THE COORDINATE REFERENCE SYSTEMS OF SPATIAL DATA INFRASTRUCTURES IN ALBANIA

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ABSTRACT

One of the basics of geoinformation systems is to guarantee an unambiguous spatial reference of the stored information. The spatial reference can be given by coordinates or by geographic identifiers. Coordinates are unambiguous when the reference system to which those coordinates are related has been fully described. The standardization activities since the nineties in the frame of the European standardization organization CEN and of the international standardization organization ISO for GIS included the spatial reference aspect as a central topic. The coordinate reference system (CRS) is an aggregate class with the component classes datum and coordinate system; geodetic datum, vertical datum and engineering datum are subclasses to the datum.
In Albania, many organizations have collections of spatial data. Few institutions have operational GIS databases. Except Municipality of Tirana, there are not online spatial data bases. Spatial data are created by several agencies as per their needs. Some realities of spatial data are: relevant data is often hard to find, frequently it is not in compatible forms, information describing data is often non-existent, framework data does not exist for broad geographic areas, data sharing across organizations is inconsistent etc. Therefore we need to do: common language, common reference system and common framework. In this paper we give some knowledge about coordinates references systems that are used in Albania to which are related the coordinates of spatial reference. Three common coordinate systems used in GIS in Albania are Geographic coordinate system (Lat-Long), planar (Cartesian) georeferenced coordinate system (easting, northing, elevation) which includes projection from an ellipsoid to a plane with origin and axes tied to the Earth surface, planar non - georeferenced coordinate system, such as image coordinate system with origin and axes defined arbitrarily (e.g. image corner) without defining its position on the Earth and projection.

Key word: ALBANIA, INSPPIRE, NSDI, GIS, CRS, CEN, ISO

1. INTRODUCTION

The realization of a geoinformation system requires that the geodetic reference system is defined and the measurements are carried out in the chosen system. In every Geographic Information Systems (GIS) project, the user must choose whether to analyze and display data in geographic coordinates or a map projection. There are potentially critical differences between these two ways of measuring the world. In other hand for building up a Spatial Data Infrastructure (SDI), one condition is that all spatial data (geodata) which are used for a specific purpose need to use the same Coordinate Reference Systems (CRS) simultaneously. For that, the definition of each CRS and their relations has to be known. In order to facilitate the exchange and use of geospatial data

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by different individuals and organizations, it is important to have a common framework and structure for expressing spatial referencing information. To further this goal, the specification of coordinate reference systems and their components conforms to the International Organization for Standardization (ISO) standard 19111:2003 entitled *Spatial Referencing by Coordinates*. The high level abstract model for spatial referencing by coordinates is shown in the diagram below (fig 1).

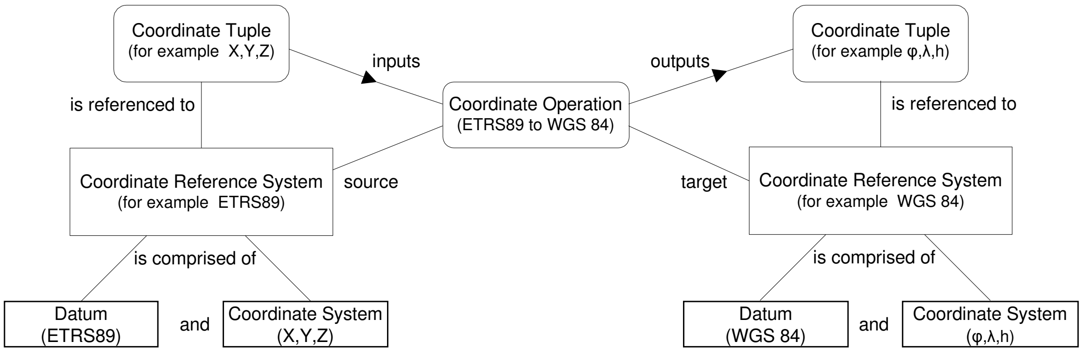

Fig. 1. The abstract model for spatial referencing by coordinates

New methods of acquiring spatial data and the advent of geographic information systems (GIS) for handling and manipulating data mean that we no longer must rely on paper maps from a single source, but can acquire, combine, and customize spatial data as needed. To ensure quality results, however, one must fully understand the diverse coordinate frameworks upon which the data are based. Datums and Map Projections provides clear, accessible explanations of the terminology, relationships, transformations, and computations involved in combining data from different sources. The paper focuses on different coordinate systems and datums that are used in Albania.

