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

Modification of the reference frame of Uzbekistan topographic maps based on the GNSS

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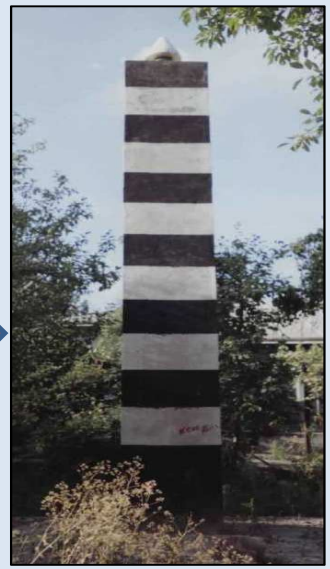
CONTENT

1. Classical mapping
2. Coordinate systems
3. Improvement of state geodetic network
4. GNSS network
5. GNSS education
6. Transformation of coordinate system
7. Determining Elevations with GPS

What is modification of the reference frame???

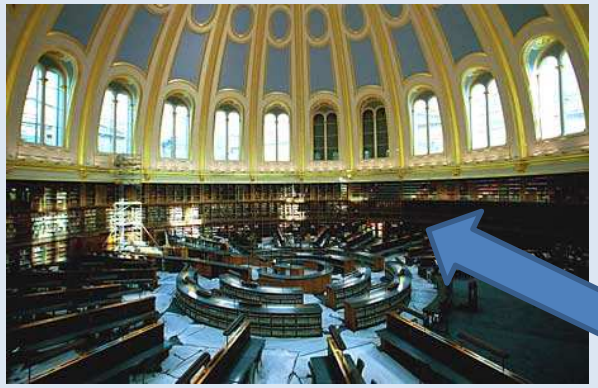
1. Renovation the state geodetic network.
2. Update the state vertical network.
3. Establishment national GNSS reference station.
4. Establishment a national GNSS geodetic control network.
5. Establishment a three-dimensional geodetic datum with high precision.



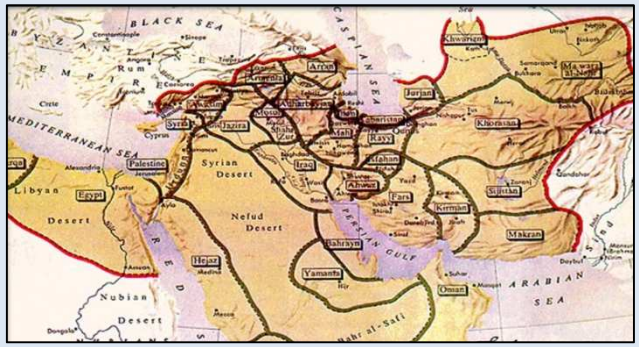

Capital: **Tashkent**
Area: **448 900 sq.km** Population:
more **32000000 people**
Density: **71.29 people/sq.km**
QOZOG'ISTON
O'ZBEKISTON
Nukus
Uchquduq
Urganch
QIRG'IZISTON
Namangan
Angren
Andijon
TOSHKENT
Marg'ilon
Quqon
Farg'ona
Bekobod
G'ijduvon
Navoiy
Guliston
TURKMANISTON
Buxoro
Kattaqo'rg'on
Samarqand
Guzar
Denov
Termiz
АНГРЕН-ПОП
2016

History

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)

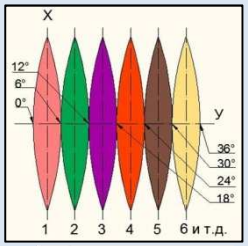
Location: The Royal Geographic Society(mr.Asis Div.464) and in the British Library(Maps, King Topographical Collection,114,53.4).

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

Tashkent coordinate system

λ=-4h37m10.80s 1891

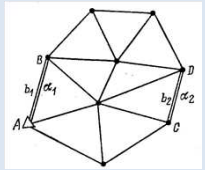
φ =41⁰ 19/ 31//.48 1895-1896



COORDINATE SYSTEM CS-32

Origin: Sablino, Russia.1930.

Reference ellipsoid-Bessel



Coordinate system CS-42

Origin: Bugry, Soviet Union.

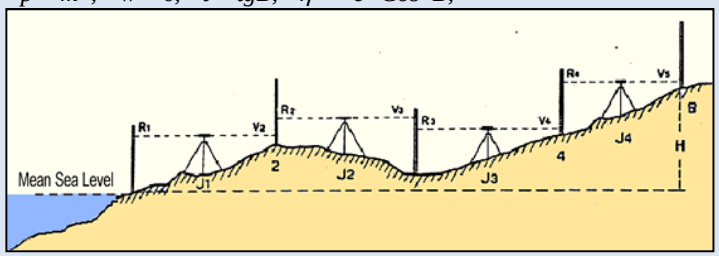
Reference ellipsoid-Krasovsky

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

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

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

Kronstadt sea-gauge



WHY DO WE HAVE TO IMPROVE GEODETIC NETWORK???

