8th Bilateral Poland-Italy Meeting
Wroclaw, Poland 22-24 June 2006

CER TeleGeomatics Applications and Projects in Central Europe

Manzoni G.

Bolzon G., Cefalo R., Gherdevic D., Martinolli S., Piemonte A., Rizzo R., Sluga T.

Interreg S.I.S.A. Project

Survey and Information System of Adriatic Roads

1000 thousand km surveyed
by M.M.S.
Mobile Mapping System

The M.M.S. gives two different type of data:

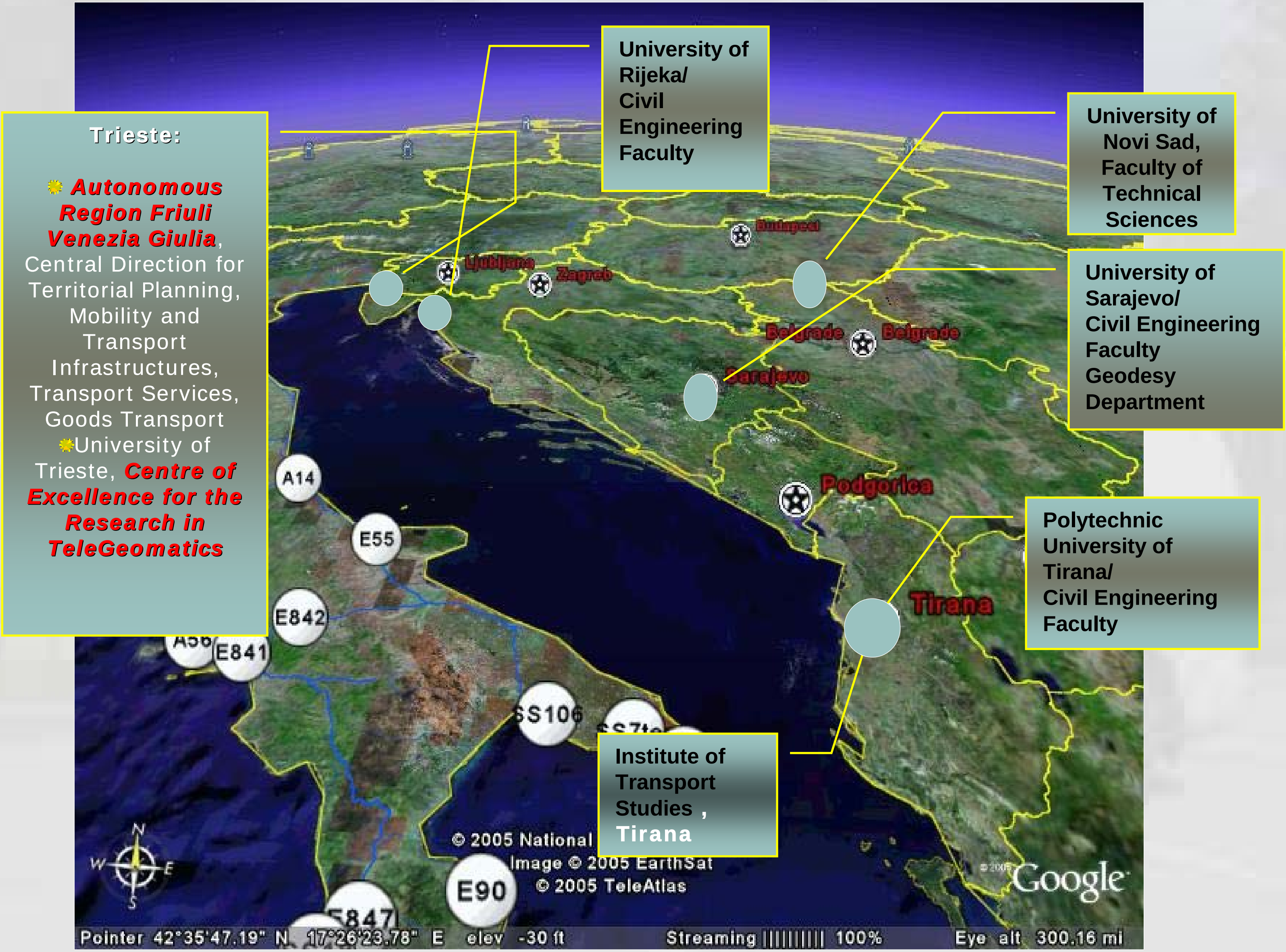
- **POSITIONING DATA**
- **GEOGRAPHIC DATA**

- Positioning data → trajectory → GPS/INS integration
- Geographic data → digital cameras, laser scanner, other sensors

M.M.S. Advantages:

- High efficency
- Absence of ground control points
- Integration between different sensors
- Digital data archiving

- Possibility to operate during traffic conditions
- Nearness between the surveying System and the surveyed objects
- The high System efficency allows to keep updated
- the road databases


Trieste:
Autonomous Region Friuli Venezia Giulia, Central Direction for Territorial Planning, Mobility and Transport Infrastructures, Transport Services, Goods Transport
University of Trieste, Centre of Excellence for the Research in TeleGeomatics
University of Rijeka/ Civil Engineering Faculty
University of Novi Sad, Faculty of Technical Sciences
University of Sarajevo/ Civil Engineering Faculty Geodesy Department
Polytechnic University of Tirana/ Civil Engineering Faculty
Institute of Transport Studies , Tirana
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Belgrade
Sarajevo
Podgorica
Tirana
A14
E55
E842
E841
SS106
E90
© 2005 National
Image © 2005 EarthSat
© 2005 TeleAtlas
Google
Pointer 42°35'47.19" N 17°26'23.78" E elev -30 ft
Streaming |||||||||| 100%
Eye alt 300.16 mi

G.I.G.I.

GPS Integrated with Glonass* and Inertial navigation system

GIGI has born in the framework of COFIN 1999 and COFIN 2000 Projects, co-ordinated by Prof. Giorgio Manzoni.
To this Projects the Universities of Trieste, Parma, Bologna, Ancona, Pisa, Roma la Sapienza, Cagliari, Napoli Istituto Universitario Navale, Catania, had joined.

G.I.G.I.one

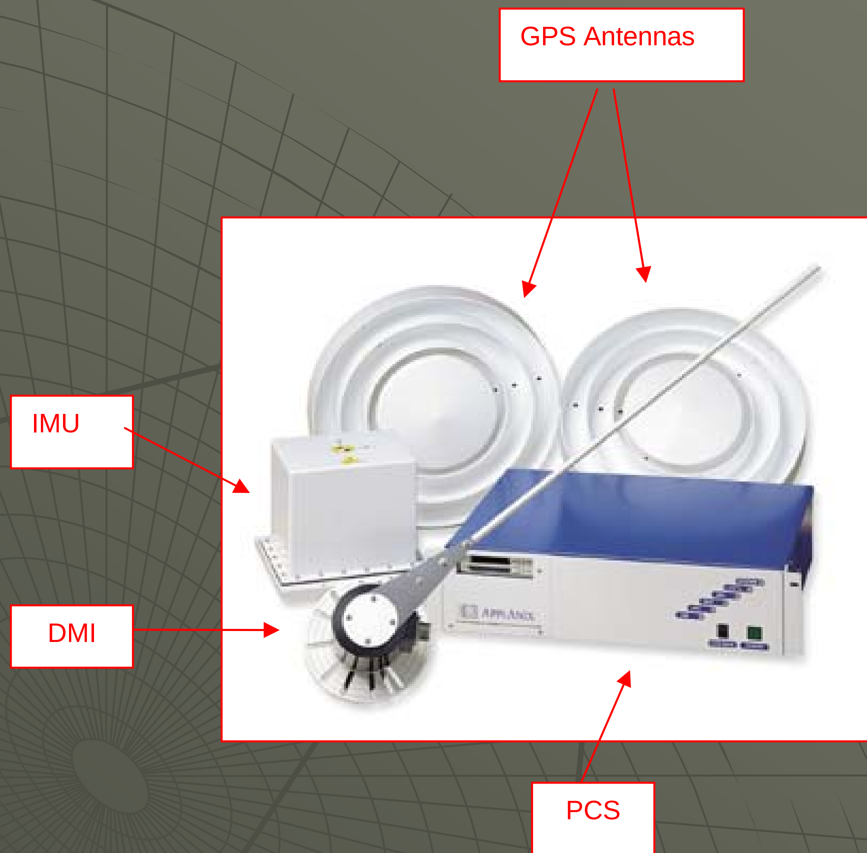
Has born in 2003 like G.I.G.I. evolution

* Glonass, Russian Satellite Navigation System;
and the European
"GALILEO" System
GNSS +EGNOS+GALILEO

From G.I.G.I. to G.I.G.I.one

- **Sostitution** of one digital camera with the equivalent color model (Basler A101fc)
- **Adding of a digital** Hitachi DZ-MV200E **camera with direct storing on DVD**
- **Adding** of a laser scanner monoaxial IBEO, mounted on the back of the vehicle