2. COORDINATE REFERENCE SYSTEMS (CRS)

Geographic locations in a geospatial object are specified in terms of the object's coordinate reference system (CRS). A CRS associates a coordinate system with an object by means of a datum (fig 2). Therefore, a CRS definition must encompass a definition of a coordinate system and a datum. In the context of ISO 19111 a CRS is defined by its datum. Three types are important in the context of this paper:

- Geodetic CRS – a CRS based on a geodetic datum (e.g. WGS 84 or ETRS 89 - note that both these names are also names of geodetic datums)
- Projected CRS – a CRS derived from a geodetic CRS by means of a map projection. The datum is expressed by the geodetic datum of the base geodetic CRS from which the projected CRS is derived (e.g. Albanian National Grid)

- Vertical CRS – a one dimensional CRS based on a vertical datum (e.g. MSL Depth). It is the definition of the CRS that must be supplied with a spatial dataset in order that a full understanding of the meaning of the coordinates in the data can be gained. By extension the CRS should also be expressed in full on any map products that are produced.

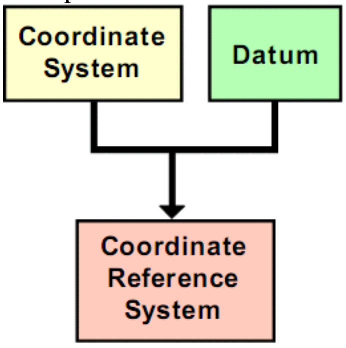

Fig. 2. A coordinate reference system combines a coordinate system with a datum, which gives the relationship of the coordinate system to the surface and shape of the Earth

A coordinate system (CS) is a sequence of coordinate axes with specified units of measure. A coordinate system is an abstract mathematical concept without any defined relationship to the earth. Coordinate systems generally have not been explicitly described in geodetic literature, and they rarely have well-known names by which they are identified. The historic colloquial use of 'coordinate system' usually meant coordinate reference system. A datum specifies the relationship of a coordinate system to the earth, thus ensuring that the abstract mathematical concept can be applied to the practical problem of describing positions of features on or near the earth's surface by means of coordinates (fig.3).

Coordinate reference systems, coordinate systems and datums are each classified into several subtypes. Each coordinate system type can be associated with only specific types of coordinate reference system. Similarly each datum type can be associated with only specific types of coordinate reference system. Thus, indirectly through their association with CRS types, each coordinate system type can only be associated with specific types of datum.

In Europe there exist a very lot of different Coordinate Reference Systems (CRS), and new CRS are defined (table 1). This collection of European Coordinate Reference Systems collects a lot of paneuropean, regional and national CRS information.

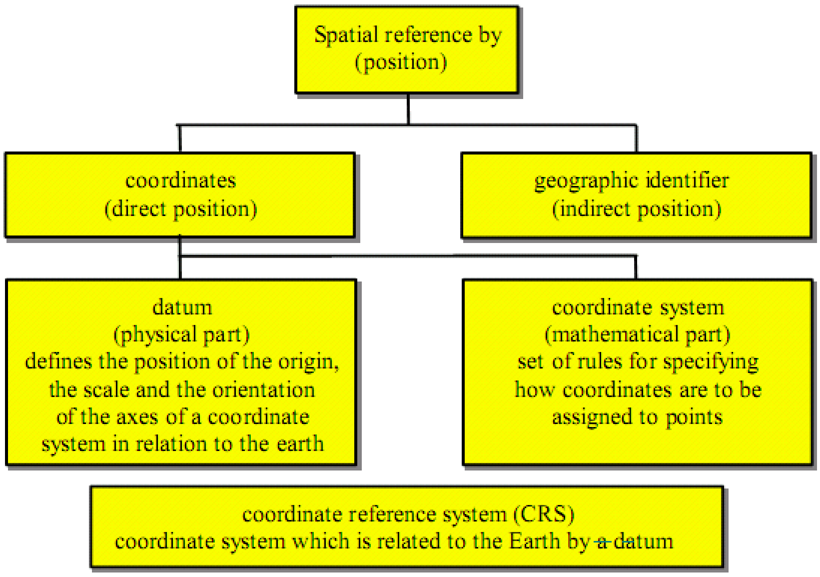

Fig. 3. The definitions of CRS, datum and coordinate system

Tab. 1. Different Coordinate Reference Systems (CRS) in Europe

CRS-EU **Information and Service System for Coordinate Reference Systems in Europe**	**EVRS** **Information System for the European Vertical Reference System**
It contains: • description of national Coordinate Reference Systems • description of pan-European Coordinate Reference Systems • description of transformation parameters from national Coordinate Reference Systems to pan-European Coordinate Reference Systems including ○ quality of transformation ○ verification data of transformation ○ possibility for online conversion and transformation of single points for test and verification purposes	It contains: • definition of EVRS • description of realizations of EVRS - EVRF2000 and EVRF2007 • projects and products for EVRS (UELN, EUVN, EUVN-DA) • references for EVRS (resolution, papers, bibliography)

