



# Using GSM/GPRS Technology For Generation Of Precise Digital Terrain Model (DTM)

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# Outline

GSM/GPRS system for data teletransmission Static tests of designed system. > Dynamic DTM creation and dynamic tests of the system with centimeter level of accuracy Statistical analyses of various GPS techniques.

Precise DTM generation

Conclusions

### **GSM/GPRS** system for data teletransmission

The project is run and coordinated by the Chair of Satellite Geodesy and Navigation, Warmia and Mazury University in Olsztyn, Poland in cooperation with:

Biatel S.A. in Bialystok,

Polkomtel S.A. in Warsaw,

Maritime Office in Gdynia,

Naval Academy in Gdynia.



**GSM/GPRS** system for data teletransmission

Growing need of GPS real-time, precise and reliable applications, where stable and not expensive wireless connection is essential

Precise navigation

Land surveying

Vehicle (fleet) monitoring

Limitations of classical UHF radio-modems

### GSM / GPRS

General Packet Radio Service

#### Advantages

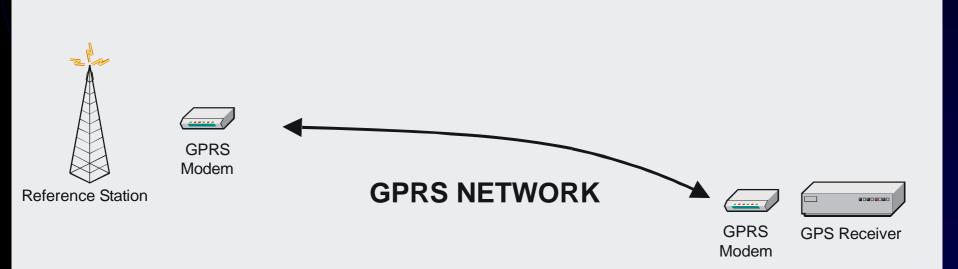
- No costs of building a network
   Easy to define costs of using
   Low rates of data teletransmission
- Fast enough speed of transmission
- Rare breakdowns and redundancy (3 operators in Poland)
- Good coverage
- Low cost of the user equipment



### **GSM/GPRS** system for data teletransmission

#### **Phase 1 (P2P connection)**

#### Direct Transmission



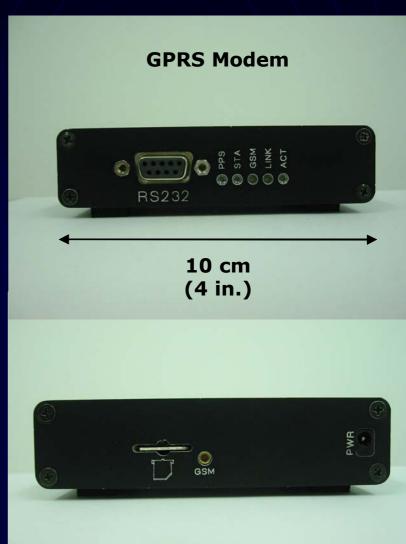
Sending DGPS/RTK corrections via direct transmission

### >> connection is limited to only two modems

# **GPRS modem**

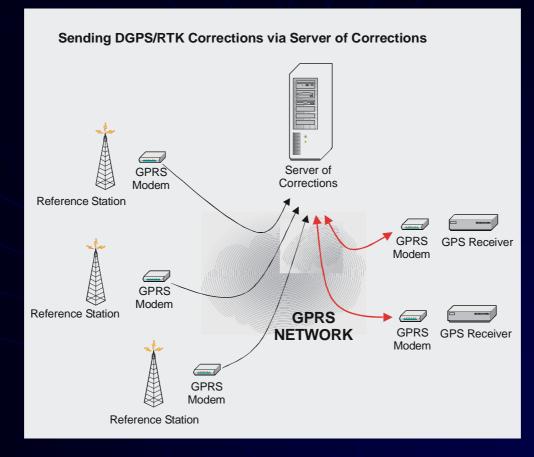
Special, dedicated to our purposes GPRS modem compact in size > not heavy operated by just one switch

