Verto2k

1.0 Introduction

Verto2k allows to carry out, in any possible sequence, coordinate conversion between the most commonly Geodetic Reference Systems used in Italy, namely Roma 40, ED50, ETRF89 and ETRF 2000. In addition to the geographic coordinates, this software also allows to deal with plane coordinates belonging to the Cartographic Systems normally associated with the aforementioned Geodetic Systems: **Gauss-Boaga** for ROMA40, UTM for ED50, and **UTM** and Fuso Italia, for the implementation of the Global System. Verto2k allows to project a point in a different time zone from the one it belongs to and allows to operate outside the selected grid, only for conversions within the same Reference System. Even without having the "* .gk?" files, Verto2k can transform both the geographic and plane coordinates of the same System throughout the national territory. Moreover, in addition to UTM, **"Fuso Italia"** has been associated to the ETRF Global Systems, in order to obtain seamlessly the projection of the whole national territory on a single plane (see below). As for the altimetric component, Verto2k allows to transform ellipsoid elevations, referring to the geocentric ellipsoid GRS80, into geoidal ones (sea level), relating to national altimetric references, and vice versa. Following the same logic as the other Verto, only algorithms needed to perform transformations are stored. Data must be purchased separately in grid form stored exclusively in "* **.gk?**" files, as it will be better clarified below.

2.0 Software installation and uninstallation

To install Verto2k, start the **"Setup_Verto2k.exe"** file, downloaded via internet, from the IGMI website (www.igmi.org). The installation automatically creates a **"Verto2k"** subfolder in **"Programmi (Program)"** folder in which it stores **Verto2k.exe**, as well as a copy of the * .dll files, taken from the system on which the compilation has been performed. The link to **Verto2k.exe**, in the "**Start/Avvio**" menu, will be placed in the "**IGM**" group; if this group does not exist it will be automatically created by the installation procedure.

The software is protected from illegal use and it needs a hardware key for its operation. After installing the software you need to put the hardware key into a USB port; the system will automatically detect it, so there is no need to install any specific driver. The uninstallation procedure can be started from the "**Pannello di Controllo (Control Panel)**" using the "**Installazione applicazioni (Add or Remove Program)**" function.

3.0 Using software

Verto2k allows to carry out coordinate conversion of both plane and altimetric coordinates between Reference Systems. The transition from geographic to plane coordinates is possible both within the same system and between different Geodetic Systems.

"* **.gk?**" files are required for switching between different systems ("* **.gk1**" and "* **.gk2**" are the currently available versions). You can select the file you want to use in the "l**ist box**", at the top of the "**Zona di lavoro (Work area)**" frame, where the work area of the selected file will be shown. The approximate limits of this area are expressed both in geographic and plane coordinates, with longitudes referring to both Greenwich and Rome, according to coordinates selected in input. Reference epochs of the grids that selected file allows you to use, are shown in the lower part of the frame. For converting coordinates within the same Reference System, throughout the national territory, you don't need the "* **.gk?**" files containing the grid's areas of interest. It is possible to operate in the area between 34 ° and 49 ° parallel, North latitude, and between the 5 ° and 20 ° meridian, East longitude, from Greenwich.

3.1 Geodetic and Cartographic Systems

In the upper left part of the form it is possible to select, both for input and output, the Geodetic Reference System and the type of coordinates, namely geographic and plane. In case of plane coordinates it is possible to select the Cartographic System.

The software considers 4 systems: ROMA40, ED50, ETRF89 and ETRF2000.
The Cartographic Systems are described below.

- **ROMA40** is the historical national geodetic system still in use; it adopts the Hayford ellipsoid, whose parameters are:

$$a = 6378388 \text{ m}, \qquad f = 1/297.$$

Ellipsoid orientation is Roma Monte Mario 1940:

$$\phi = 41° 55' 25.51'' \qquad \lambda = 0° (12° 27' 08.4'' \text{ Est from Greenwich}),$$

azimut on M. Soratte: $\qquad \alpha = 6° 35' 00.88''$.