(position) • links to the National Mapping Agencies of the European Countries	

2.1. Coordinate Reference System subtypes.

Geodetic survey practice usually divides coordinate reference systems into a number of sub-types. The common classification criterion for sub-typing of coordinate reference systems can be described as the way in which they deal with earth curvature. This has a direct effect on the portion of the earth's surface that can be covered by that type of CRS with an acceptable degree of error. The following types of coordinate reference system are distinguished: Geographic (Geographic 2D, Geographic 3D), Geocentric (ISO 19111 classifies both geographic and geocentric coordinate reference systems as geodetic CRSs), Vertical, Projected, Engineering and Compound (in historic geodetic practice, horizontal and vertical positions were determined independently). It is established practice to combine the horizontal coordinates of a point with a height or depth from a different coordinate reference system. This has resulted in coordinate reference systems that are horizontal (2D) and vertical (1D) in nature, as opposed to truly 3-dimensional. The coordinate reference system to which these 2D+1D coordinates are referenced combines the separate horizontal and vertical coordinate reference systems of the horizontal and vertical coordinates. Such a system is called a compound coordinate reference system (CCRS). It consists of a non-repeating sequence of two or more single coordinate reference systems).

For spatial coordinates, a number of constraints exist for the construction of compound CRSs. Coordinate reference systems that are combined shall not contain any duplicate or redundant axes. Valid combinations include: Geographic 2D + Vertical, Geographic 2D + Engineering 1D (near vertical), Projected + Vertical, Projected + Engineering 1D (near vertical), Engineering (horizontal 2D) + Vertical, Engineering (1D linear) + Vertical.

2.2. Coordinate System subtypes. Datum subtypes

The coordinates of points are recorded in a coordinate system (CS). Each CS type may be associated with only specific types of CRS. The following types of coordinate system are distinguished: ellipsoidal, Cartesian, affine, gravity-related, linear, spherical, polar, and cylindrical.

A "Datum" is a standard representation of shape and offset for coordinates, which includes an ellipsoid and an origin. A datum implies a choice regarding the origin and orientation of the coordinate system. It is the datum that makes the coordinate system and its coordinates unambiguous. We recognize three types of datum – geodetic, vertical and engineering (fig. 4).

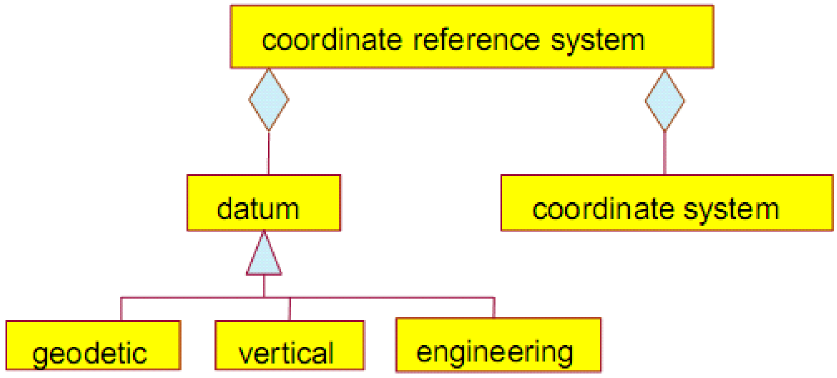

Fig. 4. The coordinate reference system (CRS) is an aggregate class with the component classes datum and coordinate system, geodetic datum, vertical datum and engineering datum are subclasses to the datum

There are a vast amount of datums, some used for measurements all over the world, and other local datums defined so they fit very well with a local area. Some common ones are: World Geodetic Datum 1984 (WGS84), European Datum 1950 (ED50) and North American Datum 1983 (NAD83) etc. The most well-known is WGS84 used by the GPS systems today. It is a good approximation of the entire world and with fix-points defined almost all over the world. When it was defined they forgot to include points in Europe though, so the Europeans now have their own ETRS89, which is usually referred to as the "realization of WGS84 in Europe". The problem here was solely because of continental drift, so they defined some points relative to WGS84 in 1989, and keeps track of the changes. In most use-cases it is of no real importance and we can use one or the other. People often refer to having their data in WGS84, and we see now why this doesn't make sense. All we know from that is that the data is defined using the WGS84 datum, but we don't know which coordinate system it uses.
A vertical datum defines the relationship of a gravity-related coordinate system to the earth. An engineering datum defines the relationship of a coordinate system used for engineering purposes to the earth. For both vertical and engineering types the most important attribute is the datum name, which implies the relationship.
A geodetic datum defines the relationship of a geographic or geocentric coordinate system to the earth. In addition to the datum name (which again implies the relationship), essential attributes of a geodetic datum are the chosen model of the earth – the ellipsoid – including details of name and defining parameter values, together with the details of the zero or prime meridian from which longitudes are reckoned.