DEDICATED INSTRUMENTS



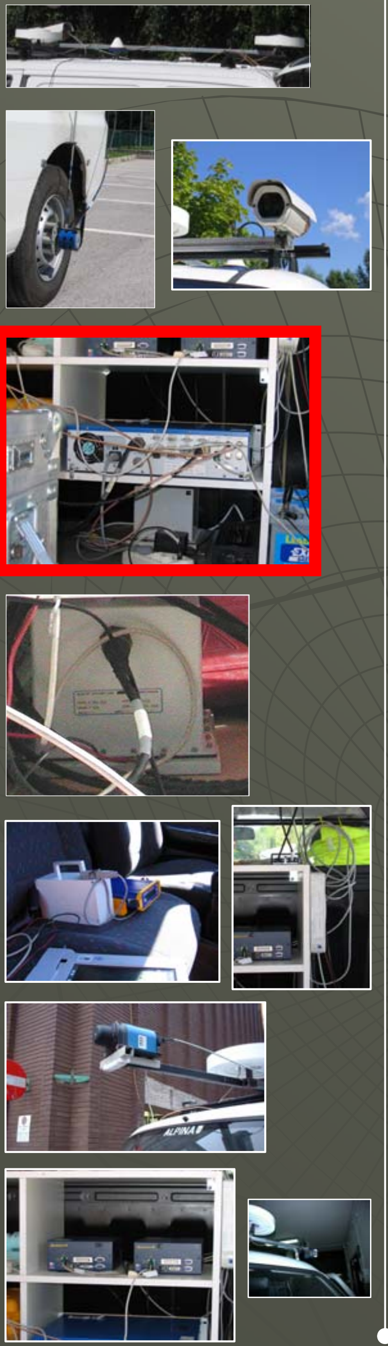
APPLANIX SYSTEM

It is a GPS/INS integrated System computing the vehicle position;

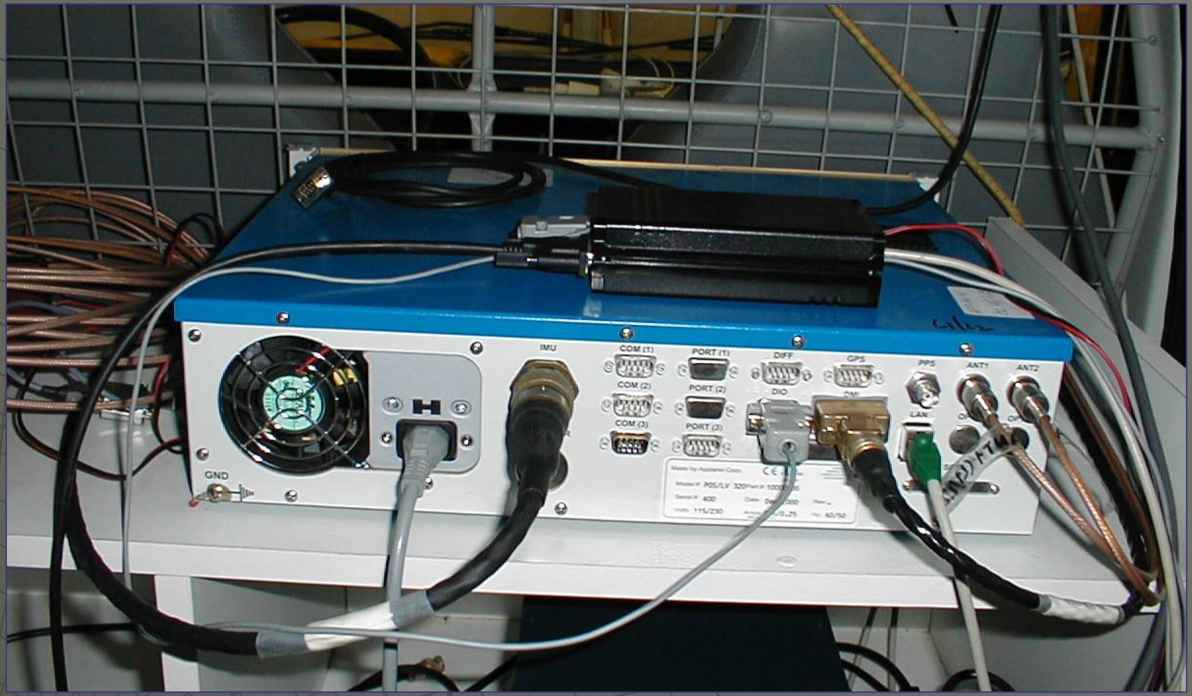
It is composed by:

- PCS (POS Computer System), a computer **containing** also two **GPS** cards, getting the data of 4 external sensors:
  - IMU, Inertial Measurment Unit,
  - DMI Distance Measuring Indicator, the odometer
- Two GPS receivers.

The sensos errors are estimated on continuous basis using Kalman filters

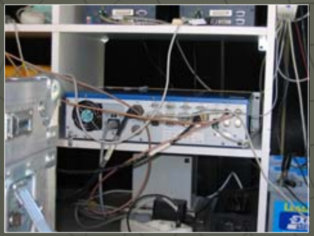


P.C.S.



The heart of the System is the PCS
that receives all the data coming from the different sensors of POS/LV for real-time processing of the vehicle position.
The real time vehicle navigational data could be store inside the PCS and get available for the post-processing, using a specific software.







G.P.S. ANTENNAS & RECEIVERS

L1 & L1L2 Antennas

Data

Two GPS receivers

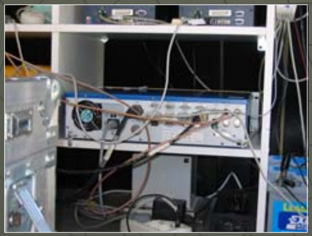
Inside P.C.S.:

- *"Secondary GPS" card* with L1 **receiver**
- *"Principal GPS"* with L1/L2 **receiver**

✓ Abilited to receive and process the RTCM and RTK differential corrections.

✓ Gives to POS/LV the position and speed informations.

- Located at the end of a rigid support mounted on the roof of the vehicle.
- "Choke ring" antenas, to attenuate the multipath effect, which results to be one of the principal error source



I.N.S. INERTIAL SYSTEM - 1

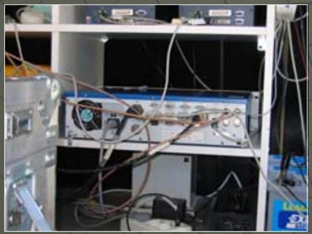
I.M.U.

The inertial System mounted on board GIGIone is a
LN-200 fiber optic gyro I.M.U. LITTON
Integrated in the System.
The inertial system is composed by
Three accelerometers and by **three** fyber optics gyroscopes

they give in real time the asset of the vehicle.

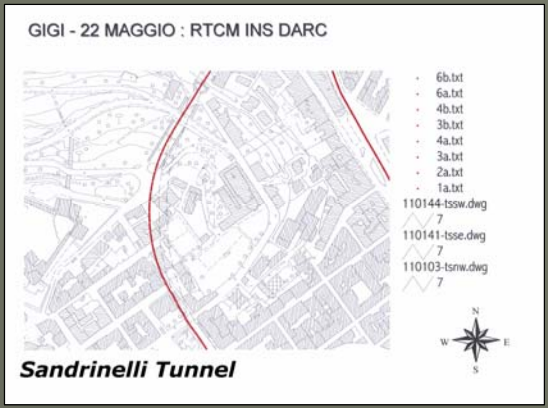
- The speed and angolar variations along the three directions are given in order to determine the vehicle asset.
- The I.M.U. is separated by the other instruments and it is linked to P.C.S. by a data transmission cave.
- The box is made of smalted steel, perfecly sigilled and empty using azoth.

The I.N.S. Inertial System - 2



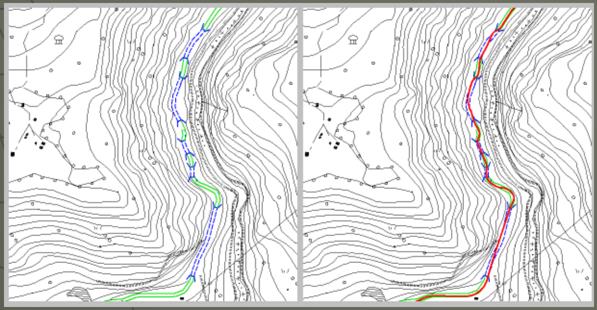
D.M.I.

Distance Measuring Indicator



- The odometer (D.M.I.) is an external sensor mounted on the left back wheel of the vehicle.
- The output of D.M.I. consists in the run distance.
- The data entering into the P.C.S. are acquired to recostruct the whole run distance, in order to reconstruct the trajectory in case a blackout or a temporary absence of the G.P.S. signal occours.

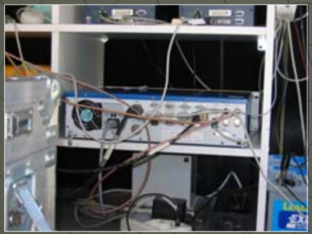
- The D.M.I. (Distance Measuring Indicator) guarantees the continuity of the positioning data also in absence of G.P.S.signals.