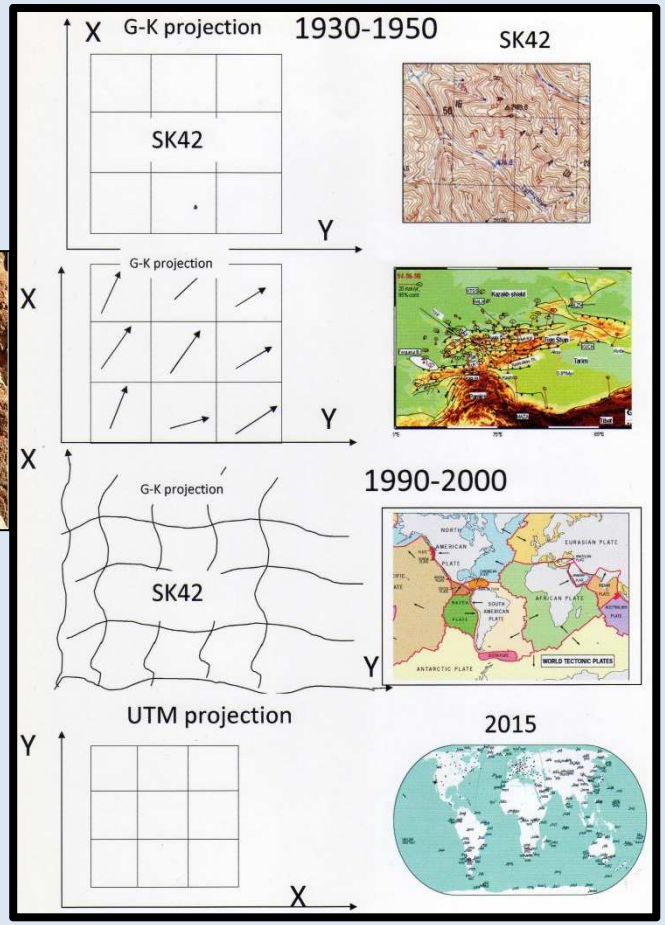
Geodetic signal and benchmark







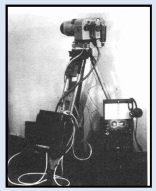
Map projection



Topographic maps store

Geodetic tools






WAYS OF IMPROVEMENT OF STATE GEODETIC NETWORK

RECONNAISSANCE OF GEODETIC POINTS







WAYS OF IMPROVEMENT OF STATE GEODETIC NETWORK

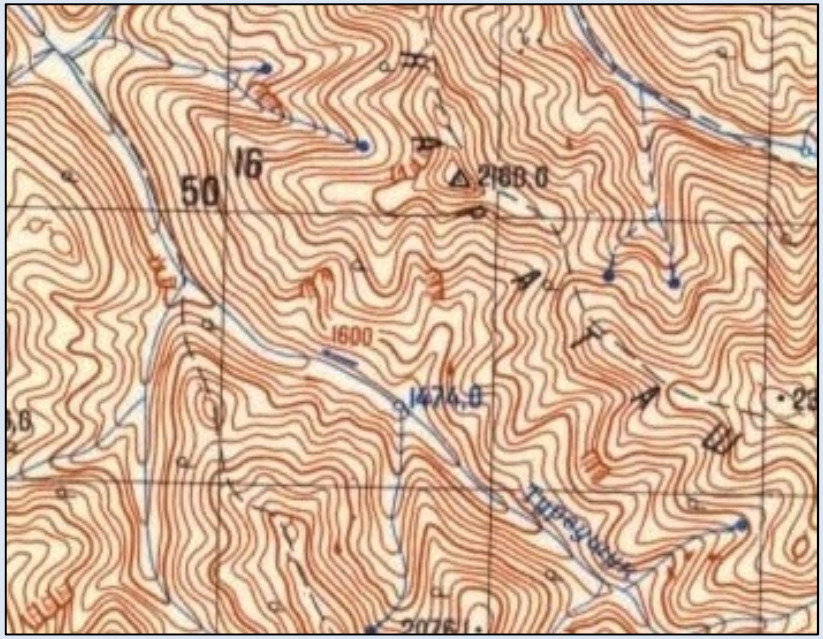
RENOVATION OF A TRIANGULATION TOWER .

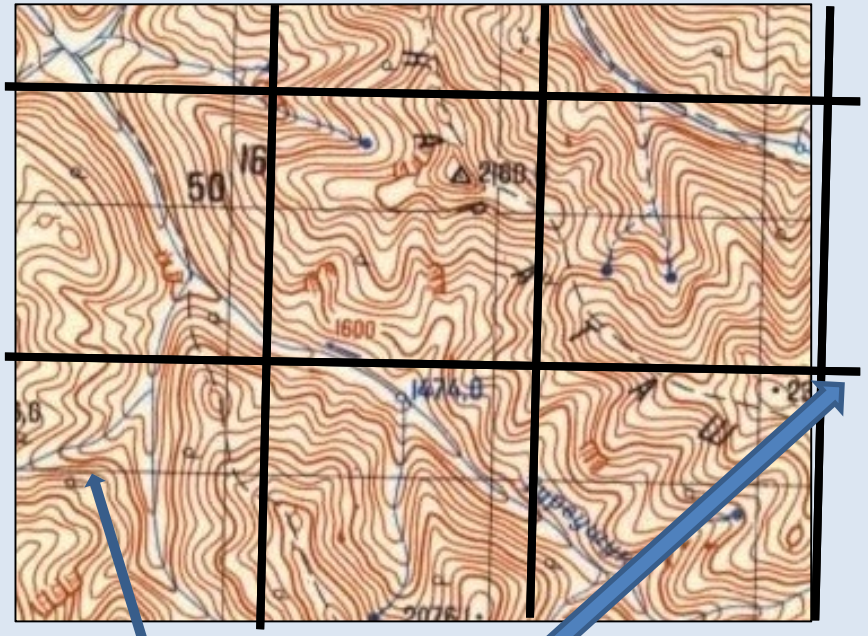





WAYS OF IMPROVEMENT OF STATE GEODETIC NETWORK

Modification of Gauss-Kruger projection (cylindrical projection)





SK42(Pulkovo) SK42, WGS84

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

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	

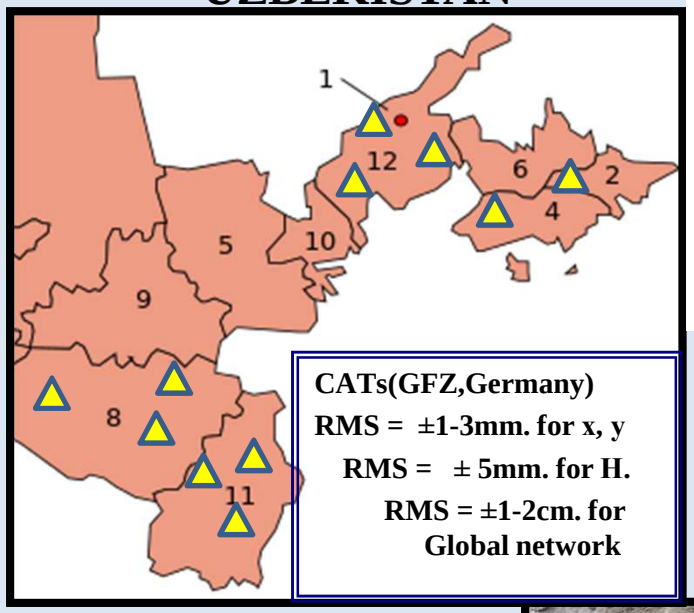
$y_{wgs84}-y_{sk42}$=64m. , $L_{wgs84}-L_{sk42}$ = 2.90 arcsec
$x_{wgs84}-x_{sk42}$=9m. , $B_{wgs84}-B_{sk42}$ = 0.23 arcsec

$h_{wgs84}-h_{sk42}$=37m

WAYS OF IMPROVEMENT OF STATE GEODETIC NETWORK

Central Asian Tectonic Science network in Uzbekistan(CATS), GFZ, Potsdam, Germany(1992-1996)

UZBEKISTAN



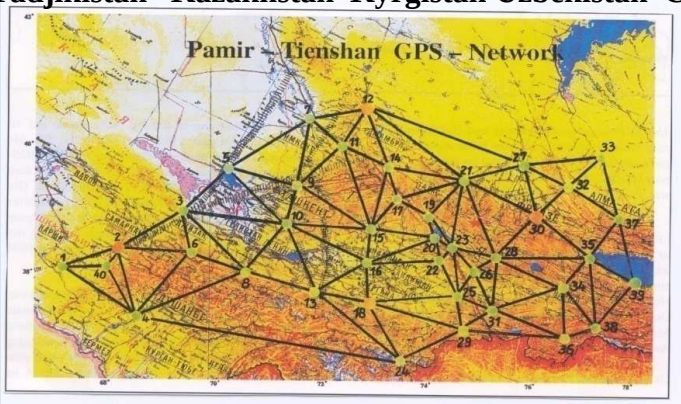
CATs(GFZ,Germany)
RMS = ±1-3mm. for x, y
RMS = ± 5mm. for H.
RMS = ±1-2cm. for Global network