The software associates **ROMA40** system with orthometric heights, referring to the average sea level. For continental Italy, altimetric reference is Genoa tide gauge, whereas Catania and Cagliari tide gauges are the reference for Sicily and Sardinia.

ROMA40 system is associated with the **Gauss-Boaga** cartographic system which uses Gauss's projection, adapting it to the national territory by means of 2 time zones of 6 °, West and East, as described below:

Gauss-Boaga Time Zone	Longitude of the central meridian from Greenwich	Longitude of the central meridian from Rome	False origin of the central meridian	Scale factor of the central meridian
Ovest	9°	-3° 27' 08,400"	1 500 000	0.9996
Est	15°	2° 32' 51,600"	2 520 000	0.9996

The historical national cartography was established in this System: namely the Map of Italy at scale 1:100,000 and its submultiple at 25,000 (tavolette). Most of the new Regional Technical Map at scale 1:5,000 and at 1:10,000 (numerical format) refers to the Gauss-Boaga projection, despite having a cut related to the ED50 system.

- **ED50** (European Datum 1950) is the European system also adopted in Italy since the 1950s, essentially used for cartographic purposes. It also adopts Hayford's ellipsoid but with a European medium orientation. In this system Rome M. Mario has the following coordinates:

$$\phi = 41° 55' 31.487'' \qquad \lambda = 12° 27' 10.93''.$$

The software associates the orthometric heights to the **ED50** system as for **ROMA40**.

The ED50 system is associated with the UTM Cartographic System designed to map the whole Earth using Gauss's conformal representation. The **UTM** system therefore considers 60 time zones with 6° numbered from West to East starting from the Greenwich antimeridian; Italy falls in 3 time zones: **32, 33** and **34**, which have the following characteristics:

UTM Time Zone	Longitude of the central meridian from Greenwich	False origin of the central meridian	Scale factor of the central meridian
32	9°	500 000	0.9996
33	15°	500 000	0.9996
34	21°	500 000	0.9996

The new Map of Italy at scale 1: 50,000 and its submultiple, the new 25,000 are realized in this system.

- **ETRF89** and **ETRF2000** (European Terrestrial Reference Frame) are two realizations of the Global Earth-centred/Earth-fixed System adopted in Europe to which the GRS80 ellipsoid (Geodetic Reference System 1980), still Earth-centred/Earth-fixed, is associated; it has the following parameters:

$$a = 6378137 \text{ m}, \qquad f = 1/298,257222101.$$

UTM The software associates the ellipsoidal heights referring to the GRS80 and the Cartographic System to the **ETRF** systems, as described above.

Moreover, "**Fuso Italia**" has been associated to the ETRF Systems; it is a Cartographic System allowing to obtain, seamlessly, the projection of the whole national territory on a sole plan.

This system, designed to minimize deformations over large areas, is particularly suitable for georeferencing the information systems covering the whole national territory

"Fuso Italia"	Longitude of the central meridian from Greenwich	False origin of the central meridian	Scale factor of the central meridian
	12°	7 000 000	0.9985

Different heights are indicated in each of the 2 frames located under the respective selected systems. When different heights are associated to 2 selected systems in input and output (ellipsoidal in input and orthometric at sea level in output, or vice versa) the software automatically activates the button allowing also to perform the altimetric transformation.
In case of keyboard input, as a result of activating this button, the text boxes allowing the input and output of the heights become available.

<u>Warning</u>
The software allows point projection also in time zones other than that of belonging, offering the possibility of extending the Gauss-Boaga and UTM systems zones, beyond their real dimension of 6 °(for example in UTM a point at 10 ° East, falling in zone 32, can be projected in zone 33 or 34) . However, this option must be used carefully because it provides coordinates that, strictly speaking, no longer belong to the selected cartographic system (for example Gauss-Boaga coordinates time zone East with the first digit of the East coordinate 1 instead of 2). Furthermore, it should be considered that by extending the time zone, deformations grow exponentially. Except for "Fuso Italia", if there is no particular need, it is advisable to use time zones, in their original size, by selecting the word "fuso automatico/automatic time zone".