- The odometers generates 1024 impulses per second. Known the wheel diameter *d* the number of pulses per meter is:

$$S = 1024/(d\Pi) = 1024/(0.5x3.14) = 652 \text{ pulses/m}$$







SOFTWARE LV-POSView

Software POS/LV

Algorithm for inertial navigation

(Newton equations)

Uses the informations getting from the accelerations and the angular variations derived from the inertial system IMU.

Kalman filter

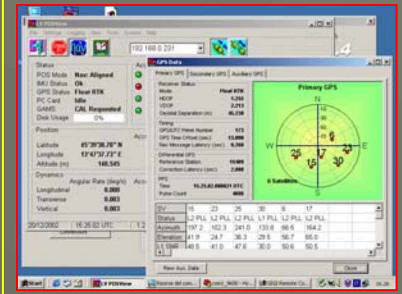
Solutions of the INS System

Primary GPS data

Odometer data

=

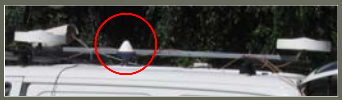
Calculation of the inertial navigator error

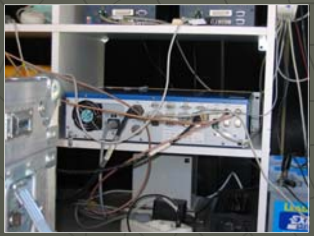


The software compensates the inertial navigation solution with the errors estimated by Kalman filter.

The secondary GPS receiver is used by GAMS (GPS Azimut Measurement Subsystem)

Designed to give precise informations of the vehicle asset; using two GPS receivers, two antennas and an algorithm for the phase ambiguities computation, the GAMS gives the orientation with an accuracy up to 0.002°

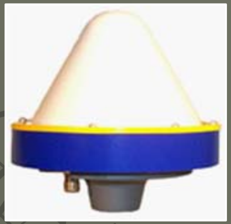




DIFFERENTIAL G.P.S.

After SA (Selected Availability) switching off, that gave a positioning uncertainty of nearly 100-150 meters, the Stand-Alone accuracy is in the range of 10-15 meters

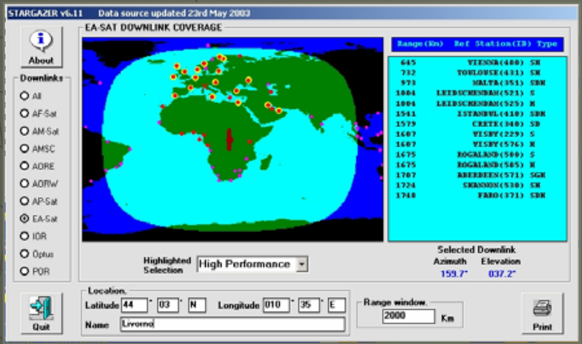
DGPS MAX CSI WIRELESS



DGPS Max Receiver is able to receive and process the differential correction data transmitted from the Omnistar Geostationary Satellites.

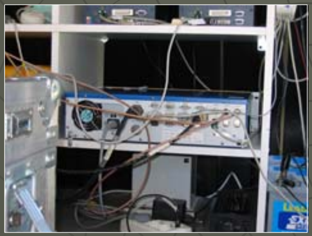
The corrections are used by DGPS Max receiver and can be given as input to another receiver, like the Applanix one.

RTCM OMNISTAR coverage



OMNISTAR coverage , in the European zone (EA-SAT)

DIGITAL CAMERAS – 1



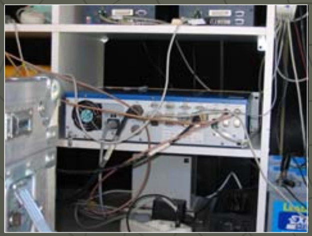
Two digital cameras mounted on the front of the vehicle

- On **right** a black/white camera rotated by nearly 40° towards right
- On **left a color digital camera,** positioned horizontally and looking frontally.

The photogrammetric data are processed using **monoscopic** techniques and most of the informations are derived from the photograms stored by the color digital camera.

The black/white photograms are used to accurate define the road borders, the lateral accesses, the crosses, and so on.







DIGITAL CAMERAS – 2

The digital cameras are:

- Basler industrial Cameras A101f
- Resolution 1.3 Mpixel (1300x1030)
- Frame grabber →Matrox 4Sight II

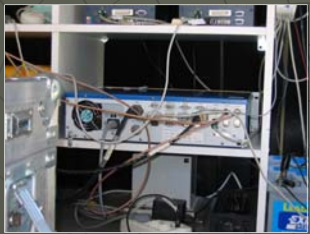
Fundamental characteristics:

- Max resolution 1280x960
- Power 12V, 5w
- Objective manual diafram
- Acquisition by external trigger
- Exposition time regulated by software

Matrox 4Sight II, contains the software for the managing and storing of the acquired images.

The acquired images are compressed in **jpeg format** before saving.
At the end of the survey all the images are transferred to a local network resident on a personal computer.

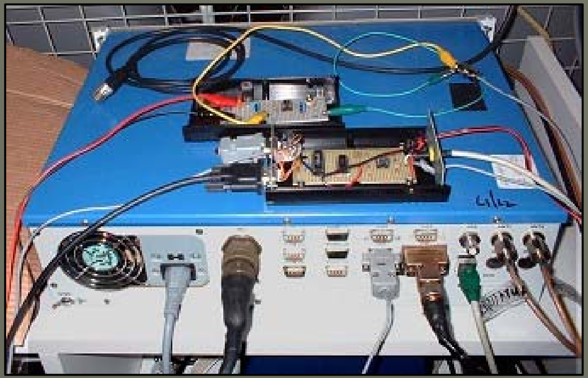


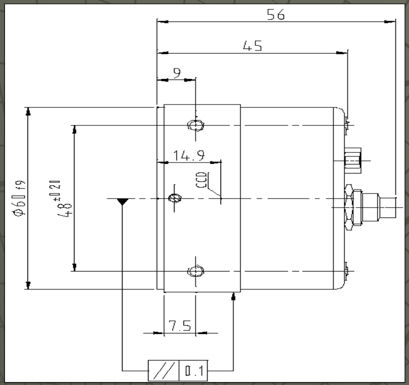





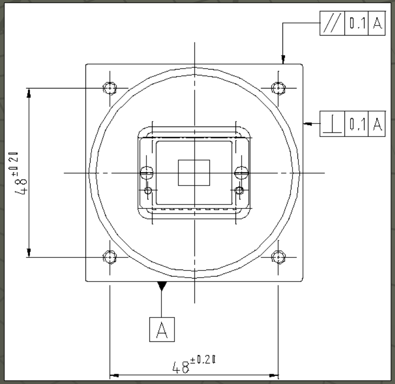


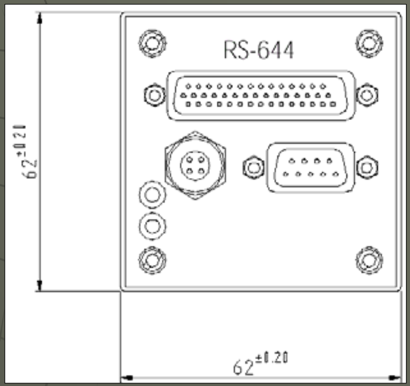
CAMERAS – 3





Above the P.C.S. there is a trigger signal generator linked to the P.C.S., for the photograms syncronization to GPS time







