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MONITORING THE CHANGES IN TABÁN PARK WITH GPS AND GIS TECHNIQUES

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1 - DATA ABOUT THE AUTHOR

This project was carried out by Andoni Ochoa Campo student of Topography Engineering, Industrial Engineering University of Vitoria-Gasteiz, institution member of the University of the Basque Country.

This is a research made on the scope of the ERASMUS agreement between the above mentioned university and the Eotvos Lorand University. The project was developed in the Department of Cartography and Geoinformatics of the Faculty of Informatics of the University (ELTE), located in Budapest, Pázmány Péter sétany 1/a.

The work has been made under the supervision of José Jesús Reyes Nuñez, Associate Professor (Department of Cartography and Geoinformatics) and the help of János Mészáros, PhD student.

The project is about measuring a park with a GPS , draw it with a computer aided design software and finally introduce it in a GIS software to see the changes that the park has had in the last years.

2 – INTRODUCTION

2.1 - Brief history about Tabán

Tabán is a small zone of the city, located in Buda, limited by three nearby mountains: Mount Castle (Várhegy), the Mount of Sun (Nap-hegy) and Mount Gerard (Gellért-hegy

In this area were the oldest human sites and archaeological investigations proved that the land belonged to villages in the Bronze , Copper and Steel Age. The Tabán name was given during the Turkish occupation, when in the hills established artisans under the name of Rácváros (Rác City) because it was inhabited by Serbs called "Rác" in Hungarian.

Tabán has been inhabited since Neolithic times, due to its location in a sheltered valley, hot springs at the bottom of the Gellért Hill and the ford over the Danube. In the Iron Age, was inhabited by a Celtic tribe, who was replaced by Romans in the 1st century BC.

In the Middle Age, the Turks developed the thermal medicinal baths in this area, attracting immigrants from the Balcans. Population increased after the liberation of Hungary from the Turks and refugees came from Greece, Bosnia and Serbia. The Franciscans of Bosnia established the parish church in the 17th century, which still exists today. In the 18th century, the city was inhabited by Serbs, Greeks, Germans, Croats, Slovaks and Gypsies.

At the end of the 19th century the neighbourhood became the slums, inhabited by the poorest inhabitants of Budapest. The extremely narrow and dirty streets became a real source of epidemics and diseases, which threatened the population of the capital. The rulers decided to demolish the barracks and to create a new modern area. The works ended in the third decade of the 20th century - Tabán was converted into a beautiful park the resting place of the inhabitants of the city and center of cultural events.

In the 30's, the Tabán was demolished to facilitate urban planning in Budapest.

Figure 1 - Tabán after its demolition in 1930

After urban planning in Budapest in the 30's, only some old houses Tabán were kept in the Naphegy district. One of them was the Tabán school, which was destroyed in January 1945 during the battle of Budapest. A football field can be found today where the school was placed. The only original streets remaining are the Gellérthegy Orom street and the street in Naphegy Czako Tabán.

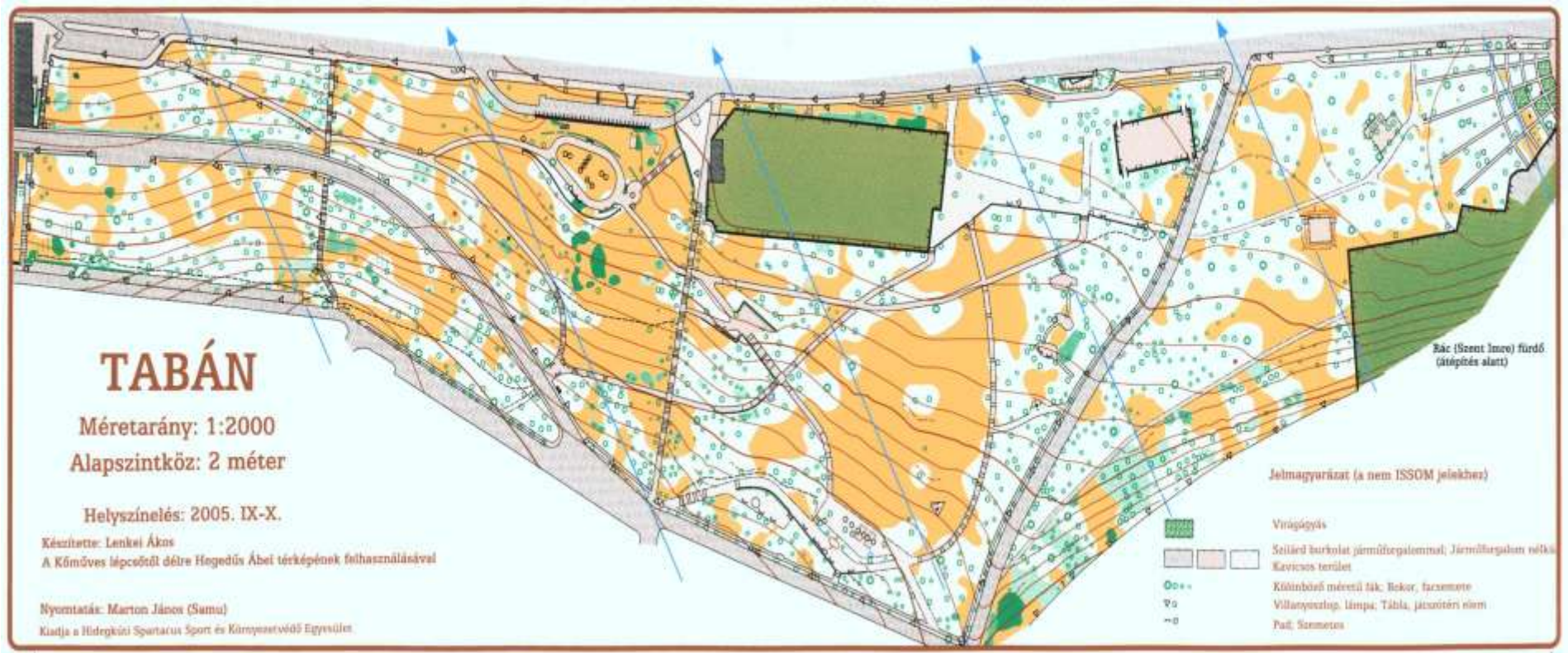*Figure 2 - Tabán park nowadays with the monument in memory of the Hungarian revolution*

Figure 3 – The scanned image of the map of Tabán in scale 1:2000

2.2 – Introduction about the aims/goals of the project

I divided the project in different parts:

- GPS survey
- Data collection
- Digital processing of the information
- Making of the map

First of all it was important to determine in detail the limits of the park and how could be taken information with the GPS to organize the measurement.

When I have all the information exported in the computer, it's important to check if it is correct, because working with the GPS accuracy (between (2 – 10 m) some points could be wrong or useless. In this case is better to delete these points to avoid mistakes drawing the map. Before draw the map, it is very important to change the projection to work with correct coordinates.

To draw the map first I use Autodesk Map 2000 and later I use MapInfo Professional to change the map and to see the differences between the old map and the new map. (the paths, streets, monument, etc.) and to represent the results of my survey in a definitive format. The following main information can be found in MapInfo

- The actual road system in the area , the including the numerous footpaths within the park
- Information that can be interesting for the tourism, as the different monuments, buildings or leisure places all of them represented with photos

3 - INSTRUMENTS USED IN THE PROJECT - THE GPS

3.1 - The GPS system

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides location on the surface in the Earth when and where there is a line of sight to four or more GPS satellites. It is created by the United States government and the access is free for anyone with a GPS receiver. In addition to GPS other systems are in use or under development. The Russian Global NAvigation Satellite System (GLONASS) was for use by the Russian military only until 2007. There are also the planned Chinese Compass navigation system and Galileo positioning system of the European Union (EU). GPS was created and realized by the U.S. Department of Defense (USDOD) and was originally run with 24 satellites.

It is based in an orbiting network of 27 satellites around the Earth. At present only 24 of them are operative, counting with four control and monitoring stations on Earth and the GPS receivers. The satellites have synchronized trajectories to cover all the Earth's surface. They are distributed in 6 orbital planes with 4 satellites each one

Each satellite broadcasts a signal that is continuously recorded by a receiver on Earth's surface. Thus, if the clocks that are the satellites and in the receiver are synchronized, is possible to calculate the travel time of the signal, knowing the time that the satellite broadcast on the signal and the time is received in the receptor.

Multiplying this time by the velocity of light find is easy to calculate the distance between each satellite and receiver. Each distance defines a sphere centered on the satellite, and the intersection of 3 spheres analytically we would point position through its 3-dimensional coordinates (X, Y, Z).

However, it is very difficult to the clocks or oscillators of the satellites and the receiver to be perfectly synchronized, because the precision of the receiver clock is less than the satellite. To solve this problem we need the signal from at least 4 satellites.

This operation system is called triangulation because is based in the intersection between al least three signals.

The GPS is divided into three segments: **space segment, control segment and user segment.**

The **space segment** contains the satellites emitting signals, known as NAVSTAR (Navigation Satellite Timing And Ranging), which consists of a minimum of 24 satellites arranged in 6 orbital planes with 55 ° tilt with respect to Ecuador. It also has some spare satellites in case some of which are in operation fail. The satellites are arranged to guarantee at least 4 satellites visible from anywhere in the world, 24 hours a day.

The **control segment** is who controls the system, through 5 stations on Earth . These stations are Hawaii, Colorado Springs, Ascension Island in the South Atlantic, Diego Garcia in the Indian Ocean and Kwajalein in the North Pacific. These stations continuously monitor the satellites and can make changes to the information transmitted by satellites.

Finally, the **user sector** consists of all equipment used for receiving signals from satellites and used for positioning, navigation or for determining the precise time.

The GPS is used in many fields such as geodesy, geophysics, geodynamics, astronomy, meteorology, topography and cartography. Also used in marine navigation, air or land in the synchronization of time, to monitor fleets and machinery, the automatic vehicle location or exploration and adventure sports.

Figure 4 – The operation of the GPS

http://www.genciencia.com/tecnologia/fundamentos-del-gps

3.2 – GPS features

The GPS that I use in the project is a GARMIN GPS Navigator GPSmap 60CS

Figure 5 - GARMIN GPS Navigator GPSmap 60CS

This type of navigators are usually used to go hiking or mark paths in the mountains, but it could be used to activities related to orienteering wherever you want to go in the city or in the sea or to do works that doesn't need so much accuracy.

The accuracy of this GPS technology is poor comparing with others like the differential GPS, VRS or a static observation. It's between 1m – 10m but it depends on so many factors:

Atmospheric conditions: The GPS signal when is transmitted through the atmosphere is refracted because of the particles that are in the ionosphere and troposphere. Due for this the speed of the GPS signal changes when is crossing the atmosphere and the distance calculated from the signal speed causes an error in the position of the GPS.

-Ephemeris Errors/Clock Drift/Measurement Noise: This error is the gap that has the satellite clock time with the GPS Time. The errors in the satellite oscillators may be removed by the corrections sent in the navigation message received by the rover, and are calculated and updated by the monitoring stations.

These parameters are recorded in the corresponding satellite and included in the navigation message that sends the satellite.

To calculate its position, the receiver must know the positions of the satellites. Monitoring stations recorded data pseudorange and phase measurements to send to the master control station and to transmit in the satellite navigation message. The ephemeris broadcast by the satellites will have an associated error because it is impossible to predict accurately their positions. Errors in the orbital parameters can be eliminated by working with the precise ephemeris days of observation, which shows the true positions of the satellites.

-Selective availability Selective Availability is an alteration or manipulation of information that the GPS satellite constellation sent to users in the navigation message, handling that the Department of Defence (DOD). It acts on the states of the clocks and orbital parameters. Working with relative positioning or differential can eliminate this error.

-Multipath: Multipath effect is mainly caused by multiple reflections of the signal emitted by the satellite in near-surface receptor. These reflected signals have a longer travel time and can significantly distort the amplitude and waveform. This effect can be considerably reduced by choosing protected station points reflections (buildings, vehicles, trees, etc.) avoid reflective surfaces near the receiver and appropriate design of the antenna. The multipath effect depends on the frequency of the signal; phase measurements will be less affected than the measures of code.

-DOP: DOP is an indicator of the quality of the geometry of the satellite constellation. Measurements from satellites can be better or worse depending on which satellites are used to make a measurement of position, because depending on the relative geometry space can increase or decrease the accuracy. Its ideal value is one, but increases if the geometry is worse, being able to produce a situation where having enough satellites in view, the observation must be suspended because the DOP exceeds a value such as 6. Thus, the DOP is a factor that is multiplied by the error in the determination of the distances to the satellites to establish the final positioning error.
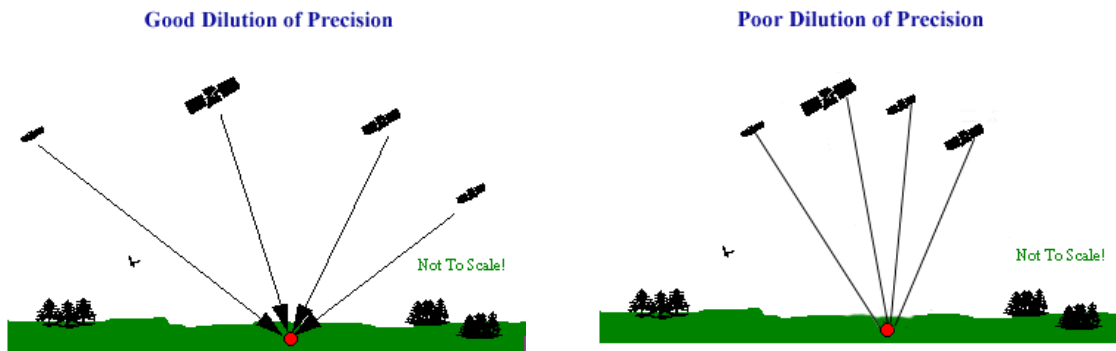
Figure 6 – The Dilution of Precision (DOP)

Due for this is almost impossible to determinate the real precision of the GPS, but it s possible to know more or less the range of each type of GPS to know if it is valid to the work that I want to do.

