UDK 528

Yertay Talgatovich Yeskaliyev
East Kazakhstan State Technical University after Daulet Serikbayev, 070003, Republic of Kazakhstan, East Kazakhstan Region, Ust'-Kamenogorsk, Serikbayev st, 19, master of Geodesy, phone number: (776) 255-55-96, email: yeskaliev96@mail.ru

In this scientific article shows potential of created microtriangulation network, results what we have got if we will use this method of surveying. All works has done in Oil&Gas project in Kazakhstan. Beside new method article has all process detail explanation about coordinate systems, its calculation, determination and transformation. After all, article shows rconclutions of searching and checking new method in construction.

Key words: microtriangolation, survey control works, geodetic system, verification, new method of survey works, field survey methodology.

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Introduction

The availability of accurate and reliable information relating to the position and uncertainty of the site survey control marks is critical to the integrity of the Project. The purpose of this report is to introduce innovations in higher geodesy by creating new microtriangulation network and thereafter use it for survey control works. In addition, as the Survey Control Network itself defines the accuracy of all survey work carried out on the project, it is imperative the survey control used placement matches the design coordinate system used throughout the design and fabrication of all next works. This report outlines the existing spatial framework on the site, the methodology used to verify the survey control network, the results as coordinate delta listings, the procedure for performing surveys on the subject site and the recommendations and conclusions.

World Geodetic System 1984 (WGS 84).

The WGS84 is an Earth- centred, Earth fixed terrestrial reference system and geodetic datum that comprises four components: An ellipsoid, a horizontal datum, a vertical datum and a coordinate system.

When using WGS84 as a reference frame and an ellipsoid it is necessary to define a reference time (date) or epoch for positions established. This is because continents move under this grid and therefore the coordinates of any point will change over time, relative to the grid.

At time of report, this reference epoch has not been forthcoming. "Geodetic Coordinate Systems" to WGS-84 coordinates in the cartesian format. Refer table 1 below:

Table 1 - "Geodetic Coordinate Systems"

	Site	WGS 84
Site Datum	E. 0000.000	E. 680005.251
Location 122	N. 0000.000	N. 5108168.5210

The reference to WGS 84 in these tables is incorrect. The coordinates represent UTM 39 Grid coordinates, not WGS 84 cartesian coordinates. Conversion of these values from the UTM 39 Grid to geodetic coordinates is 46. 1033076610492 Latitude and 53. 329045626373 Longitude.

UTM 39

The UTM 39 coordinate system is a Universal Transverse Mercator (UTM) projection of the WGS 84 global reference system onto a plane.

The UTM 39 coordinates and related North Baltic heights of the primary control is using for CIS countries.

Important Note: UTM 39 does not have a unit scale factor. Refer to Section "scale factor and its implications" for details about the scale factor and the use of UTM 39 coordinates for design and survey. As mentioned above, all coordinates listed as WGS in "Geodetic Coordinate Systems" are in fact UTM 39 coordinates. Any further reference to that documents hall reflect this correction.

Project Coordinate System

The project coordinate system is based on a flat cartesian plane orientated parallel to WGS-84 (Require realisation). The site datum is at location 122 with the project site located to the North East of the site Datum.

The project localised Grid is essentially an assumed coordinate system. This assumed coordinate system is tied to the grid coordinate system (in this instance UTM 39) by a base point. To be useful, all distances on the plan should be of the same length as the distances measured on the ground. To do this a combined scale factor must be applied to the project Grid. (Refer Scale Factor and its implications).

Important Note: The project Grid is a localised grid, however, a combined scale factor has never been applied to this grid, therefore distance measured on the plan does not relate to the distances measured on the site. Refer Table 2 - "Ground to Grid comparison" for an onsite project measurement comparison.

The project grid utilises UTM 39 as its reference grid. It should be noted however, that UTM 39 is a map grid created for mapping a zone, representing the earth's surface with a flat grid. Through the process of projecting points on the earth surface to the grid, distortions occur. All projected grids (including UTM 39) introduce a variable distortion referred to as scale factor. The scale factor between the terrain, in this case the project site, and the grid varies proportionate to the terrain level and grid easting. The larger the distance between points the greater the affect.