possibility of upgrading the modem's software



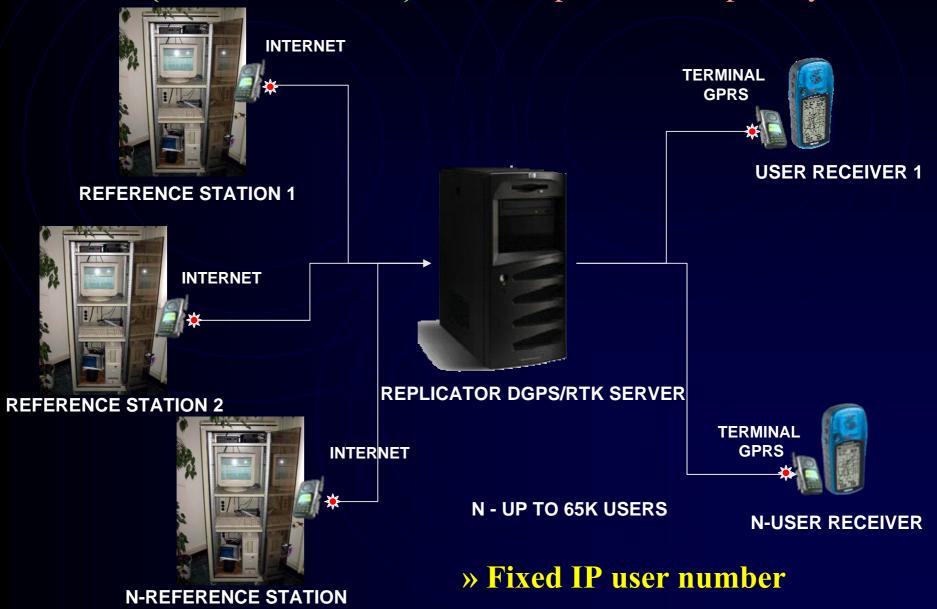
### **GSM/GPRS** system for data teletransmission

#### **Phase 2 (server of corrections)**



» unlimited number of users» delays in transmission

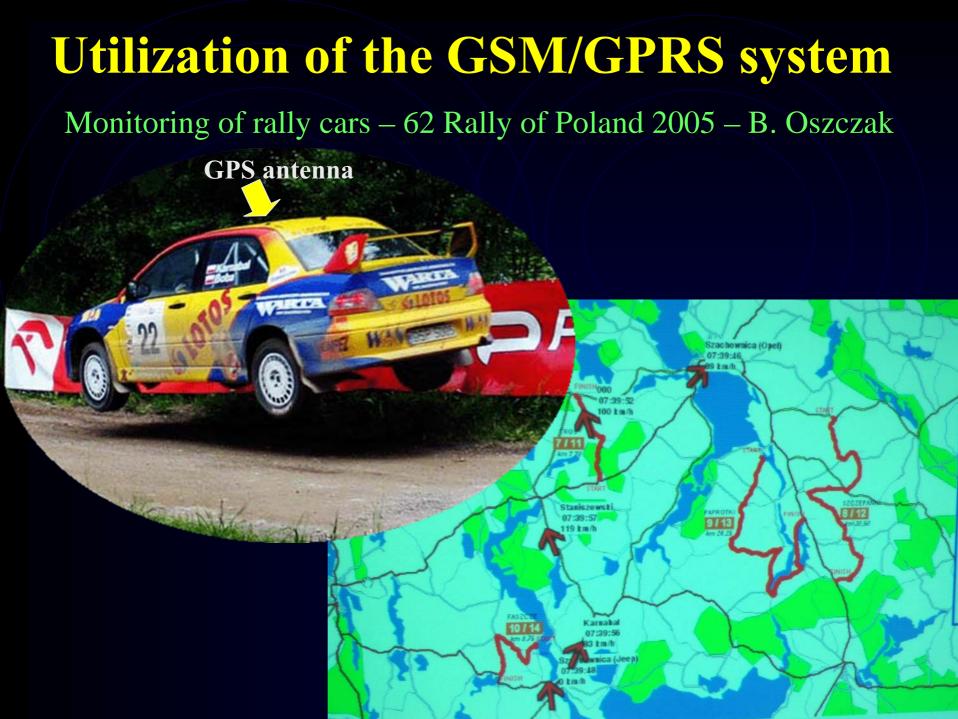
### **GSM/GPRS system for data teletransmission Phase 3 (IPSEC tunnels ) -** Initial Operational Capability status



