Definition of a Unique Transformation Parameters for Bursa Metropoliten Municipality Area of Responsibility

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SUMMARY

In the frame of Bursa Metropoliten Municipality 1/1000 Scale Digital Photogrammetric Line and Orthophoto Map Production Project, one of the important demands were to define a unique transformation parameters for the area of responsibility of 12000 km2. Main target was to correlate the products produced in ITRF96 Datum and epoch 2005.0 with the European Datum 1950 which was the previous Datum of Turkey up to 2005.

When the Project area is examined, the existence of 119 different transformation parameters was determined, belonging to previous mapping and survey Project in the Project area and surroundings.

Data belonging to 109 Different transformation are provided from related governmental organizations. Total number of Joint Ground Control Points set of different projects in both datum were 954.

Previous transformations were realized either Bursa & Wolf or Molodensky & Badekas Helmert Similarity transformation methods as per governing regulations. All groups are controlled, conjugate points were extracted and a group of 887 Points defined as Transformation Set.

A set of 12 First and Second Order Triangulation network point, found living firmly in the field and added to Transformation set.

Different type of transformations are executed; Namely , Helmert Similarity Transformation , Direct Solution and Hybrid solution of Helmert Similarity & Direct Solution.

During this performances; some constraints were used especially based on the previous 1/1000 Photogrammetric Line Map Production datum transformation. In this respect Deductive and Inductive algorithm, then direct solution and hybrid solutions via integrating this methods are used, evaluated and discussed.

In addition a study to check the effective application zone of the defined transformation parameters is executed, results are discussed and a unique transformation parameters are defined which fits existing parameters best.

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1. BACKGROUND :

Bursa Metropolitan Municipality (BMM) Phase 5; "1/1000 Scale Digital Photogrammetric Line and Orthophoto Map Production Project started in 2015 for the area of responsibility of 12000 km^2. Phase1 and 2 projects of 1000 km^2 datum were ED50 while Phase 3 and 4 of 3500km^2 were ITRF96 cause of the formal Datum change to ITRF96 in 2005.

One of the important demands of the TOR were to define a unique transformation parameters for the whole AOR. Main target was to correlate the products produced in ITRF96 Datum and epoch 2005.0 with the European Datum 1950.

119 different transformation was determined and of which 109 are provided from related govermental organizations in the AOR , belonging to previous mapping and survey Projects.

2. PREPARATORY WORKS

Total number of Joint Ground Control Points (JGCP) of different projects in both datum were 954.

Previous transformations were realized either Bursa & Wolf or Molodensky & Badekas Helmert Similarity transformation methods as per governing regulations. All groups are controlled, conjugate points were extracted and a group of 887 Points defined as Transformation Set. Cause the JGCPs are both in 27th and 30th zones, positions in both TM zone coordinate system in both datum are computed.

In addition a set of 12 First and Second Order Triangulation network points, found living firmly in the field and added to Transformation set.

3. CONSTRAINTS

Some constraints were used imposed by either TOR or Governing regulations .

- Constraints imposed by TOR ;
    - Cause Phase5(M5) Project is a continuation of Phase3(M3) and Phase4(M4); at the edge matching zones of these projects no matching problems requested.

Cause there are other datum transformation exist realized after 2005, definition of a unique transformation parameters set is a must for BMM AOR (Phase5 Project area) which fits existing transformation parameter, especially the one defined during Phase3(M3) best.

- Constraints imposed by Regulations ;

    - After transformation adjustment, corrections to surveys and during External Quality Control differences in between known and estimated (transformed) coordinates; should be less than 0.15m.

    - Mean square error of Datum Transformation Adjustment should be less than ±0.10m

4. TRANSFORMATION MODELS IMPLEMENTED :

Three Different transformation model used :

- Helmert Similarity Transformation (HST) with Bursa&Wolf Model: These method is the one adviced by governing regulation.

- Direct Solution with Spline Functions: Cause the spline function constraint to pass through all the reference points used, resulting differences will be or at least close to zero in between known and transformed coordinates for the reference points.

- Hybrid Solution with the Harmonization of Helmert Similarity and Direct solutions: Since there are important Δy:Δx differences exist in between known and HST transformed coordinates , to be able to import the excluded points to transformation , spline functions used for a complementary step of HST. So BMM must “to represent all existing transformation best” is satisfied .

5. SELECTED TRANSFORMATION APPLICATIONS :

5.1 Helmert Similarity Transformation:

- If we memorize, during Phase3(M3) project a set of transformation parameters defined by 34 JGCPs selected in M3Project area and used during Phase3 and Phase4 . As the final products all Digital Line and Orthophoto maps produced in ITRF96 datum transformed to ED50 via using these parameters. For the Phase5(M5) ; Phase3(M3) and Phase 4(M4) areas of total 3500km^2 are just a part of M5 Project area of 12000km^2.

- In addition the number of existing JGCPs are 887.Which means an HST with such a big data set , can be resulted in a better and accurate datum transformation and a set of more representing transformation parameters in between ITRF96 and ED50.

- In addition to this data set, based on the field reconnaissance 12 First and Second order triangulation point determined physically living firmly in the field. Cause all this 12 triangulation points are adjusted in 1954 adjustment which defines ED50 for Turkey. In another say these points are representing directly ED50.

- Finally these points are included in and also observed during the establishment of Bursa Basic GPS network and adjustment. So the accurate positions of these points are known in both datum.

- In this respect Deductive and Inductive algorithm for HST applications are implemented.

  - <u>Deductive approach (“DA”:”TG”) to HST</u> :

    - During this approach 34 JGCPs(M3) and a set of 12 First and Second order triangulation point(HGK), totally 46 points kept as fixed to constrained M3 Transformation parameters.

    - 106 TKGM group are respectively subjected to HST with this data set.

    - Following each dual HST adjustment, errors defined as the difference of known and adjusted positions for each joint point are classified based on the absolute values.

    - Cause , some points or some TKGM Groups showing big differences which can be evaluated as gross error are excluded from the JGCPs set hierarchically in order not to make a mistake during this elimination.

    - As per the final HST processs governing technical regulation’s constraints $\Delta y{:}\Delta x<0.15$ and $m_0<0.10$m are considered and the ones above are excluded from the joint transformation GCPs set.

    - This points are registered as fiducial points of that dual solution.

    - At the end of each dual HST application of M3+HGK Point set with each TKGM group points, all resultant sets of fiducial points are summed to form the final JGCPs set of final Joint HST.

    - As a precaution not to cause any mistake induceable or omitted points for the final process, some combinations created as to include some points excluded during previous transformation processes although having bigger $\Delta y{:}\Delta x$ differences for the targeted HST.

    - Results are interpreted and evaluated.

- Inductive approach (“IA”:”TV”) to HST :

  - The main target of this approach is to avoid any problem that may be induced by the constraints.
  - So all relevant points exist in 106 group data used for HST process. Process started with 887 JGCPs set.
  - As it is clear there is not any constraints for this case.
  - HST Process started with 887 JGCPs set. After adjustment , differences in between known and computed coordinates, calculated with defined transformation parameters are classified based on previously defined Δy:Δx error class .
  - Respective HST process executed and the points having bigger Δy:Δx differences than selected error class are excluded from JGCPs set and new Δy:Δx classification done. This process continued up to no Δy:Δx>0.15m.
  - Results are interpreted and evaluated.

- Combination of Deductive and Inductive approaches (Joint Solution (JS) for CA+IA approaches .

  - The main target of this approach is also to avoid any problem that may be inducible by the constraints and excluded points.
  - Similar methodology defined in Inductive approach applied and process continued up to no point exist in JGCPs set creating Δy:Δx>0.15m.
  - Results are interpreted and evaluated.

- Direct Solution (DS) : Cubic Spline:

  - As explained before TORs demands a unique solution for all existing groups in and around the project area. This means the unique transformation parameters should also provide a best fitting solution to all TKGM Groups in addition to M3 Transformation.
  - The only solution which covers above constraint is the direct solution or Cubic spline cause Spline function constraint to pass through the reference or JGCPs. So there will be no residual or in another say there will be no difference in between known and transformed coordinates or Δy:Δx will be zero.

- Results are interpreted and evaluated.

- Hybrid Solution of HST and DS :

  Target of this solution is to combine what the regulation and TOR demand. Cause regulation demands HST but TOR indicates DS. Eventually the workflow is arranged as follows;

  - Phase 1 is dedicated to HST with selected JGCPs set and $\Delta y:\Delta x$ differences are computed.

  - Phase 2 is designed as DS for the differences of known and transformed coordinates with Phase 1 transformation parameters.

  - Results are interpreted and evaluated.

6. EXTERNAL QUALITY CONTROL(EQC) APPROACHES TO DATUM TRANSFORMATION:

External Quality Control process aim is to check both geodetic and cartographic accuracy of the transformations. Normally geodetic control is good enough to check executed transformations, but cause there were a constraint used during transformation: ”not to cause any edge matching problems” in between previous M3/M4 digital line and ortho products with the ones of M5 project.

6.1 Geodetic External Quality Control Process :

Normally for EQC process, there must be some more points other than the points used as JGCPs set for any kind of transformation.

For HST, DS and Hybrid HST+DS solutions, points creating $\Delta y:\Delta x$ >0.15m differences are excluded from JGCPs set and EQC Control Points Set (EQC CPS) formed with these points. Some alternatives which are tried during EQC Process are summarized below;

- All Points (EQC CPS) Excluding the ones used as JGCPs for datum transformation are used for EQC”0” (“0” Coded EQCs)

- Ground Control Points Creating $\Delta y:\Delta x$ > 1.0m differences (GCPC>1) are excluded from EQC CPS and EQC named as EQC”-1” realized with these excluded points (“-1” Coded EQC)

- New Ground Control Points Set (NGCPS-A) after exclusion of the points (GCPC>1) from EQC CPS, EQC named as EQC “A”realized with these points, (“A” Coded EQC)

- New Ground Control Points Set(NGCPS-B) after exclusion of the points outside the outer boundary of M5 project area from NGCPS-A , EQC named as EQC “B” realized with these points, (“B” Coded EQC)

- New Ground Control Points Set(NGCPS-C); after exclusion of the points outside the outer boundary of the TKGM Grup’s used for the HST Datum Transformation from the points NGCPS-B, EQC named as EQC “C” realized with these points, (“C” Coded EQC)

- New Ground Control Points Set(NGCPS-D) after exclusion of the points outside the outer boundary of the JGCPs used for the HST Datum Transformation from the points NGCPS-C, EQC named as EQC “D” realized with these points, (“D” Coded EQC)

6.2 Cartographic External Quality Control Process (CEQC) :

Purpose of digital line and orthophoto maps and the ones produced than after say during M5 Project. Cartographic EQC is to check if any edge matching problem in between previously produced M3/M4 Project’s Similar to JGCPs known in both datum, some details or points conjugate are needed at previous M3/M4 and final M5 productions. Cause there are too many points or details exist just over on matching zones, tile corners or sheet corners which coordinates are known in both datum are used as Joint Cartographic External Quality Control points for EQC process.

For this purpose ;

- To check if any misalignment or mismatching exist on polyline or area details,

- To check the difference (or Position vectors) for 1/1000 scale sheet’s corner coordinates known at two datum over adjacent zones in between M3/M4 and M5 projects.

- To see the east-west and north-south directional cross section’s differences for M3/M4 and M5 projects

Δy:Δx differences are computed and evaluated.

7. DATUM TRANSFORMATION APPLICATIONS, GEODETIC AND CARTOGRAPHIC EXTERNAL QUALITY CONTROLS

Three different Datum transformation methods are used . Namely ; Helmert Similarity Transformation (HST) , Direct Solution (DS) with Spline Functions and Hybrid solution of HST+SD applications. The Principles considered during datum transformations are ;

- <u>*Datum Transformation Parameters should be unique for the whole M5 project area,*</u>

- *Products produced during M5 phase should not create any edge matching problems with the previous M3/M4 phase products either in ITRF96 or ED50 datums, based on the accuracy expectations of the Map scale used.*
- *In addition , Datum transformation process must be realized with minimum differences in between known and computed(or transformed) coordinates for other TKGM groups which are ratified before*
- *Finally ; cause there are some TKGM Groups exist in adjacent provinces and to control them from accuracy expectations point of view was beyond the project responsibilities, so the TKGM Groups located in and nearby to M5 project area(53 Groups) are preferred to provide a better representation of M5 datum transformations and mostly the groups in 30^0 Central Meridian's TM zone are used.*

7.1. Helmert similarity transformations (HST)

During HST applications, three different approach are applied, namely Deductive, Inductive and Joint Solutions of Deductive and Inductive approaches. In addition to these, in order not to omit any points which are excluded from the Joint Ground Control Points set during different Deductive and Inductive solutions, some internal implementation for Deductive and Inductive solutions are realized.

7.1.1. Deductive approach applications (DA)

During deductive approach applications, In principle a cumulative set of 46 Joint Ground Point, comprising 34 Joint GCPs of M3(34) datum transformation and 12 General Command of Mapping -"HGK(12)"- point's detected firmly in the field are used as reference GCPs set for dual datum transformation with TKGM Groups. The reason to define such a reference GCPs set for Datum transformations to be executed are;

- Cause;12 HGK Points of National Horizontal Control Network are the First and Second Order fiducial points directly representing the ED50 and

- Cause;During M3/M4 projects and than after for some other projects these M3(34) derived datum transformation parameters are used, in order not to create or to minimize any edge matching or mismatching problem in between previous and new project's adjacent zones, to keep M3(34) and HGK(12) JGCPs as reference is a must.

Deductive approach executed with M3(34)+HGK(12) set and 53 TKGM Groups dually which are located in and nearby M5 project area .18 TKGM Group of total 53 were in 27^0 Central Meridian's TM zone where the rest were in 30^0.

