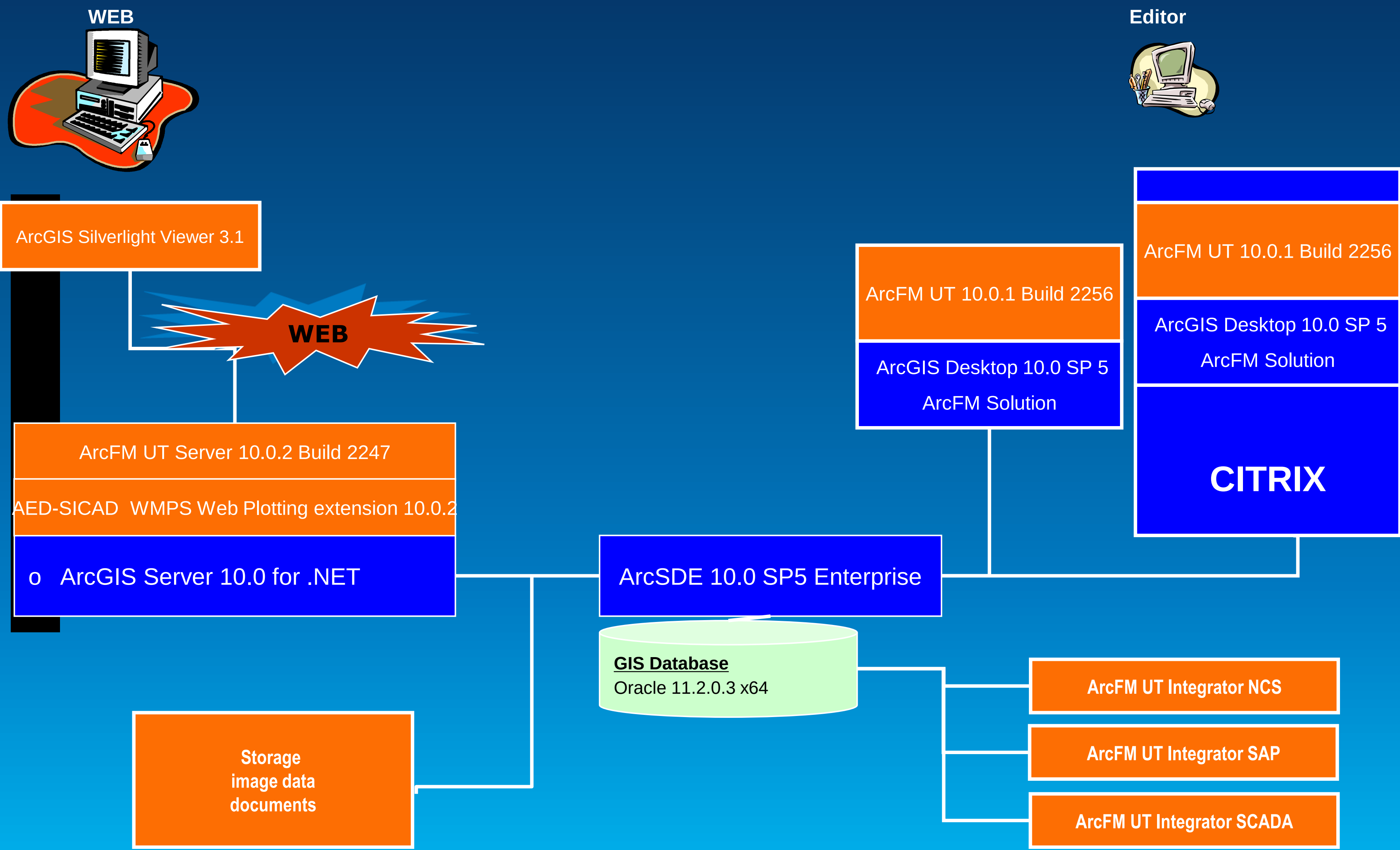
GPS data collection HV,MV,LV network - losses

- the precise documentation of the overhead network does not exists .
- A large percentage of the network does not exist in electronic form as a CAD file or part of the geodatabase.
- Graphic documentation is not part of the system that would be available to all structures of the company. Many parts companies maintain documentation for their needs.

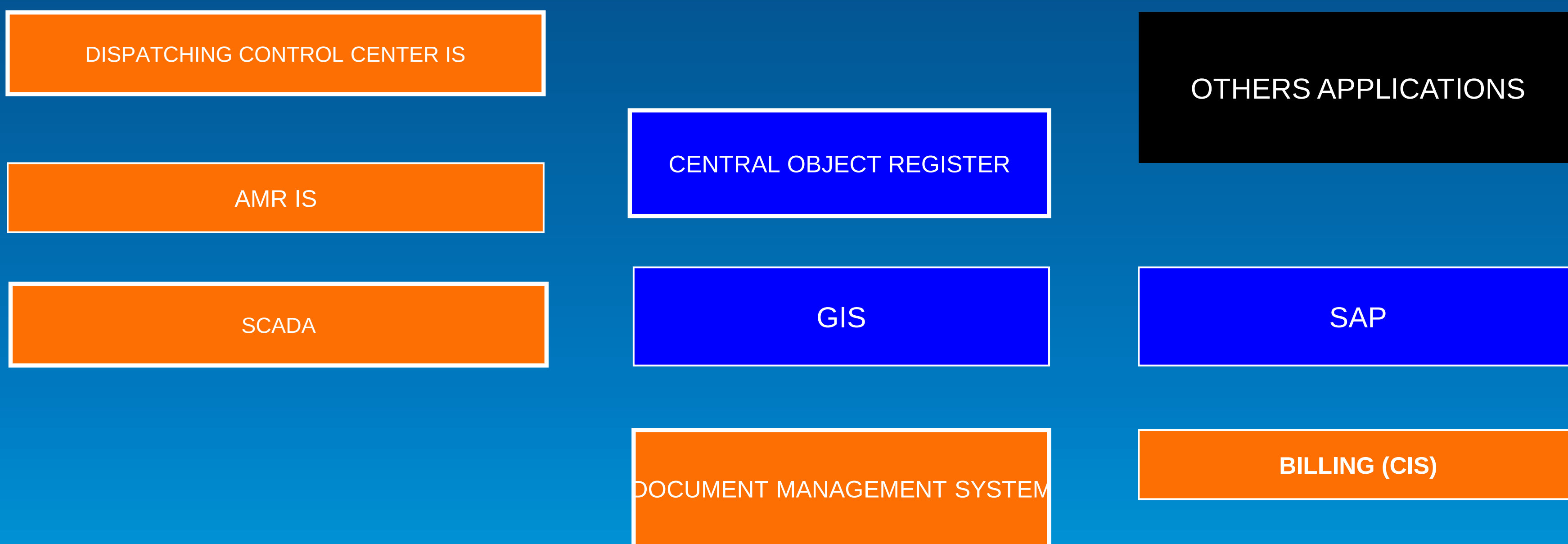
GPS data collection HV,MV,LV network - losses

- the data collection with GPS devices is the most efficient way to gather information about the network components in the field.
- GIS EDB is an advanced system for the collection, maintenance and use of spatial, technical and other data on the electricity network.
- Simply, it is a digital technical documentation of the entire electric power (EE) network EDB, implemented in a single GIS database.
- GPS record as the fastest, most efficient and most accurate data capture.
- Instead geodesic we get a complete GPS data with topological characteristics of EE network.
- New technologies and processes are not in the job description, so we form a project team

GIS System architecture



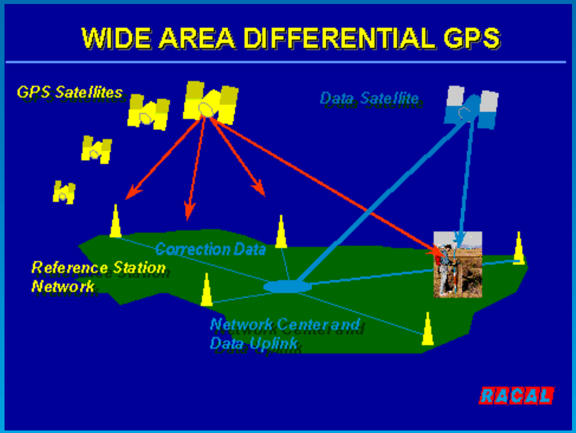
EDB System architecture



GPS equipement

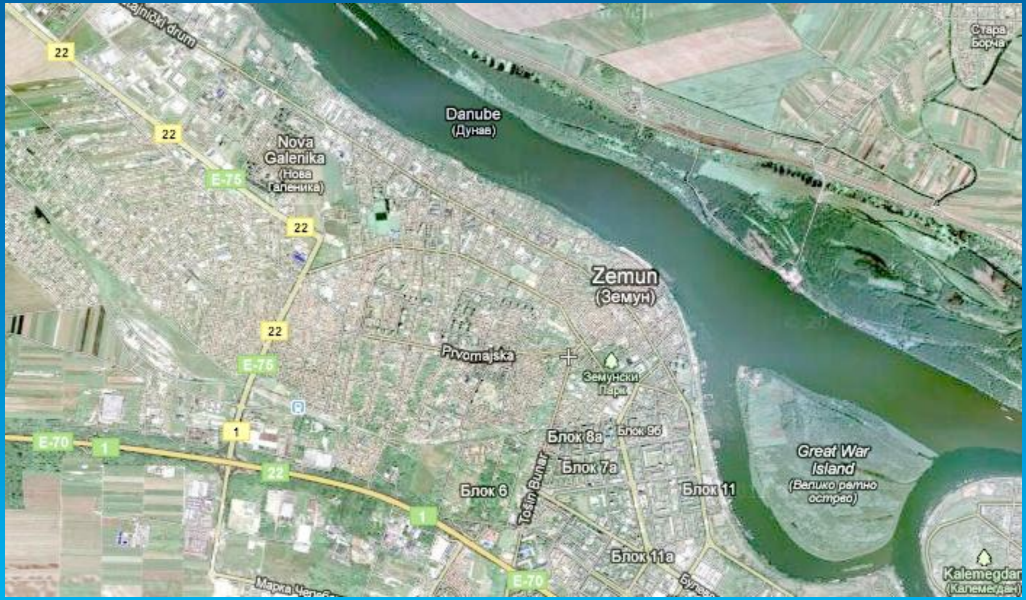
- GPS handheld devices
- Tablets
- laser rangefinder
- Camera