# **Utilization of the GSM/GPRS system**

#### Monitoring of rally cars – 62 Rally of Poland 2005 – B. Oszczak





# Utilization of the GSM/GPRS system

System of recording road accidents with DGPS/GPRS technique – S. Oszczak, T. Templin

DGPS/RTK CORRECTIONS

GPS

SATELLITE SIGNAL



REFERENCE STATION

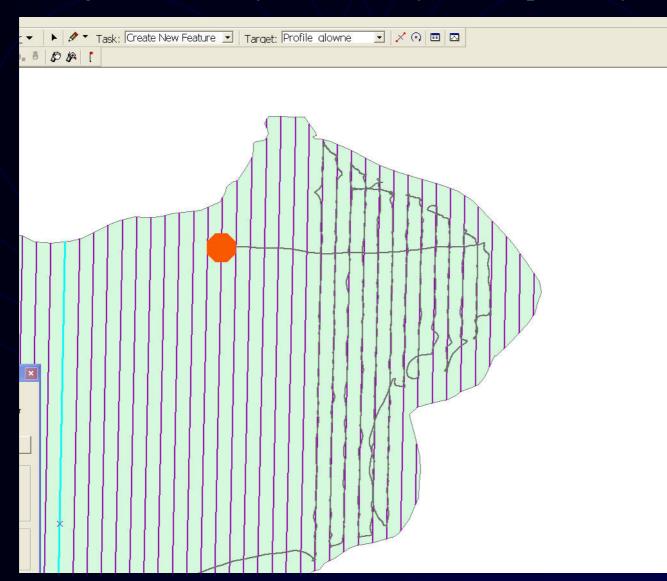


### **Utilization of the GSM/GPRS system** IACS (Integrated Administration Control System) – subsidies for farmers



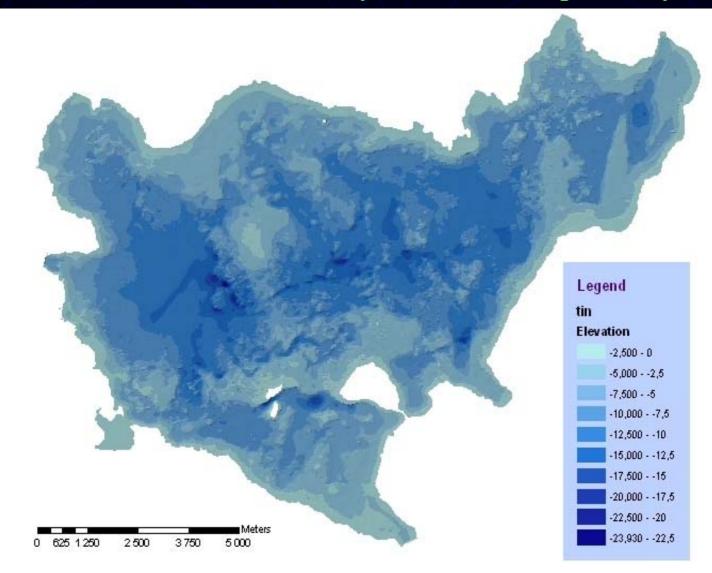
# **Utilization of the GSM/GPRS system**