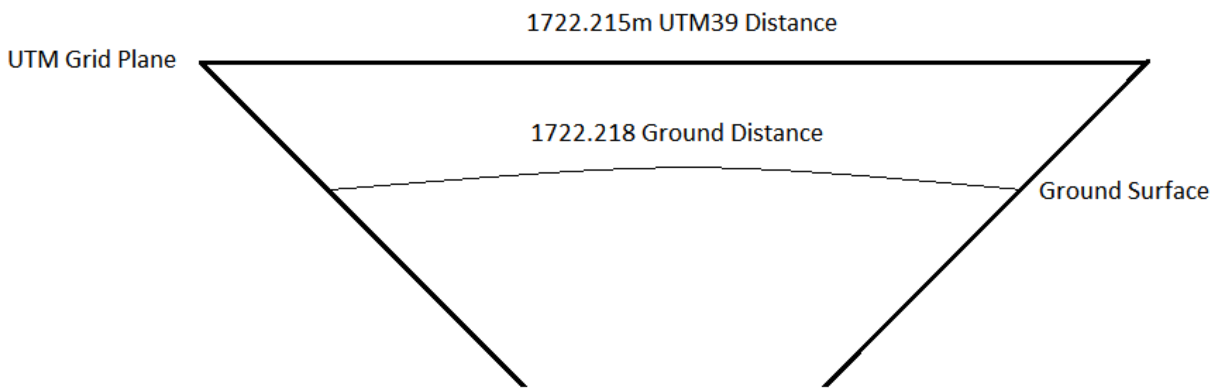
The real impact of scale factor is experienced during construction. At the plant site on project the combined scale factor, a combination of sea-level correction and point scale factor is between 1.0mm and 2.0mm per 100 meters. This is of small affect constructing roads, pipelines and other linear objects. It is excessive when the construction includes pre-fabricated structures of accurate dimensions, as all pre-fabricated dimensions must be replicated by the set-out on-site.

Proposed New Localised Site Grid. The project coordinates supplied have not considered the scale factor and associated sea level correction. The coordinated have been derived by directly translating the UTM 39 coordinates 680005.251m east and 5108168.210m north respectively. The implications of which, is a distortion in coordinated positions relative to actual ground positions. This distortion is in the order of 12mm to 38mm across the width of the site. Refer "Table 2 - Ground to Grid comparison" for a comparison of actual distance ground measurements to the calculated grid coordinate distance (UTM 39) across the width and length of the site.

Table 2 – Ground to Grid comparison

Survey monument ID	Orientation across site	Measured ground distance (m)	Computed Coordinate distance UTN 39 (m)	Diff (m)
PJ4 to GEO4	East-West	1722.188	1722.215	0.027
PJ1 to PJ6	North-South	1937.3430	1937.371	0.028

Figure 1: Ground to Grid Distance Comparison



Re-Coordination of 3GP Survey Control Marks

A resurvey and subsequent re-coordination of the survey control network and new piled monuments has provided coordinates which have considered the scale factor and negated the distortions. This re-survey provides a network of survey control points with coordinates that are internally consistent, tied to existing control marks.

Survey work is currently underway, both in the field and through computation, to assess and determine the impact of such a coordinate shift on already completed works. This investigation is primarily focused on the already installed pipe rack foundations and anchor bolts. Depending on the outcome of this investigation, the location of the scale factor origin may need to be changed.

Important Note: This investigation is only validating the relativity of the As-Constructed works with reference to the survey control in and around the immediate site. It is not validating absolute position from Site Datum 122. Refer to Section: "Connection to Horizontal Datum" - Survey Control Network Verification.

Implications of Coordinate Shift Issues relating to the adoption of a new localised site grid that includes a datum shift and scale factor may include:

– Disconnection between previous (2014 survey Control) and new adopted control coordinates;

– As built coordinates no longer apply to the adopted survey control;

– Set out to date (works completed) may be out of tolerance or further reduce SWHU tolerance with respect to the new localised grid;

– Design may be disconnected from future survey Setout.

Synopsis

Provided the proposed new localised site grid contains survey control points that are homogeneous, accurate and reliable with respect to position and uncertainty and:

– the above-aforementioned factors mentioned in the "Implications of Coordinate Shift" are of no significance or are negligible;

– the positioning relative to the site datum 122 or any other datum is of no significance., then the revised coordinate values with applied scale factor should be adopted.

