MNISTRY OF HIGHER AND SECONDARY SPECIAL EDUCATION OF THE REPUBLIC OF UZBEKISTAN
NATIONAL UNIVERSITY OF UNIVERSITY

# GNSS based geodetic infrastructure in Uzbekistan

## (Coordinate Systems in Uzbekistan – Overview)

**Mirmakhmudov E, Safarov E., Abdullaev T.**



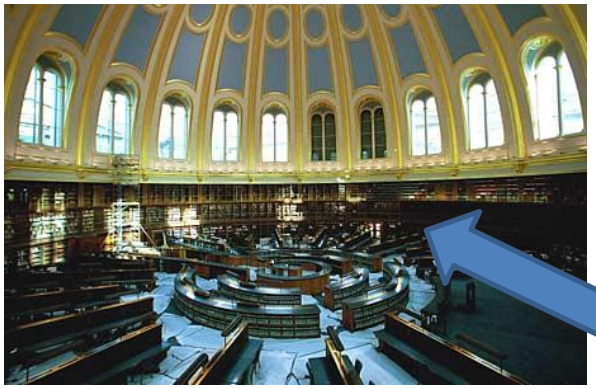
phone: (+998-71)234-67-54, (+998-90) 966-38-80 (cell.)
e-mail: erkin_mir@yahoo.com , erkin_mir@mail.ru

The 3rd *EUPOS*® Council and Technical Meeting ,
14-15 November 2016, Prague, CZECH REPUBLIC

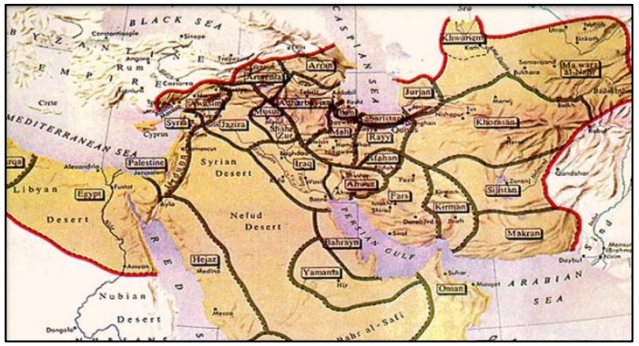
EUPOS
European Position Determination System

Capital: **Tashkent**
Area: **448 900 sq.km**
Population: more **32000000 people**
Density: **71.30 people/sq.km**


**Mapping and positioning of Central Asia were started by Abu Rykhan Beruny (973-1048) in XI century.**



The British Library




**The first map of Uzbekistan (1772)**

**Location:** The Royal Geographic Society(mr.Asis Div.464) and in the British Library( Maps, King Topographical Collection,114,53.4).

# Geodetic works in1860-1917

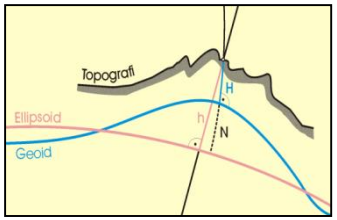
**The first classical geodetic works in Turkestan were produced from 1871-1895 .**

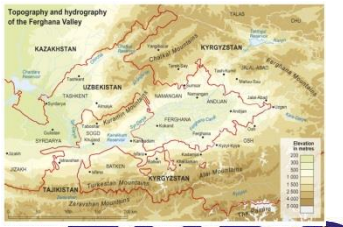

**Gedeonov D.D 1854-1908**

**From 1890 to 1900 Gedeonov D.D was the director of the Tashkent Observatory.**

**He worked out a new method of precise leveling (1884).**

**The longitude and latitude of Tashkent astronomical observatory**
**$\lambda$=-4$^h$37$^m$10.80$^s$ 1891**
**$\varphi$ =41$^0$ 19$^/$ 31$^{//}$.48 1895-1896**
**The first geoid for Ferghana valley was worked out in 1897 by prof. Pomeranzev**
**1847-1921**



# Tashkent coordinate system

Central Asian triangulation measurement were produced in Tashkent coordinate system (1875). This works are based on the Bessel –ellipsoid (1841), a=6 377 397m., α= 1/299.14

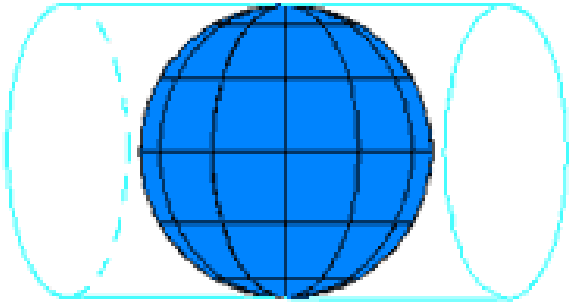
**The were measurement and calculated the longitude for 900 points (rms= ± $0^s.25$).**

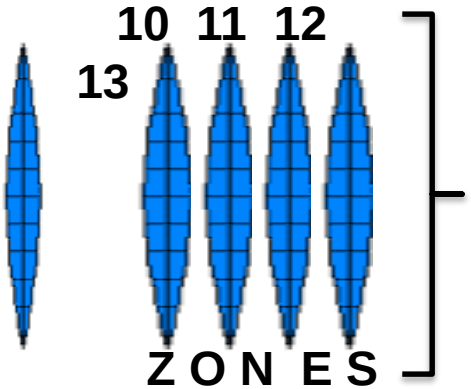

**In 1950 about 50% of the European triangulation networks and about 20% of other continents networks (also Russia and Uzbekistan ) were based on the Bessel ellipsoid.**

$\lambda = -4^h37^m10.80^s$ 1891

$\varphi = 41^0\ 19'\ 31''.48$ 1895-1896

# THE GAUSS-KRUGER PROJECTION






**Gauss K F**
(1777 – 1855)

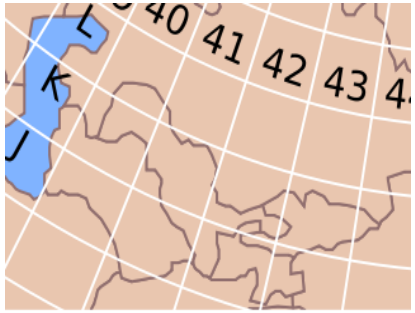
J. Krüger

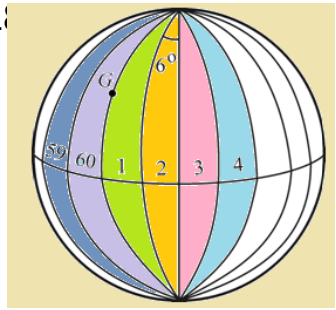
**UZBEKISTAN**

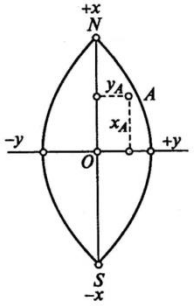
$$x = S + \frac{l^2}{2} r\ SinB + \frac{l^4}{24} r\ Cos^2 B\ SinB(5 - t^2 + 9\eta^2 + 4\eta^4);$$