Reference GPS station
- Trimble GPS software



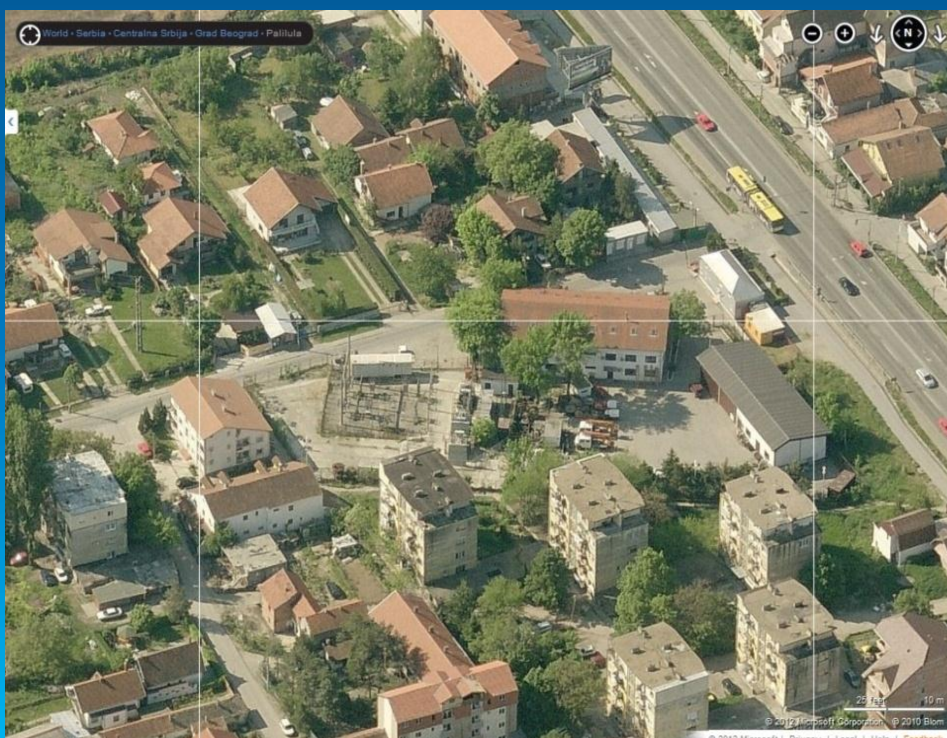
FIELD TEAM

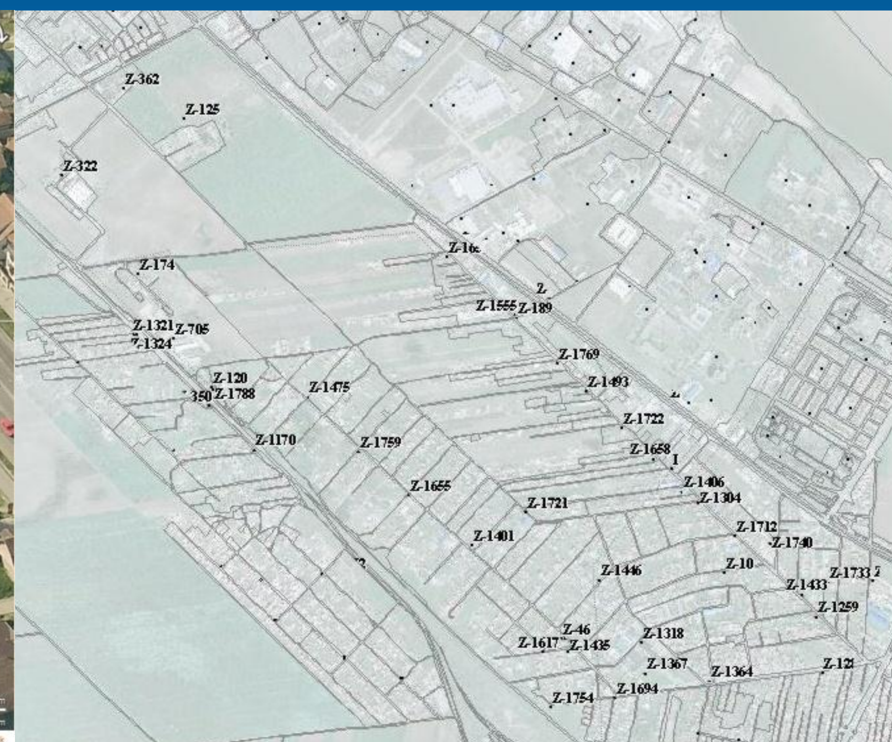
- **Capture network requires knowledge of the network (recognizing types of attributes of objects, identifying the connection network, borders, components, draw sketches, knowledge of the GPS device, a camera and a laser rangefinder.**
- **two-member field teams + meters reader**
- **Demanding training**



PREPARING FOR GPS DATA Acquisition

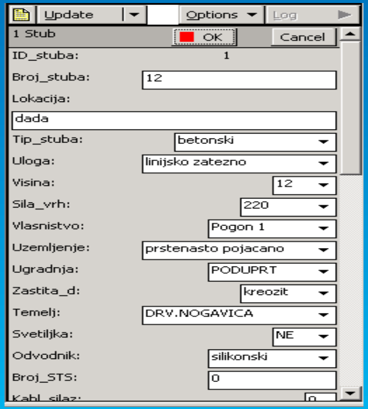
- Preparation of raster and vector documents(aerial photo and scanned maps)
- Defining the data dictionary for the network elements (type, height, material, function ...)





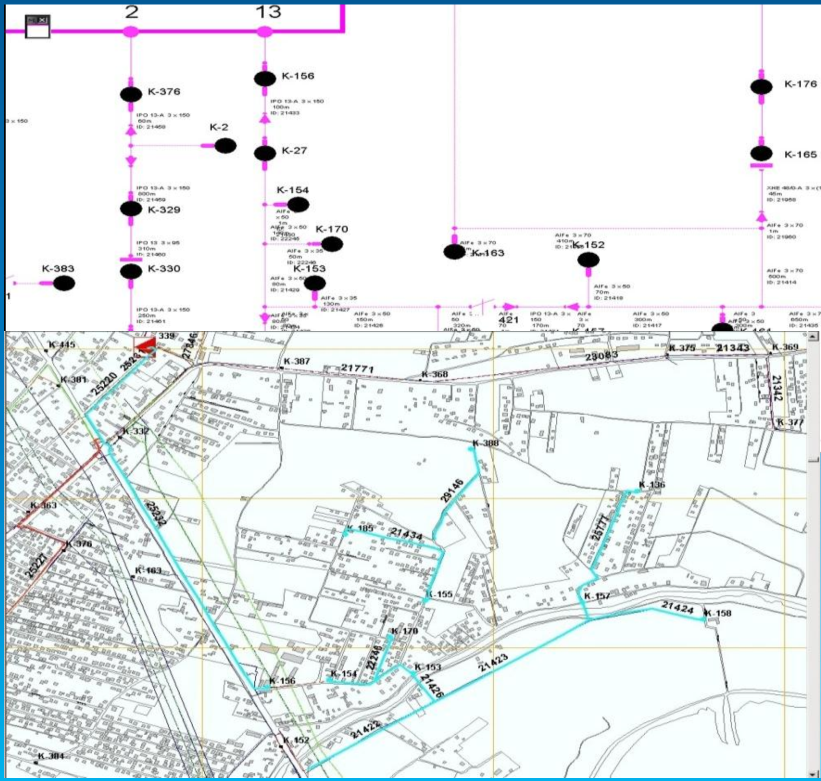
GPS data acquisition - procedure

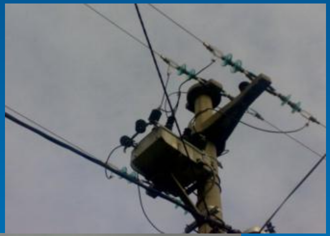
- Record the coordinates of the object. Input shift using a laser rangefinder for inaccessible objects.
- Recording facilities: poles, service points, substations, distribution boxes...
- The object of interest is photographed. Photos name should match with the number of the object.
- The data collected by GPS are corrected by reference EDB station witch was placed at EDB location.
- Processing data in the GPS software in the office.
- Checking the validity of the data and the accuracy of the entered attributes and coordinates.

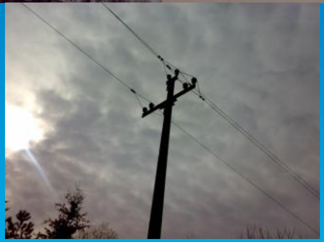


GPS data collection – MV network

With GPS devices we started to collect data for MV network, with intention to synchronize geographical pattern with up to date synoptic scheme. Results obtained by recording MV network in GIS and possibility of analysis in a GIS-based software, GPS recording has become an inevitable part of other ongoing processes in the company. Collecting data for about 35000 poles on MV network.

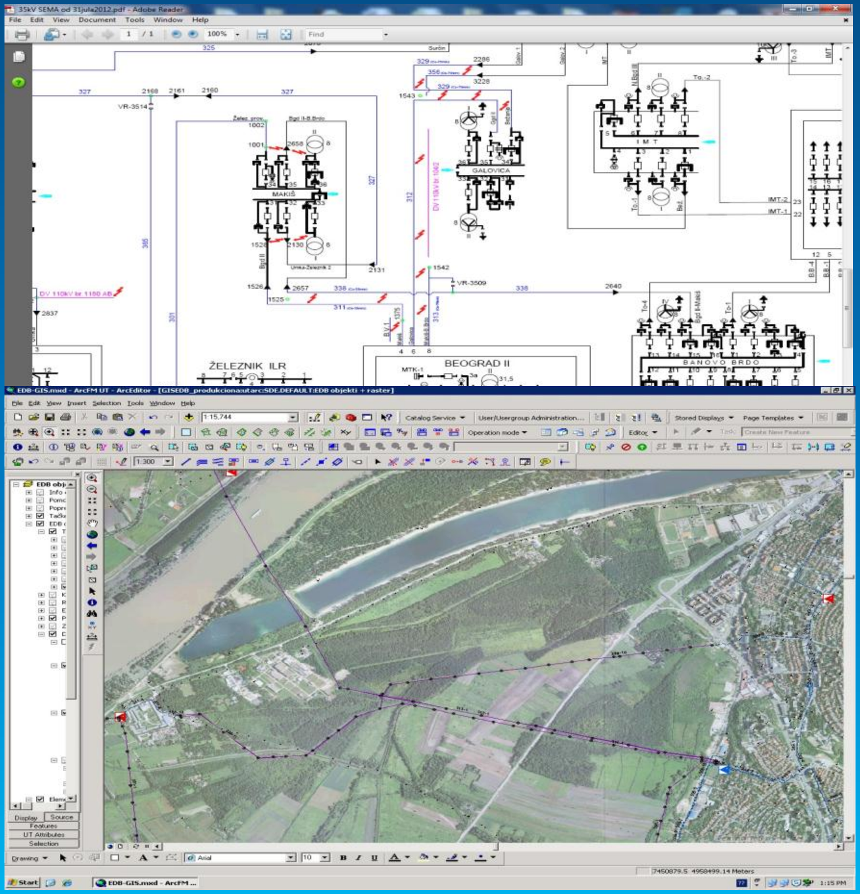






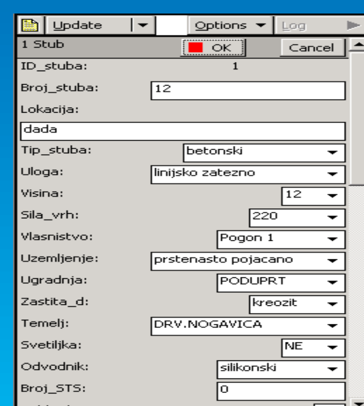
GPS data acquisition – HV network

Therefore, this process included recording of HV networks as well.
Collecting data for about 3500 poles on HV network



GPS data acquisition – LV network

The need to reduce commercial and technical losses resulted in development of accurate network topology of individual LV substation consumption area and the precise identification of the power supply of each customer. Again, it was concluded that the best way for solving this problem is GPS recording with a list of attributes. At the moment mass collection of data for LV substation consumption area is taking place (which includes 7000 MV / LV substations and 830,000 customers). Collecting data for about 1500 substation consumption area on LV network.



GPS data collecting methodology (LV network)

- reducing commercial and technical losses.
- accurate network topology for individual substation transformer consumption area.
- precise identification of the power suply of each customer.
- commercial losses 18%

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														p52			Skinuto brojilo
8		49	3300	809653311	1	1000000012001		5005	VELIKI BORAK	SIME MARKOVIĆA	18			p53	JELIĆ SLAVOLJUB	400	
8		49	3200	834698350	1	1008746681		5005	VELIKI BORAK	SIME MARKOVIĆA	16			p54	JELIĆ NEGOVAN	400	
8		49	2900	834698430	1	9202551		5009	VELIKI BORAK	ŠUMADIJSKA	3			p55	JOVIČIĆ MIODRAG	400	
8		55	2400	807991601	1	5197667		5005	VELIKI BORAK	SIME MARKOVIĆA	17	A		p56	TRIFUNOVIĆ BRANKO	400	
8		55	2300	834697860	1	8232231		5005	VELIKI BORAK	SIME MARKOVIĆA	19			p57	PAVLOVIĆ SLOBODAN	400	
8		49	3700	858428150	1	1000000013765		5005	VELIKI BORAK	SIME MARKOVIĆA	22			p58	TRIFUNOVIĆ MIODRAG	400	
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8		55	2100	841096200	1	2000000013018		5005	VELIKI BORAK	SIME MARKOVIĆA	23	A		p61	ILIĆ V.ŽIVAN	400	
														p62			Zaključano
8		55	2110	872159530	1	13862		5005	VELIKI BORAK	SIME MARKOVIĆA	25			p63	SAKOVIĆ LJILJANA	400	
8		49	4000	804743321	1	2000000013646		5005	VELIKI BORAK	SIME MARKOVIĆA	28			p64	TRIFUNOVIĆ DRAGOSLAV	400	
8		49	5400	852529150	1	5357251		5011	VELIKI BORAK	SKOJEVSKA	10			p65	JOVIČIĆ SINIŠA	400	
8		49	5600	853999311	1	1000000012785		5011	VELIKI BORAK	SKOJEVSKA	1	C		p66	PETROVIĆ BLAGOJE	400	
8		49	4400	834695200	1	12374		5011	VELIKI BORAK	SKOJEVSKA	6			p67	JELIĆ BORISAV	400	
8		49	5700	848726572	1	13764		5011	VELIKI BORAK	SKOJEVSKA	1	A		p68	RADOSAVLJEVIĆ MIRJANA	400	
8		49	5500	839119430	1	15481		5011	VELIKI BORAK	SKOJEVSKA	1	A		p69	PETROVIĆ VESNA	400	
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8		49	4200	852195850	1	13656		5011	VELIKI BORAK	SKOJEVSKA	2			p76	VLADISAVLJEVIĆ STOJNA	400	
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8	4	50	3100	99669060		55132		5011	VELIKI BORAK	SKOJEVSKA	8			p80	FILIPOVIĆ MILAN - DOMAĆINSTVO	V	Zaključano -odjavljeno
8		61	550	868445710	1	1000000013668		4994	VELIKI BORAK	TRG PALIH BORACA	4	A		p81	MILOVANOVIĆ ZDRAVKO	400	
				98469260		76237		4994	VELIKI BORAK	TRG PALIH BORACA	8			p82	MARIĆ RADIŠA - DOMAĆINSTVO	V	
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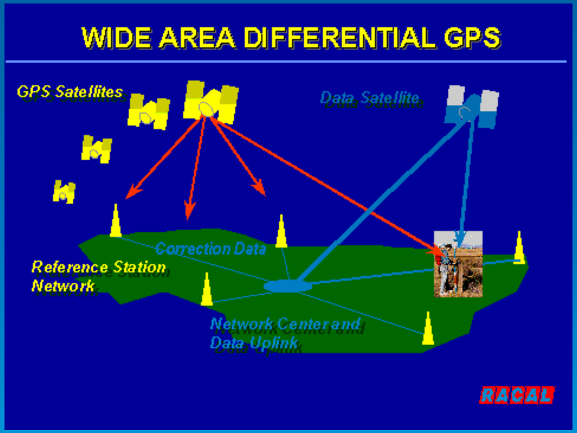
				56620790				4994	VELIKI BORAK	TRG PALIH BORACA	3			p85	PTT SRBIJE JP RJ BEOGRADSKI VENAC		