3.2 Grid's release forms
Grid's areas are released separately. They are available in the two formats described below.

- *Data covering about 10 km around each IGM95 point. These data are useful for those who work on the ground and carry out determinations by GPS measurements. These ones allow to obtain ETRS89 coordinates of points by connecting them to an IGM95 point, ellipsoid height included.* Files consist of a 6 alphanumeric characters name (the same that identify the IGM95 point to which they refer), they can be purchased separately from the point's monograph. In this way the user, who has already the monograph, can acquire only the section related to the transition between Systems with "**??????.gk?**" file. The approximately 4500 files are the same number as the IGM95 points. It should be noted, however, that if you purchase several of these files, associated to close IGM95 points, you could get the same data for several times. On the other hand, due to the way files are made of, you are not guaranteed to completely cover a zone.
- *Data corresponding to the area of each sheet of Italy's map at scale 1:50,000.* Files consist of a 3 or more alphanumeric characters name corresponding to the cartographic element

number. These files are perfectly "modular" one next to the other in order to cover the entire national territory. There are 676 files having the following characteristics:

- 654 files numbered as the corresponding sheets at scale 1: 50,000, (including the 2 sheets 577bis and 580bis);

- 3 files with double specification: 588sicilia, 601sicilia, 614sicilia, to be used for the Sicilian territory of the aforementioned sheets, along with 588calabria, 601calabria, 614calabria, to be used for the Calabrian territory;

- 2 files corresponding to 2 particular sheets, identified with the following names:

  - **Elba -** covering the entire surface of the island corresponding to the areas falling on sheets 316, 328 and 329 (printed in a single element called "Elba Island");

  - **PianosaN -** corresponding to 328 and 341 sheets areas (printed in a single element called "Pianosa and Montecristo Island") covering an area in the Tuscan Archipelago where Pianosa Island is located, ;

- 17 files relating to one or more islands whose surfaces are represented in boxes of other sheets of the Italian map at scale 1: 50,000, as detailed in the table below.

File name	territory covered
Montecristo	Montecristo island described in a box, on sheet no. 328 - 341
Scoglio	"Rock of Africa or Formica di Montecristo" island described in a box, on sheet no. 328 - 341
Capraia	Capraia island described in a box, on sheet no. 317
Gorgona	Gorgona island described in a box , on sheet no. 283
Giglio	Giglio island described in a box, on sheet no. 352
Formiche	"Formiche di Grosseto" islands described in a box, on sheet no. 331
Tremiti	Tremiti islands described in a box, on sheet no. 383
PianosaS	Pianosa island described in a box, on sheet no. 384
Ponziane	Ponziane islands described in a box, on sheet no. 413
Ventotene	Ventotene island described in a box, on sheet no. 414
Ventre	"Mal di Ventre" island described in a box, on sheet no. 528
Stromboli	Stromboli island described in a box, on sheet no. 577Bis
Ustica	Ustica island described in a box, on sheet no. 585
Pantelleria	Pantelleria island described in a box, on sheet no. 626
Lampedusa	Lampedusa island described in a box, on sheet no. 635
Linosa	Linosa island described in a box, on sheet no. 635
Lampione	Lampione island described in a box, on sheet no. 635

Each line of the following table shows the "two for the price of one" files sold together, as specified in the last column.

1	7				sheet 1 is only an out-of-margin printed on the sheet 7
2	8				sheet 2 is only an out-of-margin printed on the sheet 8
19	20				sheet 19 is only an out-of-margin printed on the sheet 20