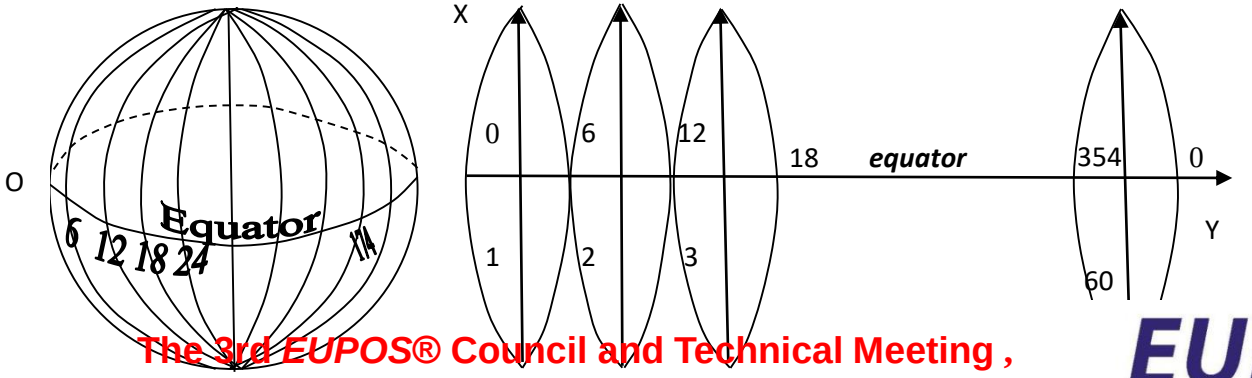
$$y = lr + \frac{l^3}{6} r\ Cos^2 B(1 - t^2 + \eta^2) + \frac{l^5}{120} r\ Cos^4 B(5 - 18t^2 + t^4 - 14\eta^2 - 58\eta^2 t^2);$$

$$m = n = 1 + 0{,}000152 l^2 Cos^2 B; \quad p = m^2; \quad w = 0; \quad t = tgB; \quad \eta^2 = e'^2 Cos^2 B,$$

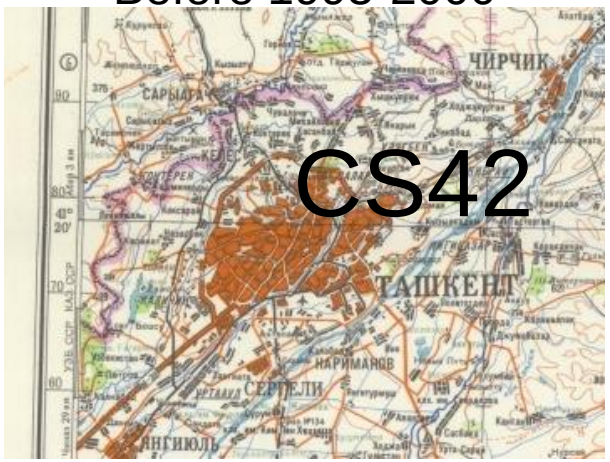


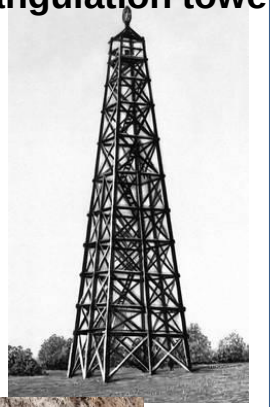



## Before 1995-2000



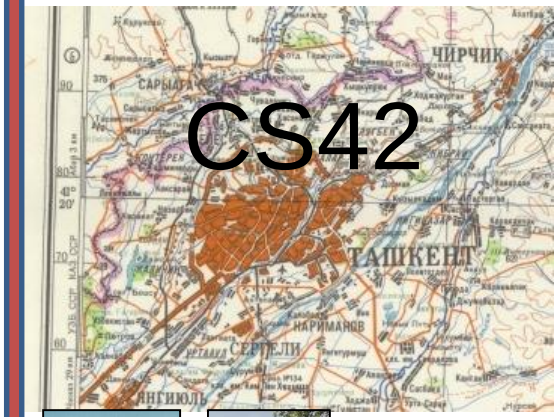

Triangulation towe






BENCH MARK

## Now



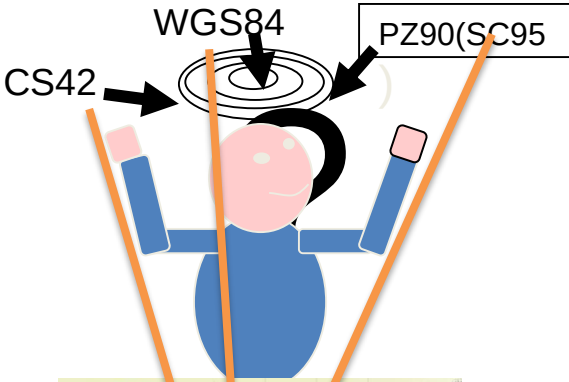








## In the future





# WHAT IS PROBLEMS???

1. RECONNAISSANCE OF GEODETIC POINTS
2. RENEVATION OF A TRIANGULATION TOWER
3. IMPROVING OF THE TOPOGRAPHIC SHEET MAPS
4. CREATING OF LOCAL GEOID
5. WORK OUT OF UZBEKISTAN DATUM
6. DEVELOPMENT OF TRANSFORMATION COORDINATES
7. DIGITAL MAPS FOR UZBEKISTAN
8. ADJUSTMENT
9. SOFTWEARE

# RECONNAISSANCE OF GEODETIC POINTS







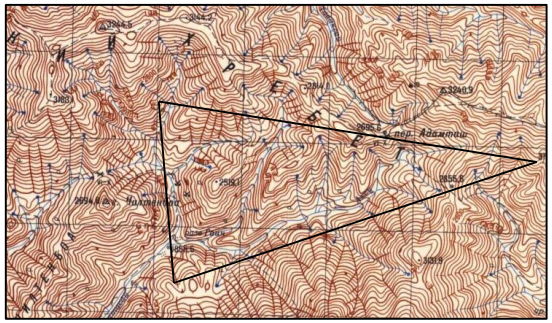


MNISTRY OF HIGHER AND SECONDARY SPECIAL EDUCATION OF THE REPUBLIC OF UZBEKISTAN

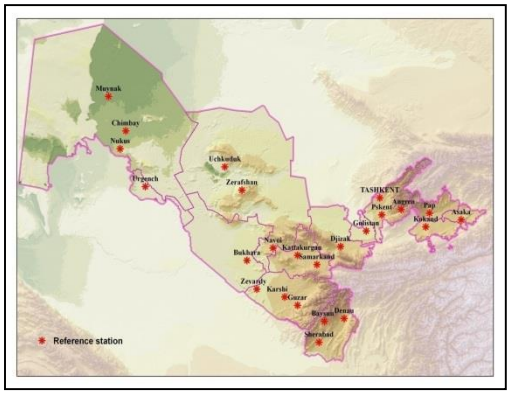
NATIONAL UNIVERSITY OF UZBEKISTAN

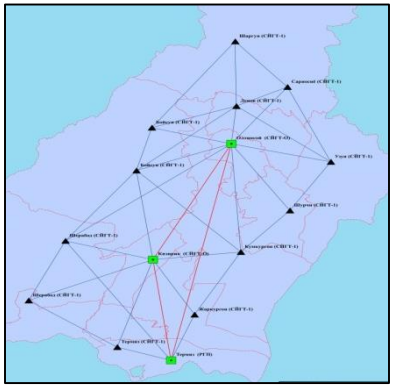
**State Committee of the Republic of Uzbekistan on Land Resources, Geodesy, Cartography and State Cadastre**