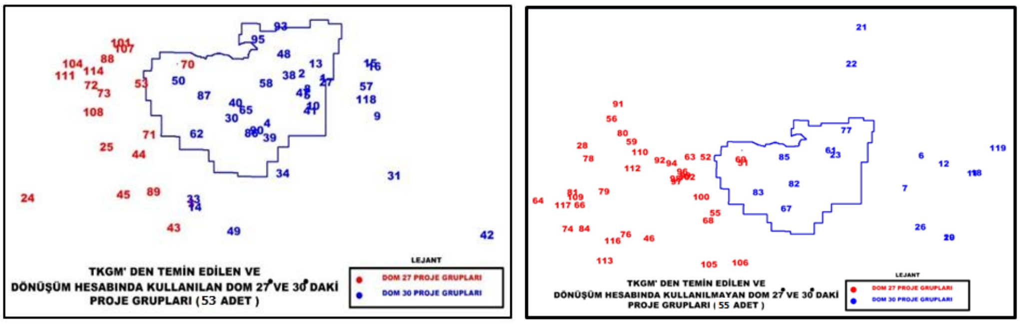


Figure 1 Distribution of TKGM Groups used or not used for Datum Transformation in and nearby M5 Project area.

Again the reason of dual transformation was not to force the groups all together which could cause some deficiencies to the solution. At the end 53 different dual HST datum transformation executed for each selected TKGM Group having 517 points in total and as per the result of these separate transformations 441 GCP found consistent. Together with M3(34)+HGK(12) constrainted points, total number of the JGCPs set to be subjected to HST goes to 487. Again 12 of 487, defined as conjugate and excluded from the set and than the number JGCPs down to 473. A hierarchical datum transformation process started, group or point based elimination applied sequentially based on the Δy:Δx difference classification (Δy:Δx <0.15 ; 0.15< Δy:Δx<0.25 ; 0.25<Δy:Δx<0.50;0.50< Δy:Δx<0.85;0.85< Δy:Δx<1.00; Δy:Δx>1.00m) and continued till no GCP exist causing Δy:Δx bigger than 0.15m. Summary of the HSTs executed are summarized in Table 1.

In addition to above trials ; following the 365 JGCPs HST application an elimination applied for the points having Δy:Δx>1.0m and second considering if any points consistent in a group the other can react in similar manner. Pre-Elimination-1 solution enlarged with all points of the groups used for this solution. Than eliminating the points creating over 1m differences, first and subsequent processes of elimination based on Δy:Δx difference classification applied to the both trials up to no point exist Δy:Δx >0.10m.In this respect two different approch executed and results summarized in Table 2 and 3.

7.1.2. Inductive Approach applications (IA) :

In this approach no enforcement has been envisaged to constraint the solutions. Although located in the 30^0 Central Meridian's TM zone; Ground Control Points of the TKGM groups 5,6,11,12,18,19,20, 21,22 and 23 and TKGM groups 61,67,77,82 and 83 which are not used during dual HST Transformation , In addition to all groups used in deductive approach are included in Joint Ground Control Points set of Inductive approach.

			Number of .... points			Transformation Parameters				Adjust. Statistics		MAXSIMUM		MINIMUM	
JOINT GROUND CONTROL POINTS SET FORMED AS PER THE DUAL HELMERT SIMILARITY TRANSFORMATION SOLUTIONS OF (M3+HGK) AND EACH TKGM GROUP SETS AND SUMMARY OF TRANSFORMATIONS															
Explanations	Solution No	Elimination	Joint	Eliminated	Used	Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx) (m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
M3	M3	Δy:Δx=> 0,5	34	0	34	6,506	0,00010	39,531	156,137	0,057	0,080	0,45	0,16	-0,23	-0,22
DUAL SOLUTNs	M3+HGK↔TKGM M5	CONJUGATE	487	14	473	15,826	-0,00026	47,756	114,365	1,481	2,095	2,71	1,66	-5,50	-2,91
GROUP BASED ELIMINATION	PRE-ELMNT.1	Δy:Δx=> 2m	473	89	384	15,826	-0,00026	47,756	114,365	1,481	2,095	2,71	1,66	-5,50	-2,91
	PRE-ELMNT.2	Δy:Δx=> 2m	384	19	365	4,134	0,00000	33,982	167,447	0,201	0,284	1,15	1,28	-1,93	-1,47
POINT BASED ELIMINATION	PRE-ELMNT.3	Δy:Δx=>0,3m	365	52	313	4,068	-0,00001	34,092	167,737	0,181	0,256	0,67	0,57	-0,46	-0,61
	PRE-ELMNT.4	Δy:Δx=>0,25	313	8	305	3,886	0,00000	34,066	168,547	0,174	0,246	0,50	0,57	-0,44	-0,61
	PRE-ELMNT.5	Δy:Δx=>0,25	305	4	301	3,85	-0,00001	34,268	168,688	0,174	0,241	0,27	0,56	-0,43	-0,62
	PRE-ELMNT.6	Δy:Δx=>0,15	301	29	272	3,798	-0,00002	35,283	168,839	0,164	0,232	0,24	0,55	-0,41	-0,63
	PRE-ELMNT.7	Δy:Δx=>0,3m	272	31	241	4,072	-0,00004	36,654	167,481	0,129	0,183	0,25	0,29	-0,34	-0,34
	PRE-ELMNT.8	Δy:Δx=>0,15	241	95	146	3,891	-0,00003	36,229	168,297	0,090	0,128	0,22	0,23	-0,32	-0,19
	PRE-ELMNT.9	Δy:Δx=>0,15	146	14	132	3,872	-0,00002	35,139	168,465	0,081	0,115	0,21	0,22	-0,23	-0,19
	PRE-ELMNT.10	Δy:Δx=>0,15	132	12	124	3,934	-0,00002	35,267	168,172	0,076	0,107	0,13	0,17	-0,15	-0,15
	PRE-ELMNT.11	Δy:Δx=>0,15	124	3	121	3,961	-0,00002	35,246	168,060	0,074	0,105	0,13	0,15	-0,15	-0,14
	PRE-ELMNT.12	Δy:Δx=>0,15	121	19	102	4,103	-0,00002	34,855	167,462	0,065	0,092	0,13	0,13	-0,10	-0,11
	MEAN(CONJ-PRE-ELMNT 1)		480	52	429	15,826	-0,00026	47,756	114,365	1,481	2,095	2,71	1,66	-5,50	-2,91
	MEAN (PRE-ELMNT.2-7)		323	24	300	3,968	-1,3E-05	34,724	168,123	0,171	0,240	0,51	0,64	-0,67	-0,71
	MEAN(PRE-ELMNT 7-12		153	29	125	3,952	-2,1E-05	35,347	168,091	0,077	0,109	0,16	0,18	-0,19	-0,16
	MEAN(ALL)		264	28	237	5,838	-4,3E-05	37,152	159,576	0,316	0,447	0,70	0,59	-1,16	-0,79

Table 1 . As per the dual deductive solutions, starting with 487 consistent JGCPs Helmert Similarity Transformations, Hierarchic point based elimination of the GCPs based on defined Δy:Δx interval classified and summary of resulting transformation parameters.

		Number of ..... Points			Transformation Parameters				Adjustment Statistics		MAXSIMUM		MINIMUM	
Solution No III	Elimination	Joint	Eliminated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx)(m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
Pre-Elimination 1	Δy:Δx=> 1m	365	34	331	4,374	-4E-05	36,166	166,137	0,175	0,247	0,58	0,51	-0,42	-0,39
Pre-Elimination 2	Δy:Δx=> 0,30m	331	50	281	4,629	-8E-05	38,735	164,738	0,175	0,247	0,58	0,44	-0,43	-0,32
Pre-Elimination 3	Δy:Δx=> 0,2m	281	141	140	4,261	-8E-05	39,479	166,313	0,100	0,141	0,27	0,26	-0,28	-0,24
Pre-Elimination 4	Δy:Δx=> 0,15m	140	26	114	4,074	-8E-05	39,065	167,184	0,100	0,141	0,18	0,21	-0,13	-0,19
Pre-Elimination 5	Δy:Δx=> 0,15m	114	1	113	4,204	-9E-05	39,784	166,535	0,079	0,112	0,14	0,14	-0,13	-0,14
Pre-Elimination 6	Δy:Δx=> 0,15m	113	6	107	4,032	-7E-05	38,830	167,384	0,079	0,111	0,51	0,18	-0,28	-0,28
Pre-Elimination 7	Δy:Δx=> 0,15m	107	4	103	4,060	-8E-05	39,217	167,224	0,071	0,101	0,14	0,17	-0,26	-0,15
MEAN(1,2)		348	42	306	4,502	-0,00006	37,451	165,437	0,175	0,247	0,58	0,48	-0,43	-0,36
MEAN(3,4,5,6,7)		151	36	115	4,126	-8E-05	39,275	166,928	0,086	0,121	0,25	0,19	-0,22	-0,20
MEAN(WHOLE)		207	37	170	4,233	-0,00007	38,754	166,502	0,111	0,157	0,34	0,27	-0,28	-0,24

Tablo 2: Hierarchic HST applications and elimination of 365 JGCPs set based on defined Δy:Δx classification.

		Number of ..... Points			Transformation Parameters				Adjustment Statistics		MAXSIMUM		MINIMUM	
Solution No III	Elimination	Joint	Elimi-nated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx)(m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
Pre-Elimination 1	Δy:Δx=> 0,35	350	35	315	4,116	-4E-05	36,744	167,229	0,180	0,254	0,63	0,48	-0,52	-0,38
Pre-Elimination 2	Δy:Δx=> 0,30m	315	23	292	4,053	-5E-05	36,975	167,494	0,154	0,217	0,36	0,33	-0,34	-0,31
Pre-Elimination 3	Δy:Δx=> 0,25m	292	52	240	4,187	-5E-05	37,108	166,818	0,141	0,200	0,30	0,30	-0,29	-0,28
Pre-Elimination 4	Δy:Δx=> 0,20m	240	60	180	4,181	-4E-05	36,718	166,965	0,121	0,171	0,25	0,26	-0,23	-0,24
Pre-Elimination 5	Δy:Δx=> 0,15m	180	44	136	4,097	-4E-05	36,568	167,340	0,097	0,137	0,20	0,18	-0,16	-0,21
Pre-Elimination 6	Δy:Δx=> 0,15m	136	2	134	4,024	-3E-05	36,112	167,690	0,077	0,109	0,14	0,14	-0,13	-0,18
Pre-Elimination 7	Δy:Δx=> 0,15m	134	0	134	3,989	-3E-05	35,974	167,858	0,076	0,108	0,14	0,14	-0,13	-0,14
MEAN(1,2,3,4,5,6,7)		196	32	165	4,096	-4E-05	36,496	167,334	0,102	0,145	0,21	0,20	-0,19	-0,21

Tablo 3: Hierarchic HST applications and elimination of 350 JGCPs set based on defined Δy:Δx classification.

There are 18 and 53 Groups respectively in 27^0 and 30^0 CM's TM zones. In total 73 TKGM Group are used. Total number of JGCP's set is 573 in addition to 34 an 12 points of M3 General Command of Mapping (HGK) respectively. Total Number of Ground points for Inductive solution goes to 619. Results of Inductive solution and attitude of 34 M3 and 12 HGK points are summarized respectively in Table 4 and 5.

		Number of ..... Points			Transformation Parameters				Adjustment Statistics		MAXSIMUM		MINIMUM	
Solution No VI	Elimination	Joint	Elimi-nated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx)(m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
Solution 1	Δy:Δx=> 0,35	619	219	400	19,867	-0,00020	42,641	96,829	1,826	2,582	3,4	3,28	-14,5	-20,3
Solution 2	Δy:Δx=> 0,30m	400	161	239	6,35	-0,00004	29,812	157,962	0,430	0,609	0,7	1,29	-6,34	-1,68
Solution 3	Δy:Δx=> 0,25m	239	107	132	4,302	-0,00002	32,300	166,833	0,124	0,176	0,23	0,27	-0,33	-0,31
Solution 4	Δy:Δx=> 0,20m	132	8	124	4,074	-0,00002	32,111	167,852	0,075	0,106	0,16	0,12	-0,11	-0,23
Solution 5	Δy:Δx=> 0,15m	124	2	122	4,014	-0,00002	32,275	168,099	0,069	0,097	0,16	0,11	-0,11	-0,14
MEAN(1,2,3,4,5)		165	39	126	4,130	-0,00002	32,229	167,595	0,089	0,126	0,18	0,17	-0,18	-0,23

Table 4 : Inductive approach application summary

	Solution Number									
	TV VI-1		TV VI-2		TV VI-3		TV VI-4		TV VI-5	
	Points Nu	Elmtd Nu	Points Nu	Elmtd Nu	Points Nu	Elmtd Nu	Points Nu	Elmtd Nu	Points Nu	Elmtd Nu
ONS	619	219	400	161	239	107	132	8	124	5
M3	34	0	34	7	27	10	17	0	17	0
HGK	12	6	6	1	5	3	2	0	2	0

Table 5 : 34 M3 and 12 HGK point attitude during Inductive solutions

7.1.3. <u>Unified Solution Approach to create for cumulative Deductive and Inductive Joint Control Point set</u>

In this scope;

- Firstly, from various alternative deductive solutions, using solutions giving similar transformation parameters, some Unified Ground Control Points Sets defined , HST applied , continued till Δy,Δx differences and m_0 obtained respectively less than 0.15m and 0.10m, Unified Deductive Solutions (UDS) created and evaluated
- Secondly Combining some deductive and Inductive solutions -UD/IS- together,a unified JGCPs Set created and similar algorithm given above applied.

SAMPLE TRIAL I: With the unification of M3(34),M3TKGM(30),HGK12 ,Pre-Elimination 102 II-12 and 107 III-7 sets; a 143 UGCPs set achieved. 11 Points having Δy:Δx>0.15m excluded and HST executed .Results are given in Table 6 and Figure 2. Although unified solution used,there are important gaps exist

		Number of ..... Points			Transformation Parameters				Adjust. Statistics		MAXSIMUM		MINIMUM	
Solution No VIII	Elimination	Joint	Elimi-nated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx)(m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
UDS 143 VII-1	Δy:Δx>0,15m	143	11	132	4.029	-0,00004	36,738	167,6	0,081	0,115	0,24	0,21	-0,23	-0,19
UDS 132 VII-2	Δy:Δx>0,15m	132	0	132	4,073	-0,00004	36,631	167,41	0,073	0,104	0,14	0,13	-0,12	-0,13

Table 6: Unified solution VII with 143 and 132 UGCPs set and statistics

Figure 2 : Unified GCPs sets of 143 and 132 points and distribution to project area M5 and gaps

SAMPLE TRIAL II : Another sample is the unification of M3(34),M3TKGM(30),HGK12, Pre-Elimination 102 II-12 ,107 III-7 and UDS VII-2 sets; a new 140 UGCPs set achieved. Hierarchic seven more HST and Point elimination having Δy:Δx>0.15m executed .Point distribution to M5 project area and gaps are given in Table 7 and Figure 3. Again, although a unified solution used there are still important gaps exist.