GFZ Helmholtz-Zentrum POTSDAM

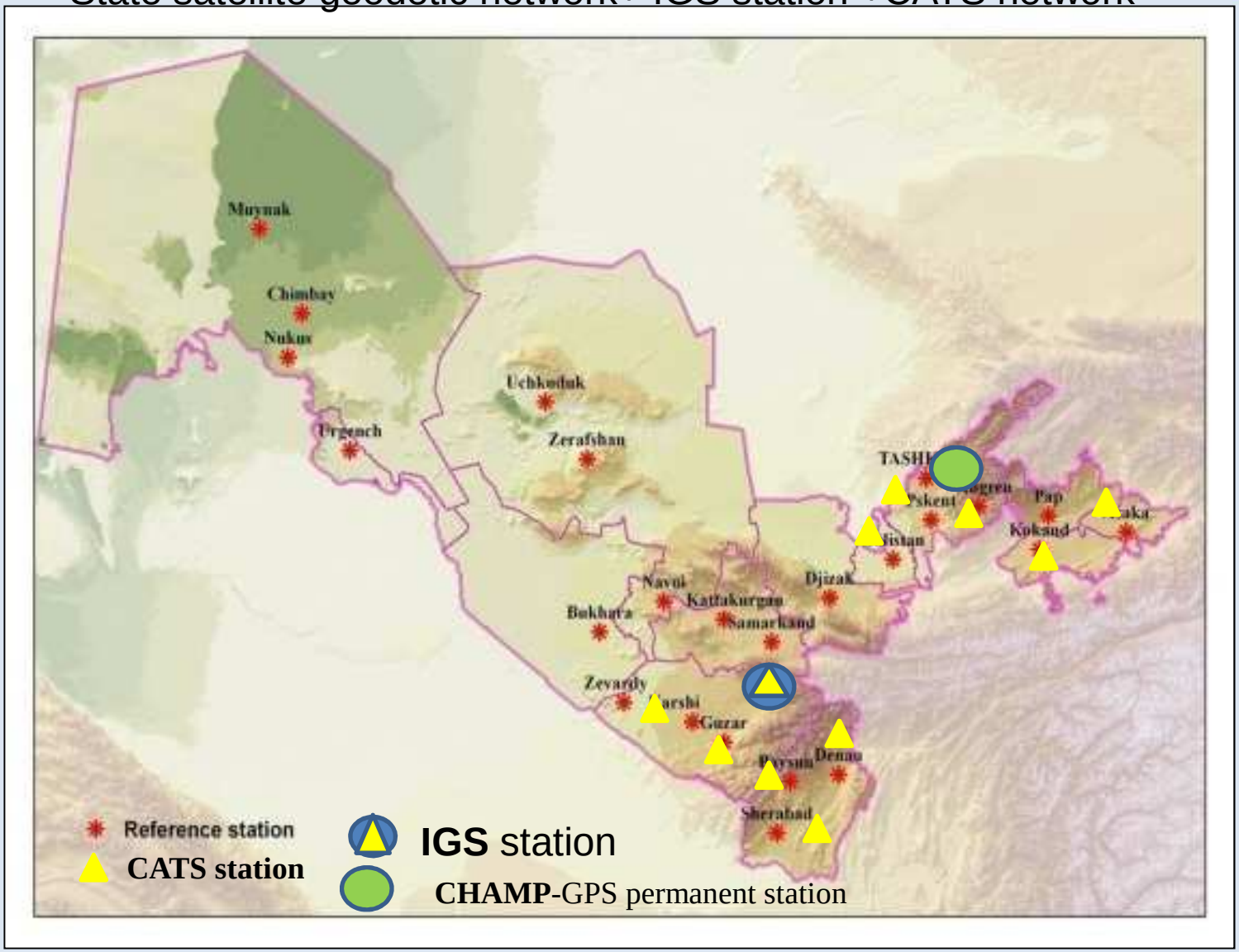
Department of Geodesy and Remote Sensing

№ст		B_{wgs84}	L_{wgs84}	H,м
1	DJAN	38°20′16″.1	66°06′21″.7	790.5
2	KITB	39°08′05″.2	66°53′07″.6	622.6
3	OKTO	40°17′25″.7	67°40′11″.3	334.5
4	DENA	38°14′06″.7	67°52′48″.8	477.5
6	SANZ	39°41′37″.7	68°14′46″.1	1942.5
9	CICR	41°34′20″.8	69°39′39″.0	771.2
10	ALMA	40°49′42″.9	69°43′49″.0	737.9
16	SARY	40°46′25″.2	71°42′02″.3	351.0
40	MADA	38°41′04″.1	66°56′29″.3	2690.7
54	ANGR	41°06′07″.7	70°04′53″.7	1307.3
55	ADRA	40°48′01″.3	70°01′21″.6	1556.0
56	BESH	40°21′24″.0	70°31′25″.2	421.7
58	BAYS	38°10′31″.0	67°02′45″.6	1061.3
59	KFIR	37°50′17″.3	67°52′05″.5	590.9
79	BOZB	41°28′44″.6	71°47′07″.9	1758.7