The coordinates obtained wit this GPS are geographic coordinates (latitude and longitude) and the height is referred to the WGS84 ellipsoid. In the specific case of Hungary the projection used is the EOV, that is the "Egységes Országos Vetület" (Unified National Projection). This projection system was introduced by the civilian National Mapping Agency in 1972. It is a conformal cylindrical projection in transversal position used for the Hungarian civilian base maps.

The maximum horizontal error of the approaching projection is 0.17 millimetres in Hungary. This enables the definition of the Hungarian EOV projection in worldwide used GIS software packages, and even for precision-claiming geodetic applications. The parameters are the following:

- Latitude of the central point:

$F_0 = 47\ 08'39.8174"$

- Longitude of the central point:

. $c = 19\ 02'54.8584"$;

- Scale factor:

$k_0 = 0.99993$;

- Azimuth of the central line at the central point:

$a = 90$

- False Northings:

$y_0 = 200000.00114$ m;

- False Eastings:

$x_0 = -9370549.28432$ m

The reference system used by the GPS is the "**The World Geodetic System (WGS)"** is a Conventional Terrestrial Reference System (CTRS). Is a geocentric reference system positively oriented and their parameters have been defined by the IERS (International Earth Rotation System) and is the reference system used by the Global Position System (GPS).

Is used like a standard coordinate frame for the Earth using a standard spheroidal reference surface for the altitude data and like a gravitational equipotential reference surface that defines the average level of the sea.

These are the parameters that defines the frame:

- The origin of WGS is in the center of the mass of the Earth.

- The OZ axis is oriented to the Reference Pole IERS and matches with the Conventional Terrestrial Pole.

- The OX axis is the intersection between the Reference Meridian of the IERS and the perpendicular plane of the origin of the coordinates.

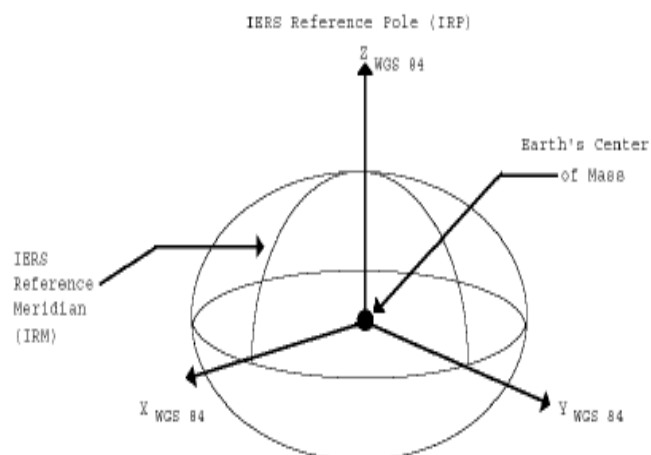- The OY axis is perpendicular to the two axes above.

Figure 7 – The WGS 84 frame axis

The latest version of the frame is the WGS84 created in 1984, but are other older version like WGS72, WGS66 and WGS60. The error of the frame is believed to be less than 2 cm

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3.2.1 - Characteristics of Garmin GPSmap 60CS

Navigation features

Waypoint/icons: 1000 with name and graphic symbol, 10 nearest (automatic), 10 proximity

Routes: 50 reversible routes with up to 250 points each, plus MOB and TracBack modes®

Tracks: 10K point automatic track log; 20 saved tracks 500 points each let you retrace your path in both directions

Trip computer: Current speeed, average speed, resettable max. speed, trip timer and trip distance

Alarms: Anchor drag, approach and arrival, off-course, proximity waypoint, shallow water and deep water

Tables: Built-in celestial tables for best times to fish and hunt, sun and moon rise, set and location

Map datums: More than 100 plus user datum

Position format: Lat/Lon, UTM/UPS, Maidenhead, MGRS, Loran TDs and other grids, including user UTM grid only

GPS performance

Receiver: 12 channel SiRFstar III™ high-sensitivity GPS receiver (WAAS-enabled) continuously tracks and uses up to 12 satellites to compute and update your position

Acquisition times: Warm: < 1 sec
                       Cold: <38 sec

Update rate: 1/second, continuous

GPS accuracy: Position: <10 meters, typical

Velocity: .05 meter/sec steady state

DGPS (WAAS) accuracy: Position: <5 meters, typical

Velocity: .05 meter/sec steady state

Antenna: Built-in quad helix receiving antenna, with external antenna connection (MCX)

*http://www8.garmin.com/products/gpsmap60csx/spec.html*

3.2.2 - Brief manual operation of GPS

Obtaining coordinates of a point with the GPS is very easy.

In this chapter are explained the different options and features used during a GPS data collection.

The first feature to know is the function of each key of the GPS, to be able to move properly within the menus and interface of the GPS. This is the scheme of the GPS functions:
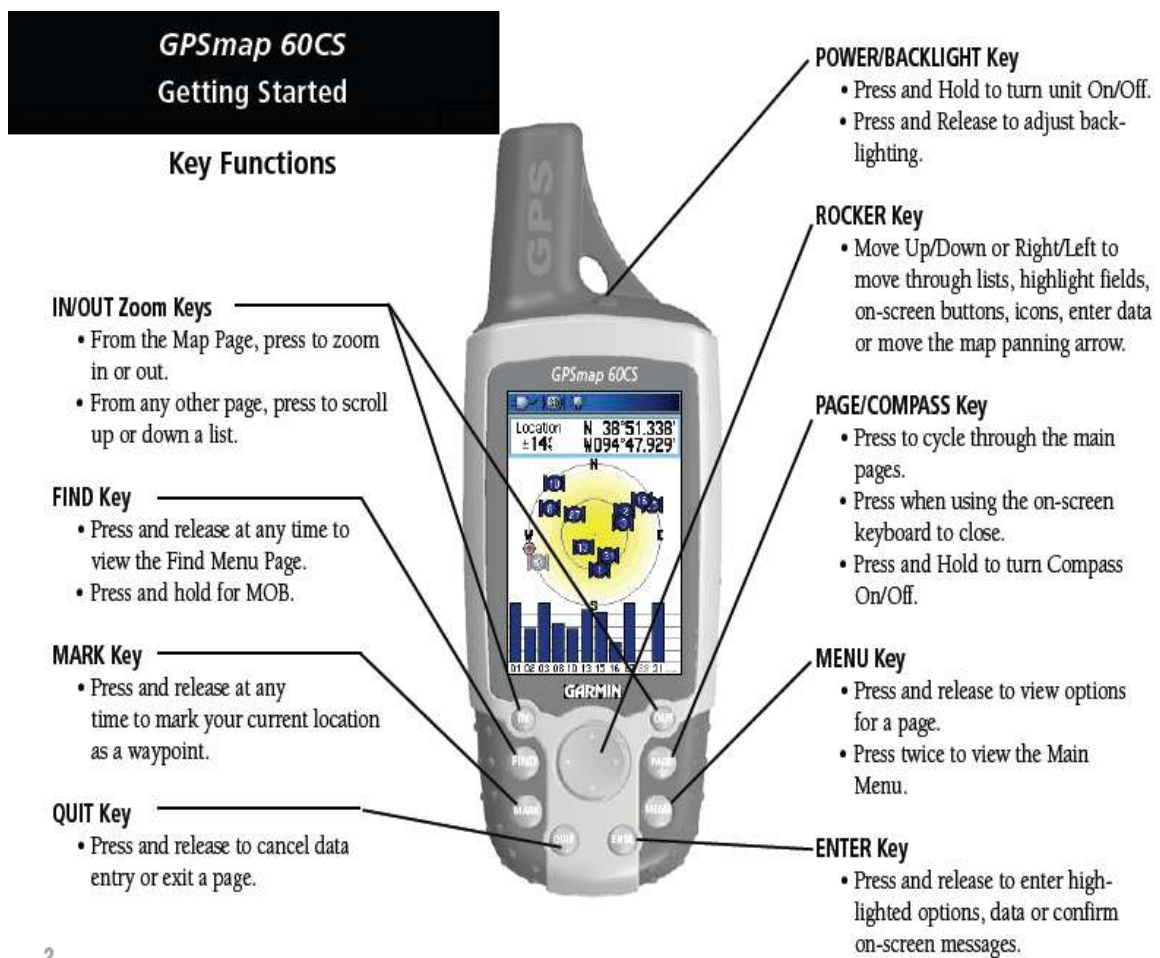
Figure 8 – Functions of the bottoms of GARMIN GPS Navigator GPSmap 60CS

GPSMAP60CS_OwnersManual.pdf

Starting Up the GPS receiver

When the GPS is turned on, the GPS receiver begins to search for satellites in order to determine and fix its location. This process is called "initialization" and can take from 5 to 15 minutes the first time is used. In order to receive satellite signals is required to be outdoors and have a clear view of the sky. The satellite signals cannot pass through solid materials or dense overhead tree cover. Due for this, the signal received from the satellites depends on the atmosphere and other many factors. This is the display to show the number of satellites:
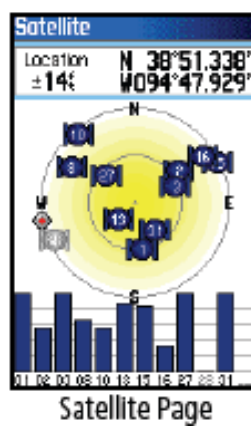

Satellite Page

Figure 9 – Satellite Page

In this display is possible to read the accuracy of the GPS (Location ± 14), the geographic coordinates of the point (in this case N, latitude, W longitude) and the number of the satellites located by the unit to receive their signal, as well as, the quality of the signal.

Different options and menus offered by GPS

When the GPS is initialized with the "PAGE" key the next information can be read

Trip Computer page

The Trip Computer page shows a variety of travel data that is useful when navigating a long distance. It indicates the current speed, average speed, trip odometer and many other helpful statistics useful for navigation.

Figure 10 – Trip Computer Page

Map page

The Map page is the primary navigation feature of the GPS. This page displays a detailed map of the area surrounding the current location. With the "Rocker "key the user can pan the map as well as view the progress when navigating.

The map also displays geographic details such as rivers, lakes, high-ways and towns.

Figure 11 – Map Page

Compass page

The Compass page is the guide to accurate and efficient navigation. It uses traditional navigation displays to provide navigation information like the direction is heading, the current speed, distance to the next point on the route, estimated arrival time etc.
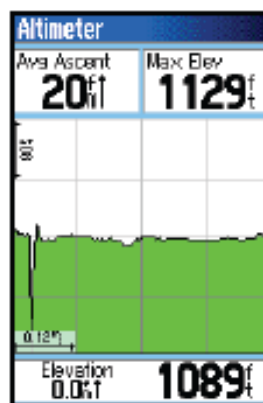
Compass Page

Figure 12 – Compass Page

Altimeter page

The Altimeter page provides the user the current elevation, rate of ascent / descent, a profile of elevation changes over the distance or time, or a profile of pressure changes over time.

Altimeter Page

Figure 13 – Altimeter Page

Main menu

The Main menu is the principal menu of the interface. In this menu is possible choose a lot of options but the most interesting one is the "Tracks "item.

Figure 14 – Main menu page

Track log

This option creates an electronic trail on the map as the user is moving around it is called "track log ". A track log contains information about measured points along its path, including time, position, elevation and depth. This option is used to record the movements for a given time and to place and to save it.
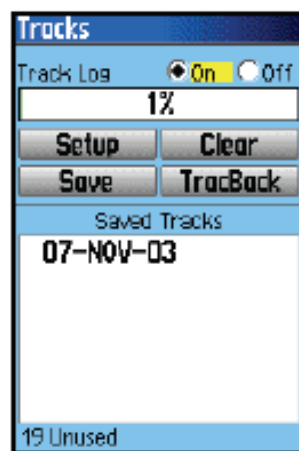

Figure 15 – Track page

It's useful to measure lines with a constant interval of points, time or distance.
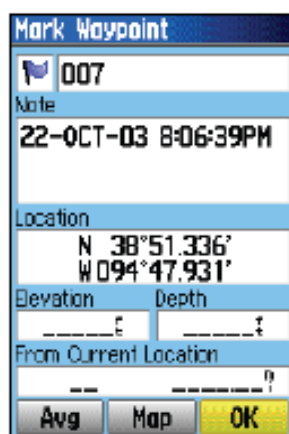
<u>Waypoints</u>

This is the option that I used to measure the park, because with this option you can mark the point of the map that you wish the more interesting points, predefined points etc...

Only pushing the "Mark "key in the GPS we can mark the wanted point and open the Mark Waypoint page.

The Mark Waypoint page allows us to mark and record the current location as a waypoint and displays the name for that waypoint, as well as, a waypoint symbol in the map.
It is also possible to mark the current location at any time. Is possible to change the name of the waypoint, the date, and to see it in the map and its coordinates in real time.

Mark Waypoint Page
Figure 16 – Mark Waypoint page

<u>Setup Units page</u>

The last and important page or option to show about the GPS is the Setup Units page.

This page allows to choosing the units of measurement, reference system, type of coordinates and the datum which GPS is going to use to show and measure the coordinates of the waypoints. The access to this page is going to the *Main menu – Setup - Units*

In this project I used the Hungarian Grid as position format, the datum is WGS84, (the datum of the ellipsoid that usually uses all the GPS instruments) and the units are in the meters.