3. COORDINATE DATUMS

Since coordinate reference systems are idealized abstractions, they can only be accessed through their physical materialization (or realization) called reference frames or datums. The datum effectively defines the origin and orientation of the coordinate reference system at a certain epoch, generally by adopting a set of station coordinates. Over time, different techniques with varying levels of sophistication have been used to define the shape of the Earth's surface, resulting in the adoption of many different datums. Here we briefly describe some of the datums used by spatial professionals today.

The International Terrestrial Reference Frame (ITRF) is the most precise earth-centered, earth-fixed datum currently available and was first introduced in 1988. It is maintained by the International Earth Rotation and Reference Systems Service (IERS) and realized by an extensive global network of accurate coordinates and their velocities derived from geodetic observations using GPS, Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Lunar Laser Ranging (LLR) and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) (Altamimi et al., 2007). These coordinates are based on the GRS80, a geocentric ellipsoid designed to approximate the geoid on a global scale. The ITRF is a dynamic datum and changes according to temporal variations of its network coordinates and their velocities due to the effects of crustal motion, earth orientation, polar motion and other geophysical phenomena such as earthquakes and volcanic activity (Bock, 1998). It is updated regularly in order to account for the dynamics of the Earth and now sufficiently refined to ensure that the change between successive ITRF versions is in the order of 1-2 cm. So far the following versions have been released: ITRF88, ITRF89, ITRF90, ITRF91, ITRF92, ITRF93, ITRF94, ITRF96, ITRF97, ITRF2000 and ITRF2005. A new version, ITRF2008, is anticipated to be released in the near future. Coordinates given in any of the ITRF realizations are referred to a specific epoch in order to enable appropriate consideration of the Earth's dynamics.

The most popular global coordinate system used by the GPS navigation system is WGS 84. The World Geodetic System 1984 (WGS84) was developed for the U.S. Defense Mapping Agency (DMA), later named NIMA (National Imagery and Mapping Agency) and now called NGA (National Geospatial-Intelligence Agency), and is the nominal datum used by GPS (NIMA, 2004). It is based on the WGS84 ellipsoid which can generally be assumed identical to the GRS80. The WGS84 datum was introduced in 1987 based on Doppler observations and has since been refined several times to be closely aligned with the ITRF in order to prevent degradation of the GPS broadcast ephemerides (i.e. orbit parameters) due to plate tectonics (True, 2004). The first refinement was introduced in 1994 to align the WGS84 with ITRF91 and included a revised set of station coordinates for the tracking network, based entirely on GPS observations (Malys and Slater, 1994). It is known as WGS84 (G730) where G stands for 'GPS' and 730 denotes the GPS week number when NGA started expressing their derived GPS precise ephemerides in this frame, i.e. 2 January 1994. Swift (1994) estimated that the refined WGS84 agreed with the ITRF92 at the 10 cm level. The second refinement, WGS84 (G873), occurred on 29 September 1996 and resulted in coincidence with the ITRF94 at better than 10 cm (Malys et al., 1997). It should be noted that the GPS Operational Control Segment did not implement the WGS84 (G730) and WGS84 (G873) coordinates until 29 June 1994 and 29 January 1997, respectively. The latest refinement, WGS84 (G1150), was introduced and implemented on 20 January 2002 based on 15 days of GPS data collected during February 2001 at six U.S. Air Force monitoring stations, 11 NGA stations and several additional global tracking stations. After this alignment with the ITRF2000, it was shown that the WGS84 coincides with the ITRF within a few centimeters at the global level (Merrigan et al., 2002). For all mapping and charting purposes, the WGS84 and the most current ITRF can therefore be assumed identical (NIMA, 2004). However, it should be noted that the level of agreement worsens as the time gap between WGS84 (G1150) and the latest realization of ITRF grows.

In order to move to a geocentric (i.e. GPS-compatible) datum, the European Terrestrial Reference System 1989 (ETRS89) was introduced in 1989. This datum is based on the GRS80 ellipsoid, coincident with ITRF89 at epoch 1989.0 and realized by an extensive permanent GPS station network across Europe (Boucher and Altamimi, 1992). The ETRS89 has undergone several realizations, denoted European Terrestrial Reference Frames (ETRF), relating it to more recent versions of the ITRF. The latest realization, known as ETRF2000, has been derived from the ITRF2000 through a set of known transformation formulae (Altamimi and Boucher, 2002). While many European countries continue to use their individual national datums, an increasing number of these are linked to the ETRF.

4. PROJECTION COORDINATES

In practice, it is often required to express positions on a flat surface in the form of grid coordinates, i.e. in a 2-dimensional Cartesian coordinate system such as Easting and Northing. Here we briefly reviews map projections and introduces the principle of grid coordinates.