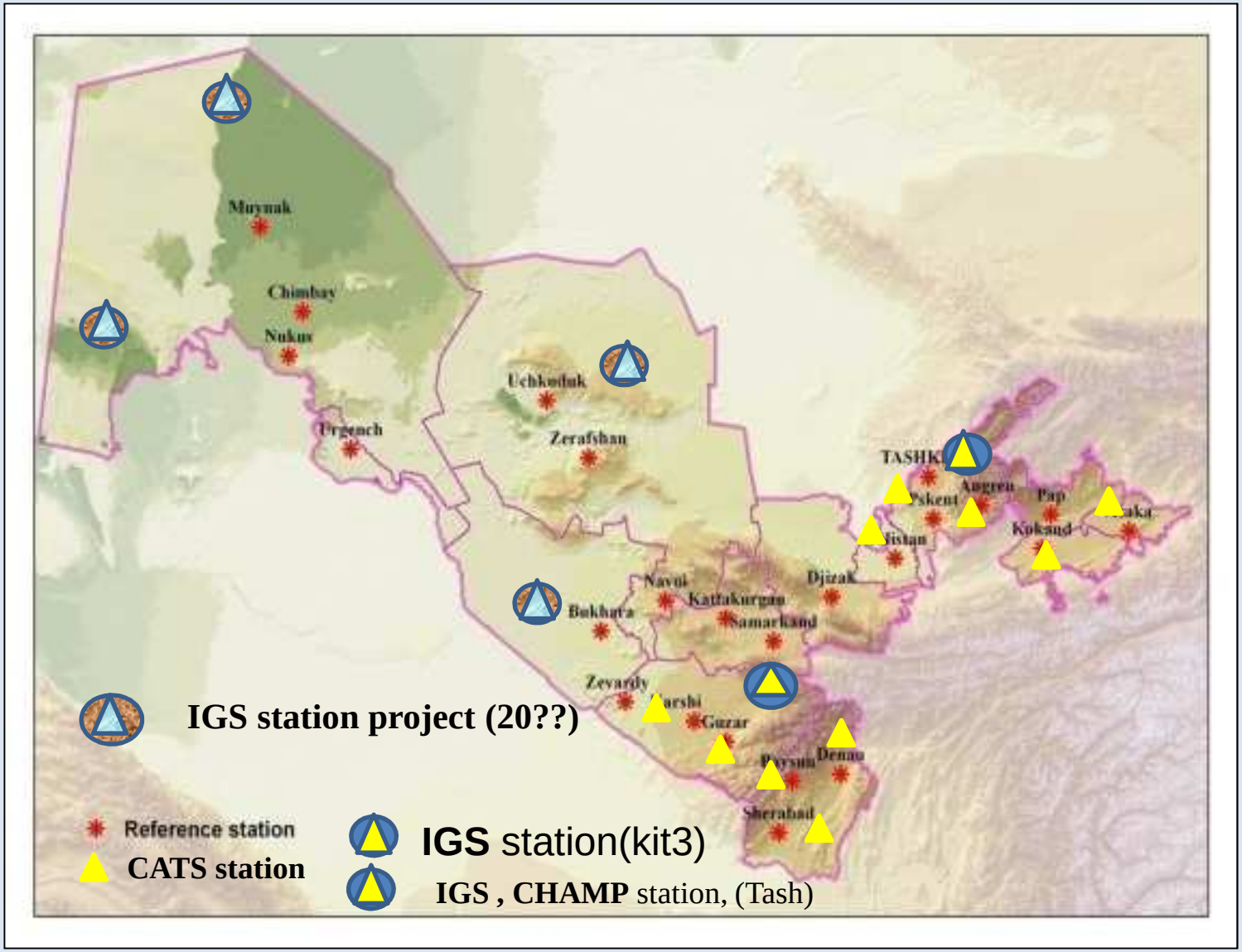
Tadjikistan Kazakhstan Kyrgistan Uzbekistan China



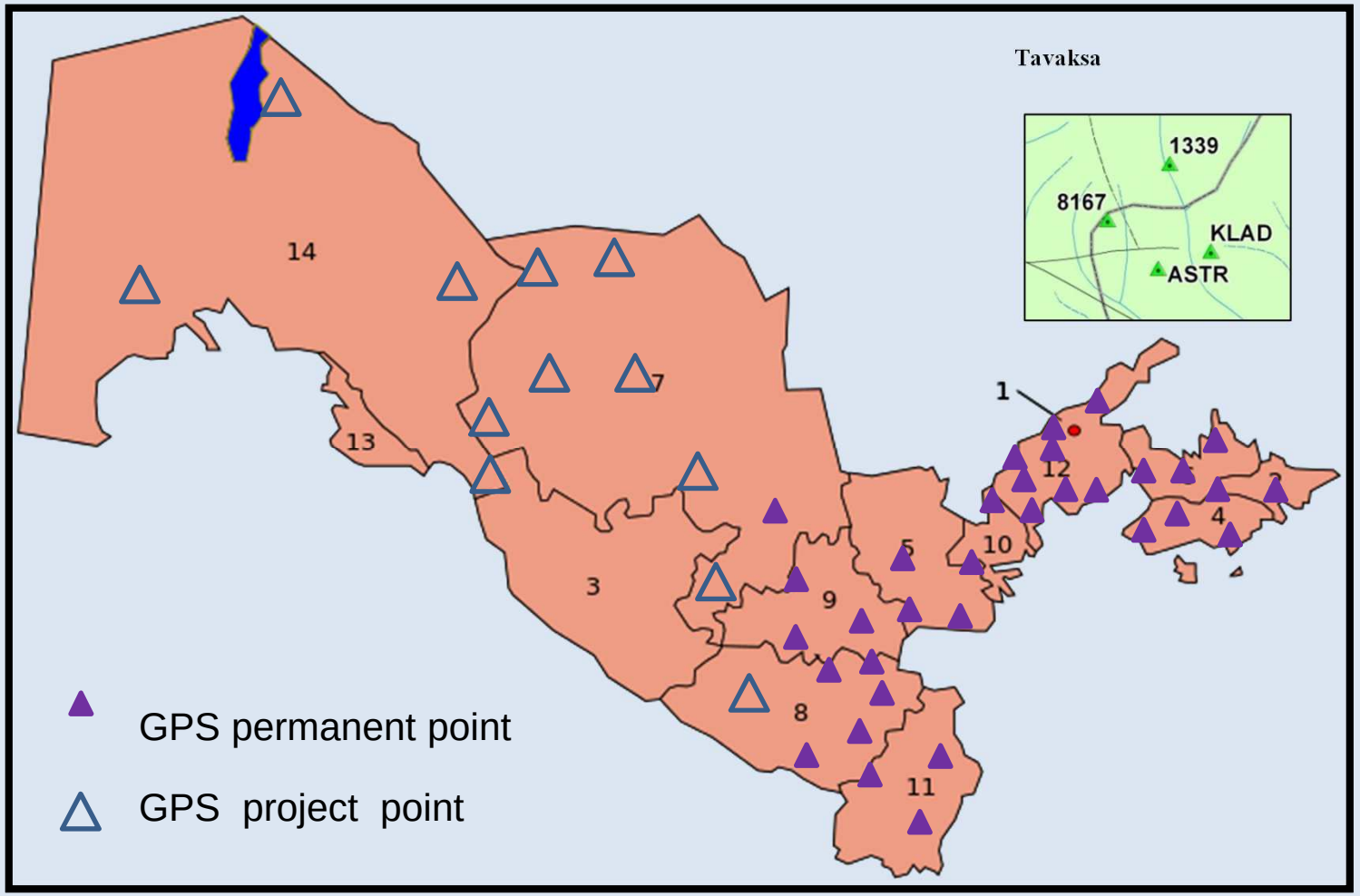
State satellite geodetic network+ IGS station +CATS network



State satellite geodetic network+ IGS +CATS network+(new stations ?)