		Number of ..... Points			Transformation Parameters				Adjust. Statistics		MAXSIMUM		MINIMUM	
Solution No VIII	Elimination	Joint	Elimi-nated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx)(m)	mo (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
UDS 140 VIII-1	Δy:Δx>0,15m	140	11	129	4.012	-0,00003	36,083	167,744	0,082	0,117	0,23	0,20	-0,23	-0,19
UDS 93 VIII-7	Δy:Δx>0,15m	93	0	93	4,117	-0,00002	35,138	167,375	0,059	0,083	0,12	0,12	-0,09	-0,10

Table 7: Unified solution VIII with 140 and 93 UGCPs set and statistics

Figure 3 : Unified GCPs sets of 143 and 132 points and distribution to project area M5 and gaps

SAMPLE TRIAL III: As a sample to Unified Deductive and Inductive Solutions (UD/IS); the GCPs sets of DS 331 Pre-Elimination III-1 and IS 400 Pre-Elimination VI-2 solutions are unified (331 U 400) and a new UGCPs set of 469 points created. After 17 consequtive HSTs execution to UD/IS set to provide a solution which no points exist causing Δy:Δx>0.15m differences in transformation (Solution X). Summary and statistics of solution X are given in Table 8 and Figure 4.

		Number of ..... Points			Transformation Parameters				Adjust. Statistics		MAXSIMUM		MINIMUM	
Solution No VIII	Elimination	Joint	Elimi-nated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx) (m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
UD/IS 469 X-1	Inconsistent	469	3	466	5,963	-0,00003	31,328	159,575	0,407	0,575	0,70	1,38	-6,44	-1,55
UD/IS 207 X-13	Δy:Δx>0,20m	207	67	140	4,086	0,00003	36,075	167,436	0,099	0,104	0,21	0,18	-0,17	-0,20
UD/IS 125 X-17	Δy:Δx>0,15m	125	0	125	4,144	-0,00002	35,287	167,237	0,067	0,094	0,14	0,13	-0,10	-0,13

Table 8 : Summary of Unified Deductive and Inductive Solutions of DS 331 and IS 400 and statistics

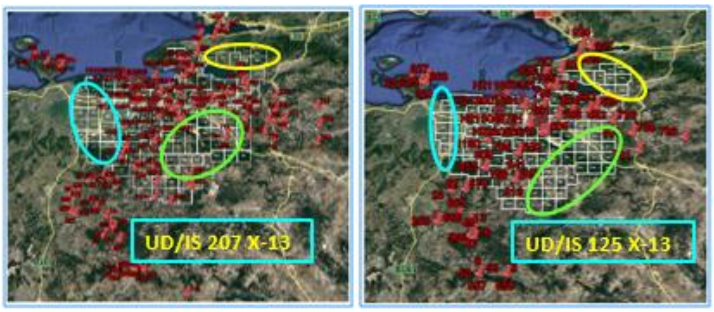


Figure 4 : Unified Deductive and Inductive Solutions of DS 331 and IS 400, distribution to project area M5 and gaps

CONCLUSIONS

as per the all HSTs realized up to now,

- Consistent differences (Δy:Δx $\leq$ 0.15m) and statistics ($m_0 \leq 0.10$m) can be obtained only with a set of points in between 120-140 pieces which are %90 common in the all the consistent HST solutions,
- When the JGCPs sets distribution of HST's are checked there are gaps or deficiencies in North East, South East and North West parts of M5 Project area.
- Actually one of the important goal of Unified solution is to protect the solutions from any point distribution deficiencies,but cause there is not any points or groups exist over that zones, problems can not be overcomed.
- As per the result of HSTs we can simply conclude ;
    - Although there are too many common points in both datum, existence of limited solutions satisfying the technical constraints are not cause of Logical approach , transformation and adjustment models , but cause of the distribution of common points to M5 Project area and accuracy deficiencies especially with ED-50 Coordinates.

- So in order to better satisfy the distribution problem a decision maker intervention without taking into account the statistical constraint of Δy:Δx<0.15m. is a must.
- *As per this conclusion;*
    - Some points which are used previous transformation but cause of thr negative effects on statistics excluded from JGCPs set , re-selected manually to provide a firm distirubition and fill the gaps.
      A new set of 146 JGCPs is formed, point distribution and statistics are given respectively Figure 5 and Table 9.

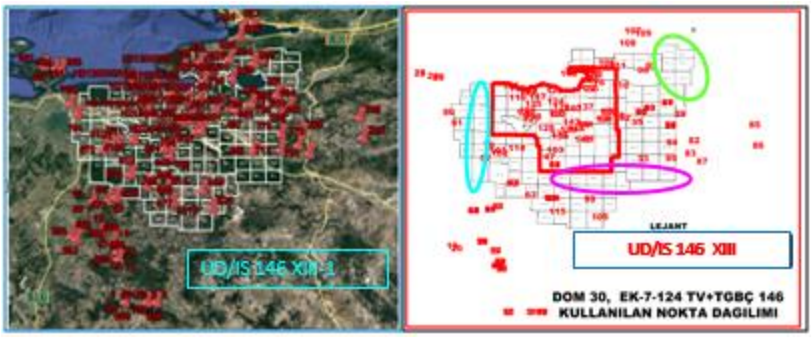


Figure 5 : UD/IS 146 XIII-1 Solution's Point Distribution to M5 Project area

		Number of ..... Points			Transformation Parameters				Adjust. Statistics		MAXSIMUM		MINIMUM	
Solution No XIII	Elimination	Joint	Elimi-nated	Used	1+Δ ppm (Scale	(α) (grad)	Cy (Δy) (m)	Cx (Δx) (m)	m0 (m)	mp (m)	(Δy) (m)	(Δx) (m)	(Δy) (m)	(Δx) (m)
UD/IS 146 XIII-1	Δy:Δx>? m	146	8	138	3,970	-0,00005	37,106	167,84	0,106	0,15	0,30	0,34	-0,38	-0,31

Table 9: UD/IS 146 XIII-1 Solution and statistics .

As it is clear; best point distribution to project area but less accurate statistics achieved. This transformation decided as the main solution for M5 project area.

- When (Δy, Δx) differences checked, detected issues are summarized below;
    - In some TKGM groups; where differences are in statistical limits based on the defined Transformation parameters, so these groups are used mostly for all HSTs and named as Groups used for Datum Transformations.
    - In some groups it is observed that each group points or the group itself showing big differences mostly bigger than 1.0m and can not be explained with an observation error of former triangulation network or adjustment deficiencies. Probably they are cause of the gross errors or most likely have systematic charecteristics. (Groups not used for the datum transformations)

- In some groups, while some points having acceptable Δy:Δx differences, some points are showing big and beyond the acceptable limits differences , most likely having systematic characteristic. (Groups partly used for the datum transformations)
- Cause the groups or points excluded from transformations set, exported to the EQC set.

Helmert Similarity Transformation External Quality Control (EQC)

Geodetic EQC for HSTs : *First step of EQC is the geodetic external quality control. For this purpose 20 best fitting HST's selected for the EQC process and adjusted transformation parameters*

are given in Annex 1.

SELECTED 2D HSTs			
102 Pre Elm. II-12>0,15	DS 124 VI-5>0.15m	UD/IS 125 X-17	UD/IS 140 XI-6
114 Pre Elm. III-6>0,15	UDS VII-1 143	UDS 93 VIII-7	UD/ID 142 XII-3
107 Pre Elm. III-7>0,15	UDS VII-2 132	UDS 2005.0 140 IX-1	UD/IS 147 XIII-1
136 Pre Elm. IV-6>15	UDS 140 VIII-1	UDS 2005.0 93 IX-13	UD/IS 139 XIII-3
DS 132 VI-4>0.15m	UDS 127 VIII-3	UD/IS 140 X-17	UD/IS 146 XIV

Table 10 : Selected HSTs for the external quality control

For each group; Δy:Δx differences in between known and computed positions calculated via related group's transformation parameters and classified as per the defined class intervals. During EQC process; JGCPs used for the HST are excluded from the EQC JGCP's set. EQC process executed as per the pre-explained run stream of ”0,-1,A,B and D”. Below as asample HST with 102 and 146 JGCPs are explained

EQC with all group points JGCP's set except used in HST's JGCPs set of 102 Points(”0” Coded EQC): This process implemented with 785 JGCP of 106 TKGM Groups. Achieved with the exclusion of 102 HST and 146 points from the total 887 points of 106 TKGM Group. Δy:Δx differences distribution to class intervals and resulting statistics are given in Table11 and Table12. In Table 12 based on the computed wiegth center's of each TKGM Goup some more statistics included.

POINT BASED EQC				
102 Pre-Elmnt II-12: HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	57	37	1,2,3,5,10,14,27,30,33,38,40,43,44,47,48,49,55,57,58,61, 62, 67,68,71,82,83,85,86,89,90,93,94,95,101,105,106,107	7,3
0,15<ΔY:ΔX<0,25	120	43	1,3,5,10,13,14,27,30,33,40,41,43,44,47,48,49,50,51,52,55,57,58,61, 62,65, 67,68,69,70,71,77,82,83,85,86,87,89,90,93,101,105,106,107	15,3
0,25<ΔY:ΔX<0,50	191	54	1,2,3,4,5,10,13,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,51, 52,53,55,57,63,65,67,68,69,70,71,73,77,82,83,86,87,88,90,93,95,96, 97,99,100,101,102,105,106,108	24,3
0,50<ΔY:ΔX<0,85	104	34	4,10,25,28,46,47,50,51,52,53,63,65,68,72,73,77,78,81,88, 90,91,94,96,97,98,99,100, 102,104,108,109,110,111,112	13,2
0,85<ΔY:ΔX<1,00	39	18	24,28,59,66,72,78,79,81,94,96,97,98,104,109,110,111,112,116	5,0
ΔY:ΔX>1,0	193	29	6,7,8,9,11,12,15,16,18,19,21,22,23,26,31,34,39,42, 56,64,74,76,84,92,103,113,114,118,119	24,6
	81	14	24,25,46,59,66,79,81,91,97,109,110,111,112,116	10,3
TOTAL	785			

POINT BASED EQC				
UD/IS 146 XIV: HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	42	39	1,2,3,5,10,14,27,30,33,38,40,43,44,47,48,49,55,57,58,61, 62,65,67,68,71,82,83,85,86,87,89,90,93,94,95,101,105,106,107	6%
0,15<ΔY:ΔX<0,25	106	41	1,3,5,10,13,14,27,30,33,40,41,47,48,49,50,51,52,53,55,57,58,61 ,62,65,67,68,69,70,71,77,82,83,85,86,87,89,90,93,101,106,107	14%
0,25<ΔY:ΔX<0,50	173	51	1,2,3,4,5,13,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,5 1,52,53,55,57,63,65,67,68,69,70,71,77,82,83,86,87,88,90,93,95, 97,99,100,101,102,105,106,108	23%
0,50<ΔY:ΔX<0,85	98	29	4,10,25,28,46,47,52,63,65,68,72,73,77,78,81,88, 90,91,94,96,97,98,99,100,102,104,108,110,112	13%
0,85<ΔY:ΔX<1,00	26	18	24,28,59,66,73,78,79,81,94,96,97,98,104,109,110,111,112,116	4%
ΔY:ΔX>1,0	193	29	6,7,8,9,11,12,15,16,18,19,21,22,23,26,31,34,39,42, 56,64,74,76,84,92,103,113,114,118,119	26%
	103	18	24,25,28,46,59,66,72,78,79,81,91,94,97,109,110,111,112,116	14%
TOTAL	741			

Table 11: External QC of 102 JGCPs HST's and UD/IS 146 XIV with 785 Points of 106 TKGM Groups

102 Pre Elmnt II-12 HST EQC	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	7,229	2,737	7,082	2,624	7,229	2,737	7,404	7,082	2,624	7,154
MINIMUM	-2,042	-1,504	-1,593	-1,199	0,001	0,001	0,018	0,033	0,034	0,088
MEAN	0,738	0,491	0,970	0,526	1,186	0,585	1,432	1,421	0,623	1,653
m0	1,625	0,584	1,938	0,582	1,506	0,523	1,507	1,771	0,522	1,762

UD/IS 146 HST EQC	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	7,258	2,732	7,116	2,609	7,258	2,732	7,397	7,116	2,609	7,177
MINIMUM	-2,011	-1,574	-1,571	-1,247	0,001	0,001	0,018	0,045	0,028	0,086
MEAN	0,734	0,519	0,970	0,552	1,198	0,603	1,458	1,432	0,639	1,678
m0	1,632	0,595	1,947	0,586	1,507	0,539	1,508	1,776	0,530	1,758

Table 12: External QC of 102 and 146 Statistics of JGCPs HST's with 785 Points of 106 TKGM Groups

Cause there is not any point having $\Delta y:\Delta x > 0.15$m exist, all 102 points of HST 102 II-12 transformation adjustments are in the first class interval($\Delta y:\Delta x < 0.15$m) and based in 28 group. But for UD/IS 146 HST EQC based on to provide a good covarage for the transformation there are while 127 points were in first group of $\Delta y:\Delta x < 0.15$, 9 and 10 groups are respectively based in the second and third classes.

Analysis of EQC Groups and Points having $\Delta y:\Delta x > 1.0$m differences ("-1" Coded process): As it is clear from Table 11 and 12, there are too many points having differences greater than 0.15m. In principle these points can not be used in EQC process . But only 7.3% and 6% of the total points are in this class and the rest 92.7% and 94% should be excluded from the EQC JGCPs set respectively for 102 II-12 HST and UD/IS 146 XIV solutions. So this is the signal of some problems or gross errors. With this understanding a special care is given to $\Delta y:\Delta x > 1.00$m points and groups. There are 193 points in 29 Groups in both solution which all points in these groups are totally greater than 1.00m and where 81 points in total 137 points of 14 groups are partly greater than 1.00m for 102 Pre Elmnt II-12 and 103 points in total 171 points of 18 groups are partly greater than 1.00m for UD/IS 146 XIV. Shortly 274 Points or 34.9% and 296 Points or 40% of total 785 points are gretaer than 1.00m.