GPSMAP60CS_OwnersManual.pdf

4 - THE TABÁN SURVEY

The first step was to organize the work, because it is very important to analyze the type of the information that we should get and the topography of the park.

The extends of the park are too large to start collecting data in a disordered way. Analyzing the source map I divided the park into three different sections to have better organized the data. Each work day I measured data in one predetermined section of the park, and then exported this data to the computer and analyzed it, to see I made any mistake during the measure or if something was missed, repeating the measure if it was necessary.

This is the plan that I followed to get the coordinates of selected points and the thematic information of the park:
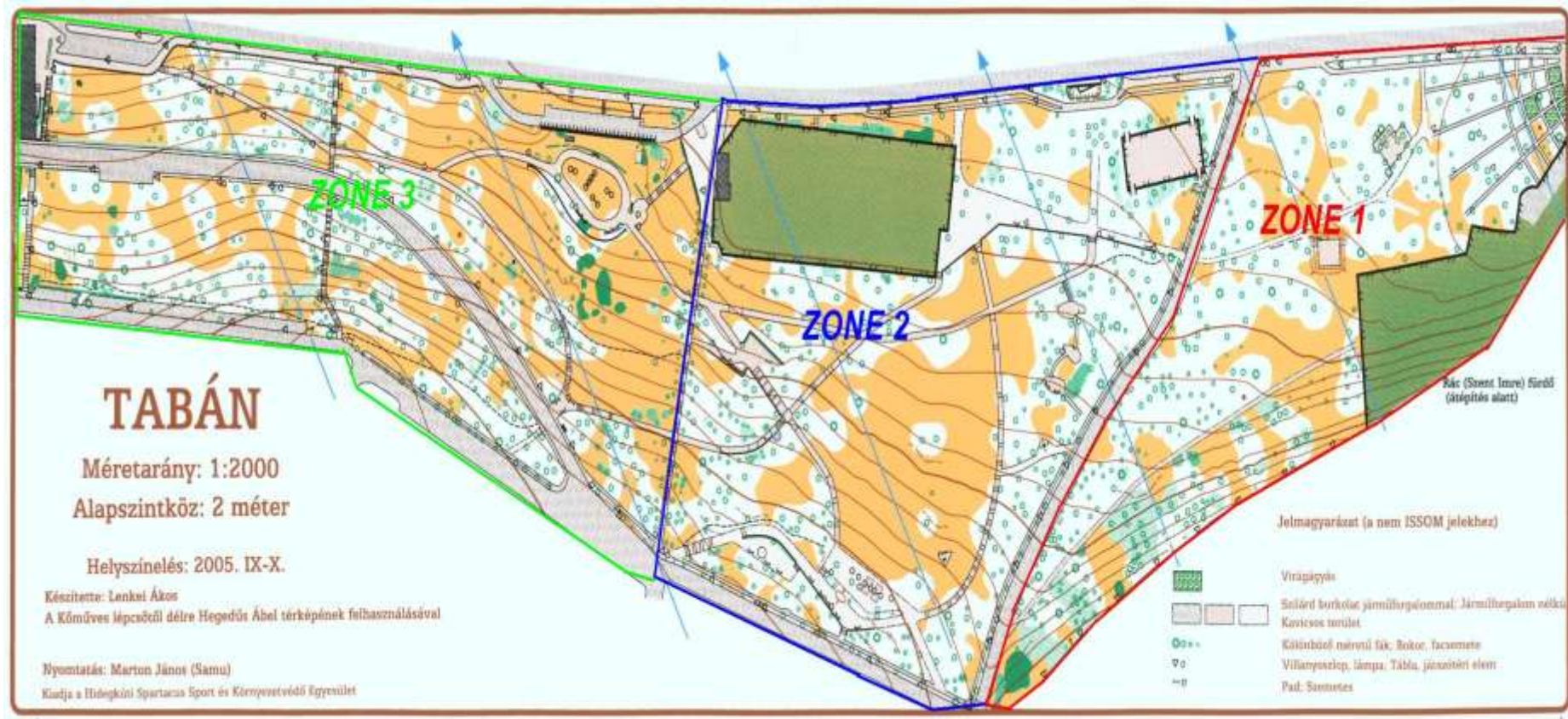
4 - THE TABÁN SURVEY

Figure 17 – Tabán map divided in survey areas

The information that I needed to collect are the streets, the paths, the interesting places: monuments, football fields, modified buildings discarding the trees, the benches, the bins and other many elements that could be seen in the park, but especially the right part of the park located in the *Zone 1* (in the map could be seen as region in green) because there has been important changes in the last years and it is one of the main aims of the project.

I differentiated 4 categories of paths when I started to take information:

- The sidewalks (are going to be represented by the "limit park")
- The roads that cross the park,
- the paths that were into the park,
- the bike lane
- the stairs that crosses the park

The first day I went to the park only to identify where is it, the way to arrive there, to determinate the limits of the park and to see the changes in the Zone 1 that I mentioned above. This part of the park has undergone several changes: there is a new building, with a parking and an entrance to this parking and it is still running out.

When I have the needed information to organize the data collection, I returned to the park to test the use of the GPS. I took some random points, and I exported them to the computer, only to test the use of the GPS and the software that I had to use to download the data.

It was important to collect the data before the winter started in Budapest, otherwise the paths and the streets could be covered by the snow.

5 - DATA COLLECTION

To take the data from the park was necessary a source map that Prof. Jesús Reyes and Prof. László Zentai gave to me. It is a scanned orienteering map of Tabán made in 2005, at scale of 1 / 2000, with an equidistance of 2 meters. The standard legend of the map was very useful to understand the symbols on the map, to know how many elements are in each zone and to identify the correct position of each measured point.

All the points that defined the limits of the park and its roads, paths, swings, monuments and transport stops were measured. It was very important to choose an interval of meters between one point and the next waypoint to have a minimum criterion to measure.

The selection of the waypoints depended on the topography of the park and the accuracy of the GPS. It was not possible to measure two points that are closer each other, than the minimum accuracy defined by the GPS, because in this case the results were be contradictories: - When the surface was plain, mostly without a notorious elevation, I marked a waypoint inside a 15 – 20 m long line.

- When the line of the surface that I wanted to measure had a notorious elevation, then I reduced the interval of the measurement to an interval between 10 – 15 m long or less in some cases.

- When the line that I wanted to measure had a curve, then I reduced the interval to mark correctly the curve, but always taking into account the accuracy of the GPS, so depending on the radio of the curve I used an interval between 5 – 10 m

These scales are not exactly what I followed during all the survey, because sometimes the surface has a high gap and it was better to mark waypoints with a less interval of meters, but in general, is important to respect these scales to have a minimum criterion to measure and to have a consequent and regular cloud of points in the Computer Aided Design software that later used to draw the map

5.1 - Experiences acquired during the data collection

For obtaining enough information of all the paths in the park, I took as much points as it was necessary, considering the shape of each path; if there are parts that have more curvature I had to take more points to determine it more accurately, but if it is a straight path or road, I did not need to take so many points.

The most important fact to consider while I was taking points with the GPS, was to know which element of the park I was measuring, I decided to record each waypoint number was measured to know which item was referring in the park. Thus, I had notes about each point that I measured to identify the point later, when I'm going to draw the park. E.g. the interval of waypoints between numbers 54 and 78 is the limit of the park. Starting from these waypoints I measured the path number 1, that was annotated in the Tabán map too. It was very useful when I started to draw points with AutoCAD, because there are almost 1000 points and it could have been so difficult to locate each part or element of the park.

At first, I was taking points of each side of the narrowest footpaths, but when I downloaded the data I realized that some points were not in the position they should have been, being contradictory the information. The problem was that the width of the paths or roads was less than the precision of the GPS, so if I measure the two sides the results will not have any sense. Due for this, I only took points in the middle of each path and I measured, more or less, the width of each path to be able to draw it with AutoCAD.

I made the mistake of trying to mark more points than the necessaries, being these points so close one to each other. This was a severe mistake because when I download the data I realized that so many of them were in a position that don't should be, so I decided to start to simplify the survey to avoid this type of errors and to draw easier the map.

I had many difficulties with the accuracy of the GPS. When I took the points of the first zone and I downloaded it, I realized that a lot of them were so far of the position that they should be (200 meters in average), an unacceptable value. I realized that the points that were wrong were the first points that I measured, so first I thought that it was a mistake taken during the initialization of the GPS, because I didn't let the GPS to catch a minimum of satellites and the precision could have been affected.

I returned to the park and with a longer time of initialization I took again the points that were wrong, take into account the precision marked by the GPS, and joined this information with information collected during the first day.

In both cases the accuracy of the GPS was very low, because of multipath and other facts. The park was surrounded by huge buildings, the Buda palace and a high hill are in front of the park, and in the other side the park has a lot of slopes, so the effect caused by them is like a huge wall reflecting the signal of the GPS. If you add that the park is crowded of trees and that the technology of the navigator was not optimal, then the accuracy hardly could overcome 5 – 6 meters, and sometimes it is difficult to have less than 10 meters of accuracy.

Considering the number of paths, sometimes it was difficult to remember if each path was measured, so I started to mark each measured path on the printed map of Tabán.

6 - DIGITAL DATA PROCESSING

The digital processing of the information consists in all the operations that are needed to import/ export the measure data from the GPS unit and to download it into a Computer Aided Design software to process and edit the information.

In this specific case the objective is to create an information map about a park, showing the changes supported during the last years and to show thematic information about the interesting places of this park.

In interest of reaching this aim I need to try different CAD and GIS software like the GPS Trackmarker, Global Mapper, AutoCad and MapInfo.

Next all this process is explained, differentiating between the different operations and steps that I had to do with each software or phase of the data processing.

6.1 - Import / export data from the GPS

The first step is to download the data measured with the GPS to the computer. To do this the GPS should be connected to the computer using an USB 2.0 cable. Next, data should be imported to a software, in this case GPS Trackmarker.

- <u>GPS Track marker</u>: GPS TrackMaker is a communication program to connect GPS to PC. It supports many types of GPS units to download the data, like Magellan, Garmin or Lowrance. The software includes many features like create, edit and delete tracklogs, routes and waypoints, calculate length, instantaneous and average speeds in tracklogs, edit the names, commentaries, dates of the waypoints etc.

The data can be stored in TXT, GTM and other exchange formats to open the data using other software too. This software uses its own file format *. GTM, which could be exchange eg. to Global Mapper. This format contains all the waypoints or tracklogs and its properties.

http://www.globalmapper.com/

After connecting the GPS to the computer using the USB 2.0 cable, I opened the GPS Trackmarker software to know better the workspace and it's menus and items.

The download of the data from the GPS is using the *Main menu → GPS → Garmin interface,* appearing the next window:
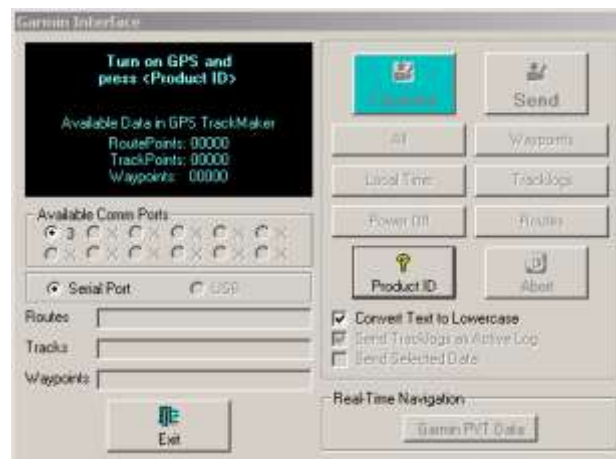

Figure 18 – Track marker data importing window

In this window we selected the *"Capture"* key and all the data from the GPS is automatically imported to the workspace as we can see in the *Figure 19.*
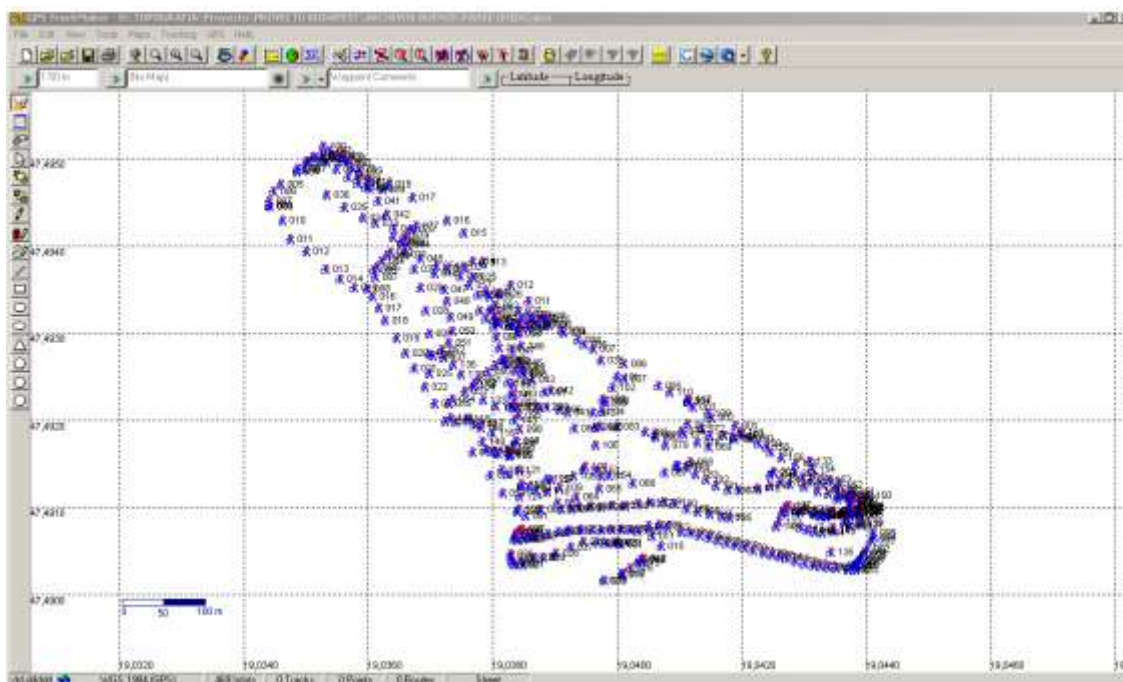

Figure 19 – Imported waypoints from the GPS

As I have the data of the park divided into three different zones it was needed to join them, before we export this data to the Global Mapper. To join the information each *. GTM file should be open and the program automatically join it in the same workspace, saving it together.