#### Navigation for bathymetric survey – D. Popielarczyk



# **Utilization of the GSM/GPRS system**

#### DTM creation of Sniardwy Lake – D. Popielarczyk



#### Static tests of RTK/GSM/GPRS teletransmission the system

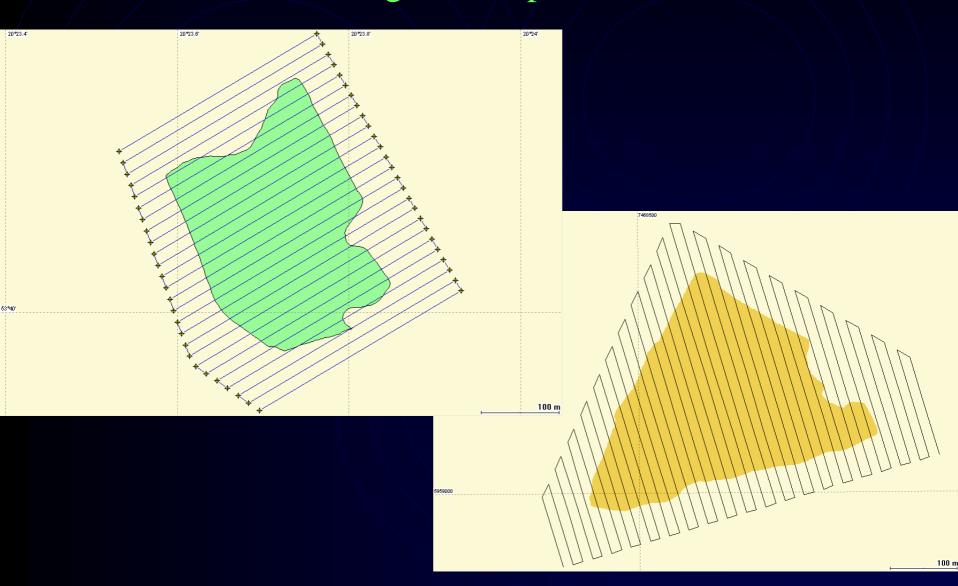
Ashtech Evaluate - Analysis Active - GPS Receiver type: uZ	- [Position information]		_ & ×
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ଷ୍ର୍ଷ୍	Position Accuracy		•
	Number of used points	1278	
	CEP	0.0066 m	
	Horizontal rms	0.0179 m	
	Eastirms	0.0106 m	
	North rms	0.0144 m	
	Horizontal 95%	0.0243 m	
	Vertical rms	0.0380 m	
	Vertical 95%	0.0459 m	
	Mean East error	0.0002 m	
0.189	Mean North error	-0.0042 m	
	Mean Altitude error	0.0031 m	
	Mean Latitude	53° 45' 37.618354" N	
	Mean Longitude	20° 27' 28.862423" E	
	Mean Altitude	160.3741 m	
	Heading standard deviation	0.0000 °	
	Pitch standard deviation	0.0000 °	
	Roll standard deviation	0.0000 °	
	Mean Heading	0.000 *	
Scatter Plot Units: m	Mean Pitch	0.000 °	
Ring1 = 0.007	Mean Roll	0.000 °	
Outlier Ring = 0.00	Mean BRMS	0.00 mm	
Oduller King – 0.00	Mean MRMS	0.00 mm	
	Number of bad attitude measurements	0	
	Percentage good attitude availability	100.00 %	
	0.08	Horizontal distribution around known position	-
	] [		
Differential GPS position Used SVs: 8 UTC Time: 15:08:46.00	- 14/00 04: 400 07		
Lat: 53° 45' 37.618260" N Lon: 20° 27' 28.862580" E Altitude abov PDOP: 1.7 HDOP: 0.9 VDOP: 1.5 TDOP: 0.9	8 VVGS-04: 160.37 M		
ADU Double Differences: V1-2: 0 V1-3: 0 V1-4: 0 BRMS: 0.0 mm	MRMS: 0.0 mm		
	MIXWS, 0.0 MIM		
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#### Static tests of RTK/GSM/GPRS teletransmission the system