Survey Control Network Verification

GNSS equipment and observation techniques employed have a direct impact on the accuracy and uncertainty of the survey results. Discussions with the project surveyor revealed the original supplied control (second order control) was performed by GNSS observations connected to only one 1st order control point. This is far from ideal and not the standard practice of utilising surround control. Further, static observations session length at each of the second order control marks was apparently in the order of 1 to 1.5 minutes. The standard practice for GNSS control surveys to the accuracy required on the project is a session length of one (1) hour plus five (5) minutes per one (1) km baseline length. The project surveyor has informed me that the stated accuracy of these control points is in the order of 20mm at best (Report required for confirmation).

Quality of Control Network is beyond the scope of this verification survey to audit the quality of the originally supplied survey control network as it is dependent upon the following components:

– The Network Design;

– The survey practices adopted to older will;

– The equipment and instrumentation used;

– The reduction techniques employed.

These components are usually proven by the results of a successful, minimally constrained least squares network adjustment computed on the ellipsoid associated with the datum on which the observations were acquired.

Survey Control verification surveys have been performed with precision total stations utilizing methods appropriate to achieving the standards specified.

The quality of the control survey were qualified in terms of uncertainty in three ways:

1. Survey Uncertainty. The uncertainty of the horizontal and vertical coordinates of the survey control marks relative to the survey in which it was observed. This verification process is independent from the influence of any imprecision or inaccuracy in the underlying datum realisation.

2. Positional Uncertainty. The uncertainty of the horizontal and vertical coordinates of the survey control marks with respect to the defined datum. This represents the combined uncertainty of the existing datum realisation and the new control survey.

3. Relative Uncertainty. The uncertainty between the horizontal and vertical coordinates of any two survey control marks within the survey control network.

Field Survey Methodology

Lack of inter-visibility and line of sight between survey control marks within the supplied survey control network restricted the use of direct observation verification. Instead, a separate network of interconnecting control stations with sufficient redundancies was set up to connect the relevant survey control marks. This process involved large degrees of freedom and eliminated traditional traverse errors providing a solution that:

– Had no instrument plumbing errors (everything is measured from the perspective of the instrument axis);

– Minimised orientation errors;

– Provided the opportunity to set the Instrument closer to the survey control mark (increased accuracy), as free stations are not reliant upon pre-existing ground control to setup over;

– Provided substantial redundancy leading to sub millimetre residuals;

– Enabled easy and fast future identification survey control verification.

Survey instrument setup coordinates for each station within the interconnecting network were established through a minimum of six (6) to ten (10) pre-established control points. Refer "Table 3 – Existed Control Points". A least squares multiple iteration bundle fit was then applied to the network and further transformations applied to set the coordinate system.

Table 3 – Existed Control Points

Supplied				Verification				Difference		
Point ID	Easting	Northing	Elevaton	Point ID	Easting	Northing	Elevaton	□E	□N	ΔELE
C13	2924.994	2922.679	103.47	C13	2924.994	2922.679	103.470	0.000	0.000	0.000

C30	2919.187	2911.501	104.663	C30	2919.187	2911.501	104.663	0.000	0.000	0.000
C31	2915.49	2911.683	105.153	C31	2915.489	2911.684	105.153	0.001	-0.001	0.000
C32	2913.218	2911.499	105.079	C32	2913.217	2911.500	105.079	0.001	-0.001	0.000
C33	2913.961	2911.781	106.536	C33	2913.960	2911.782	106.536	0.001	-0.001	0.000
C34	2917.113	2911.781	106.521	C34	2917.113	2911.782	106.522	0.000	-0.001	-0.001
C35	2913.21	2922.293	104.686	C35	2913.210	2922.295	104.686	0.000	-0.002	0.000
C36	2919.106	2922.292	104.888	C36	2919.106	2922.293	104.889	0.000	-0.001	-0.001
C37	2918.209	2922.01	106.663	C37	2918.210	2922.011	106.663	-0.001	-0.001	0.000
C38	2915.69	2922.012	106.64	C38	2915.691	2922.013	106.640	-0.001	-0.001	0.000
C41	2931.318	2911.534	104.869	C41	2931.317	2911.534	104.869	0.001	0.000	0.000
C46	2919.201	2922.288	107.953	C46	2919.202	2922.290	107.953	-0.001	-0.002	0.000
C47	2925.184	2922.297	107.915	C47	2925.184	2922.297	107.915	0.000	0.000	0.000
C48	2931.203	2922.293	107.902	C48	2931.202	2922.292	107.901	0.001	0.001	0.001
C49	2922.723	2922.012	107.061	C49	2922.724	2922.013	107.062	-0.001	-0.001	-0.001
C50	2913.206	2911.509	107.501	C50	2913.205	2911.510	107.501	0.001	-0.001	0.000
C51	2919.205	2911.514	107.872	C51	2919.204	2911.515	107.872	0.001	-0.001	0.000
C52	2925.203	2911.516	107.929	C52	2925.203	2911.516	107.929	0.000	0.000	0.000

This control method is very similar to the triangulation technique. Refer "Table 4 - Triangulation classes and categories". However, none of existing classes does not fit the parameters.

