FIG Working Week 2004

4D Geo-referenced Database Approach for GIS

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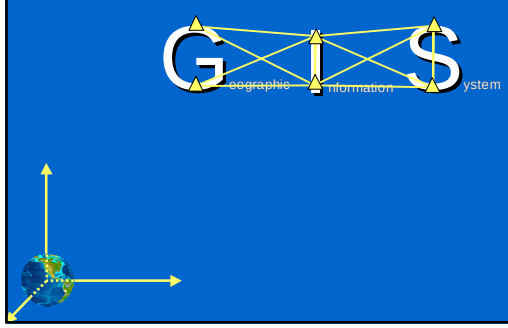
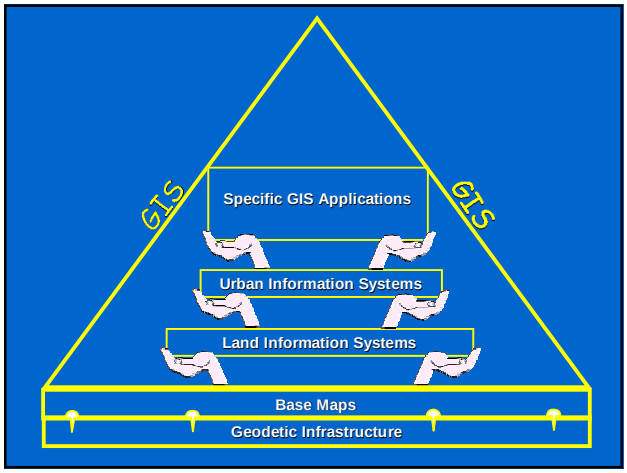
Components of GIS

- Hardware
  - Where GIS software is run
- Software
  - The hardware and data is controlled, organized and used
- Data
  - Without it no GIS is concerned, since it makes GIS meaningful
- People
  - Why GIS for? Creator, builders and users
- Method
  - Way of using and benefiting from data

GIS Approach



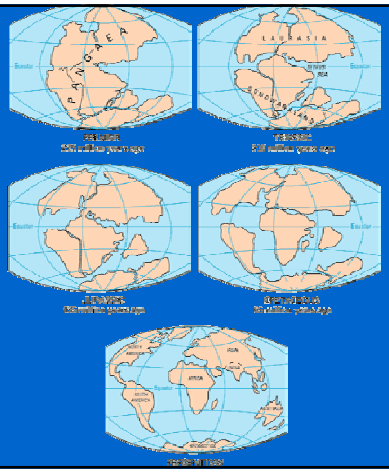


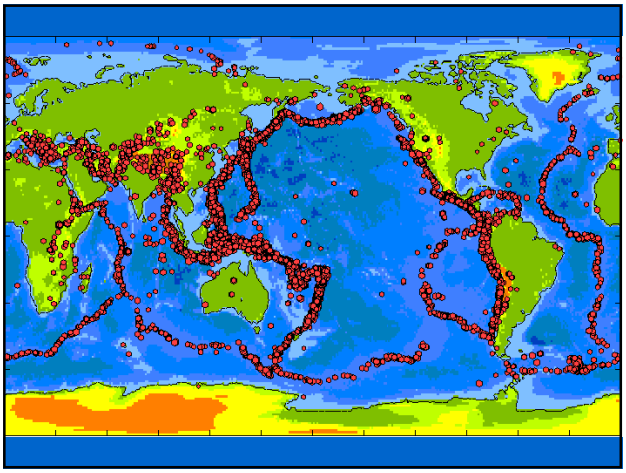
How to Produce Maps

- Whatever the method is used (Conventional, GPS, Photogrammetric,…) a geodetic infrastructure is essential
- Global or national geodetic network exists therefore it needs to be condensed up to providing comfortable detail survey.
- Processes of condensing a geodetic survey constitute a hierarchical status among control and detail points. In affect we might call this as a geodetic topology or topology of geodetic measurements
- Therefore if any control station's location is changed by a crustal movement, an earthquake or a landslide location of detail points are also changed.
- This means the locations of information on the map are changed
- Unfortunately, today base maps are used as stable geospatial information provider rather then dynamic geospatial information provider

Everything is Moving with Earth by Time

- Finding a fix point somewhere in space would make the things much easier for Geomatics Engineers; but unfortunately nothing stable and furthermore everything is moving. The only way of having a fix point in space might be frozen the time and defining the location of point for that instant of time. ITRF??
- Due to the dynamics of earth all objects on and in the earth is moving. Moreover tectonic activities cause partial movements on earth. The continents that are the large areas are moving towards each other.
- Hence their activities cause also changes in smaller areas. These changes might suddenly or gradually be occurred due to earthquake or self-movements of faults by time respectively. Geomatics Engineers establish control stations on surface of the earth for making maps. Therefore the locations of these control stations also change regarding these actives.





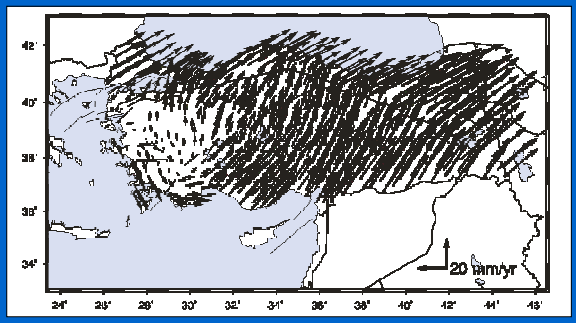
Therefore, in order to sense the earth breathing

- Global to regional, regional to local approach is essential
- A, B, $C_{1,2,3,4}$ order geodetic GPS networks is to be considered
- And moreover some of these networks continuously and some of them periodically be observed
- Today these aspects are used to produce updated maps and for scientific crustal researches; however this information might be used to produce dynamic base maps for GIS applications.