## STATE GEODETIC NETWORK

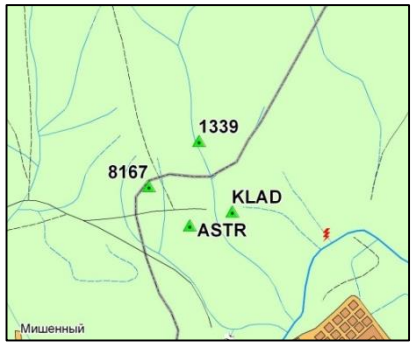


## STATE SATELLITE GEODETIC NETWORK



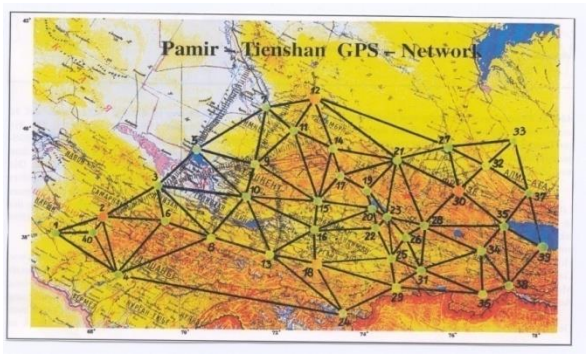



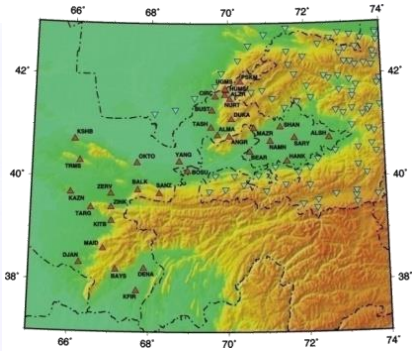
## SEISMOLOGY NETWORK

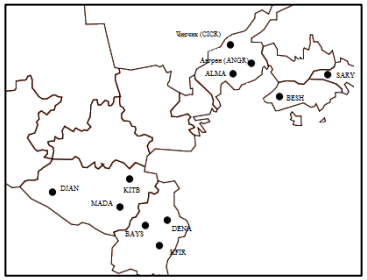



## CENTRAL ASIAN TECTONIC SCIENCE network

**Tadjikistan Kazakhstan Kyrgistan Uzbekistan China**



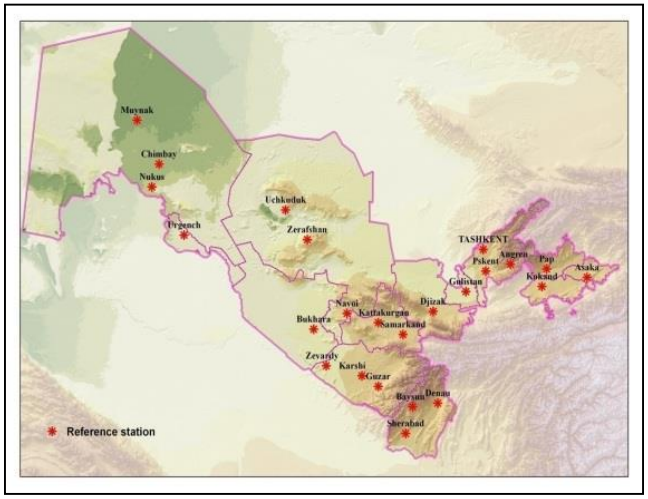





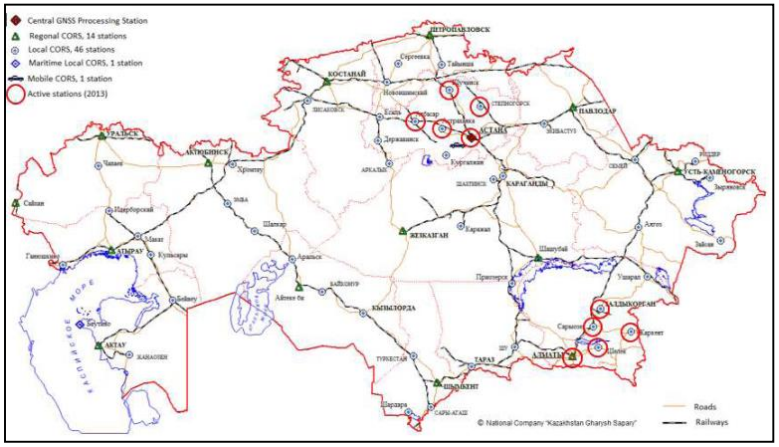
MNISTRY OF HIGHER AND SECONDARY SPECIAL EDUCATION OF THE REPUBLIC OF UZBEKISTAN
NATIONAL UNIVERSITY OF UZBEKISTAN