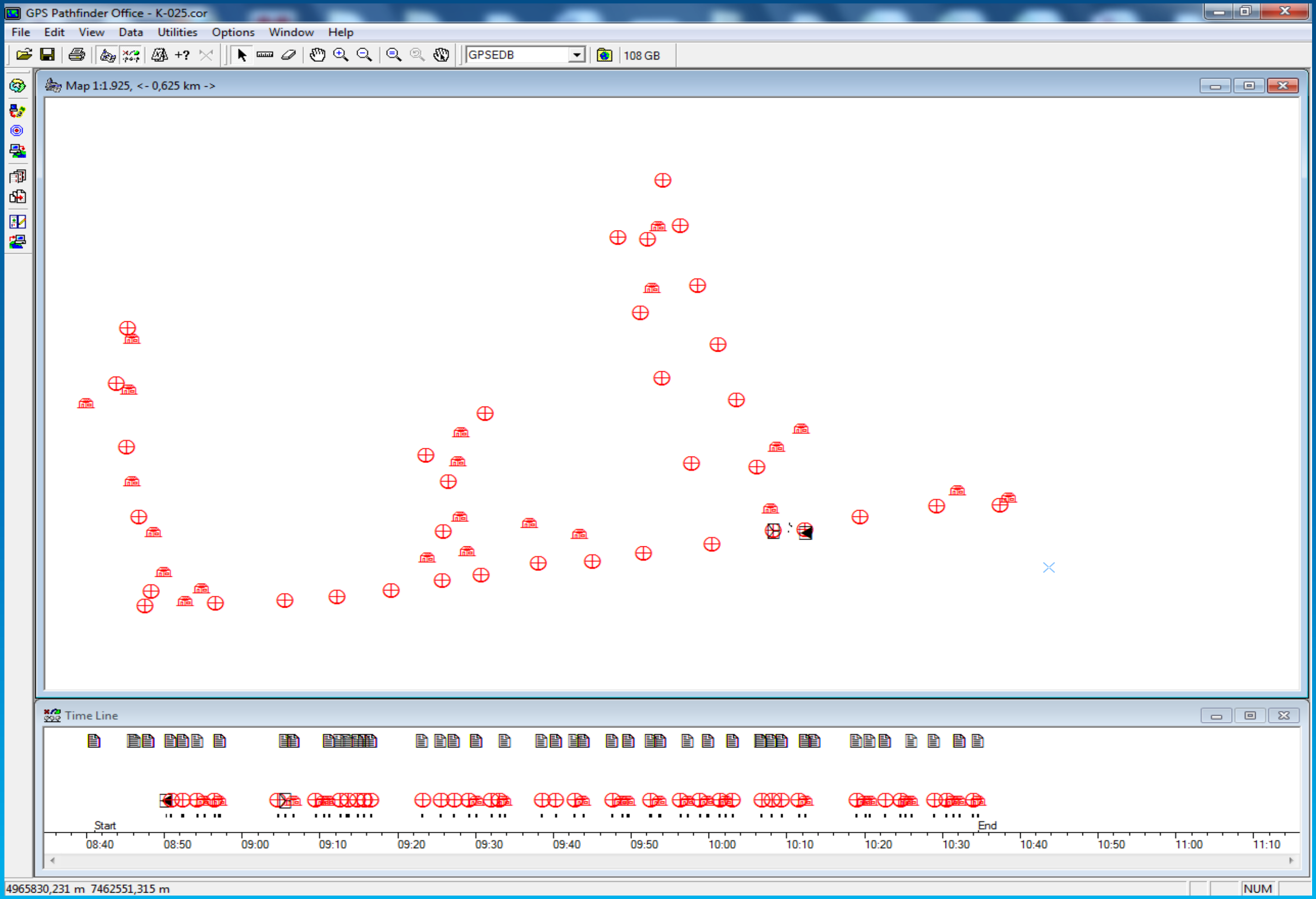
Reference station EDB

- GPS data correction



DATA POST-PROCESSING

- **Processing data in the GPS software in the office.**
- **Checking the validity of the data and the accuracy of the entered attributes and coordinates.**

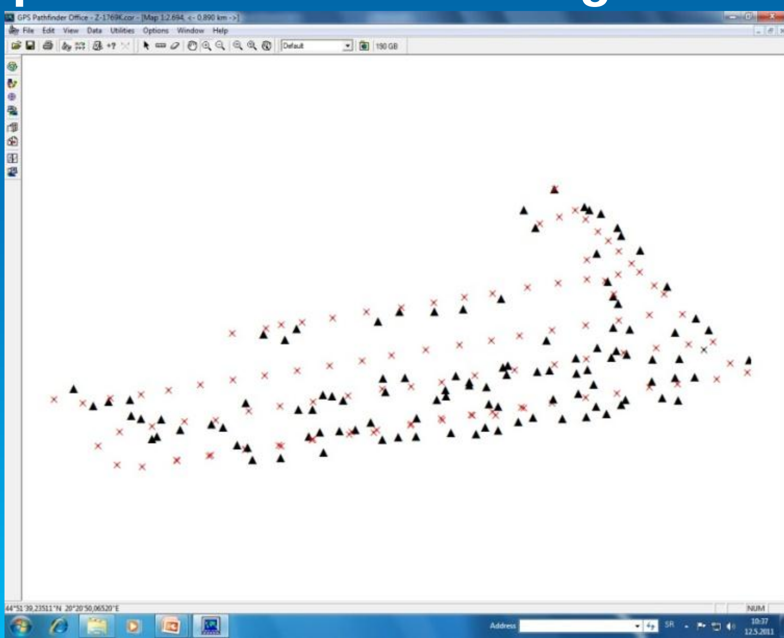


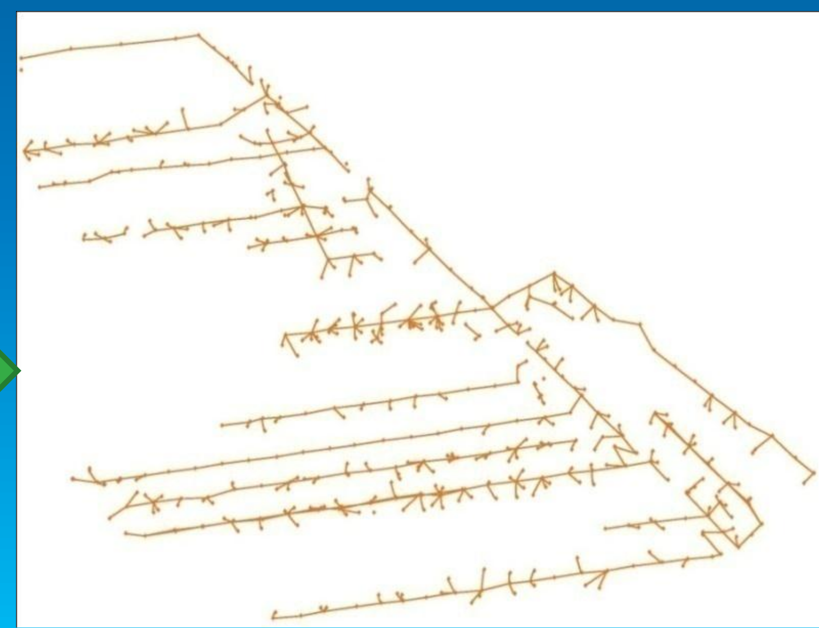
GPS capturing results

It turned out that one GPS team can record 15 to 20 objects per hour, on average. Complete HV and MV networks were recorded in such maner (about 40,000 of poles), as well as 1,500 substations regions at low voltage levels, with all data transferred to the GIS database.

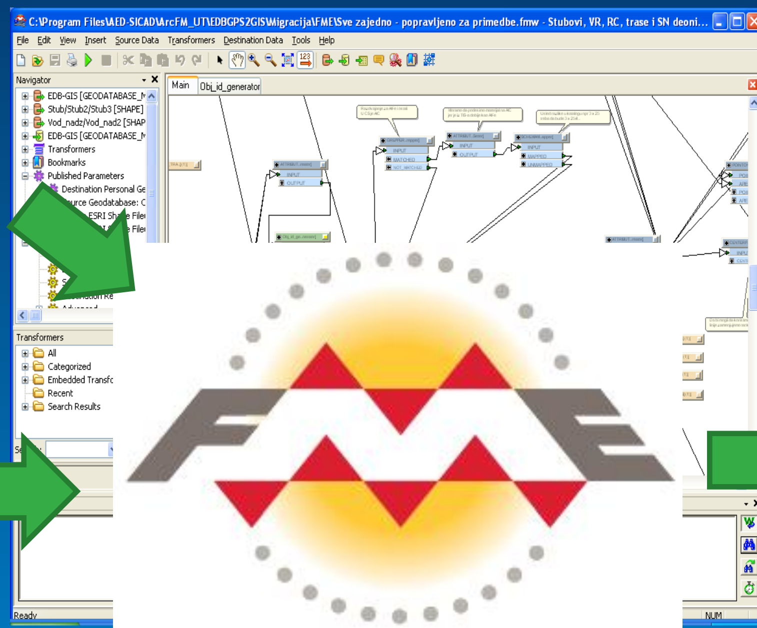
GPS data acquisition methodology

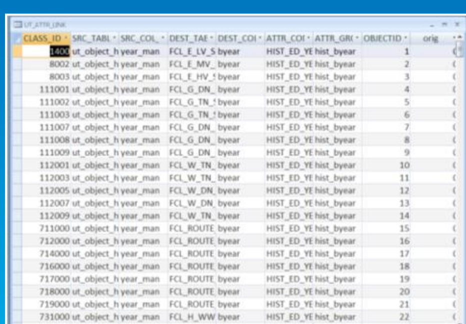
- The mass data acquisition and lack of personnel required such application solution that would directly form network graph of the collected data. Methodology for data entry into the GPS device is designed to include only dotted elements - nodes (poles, substations, switching equipment, distribution boxes and service points). Developed software solution automatically forms a graph network based on their topological attributes. This creates a topological reconstruction graph network without the need for time consuming vectorization process of power lines at all voltage levels.