111	112				sheet 111 is only an out-of-margin printed on the sheet 112
130	131	150	151		sheets 130, 150 and 151 are printed on sheet 131
132	152	153			Sheets 132 and 152 are only out-of-margin printed on the sheet 153
148	149				sheet 149 is only an out-of-margin printed on the sheet 148
188	206				sheet 206 is only an out-of-margin printed on the sheet 188
213	230				sheet 230 is only an out-of-margin printed on the sheet 213
229	246				sheet 246 is only an out-of-margin printed on the sheet 229
258	271				sheet 271 is only an out-of-margin printed on the sheet 258
283	Gorgona				Gorgona is a frame inside sheet 283
316	328	329	Elba		parts of sheets 316, 328 and 329 are inside the Elba sheet
317	Capraia				Capraia is a frame inside sheet 317
328	341	PianosaN	Montecristo	Scoglio	parts of sheets 328 and 341 are inside the sheet "Isola di Pianosa e di Montecristo" in which there are the 3 islands in boxes.
331	Formiche				Formiche is a frame inside sheet 331
352	Giglio				Giglio is a frame inside sheet 352
383	Tremiti				Tremiti is a frame inside sheet 383
384	PianosaS				Pianosa is a frame inside sheet 384
413	Ponziane				Ponziane is a frame inside sheet 413
414	Ventotene				Ventotene is a frame inside sheet 414
577bis	Stromboli				Stromboli is a frame inside sheet 577bis
446	447				sheet 446 is only an out-of-margin printed on the sheet 447
476	477				sheet 477 is only an out-of-margin printed on the sheet 476
528	Ventre				Ventre is a frame inside sheet 528
581	586				sheet 581 is only an out-of-margin printed on the sheet 586
585	Ustica				Ustica is a frame inside sheet 585
626	Pantelleria				Pantelleria is a frame inside sheet 626
635	Lampedusa	Linosa	Lampione		Lampedusa, Linosa and Lampione are frames inside sheet 635
588calabria	588sicilia				To be used each for its own territory
601calabria	601sicilia				To be used each for its own territory
614calabria	614sicilia				To be used each for its own territory

- *Remarks:* collect all the files purchased in a subfolder (e.g. "DATI (DATA)") specially created in the subfolder "Verto2k" (where Verto2k.exe is stored) which is in the "Programmi (Program)" folder.

- use the mouse while working with the program; it is however possible to exit the program by pressing the Alt+F4 keys.

4.0 Keyboard Input and Output

IMAGE

Keyboard Input and Output example (didascalia)

Keyboard input provides results directly on the screen and it is useful when there is a small number of points to convert. In this case you cannot print the results. To enter input coordinates, click on the corresponding text boxes. By clicking on "**Invio (Enter)**" it is possible to switch from one field to another according to a logic that is normally useful. "**Tab**" key is not operating. This software accepts both geographic coordinates, expressed in sexagesimal degrees (which must be entered in gg.ppssdddd format), and plane coordinates expressed in meters. Heights are expressed in meters. When you point your mouse over the input text boxes, you can see an image similar to the input format. Decimal separator can be either a dot or a comma, according to what is selected in the Windows "**Pannello di Controllo (Control Panel)**". This software does not perform any conversion of a point falling outside the area of interest. A message box will warn the user.

5.0 Input and Output from file

By using input / output from a file, up to a maximum of 50,000 points can be processed simultaneously. After performing a conversion, the "**Esegui (RUN)**" button remains shut off; it will be automatically reactivated by selecting a new output file or switching to keyboard input. Once the conversion completed, a message-box will inform the user about the procedure outcome and will provide the number of points both processed by the program and not processed because outside the area of interest.

IMAGE

5.1 Input and Output from Microsoft Excel® file

This software supports data input from *.xls files (Excel); in this case results will also be made available in the same format file. In the "**file list box**" related to the input and output the software proposes only files with the extension "**.xls**"; if the output file's name is not selected but entered from the keyboard without extension, the software will automatically add ".**xls**" extension .
The input file must be organized with the following criteria:

- each line collects all and only the information related to a point;

- first line is ignored by the software and can be used for headers;

- in column "A" the identifying number of the point (also alphanumeric) must be entered;

- in column "B" either the latitude of the point expressed in sexagesimal degrees in the format gg.ppssdddd or the North coordinate expressed in meters shall be entered;

- in column 'C' either the longitude of the point expressed in sexagesimal degrees in the format gg.ppssdddd or the East coordinate expressed in meters shall be inserted;

- in column "D" point's heights expressed in meters shall be entered (only if you want to obtain its conversion);

- no blank lines must be left between the data (blank line means the end of the data);

- the decimal separator may be either a dot or a comma.