# STATE SATELLITE GEODETIC NETWORK OF CENTRAL ASIA

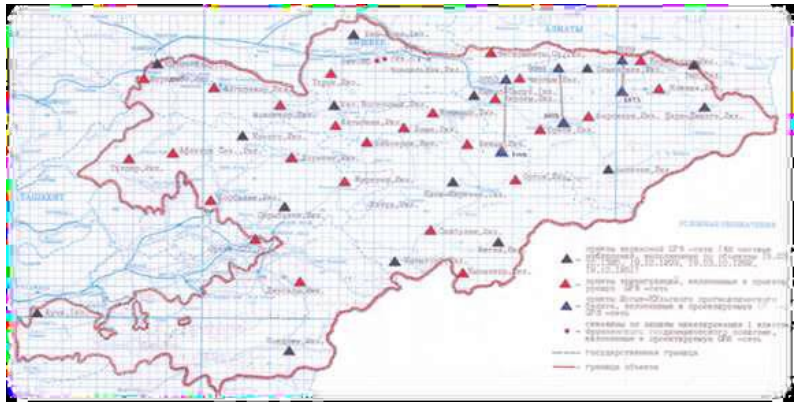
## UZBEKISTAN



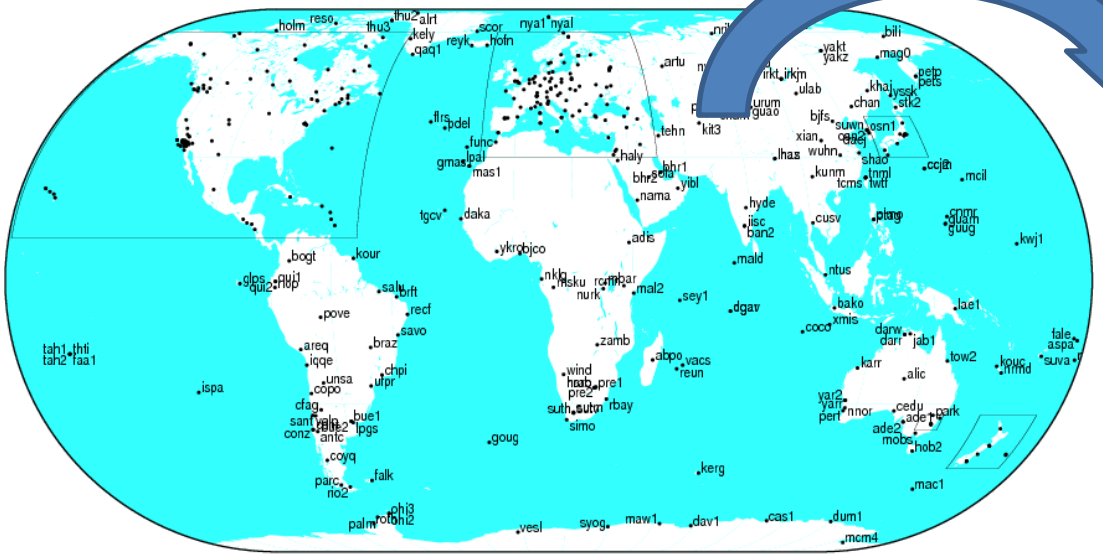

## The National GNSS Network of Kazakhstan




## The ITRF based Kyrgyz State Geodetic Network (SGCS KR)



## IGS Network

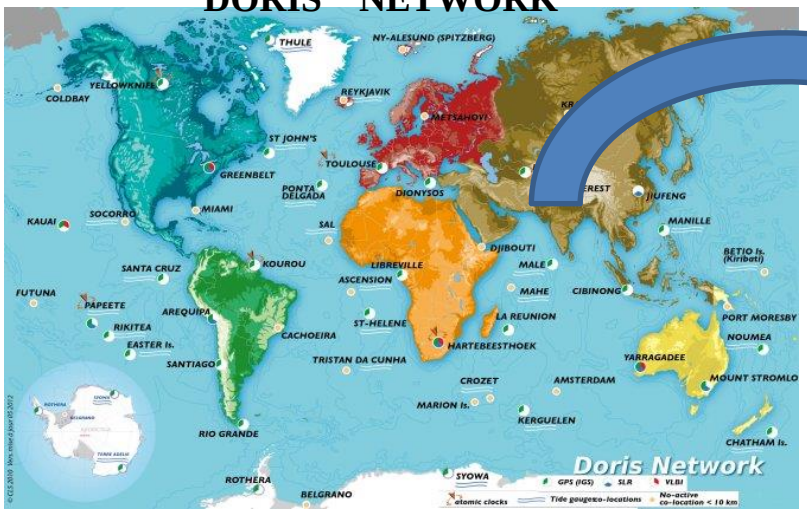


GPS, KIT3, KITAB, UZBEKISTAN

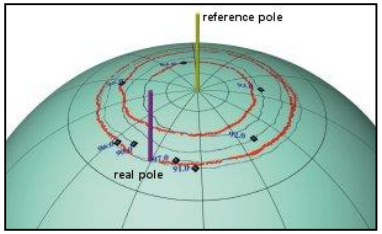
CHAMP, Tashkent

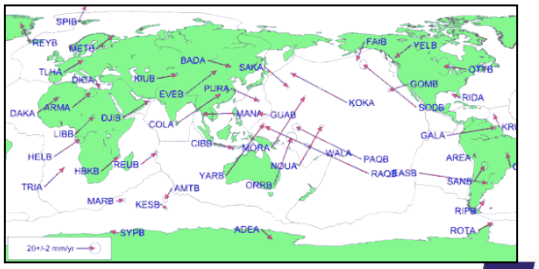
$\varphi = 39° 07' 59''$, $\lambda = 66^0 52' 57.0''$, H=657м.

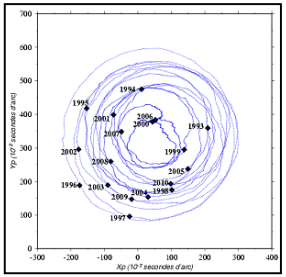
## DORIS NETWORK




DORIS, KITAB,UZBEKISTAN





# GNSS

## EDUCATION

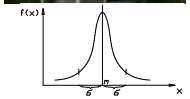
**NUU,TABI,TIMI**





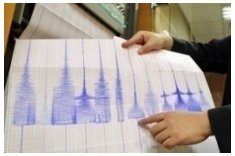

## SCIENCES INVESTIGATION

**AI, SI**

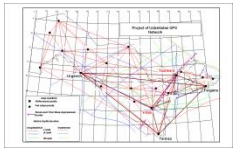
$$D = \sigma^2$$

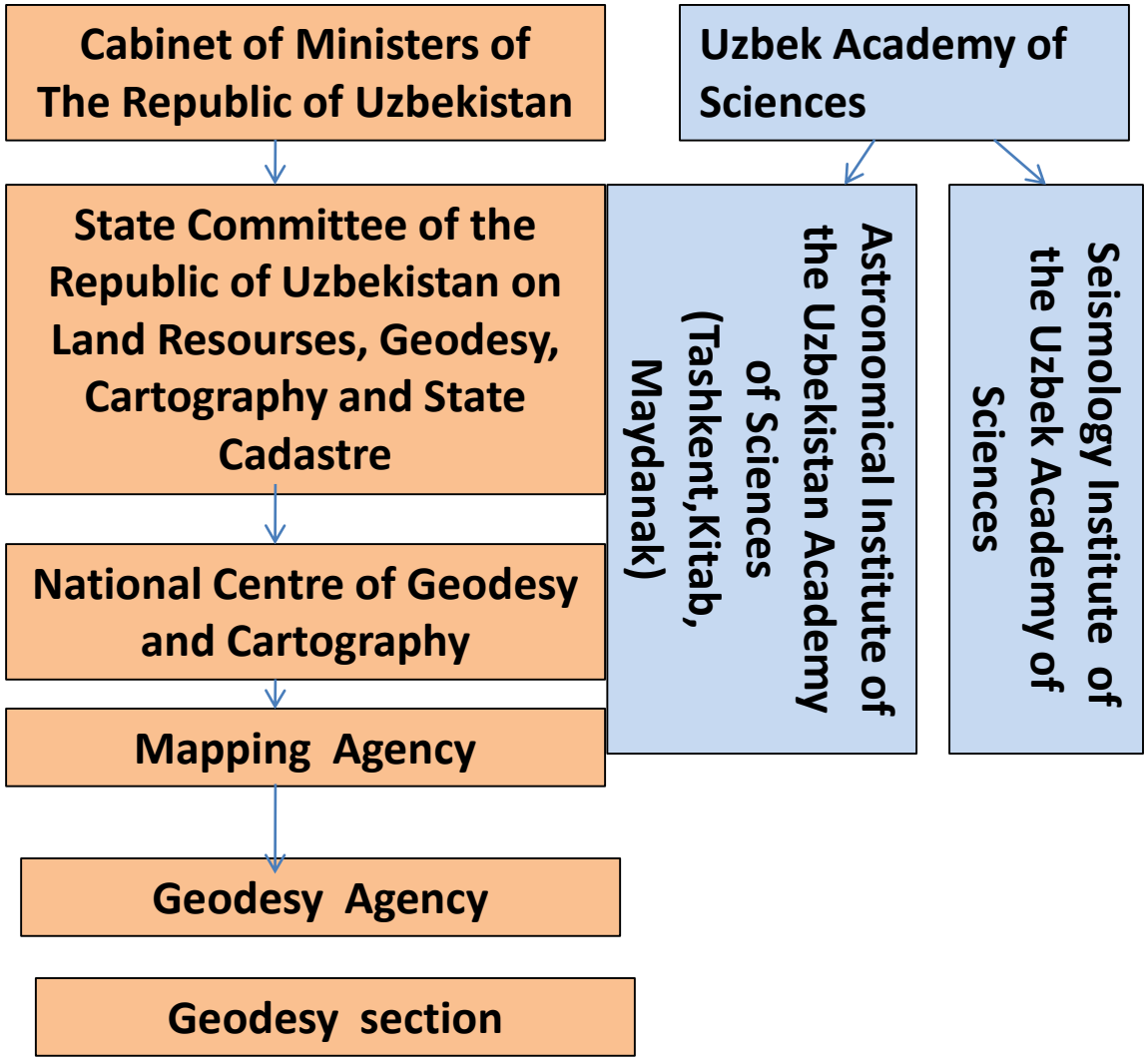
$$\sigma^2 = \frac{\sum (X_i - \bar{X})^2}{n}$$