GPS data migration




UT_ATTR_LINK

CLASS_ID	SRC_TABL	SRC_COL_	DEST_TAE	DEST_COI	ATTR_COI	ATTR_GR(	OBJECTID	orig
1400	ut_object_h	year_man	FCL_E_LV_S	byear	HIST_ED_YE	hist_byear	1	(
8002	ut_object_h	year_man	FCL_E_MV_	byear	HIST_ED_YE	hist_byear	2	(
8003	ut_object_h	year_man	FCL_E_HV_!	byear	HIST_ED_YE	hist_byear	3	(
111001	ut_object_h	year_man	FCL_G_DN_	byear	HIST_ED_YE	hist_byear	4	(
111002	ut_object_h	year_man	FCL_G_TN_!	byear	HIST_ED_YE	hist_byear	5	(
111003	ut_object_h	year_man	FCL_G_TN_!	byear	HIST_ED_YE	hist_byear	6	(
111007	ut_object_h	year_man	FCL_G_DN_	byear	HIST_ED_YE	hist_byear	7	(
111008	ut_object_h	year_man	FCL_G_DN_	byear	HIST_ED_YE	hist_byear	8	(
111009	ut_object_h	year_man	FCL_G_DN_	byear	HIST_ED_YE	hist_byear	9	(
112001	ut_object_h	year_man	FCL_W_TN_	byear	HIST_ED_YE	hist_byear	10	(
112003	ut_object_h	year_man	FCL_W_TN_	byear	HIST_ED_YE	hist_byear	11	(
112005	ut_object_h	year_man	FCL_W_DN_	byear	HIST_ED_YE	hist_byear	12	(
112007	ut_object_h	year_man	FCL_W_DN_	byear	HIST_ED_YE	hist_byear	13	(
112009	ut_object_h	year_man	FCL_W_TN_	byear	HIST_ED_YE	hist_byear	14	(
711000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	15	(
712000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	16	(
714000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	17	(
716000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	18	(
717000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	19	(
718000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	20	(
719000	ut_object_h	year_man	FCL_ROUTE	byear	HIST_ED_YE	hist_byear	21	(
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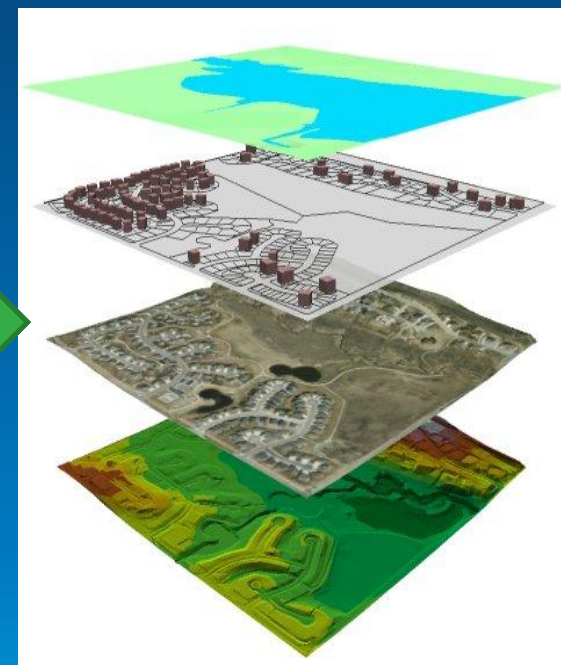
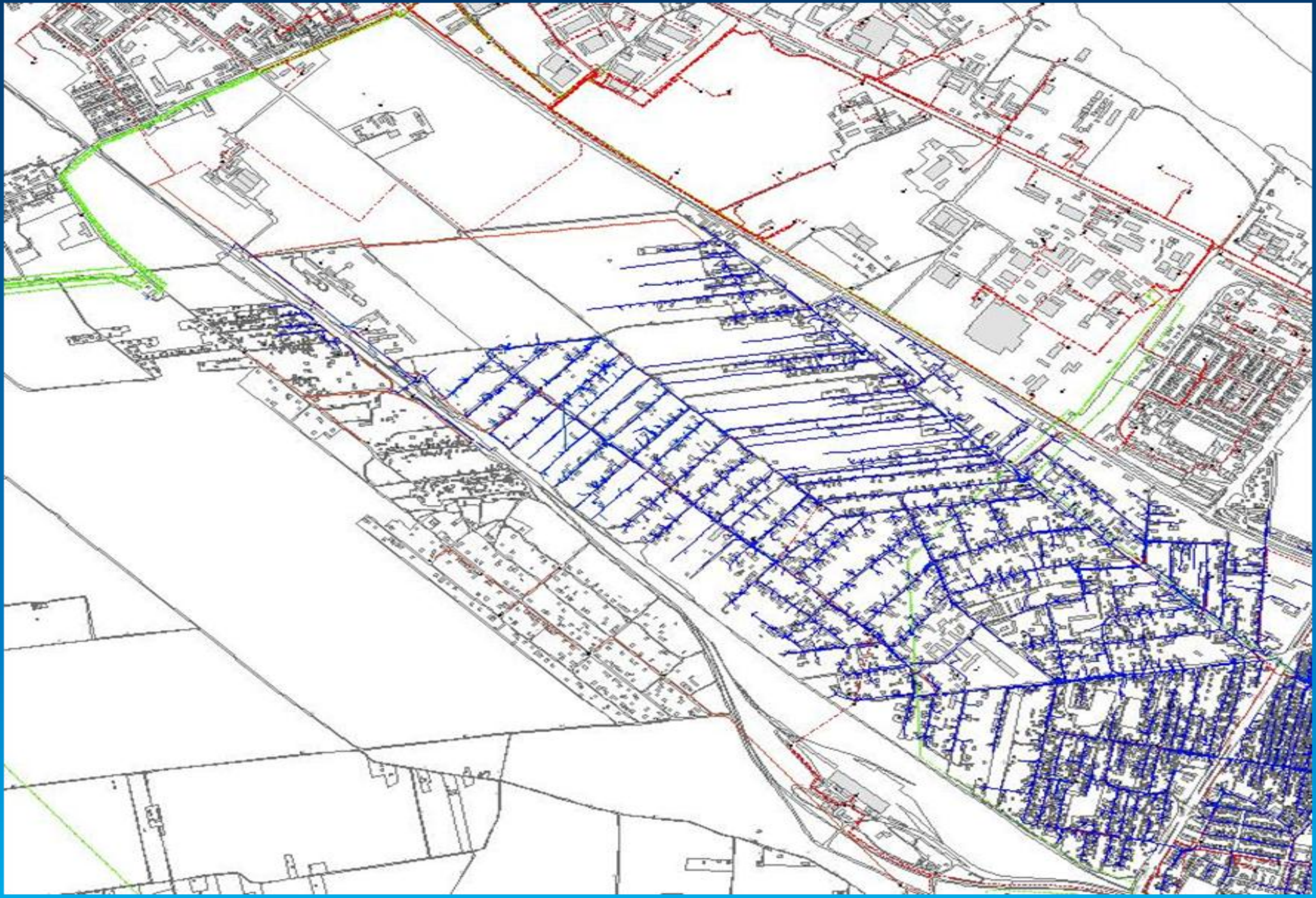


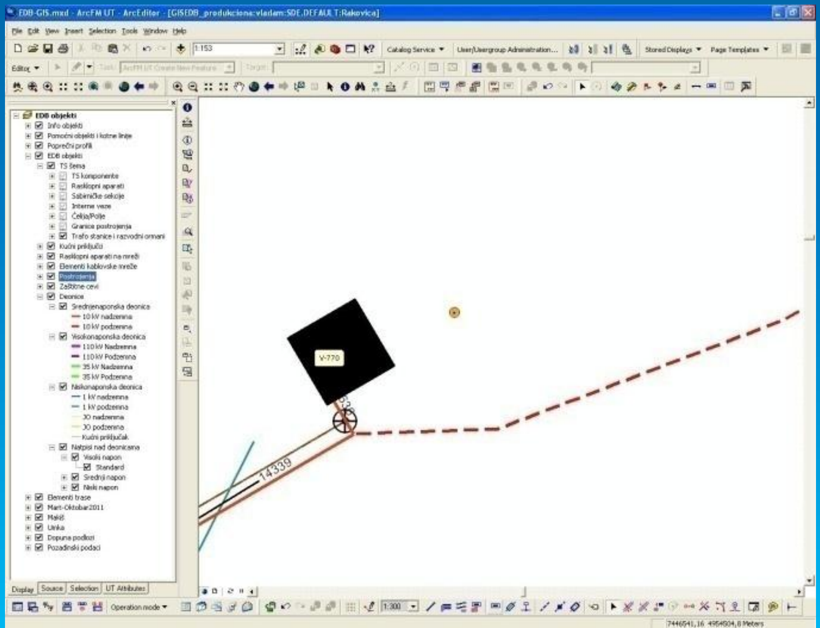
- Migration data in GIS via FME software
- GPS - GIS

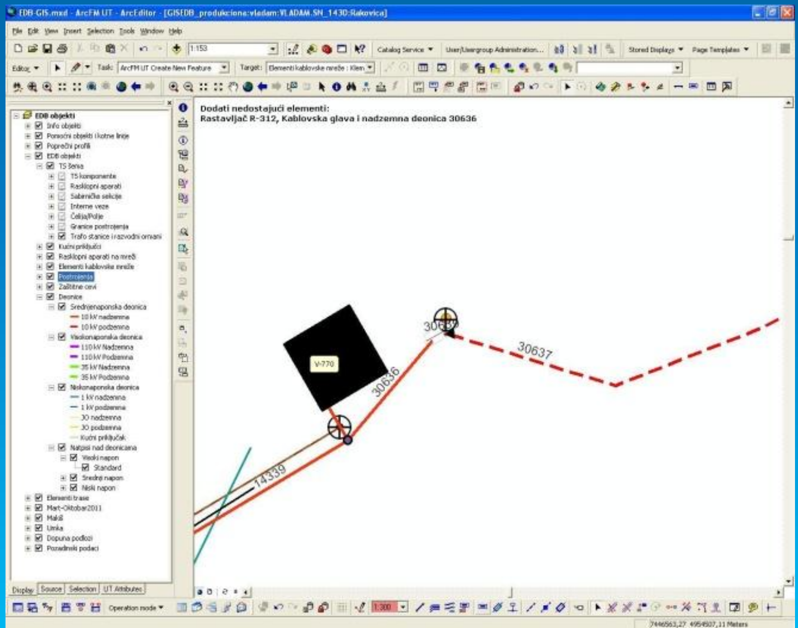
GPS DATA IN GEODATABASE



DATA POST-PROCESSING

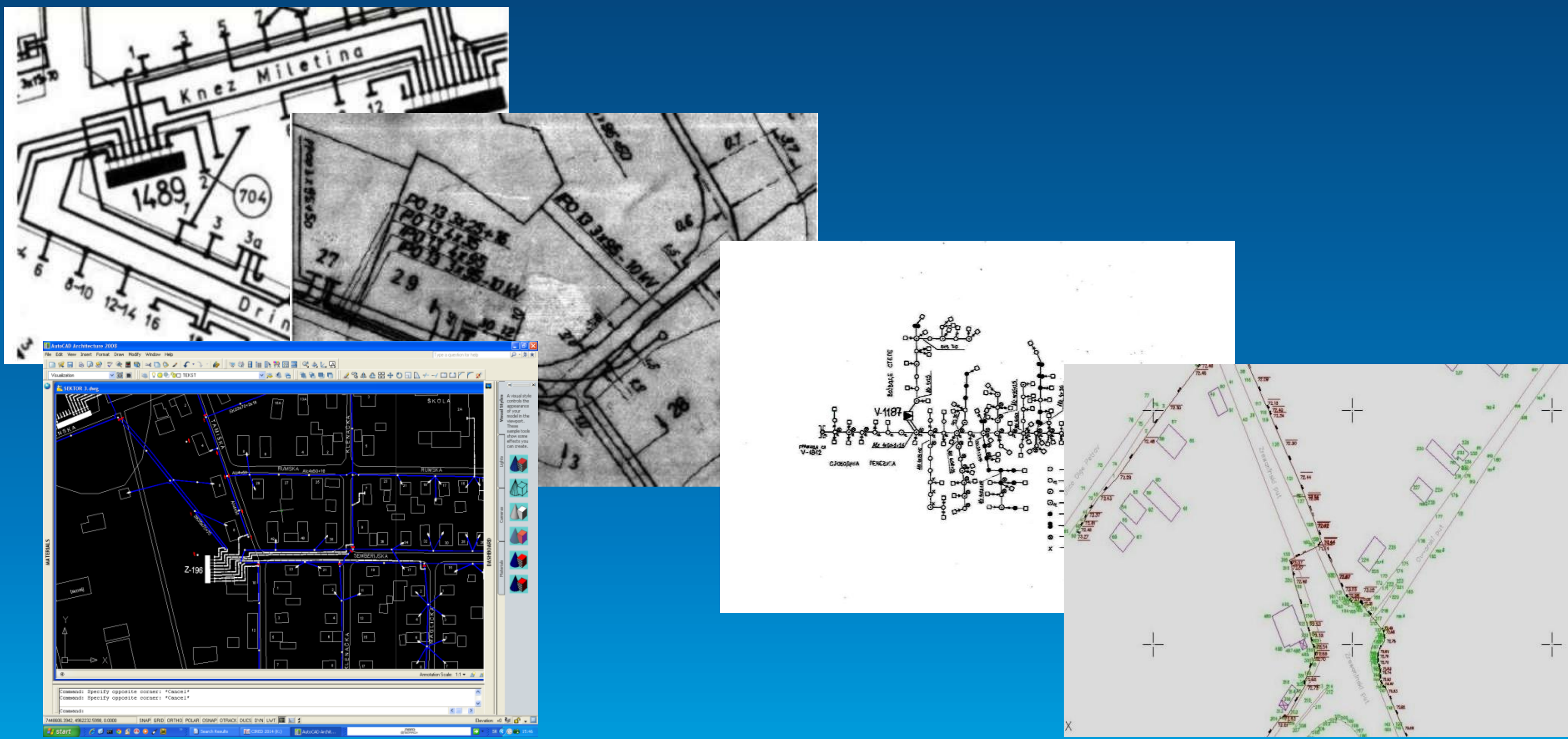
- **Corrects errors made during GPS collecting and during migration, and verifies the data.**
- **PRINT LARGE AREA**