Table 4 – Triangulation classes and categories

Class, category	Angle root-mean-square error, min	Fractional error of basis	Length of triangle side, km
I class	0,7	1: 400000	>20
II class	1,0	1: 300000	7 - 20
III class	1,5	1: 200000	5 - 8
IV class	2,0	1: 200000	2 - 5
1 category	5,0	1: 50000	0,5 - 5
2 category	10,0	1: 20000	0,25 - 3

Micro triangulation network is a chain of triangles with sides not less than 200 m and not more than 1000 m, laid between two sides or points of triangulation.

The triangles that define the analytic network should be close to equilateral. Angles at the defined points must be at least 30° and not more than 150°. All angles in the theodolite triangles shall be measured with an accuracy of not less than 30", the residual angles in triangles shall not exceed 1’. The relative error of the farthest side should not exceed 1/2000.

The new type of microtriangulation with the following parameters:

1. The use of auxiliary control points for triangulation;
2. Using at least 12 control points;
3. Distance not more than 80 m;
4. Full accounting of atmospheric parameters (temperature, atmospheric pressure, humidity).

Compliance with these parameters ensures maximum accuracy in the initial data up to microns. Also identified those strong points:

– which were affected by external physical factors and exceeded the permissible residual or destroyed, were subsequently excluded from the catalogue;

– which had incorrect initial data in the directory of strong points, were subsequently changes to correct data.

Results

Table 5 – Results of verification

	Supplied Local Control		Verification Survey Local Control		Comparison	
ID	Easting	Northing	Easting	Northing	Easting	Northing
KV1	2630.658	3193.177	2630.656	3193.174	-0.002	-0.003
KV2	2440.048	3069.360	2440.050	3069.361	0.002	0.001
KV3	2440.075	2888.601	2440.076	2888.603	0.001	0.002
KV4	2550.611	2813.670	2550.614	2813.675	0.003	0.006
KV5	2707.369	2813.673	2707.370	2813.675	0.001	0.002
KV7	3153.547	2454.590	3153.538	2454.611	-0.009	-0.021
KV9	3277.315	2340.259	3277.299	2340.273	-0.016	-0.014
NM4	3040.725	3238.008	3040.720	3238.003	0.005	-0.005
NM5	2849.264	3069.284	2849.265	3069.283	0.001	-0.001
NM6	3087.560	2918.929	3087.561	2918.928	0.001	-0.001
NM7	3155.101	2696.211	3155.101	2696.219	0.000	0.008
NM8	3491.691	2811.346	3491.686	2811.348	0.005	0.002

Conclusion

All Local coordinate values listed in the "Catalogue for Coordinates and Elevations of Monuments in site" that are not highlighted in yellow are suitable for use on the site for further survey control identification and module installation works. However, prior to implementation and issuance of any "new localised" survey control coordinates, it is recommended that:

– Any impact associated with datum and/or survey monument coordinate shifts is considered;

– Reference is made referring actual position of R. L. on the survey monument;

– Transformation parameters are provided to allow conversion between UTM 39 grid and 3GP plant grid and;

– Coordinates are supplied in both UTM-39 and 3GP Plant Grid.

The survey control coordinates that are highlighted in yellow, namely KV7, KV9 and NM7 will need to be rechecked, re-coordinated and re-verified for position prior to release and issuance.

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Compliance with these parameters ensures maximum accuracy in the initial data up to microns. Also identified those strong points:

– which were affected by external physical factors and exceeded the permissible residual or destroyed, were subsequently excluded from the catalogue;

– which had incorrect initial data in the directory of strong points, were subsequently changes to correct data.

In the end, new microtriangulation method of control gives the most accuracy coordinate data. Precise quality of measurement is the most important in all survey works and appears the valuation of surveyor qualification.