Sometimes the waypoints appear with the date of the measurement day but it is possible to change to the number given to the waypoint. To do this you have to select all the waypoints, go to the *Main menu → Tools → Waypoints → Change the selected waypoints -->* and then choose the option "Symbol *with name* " instead of *Symbol with commentary.*

6.2 - Changing the projection

Once the data is saved in the *.GTM format the next step is to change the projection, because if we want to draw the map with AutoCAD the work should be made with plane coordinates and not with spherical (geographic) coordinates.

To do the change I used the Global Mapper software.

- Global Mapper: Global Mapper is a software that can be considered a kind of geographic information system (GIS). This software competes with ESRI, Manifold System, and MapInfo GIS products. Global Mapper handles both vector, raster and elevation data, and provides viewing, conversion, and other general GIS features, but the analysis features do not reach the level of the most important GIS systems.

This software allows the user to change the projection of the original data, to convert formats into other ones, and to add and change to one project more specific (thematic) information.

- http://www.globalmapper.com/

First I had to open the joint data saved from the GPS Trackmarker in *.GTM format.
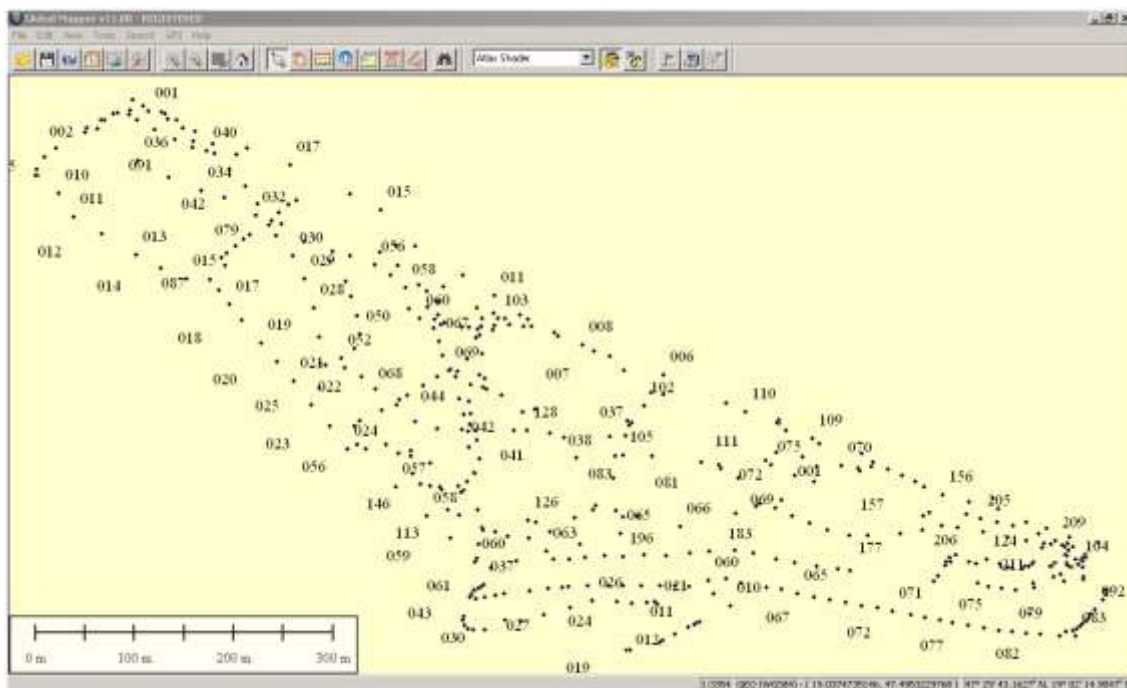
When the data was open, we could see the waypoints:

Figure 20 – The waypoints measured in Global Mapper software

With the option *Main menu → Tools → Configure → Projection* the source parameters can be changed to the parameters of the Hungarian National Grid (EOV) and to the Hungarian Datum 1972.
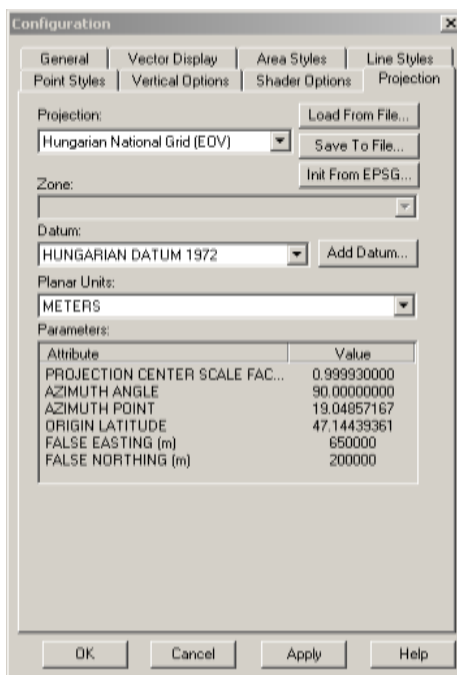

Figure 21 – Changing the projection window in Global Mapper

After the projection and datum is changed, the data had to be exported to a format that AutoCAD can identify. The native formats of the AutoCAD are the *.dxf exchange format or the *. dwg format. To export the data to these formats we can select the next option:
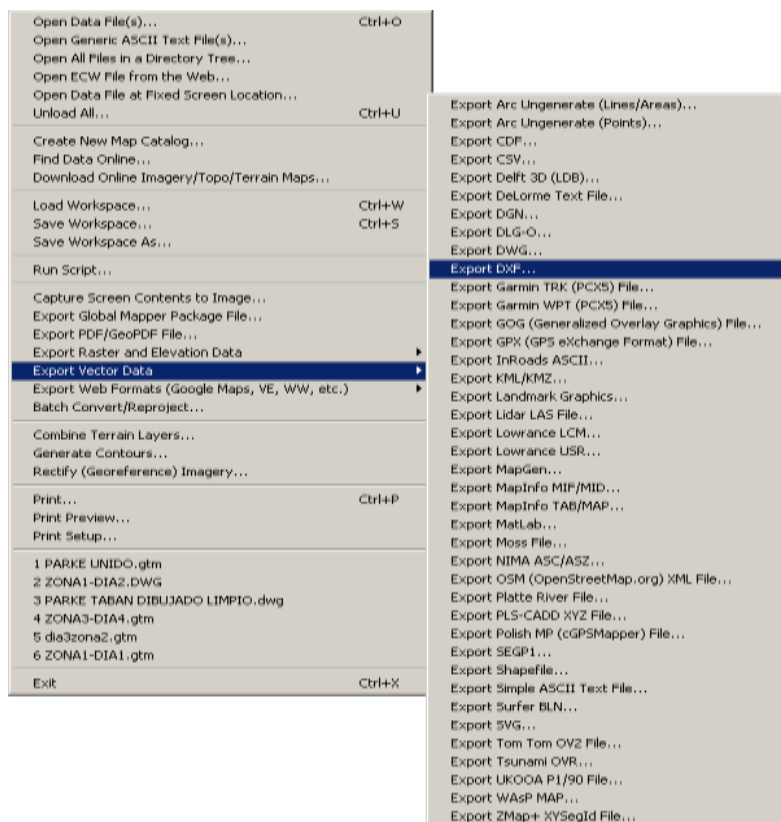
Figure 22 – Export data menu to DXF format

Between this two formats (*.dxf and *.dwg) I decided to export the data to *.dxf format, because if I use the *.dwg format, when I open the data with AutoCAD, the points do not appear, only the label of the point.

6.3 - Coordinate checkout

Before starting to draw the map with AutoCAD, it is important to check the coordinates of the points to verify if they are in the correct position. There are so many ways to check the coordinates, like obtaining a referenced map of the zone and checking manually some points to know if the coordinates are valid or not. Other option is to export using Global Mapper all the points to the Google Earth format, *.kmz or *.kml, using this program to see if the coordinates of the points are correct or not.

I choose this second option because I thought that is a more comfortable and precise option.

Exporting the data to the Google Earth format is similar to export the data to AutoCAD, which I explained before. Select in *the Main Menu → File → Export vector data → Export KML / KMZ*
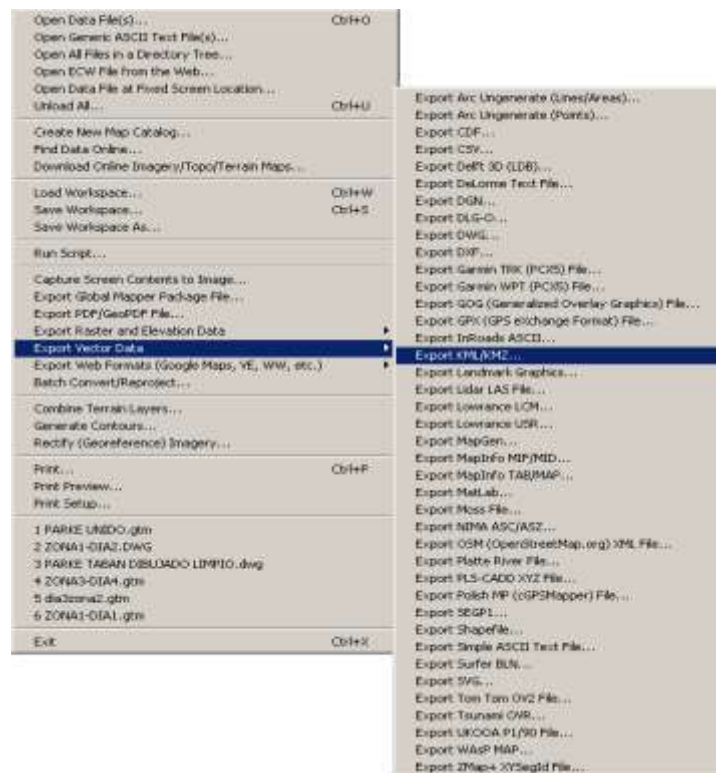

Figure 23 – Export data menu to KML/KMZ format

Once I have all the data in *.kml format, opening this file in Google Earth the program places automatically the points according their coordinates. The results were acceptable, placing all the points, considering the error of the GPS, to the place that they should be.
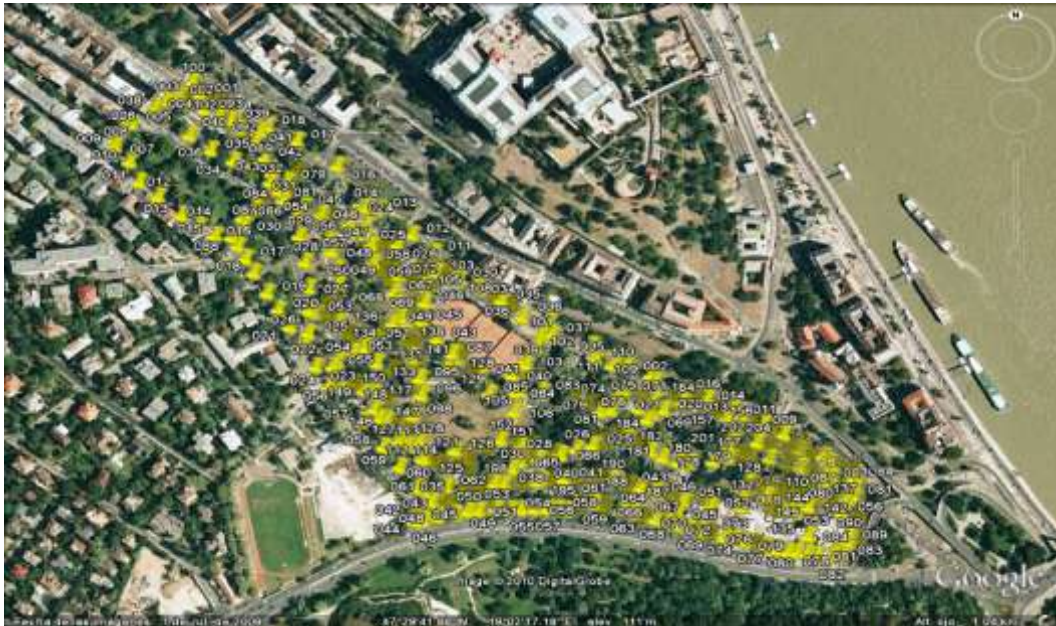
Figure 24 – Measured points introduced in Google Earth

Checking the coordinates of all measured points in the park by this way, I know before importing into Autocad some of the mistakes made by measuring with GPS.

Once I checked out that all the points were in the correct position I started to draw the park with AutoCAD.

6.4 – Drawing the previous map

When the joined data is exported to *. dxf format in the correct projection, it is ready to begin to draw the map in AutoCAD.

- - <u>AutoCAD:</u> It is a Computer Aided Design software for drawings in two and three dimensions. The vectorial processing is based on geometric entities (points, lines, polygons, etc). The user can edit these entities in a powerful graphic screen, named also drawing editor. The objects are organized by layers, giving the choice to change the graphic properties of the objects (eg. to define different colors for each layer).
  The native extension of AutoCAD files is ".dwg", although the software exports data also to other formats, being the most popular the ".dxf", a file saved in text format that can be identified and imported by the majority of graphic software in the market (GIS, CAD, general graphic, etc).