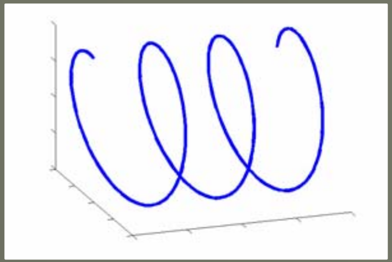






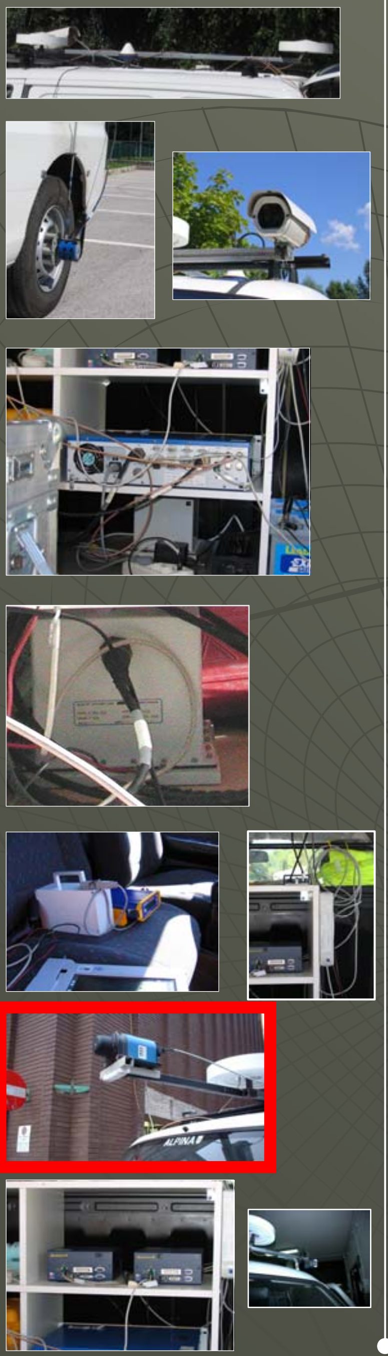

LASER SCANNER IBEO LD AUTOMOTIVE – 1 -

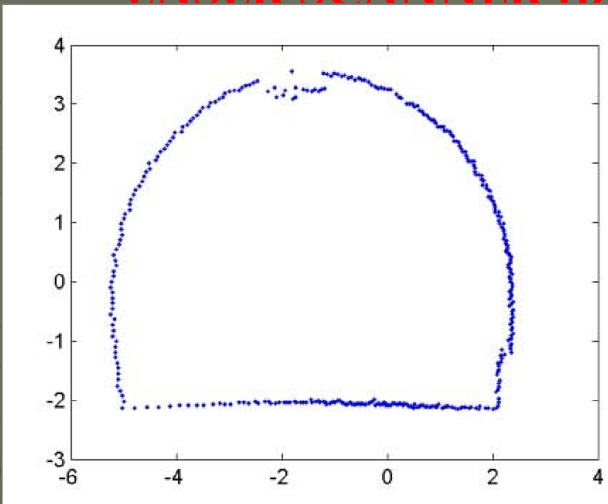
- IBEO LD Automotive
- 12 VDC
- 40m (reflectivity > 5%)
- Accuracy: 5cm
- Scan time: 50ms (min)



- The laser scanner operates during the survey,thus the obtained sections envelope along an elicoidal trajectory
- Knowing the continuous vehicle position it is possible to determine the position relative to the various scans.
- Having also the vehicle asset, the various scans can be corrected considering the spatial laser sensor position during each scanning.

LASER SCANNER IBEO LD AUTOMOTIVE – 2 -





Measured values Derived values

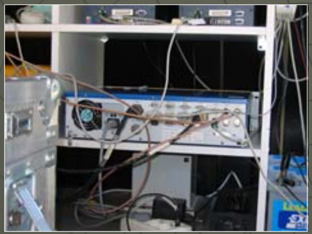
Max height 5.579m 5.547m

Width (1m) 7.439m

7.465m

LASER SCANNER IBEO LD AUTOMOTIVE – 3 -

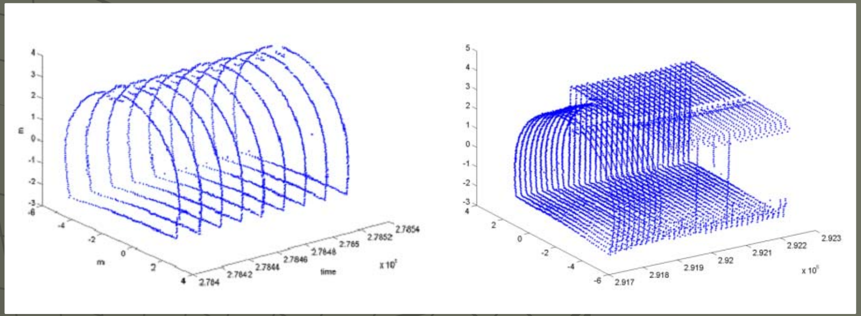


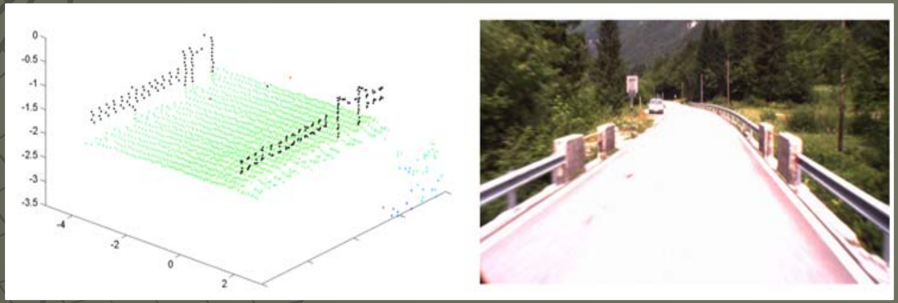




3D Laser scanner

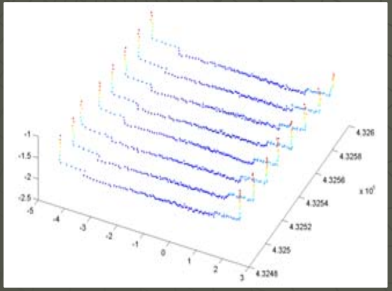
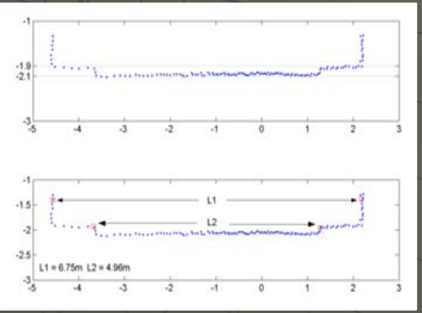