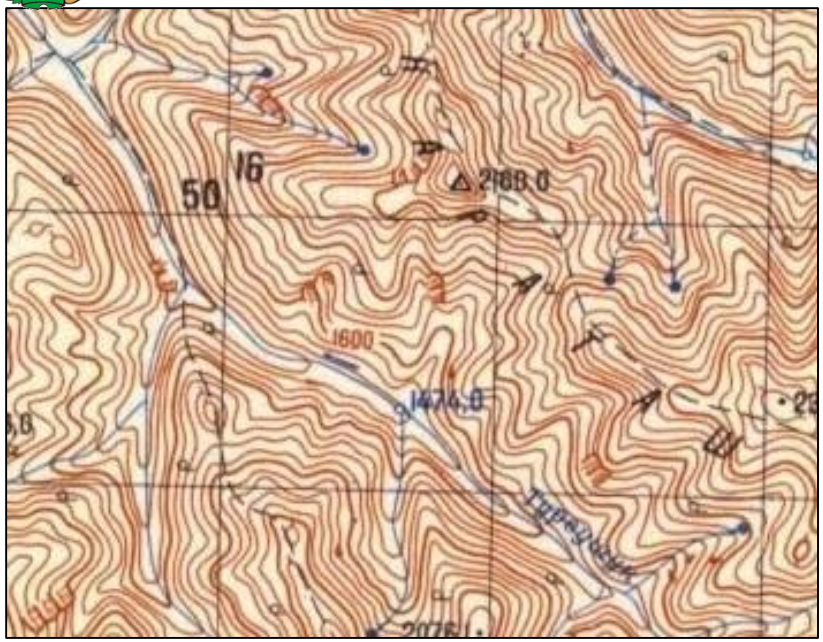


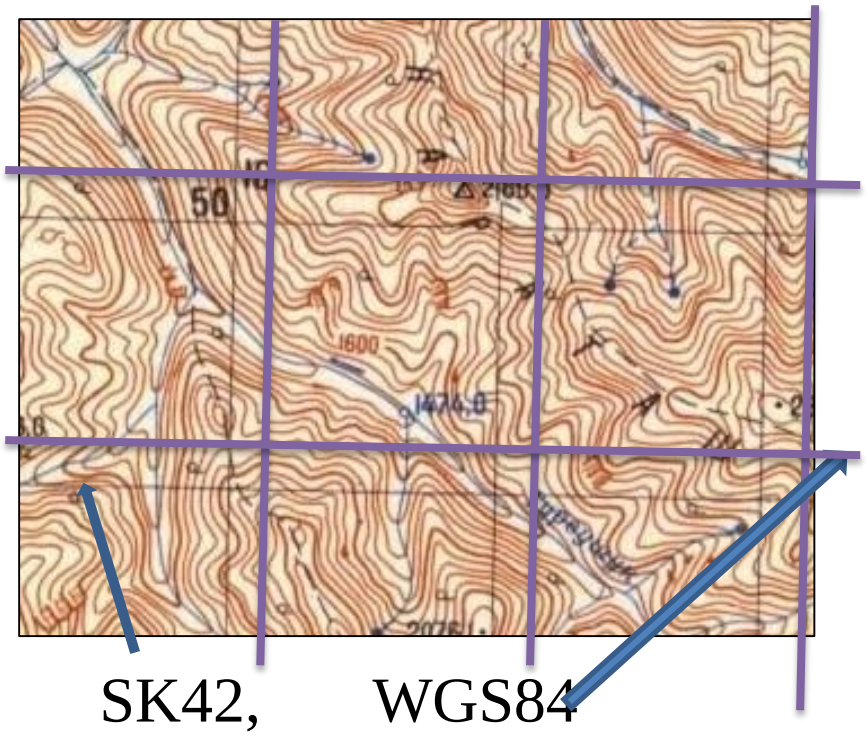
## APPLICATION

**NCGC,UZGASHLITI**



Cabinet of Ministers of The Republic of Uzbekistan
State Committee of the Republic of Uzbekistan on Land Resourses, Geodesy, Cartography and State Cadastre
National Centre of Geodesy and Cartography
Mapping Agency
Geodesy Agency
Geodesy section
Uzbek Academy of Sciences
Astronomical Institute of the Uzbekistan Academy of Sciences (Tashkent,Kitab, Maydanak)
Seismology Institute of the Uzbek Academy of Sciences
Ministry of High Education
NUU,TACI,TIMI
Department of geodesy and cartography





SK42, WGS84

SK42(Pulkovo)

$B_0=\varphi_0-\xi_0$
$L_0=\lambda_0-\eta_0 \sec B_0$
$A_0=\alpha_0-\eta_0 \operatorname{tg} B_0$

$y_{wgs84}-y_{sk42}$=64m. , $L_{wgs84}-L_{sk42}$ = 2.90 arcsec
$x_{wgs84}-x_{sk42}$=9m. , $B_{wgs84}-B_{sk42}$ = 0.23 arcsec
$h_{wgs84}-h_{sk42}$=37m

| Scale | $\Delta X_{wgs84-sk42}$ | $\Delta Y_{wgs84-sk42}$ | |
|---|---|---|---|
| 1:100 000 | 0.09mm | 0.64mm | |
| 1:50 000 | 0.18mm | 1.28mm | |
| 1:25 000 | 0.30mm | 2.56mm | |
| 1:10 000 | 0.9mm | 6.40mm | |
| 1:5 000 | 1.8mm | 12.8mm | |