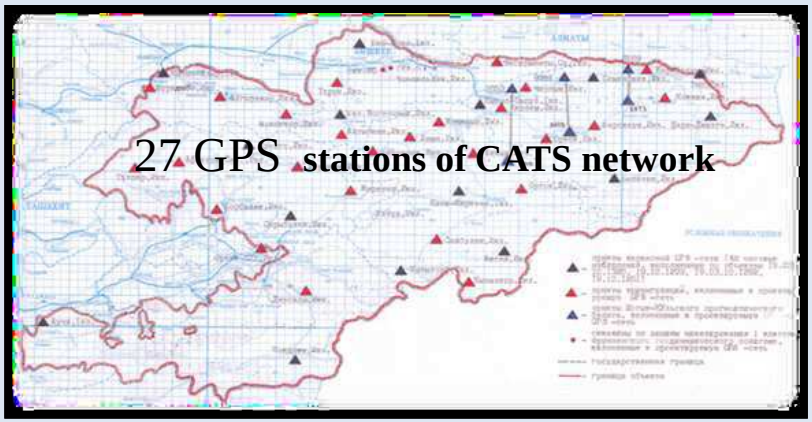


GPS stations of Seismology network

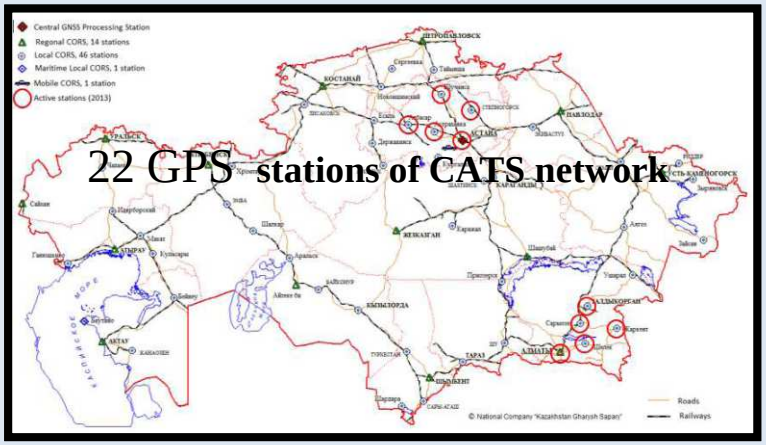


STATE SATELLITE GEODETIC NETWORK OF CENTRAL ASIA

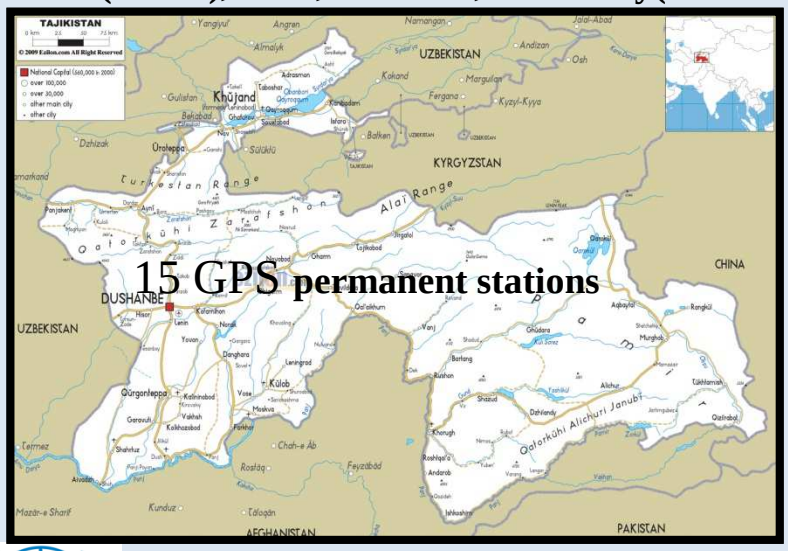
The ITRF based Kyrgyz State Geodetic Network (SGCS KR)



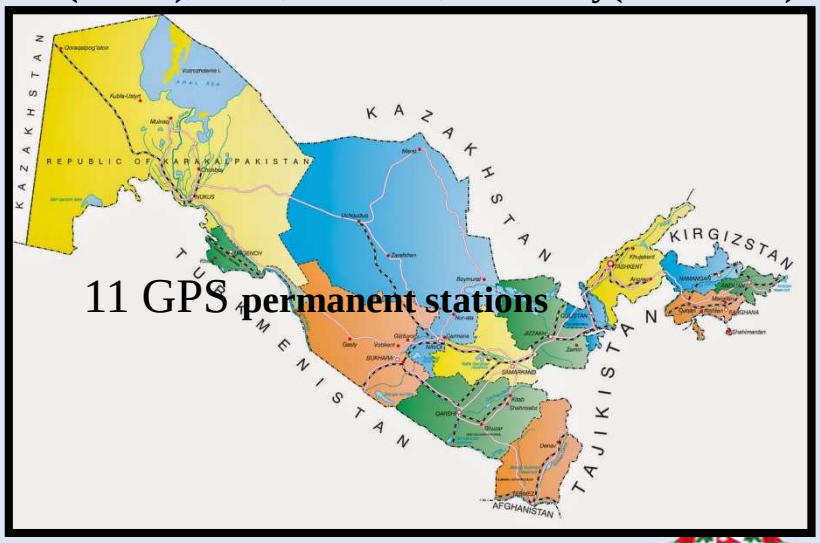
The National GNSS Network of Kazakhstan



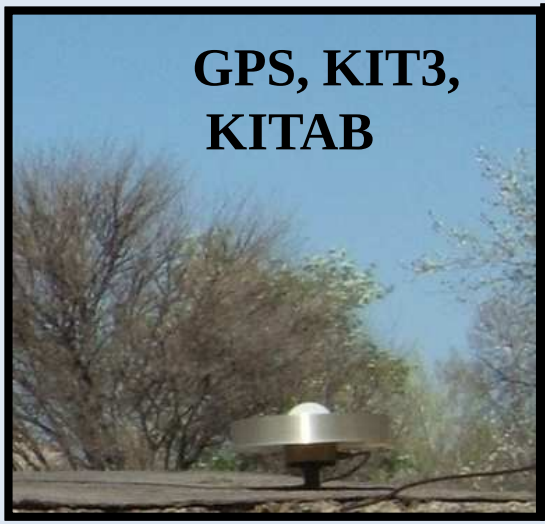
Central Asian Tectonic Science network in Tadjikistan (CATS), GFZ, Potsdam, Germany(1992-1996)



Central Asian Tectonic Science network in Uzbekistan (CATS), GFZ, Potsdam, Germany(1992-1996)

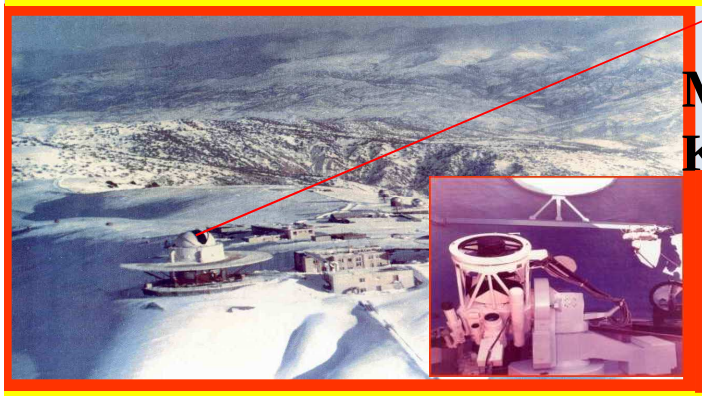


IERS GEODETIC SERVICES

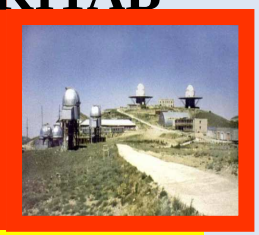


International GNSS Service

International GNSS Service



Maydanak, KITAB



International Laser Ranging Service

IDS, KITAB

International DORIS Service

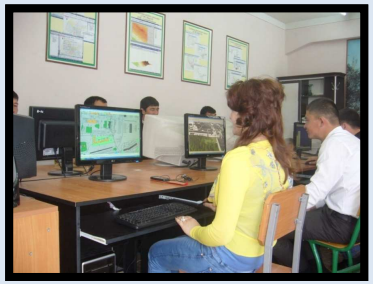
GNSS education











UN Workshop on the Applications of
Global Navigation
Satellite Systems,
Chisinau, Moldova, May 2010,
Working Group #2
Geodetic Reference Networks

Resolution

- Cross-border use of reference stations of neighboring countries.
- The working group indicated the importance of the high precision geoid models to be used for scientific exploration.