Evaluation from Plate tectonic point of view:

Anatolian Peninsula is one of the most active region in the world from the tectonic point of view. Bursa Project area is just located on north west part of Turkey , where the North Anatolian Fault Zone west end and some other active faults zones exist. Anatolian Plate tectonic and active fault zones, latest 50 years earthquakes having greater magnitudes than 6.0 and Kocaeli and Duzce Earthquakes half elastic space co-seismic effects are respectively given in Figure 6,7 and 8.

Very Simple Modelling for GCPs displacements, as per the Figures and Table given:

- Turkish triangulation network adjustment realized in 1954 . So we can simply accept till 2015 , 59 years past since the points establishment.
- Anatolian Plateapproximate velocity to west south direction is 2.5 cm/year , so the skalar value of displacement vector will be around (IΔsI = 0.025m/year * 59year =) 1.475 m .
- In this respect displacement vector $I\Delta s_{i}I_{ED50}$ (i=1,n n= 274)values of Pi (Yi , Xi) $_{ED50}$ points are controlled if they are in the range of $I\Delta s_{i}I_{ED50}$ < 1,475 m .
- It is found ;At 191 points $I\Delta s_{i}I_{ED50}$ >1,475 m , and at 83 $I\Delta s_{i}I_{ED50}$ < 1,475 m.
- If it conclude that at 83 points displacement vector skalar values are comply with the velocity field foundings. But the rest or the greater displacement values at 191 points can not be explained with velocity field effects.
- So if we consider approximately known co-seismic effects of Izmit and Düzce Earthquakes which are in between 0.30 to 0.0 meters and the other two important earthquake namely Yenice-Gönen ve Manyas nearly in the project area possibly effected the positions at least Kocaeli Earthquake. If we consider co-seismic effects and accept Yenice and Manyas both located in west part of M5 and have similar amount of effect in similar direction and Kocaeli located east part of M5 project in counter direction and approximately similar amount of effect on the displacement vector.Simply we can only consider Manyas effect (A+A-A=A) of approximately 0.30 cm. as total displacement vector of co-seismic effect. So we can conclude 1.475m Velocity and 0.30m Manyas co-seismic total effects as +0.30 in east and -0.30 in west direction relative to focal point ; 1.475-0.30m<Δs<1.475+0.30m ; 1.175m< Δs<1.775m
- Last but not the least cause most of the GCPs are III order triangulation points, established after Triangulation network adjustment of 1954. If we assume the First Production of 1/5000 sheets in 1975 and points established at same date than the velocity field effect will be 1.00m to displacement vectors. Together with co-seismic effect total displacement could be in the range of 0.70m< Δs<1.30m
- The groups having Δy:Δx>1.0m displacement vectors are shown In figure 10 as the groups disqualifed and partly used in EQC Process.

- If we back to 102 Pre-Elimination II-12 and UD/IS 146 XIV HSTs EQC solutions Table 11 and 12 and combine the results Anatolian Plate velocity field and co-seismic effects ;
  - Based on both EQC solutions, For the point's located in Table 11 Class Six Difference interval of $\Delta y:\Delta x>1.0$m and the group's weigth center where these points are; displacement vectors are defined as per the HST and shown in Figure 9.
  - As it is clear; except the number of group's weight centers , scalar values for common groups and directions are mostly similar in both solution.
  - Again , What is interesting are ;
    - Where all Partly Used Group's Δs vectors of $\Delta y:\Delta x<2$ -except one- are in TM zone of 27^0 CM , while unused Δs vectors of $\Delta y:\Delta x>6$m are all placed in TM zone of 30^0 CM,
    - Where all Partly used groups and Un-used 8 group of $\Delta y:\Delta x<2$, in TM zone of 27^0CM and one in 30^0 CM , the rest 20 groups are in ; TM zone of 30^0 CM
  - Based on these foundings ; it can be conclude some partly used group's or points located in these groups can satisfy 1.175m< Δs<1.775m condition and can be considered as a EQC control points , but the rest should be studied again cause of some gross errors. By the way for Kocaeli earthquake of 7.4 magnitude co-seismic effect measured as approximately 6.5m in both lateral. So Δs vectors can only be in the range of 6m at the focal point.
  - So it is decided to exclude all points having $\Delta y:\Delta x>1.0$m from the set of EQC JGCPs.
  - Δs displacement vectors computed with $\Delta s_{ED50} = \sqrt{(\Delta Yi^2 + \Delta Xi^2)}ED50$

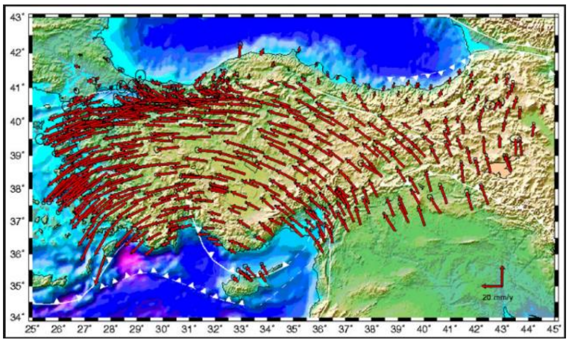


Figure 6: Plate Tectonic of Anatolian Peninsula and Anatolian Plate Velocity Field

Location	Date	Mag.	Dist. ToPrj. Area(km)	Location	Date	Mag.	Dist. ToPrj. Area(km)
YENİCE-GÖNEN	18.03.1953	7.4	120	AKYAZI	30.07.1967	6.0	144
ESKİŞEHİR	20.02.1956	6.4	134	DEMİRCİ	23.03.1969	6.1	132
BOLU-ABANT	26.05.1957	7.1	195	ALAŞEHİR	28.03.1969	6.6	210
ÇINARCIK	18.09.1963	6.3	50	KOCAELİ	17.08.1999	7.4	110
MANYAS	06.10.1964	7.0	95	BOLU-DÜZCE	12.11.1999	7.2	193
ADAPAZARI	22.07.1967	6.2	133	ÇANKIRI-ORTA	06.06.2000	6.1	346

Figure 7: Latest 50 Year Earthquakes in and around M5 Project area

Co-seismic effects half elastic space modelling for İzmit 1999 and Düzce 1999 Earthquakes

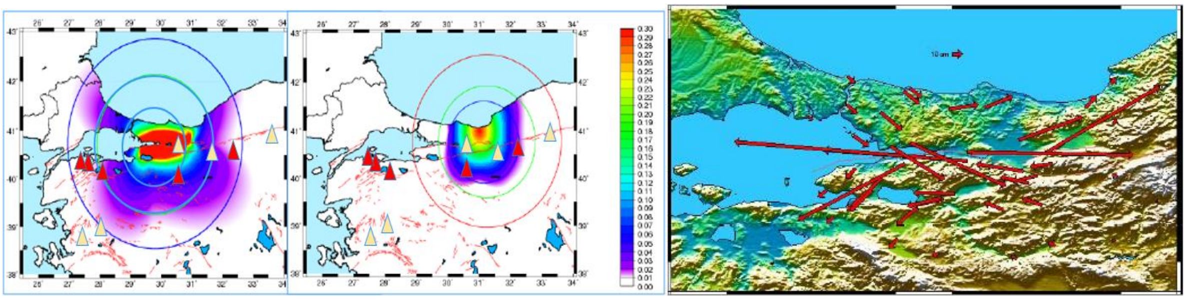


Figure 8: Half elastic space modelling for Co-seismic effects of İzmit 1999 and Düzce 1999 Earthquakes.

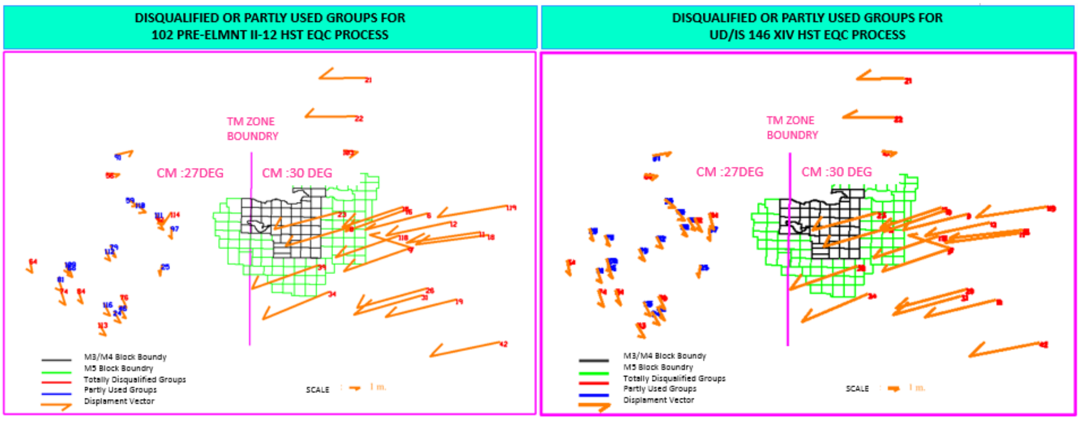


Figure 9 : Based on 102 Pre-Elmnt II-12 and UD/IS 146 XIV HST EQC process ,Disqualified or Partly used groups, cause of Δy:Δx>1.0m,

”A” Coded EQC Process : EQC Process implemented after exclusion of the points and groups of Δy:Δx>1.0m . New Δy:Δx differences and distribution of 102Pre-Elmnt II-12Aand UD/IS 146XIVA and new Δs displacement vectors for the project area are given in Table 13 and Figure 10.

POINT BASED EQC				
102 Pre-Elmnt II-12"A" : HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	57	37	1,2,3,5,10,14,27,30,33,38,40,43,44,47,48,49,55,57,58,61, 62, 67,68,71,82,83,85,86,89,90,93,94,95,101,105,106,107	11%
0,15<ΔY:ΔX<0,25	120	43	1,3,5,10,13,14,27,30,33,40,41,43,44,47,48,49,50,51,52,55,57,58,61, 62,65, 67,68,69,70,71,77,82,83,85,86,87,89,90,93,101,105,106,107	23%
0,25<ΔY:ΔX<0,50	191	54	1,2,3,4,5,10,13,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,51, 52,53,55,57,63,65,67,68,69,70,71,73,77,82,83,86,87,88,90,93,95,96, 97,99,100,101,102,105,106,108	37%
0,50<ΔY:ΔX<0,85	104	34	4,10,25,28,46,47,50,51,52,53,63,65,68,72,73,77,78,81,88, 90,91,94,96,97,98,99,100, 102,104,108,109,110,111,112	20%
0,85<ΔY:ΔX<1,00	39	18	24,28,59,66,72,78,79,81,94,96,97,98,104,109,110,111,112,116	8%
TOTAL	511			

POINT BASED EQC				
UD/IS 146 XIV "A" : HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	42	39	1,2,3,5,10,14,27,30,33,38,40,43,44,47,48,49,55,57,58,61, 62,65,67,68,71,82,83,85,86,87,89,90,93,94,95,101,105,106,107	9%
0,15<ΔY:ΔX<0,25	106	41	1,3,5,10,13,14,27,30,33,40,41,47,48,49,50,51,52,53,55,57,58,61 ,62,65,67,68,69,70,71,77,82,83,85,86,87,89,90,93,101,106,107	24%
0,25<ΔY:ΔX<0,50	173	51	1,2,3,4,5,13,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,5 1,52,53,55,57,63,65,67,68,69,70,71,77,82,83,86,87,88,90,93,95, 97,99,100,101,102,105,106,108	39%
0,50<ΔY:ΔX<0,85	98	29	4,10,25,28,46,47,52,63,65,68,72,73,77,78,81,88, 90,91,94,96,97,98,99,100,102,104,108,110,112	22%
0,85<ΔY:ΔX<1,00	26	18	24,28,59,66,73,78,79,81,94,96,97,98,104,109,110,111,112,116	6%
TOTAL	445			

Table 13: ”A” Coded External QC of 102Pre-Elm.II-12A and UD/IS 146 XIVA with 106 TKGM Groups

After exclusion of Δy:Δx>1.0m points with 511 and 445 JGCPs respectively for 102 Pre-Elmnt II-12A and UD/IS 146 XIVA HST EQC process are executed. Final Δy:Δx values are clasified, displacement vectors are calculated . Statistics are given in Table 14.

From Figure 10, complicated active fault zones activities are clear. There is a great similarity for the both solution results. Again many different activities can explicitly be evaluated if Fault zones , graben systems are known. It is believed if we limited the Δy:Δx differences <0.15cm to reach such an explicit figure can not be reached.

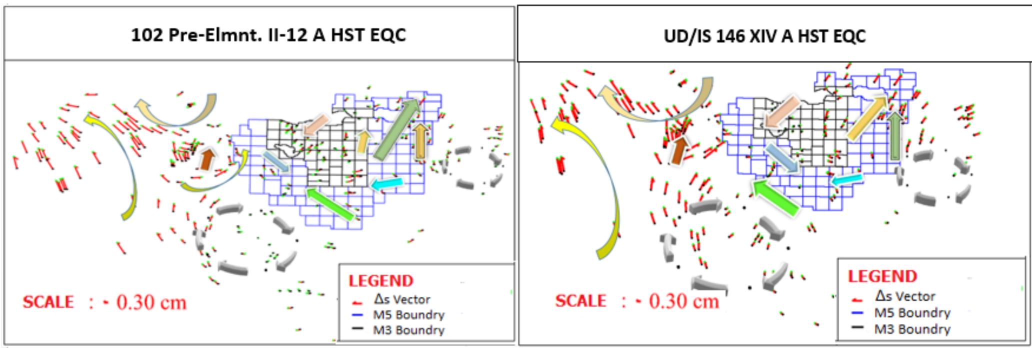


Figure 10: 102 Pre-Elmnt II-12A and UD/IS 146 XIVA HST EQC process with Δy:Δx<1.0m Points,

102 Pre Elmnt II-12"A" HST EQC	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	0,871	0,999	0,375	0,932	0,976	0,999	1,264	0,957	0,932	1,264
MINIMUM	-0,976	-0,512	-0,957	-0,386	0,001	0,001	0,018	0,010	0,013	0,090
MEAN	-0,135	0,182	-0,153	0,232	0,257	0,291	0,426	0,281	0,327	0,455
m0	0,236	0,276	0,234	0,265	0,161	0,198	0,219	0,154	0,195	0,225
UD/IS 146 "A" HST EQC	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	0,862	0,978	0,362	0,978	0,972	0,978	1,322	0,950	0,978	1,322
MINIMUM	-0,972	-0,464	-0,950	-0,336	0,005	0,001	0,018	0,033	0,047	0,085
MEAN	-0,134	0,197	-0,164	0,260	0,265	0,289	0,432	0,297	0,342	0,476
m0	0,244	0,266	0,247	0,273	0,159	0,200	0,213	0,162	0,216	0,247

Table 14: ”A” Coded External QC of 102Pre-Elm.II-12A and UD/IS 146 XIVA process statistics

”B” Coded EQC Process : Cause the BMM’s main AOI is limited with M5 project external boundry, points out of this boundry are excluded from EQC JGCPs set .