*Three points with the same latitude and longitude in three different coordinate systems.* **WGS84, CS42, CS32**

# Transformation of coordinate system

$$x = (N+H)\cos B \cos L$$
$$y = (N+H)\cos B \sin L$$
$$z = (N(1-e^2)+H)\sin B$$

**B, L,H,** WGS84

X,Y,Z (WGS84)

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{84} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{42} + \begin{bmatrix} T_X \\ T_Y \\ T_Z \end{bmatrix} + \begin{bmatrix} \mu & \omega_Z & -\omega_Y \\ -\omega_Z & \mu & \omega_X \\ \omega_Y & -\omega_X & \mu \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{42}$$

X,Y,Z (CS42)

$$L = arctg\frac{Y}{X} \qquad B^{(i)} = \arctan\frac{Z + N^{(i-1)}e^2 \sin B^{(i-1)}}{r_p}$$

$$H = \sqrt{X^2 + Y^2} \times \sec B - N$$

**B, L,H,** CS-42

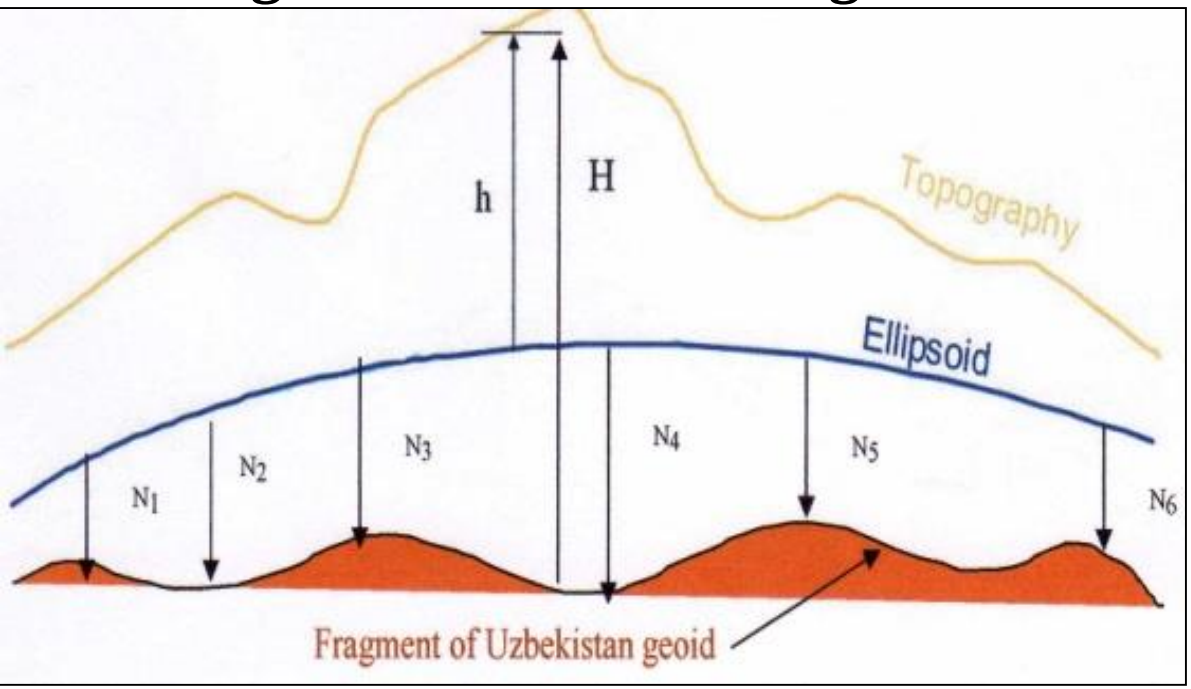
$$x = S + \frac{l^2}{2} r\, SinB + \frac{l^4}{24} r\, Cos^2 B\, SinB(5 - t^2 + 9\eta^2 + 4\eta^4);$$
$$y = lr + \frac{l^3}{6} r\, Cos^2 B(1 - t^2 + \eta^2) + \frac{l^5}{120} r\, Cos^4 B(5 - 18t^2 + t^4 - 14\eta^2 - 58\eta^2 t^2);$$
$$m = n = 1 + 0{,}000152 l^2 Cos^2 B; \quad p = m^2; \quad w = 0; \quad t = tgB; \quad \eta^2 = e'^2 Cos^2 B,$$

x,y(CS42)
G-K projection

$$y_{wgs84} = y_{sk42} + \Delta y$$
$$x_{wgs84} = x_{sk42} + \Delta x$$

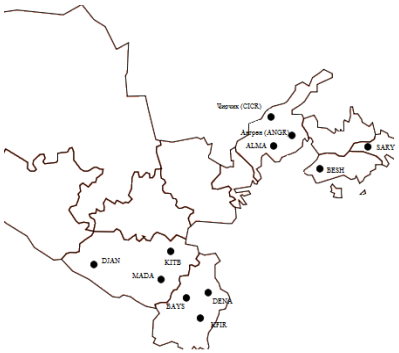
Intermediate
G-K projection

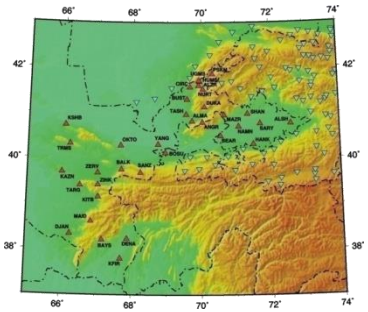
# Fragment of Uzbekistan geoid



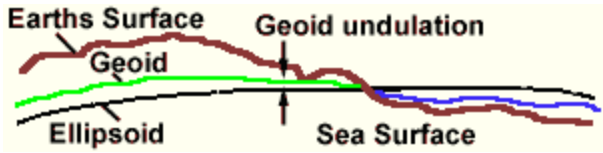

CATS network (Uzbekistan)(1992-1996)

| №ст | N,м |
|---|---|
| 1 | -37.73 |
| 2 | -36.71 |
| 3 | -40.14 |
| 4 | -41.37 |
| 6 | -36.96 |
| 9 | -41.60 |
| 10 | -42.90 |
| 16 | -50.97 |
| 40 | -35.64 |
| 54 | -40.41 |
| 55 | -42.86 |
| 56 | -46.79 |
| 58 | -37.90 |
| ) | -43.85 |
| ) | -43.16 |