  - http://www.autodesk.es/adsk/servlet/index?siteID=455755&id=12382581

I opened the *.dwg data with AutoCAD and first I created the layers that are going to be used to differentiate the categories of the map, because as I described above, there are many different types of roads, paths and other elements in the map.

To create a new layer we should only click on the "New" button in the Layer menu and the new layer will be created. We can change the properties of this layer giving it a new name, creating a different line style and choose a colour. In this case the layers made were:

- Limit park
- Roads
- Paths
- Stairs
- Bike lane
- Buildings
- Monument points
- Building points
- Leisure points
- Transport points
- Waypoints layer

To this last layer were introduced all the waypoints downloaded from the GPS and pre-processed in MapInfo. I gave to each layer different colours to differentiate them.

The Building points, Monument points, Building points, Leisure points and Transport points layers were created because when I export all the layers to MapInfo I want to assign the information and a photo of each interesting place, so I will use these points to assign this information.

I only differentiate two categories of roads, the wider paved roads and the paths inside the park that are narrower. There were also other type of paths like the bike lane, the stairs and the side walks and I choose a different colour for each one.

The importance of each one is going to take into account when I do the final GIS map differentiating different categories and giving different style properties.
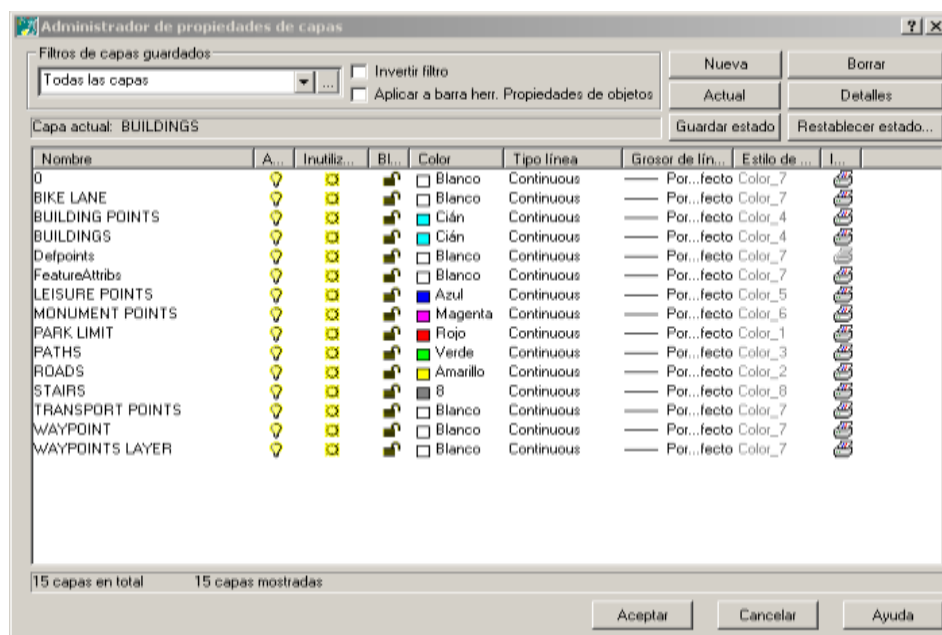
Figure 25 – Layer administrator in AutoCAD

With the layers created I started to draw the map. It was important to take into consideration the categories of the paths since depending on them they were drawn in the corresponding layer. For drawing the map I took as reference the base map and the notes that I took to know what type of element (limits of the park, stairs or other) is each number or interval of points.

Is adequate, all the points should have been in the correct position, but the result was different: a lot of points were not in a straight line or they were very far from the position they were supposed to be.

So for drawing the map and joining the points I simplified some information, omitting some points to avoid those errors and to achieve a map the most similar to the reality.

Using drawing commands like Polyline, Circle, Rectangle, Cut, Lengthen etc. I obtained the next result in different layers
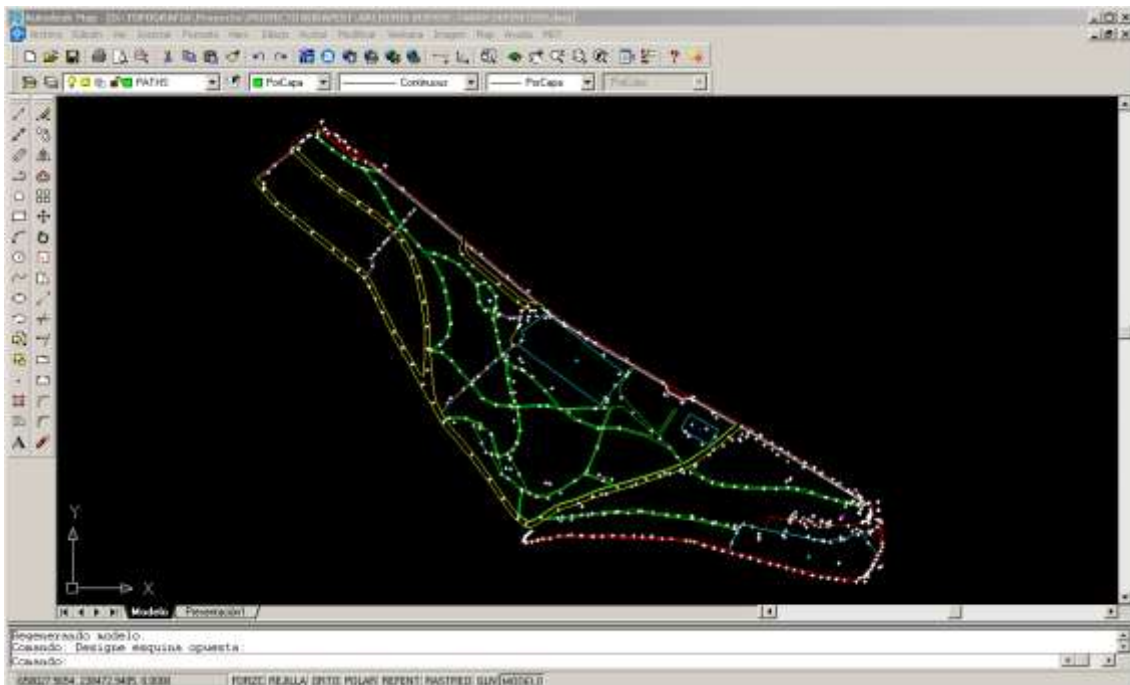
Figure 26 – Drawing of the map with AutoCAD

6.4.1 – Map smoothing

To have an optimal result of the drawing of the map, it is convenient to improve the shape of many lines and textures to have a more accurated shape of the roads, paths etc. Taking into consideration the accuracy of the GPS and the interval of the measured points, some paths, roads and other elements present errors that I corrected using the Circle command.

With this procedure the appearance of the general view of the map was better and it seems closer to the reality.

6.5 - Preparing the map to export to MapInfo (GIS)

Before exporting the AutoCAD drawing to MapInfo is important to clean the drawing, in interest of avoiding graphic problems when the map is imported to MapInfo. In the drawing can be so many lines or pieces of other graphic elements that I was drawing, cutting, lengthening, etc but not deleted. The size of some of them is very small and often we can not see these small objects on the display. To clean them automatically we need to select the next option in the main menu: *Main menu → Map → Tools → Clean drawing*
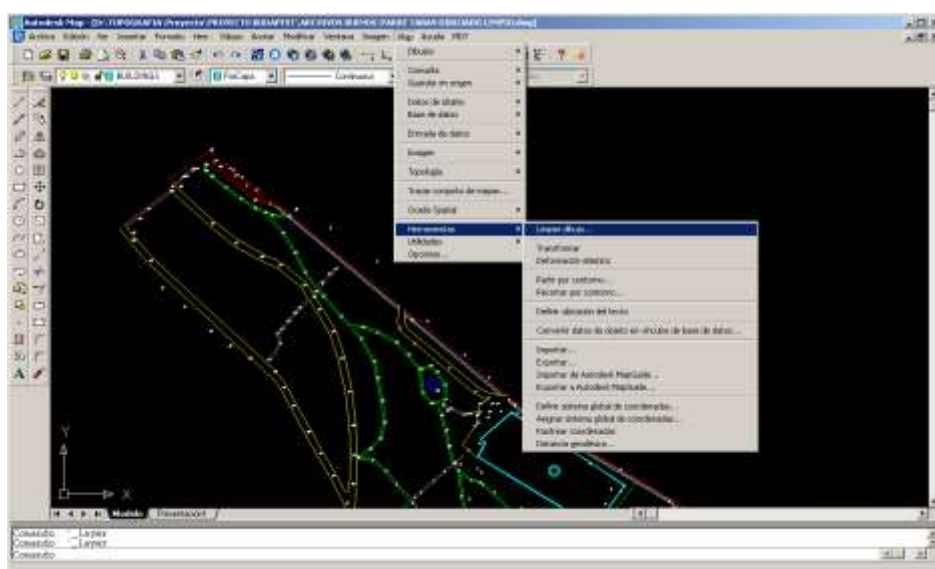
Figure 27 –Opening the cleaning drawing menu in AutoCAD

When this option is selected a new window appears to choice between many options. An important condition is to select the three options in the order given below and to select the correct options inside each one:

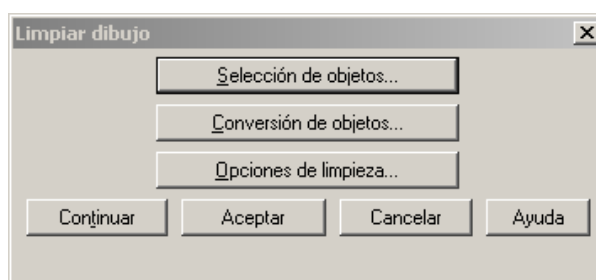1 – Select the objects
2 – Object conversion
3 – Cleaning options

Figure 28 – Cleaning menu

First *Select the objects*, we can choose an option automatically or manually, I choose the automatical one and the software selected all the lines.

Next is the option *Object conversion*. With this option the software modifies all the original objects to convert them to polylines. An important requirement is to store all the objects as polylines to avoid problems in MapInfo when all the layers are imported:
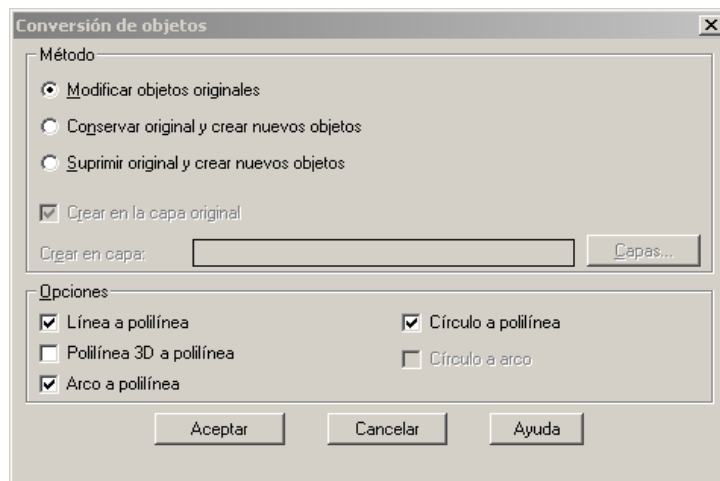
Figure 29 – Cleaning and conversion menu options

To finish, the last option is *Cleaning options.* In this option I selected the type of objects that the program is going to modify, delete or fix.

I selected to delete the *duplicated objects, delete short objects, extend the insufficient objects and to delete the individual objects.*

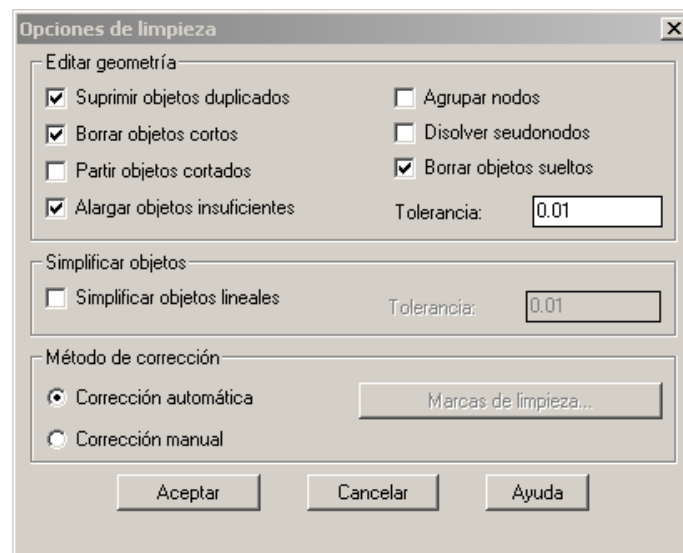*Figure 30 – Cleaning options*

The last option to select is the *Automatic correction* option.

When I had all of the options selected, I pushed the Continue option and the software automatically do all the work. In the command window, in the bottom of the workspace can be seen two messages with the number of deleted and created objects.

```
Objeto(s) eliminado(s)  :66
Objeto(s) creado(s)     :66
Comando:
```

Figure 31 – Command window in AutoCAD

After this, the drawing is ready to be exported to MapInfo. It is only necessary to save it to the AutoCAD exchange format (*.dxf),* to make able MapInfo to open it

7 - MAKING OF THE MAP

The GIS work in this project consists in exporting the drawn map from AutoCAD, to a GIS software and editing the map to compare the old map with the current new, to determine the differences arising over the time and to create an informative map with all the interesting places within the park.