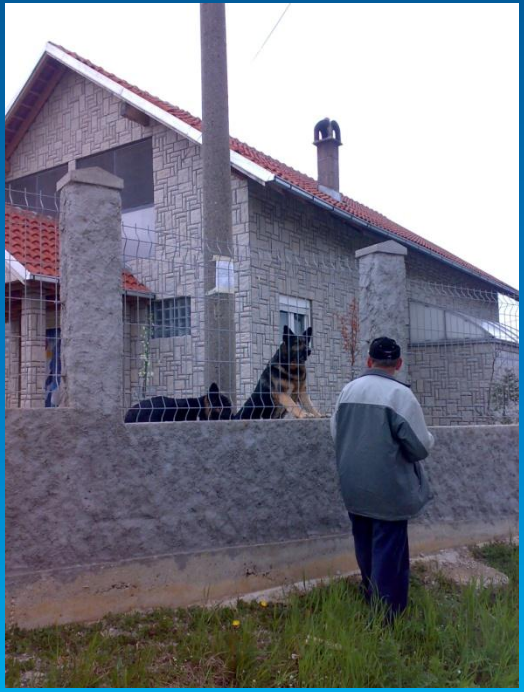
PROBLEMS - INITIAL CONDITION

- **Different initial condition in various types of documents - which is correct?**



PROBLEMS IN THE FIELD

- One of the reasons for the use of laser rangefinder
- Disabled the arrival at the measuring point.
- Direct contact with customers
- Locked, dog

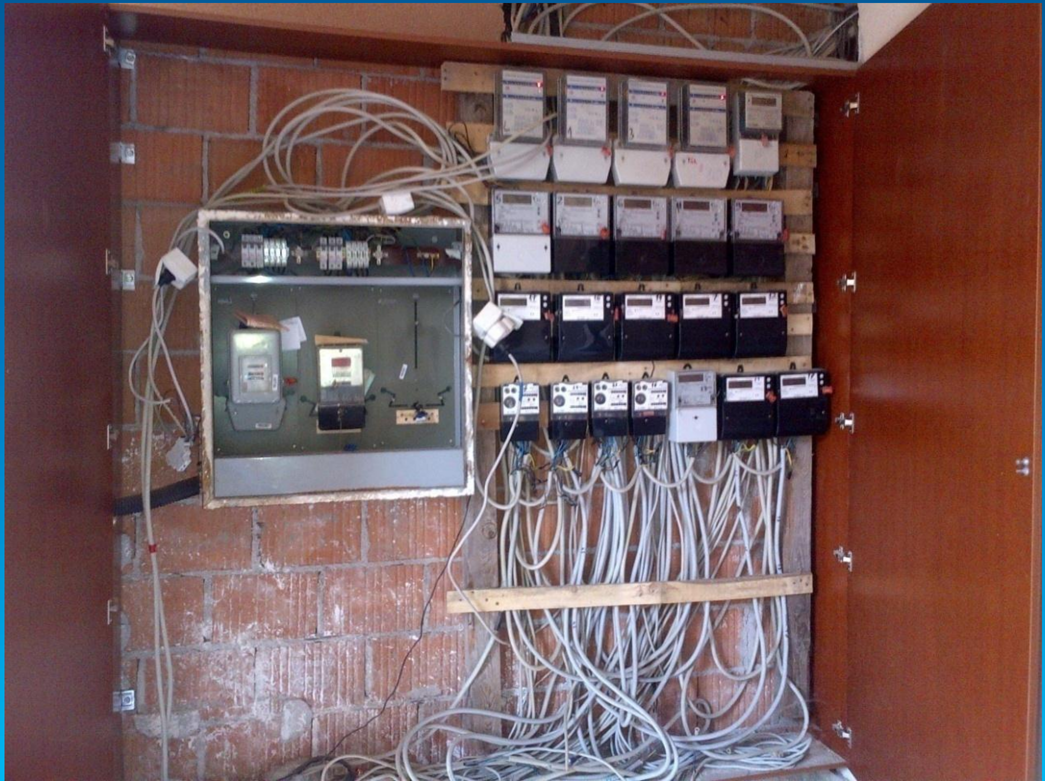


ILLEGAL CONSUMPTION

ILLEGAL CONSUMPTION

PROBLEMS IN THE FIELD - ILLIGAL CONSUMPTION

- New service points that are kept in the system in application stage are already energized
- consumers are not in the system
- There are not the meter reading.
- Border changes affect the topology of substation consumption area, and therefore the measurement results.



PROBLEMS – LASER BEAM

in foggy day happens reflection of the laser beam which produces the wrong length. Also local magnetic fields affect the compass located in the laser rangefinder and it happens that the object is wrongly recorded.

PROBLEMS – PUBLIC LIGHT NETWORK

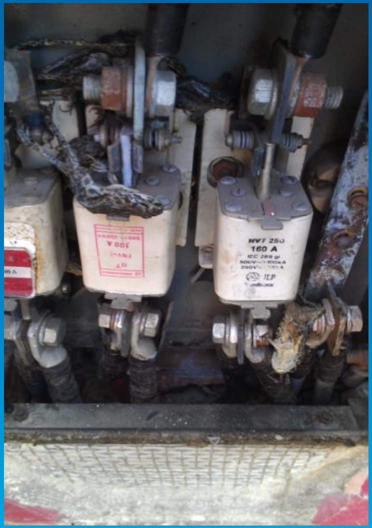
- Incomplete documentation of public lights.
- Recording consumption public light region of the transformer requires tracking stocks public lights whose boundaries do not coincide with the boundaries of the regions with the transformer which supplies public lights network.
- No measurements in public lights distribution boxes.
- illegal lights on the network (reflectors)

Unauthorized consumption by connecting directly to the public lights poles.

TS	Brojilo	RO JO			snaga JO W
V-1091	NE	NE	150	500	10350
B-474	NE	NE	150	500	0
B-1461	u ormanu	DA	150	500	0
B-685	NE	NE	150	500	0
B-694	NE	NE	150	500	0
B-961	NE	NE	150	500	0
V-13	NE	NE	150	500	3150
V-1114	NE	NE	150	500	1500
V-1115	NE	NE	150	500	3000
V-35	NE	NE	150	500	14150
V-296	DA	DA	150	500	2550
Z-1073	neprovereno	DA	150	500	0

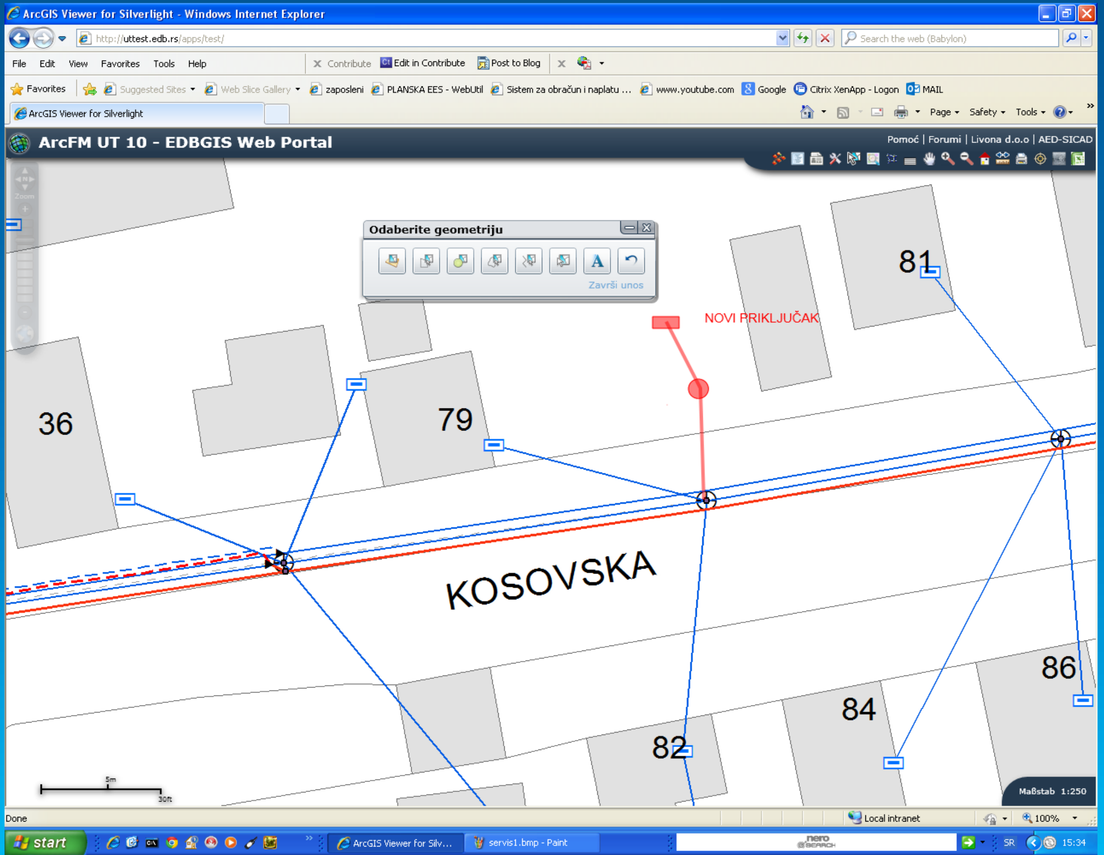
PROBLEMS – UNMARKED CABLES

- Unmarked cables in the terminal cable boxes
- Unmarked feaders in substations



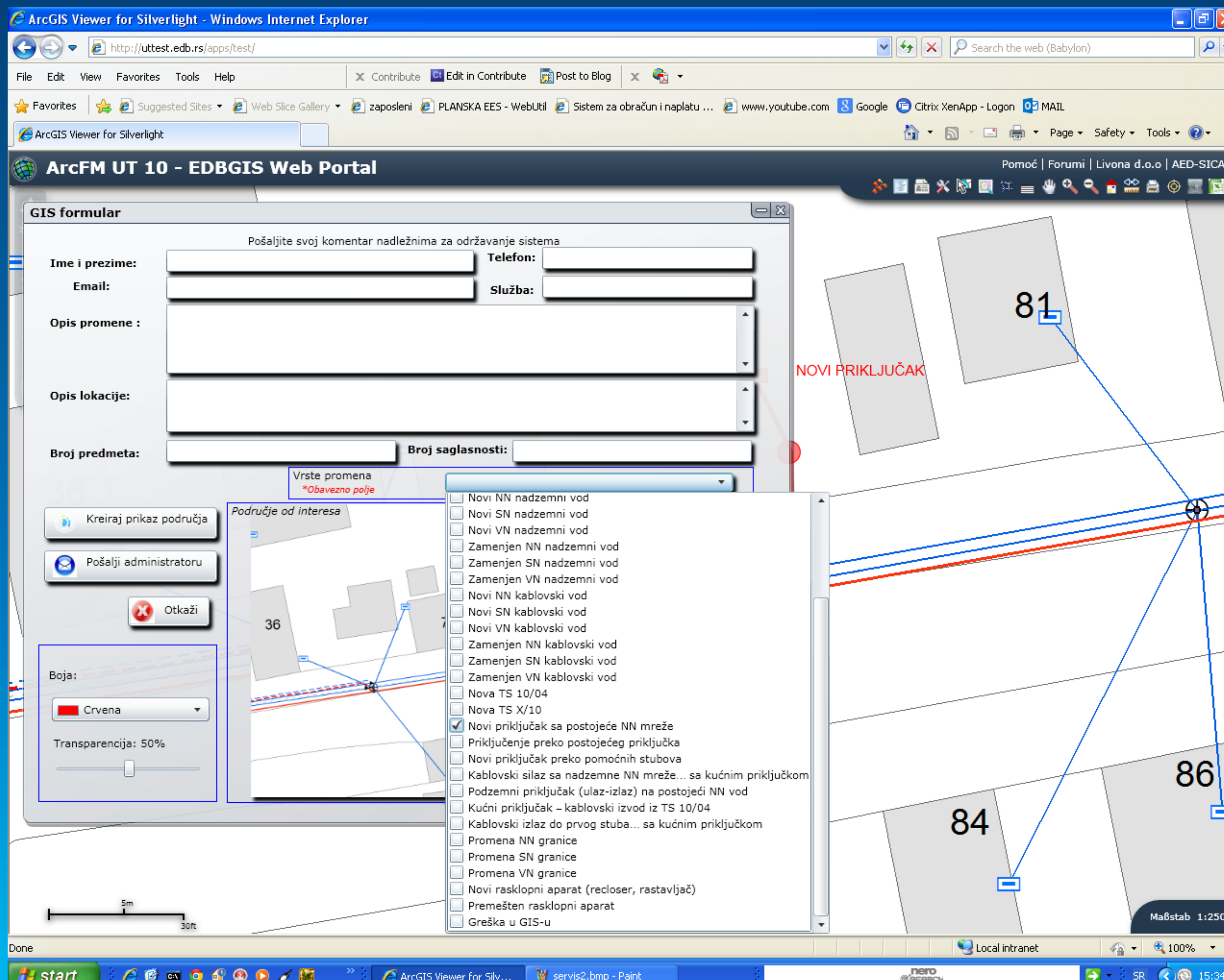
PROBLEMS – NETWORK CHANGES

- **The changes are not submitted to a whole completely, or not submitted in proper form that would allow fast and accurate updating of data. It is therefore created a procedure of submitting changes centrally so that all changes are coming in GIS team.**