Consecutive galleries section

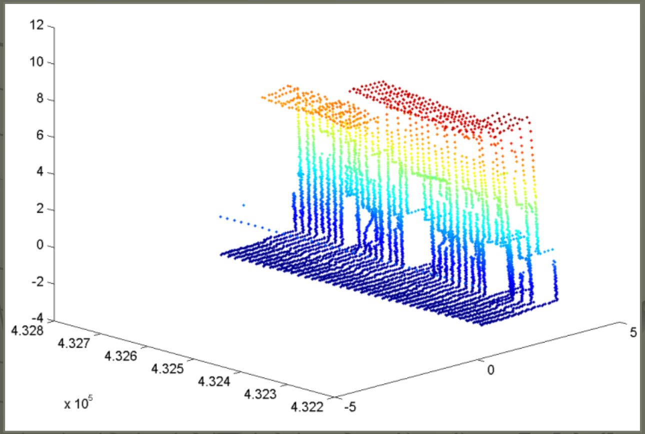


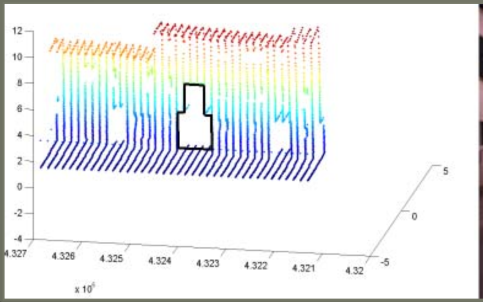
Guardrail and colums

Sections with the pavement

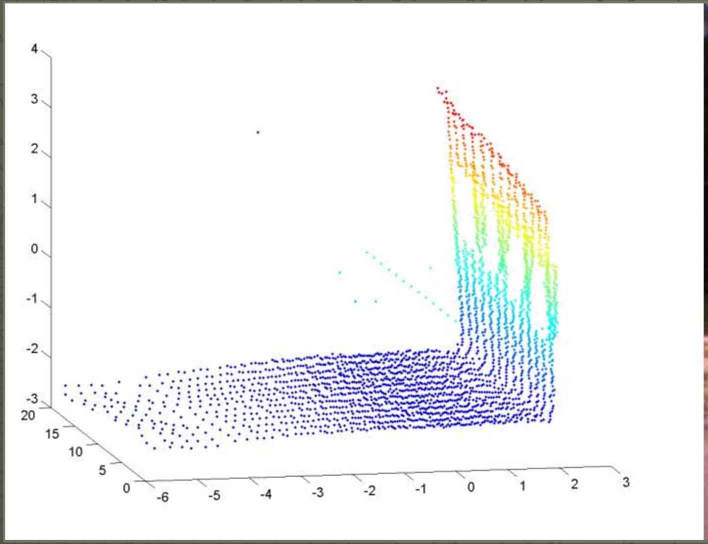



LASER SCANNER IBEO LD AUTOMOTIVE – 3 -



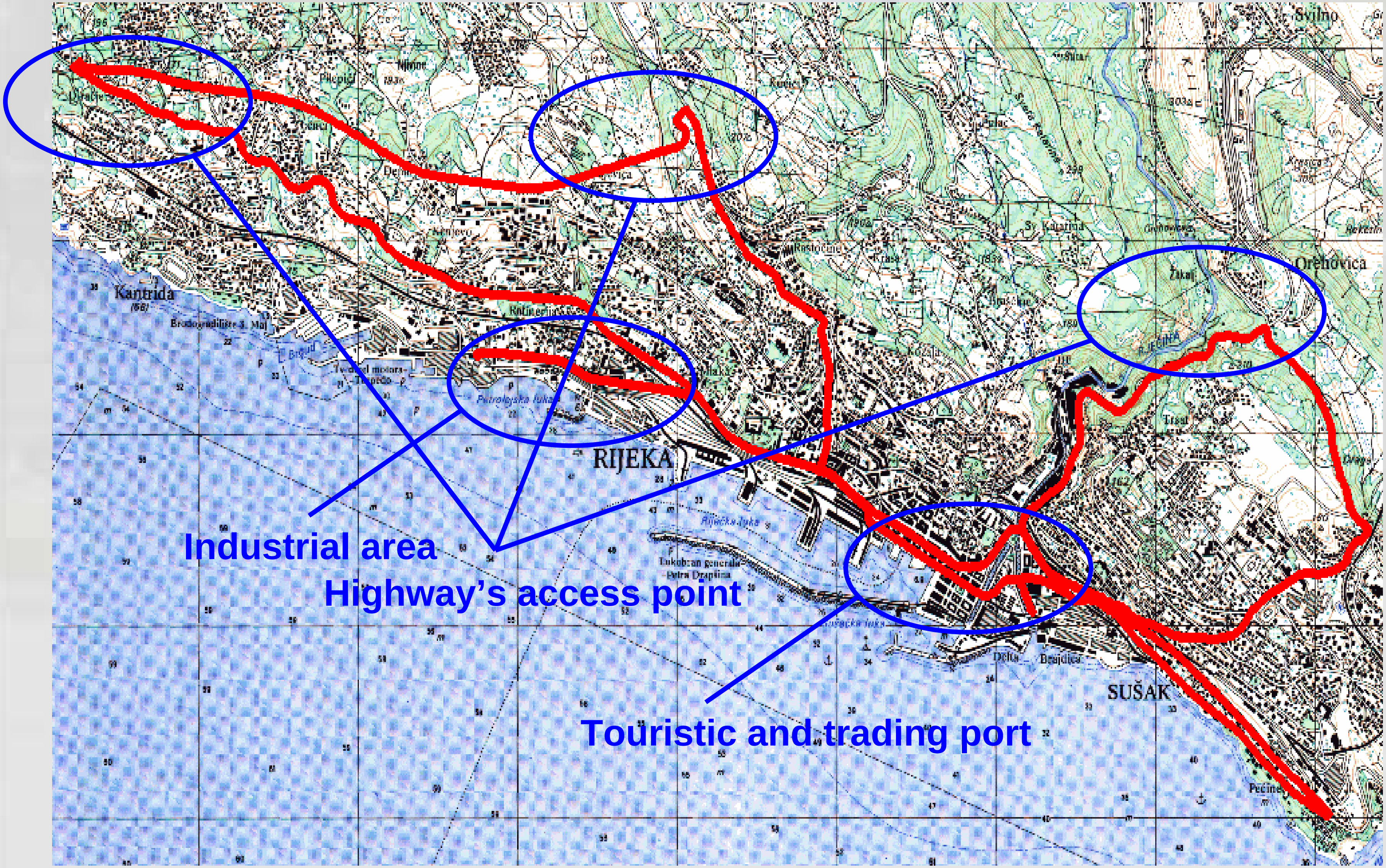


Scanning of the buildings on the right side

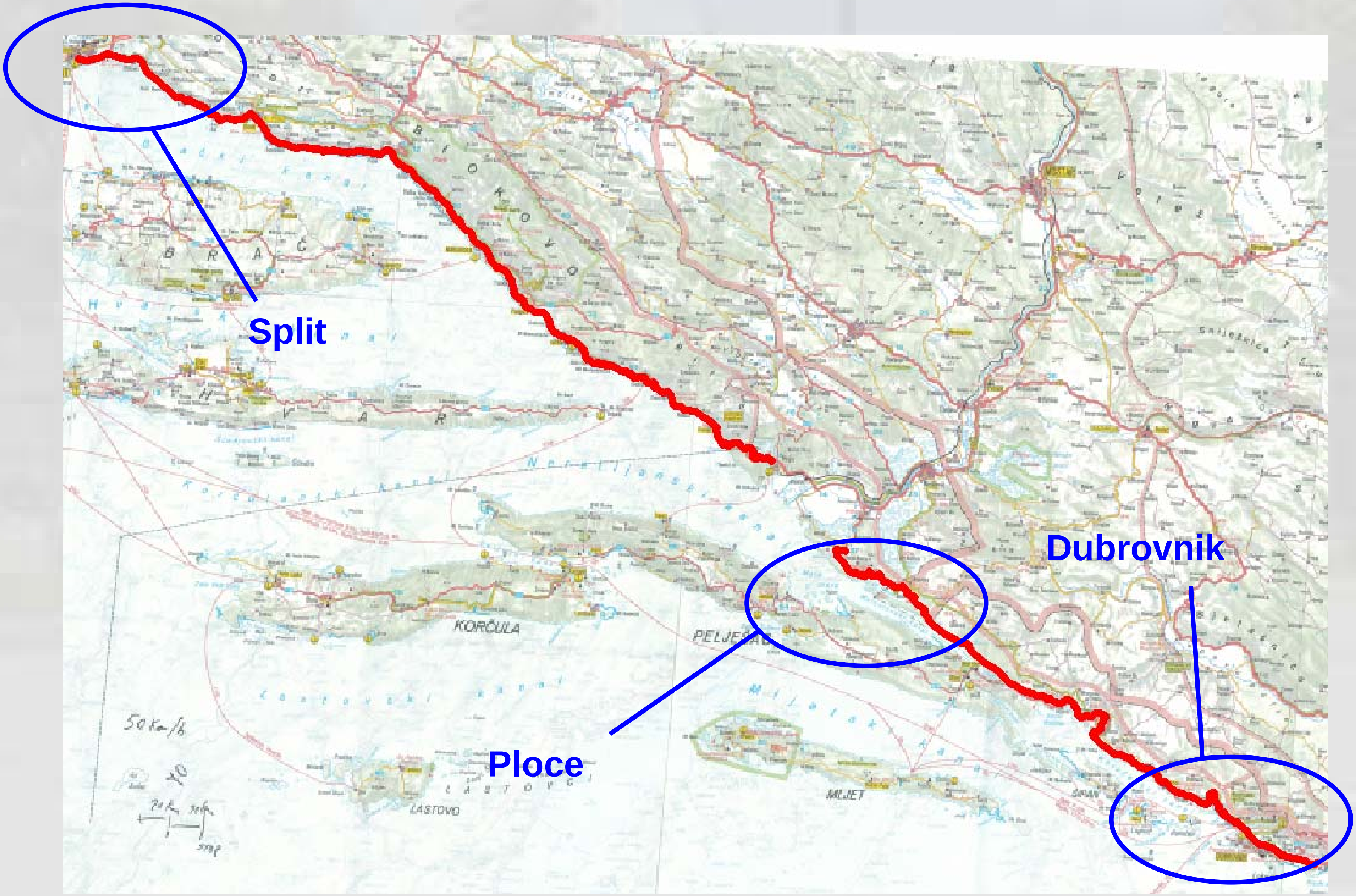


Corrected scan using the roll angle

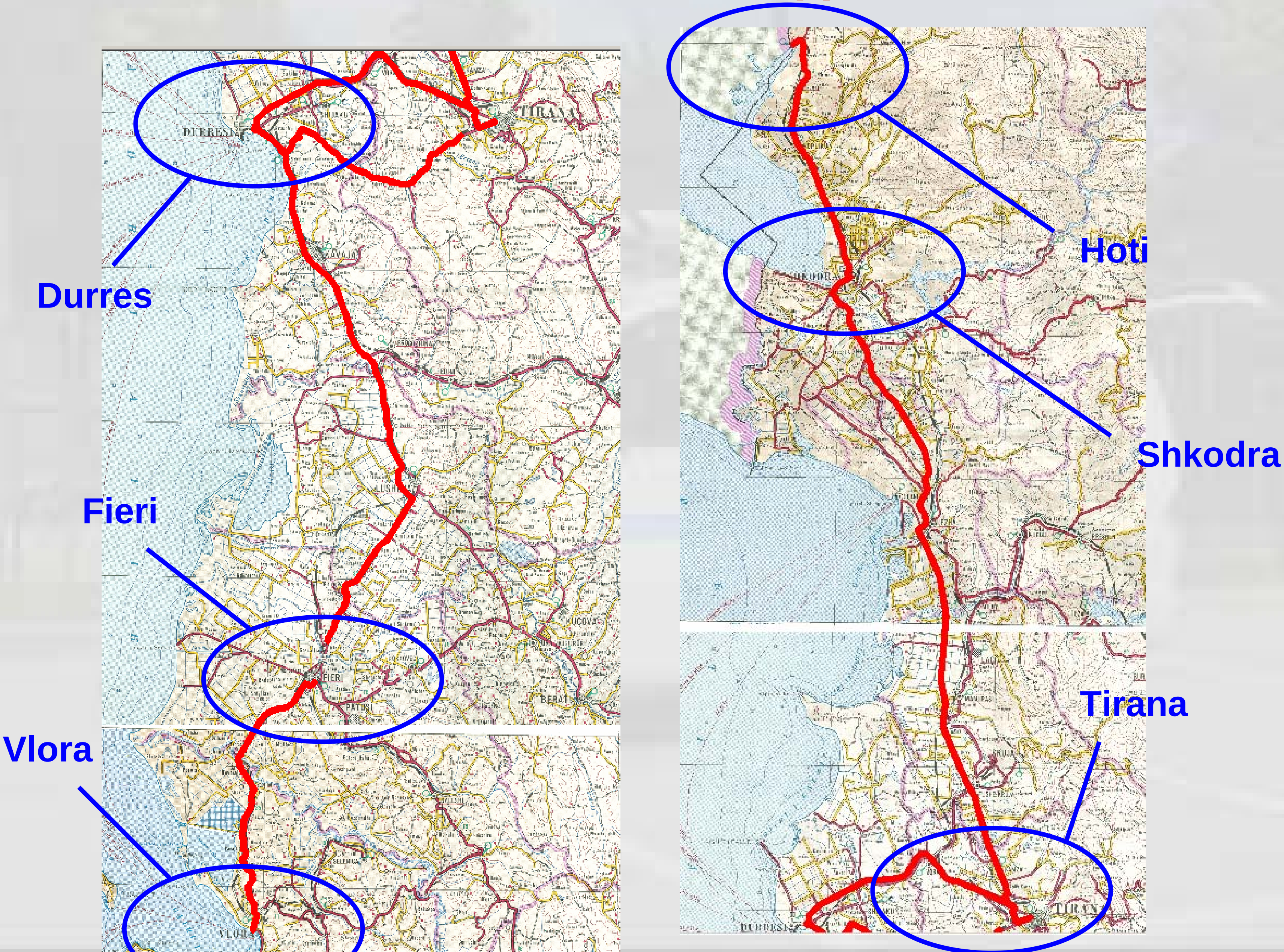
Rijeka - Hrvatska



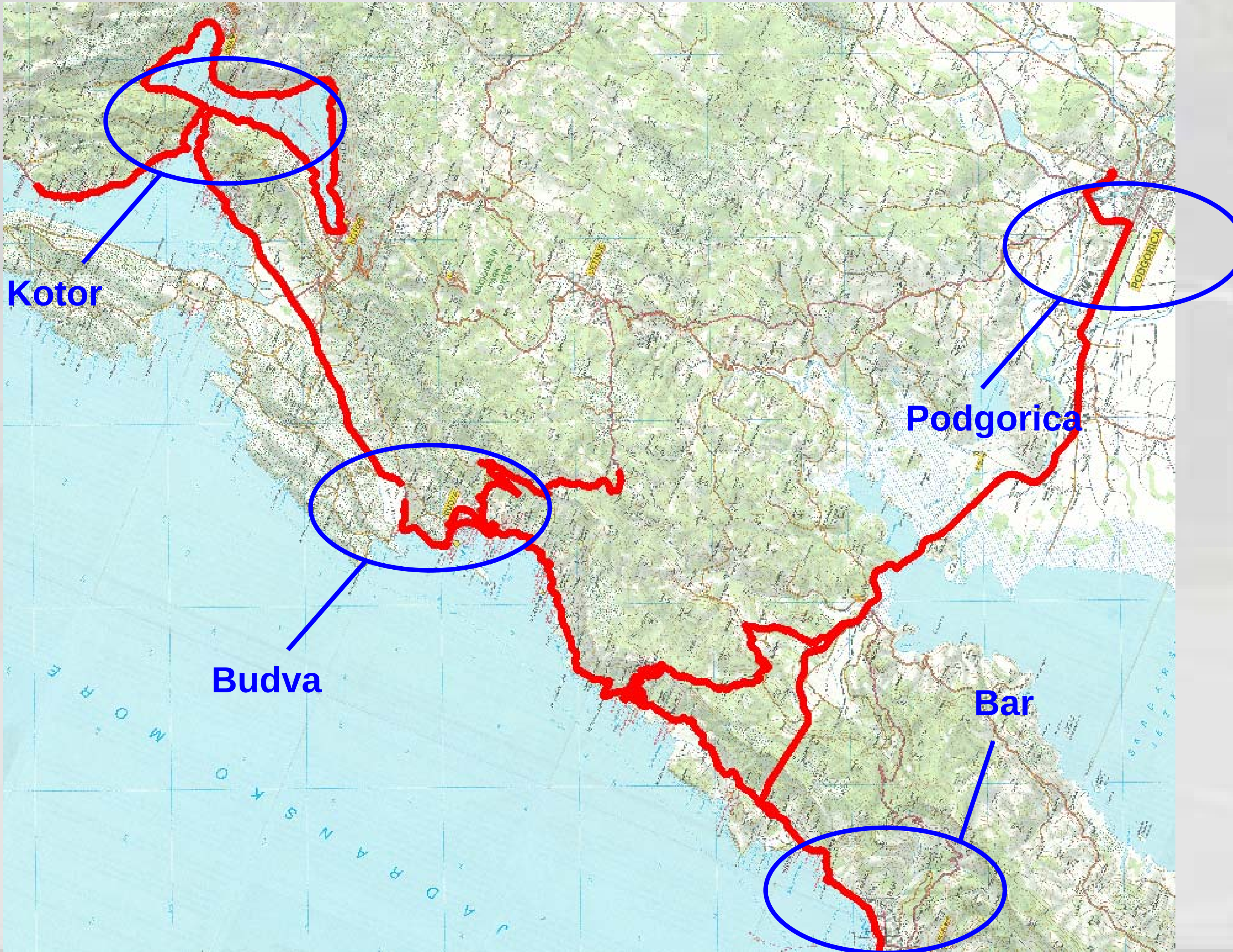
From Dubrovnik to Split - Hrvatska



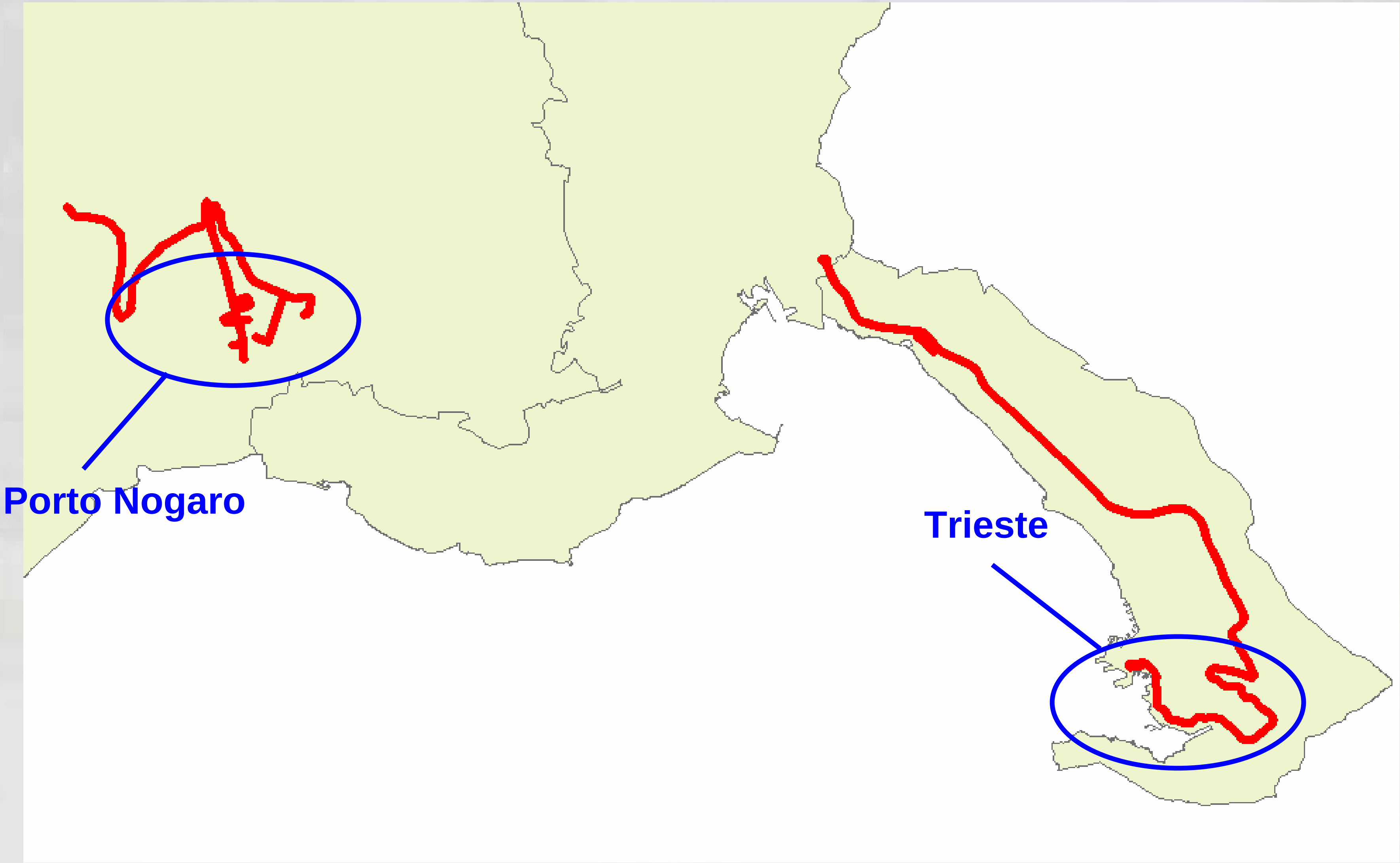
From Vlora to Hoti - Shqiperia



From Zelenika to Bar – Crna Gora



Trieste and Porto Nogaro - Italia



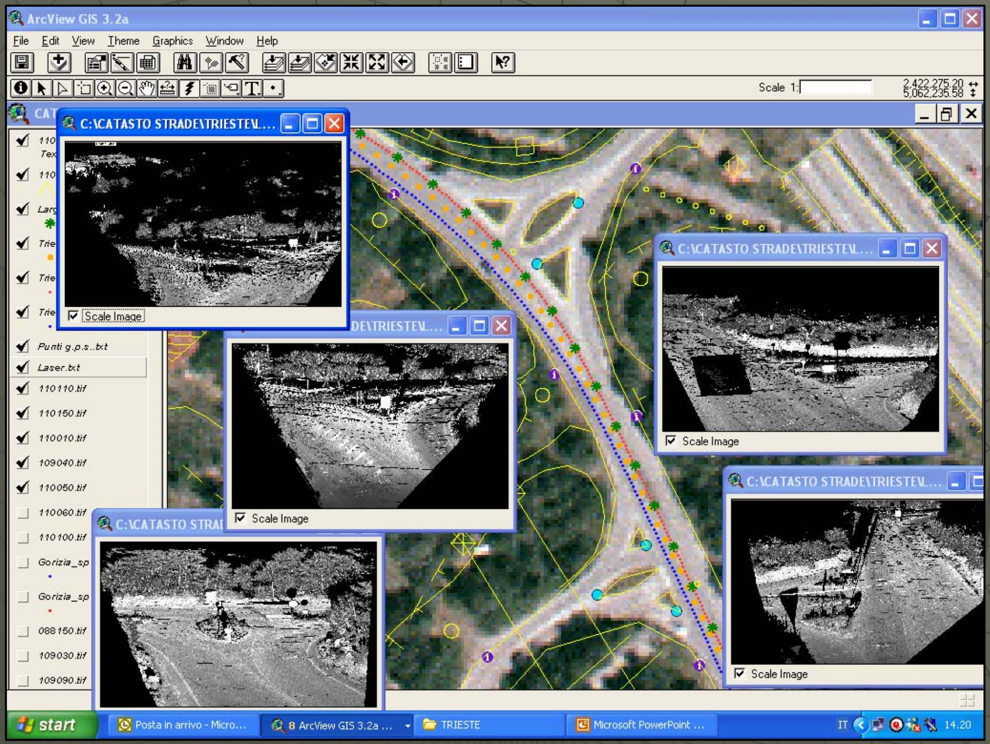
Trieste - Italy

Software ROADVIEW

Software ROADVIEW

Software ROADVIEW

COMPARISON & CROSS VALIDATION : EFFICENCY OF THE DATA SURVEYED BY GIGIone MMS