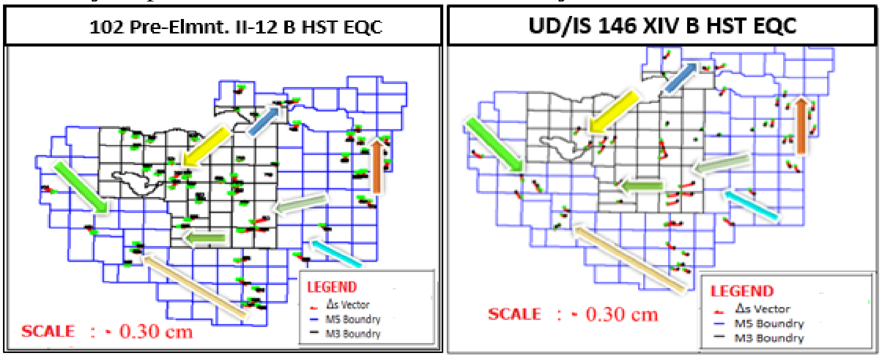


Figure 11: 102 Pre-Elmnt II-12B and UD/IS 146 XIVB HST EQC process limited with M5 Boundry

POINT BASED EQC				
102 Pre-Elmnt II-12"B" : HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	16	6	1,27,58,62,85,95	3%
0,15<ΔY:ΔX<0,25	28	13	1,5,27,30,40,47,48,58,62,85,86,90,93	5%
0,25<ΔY:ΔX<0,50	48	17	1,2,3,5,27,30,33,38,40,47,48,57,71,86,90,93,95	9%
0,50<ΔY:ΔX<0,85	2	2	48	0%
TOTAL	94			

POINT BASED EQC				
UD/IS 146 XIV "B" : HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	8	3	58,67,95	2%
0,15<ΔY:ΔX<0,25	41	19	1,3,5,10,13,27,40,41,47,48,50, 62,65, 67,71,85,86,87,93	9%
0,25<ΔY:ΔX<0,50	57	21	1,2,5,13,27,40,41,47,48,50,57,65,67,71,77,85,86,87,93	13%
0,50<ΔY:ΔX<0,85	5	4	47,65,77,90	1%
TOTAL	111			

Table 15: ”B” Coded External QC of 102Pre-Elm.II-12B and UD/IS 146 XIVB limited with M5 Boundry

102 Pre Elmnt II-12"B" HST EQC	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	0,392	0,720	0,251	0,336	0,599	0,720	0,756	0,396	0,336	0,415
MINIMUM	-0,599	-0,293	-0,396	-0,242	0,001	0,008	0,018	0,010	0,086	0,100
MEAN	-0,098	0,055	-0,040	0,075	0,164	0,180	0,278	0,153	0,199	0,275
m0	0,159	0,178	0,146	0,164	0,121	0,086	0,090	0,089	0,074	0,057

UD/IS 146 "B" HST EQC	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	0,419	0,724	0,328	0,321	0,622	0,724	0,756	0,452	0,342	0,474
MINIMUM	-0,622	-0,275	-0,452	-0,230	0,005	0,001	0,033	0,008	0,010	0,085
MEAN	-0,126	0,033	-0,062	0,060	0,201	0,176	0,303	0,174	0,184	0,280
m0	0,182	0,179	0,159	0,160	0,124	0,088	0,090	0,097	0,074	0,059

Table 16: ”B” Coded External QC of 102Pre-Elm.II-12B and UD/IS 146 XIVB process statistics

As the JGCPs set is getting smaller , statistics sounds getting good , this situation can not be reflect the real situation in the field and cause some un-realistic evaluations and conclusions.

”C” Coded EQC Process : Cause the BMM’s main AOI is limited with M5 project external boundry, points out of this boundry are excluded from EQC JGCPs set .

After introducing M5 boundry limit points with 94 and 111 JGCPs respectively for 102 Pre-Elmnt II-12B and UD/IS 146 XIVB HST EQC process are executed. Final Δy:Δx values are clasified, displacement vectors are calculated . Statistics are given in Table 15.

From Figure 11, some complicated active fault activities are clear. There is a great similarity for the both solution. Again many different activities can explicitly be evaluated if Fault zones , graben systems are known. It is believed if we limited the Δy:Δx differences <0.15cm to reach such an explicit figure can not be reached.

POINT BASED EQC				
102 Pre-Elmnt II-12"C" : HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	48	21	1,3,27,33,49,55,57,58,61,62,67,68,82,83,85,94,95,101,105,106,107	9%
0,15<ΔY:ΔX<0,25	89	35	1,3,5,10,13,14,27,30,33,40,41,47,48,49,50,51,52,57,58,61,62,65,67, 69,70,77,82,83,85,86,87,89,90,93,107	17%
0,25<ΔY:ΔX<0,50	126	38	1,2,3,4,5,10,13,27,30,33,38,40,41,44,47,48,49,50,51,52,55,57,65,67, 68,69,70,71,77,82,83,86,87,90,93,95,99,100	25%
0,50<ΔY:ΔX<0,85	10	8	4,10,47,50,51,65,77,90	2%
TOTAL	273			

POINT BASED EQC				
UD/IS 146 XIV "C" : HST EQC AND ABS(Δy.Δx) DIFFERENCES CLASSIFITION				
CLASS INTERVAL	NOP	NOG	GRUP ID NUMBER	%
ΔY:ΔX=<0,15	34	15	3,14,33,49,55,58,61,67,68,82,83,89,95,105,106	8%
0,15<ΔY:ΔX<0,25	87	35	1,3,5,10,13,14,27,33,40,41,47,48,50,51,52,53,55,57,58,61, 62,65,67,68,69,70,71,82,83,85,86,87,93,101,107	20%
0,25<ΔY:ΔX<0,50	103	38	1,2,3,4,5,13,14,27,30,33,38,40,41,44,47,48,49,50,51,52,53, 55,57, 63,65,67,68,69,70,71,77,82,83,86,87,90,99,100	23%
0,50<ΔY:ΔX<0,85	8	6	4,10,47,65,77,90	2%
TOTAL	232			

Table 15: ”C” Coded External QC of 102Pre-Elm.II-12C and UD/IS 146 XIVC limited with

the points of the groups used for Transformations.

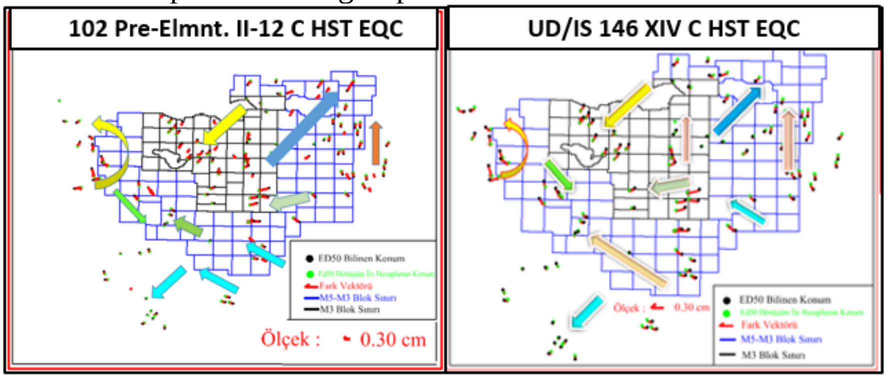


Figure 12: 102 Pre-Elmnt II-12C and UD/IS 146 XIVC HST EQC process limited with the Transformations Groups

102 Pre Elmnt II-12"C"	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
HST EQC	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	0,430	0,720	0,430	0,408	0,619	0,720	0,756	0,455	0,408	0,472
MINIMUM	-0,619	-0,512	-0,455	-0,352	0,001	0,001	0,018	0,010	0,001	0,025
MEAN	-0,079	-0,005	-0,017	0,022	0,176	0,176	0,280	0,173	0,173	0,267
m0	0,171	0,176	0,145	0,145	0,107	0,097	0,098	0,087	0,088	0,083

UD/IS 146 "C"	DIFFERENCES		GROUP'S WC		ABSOLUTE DIFF.			ABS DIFF FOR GWC		
HST EQC	ΔY	ΔX	ΔY	ΔX	ΔY	ΔX	Δs	ABS(ΔY)	ABS(ΔX)	Δs
MAXSIMUM	0,427	0,724	0,427	0,499	0,622	0,724	0,756	0,452	0,499	0,601
MINIMUM	-0,622	-0,464	-0,452	-0,336	0,005	0,001	0,018	0,033	0,039	0,059
MEAN	-0,090	0,004	-0,023	0,031	0,186	0,169	0,283	0,185	0,173	0,273
m0	0,179	0,169	0,157	0,146	0,111	0,091	0,091	0,090	0,079	0,082

Table 16: ”C” Coded External QC of 102Pre-Elm.II-12C and UD/IS 146 XIVC process statistics

Cartographic External Quality Control : The goal of this process are ; to check If realized transformation is sufficient to which extent ? and if any edge matching problem exist in between the new and former cartographic products over neighbouring zones.Process is realized in two phase.

Phase 1 : With the points defined in M3 project area, but not used in JGCP set of HST, inspection of inside power of transformation parameters at M3 project,

Phase 2 : Control if any edge matching problem exist in boundry zones in between M3 and M5 Projects.

Phase 1: Control the power of transformation inside the M3 Project area .16 firmly distributed GCPs selected as sharp objects from Digital Line maps,Coordinates of these GCPs measured in ITRF96 and ED50 datums from Digital Line Maps and used as Cartographic Control Points Set (CCPS) for transformation. UD/IS 146 HST transformation parameters used to transform this set to M3ED50 and compared with the measured ones. Result are given in Table 17 and Table 18. As can be seen from the tables although some points has diffrences up to -0,220m in M3 and

-0,275m in M5 for the known and transformed coordinates, differences in between Transformed coordinates in ED50 datum are all less than Δy:Δx<0.15m. So Both transformation are compatible to each other for M3ProjectArea.

	ED50 WITH JGCP:34 WITH M3 TR			ED50 WITH JGCP :146 M5 TRANS. PR			WITH JGCP 34 AND 146 PRMT.s		
	(KNOWN- COMP)ED50			(KNOWN- COMP)ED50			(COMP M3-COMP 146) ED50		
	Y-Y'M3(34)	X-X'M3(34)	Δs	Y-Y'M5(146)	X-X'M5(146)	Δs	Y'M3-Y'M5	X'M3-X'M5	Δs
MAKSİMUM	0,076	0,095	0,281	0,118	0,039	0,364	0,083	-0,002	0,115
MİNİMUM	-0,220	-0,187	0,060	-0,239	-0,275	0,000	-0,080	-0,111	0,019
ORTALAMA	-0,075	-0,083	0,151	-0,086	-0,152	0,204	-0,011	-0,069	0,091
m0	0,064	0,074	0,056	0,102	0,098	0,106	0,047	0,027	0,021

Table 17: Difference control statistics at M3(ED50) datum in between M3(34) and M5(146) Transformation parameters.

	WITH M3 34 TRANS PRMTs			WITH M5 146 TRANS PRMTs			M3 34&M5 146 dΔy:dΔx DIFF.		
	POINT BASED CLASSIFICATION			POINT BASED CLASSIFICATION			POINT BASED CLASSIFICATION		
	ΔY	ΔX	Δs	ΔY	ΔX	Δs	ΔY	ΔX	Δs
Δy:Δx<0,15	9	6	7	9	6	6	16	16	16
0,15<Δy:Δx<0,25	7	8	8	7	7	1			
0,25<Δy:Δx<0,50		2	1		3	9			
TOPLAM	16	16	16	16	16	16	16	16	16

Table 18: Classification of differences

Phase 2: CARTOGRAPHIC CONTROLS

- Control the power of transformation over boundry zones in between M3 and M5 Project area. 98 firmly distributed Cartographic details selected as Cartographic Control Points Set(CCPS) in M5 Project area including M3 Project area respectvly over boundry zones , in west-east and north-south direction to see if any edge matching problem exist and to inspect the changes of the differences over cross sections direction.Coordinates measured both in ITRF96 and ED50 datums and used as Cartographic Control Points Set(CCPS) for transformation. UD/IS 146 HST transformation parameters used to transform this set to M3ED50. In addition 102 Pre-Elmnt II-12 HST to inspect different new induced parameters difference (M5(102)-M5(146). These values are compared to eachothers. Results for CCPS and distrubution to M5 project area are respectively given in Table 18 and Table 19.