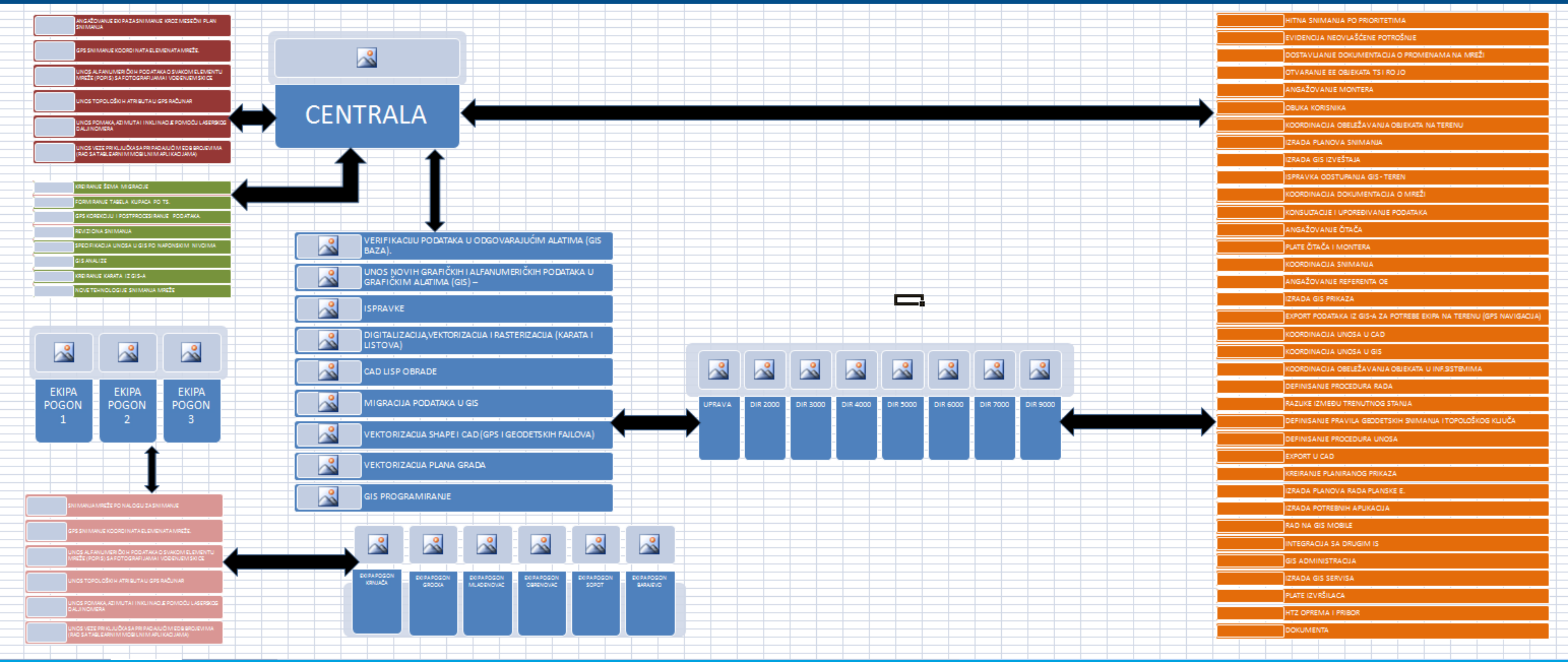
PROBLEMS – NETWORK CHANGES

- **GIS WEB form**



PROBLEMS – GIS STRUCTURE

The project team - required GIS sector
Coordination of many different departements.
Permission for GIS team
opening objects



GIS SERVICES - NAVIGATION TO POI

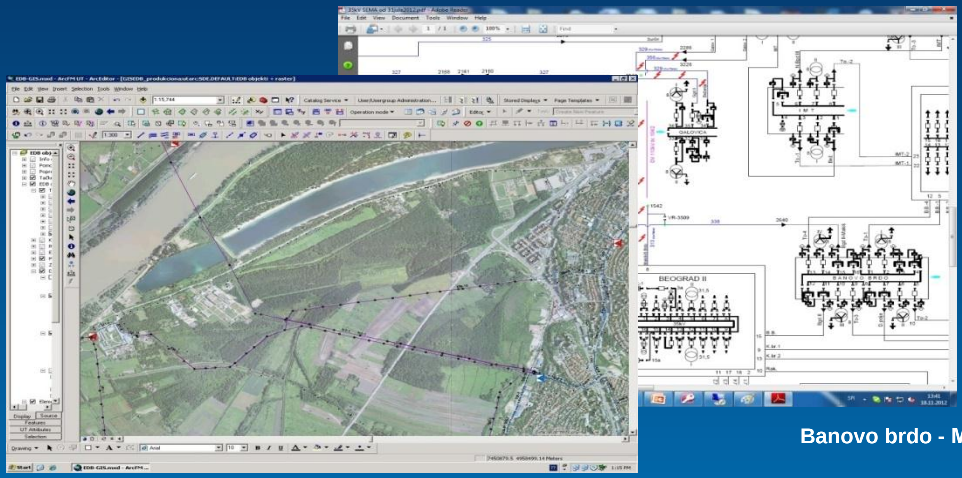
If we avoid all the problems in the field and office we obtain GIS services and analysis.

•Problem navigating dispatch team to the location of objects of interest

•Poles, switches, reclosers, substations.

•Export from geodatabase, convert and import in GPS navigation device.

GIS ANALYSIS



TS	Podzemna (m)	Nadzemna (m)
B-474	354.15	0.00
B-685	277.44	0.00
B-694	951.20	1126.64
B-1461	248.52	0.00
B-961	537.04	21.59
V-13	921.18	1532.32
V-296	754.14	1184.99
V-1091	1697.78	1856.07
V-1114	727.57	679.04
V-1115	765.50	1126.64
V-35	129.44	7332.16
Z-1073	446.95	0.00

Banovo brdo - Makiš

TS - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - 2640
2640 - 2656
2656 - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - spojnica
spojnica - TS

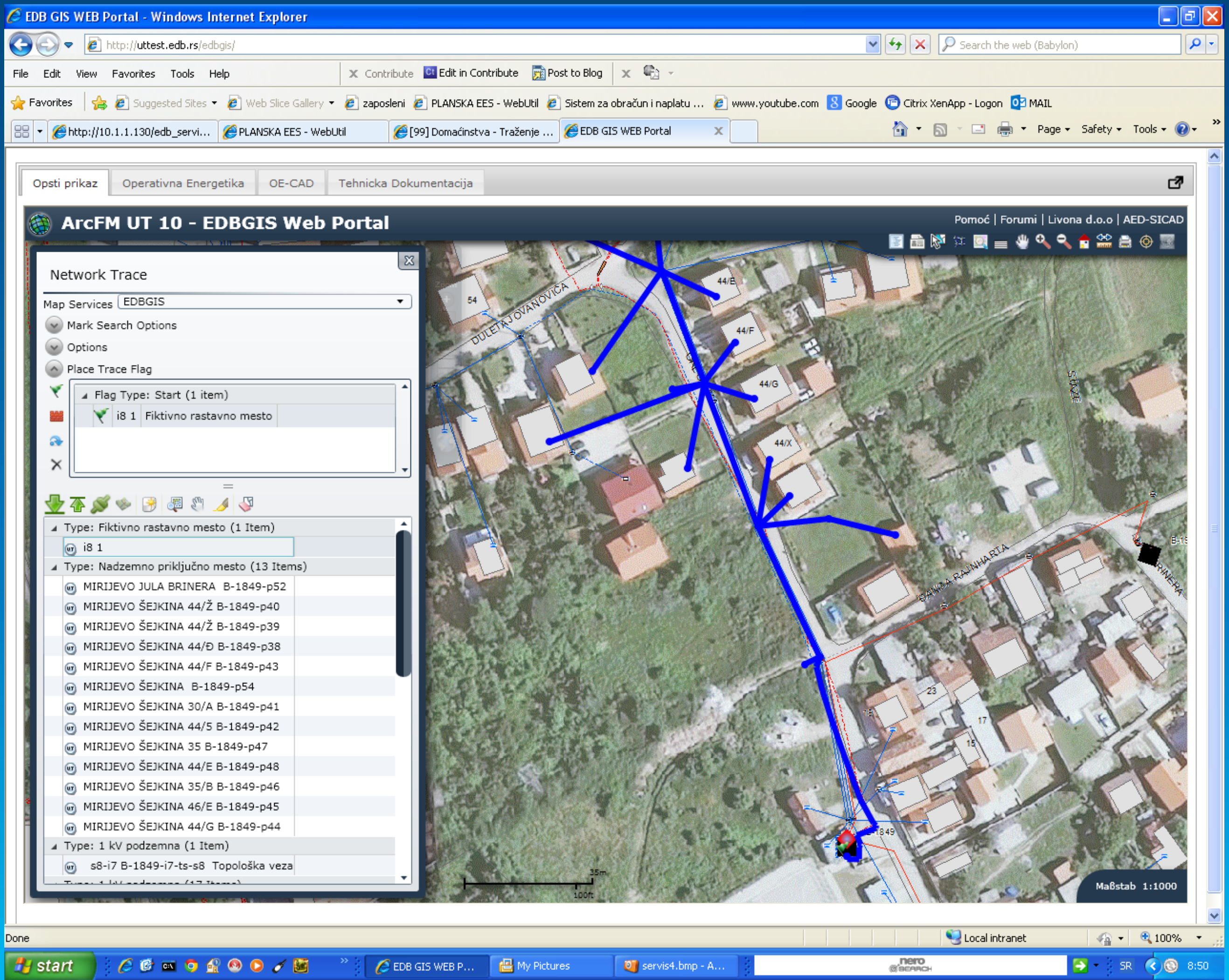
Naponski nivo	85 stubova 10kV, 490 stubova 1kV
Tip	2 rešetkasta, 2 cevna, 571 okrugli
Materijal	41 drveni,5 čeličnih, 529 betonskih
Dužina stabla	630/9=43 stuba, 630/12=3,630/11=1, 400/12=1, 400/11=1, 315/12=14, 315/10=1, 250/9=351, 220/8=6, 2000/9=1, 1600/9=4, 1600/12=4, 1600/11=3, 1000/9=119, 1000/12=2, 1000/11=3
Stanje	17 krivih I 2 oštećena stuba
Druge instalacije	Telekom+kds=50, Telekom=61,kds=172
Svetiljka	O reflektora I 353 stubova sa jednom svetiljkom I 7 sa dve svetiljke
Odvodnik prednapona	2 silikonska I 6 porcelanskih
Vodjenje	37 dvostruko,467 jednostruko I 62 mešovito I 9 trostruko
Broj priključaka	5 stubova sa po 6 priključaka, 13 stubova sa po 5 priključaka, 27 stubova sa po 4 priključaka, 69 stubova sa po 3 priključka, 108 sa po 2, 173 sa 1 i 178 bez priključaka
Osigurači	147 stubova sa osiguračima
IMM	0 izmeštenih mesta merenja
Zajednički stub	42 zajedničkih stubova pod granicama