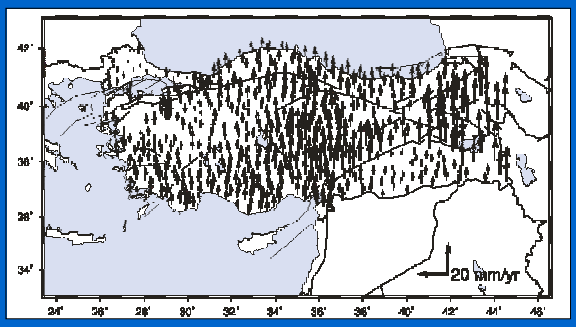
Why 4D Geo-referenced Database Design?

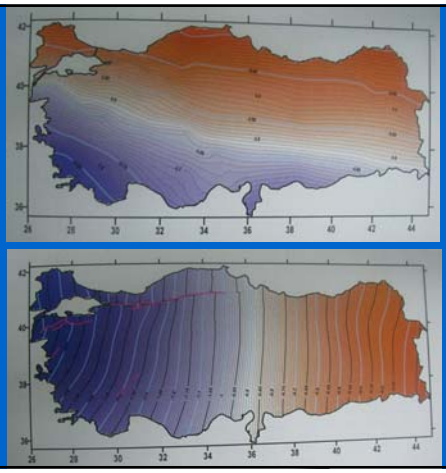
- Most GIS applications are currently considered as 2D. The third dimension also exists in the system; but it is not part of coordinates, it is an attribute of objects as graphics that are constituted by group of coordinates. This is certainly beneficial for 3D query, analysis and decision making; however this is indirect benefit of 3rd dimension.
- Nowadays, when 4D is concern temporal GIS comes up as the topic; since, in that case, the 4th dimension is time. However temporal GIS mainly focus on changes of semantic data by time.

Horizontal Velocities - ITRF96



Vertical Velocities - ITRF96





- The concept of this paper is different than today's GIS applications. The concept is here; changes of base maps geometry by means of natural dynamics of the earth.
- Today these changes are not integrated to GIS, they mostly are omitted. However if the topology of mapping process is used or functioned, in other words if dynamic base maps are used, much more realistic query and analysis might be made and hence better decision making process might be carried out within certain period of time, backwards and forwards .
- Since in that case changes of topography and changes of objects exist on the topography might be monitored within the GI System.

- Therefore the geo-referenced database should be design including the velocities of coordinates whose values are defined for an instant of time,

$X_o, Y_o, Z_o, v_x, v_y, v_z$

- Additionally the velocities should be function of time
- linear case

$X_i = X_o + (t_i - t_o)\, v_x$; $Y_i = Y_o + (t_i - t_o)\, v_y$; $Z_i = Z_o + (t_i - t_o)\, v_z$

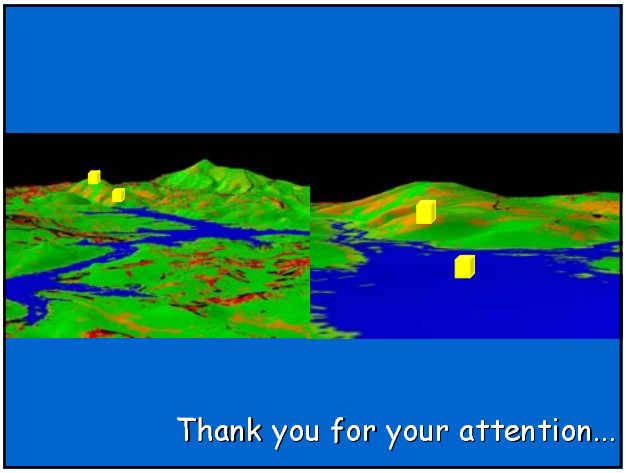
- nonlinear case

$X_i = X_o + (t_i - t_o)\, Fv_x(\Delta t)$; $Y_i = Y_o + (t_i - t_o)\, Fv_y(\Delta t)$; $Z_i = Z_o + (t_i - t_o)\, Fv_z(\Delta t)$

Discussions

- The approach looks has a very simple algorithm. In fact it is not. Since the dynamic of the earth is not simple.
- However in close future demands from GI Systems will appear on similar approach
- GI Systems develop with a great acceleration everyday and sooner or later these systems will turn to artificial intelligence.
- Today, time in GIS has limited meaning, however we should design GIS to sense earth breathing. And today the only Geomatics Engineers and scientists benefit of precisely knowing the crustal movements of earth.

- Today we hardly discuss on achieving sub-cm accuracy of GPS. Consider Greece, Turkey, California and etc. moves 2 or more centimetres a year??? What do you think that how much LIS are affected???
- Therefore as Geomatics Engineers we should lead the other professions and introduce them with this existence value added dynamic geo-information for their professional profits and markets.
- For instance a summer house they plan will remain as summer house or will turn to a floating house or will turn to a winter house due to the see level changes or vertical movements of land within several 10 years of time.
- Therefore the benefits of using such dynamic geo-database supported systems is limited with a man imaginations.


Thank you for your attention…