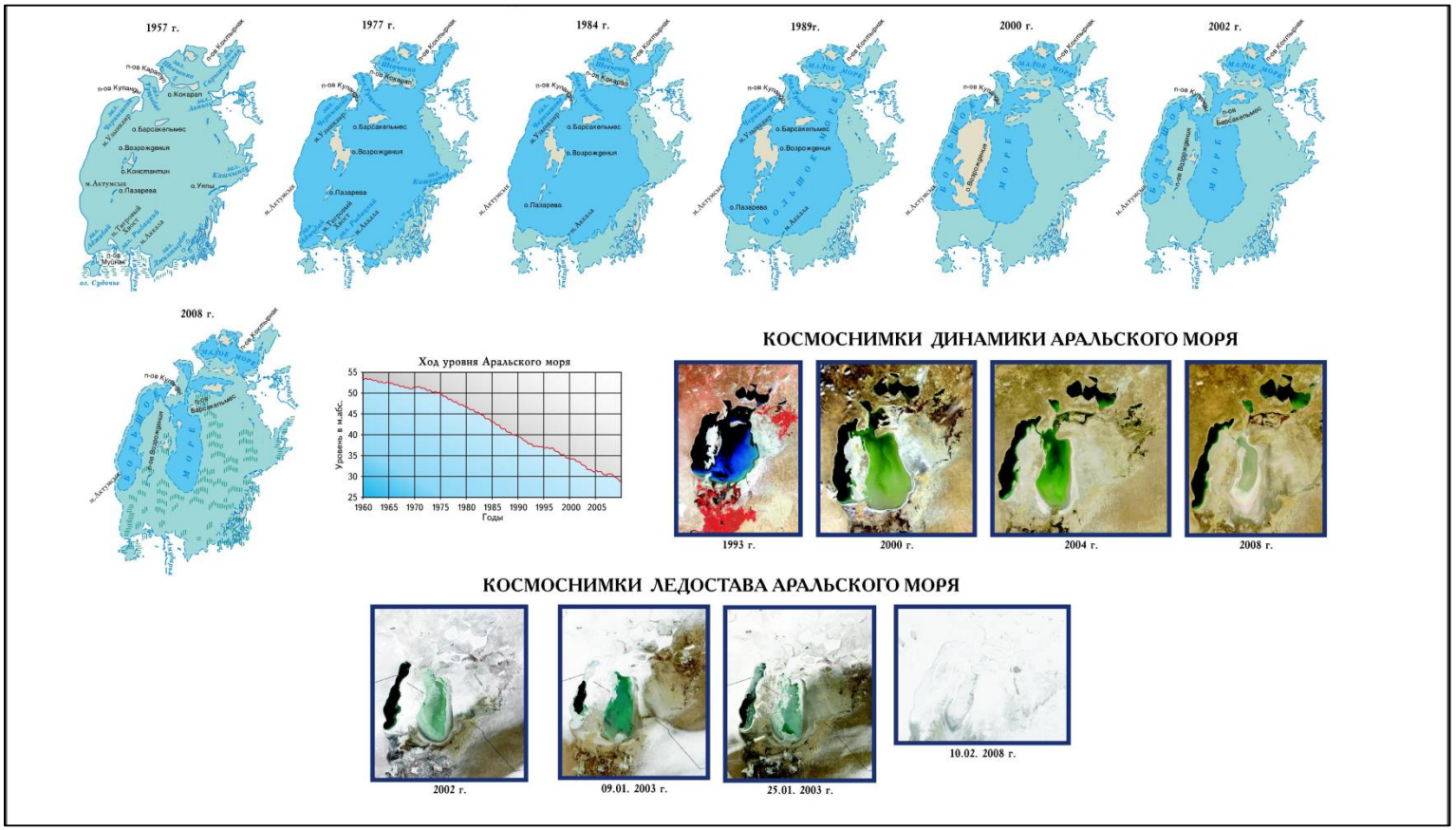


$$N = \frac{GM}{\rho\gamma_0}\left[1+\sum_{n=2}^{\infty}\sum_{m=0}^{n}\left(\frac{a}{\rho}\right)^n P_{nm}(\sin\varphi_r)\times(C_{nm}\cos m\lambda_r + S_{nm}\sin m\lambda_r)\right].$$



# ARAL SEA


1957 г.
1977 г.
1984 г.
1989г.
2000 г.
2002 г.
2008 г.
Ход уровня Аральского моря
Уровень в м.абс.
Годы
КОСМОСНИМКИ ДИНАМИКИ АРАЛЬСКОГО МОРЯ
1993 г.
2000 г.
2004 г.
2008 г.
КОСМОСНИМКИ ЛЕДОСТАВА АРАЛЬСКОГО МОРЯ
2002 г.
09.01. 2003 г.
25.01. 2003 г.
10.02. 2008 г.