Legal basis for Geodesy and Cartography
Law "On Geodesy and Cartography" (1997)
Law "On State cadastres" (2000)
Law "On Informatization" (2003)
Law "On Electronic Document Flow" (2004) etc.

Transformation of coordinate system

B, L,H, WGS84

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

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)

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

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

B, L,H, CS-42

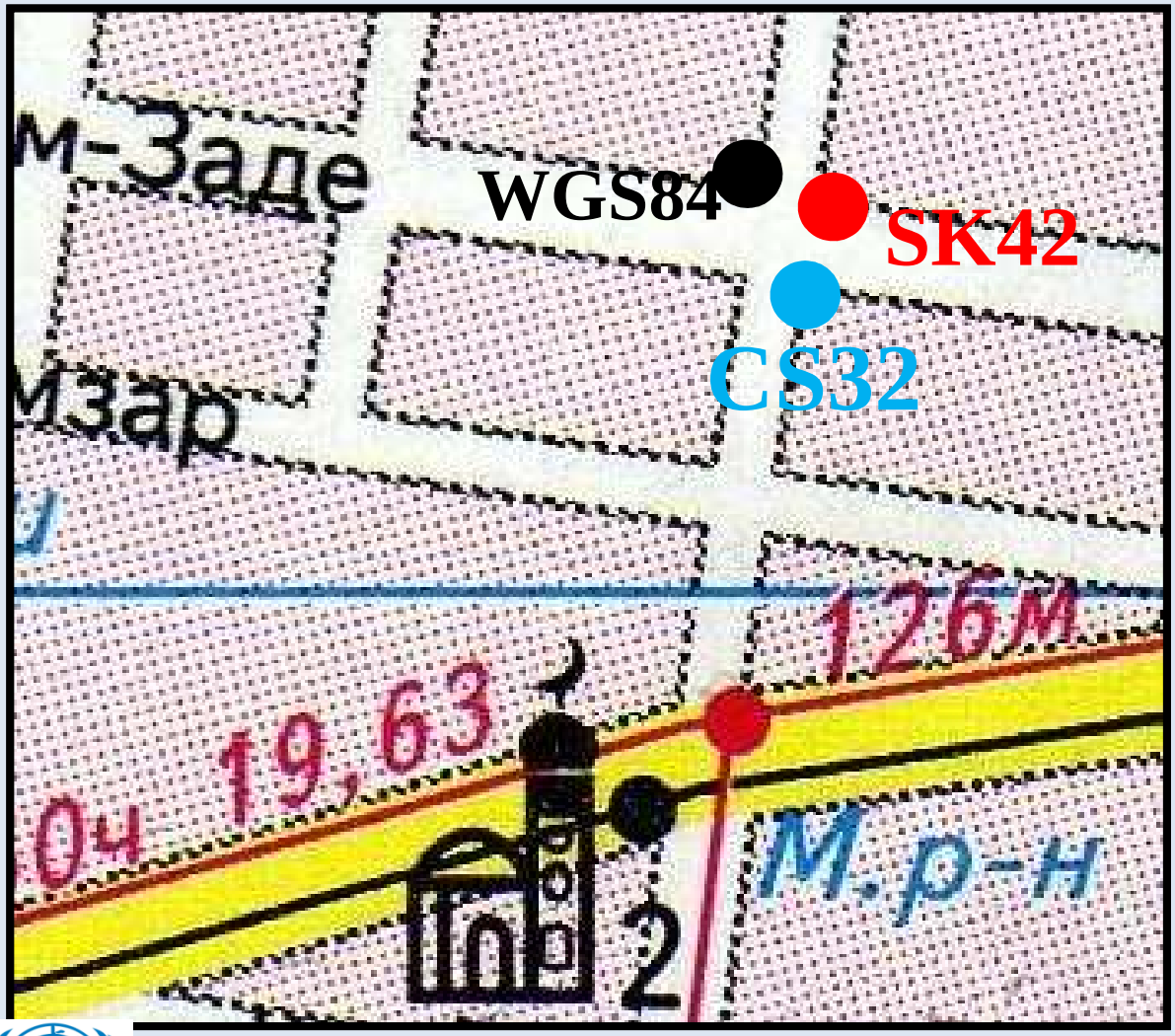
$$x = S + \frac{l^2}{2} r\, SinB + \frac{l^4}{24} r\, Cos^2 B\, SinB\,(5 - t^2 + 9\eta^2 + 4\eta^4);$$
$$y = lr + \frac{l^3}{6} r\, Cos^2 B(1 - t^2 + \eta^2) + \frac{l^5}{120} r\, Cos^4 B(5 - 18t^2 + t^4 - 14\eta^2 - 58\eta^2 t^2);$$
$$m = n = 1 + 0{,}000152\, l^2 Cos^2 B; \quad p = m^2; \quad w = 0;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