4.1 Map Projections

Map projections are used to represent a spatial 3dimensional surface (e.g. the Earth) on a plane 2dimensional surface (e.g. a paper map) according to a recognized set of mathematical rules, resulting in an ordered system of meridians (lines of constant longitude) and parallels (lines of constant latitude). It is therefore necessary to project the Earth onto a *developable surface* that can be cut and flattened, i.e. a plane, cylinder or cone, resulting in an azimuthal, cylindrical or conic projection, respectively. This *projection surface* is located tangent or secant to the Earth and its axis is either coincident with the Earth's axis (polar or normal aspect), at right angles to it (equatorial or transverse aspect) or at an arbitrary angle (oblique aspect). The projection parameters needed to convert curvilinear coordinates to grid coordinates are derived either geometrically or mathematically. It is impossible to convert a 3D surface into a 2D surface without introducing distortions. Several hundred map projections have therefore been developed in order to satisfy certain cartographic properties, i.e. the preservation of shape locally (conformal projection), scale (equidistant projection) or area (equal-area projection). Thus it is possible to eliminate certain distortions at the expense of others or to minimize all types of distortions, but some distortion will always remain. On a conformal map, meridians and parallels intersect at right angles, and the scale at any point on the map is the same in any direction, although it will vary from point to point. Conformal maps therefore allow the analysis, control or recording of motion and angular relationships. Two well known conformal projections are the Gauss Kryger and the Transverse Mercator projection, which are used extensively in Albania as a basis for grid coordinates.

4.2. UTM Projection

The Transverse Mercator projection is mathematically derived and utilizes a cylinder that is tangent to a chosen meridian, called the *central meridian* (CM). The scale is therefore true along the central meridian but increases with increasing distance from it, thereby causing a growing distortion in scale. The Transverse Mercator projection is most appropriate for regions exhibiting a large north-south extent but small east-west extent. However, by splitting up the area to be mapped into longitudinal zones of limited extent and merging the resulting plane maps, the entire world can be mapped with minimal distortion. The Universal Transverse Mercator (UTM) projection utilizes a zone width of 6° and ensures that the scale is very close to unity across the entire zone by defining a *central scale factor* of 0.9996 for the CM which results in a scale of 1.0010 at the zone boundary located 3° away from the CM. The UTM projection divides the world into 60 zones, zone 1 having a CM at longitude 177°W, while the latitudinal extent of each zone is 80°S and 84°N, indicated by 20 bands labeled C to X with the exclusion of I and O for obvious reasons. All latitude bands are 8° wide, except the most northerly (X) which is 12° wide to allow Greenland to be mapped in its entirety. For a UTM map of the world, the reader is directed to http://www.dmap.co.uk/utmworld.htm. The increasing distortion in scale evident at high latitudes is caused by the north-south gridlines not converging at the poles, i.e. the poles would be projected as lines rather than points. The Albania is located in zone 34S and 34T. Note that while the latitude extent is generally part of the coordinate display in most GNSS receivers, in a GIS environment it is often replaced by N or S to indicate the hemisphere when a global UTM system is used.

4.3. Grid Coordinates

In each UTM zone, the projected grid coordinates, i.e. Easting and Northing, are initially referenced to the origin defined by the intersection of the CM and the equator, resulting in negative Easting coordinates west of the CM and negative Northing coordinates in the southern hemisphere. In order to ensure positive coordinate values across the entire zone, the UTM system applies false coordinates to the origin by adding 500,000 m to the true Easting and, in the southern hemisphere, 10,000,000 m to the true Northing. It should be noted that variations of this global UTM convention are used in numerous national mapping datums, applying different zone widths, false coordinates and central scale factors.

The Military Grid Reference System (MGRS) is a two-dimensional grid that uniquely identifies a square meter anywhere on the earth. The MGRS attempts to represent the entire surface of the Earth on a worldwide grid. The grid is based on the UTM (between 80°S and 84°N latitudes) and UPS (Universal Polar Stereographic) systems. The MGRS coordinate consists of seven parameters: Datum (as applied to MGRS), Zone number, Band letter, Column letter, Row letter, MGRS Easting and MGRS Northing

5. VERTICAL DATUM

A vertical datum defines a reference for elevation comparisons and is essential for a wide range of spatial applications such as floodplain management, waterway navigation management, roadway and drainage design, agricultural management and surveying in general. Most countries utilize an approximation of the *orthometric* height system related to the geoid as reference for vertical coordinates. Generally, vertical datums are based on MSL. However, MSL has been specified differently in different countries, resulting in a multitude of zero-levels. The history of and the various relationships between the many existing national vertical datums is a very complex topic.