Thanks to the co-operation between the **STT** Trieste, and the **Center of Excellence for the Research in TeleGeomatics,** the laser scanner data have been compared with the data obtained by M.M.S., thus verifying the efficency and accuracy of the results obtained from the vehicle to respect to the Numerical Tecnical Cartography and the affidability of this and the ortho images given by Friuli Venezia Giulia Autonomous Region.

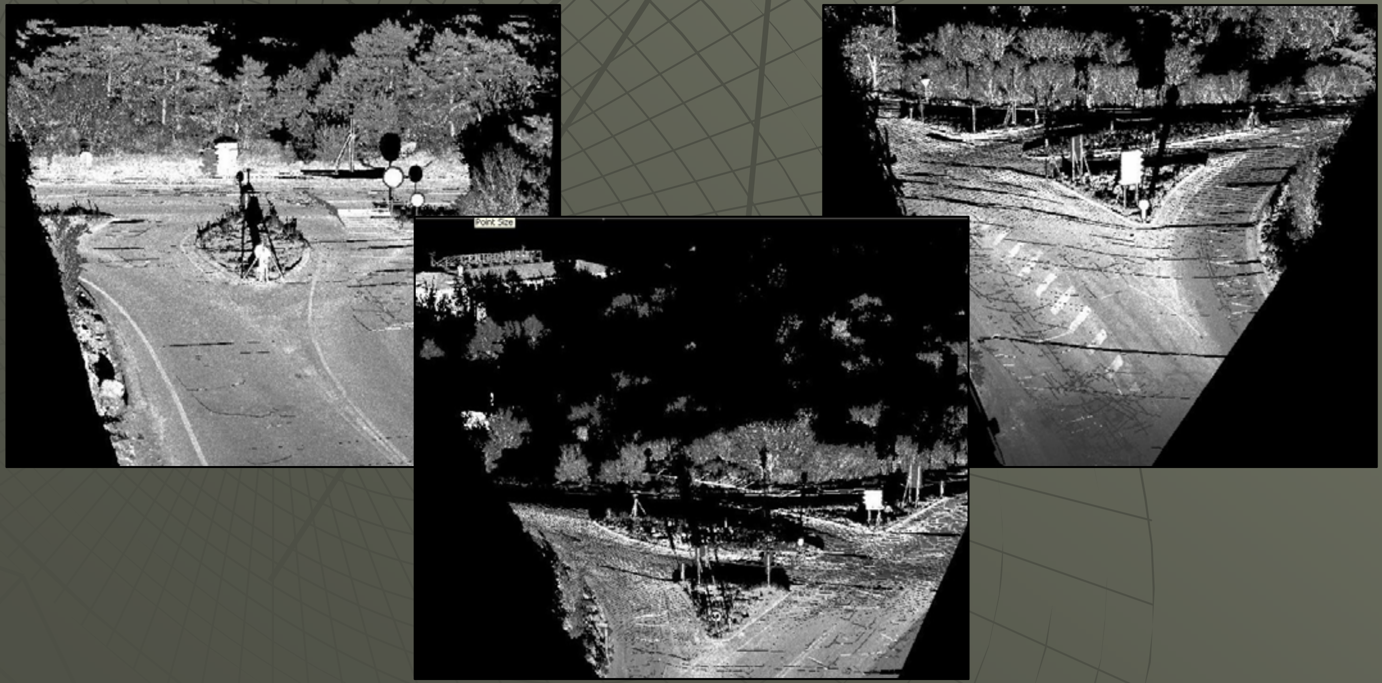
- A road intersection has been analysed on a provincial road, the SP1, near Prosecco, Trieste - Italy

- The analysis included the run road (in red the to trajectory, in blue the from trajectory and in orange the centre of the road), and two fundamental crosses of this provincial road.
- the points of the GPS stations in light blue, and the basis of the laser scans in violet are presented in the above Figures.