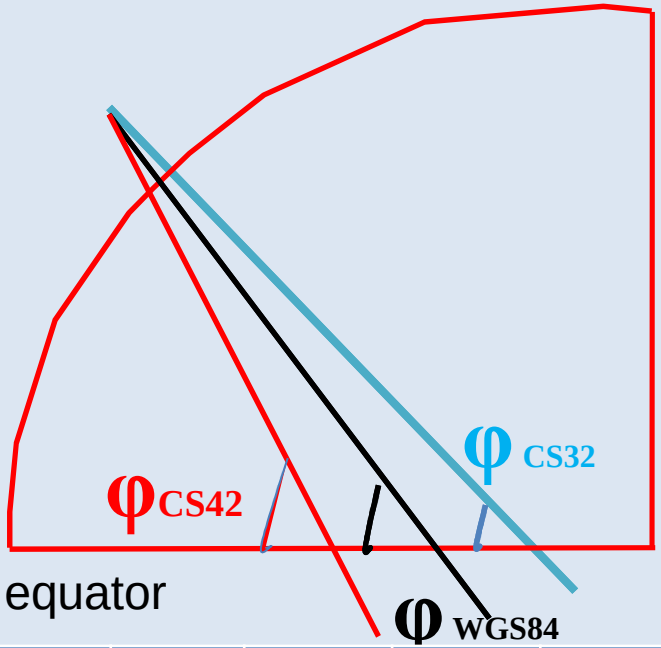
x,y(CS42)
G-K projection

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

Intermediate
G-K projection

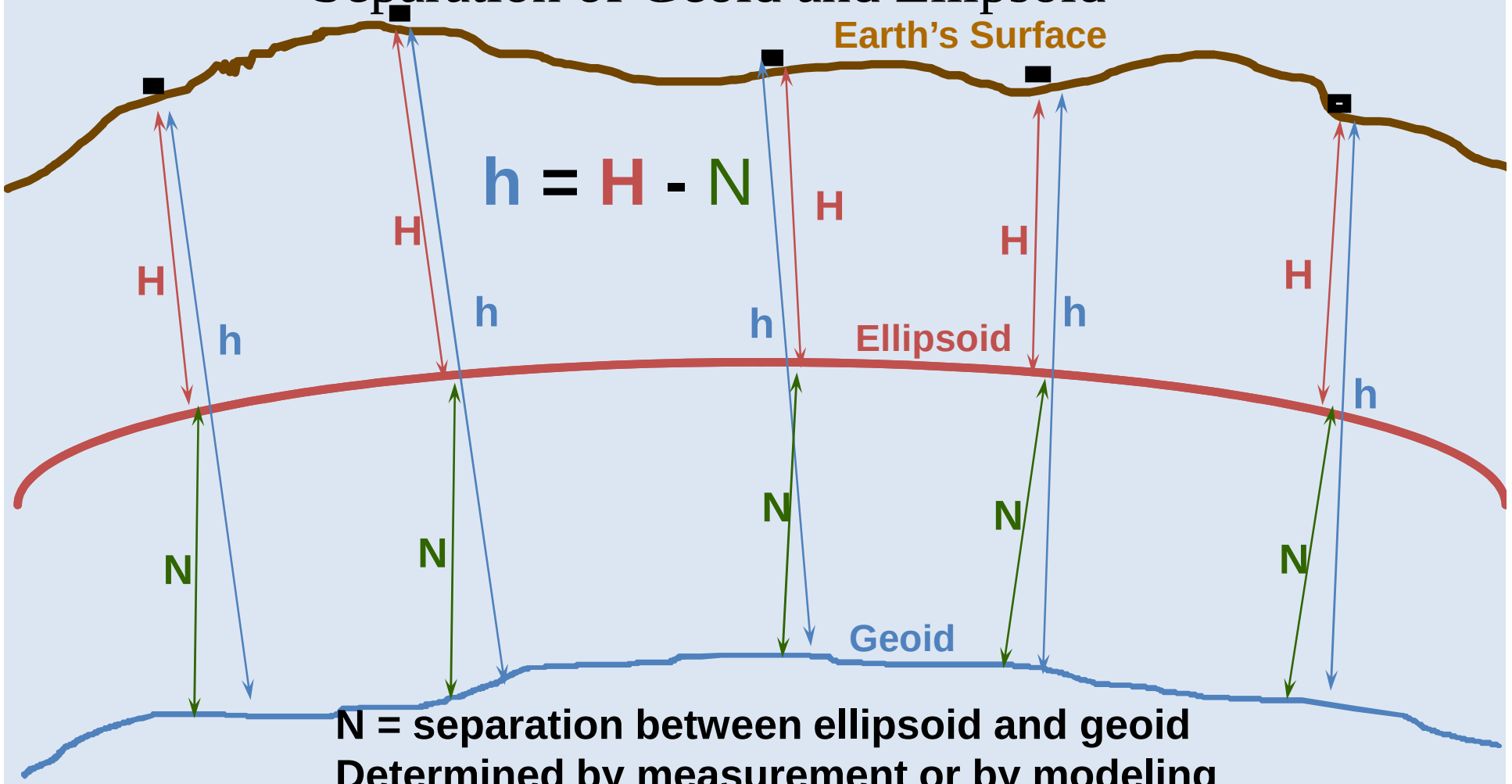
Three points with the same latitude and longitude in three different coordinate systems. WGS84, CS42, CS32





ϕ_{sk42}	λ_{sk42}	B_{wgs84}	L_{wgs84}	Country
42 11 00.69	77 33 52.81	42 11 01.55	77 3350.76	Kirgiztan
42 32 20.52	76 32 17.21	42 32 21.45	76 32 15.06	Kirgiztan
42 45 22.36	78 15 05.28	42 45 23.32	78 15 03.27	Kirgiztan
42 29 26.79	78 37 25.12	42 29 27.73	78 37 23.18	Kirgiztan
39 08 05.28	66 53 10.8	39 08 05.2	66 53 07 .6	Uzbekistan
38 41 04.27	66 56 32.47	38 41 04.1	66 56 29.3	Uzbekistan

Determining Elevations with GPS
Separation of Geoid and Ellipsoid



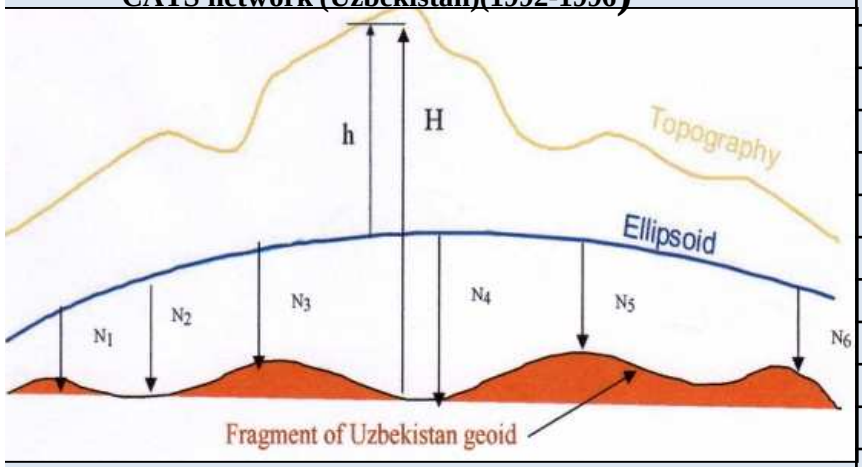
N = separation between ellipsoid and geoid
Determined by measurement or by modeling

How many points do you need?

As many a possible.
4 is really the minimum you would want to use.
5 is strongly recommended.