The GIS program that I used to do it is MapInfo:

- **MapInfo:** is a Desktop Mapping System software originally developed by the MapInfo Corporation.

  MapInfo Professional has the ability to combine and display data from a variety of sources that are in different formats and projections. The software is capable of overlaying raster and vector layers on the same map; the format can be made semi-transparent, so that they can serve as more than mere backdrops.

  MapInfo is popular both in business and the public sector, where a typical user is analyzing pre-built map data layers.

  - http://www.pbinsight.com/products/locationintelligence/applications/mapping-
  analytical/mapinfo-professional/

7.1 - Importing the data to MapInfo

Once the database map had been done in AutoCAD and saved as DXF file, it had to be loaded into MapInfo.

To open the map with MapInfo it is necessary to select the *Main menu →
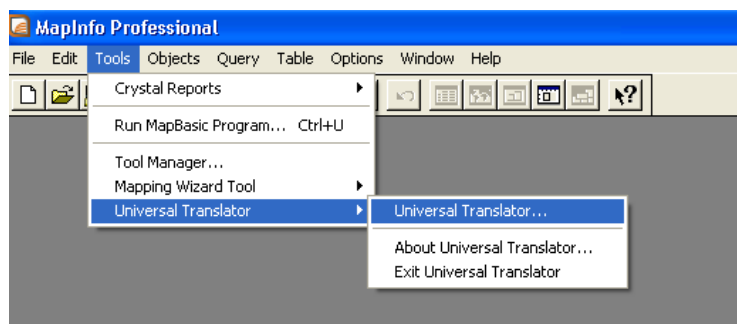Tools → Universal Translator* and the next window appear with some options:

Figure 32 - Opening the Universal Translator tool

First I choose the native format used by AutoCAD (DWG / DWF) and selected the file that I wanted to open. The next option asked about MapInfo format and the place where I wanted to save the tables that are going to be created. The last option that I had to change was the projection that the map is going to use; in this case I used the same projection than in Global Mapper and in AutoCAD, the Hungarian Projection System (EOV).
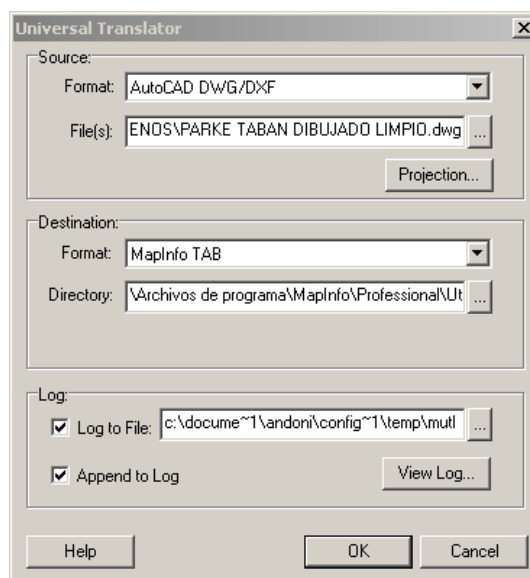

Figure 33 - Universal Translator tool menu
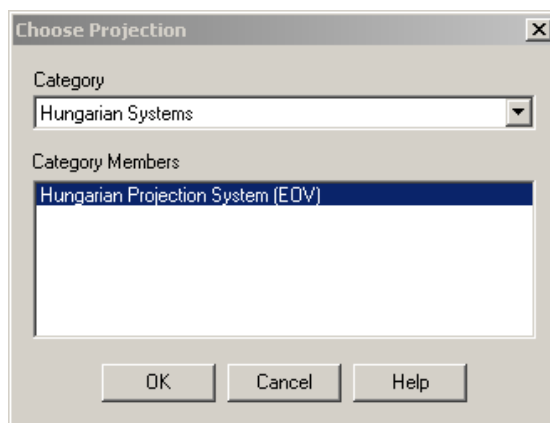
Figure 34- Projection menu in the Universal Translator tool

To have the data correctly stored in MapInfo format (*.tab), each layer created in AutoCAD must be imported to MapInfo one by one. To do this, I selected the option *Open* in the main menu and I started selecting all the *.tab* format files that I have created in the selected location. The software automatically imported each layer and put it in the correct position in the workspace. I imported all the layers but I didn't use the waypoints layer to represent the park.
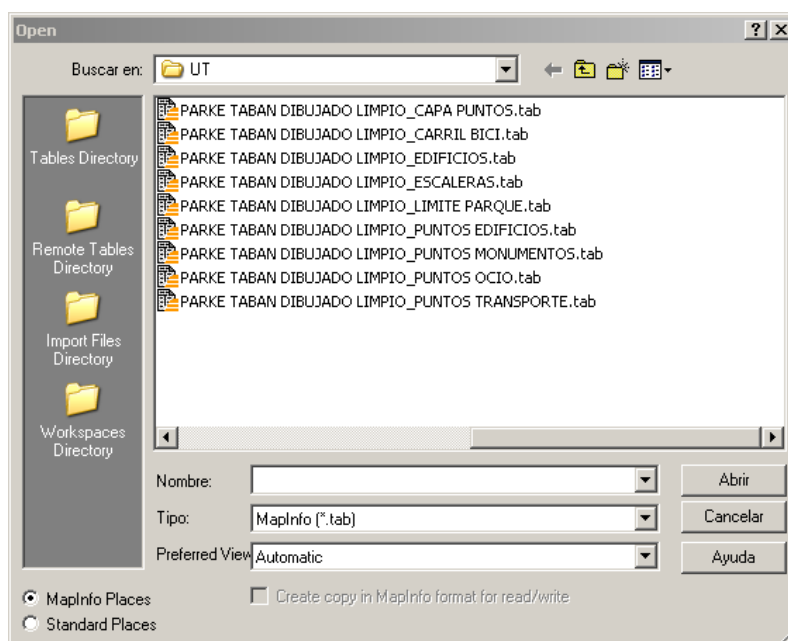
*Figure 35 - Open table *.Tab with MapInfo*
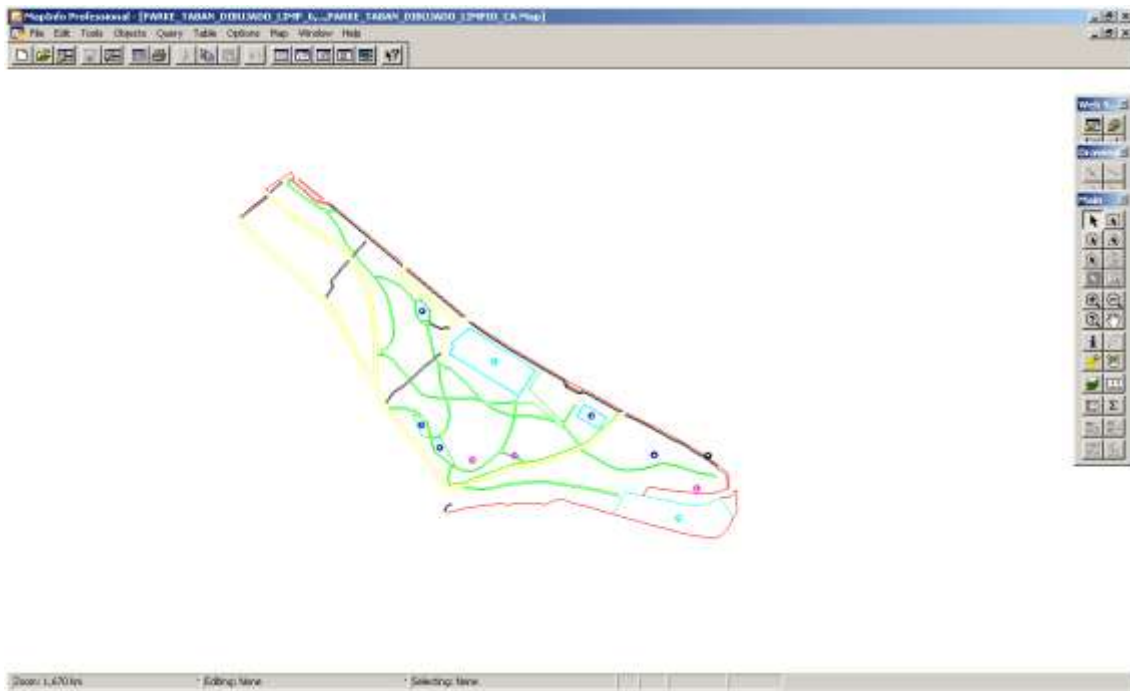
Figure 36 – Drawing map in MapInfo

7.2 - Editing the properties of the map

After loading the AutoCAD file I had a map with different layers and colors. The first task I accomplished was to change the lines properties for each layer. As it was described above, the map different kinds of lines: the roads, the limits of the park, the paths, the bike lanes, the buildings and the stairs. Taking into account the importance of each element of the park, I divided the different elements into four different categories to give to each category a different line style to differentiate them easily.

-Category 1: The roads (asphalted paths)

-Category 2: The limit of the park

-Category 3: The stairs

-Category 4: The paths, buildings and bike lane

To edit the lines I have to select the *Main menu → Map → Layer control* and appear the next window:

Figure 37 – Layer control in MapInfo

With this option can be seen all the layers that I have in the drawing and can be changed the properties of each layer, indicating to the user if they are visible, editable, selectable and/or automatic labeled. With this command it is also possible to change the order of the layers and remove one or more of them from the map.

In this case I wanted to change the width, the style and the colour of the lines and the points of each layer.

To edit the selected layer is necessary to select the Display option:
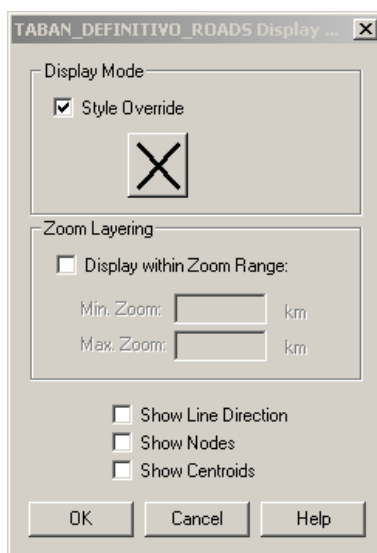
Figure 38 – Editing the properties of an element menu

I marked the Style Override and select the big cross of the window to change the properties. In the next window appear different options:

- Style: this option is used to change the line type to be used.
- Color: used to change the color of the lines
- Pixels: enter a number between 1 and 7; each number represents a line width in pixels.
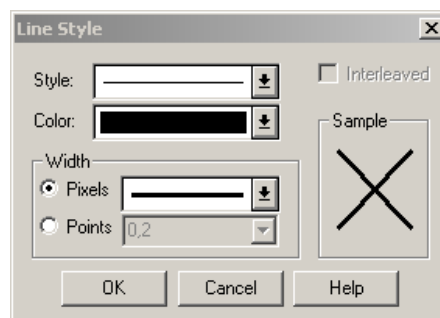- Points: you can choose a size from the list.

Figure 39 – Line style editing menu

Taking into account the categories of each layer I change the width of the line with the pixels, and I chose the black color to all the lines.

I did this step for each layer defined in the map. With the layers of points I determined four different types of points: one for monuments, another for buildings, other for the leisure points and other for the transport points. So I assigned them symbols depending what they were referring to. All the lines are going to be black because I thought that is was the best colour to see the differences between the old map and the new drawing. If I choose other colour the lines weren't well defined and contrasted with the background map.

-<u>Category 1</u>: The roads (asphalted paths) → 3 pixel width and continuous style

-<u>Category 2</u>: The limit of the park → 2 pixel width and continuous style

-<u>Category 3</u>: The stairs → 1 pixel width and flashing style

-<u>Category 4</u>: The paths, buildings and bike lane → 1 pixel width and continuous style

I didn't use any symbols according to any international or conventional symbols, I choose the symbols that in my opinion, taking into account the type of symbols that were in MapInfo, best represents what was representing.

- Monuments points:

-Transport points:

-Leisure points:

-Building points:

To change the style of the points I followed the same steps than for the lines. In this case the options to change the style of the points were different:

- Font: this option allows change the type of symbols we want to use from a drop list, eg. Cartographic symbols.
- Font size: it allows change the size of the symbols that are going to be used.
- Symbol: select the symbol you want to use in the map from the list selected before. Changing the "Font" option different options are available in this list.
- Color: change the color of the symbol is going to be used.
- Rotation angle: for changing the position of the symbol.
- Background: The options, None, Halo and Border set the background of the selected symbol.
- Effects: The options, Drop Shadow and Bold can improve the look of the symbol on the map.
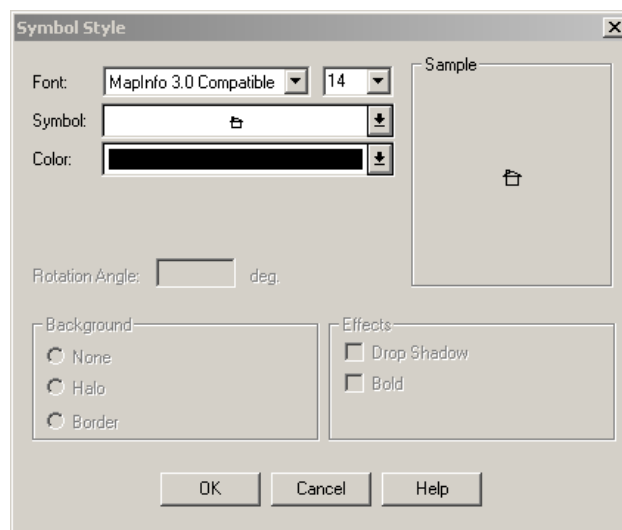
Figure 40 – Symbol style editing menu

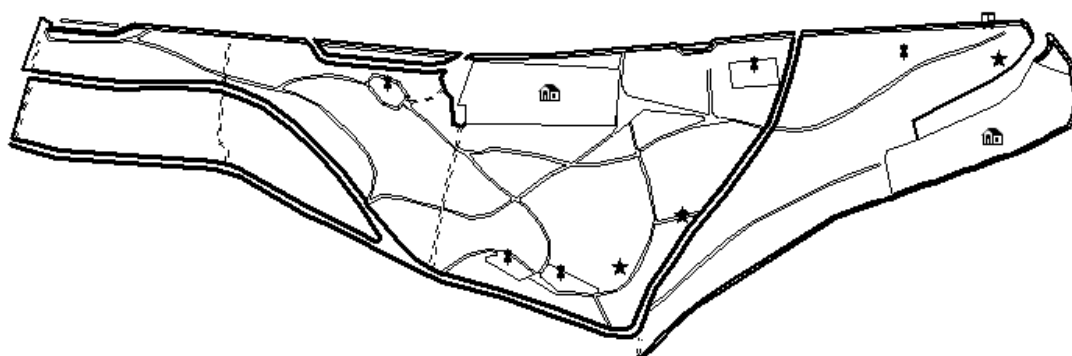The final result of the map was this:

Figure 41 – Edited drawing in MapInfo

7.3 - Importing a Raster Image

To check the changes that the park has had, it is necessary to put the scanned old map of Tabán behind the drawing made by me.