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<u> </u>	Position Accuracy			<u> </u>
	Number of used points	31713		
+ N +	CEP	0.0024 m		
	Horizontal rms	0.0094 m		
	East rms North rms	0.0051 m 0.0079 m		
+ +	Horizontal 95%	0.0079 m 0.0144 m		
	Vertical rms	0.0174 m		
	Vertical 95%	0.0219 m		
	Mean East error	0.0002 m		
	Mean North error	0.0002 m		
	Mean Altitude error	0.0028 m		
$\begin{array}{c} \begin{array}{c} & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ $	Mean Latitude	53° 45' 37.618513" N		
	Mean Longitude	20° 27' 28.862420" E		
	Mean Attitude	160.3738 m		
	Heading standard deviation	0.0000 °		
	Pitch standard deviation	0.0000 *		
	Roll standard deviation	0.0000 °		
	Mean Heading	0.000 °		
Scatter Plot Units: m	Mean Pitch	0.000 °		
Ring1 = 0.007	Mean Roll	0.000 *		
Outlier Ring = 0.00	Mean BRMS	0.00 mm		
	Mean MRMS	0.00 mm		
	Number of bad attitude measurements	0		
	Percentage good attitude availability	100.00 %		
	geod director of another			
	0.32	Horizontal distribution around known	position	<u> </u>
Differential GPS position Used SVs: 7 UTC Time: 00 : 05 : 09.00				
Lat: 53° 45' 37.618560" N Lon: 20° 27' 28.862340" E Altitude abov	e WGS-84: 160.36 m			
PDOP: 2.5 HDOP: 1.1 VDOP: 2.2 TDOP: 1.4				
ADU Double Differences: V1-2: 0 V1-3: 0 V1-4: 0 BRMS: 0.0 mm	MRMS: 0.0 mm			
Scroll: PgUp/PgDn, Up/Dn			COM1 9600	D:m A:m H:km/h V:m/s
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# **Dynamic DTM creation**

#### Design of the profiles



# **Dynamic DTM creation** Measurement of the profiles



# **Dynamic DTM creation**

#### Vehicle taking part in the measurements





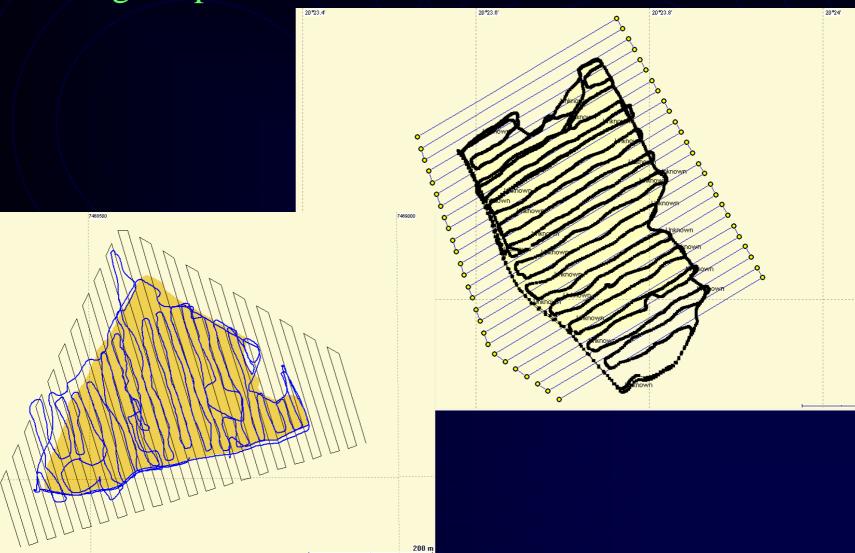
# **Dynamic DTM creation** Equipment taking part in the measurements

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# **Dynamic DTM creation** Real time navigation along measurement profiles