CCPS 98	HELMERT SIMILARITY TRANS. M3(34)ED50-M5(146)ED50			ED50 DIFFERENCES OF TRANS. M5(102)-M5(146)			HELMERT SIMILARITY TRANS. M3(34)ED50-M5(102)ED50		
	Δy	Δx	Δs	Δy	Δx	Δs	Δy	Δx	Δs
MAXIMUM	0,228	0,091	0,282	0,047	0,050	0,053	0,224	0,115	0,296
MINIMUM	-0,184	-0,276	0,007	-0,022	-0,029	0,002	-0,193	-0,288	0,002
MEAN	0,026	-0,097	0,159	0,013	0,009	0,030	0,013	-0,106	0,165
m0	0,088	0,080	0,066	0,015	0,017	0,011	0,088	0,089	0,069

Table 18: Difference control statistics at 98 CCPS at M3(ED50) datum in between M3(34),M5(146) and M5(102) Transformation parameters

HELMERT SIMILARITY TRANS.	M3(34)ED50-M5(146)ED50		
	dΔY	dΔX	dΔs
Δy:Δx<0,15	90	62	39
0,15<Δy:Δx<0,25	8	25	39
0,25<Δy:Δx<0,50		11	20
TOPLAM	98	98	98

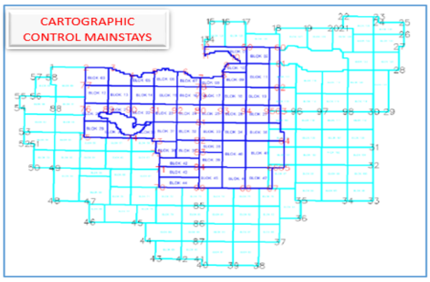


Table 19: Classification of the M3(34)$_{ED50}$ – M5(146)$_{ED50}$ transformed coordinate differences and CCPS distribution in M5 project area

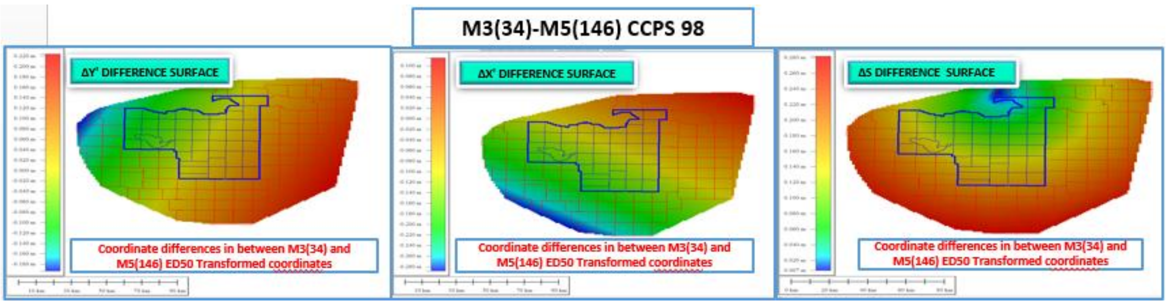


Figure 13: Difference surface of M3(34)-M5(146) in ED50

For M3-M5(146) ; some points has diffrences up to -0,276m and 0,228m for the known and transformed coordinates at ED50. Similar differences are also exist for the differences in between M3-M5(102). But the differences for M5(102)-M5(146) transformed coordinates to ED50 are reasonably small and less than Δy:Δx<0.15m. So where both M5 transformation are compatible to each other, M3 transformation, while it is working properly within the project area as expected, creates problems when it starts to move away from the M3 Boundries.

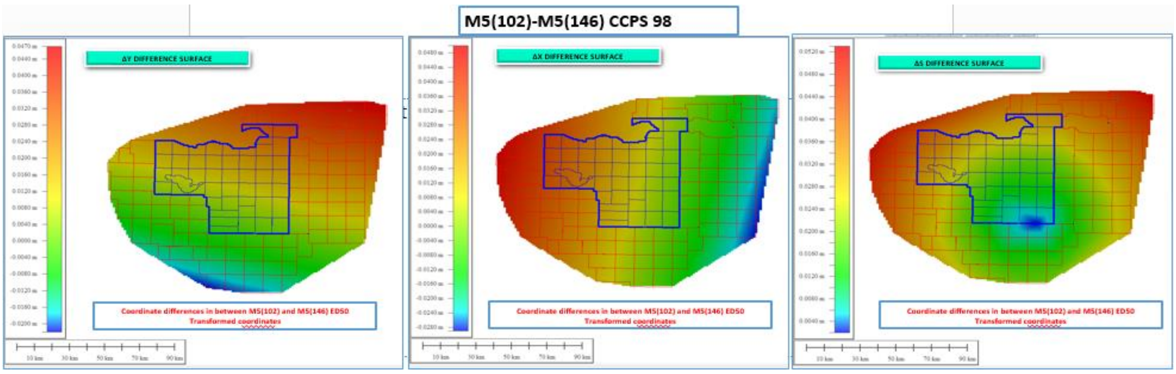


Figure 14: Difference surface of M5(102)-M5(146) in ED50

- Similar controls are executed for the 30 CCPS just located on M3/M5 Boundry. Resulted statistics are given in Table 20 and Table 21.

CCPS 30	HELMERT SIMILARITY TRANS. M3(34)ED50-M5(146)ED50			ED50 DIFFERENCES OF TRANS. M5(102)-M5(146)			HELMERT SIMILARITY TRANS. M3(34)ED50-M5(102)ED50		
	Δy	Δx	Δs	Δy	Δx	Δs	Δy	Δx	Δs
MAXIMUM	0,122	0,017	0,193	0,035	0,038	0,043	0,117	0,018	0,219
MINIMUM	-0,126	-0,191	0,013	-0,005	-0,009	0,002	-0,145	-0,207	0,002
MEAN	0,007	-0,085	0,114	0,016	0,013	0,025	-0,009	-0,097	0,123
m0	0,062	0,055	0,053	0,011	0,012	0,009	0,061	0,057	0,061

Table 19: Difference control statistics at 30 CCPS at ED50 M3/M5 boundry zone in between M3(34),M5(146) and M5(102) Transformation parameters

CCPS 30	M3(34)ED50-M5(146)ED50		
	dΔY	**dΔX**	**dΔs**
Δy:Δx<0,15	30	23	18
0,15<Δy:Δx<0,25		7	12
TOPLAM	30	30	30

Table 19: Classification of the M3(34)$_{ED50}$ – M5(146)$_{ED50}$ transformed coordinate differences

Similar evaluations can be done. Differences along with the M3/M5 Boundries are ; For M3-M5(146) ; some points has diffrences up to -0,191m and 0,122m for the known and transformed coordinates at ED50. Similar differences are also exist for the differences in between M3-M5(102). But the differences for M5(102)-M5(146) transformed coordinates to ED50 are reasonable small and less than Δy:Δx<0.15m for all points. So where both M5 transformation are compatible to each other, M3 transformation, while it is working properly within the project area as expected, creates problems just on the M3 Boundries.

- Trials for North-South and East-West cross sections respectively with 9 and 10 points executed and results are given in Figure Table 21-24.

		HELMERT SIMILARITY TRANS. M3(34)ED50-M5(146)ED50			ED50 DIFFERENCES OF TRANS. M5(102)-M5(146)			HELMERT SIMILARITY TRANS. M3(34)ED50-M5(102)ED50		
		Δy	Δx	Δs	Δy	Δx	Δs	Δy	Δx	Δs
CCPS 9 N-S CROSS SECT.	MAXIMUM	0,041	-0,047	0,182	0,023	0,014	0,027	0,044	-0,061	0,190
	MINIMUM	-0,002	-0,177	0,047	-0,003	0,008	0,008	-0,024	-0,185	0,066
	MEAN	0,017	-0,105	0,107	0,012	0,011	0,017	0,006	-0,116	0,118
	m0	0,012	0,037	0,038	0,007	0,002	0,006	0,019	0,035	0,035
CCPS 10 E-W CROSS SECT.	MAXIMUM	0,096	-0,058	0,167	0,020	0,036	0,037	0,076	-0,053	0,201
	MINIMUM	-0,110	-0,126	0,086	0,009	-0,005	0,018	-0,120	-0,162	0,084
	MEAN	-0,002	-0,090	0,112	0,015	0,015	0,024	-0,017	-0,105	0,123
	m0	0,059	0,020	0,020	0,003	0,012	0,006	0,056	0,031	0,035

Table 21 : Difference control statistics at 9 and 10 CCPS at M3/M5 N-S&E-W Cross sections

For N-S cross section while M3 and M5(146)/M5(102) differencees are increasing from north-south,while M5(102)/ M5(146) differences decreasing.There are some points pushing the difference limit of <0.15m , but in general all differences are in the acceptable range.Differences distribution to class intervals for both direction is given in Table 22.

CCPS 9 NORTH-WEST CROSS SECT.	M3(34)ED50-M5(146)ED50		
	dΔY	dΔX	dΔs
Δy:Δx<0,15	9	7	7
0,15<Δy:Δx<0,25		2	2
TOPLAM	9	9	9

CCPS 10 EAST-WEST CROSS SECTION	M3(34)ED50-M5(146)ED50		
	dΔY	dΔX	dΔs
Δy:Δx<0,15	10	10	9
0,15<Δy:Δx<0,25			1
TOPLAM	10	10	10

Table 22: Difference Distribution to class intervals

7.2. DIRECT SOLUTION :

This solution is a spline function implementation for M5 Project area. After exclusion of the 2 problematic and one conjugate group , process realized with 106 TKGM Group and total 887 JGCP set. ΔY(Y_{ITRF96}- Y_{ED50}) and ΔX(X_{ITRF96}- X_{ED50}) surface models and Statistics are given in Figure 15 and Table 23.

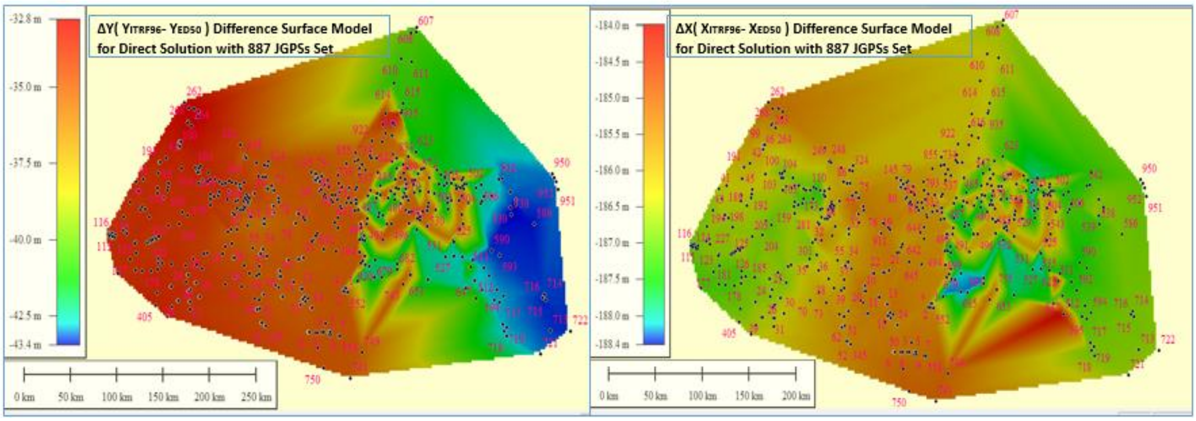


Figure 15 : Δy:Δx difference surfaces for Direct Solution with 887 JGCPs set of 106 TKM Group.

	ΔY(YITRF-YED50)	ΔX=(XITRF-YED50)
MAKSİMUM	-32,768	-183,983
MİNİMUM	-43,445	-188,397
ORTALAMA	-36,058	-186,211

SET TYPE	NO OF POINTS
TRANSFORMATION	455
EQC	432
TOTAL	887

Table23:Direct Solution with 887 JGPS set statistics. Table 24: Seperation to Transformatıon and EQS set.

In Figure 15; While ΔY values changing in between -43.445m to -62.768m and creating some sharp anomalies, ΔX values are changing in between -188.397m to -183.397m smoothly. Cause all points used for Direct solution and no points rest for EQC, any EQC cannot be realized for this solution.

- So,In order to give a chance for external quality control, 887 JGCPs set is seperated by two sub-groups of 455 and 432 points respectively to provide a balance in terms of number and distribution of the points located in Transformation and EQC Joint Control Points sets. Table 23 reads the sub set statistics

TRANS. SUB-SET	ΔY	ΔX
MAKSİMUM	-32,791	-184,400
MİNİMUM	-43,445	-188,221
ORTALAMA	-36,088	-186,205
m_0	1,837	0,573

EQC SUB-SET	ΔY	ΔX
MAKSİMUM	-32,768	-183,983
MİNİMUM	-43,429	-188,397
ORTALAMA	-36,028	-186,217
m_0	1,791	0,568

Table 23:Transformation and EQC Sub sets statistics. .

As seen from the statistics of Table 23, creation of the sub-sets are quite successfull .

- ΔY(Y_{ITRF96}- Y_{ED50}) and ΔX(X_{ITRF96}- X_{ED50}) surface models are given in Figure 16 for transformation JGCPs set of 455 points. If Figure 15 and 16 compared, the similarity will easily be seen which shows a succesful definition of 455 JGCPs sub-set for tranformation also. Following Direct solution, using EQC sub set of 432 points, corrections to be applied to that points to estimate the coordinates in ED50 , are calculated from Δy and Δx spline surfaceses and necessary corrections realized. Statistics to this EQC process is given in Table 24.During EQC Process,since 10 EQC JGCP were in outside of Project area can not be used for EQC.

- What is remaklable for the EQC process is for all EQC points ; after corrections which are calculated from Δy:Δx transformation surfaces applied, the differences in between known and corrected coordinates were 0.00 for all EQC Points. So this a very impressive result for the DS if all EQC points are in the outer boundry polygone formed by Transformation points.

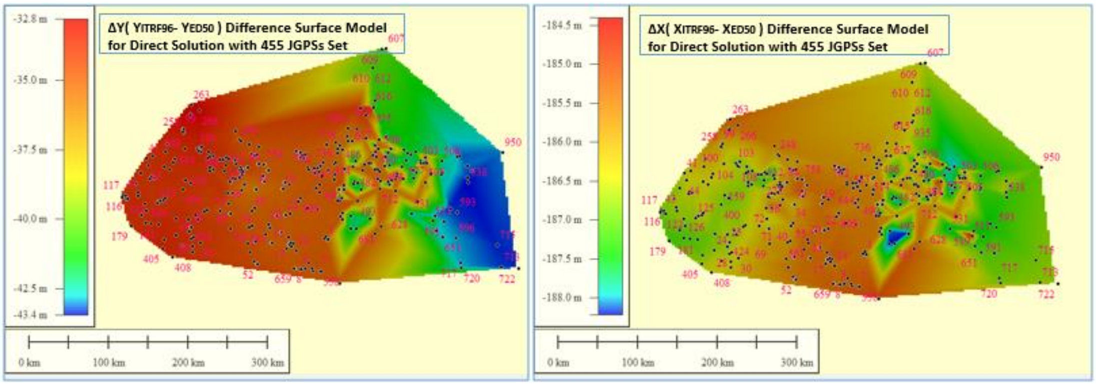


Figure 16 : Δy:Δx difference surfaces for Direct Solution with 455 JGCPs set of 106 TKM Group.