	A	B	C	D	E
1	*number*	*latitude*	*longitude*	*height*	
2	101	42.21324014	10.58202417	918.238	
3	102	42.31254169	11.18174101	1872.455	
4	111A	42.35117451	11.01020047	777.952	
5	Point 3	42.36191455	12.09478582	3567.921	
6					

Or

	A	B	C	D	E
1	*number*	*North*	*East*	*height*	
2	10215	5030214.251	2309747.184	918.238	
3	102114	5041247.254	2321417.294	1872.455	
4	111A12	5038954.978	2318941.399	945.231	
5	Point113	5047618.001	2352147.817	1547.2	
6					

An example of an input file is available while running the software by clicking the "**Esempio di file input (Example input file)**" button.

The output file will have the characteristics as listed below:

- in the first line there are the reference epochs of the grids used in the transformation, both for the plane and the altimetric part (RO-ED refers to ROMA40-ED50grid, RO-E89 refers to ROMA40-ETRF89 grid,E89-E2000 refers to the Global System realizations in-between grid);

- the second line shows the information relating to the coordinates introduced in input: Geodetic system, unit of measurement; if the coordinates are plane, the time zone to which the coordinates belong;

- the third line shows the information related to the output coordinates: Geodetic System, unit of measurement; if the coordinates are plane, the time zone in which the coordinates have been requested;

- the fourth line shows the unit of measurement of the heights and, in the case of altimetric conversions in particular areas, the indication of the geoid model used (*see paragraph "accuracy"*);

- the fifth line is for headings indicating the contents of columns;

- in the first 4 columns there are input data;

- in the next 3 columns there are the results of the conversion;

- in the eighth column, in case of output in plane coordinates, information is given of the time zone: no information for Fuso Italia; indication of the time zone if it was requested as 'automatic'; if a specific time zone has been requested, 'true' or "false" are shown referring to whether or not the point belongs to the requested time zone;

-for points falling outside the area that can be processed with the selected grid file, the columns of results will be marked as "**fuori griglia (out grid)**"

	A	B	C	D	E	F	G	H
1	Gr. Epoch	RO-ED:2002	RO-E89:2002	E89-E2000:	2008 Geoid:	2005		
2	Coordinate	Input:	ETRF89	degrees	sexag.			
3	Coordinate	Output:	ROMA40	meter	T. Zone requ.	Automatic		
4	Heights:	meters						
5	Number	Lat. ETRF89	Lon. ETRF89	h ellis.	North ROMA40	East ROMA40	H geoid.	T .Zone
6	51801	45.26021357	12.20162263	918.238	5034623.904	2311775.935	874.650	East
7	51901	45.26123378	12.21347072	1872.455	5034882.499	2313491.457	1828.880	East
8	52701	45.35329184	12.28255414	945.231	Fuori grig.	Fuori grig.	Fuori grig.	
9								

5.2 Input and Output from Ascii file

This software supports data input from ASCII files; in this case results will also be made available in the same format file. The input file extension can be any. In the "**file list box**" related to the output the software proposes only files with the extension "**txt**"; if the output file's name is not selected but entered from the keyboard without extension, the software will add ".**txt**" automatically .

The input file must be organized with the following criteria:
- lines having as first significant character the bar (/) or the apex (') are considered as comments and ignored by the software;

- each line collects all and only the information related to a point; they must be inserted in the following sequence:
        - the point's identifying number, also alphanumeric, without spaces (maximum 8 characters);
        - the latitude of the point expressed in sexagesimal degrees in the format gg.ppssdddd or the North coordinate expressed in meters;
        - the longitude of the point expressed in sexagesimal degrees in the format gg.ppssdddd or the East coordinate expressed in meters;
        - the height of the point expressed in meters (only if you want to get the conversion);

- fields must be separated by spaces (as many as you like), or by tabulation;

- the decimal separator may be either a dot or a comma.

All coordinates of a file must be of the same type: geographic or plane.
For example:

```
/ number        Latitude        Longitude       Height
101             42.21324014     10.58202417     918.238
102             42.31254169     11.18174101     1872.455
 work area B
111A             42.35117451    11.01020047     777.952
Point 3         42.36191455     12.09478582     3567.921
```

Or

```
/ number        Nord            East            Height
10              5030214.251     2309747.184     18.238
102             5041247.254     2321417.294     872.455
 work area B
111A            5038954.978     2318941.399     7.952
Point_3         5047618.001     2352147.817     567.921
```

An example of an input file is available while running the software by clicking the "**Esempio file di input (Example input file)**" button.