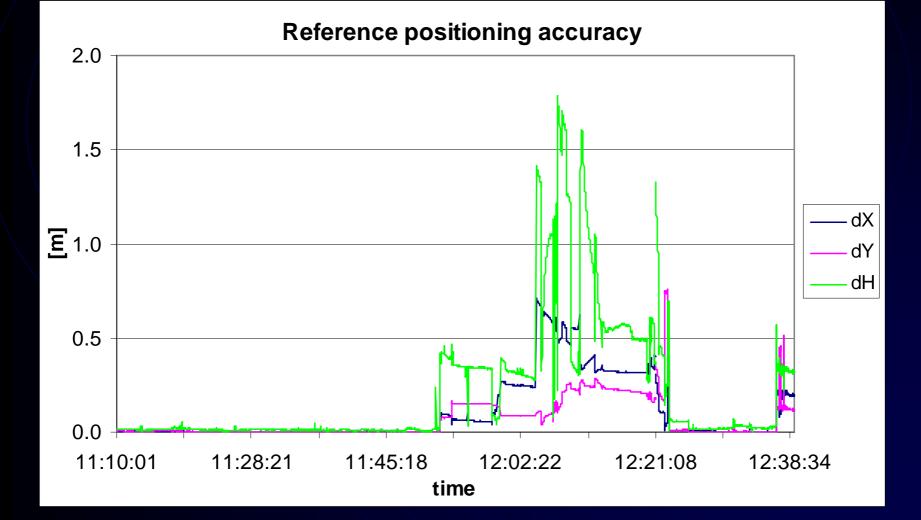
## **Dynamic DTM creation** Designed profiles and actual track of the vehicle



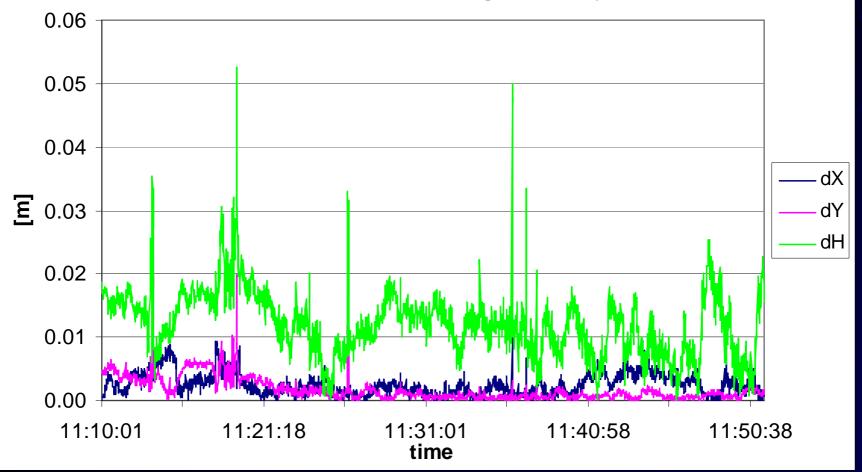
100 m

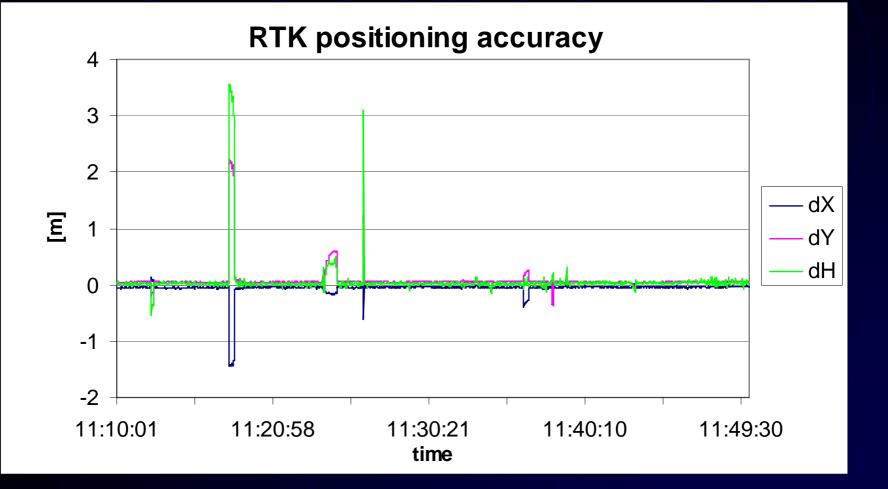
### Dynamic DTM creation Measurement of the profiles