# REFERENCE FRAME

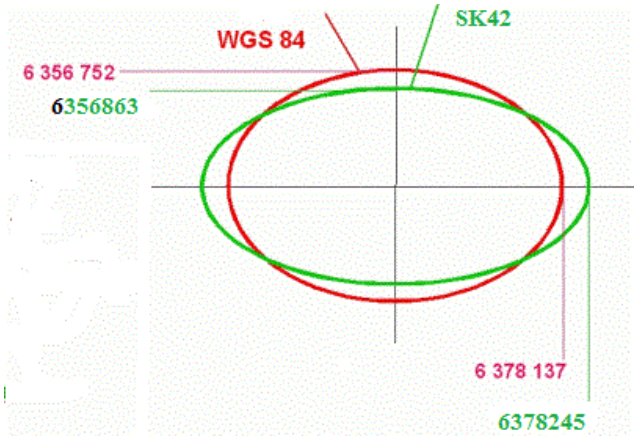
**NATIONAL**

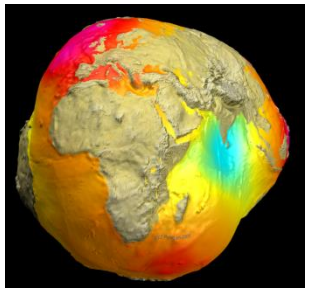

**LOCAL(1+2 regions)**

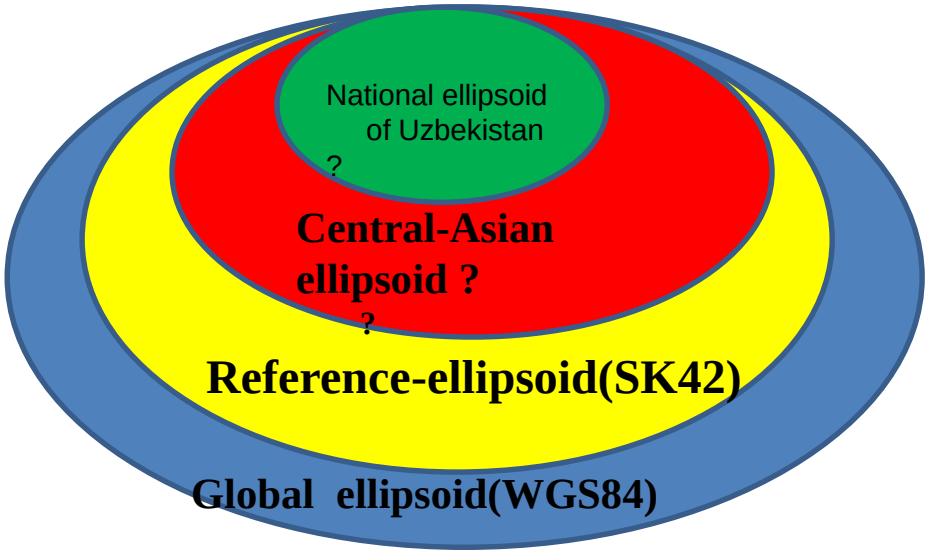

**region**



# UZBEKISTAN

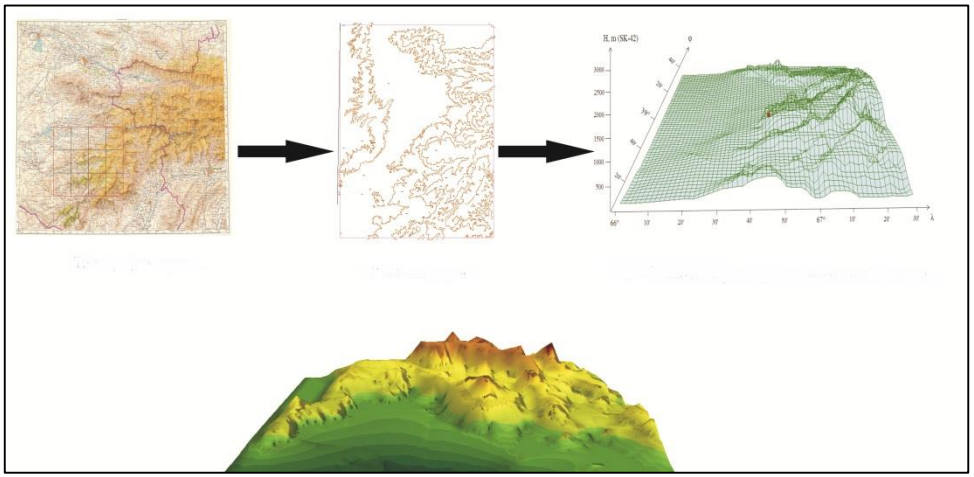

WGS 84
SK42
6 356 752
6356863
6 378 137
6378245

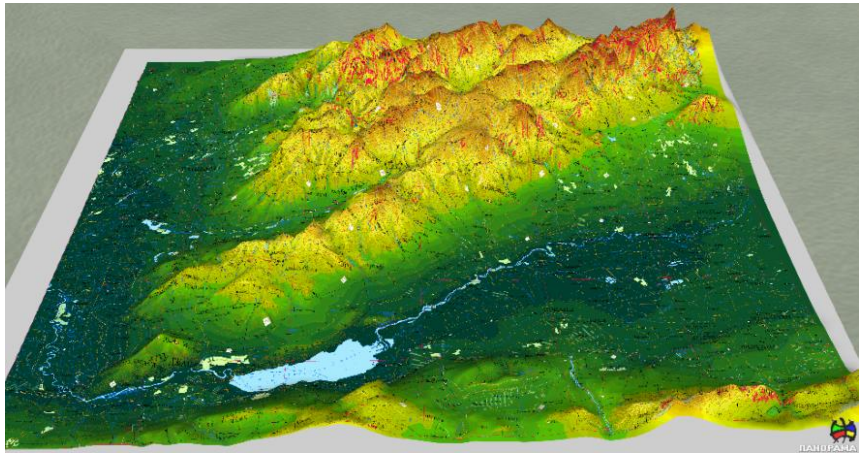


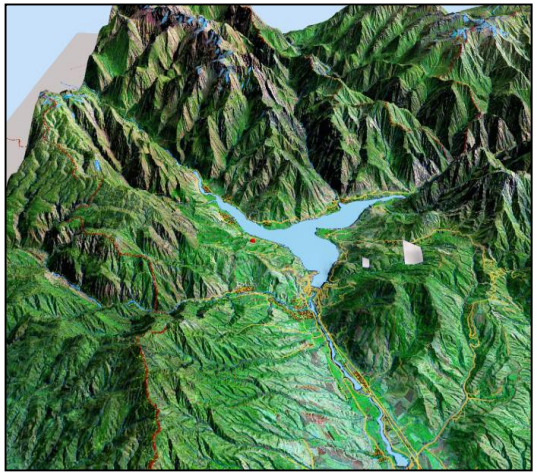

National ellipsoid of Uzbekistan
?
Central-Asian ellipsoid ?
?
Reference-ellipsoid(SK42)
Global ellipsoid(WGS84)

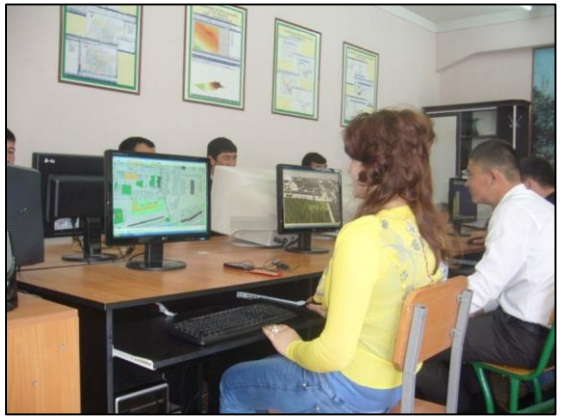

RUSSIA
MONGOLIA
Astana
KAZAKHSTAN
Aral Sea
Caspian Sea
UZBEKISTAN
Bishkek
Almaty
Tashkent
KYRGYZSTAN
CHINA
TURKMENISTAN
Ashgabat
TADJIKISTAN
Dushanbe
IRAN
PAKISTAN
AFGHANISTAN

# GIS Panorama









# References


1. Sheglov, V. P.100 Anniversary of the Astronomical Institute of the Uzbek Academy of Sciencies .Tashkent.Fan.1974.
2. Reigber, Ch, Angermann, D., Michel, G. W. Klotz, J., Galas, R., & the CATS-Team, GPS constraints on the distribution of deformation of the Tien Shan, N-Pamirs and behavior of the Tarim, 14th Himalaya-Karakorum-Tibet Workshop, Terra Nostra, 127,1999.
3. Moritz, H. (2000): Geodetic Reference System 1980. J. Geod. 74: 128–133.
4. Gunter Seeber . Satellite Geodesy. 2nd completely revised and extended edition. New York 2003.
5. Fazilova D., Mirmakhmudov E. WGS-84 and SC-42: current realizations of geodetic network of Uzbekistan and transformation parameters. Proceeding of c ce.2002.
6. Mirmakhmudov E., Safarov E. Improvement eight for maps of Uzbekistan based on of GPS data. Abstract. United Nations/United Arab States of America Workshop on the Applications of Global Navigation Satellite Systems, Dubai, 1 11.
7. Mirmakhmudov E., Safarov E. Fazilova D. Modification of vertical reference frame. Abstract. United Nations/Riga /United States of America Workshop on the Applications of Global Navigation Satellite System, Latvia, Riga, 14 –18 May 2012.
8. Mirmakhmudov E., Safarov E., Fazilova D. and Fan H. (2013). Determination oftransformation parameters between CS42 and WGS84 for Uzbekistan territory.UN/Croatia Workshop on the Global Navigation Satellite Systems, April 21-25, 2013,Baska Krk Island.
9. Mirmakhmudov E., Fazilova D. Converting between CS42 and WGS84. New Technologies and Education. Tashkent-2013. P.89-104.
10. Akylbek CHYMYROV. GNSS application trends in Central Asia. Megfelelni az új kihívásoknak * GISopen konferencia.2014.