	ITRF96-ED50		ED50	
	ΔY'(m)	ΔX'(m)	Y-Y (m)	X-X (m)
MAKSİMUM	-33,004	-185,309	6,651	2,259
MİNİMUM	-43,317	-187,947	-5,011	-2,956
ORTALAMA	-35,919	-186,204	0,051	0,014

Table 24: External Quality Control of Direct Solution of 455 JGCPs , with 432 JGCP's EQC set.

HYBRID SOLUTION: If we recall one of the constraint of datum transformation for M5 project; which was reading; the differences for all existing transformation's JGCPs should be minimum after transformation executed. In an other words not only in between M3 and M5 Projects but also all other projects exist in BMM AOI. As apreciated this is not an easy problem can be solved . Because not only the lack of information to learn how the existing Transformations executed . In addition how a big bulk of some 1000 Ground Control Points defined and found alive in the field are all issues to be questioned.

But cause it was a must to us without considering some accuracy issues related to existing JGCPs, create a solution which can satisfy the must request of BMM. So Hybrid solution is studied. The basic philosophy of this method is the stochastic process approach to the existing data set. Hybrid solution is planned as a two phase process again. First phase is the Helmert Similarity transformation which is popular transformation method known by all. The purpose of this phase is to extract the deterministic part from the data set. The residuals after deterministic parts extracted ; are stochastic part of which signals should be detected (Earthquake: pre,co,post seismic affects on data , other systematic errors can be filtered etc). In the second phase after some evaluations it is decided to proceed with out too much investigating data quality, since again it was needed a data mining process presizely which was beyond the purpose of this project. So the residuals are modelled with spline functions, to minimize the final differences for M5 project area. Some models like ”0”,”A”,”B”,”C” Coded process studied to define where or which extend we can apply this approach to Datum transformations.

In this respect ; HST M5(146) is accepted as the determinstic part of the process . So All points of 887 TKGM set ,after exclusion of HST M5(146) JGCPs (two of them are HGK Points so 144 JGCP) and 8 conjugate points with 146 transformation points rest 735 points used to calculate ED50 Coordinates with the M5(146) transformation parameters.

<u>As a preparotory process to Phase 2</u>; As the result of HST M5(146),Δy:Δx differerences in between known ED50 and Transformed ED50 coordinates for M5(146) defined , Δy:Δx difference surfaces are given in Figure 17 together with the ”Active Fault Zones in the region to understand if any correlation exist with active fault zones and differences. But as a simple conclusion any strict correlation can not be observed. But, to make it open, more detailed and presize researchs are required .

<u>Second step</u> is designed to correct the transformed coordinates for the 735 points with the Vy = -Δy ;Vx = - Δx values to be estimated from Δy:Δx difference surfaces of HST M5(146).

<u>Third step (0 Coded Proces)</u> is dedicated to spline function application. For this purpose; after correcting 735 points positions from the HST M5(146) Δy:Δx surface, differences for the known and HST Surface corrected transformed coordinates are calculated as an input to spline function implementation. After Direct Solution (Spline Function) implementation , Δy:Δx difference surfaces are defined, statistical values are de- termined and Separation of Δy:Δx differences to class interval aregiven in Figure 18 ,Table 25 and Table 26.

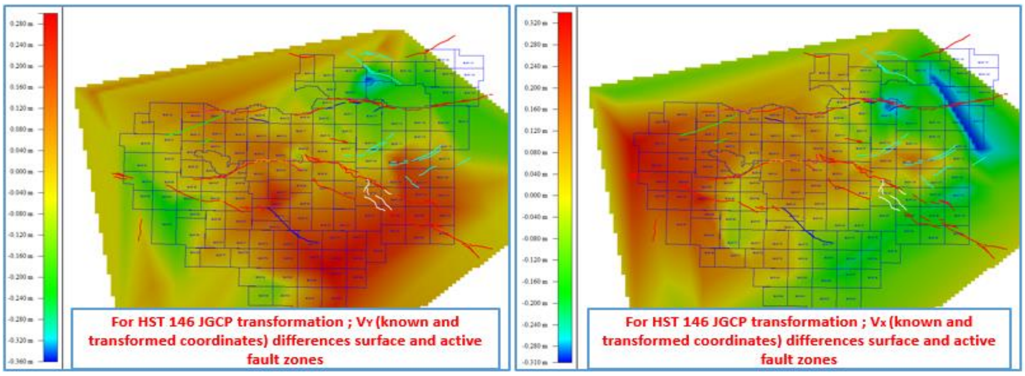


Figure 17 : HST M5(146) Vy:Vx surfaces and active fault zones in the region.

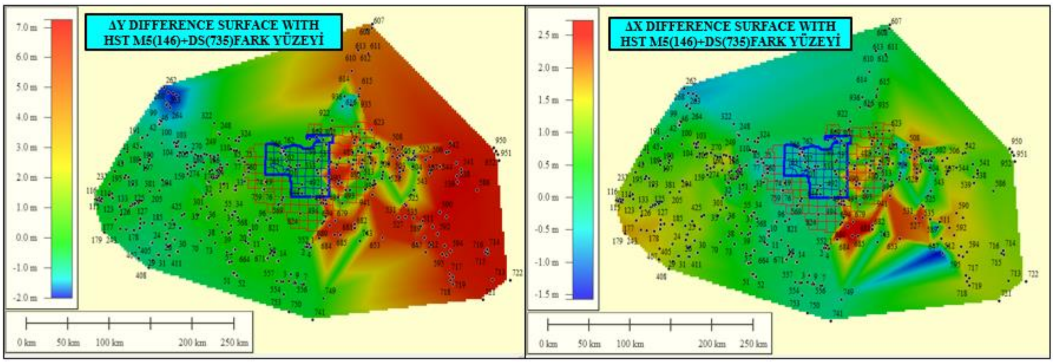


Figure 18 : HST M5(146)+DS(735) HYBRID Solution's Δy:Δx surfaces .

HYBRID SLTN.	Farklar (ED50)		M.Farklar(ED50)	
JGCPS:735	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	7,258	2,732	7,258	2,732
MINIMUM	-2,011	-1,574	0,007	0,001
MEAN	0,882	0,618	1,416	0,702
m0	1,900	0,618	1,718	0,556

Table 25 : HST M5(146)+DS(735) HYBRID Solution's statistics

HST M5(146)+ DÇ(735) HYBRID : POINT AND GROUP BASED CLASSIFICATION			
SINIF ARALIĞI	NOKTA SAY.	GRP.SAY	BU SINIFTAKİ GRUP NUMARALARI
ΔY:ΔX=<0,15	45	22	3,10,14,33,49,55,57,58,61,67,68,71, 82,83, 85,89,94,95,101,105,106,107
0,15<ΔY:ΔX<0,25	103	37	1,3,5,10,13,14,27,33,40,41,47,48,49,50,51,52,53,55,57,58, 61,62,65,67,68,69,70,71,82,83,86,87,89,93,101,106,107
0,25<ΔY:ΔX<0,50	173	50	1,2,3,4,5,13,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,51,52,53,55,57, 63,65,67,68,69,70,71,77,82,83,86,87,88,90,95,97,99,100,101,102,105,106,108
0,50<ΔY:ΔX<0,85	97	29	4,10,25,28,46,47,52,63,65,68,72,73,77,78,81,88,90, 91,94,96,97,98,99,100,102,104,108,110,112
0,85<ΔY:ΔX<1,00	25	17	24,28,59,66,73,78,79,81,94,96,97,98,104,109,110,111,116
ΔY:ΔX>1,0	191	29	6,7,8,9,11,12,15,16,18,19,21,22,23,26,31,34, 39,42,56,64,74,76,84,92,103,113,114,118,119
	101	17	24,25,28,46,59,66,72,78,79,81,91,97,109,110,111,112,116
TOPLAM	735		

Table 6.26 : Separation of Δy:Δx differences to class intervals.

<u>**Fourth step (A Coded Proces):**</u> Cause "0" coded aplication's results includes Δy:Δx>1.0m points which can create deficiencies during later actions . So this groups or points (292) are excluded from JGCPs set and prcess repeated with this new GCPs set of 443 points. Paralel to hybrid solution ;Δy:Δx difference surfaces are defined, statistical values are determined and Separation of Δy:Δx differences to class interval are given in Figure 19 ,Table 27 and Table 28.

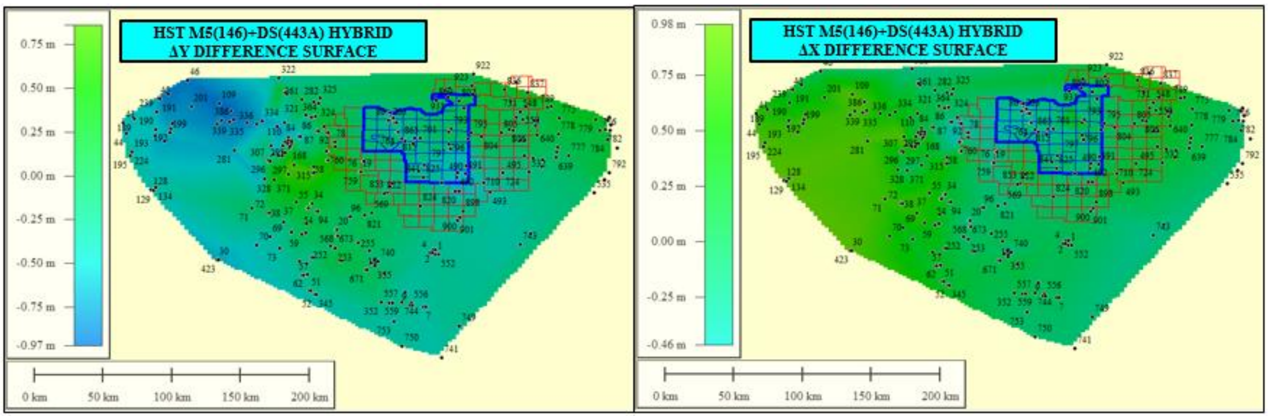


Figure : 19 HST M5(146)+DS(443A) HYBRID Solution’s Δy:Δx surfaces

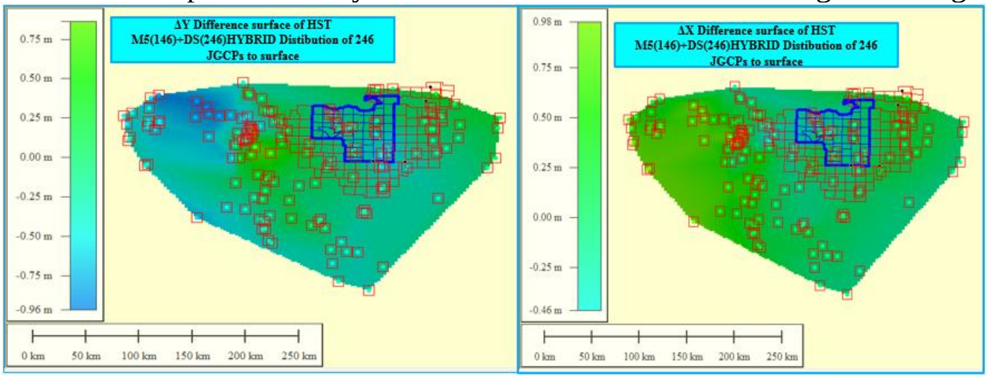
HYBRID SLTN. JGCPS:735	DIFFERENCES (ED50)		ABS DIFFERNCES(ED50)	
	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	0,862	0,978	0,972	0,978
MINIMUM	-0,972	-0,464	0,007	0,001
MEAN	-0,131	0,197	0,264	0,289
m0	0,244	0,265	0,158	0,199

Table 27: HST M5(146)+DS(443) HYBRID Solution’s statistics

HST M5(146)+DS(443) HYBRID:POINT AND GROUP BASED CLASSIFICATION			
CLASS INTERVAL	NOP	NOG	GRUP ID
ΔY:ΔX=<0,15	45	19	3,10,14,33,49,55,57,58,61,67,68,82,83,85,89,94,95,105,106,
0,15<ΔY:ΔX<0,25	103	37	1,3,5,10,13,14,27,33,40,41,47,48,49,50,51,52,53,55,57,58,61,62,65,67,68,69,70,71,82,83,86,87,89,93,101,106,107
0,25<ΔY:ΔX<0,50	173	50	1,2,3,4,5,13,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,51,52,53,55,57,63,65,67,68,69,70,71,77,82,83,86,87,88,90,95,97,99,100,101,102,105,106,108
0,50<ΔY:ΔX<0,85	97	29	4,10,25,28,46,47,52,63,65,68,72,73,77,78,81,88,90,91,94,96,97,98,99,100,102,104,108,110,112
0,85<ΔY:ΔX<1,00	25	17	24,28,59,66,73,78,79,81,94,96,97,98,104,109,110,111,116
TOPLAM	443		

Table 28 : Separation of Δy:Δx differences to class intervals.

EQC for ”A” Coded Process : During”A” coded process,cause all GCPs are used for Hybrid Solution, EQC process can not be realized. So analogous to ”0” coded approach, Existing JGCPs set is divided by two sub-groups of 246 and 197 points respectively to provide a balance in terms of number and distribution of the points located in Transformation and EQC Joint Control Points sets. For Hybrid Solution of HST M5(146)+DS(246) Hybrid ; Δy:Δx differences, Diffrence surfaces,statistical values ans Separation of Δy:Δx differences to class interval are given in Figure



20 and Table 29.

Figure 20: Δy:Δx Surface for HST M5(146)+DS(246) Hybrid solution.

From Figure 20 , similarity with Figure 19 can easily be seen. So it is the sign of succesful seperation of ”A” Coded JGCPs to Transformation and EQC sub-sets. Using 188 EQC Sub-Set points (9 points were failed since located outer boundry of 246 transformation points) EQC Process realized , Difference surfaces in between known and Hybrid Estimated positions for 197 GCP,statistics and seperation of Δy:Δx values to class intervals. are given in Figure 21 ,Table 30 and Table 31 respectively.