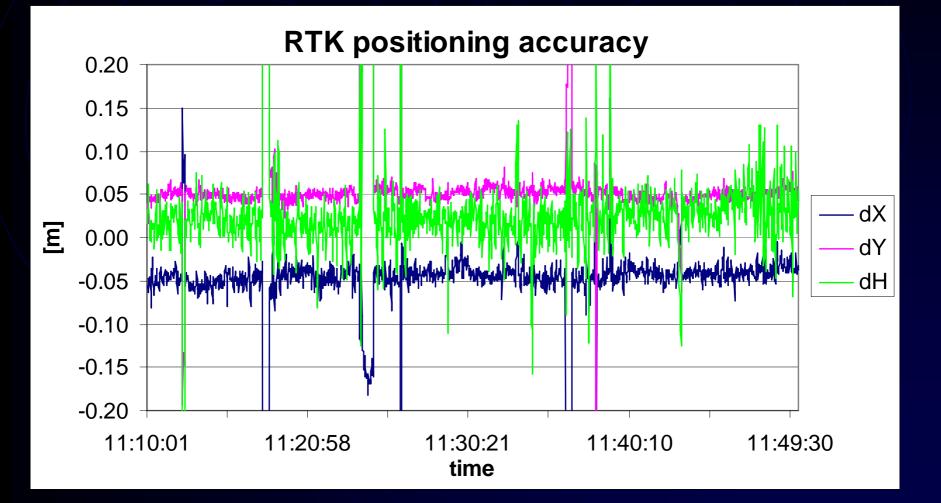




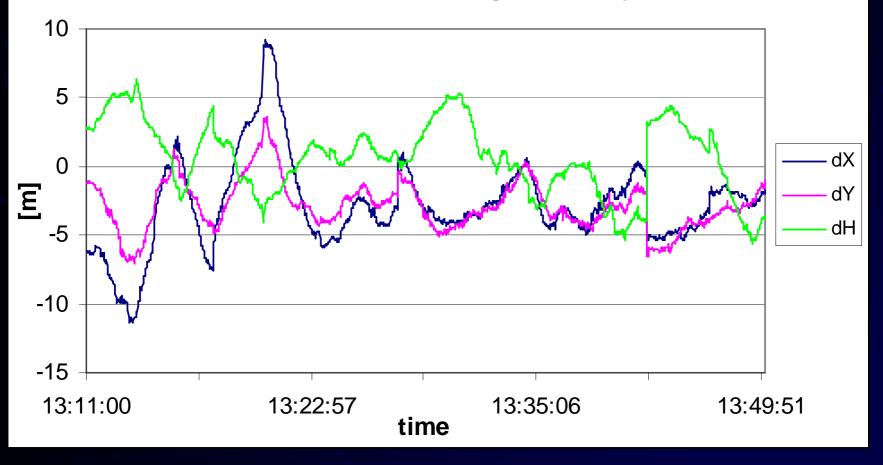
**Reference positioning accuracy** 

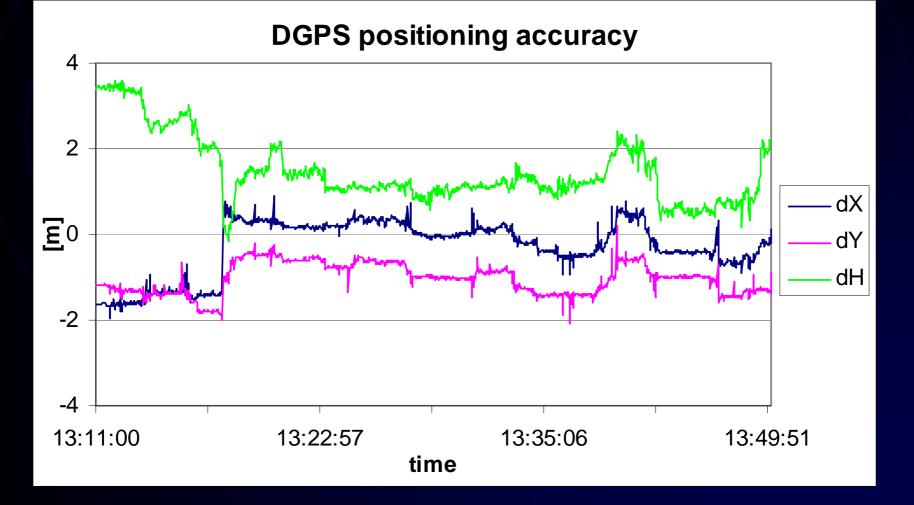




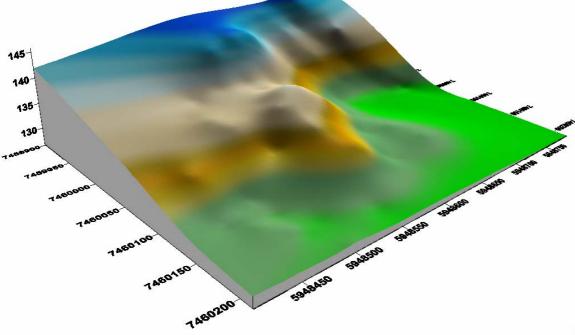


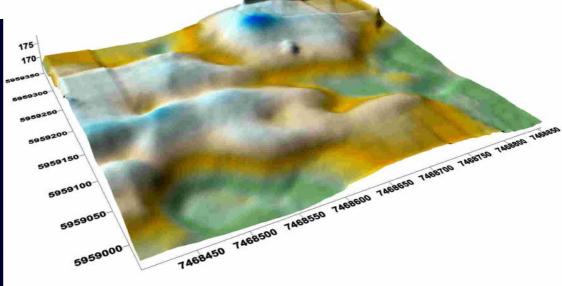
#### **EGNOS** positioning accuracy



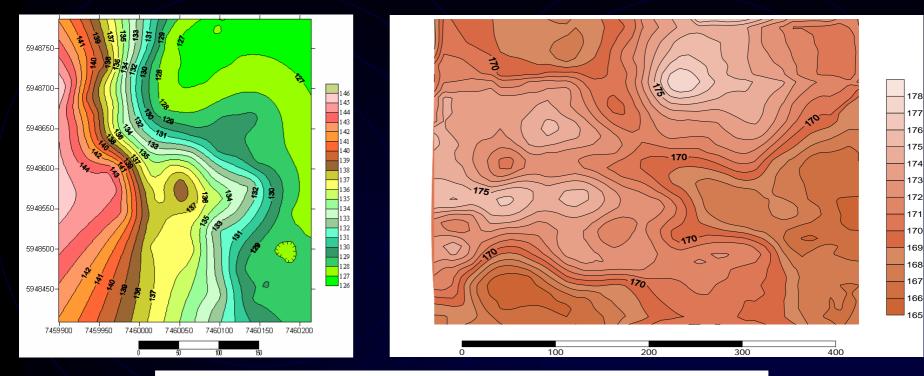


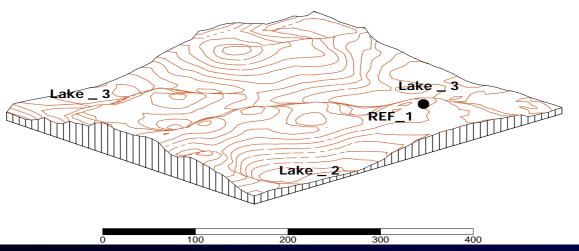
# Generation of DTM





### **Generation of DTM**





### Conclusions

> Possibility of receiving of DGPS/RTK data by n-users from freely chosen reference station. Corrections can be received at any place of Polish territory with the GSM coverage. Distribution of corrections is possible using freely chosen any GSM operator in Poland. > The system is open to any further updates, improvements and modifications.

### Conclusions

The cost of using GSM/GPRS system is quite reasonable:

A 1 hour of DGPS corrections receiving (with 2 sec. interval) is around 0.06 €
A 1 hour of RTK corrections receiving (with 2 sec. interval) is around 0.30 €

### Conclusions

Very efficient and cost-effective generation of DTM (5 ha = 90 min) with centimeter level of accuracy.

Using ATV allows driving in any kind of terrain quickly and effectively.

The whole process concerning preparation phase and actual measurement phase can be done by just one person.



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# Thank you for your attention www.kgsin.pl e-mail: adam.ciecko@uwm.edu.pl

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