5.1. Transformation of Heights

Positions obtained by GPS include heights referred to a reference ellipsoid. These heights are purely based on the geometry of the ellipsoid and therefore have no physical meaning. In practice, however, heights are generally required that correctly reflect the flow of water, e.g. for drainage and pipeline design. National height datums are therefore based on orthometric heights, referenced to the geoid or an approximation thereof.

Ellipsoidal heights (h) can be converted into orthometric heights (H) by applying the *geoid undulation* (N), also known as geoid-ellipsoid separation, geoid height (not to be confused with the height above geoid, i.e. the orthometric height) or N value:

$H = h - N$

where h and N are measured along the ellipsoid normal, while H is measured along the curved plumb line, i.e. the direction of the gravity vector (Fig. 5).

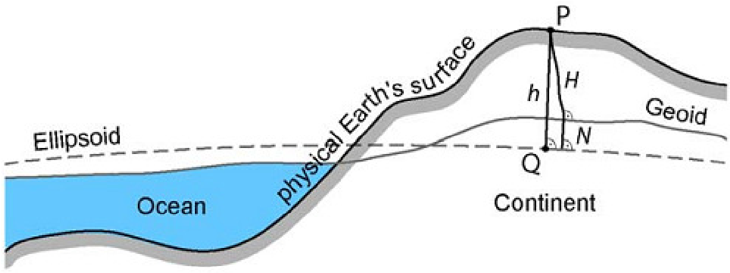

Figure 5: Relationship between ellipsoidal height (h), orthometric height (H) and geoid undulation (N), courtesy of M. Kuhn, Curtin University of Technology

6. COORDINATE REFERENCE SYSTEMS (CRS) USED IN ALBANIA

The ability to successfully change from one datum to another requires knowledge of:

a. Geoids
b. Ellipsoids
c. Coordinate Systems
d. Geodetic Height
e. Geodetic Datums
f. Coordinate Systems
g. Methodology to shift from one datum to another

From second half of XIX century, in Albanian territory are made some coordinate reference systems especially to support mapping of Albanian ground territory. Thus, we distinguish coordinate references following:

- The Triangulation Network that was established by Military Geographic Institute of Vienna (MGIW) during 1860-1873, in the framework of the construction of the geodetic basis is done for mapping of Balkan at 1:75000 scale. We have not any detailed information about, but we know that in the 1918 the geodetic coordinates of the points of triangulation were calculated on Bessel ellipsoid (dimensions determined by Friedrich Wilhelm Bessel, based on several meridian arcs and other data of continental geodetic networks of Europe, Russia and the British Survey of India), Gauss-Krüger cylindrical projection, with origin the intersection of the Equator by the meridian of Ferro.

Reference parameters of the Coordinative Reference established by Military Geographic Institute of Vienna (MGIW) in the 1860-1873 period are:
Ellipsoid: Bessel 1841, non geocentric
Ellipsoid origin of north: Earthy equator,
Ellipsoid origin of east: Ferro Meridian (-17.5^0 in west of Greenwich)
Projection: Polyconic of Bonn

- The geodetic coordinates of the points of triangulation that carried out by Military Geographic Institute of Italy (IGM), in the 1927-1943 period, were calculated on Bessel ellipsoid, Bonn projection with central meridian Lo=20', as origin was determined the astronomical point of Lapraka, Tirana. At the same time, IGM carried out the Leveling Net (about 150-170 km). The origin for Heights System was chosen the MSI, of Adriatic Sea, determined with a temporary tide gauge very short recording time (one month).
  Reference parameters of the Coordinative Reference established by Military Geographic Institute of Italy (IGM), in the 1927-1943 period are:
  Ellipsoid: Bessel 1841, non geocentric
  Ellipsoid origin of North: Earthy Equator ($\varphi = 0^0$),
  Ellipsoid origin of East: Meridian $\lambda_0 = 20^0$
  Projection: Bonn
  False origin of North: 0.000 m
  False origin of East: 0.000 m
  Scale of deformation in central meridian ($\lambda_0 = 20^0$): k_0=1
- In the 1955, the specialists of Military Topographic Group of Albania carried out the reconstruction and the densification of the IGM Net in order to grant the request for mapping at 1: 25 000 scale. At the same time, the first- order network was transformed from the IGM. System (1934) into the 1942 coordinate system, which based on Krassovsky ellipsoid, Gauss-Krüger projection with central meridian Lo=21'.
  Reference parameters of the Coordinative Reference established by of Military Topographic Group of Albania with Russian help in 1955 year are:
  Ellipsoid: Krasovski 1945, non geocentric
  Ellipsoid origin of North: Earthy Equator ($\varphi = 0^0$),
  Ellipsoid origin of East: Central Meridian $\lambda = 21^0$
  Projection: Gauss-Kryger (Mercator Transversal)
  False origin of North: 0.000 m
  False origin of East: 500 000.000 m, in west of meridian $\lambda = 21^0$
  Scale of deformation in central meridian ($\lambda_0 = 21^0$): k_0=1
- The New Albanian Net, which constituted from Triangulation and Leveling was designed, rebuilt, measured and calculated from Military Topographic Institute of Albania (MTI) during 1970-1985 (fig. 6). Leveling Networks, were designed, measured and calculated at the same time as the triangulation, during 1970-1985, from Military Topographic Institute (MTI).
  Reference parameters of the Coordinative Reference established by of Military Topographic Institute of Albania in the 1970- 1985 period are:
  Ellipsoid: Krasovski 1945, non geocentric
  Ellipsoid origin of North: Earthy Equator ($\varphi = 0^0$),
  Ellipsoid origin of East: Central Meridian $\lambda = 21^0$
  Projection: Gauss-Kryger (Mercator Transversal)
  False origin of North: 0.000 m