COMPARISON & CROSS VALIDATION: EFFICENCY OF THE DATA SURVEYED BY GIGIone M.M.S.

- 8 scans have been made in total from 5 different points, with a very dense grid (2,5cm at 50m) in order to obtain an high detail for the comparison between the horizontal signs surveyed by LS and that surveyed by the photograms obtained from M.M.S.
- Contemporaneously the road tract has been georeferenced using a GPS topographic survey.

Three examples of scans done in three different points



COMPARISON & CROSS VALIDATION:
EFFICIENCY OF THE DATA SURVEYED BY GIGIONE MMS – 2 -

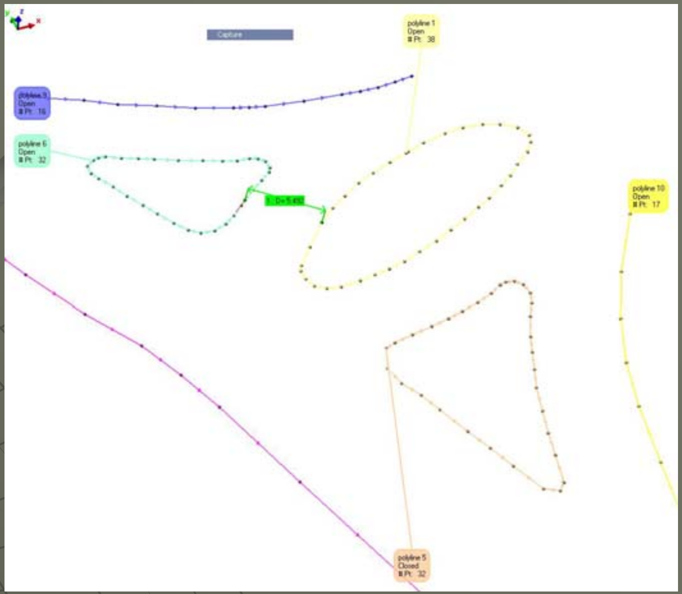
Linking together the scans with Poliworks dedicated software very good results have been obtained, **thus confirming the efficiency of the used technology (MMS GIGIone) for road cadaster purposes**.
Some examples of the obtained results are herein presented.

Blue: Tecnical Regional Numeric Cartography

Redo, white and grey scan results.