The first thing to do before importing the image to MapInfo is to edit some properties of the image of Tabán, in interest of seeing it properly and clearly behind the drawing.

I used the *Microsoft Office Image Manager* to edit the contrast, the brightness and the opacity of the image obtaining a more transparent image.
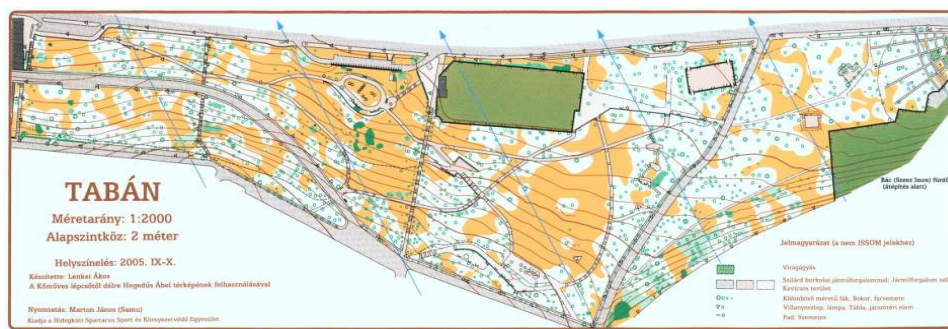

Figure 42 - Before editing the image

Figure 43 - After editing the image

With the image changed, I started to import it to MapInfo. To open it, I went to the *Main menu → Open* option. The scanned image is a raster image and it could be scanned in so many formats like JPEG, BMP, TIGG, GIF etc. In this case the format I used to open it is the JPEG format, therefore, I choose in the *Type* option the *Raster image* option to open it properly.
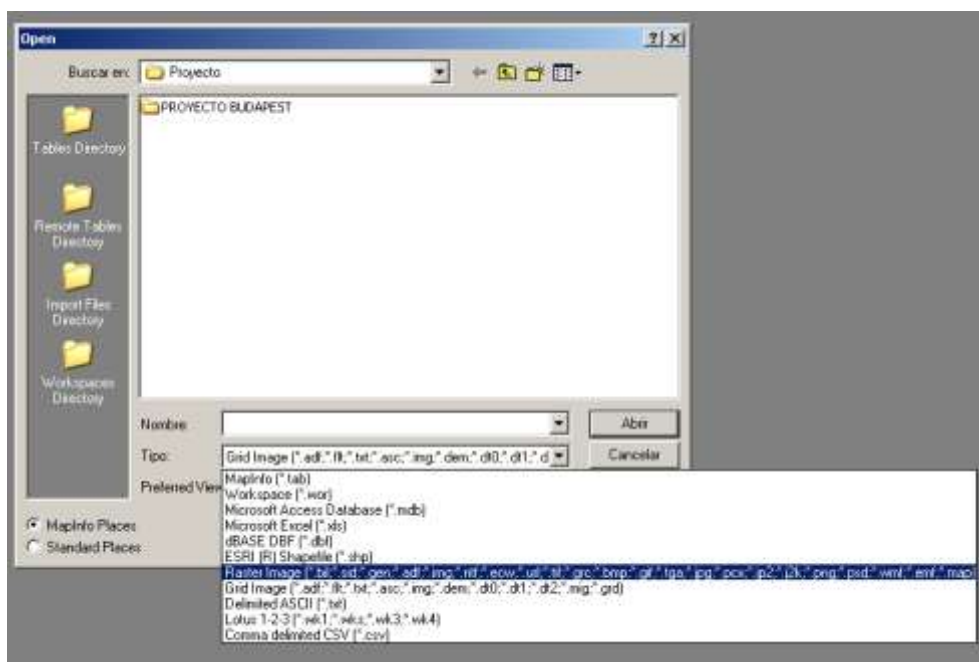
Figure 44 – Opening a raster image

When I opened the image, a window appeared with two options: it is possible to register the image manually or to do it using control points with known coordinates.

I did the registration with four control points measured in the park, selecting in the scanned image the location of the points and introducing the coordinates obtained with the GPS as accurated as possible, because the mistakes can make that the image is not registered in the correct place and the discrepancies are larger in the drawing.
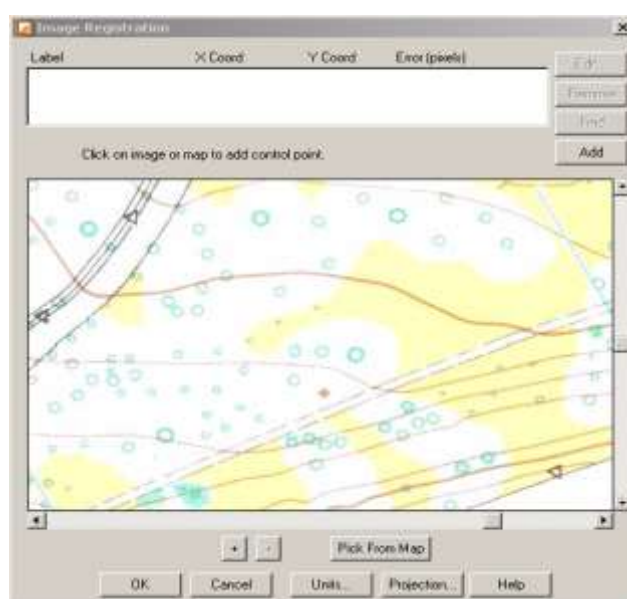

Figure 45 –Image registration window

The projection to be used on this map has to be the same used earlier: the Hungarian National Grid (EOV).

To add points, it is only needed to select the key *Add,* and the software introduces the coordinates of the control point and select the exact position for each point in the map.

The coordinates of the control points are points that I measured in the park especially for this task, because it is very important that the point should be easily recognized in the map and in the drawing to avoid mistakes. Finally I obtained the raster image of the map behind the drawn map:
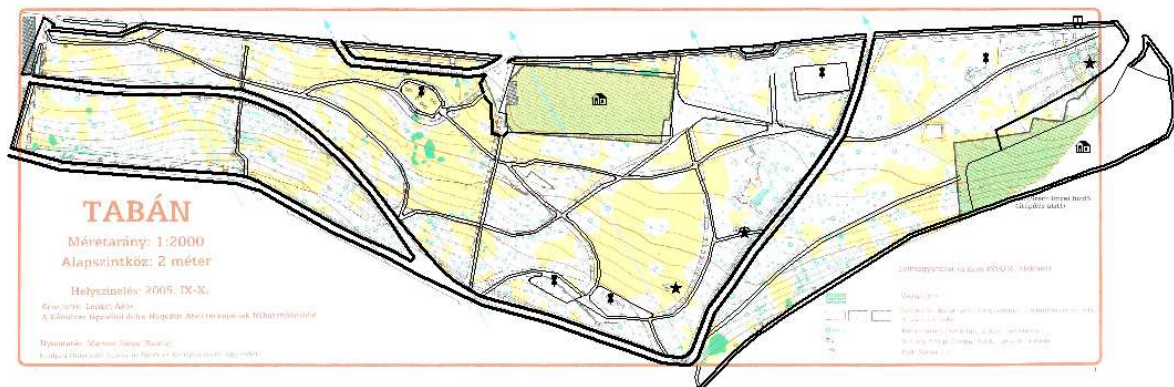

Figure 46 – Tabán drawing with the raster image behind

7.3.1 - Contol points

To register the Tabán raster image properly we should have reference points with known coordinates. It is possible to take manually points of the drawn map in AutoCAD and to take the coordinates to enter in the registration window, but the results weren't optimal because of the accuracy of the GPS. The coordinates of the points that I take in the AutoCAD drawing aren't in the same position of the corresponding points in the map, so I decided to take four points in the park that were easily recognizable in the map. This observation of the points must be precise to avoid errors in the registration image, so I stay few minutes in the selected points to obtain the maximum accuracy is possible.

After I have the four control points measured, I imported it to AutoCAD and I took the coordinates of these points to register the image in the corresponding points in the map. By this way, I obtained a more precise registration of the map and the results were better than doing the registration in the other way.

To select the points I take into account that they must cover in the best way the entire park, they should be spread around the park. The control points must be easily recognizable points in the map and in the drawing, and they must be a precise point to register exactly in the registration window.

The reviews of the measured control points are in *Annexes 1*

7.4 - Adding images to the interesting points

To give information about the interesting places in the park, I added a photo to each point defined in the map. It is necessary to use the "Hot link "option in MapInfo to do this operation. First I had to make a new column in each table of each layer (Building points, monument points, leisure points and transport points).

Going to *Main menu → Table → Maintenance → Table Structure* is possible to add a new column to the selected table:
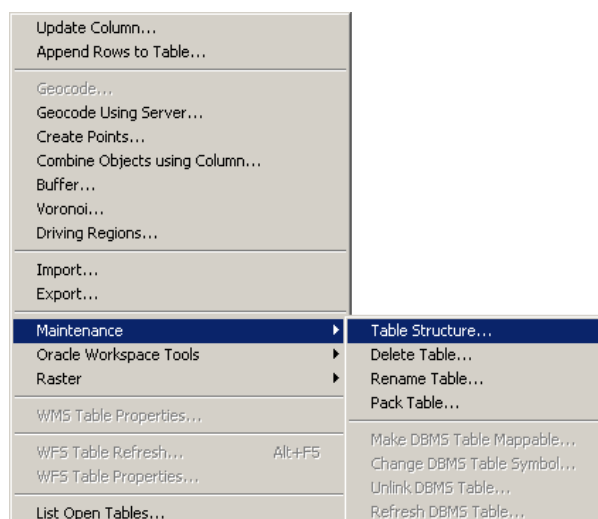

Figure 47 – Adding a column to a table menu

First I should select the table that I wanted to modify. In the window below I selected the name of the new column, the type of field that is going to be introduced and the number of characters that is going to have this field. In this case I chose to "Add" a new file and the "Character "field type, because in the new column I'm going to introduce the route to find the image file in the hard disk. To have enough space I selected a width of 100 characters.
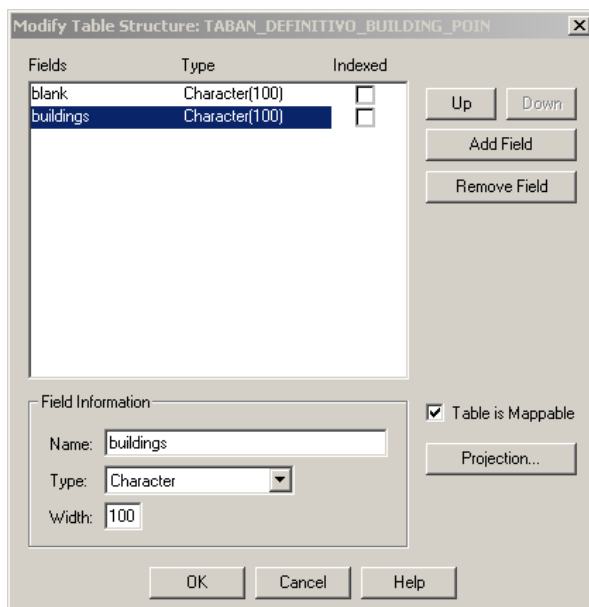

Figure 48 – Modify table structure window

I did the same operation with all the tables to be completed with photos.