The output file will have the characteristics as listed below:

- in the first line there are the reference epochs of the grids used in the transformation, both for the plane and the altimetric part;

- the second line shows the information relating to the coordinates introduced in input: Geodetic system, unit of measurement; if the coordinates are plane, the time zone to which the coordinates belong;

- the third line shows the information related to the output coordinates: Geodetic System, unit of measurement; if the coordinates are plane, the time zone in which the coordinates have been requested;

- the fourth line shows the unit of measurement of the heights and, in case of altimetric conversions in particular areas, the indication of the geoid model used (*see paragraph "accuracy"*);

- the fifth line is for headings indicating the contents of columns;

- in the first 4 columns the input data are rewritten;

- in the next 3 columns there are the results of the conversion;

- in the eighth column, in case of output in plane coordinates, information is given of the time zone: no information for Fuso Italia; indication of the time zone if it was requested as 'automatic'; if a specific time zone has been requested, 'true' or "false" are shown referring to whether or not the point belongs to the requested time zone;

- for points falling outside the area that can be processed with the selected grid file, the columns of results will be marked as "**fuori grig. (out grid**)"

For example:
Grids epoch: RO-ED 2002; RO-E89 2002; E89-E2000 2008; Geoid 2005
Input coordinates: ETRF89; sexagesimal degrees
Output coordinates: ROMA40; meters; requested time zone : Automatic
Heights expressed in meters

===

/Number	Lat. ETRF89	Lon. ETRF89	h ellis.	Nord ROMA40	Est ROMA40	H geoid.	Time zone
51801	45.26021357	12.20162263	918.238	5034623.904	2311775.935	874.650	East
51901	45.26123378	12.21347072	1872.455	5034882.499	2313491.457	1828.880	East
52701	45.35329184	12.28255414	945.231	5051895.456	2322961.795	901.369	East

6.0 Accuracy/Precision

Conversions' accuracy between different Reference Systems is not related to the software in use but it depends on the grids used and implemented by the software.

Grids files have ***.gk?** extension and, once selected, can be identified per year of realization. At the moment two grids extensions are available: **gk1** and **gk2**; grids are the same for plane coordinates and they give the same results as the ones used by IGMI. Geographic coordinates are expressed in sexagesimal format (about 3 mm), plane coordinates are expressed in mm. Accuracy is within millimetre thanks to the formulas developed by Prof Bonifacino.

ITALGEO99 is the geoidic model in use for heights and implemented in **gk1** grids (it was created thanks to the cooperation between IGMI and the Polytechnic of Milan). This geoiditic model has a mean deviation (1σ) from GEOTRAV network (part of IGM95 network) of :

- $\pm$ 0.15 m for continental Italy (Genoa tide gauge);
- $\pm$ 0.04 m for Sicily (Catania tide gauge);
- $\pm$ 0.07 m for Sardinia (Cagliari tide gauge).

At 3σ (confidence level of 99%) values are $\pm$ 0.45 m, $\pm$ 0.12 m, and $\pm$ 0.21 m respectively.

For Pelagie islands and Pantelleria island, separation values were estimated using Wenzel global model and they do not refer to the national geoidic models normally used. For these territories a message-box informs the user about the geoid model used.

ITALGEO2005 (also created thanks to the cooperation between IGMI and the Polytechnic of Milan) is the geoidic model implemented in **gk2** grids with a mean deviation (1σ) from GEOTRAV network (part of IGM95 network) of :

- $\sigma = 0.035$ m for the whole of Italy

At 3σ (confidence level of 99%) value is $\pm$ 0.10 m.

For Pelagie islands and Pantelleria island, separation values were estimated using EGM2008 global model, whose accuracy should not be lesser than 0.5 m. A message-box will inform the user about the geoidic model used for these areas

The IGMI Geodetic Service will be grateful to anyone who would like to contribute with observations and suggestions for improving the software.