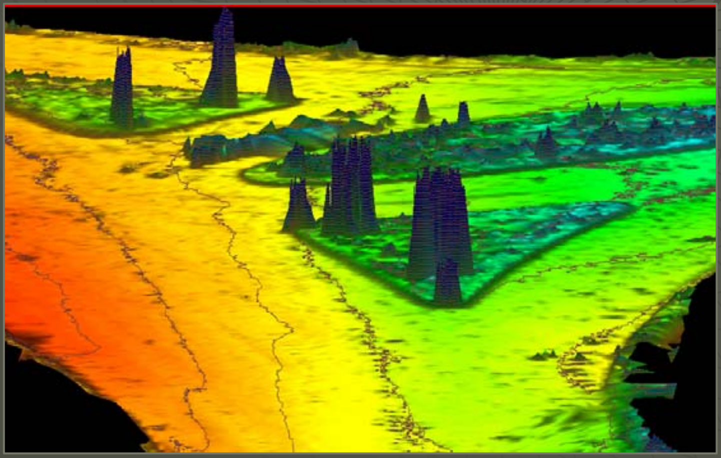
COMPARISON AND CROSS VALIDATION: EFFICIENCY OF DATA SURVEYED BY M.M.S. G.I.G.I. ONE

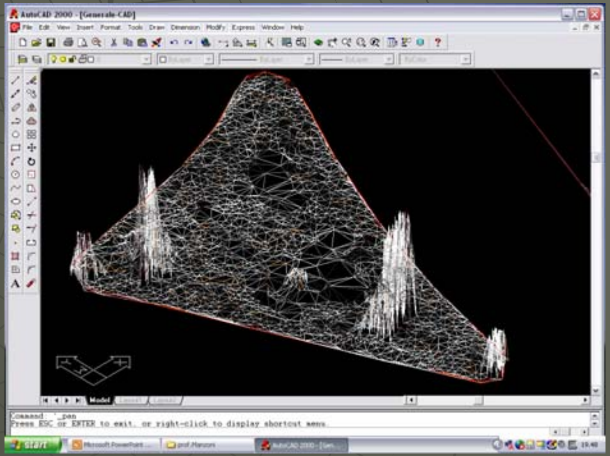
Using some software utilities, different types of informations have been extracted for the comparion and integration between the systems:

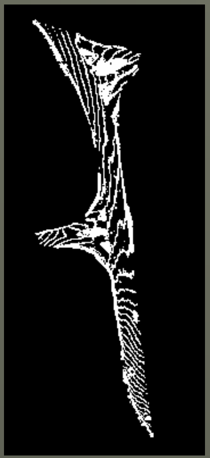


From the cloud of surveyed points the trangulated model has been created on the basis of the processing of the road sections and of the level curves.

The comparison between the measurements put into evidence the quality of the measurements done by the vehicle, also putting into evidence the limit of the integration between the two systems, using the laser scanner in static mode.



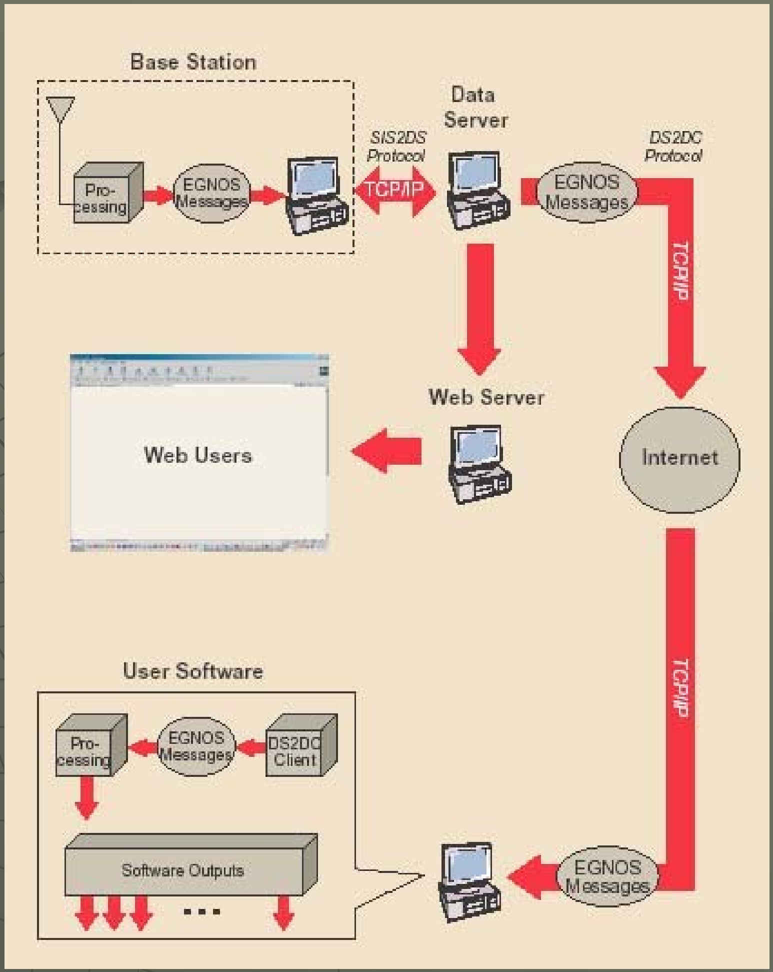




Local Data Server

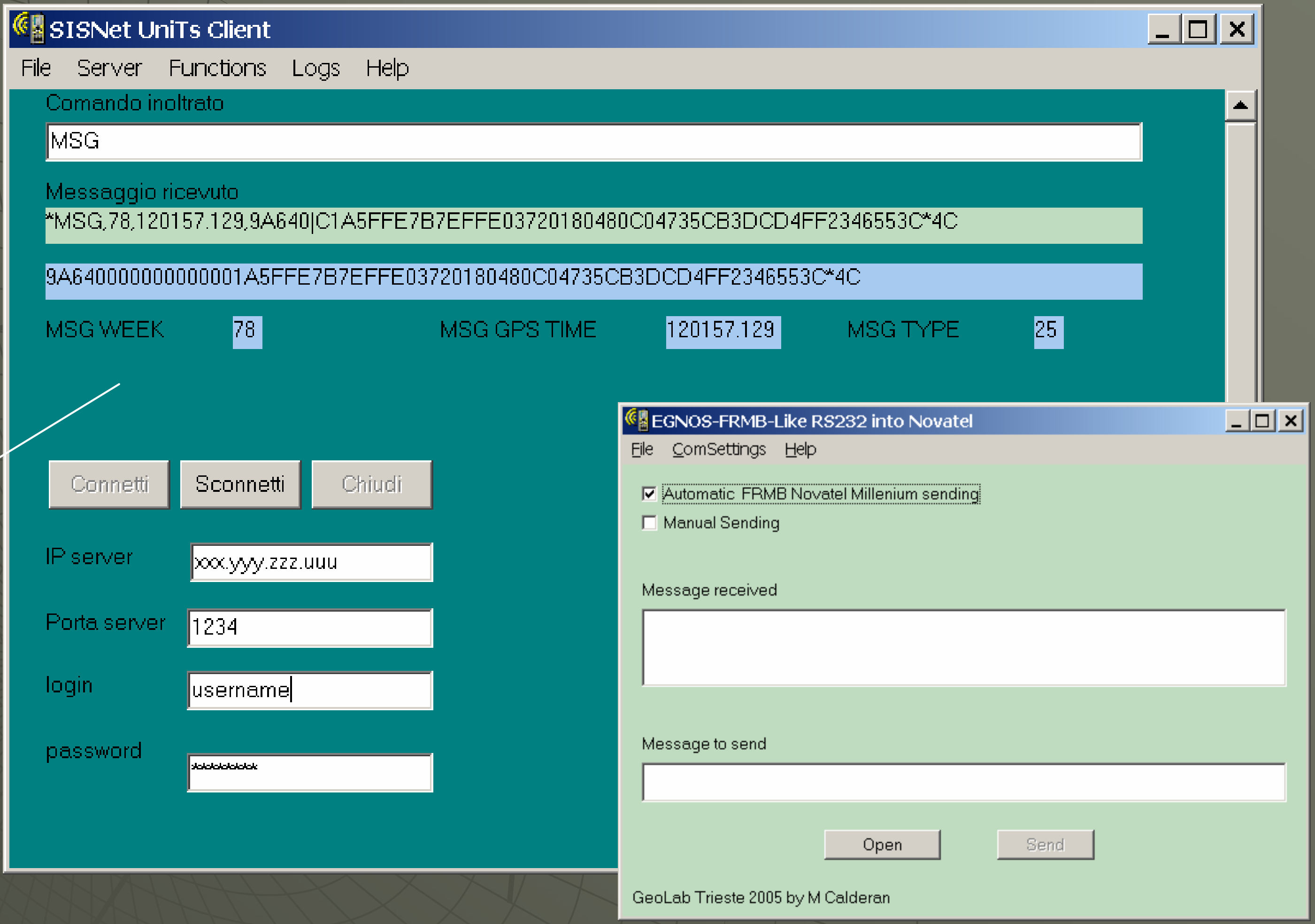
SISNET Architecture

The four main components of the SISNeT platform are:



- Base Station (BS)
- Data Server (DS)
- User Application Software (UAS)
- Web Server

UniTS Client



SISNet UniTS client Graphic Interface

Thank you for your attention…