GIS ANALYSIS

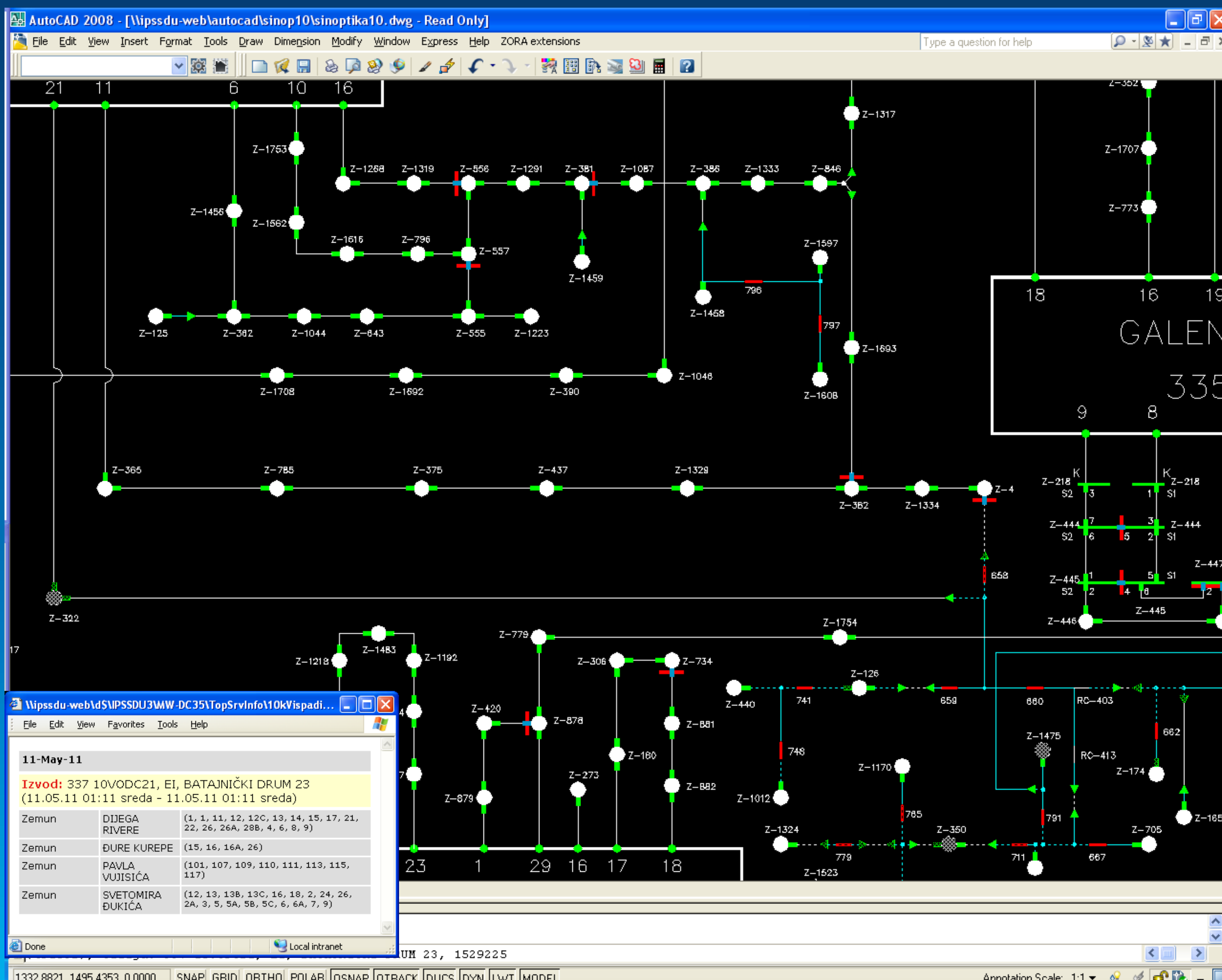
- **Substation Internal schema**

GIS ANALYSIS

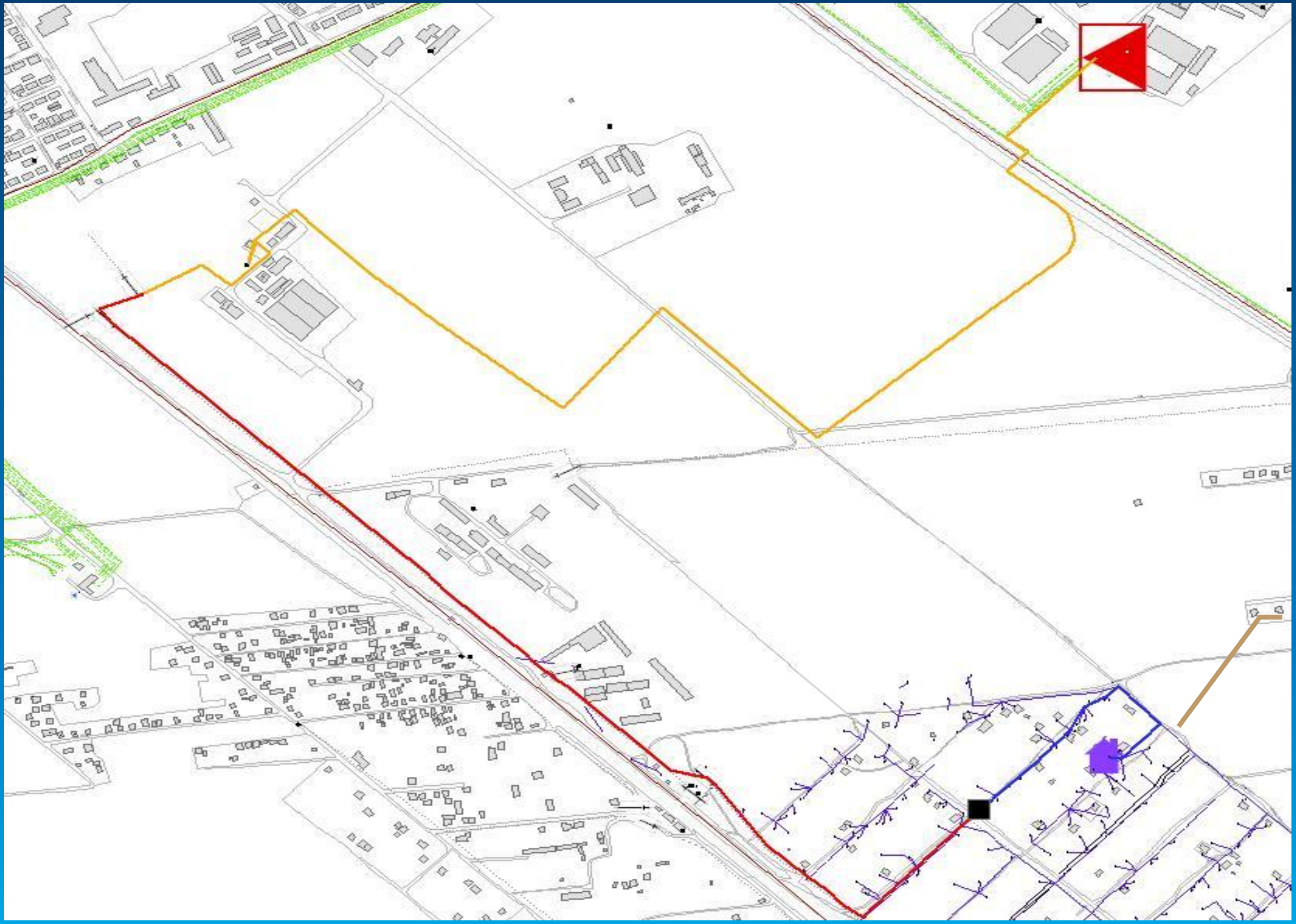
- precise identification of the power suply of each customer.



GIS – Dispatching Control Center IS

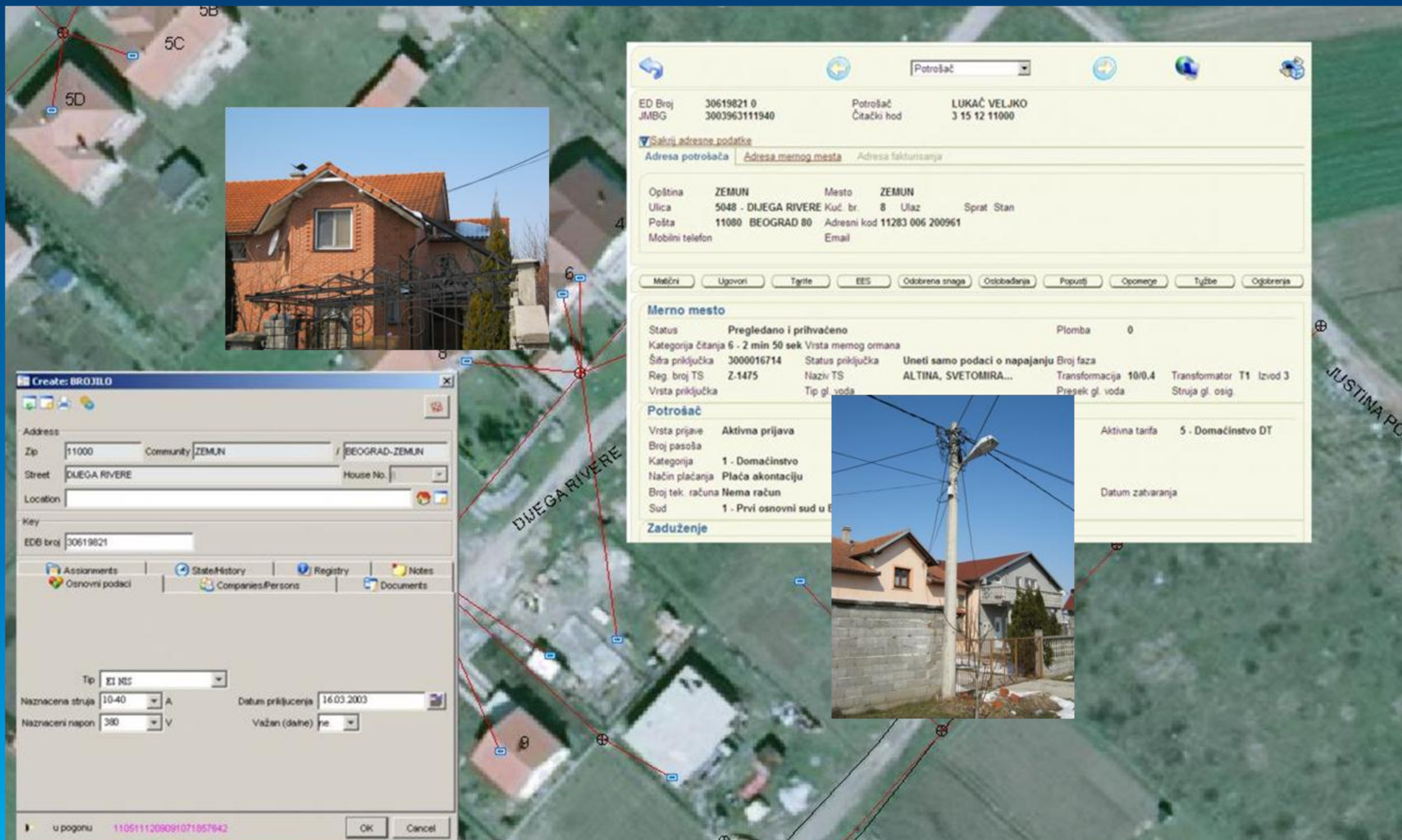


GIS – Dispatching Control Center IS



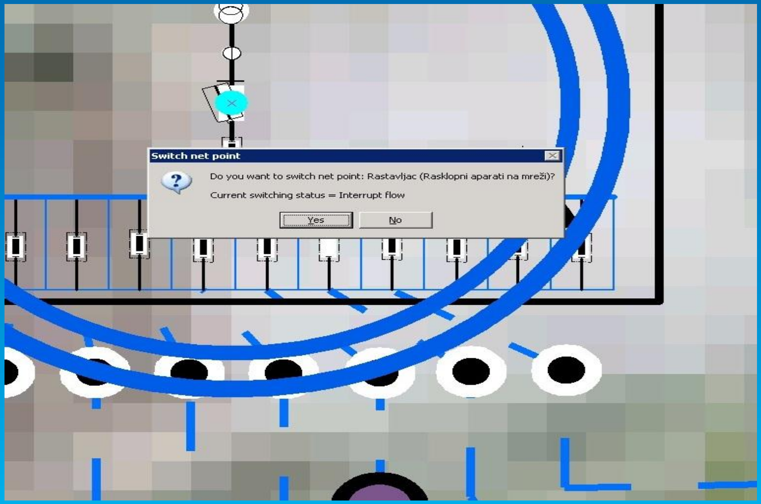
Dijega Rivere 8

GIS – BILLING(CIS)