False origin of East: 500 000.000 m, in west of meridian $\lambda = 21^0$
Scale of deformation in central meridian ($\lambda_0 = 21^0$): k_0=1

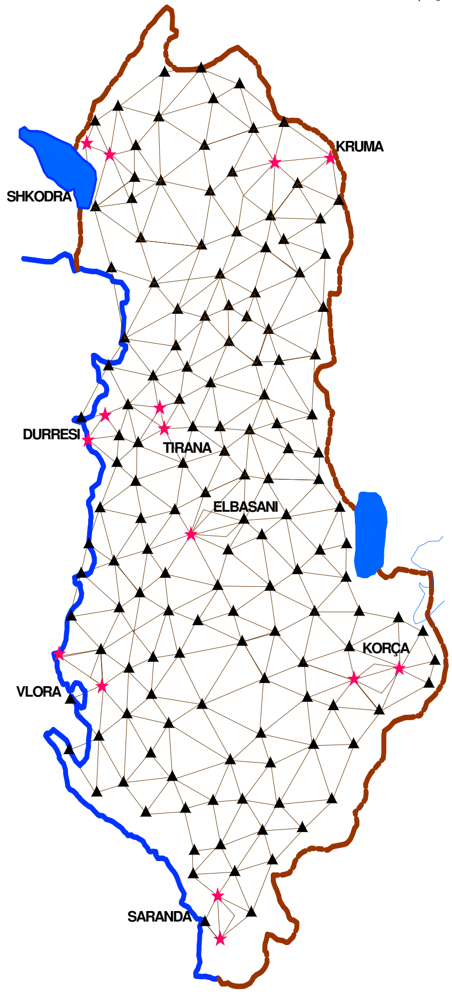

Fig. 6. First class of Albanian Triangulation Net

The Datum of the elevation system was chosen the MSL of Adriatic Sea, determined from recordings of tide gauge for 1958-1977, which was establish since before second world war from Military Geographic Institute of Florence, Italy. From this tide gauge was establish the Fundamental Bench Mark (FBM) of the First Order Leveling (FOL).
The cadastral maps that were done for about 40 years by using the classical methods (tachymetry) are a scale of 1:2500 and 1:5000. The maps were used not only for cadastral purposes but also for different considerations such as land irrigation systems, land management, and so forth. Two co-ordinate systems for cadastral maps production are applied: (1) one system based on the Bessel ellipsoid is used to produce maps at a scale of 1:2500; (2) and the other system based on the

Krasowski ellipsoid is used to generate maps at a scale of 1:5000. The Gauss-Kruger projection is used for both systems; for the first system the central meridian is 20°, and for the second it is 21°. The maps at the scale of 1:2500 in the Bessel co-ordinate system are based on a map sheet layout system unique to Albania. Map sheets produced in the Krasowski system are referenced by geographic coordinates.
Immovable Property Registration Office (IPRO), Ministry of Justice: IPRO, as part of its property registration scope, has produced a cadastral layer that includes coverage for all the eight cities. The cadastral borders are in AutoCAD DWG/DXF format, while the attribute data resides partly in a relational database, and partly in hard-copy format. The spatial data is acceptably accurate at scales of 1:500-1:1,000 in urban areas, and at 1:2,500 scale in rural areas. The data is spatially referenced in the Albanian National Coordinate System (Gauss-Kruger, Krasovski/Pulkovo 1942). IPRO is at present in the midst of a large-scale modernization project, which will produce a highly automated property registration updating procedure, as well as a GIS-compatible cadastral database. This database will be of vital importance for any regulatory planning initiative, and so the solving of the coordinate conversion issues is of utmost importance.