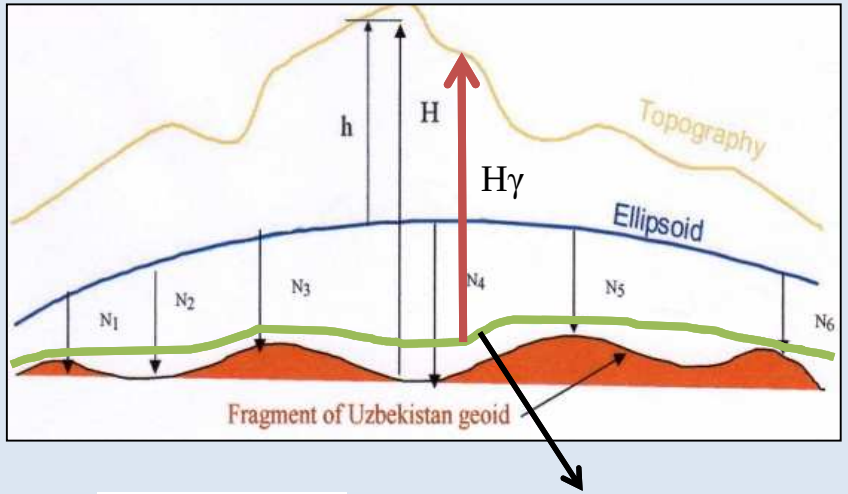
Fragment of Uzbekistan geoid (2014)

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
59	-43.85
79	-43.16

Uzbekistan quasi-geoid ?



$$\xi = \varphi - B,$$
$$\eta = (\lambda - L)\cos\varphi$$

H= *h*+ *N*

$$H_{изм} = \int_0^P dh$$

$$H_{орт} = -\frac{1}{g_m}\int_0^P \frac{\partial W}{\partial h}dh = \frac{W(O)-W(P)}{g_m}$$

$$\zeta = H - H^{\gamma}$$

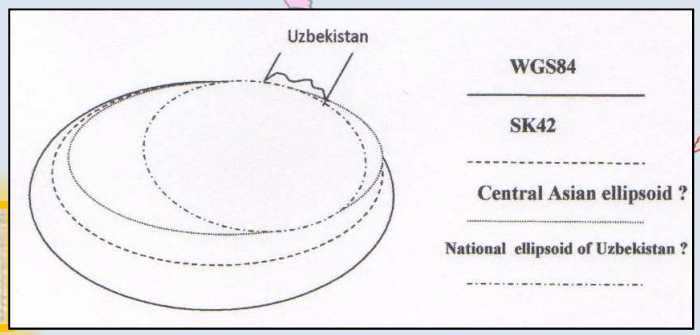
$$H^{\gamma} = \frac{1}{\bar{\gamma}}(W(O)-W(P))$$

REFERENCE FRAME

NATIONAL

LOCAL(1+2 regions)

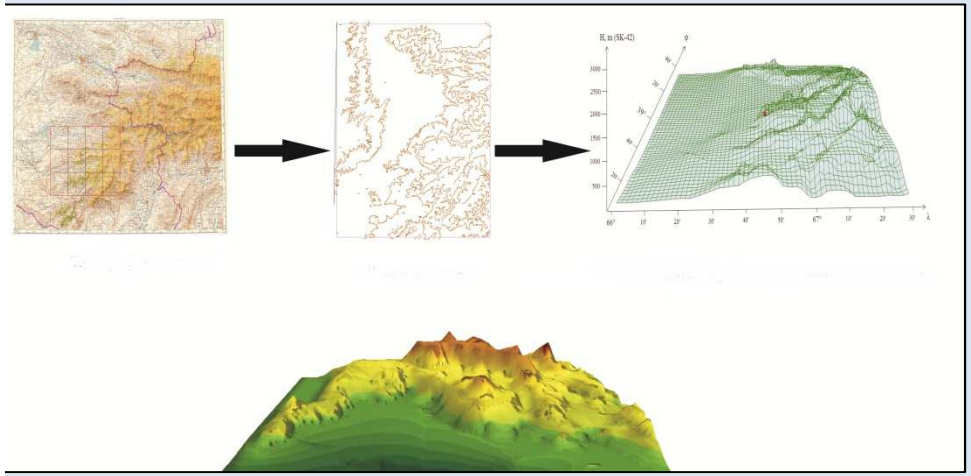
region



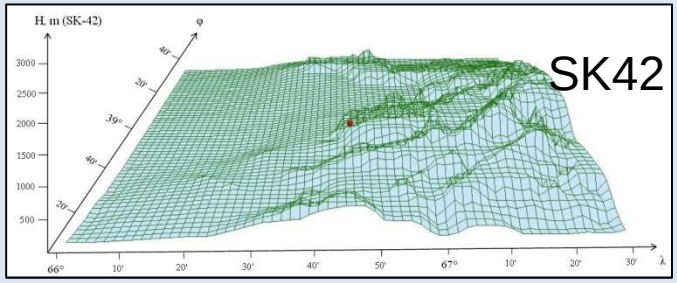
UZBEKISTAN

Digital elevation models

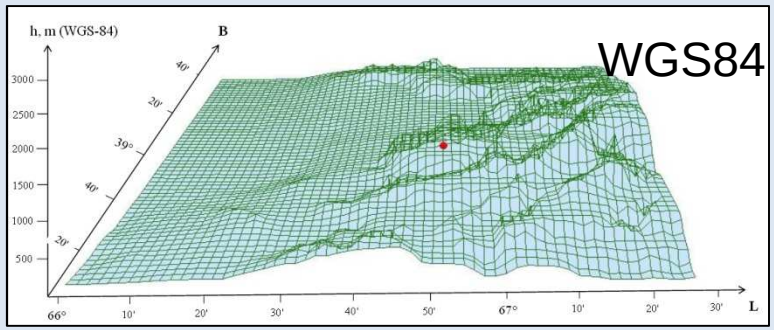
GIS PANORAMA



DEM (Kashkadary region)

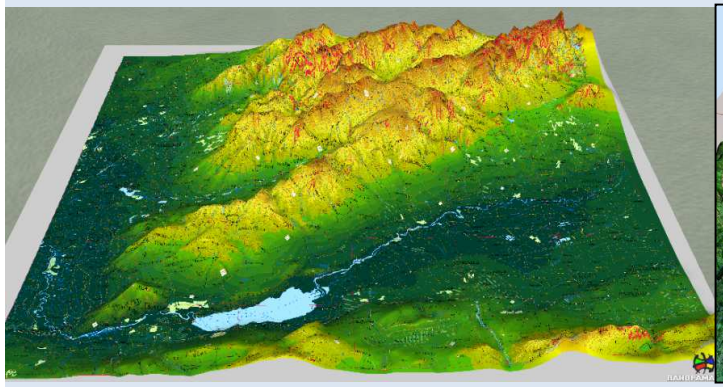


SK42



WGS84

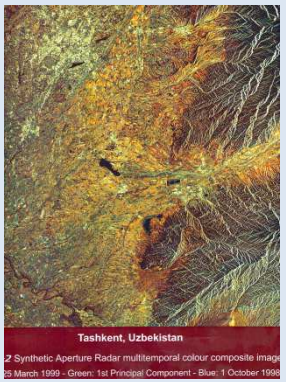
Fergana valley



Charvak

NUU

SAR(Tashkent



IN THE FUTURE

1. IMPROVING OF THE TOPOGRAPHIC SHEET MAPS
2. CREATING OF LOCAL GEOID
3. WORK OUT OF UZBEKISTAN DATUM
4. DEVELOPMENT OF TRANSFORMATION COORDINATES
5. NEW GEOID AND QUASI-GEOID
6. DIGITAL MAPS FOR UZBEKISTAN
7. ADJUSTMENT

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Thank you
for your attention!

**The author is very thankful
for financial support of the United Nations
(Office for Outer Space Affairs) and
of the DLR GfR mbH**