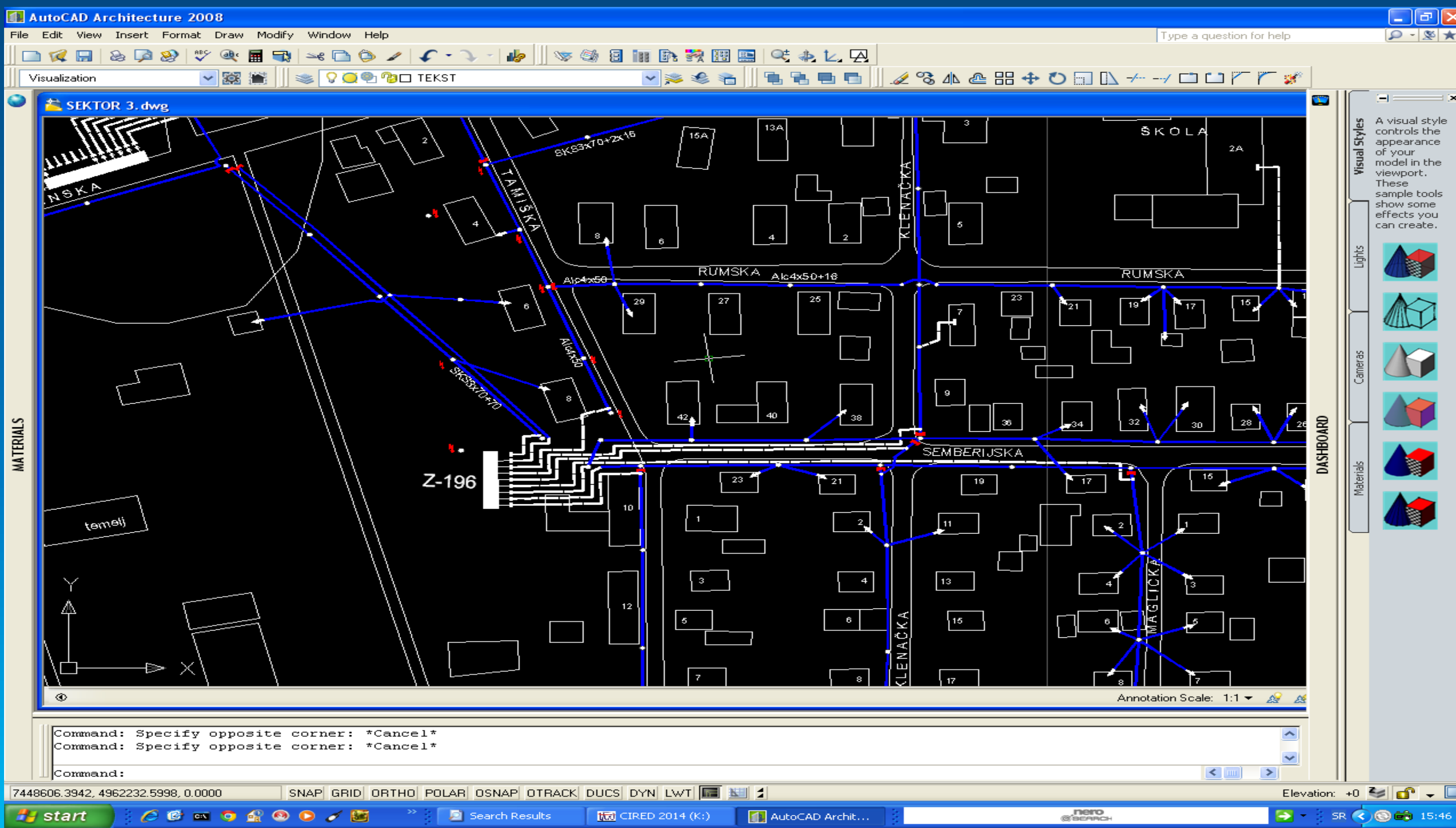
GIS ANALYSES

- - internal schema substation
- - change status elements



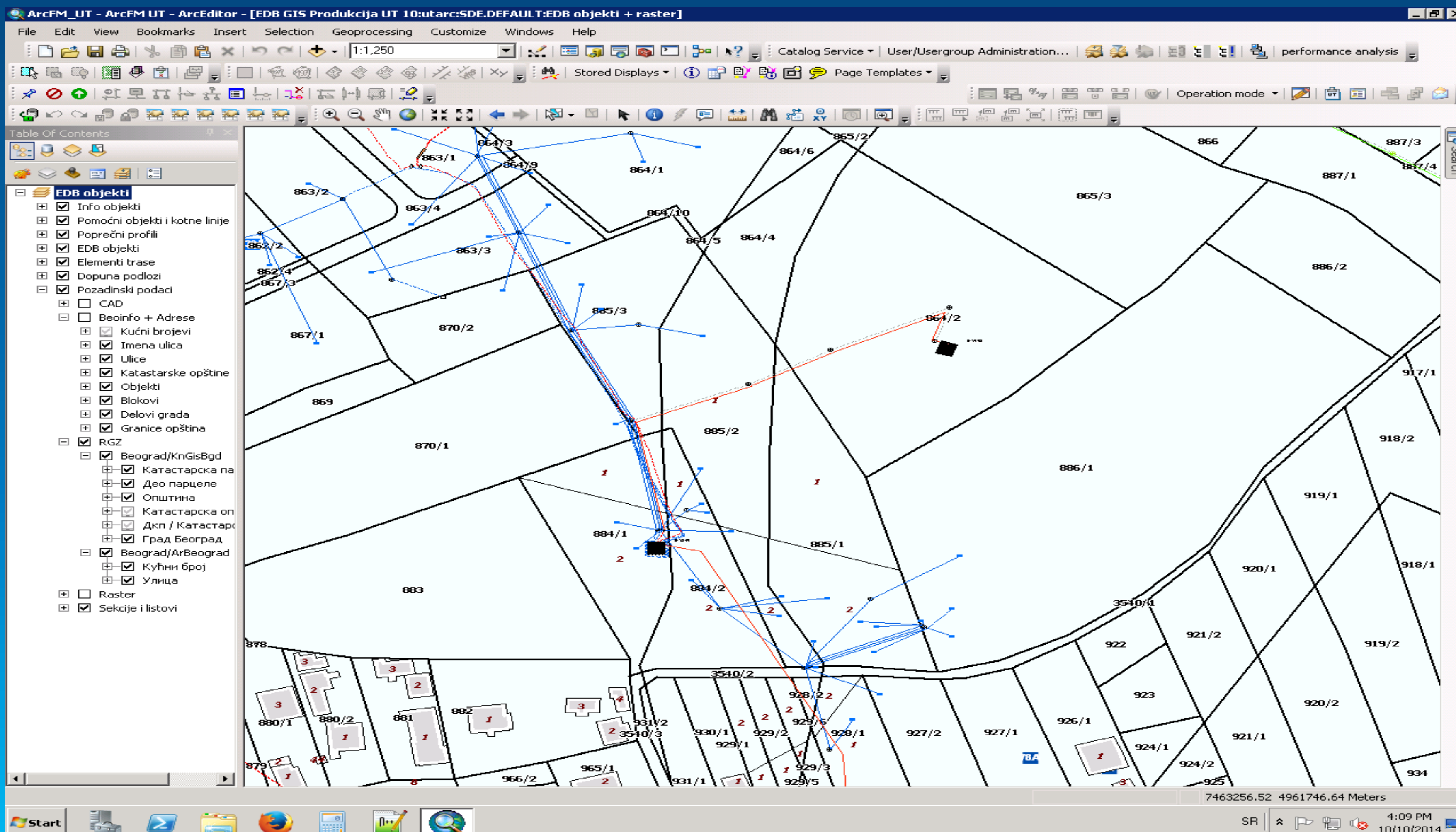
EXPORT FROM GIS

Export GIS – CAD for planning network department
Export for navigation
Export for asset management



CADASTRE REST SERVICE

incomplete
address register
cadastral parcels register



GIS ANALYSES

- Distribution of customers by categories, method of heating, type of connection
- Distribution of illegal networks, illegal consumption
- Failures, audits, repairs, items
- Locked, dangerous dog, denied access to measuring point
- Dialysis, an artificial lung, schools, hospitals

GIS – BILLING (CIS) AMR - COMERCIAL LOSSES

Losses analyses – Customers list by substation from GIS relocated meters position

POTROŠNJA PO TS 10/04

AMR - GUBICI PO IZABRANOJ TS 10/0.4

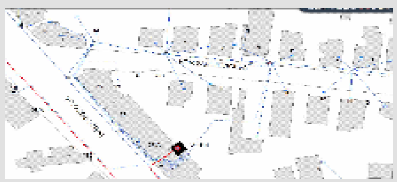
upit | sve | izbor ts

	Naziv	Broj brojila	Konstanta	Snaga TS
V-1114	BULEVAR VOJ. STEPE 37-39	00070828	300	1000

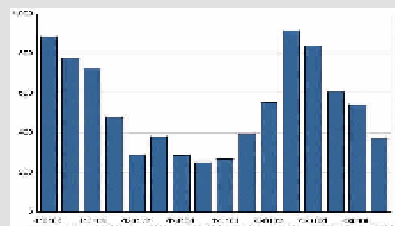
Snaga JO	Procena energije JO	Način grejanja	Nadzemna mreza(m)	Kablovska mreza(m)
5	1500	MEŠANO	679	727,57

dupli klik - spisak kupaca

Napomena



GIS PRIKAZ TERITORIJE



AMR OCITANJA PO OBRAČUNU

PDF | XLS

MERENJA AMR TS 10/0.4

Dateofreading	Stanje VTA	Stanje MTA	Stanje VTR	Stanje MTR
11.07.2014	11718	7189	2021	761
10.07.2014	11712	7186	2019	761
09.07.2014	11704	7184	2017	760
08.07.2014	11697	7181	2015	759
07.07.2014	11689	7178	2013	758
06.07.2014	11683	7176	2011	758
05.07.2014	11676	7174	2010	757
04.07.2014	11669	7171	2008	756

mesečna SNAGA AMR TS 10/0.4

Datum max	vta 01.mes	mta 01.mes	Maxpt1	Maxpt2
01.08.2014	11855,64	7237,477	,636	,464
01.07.2014	11649,07	7163,346	,728	,504
01.06.2014	11430,25	7081,428	,76	,752
01.05.2014	11190,21	6982,893	,892	1,172
01.04.2014	10929,88	6847,544	1,084	1,508

POTROŠNJA DOMAĆINSTVA

Obračun	Citanje Od	Citanje Do	Dana	Neo	Očit	kom	Kwh
440103	02.06.14	02.07.14	30	14		228	64481
440102	02.05.14	02.06.14	31	6		228	76618
440101	02.04.14	02.05.14	30	14		228	92970
430106	02.03.14	02.04.14	31	13		228	126900
430105	02.02.14	02.03.14	28	13		228	142252
430104	03.01.14	03.02.14	31	14		228	185018
430103	02.12.13	02.01.14	31		13	229	201232
430102	01.11.13	01.12.13	30		10	229	133289
430101	01.10.13	01.11.13	31		5	229	91956
420106	04.09.13	04.10.13	30		13	229	68194
420105	05.08.13	05.09.13	31		12	229	64928
420104	04.07.13	04.08.13	31		14	228	64188

POTROŠNJA VIRMANI

Obračun	Citanje Od	Citanje Do	Dana	Neo	Očit	Kom	Kwh
2220000	02.06.14	02.07.14	30		6	20	13225
2210000	02.05.14	02.06.14	31		5	20	13994
2200000	02.04.14	02.05.14	30		6	20	13975
2190000	01.03.14	01.04.14	31		3	20	23057
2180000	02.02.14	02.03.14	28	1	3	22	31508
2170000	03.01.14	03.02.14	31		2	22	39826
2160000	02.12.13	02.01.14	31		5	21	32157
2150000	01.11.13	01.12.13	30		4	21	16094
2140000	01.10.13	01.11.13	31		6	21	15436
2130000	02.09.13	02.10.13	30		6	21	13775
2120000	01.08.13	01.09.13	31		6	21	14109
2110000	25.06.13	26.07.13	31	1	6	21	13718

IZRAČUNATi GUBICI AMR -(D+V)

Citanje Od	Citanje Do	AMR Kwh	D+V Kwh	Razlika Kwh	%
02.06.14	02.07.14	89862	77706	12156	13.53
02.05.14	02.06.14	97134	90612	6522	6.71
02.04.14	02.05.14	122660	106945	15715	12.81
02.03.14	02.04.14	160153	149957	10196	6.37
02.02.14	02.03.14	188071	173760	14311	7.61
03.01.14	03.02.14	244222	224844	19378	7.93
02.12.13	02.01.14	273105	233389	39716	14.54
01.11.13	01.12.13	164988	149383	15605	9.46
01.10.13	01.11.13	118671	107392	11279	9.50
04.09.13	04.10.13	92657	81969	10688	11.54
05.08.13	05.09.13		79037		
04.07.13	04.08.13		77906		

GIS – GPS BENEFITS

Mapped networks in one place

- Address system house connections
- Network analysis - determining the directions of power, planned off ...
- better planning
- Easier approval of the location and energy compliance
- recording failures
- SSem 10/04 TS
- Calculations voltage drops
- The exact length of lines and sections
- Photos of network components
- accurately labeling

- alphanumeric up to date
- ASSETS MANAGEMENT
- Navigation on the site and the elements
- The exact positions of the poles, substations, reclosers,potheads disconnectors, lights, advertising, non-energy network
- The exact positions of the telecommunications network
- The exact locations of the illegal network
- Correct network topology
- Audited in new ways and new technologies

THANK YOU

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GIS manager

GPS Project leader

Lead IT specialist

The Electric Power Distribution – Belgrade

ICT Department