- A Global Positioning System (GPS) geodetic control network survey was performed in Albania during October 1994 in collaboration with United States Defense Mapping Agency Aerospace Center (DMAAC). The purpose of the survey was to establish World Geodetic System 1984 (WGS 84) positions on 35 existing stations within the Albanian geodetic control network. The selection of the stations to be included in the survey was made by M.T.I. personnel. The objective of GPS measurements campaign of February 98 in collaboration with University of Wisconsin, Florida, USA was: Connect the Albanian Geodetic Network to the International Terrestrial Reference System (ITRF) and define the inter-relationship between the local and international reference frameworks. It was proposed to occupy stations included in US National Imagery and Mapping Agency (NIMA) GPS network of 1994, thus it would be possible to re-adjust the NIMA network data. The fiducially network included the IGS stations GRAZ, MATERA, SOFIA and PENC and stations KAMZA, KORCA, SHKODRA. The final coordinates are referenced to ITRF 96, Epoch 1998.0, also the final WGS 84 geodetic coordinates. The final co-ordinates for the new EUREF stations were performed by fixing the co-ordinates of four ITRF stations (Wettzell1202) and are given in the International Terrestrial The Military Institute of Albania is responsible for producing a variety of cartographic products, including hard-copy topographic maps at the following scales: 1:10,000, 1:25,000, 1:50,000, and 1:100,000. All of these products are spatially referenced in the Albanian National Coordinate System. In addition, the Institute distributes 1:50,000 scale hard-copy maps produced in collaboration with the USA agency NIMA (National Image and Mapping Agency – now called NGA: National Geospatial-Intelligence Agency). These products are spatially referenced in the UTM (WGS84) coordinate system. The Institute's 1:25,000 and 1:50,000 scale series may be suitable background cartographic material for city-based GIS projects, since they exhibit a standard graphic "language", as well as indicate the regional context of the city.

Reference parameters of the Coordinative Reference established by of Military Topographic Institute of Albania after 1994 year are:
Ellipsoid name: WGS 84
Ellipsoid origin of North: Earthy Equator ($\varphi = 0^0$),

Ellipsoid origin of East: Central Meridian $\lambda = 21^0$ E
Map Projection name: UTM zone 34 N
False northing, in grid units: 0.000 m
False easting, in grid units: 500 000.000 m, in west of meridian $\lambda = 21^0$
Scale factor at natural origin in central meridian ($\lambda_0 = 21^0$): k_0=0.9996
Magnitude of projection zone: 6^0,
Projection Zone: 34
Projected CRS axes units name: meter

- Albanian National Grid (ANG) is the national standard CRS for land mapping in Albania. The components of the CRS are as follows:

1. Base Geodetic CRS – WGS 84
2. Geodetic Datum – WGS 84
3. Ellipsoid – WGS 84
4. Prime Meridian – Greenwich
5. Coordinate System - Ellipsoidal
6. Projection Parameters – ANG
7. Projection Method – Transverse Mercator
8. Coordinate System – Cartesian

ANG was originally created using classical techniques. The geodetic datum was realized by triangulation using physical monuments (Trig Points). However, the realization of the datum is now performed through the use of the coordinate transformation.
Numerous mathematical techniques have been developed to convert coordinates between Albanian System 1987 (ALB87) (Krasovski Ellipsoid and Gauss-Kryger Projection) and UTM, WGS 84. These techniques include a variety of multiple-parameter and multiple-regression transformation equations.

7. CONCLUSIONS

In order to facilitate the exchange and use of geospatial data by different individuals and organizations, it is important to have a common framework and structure for expressing spatial referencing information. Coordinates are the foundation of GIS, cartography, and surveying, to name just a few fields. Coordinate systems, covering ellipsoids, datums, and plane coordinates are used in GIS and GPS.
There are thousands of horizontal geodetic datums and Cartesian coordinate systems currently sanctioned by governments around the world to describe our planet electronically and on paper. In Albania we distinguished coordinate reference systems that based on:

- Bessel ellipsoid and Bonn polyconic projection;
- Krasovski ellipsoid and Gauss-Kryger projection;
- WGS 84 ellipsoid and UTM projection.

The Datum of the elevation system in Albania was chosen the MSL of Adriatic Sea, determined from recordings of tide gauge for 1958-1977, which was establish since before second world war from Military Geographic Institute of Florence, Italy. From this tide gauge was establish the Fundamental Bench Mark (FBM) of the First Order Leveling (FOL)

The INSPIRE theme Coordinate reference systems (CRS) provides a harmonized specification for uniquely referencing spatial information. Numerous algorithms and programs are developed to convert coordinates between Albanian System 1987 (ALB87) (Krasovski Ellipsoid and Gauss-Kryger Projection) and UTM, WGS 84. But, till now algorithms and programs are not developed to convert coordinates between coordinate reference system (Bessel ellipsoid and Bonn polyconic projection) and other coordinate reference systems.

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