To introduce the place of the photos I open the modified tables with the key "*New browser*" that can be found in the Main menu:
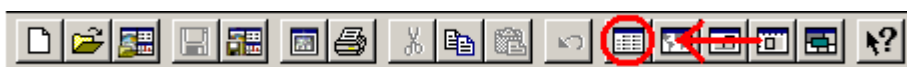

Figure 49 – Browse a table menu in MapInfo

In the next window appear two columns that are defined in the table and in the new created column I introduced the addresses of the image files.

blank	leisure
	C:\Documents and Settings\andoni\Escritorio\FOTOS TABAN\PC260051.JPG
	C:\Documents and Settings\andoni\Escritorio\FOTOS TABAN\PC260005.JPG
	C:\Documents and Settings\andoni\Escritorio\FOTOS TABAN\PC260015.JPG
	C:\Documents and Settings\andoni\Escritorio\FOTOS TABAN\PC260013.JPG
	C:\Documents and Settings\andoni\Escritorio\FOTOS TABAN\PC260034.JPG

Figure 50 – Introduced photo URL in the new column

When all the addresses are introduced in the corresponding column, I selected in the Layer control option the *"Hot link* "key to activate the connection between the point in the map and the image file in the corresponding layer.
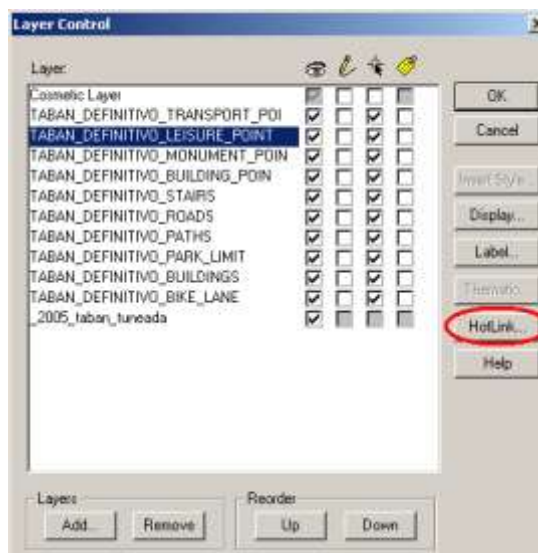

Figure 51 – HotLink option in the Layer control window

In the window below I selected the name of the field containing the addresses of the image files, and the "Labels & Objects "option to convert into an active point. It is important to select the "File locations are relative to table direction "option if I want to be able to open the photos in all the computers. With this option the software search the photos in the same field than the tables are.
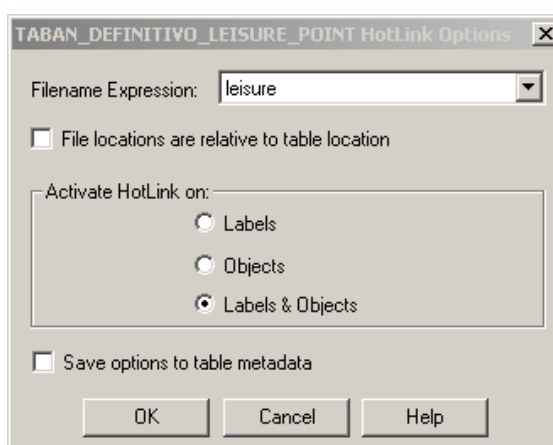

Figure 52 – HotLink option window

Finally I selected the "Hot link" icon to put the cursor over each item and see the corresponding image.

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Figure 53 – HoLink option in the Main Menu

This icon is available when at least one button is active in any map layer.

7.5 - Creating a legend

MapInfo has the option to create automatically a legend of the map. Selecting in the *Main menu → Map → Create legend* the software asked to select the layers that I wanted to represent in the legend; I selected all the layers and automatically MapInfo created the next legend:

I changed some properties in the legend, clicking in their titles, changing some options about the size and name of the titles.

Figure 54 – Legend of the map

7.5 - Creating the layout

The final results of the map were showed in two different layouts, first the new drawing of the map and second with the drawing and with the old map as background, both with the legend.

To complete this task should be selected the *Main menu → Window → New layout* command and in the window below we can select one of the next -options:
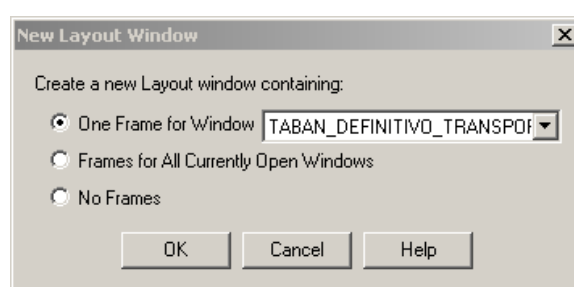

Figure 55 – New layout option menu

First I choose the *Layer control menu* to select the layer of the background map as invisible, creating the first layout without the map. Then I selected the *New layout* option and I selected the first option *One frame for window*. With this option it opened a new layout with the drawing and with the legend.

To create the second layout I activate in the *Layer control* the layer of the background map and I choose the same option to have the second layout with the drawing, the old map as background and the legend.

The results could be seen in the *Annexes 2.*

8 - COMPARISON OF THE ORIGINAL MAP WITH THE MAP BASED ON THE GPS SURVEY

The main objective of this work was to determinate the changes that the park has had since was made the original orienteering map of Tabán. The changes were made as explained above, on the right side of zone 1 where actually are located the thermal baths of Rác, at the foot of Gellért hill. We can see in the map that in this zone were doing works of renovation and remodelation. Comparing the two drawings it is easy to differentiate the changes that this zone has had: The Rác thermal baths have undergone a remodelation to make it larger and has been made a parking to these therms.

Figure 56 – The changes in the map

We can seefilled with red colour the actual limits of the new building and with blue colour the limit of the new parking. The rest of the zone continues as it was in the original base map.

In the rest of the map there don't be any changes as we can see in the next image. The paths, the roads and the other elements are as they were in the past.
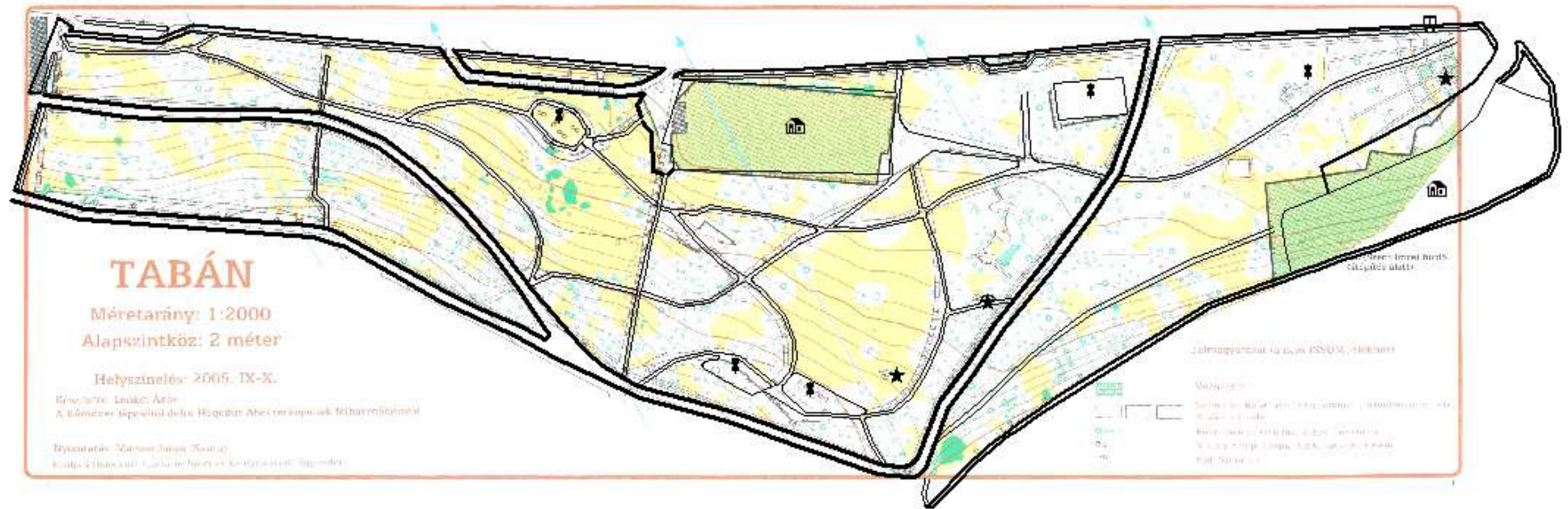
Figure 57 – Comparison of the old map with the new one

9 - POSSIBLE FUTURE DEVELOPMENTS RELATED TO THIS THEME

An extension of the work in the future could be to make a topographical map of the park and the area that has changed, using a planimetric and altimetric survey with more accurate topographic techniques for integrate it into the cartography of Budapest.

Taking into account that the used map to the survey of the park dates from 2005, is possible to do the new topographic map to update the current cartography of Budapest.

The scale of the new topographic map could be the same as the map of Tabán from 2005 which is 1 / 2000. The planimetric survey of the new park could be done using a total station, doing first a polygonal to integrate it with the known topographic urban points of the zone and then doing a radiation of all the elements of the park (limits, trees, paths, roads, etc). Using this techniques, is possible to avoid the problems with the accuracy of a GPS (multipath caused by the trees and the buildings), obtaining a sufficient accuracy for the realization of the new map with the required scale. The altimetric survey could be done using a nivelation techniques, with a topographic level or laser level, the problem with this survey could be the huge scope that has the park in some parts.

Thus the population of Budapest would have better knowledge and access to the changes made in the area, most notably in the Rác thermal baths and its installations.

10 - BIBLIOGRAPHY

-Written sources:

- MapInfo, 2006. MapInfo Professional, version 8.5, user's guide. MapInfo Corporation, Troy, New York

- GARMIN. 2004. *GPS map 60CS with sensors and maps, owners manual*. Garmin international, Inc

-Online sources:

-Budapest y Hungria. *2010. Tabán Available at :*
http://www.budapeszt.infinity.waw.pl/es/taban/otaban.html

-Departamento de Ingeniería de Sistemas y Automática. Universidad de Valladolid (Isa). 25 Of. May Of. 1999. GPS. *Fuentes de Error en GPS.* Available at:
http://www.isa.cie.uva.es/gps/GPSerrores.html

-Ecalero. 23 of March of 2003. *Sistema de Referencia WGS-84.* Available at:
http://ecalero.tripod.com/sitebuildercontent/sitebuilderfiles/wgs-84.pdf

- Free multimedia encyclopedia. *Sistema de posicionamiento global.* Available at:
http://es.wikipedia.org/wiki/Sistema_de_posicionamiento_global

- Free multimedia encyclopedia. *WGS84.* Available at:
 http://es.wikipedia.org/wiki/WGS84

- GARMIN. 2010. Garmin: GPSMAP 60CSx specifications. Available at:
http://www8.garmin.com/products/gpsmap60csx/spec.html

-Moreno Roca, Sergio; Luis Rodríguez, Jorge; Gayete Fos, Raquel; Martínez Jiménez, David. 2010. G.P.S.: *GLOBAL POSITION SYSTEM .Precision y Errores*. Available at:
http://www.upv.es/satelite/trabajos/pracGrupo4/errors.htm

- Puente, Víctor, 20 of August of 2007. *Libro GPS Theory and Practice. Fundamentos del G.P.S.* [Online]. Available at: http://www.genciencia.com/tecnologia/fundamentos-del-gps

- Translation Localization Globalization. 2010*. WorldLingo.Tabán*. Available at:
http://www.worldlingo.com/ma/enwiki/es/Tab%C3%A1n

ANNEXES

ANNEXES 1

CONTROL POINTS

CONTROL POINT	
Number point: 1	**Observation date:** 2010/11/7

Coordinates Hungarian National Grid

X = 649590,341
Y = 238659,7510

Situation map	Detail picture
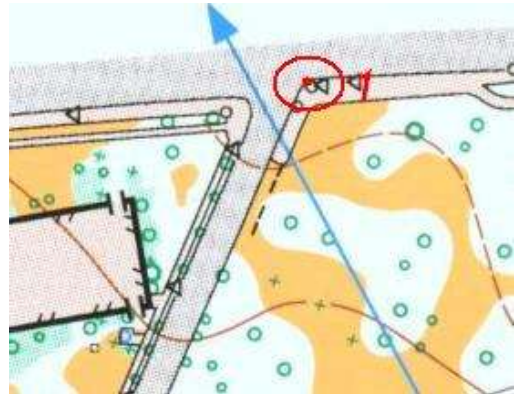
Description: The point is located in the corner between the .Kereszt utca street and Krisztina Korut utca street

CONTROL POINT	
Number point: 2	**Observation date:** 2010/11/7

Coordinates Hungarian National Grid

    X = 649416,193
    Y = 238606,559

Situation map	Detail picture

Description: The point is located in the small monument near the Kereszt utca street

CONTROL POINT	
Number point: 3	**Observation date:** 2010/11/7

Coordinates Hungarian National Grid

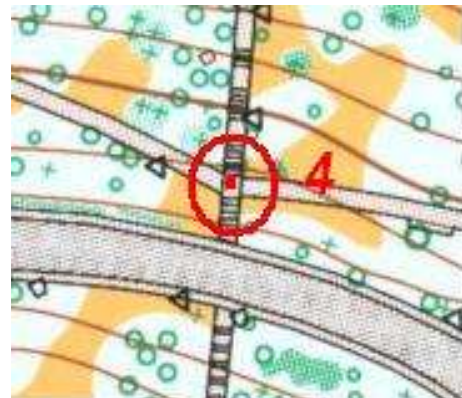   X = 649298,937
    Y = 238797,194

Situation map	Detail picture
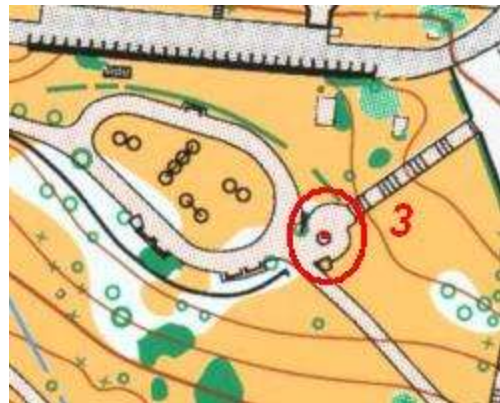
Description: The point is located in a swing near upstairs from the tennis club located in Krisztina Korut utca street.

CONTROL POINT	
Number point: 4	**Observation date:** 2010/11/7

Coordinates Hungarian National Grid

X = 649179,503
Y = 238901,151

Situation map	Detail picture

Description: The point is located in the middle of crossing of the farther west path of the park and the farther west stairs that going up to the top of the park

ANNEXES 2

LAYOUTS