HYBRID SLTN. JGCPS:246	DIFFERENCES (ED50)		ABS DIFFERNCES(ED50)	
	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	0,862	0,978	0,964	0,978
MINIMUM	-0,964	-0,464	0,008	0,001
MEAN	-0,152	0,222	0,291	0,311
m0	0,263	0,276	0,169	0,209

DENETİMDE KULLANILAN NOKTA VE GRUP BAZLI SINIFLANDIRMA			
SINIF ARALIĞI	NOKTA SAY.	GRP.SAY	BU SINIFTAKİ GRUP NUMARALARI
ΔY:ΔX=<0,15	17	17	3,10,14,33,49,55,57,58,67,68,82,83,85,94,95,105,106
0,15<ΔY:ΔX<0,25	46	37	1,3,5,10,13,14,27,33,40,41,47,48,49,50,51,52,53,55,57, 58,61,62,65,67,68,69,70,71,82,83,86,87,89,93,101,106,107,
0,25<ΔY:ΔX<0,50	102	47	1,3,4,5,14,25,27,30,33,38,40,41,43,44,45,46,47,48,49,50,51,52,53,55,57,63, 65,67,68,69,70,71,82,83,86,87,88,90,95,97,99,100,101,102,105,106,108
0,50<ΔY:ΔX<0,85	63	27	4,10,25,28,46,47,52,63,65,68,72,73,77,78,81, 88, 91,94,96,97,98,99,100,102,104,108,110
0,85<ΔY:ΔX<1,00	18	15	24,28,59,66,73,78,79,81,94,97,98,104,110,111,116
TOPLAM	246		

Table 29 :HST M5(146)+DS(246) Hybrid Soltion Statistics and seperation of Δy:Δx values to class intervals.

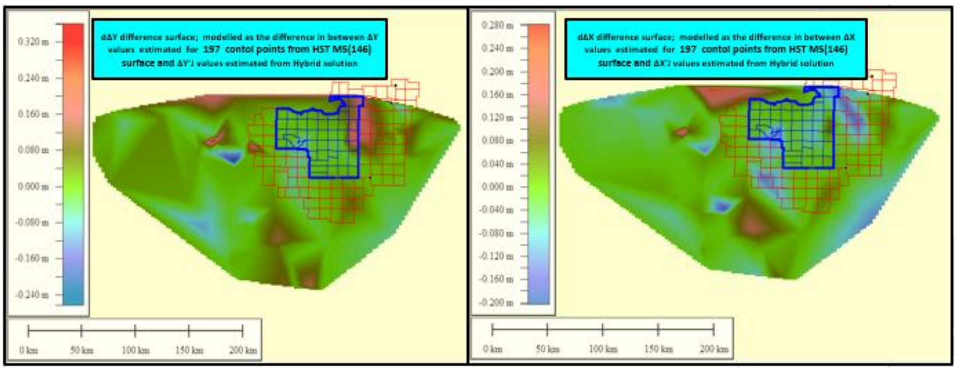


Figure 21: dΔy:dΔx Difference surfaces for the EQC of HST M5(146)+DS(246) Hybrid solution with 197 GCP.

HYBRID SLTN.	Diff HST M5(146)		Diff DS(246) Surface		Diff From Positions	
EQC JGCPS:188	ΔY	ΔX	ΔY'	ΔX'	dΔY=Yi-Y'j	dΔX=Xi-X'j
MAXIMUM	0,833	0,967	0,815	0,964	0,361	0,282
MINIMUM	-0,972	-0,464	-0,955	-0,404	-0,263	-0,203
MEAN	-0,105	0,166	-0,135	0,169	0,024	0,000
m0	0,218	0,249	0,191	0,242	0,050	0,042

Table 30 : EQC of HST M5(146)+DS(246) with 197 GCP.

EQC POINT AND GROUP BASED CLASSIFICAATION			
CLASS INTERVAL	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	167	63	1,2,3,4,5,10,13,14,25,27,30,33,40,41,43,44,45,46,47,48,49,50,51,52,53,55, 57,58,61,62,65,66,67,68,69,70,72,73,78,81,82,83,85,86,87,89,90,95,96, 97,98, 99,100,102,104,105,106,107,108,109,110,111,112
0,15<ΔY:ΔX<0,25	15	13	3,14,33,58,61,67,83,85,93,71,88,96
0,25<ΔY:ΔX<0,50	6	5	73,96,99,101,107
Out of Surface	9		
TOPLAM	197		

Table 31 :EQC of HST M5(146)+DS(246) with 197 GCP and seperation of Δy:Δx differences to class intervals.

From Figure 21, it is clear the great differences as per the result of hybrid EQC are located mostly outer boundry of M5 project area. From Table 30 ; mean of difference approaching nearly 0.0m and m_0 of solution is getting more and more reasonable.When the differences seperation to class interval it is also positive and now 89% of control points are lying in acceptable class interval of Δy:Δx<0.15m. So we can conclude that Hybrid solution is succesful. Following deterministic part represented by HST , it can be assumed DS can filter the signal part of the data.

Here ,cause the distribution of TKGM Groups are beyond the interest of BMM and adjacent groups creating problems to transformation to decrease the size of the study area is decided.

<u>"B" Coded Process :</u> In this approach points located in the outer boundry of M5 Project area are all excluded from the JGCPs set. Number of JGCPs located in M5 project area are 161.Hybrid solution with 161 JGCPs is HST M5(146)+DS(161) executed and results are given in Figure 22 and 32.

Again cause there is not any extra GCP for EQC, Set of 162 GCP, equally divided into to sub-set of Transformation and EQC respectively comprising of 89 and 73 points.

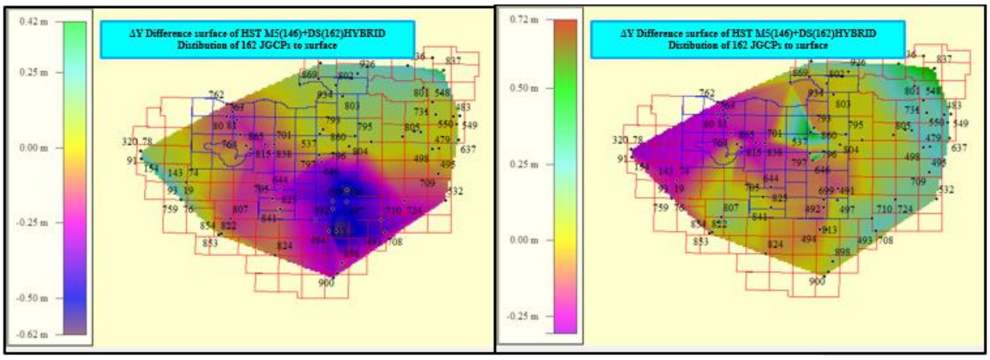


Figure 21 : Δy:Δx Surface for HST M5(146)+DS(162) Hybrid solution.

HYBRID SLTN. JGCPS:162	DIFFERENCES (ED50)		ABS DIFFERNCES(ED50)	
	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	0,419	0,724	0,622	0,724
MINIMUM	-0,622	-0,305	0,008	0,001
MEAN	-0,124	-0,003	0,203	0,177
m0	0,179	0,177	0,115	0,093

POINT AND GROUP BASED CLASSIFICATION			
CLASS INT	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	19	7	58,61,67,82,83,85,95
0,15<ΔY:ΔX<0,25	59	27	1,3,5,10,13,27,40,41,47,48,50,51,55,58, 61,62 ,65, 67,68,69,70,71,82,83,86,87,93
0,25<ΔY:ΔX<0,50	76	29	1,2,4,5,13,27,30,38,40,41,47,48,50,51,53, 57, 65,67,69,70,71,77,82,83,86,87,90,95,100
0,50<ΔY:ΔX<0,85	8	6	4,10,47,65,77,90
TOPLAM	162		

Table 32 HST M5(146)+DS(162) Hybrid Soltion Statistics and seperation of Δy:Δx values to class intervals.

<u>EQC For ”B” Coded Process:</u> Hybrid solution with 89 JGCP ; Δy:Δx Difference Surfaces, statistics and distribution to class intevals are given in Figure 22 and Table 33.

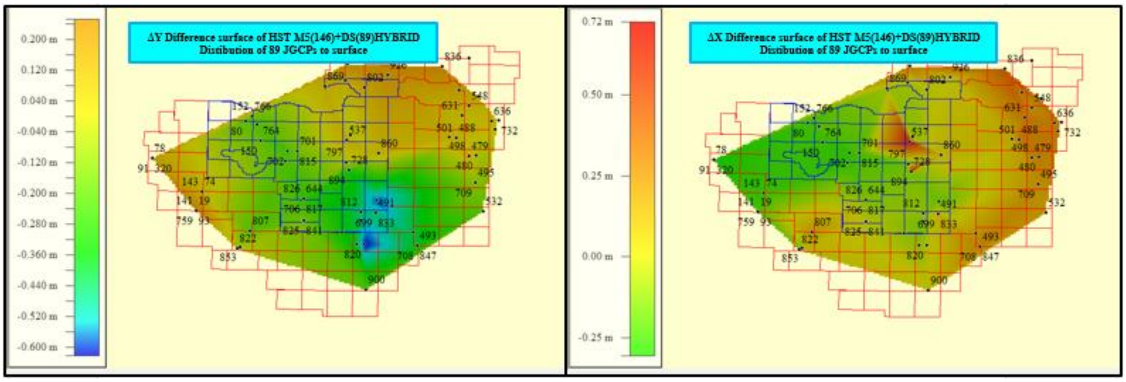


Figure 22: Δy:Δx Surface for HST M5(146)+DS(89) Hybrid solution.

HYBRID SLTN.	DIFF.(ED50)		ABS DIFF.(ED50)	
JGCPS:89	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	0,252	0,724	0,622	0,724
MINIMUM	-0,622	-0,305	0,008	0,001
MEAN	-0,106	0,015	0,194	0,185
m0	0,183	0,186	0,112	0,090

POINT AND GROUP BASED CLASSIFICATION			
CLASS INTERVAL	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	10	7	58,61,67,82,83,85,95
0,15<ΔY:ΔX<0,25	37	26	1,3,5,10,13,27,40,41,47,48,50,51,55,58, 61,62,65,68,69,70,71,82,83,86,87,93
0,25<ΔY:ΔX<0,50	38	24	1,2,4,5,13,27,30,38,40,41,48,51,53, 57, 65,67,77,82,83,86,87,90,95,100
0,50<ΔY:ΔX<0,85	4	4	10,47,65,90
TOPLAM	89		

Table 33: HST M5(146)+DS(89) Hybrid Soltion Statistics and seperation of Δy:Δx values to class intervals.

Using 73 EQC Sub-Set points (15 points were failed since located outer boundry of 89 transformation points) EQC Process realized , Difference surfaces in between known and Hybrid Estimated positions for 58 GCP,statistics and seperation of Δy:Δx values to class intervals. are given in Figure 23 , and Table 34 respectively. From Table 34 ; no bigger difference than 0.077m and 0.213m respectively for dΔy and dΔx, mean of the EQC are nearly zero and finally m_0 of the differences are around 0.001m. So To conlude ; Hybrid Solution model works fine for this case.

In this respect an another trial via excluding the GCPs creating problems from Joint set of transformation and EQC. Trials repated with 66 and 41 JGCPs respectively for Transformation and EQC. Target of this approach is to observe hybrid model is working how effective ? Result are given with only Tables of 35,36

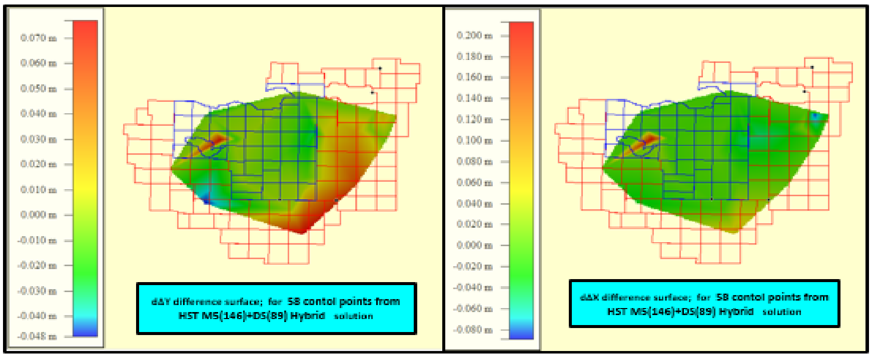


Figure 23 dΔy:dΔx Difference surfaces for the EQC of HST M5(146)+DS(58) Hybrid solution with 58 GCP.

SLTN. EQC	Diff HST M5(146)		Diff DS(246) Surface		Diff From Positions	
JGCPS:58	ΔY	ΔX	ΔY'	ΔX'	dΔY=Yi-Y'j	dΔX=Xi-X'j
MAXIMUM	0,118	0,284	0,123	0,277	0,077	0,213
MINIMUM	-0,592	-0,275	-0,582	-0,267	-0,048	-0,089
MEAN	-0,191	-0,031	-0,193	-0,031	0,002	0,000
m0	0,151	0,139	0,153	0,145	0,011	0,015

EQC POINT AND GROUP BASED CLASSIFICATION			
Class Interval	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	57	26	1,2,4,5,13,27,30,40,41,47,48,50,51,58,61, 62,65,67,69,70,82,83,86,87,90,95
0,15<ΔY:ΔX<0,25	1	1	85
TOTAL	58		

Table 34 HST M5(146)+DS(89) Hybrid Solution EQC Statistics with 58 GCPs and seperation of Δy:Δx values to class intervals.

HYBRID SLTN.	DIFF.(ED50)		ABS DIFF.(ED50)	
JGCPS:66	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	0,246	0,288	0,292	0,288
MINIMUM	-0,292	-0,275	0,008	0,001
MEAN	-0,041	-0,016	0,138	0,175
m0	0,137	0,174	0,071	0,077

POINT AND GROUP BASED CLASSIFICATION			
CLASS INTERVALS	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	10	7	58,61,67,82,83,85,95
0,15<ΔY:ΔX<0,25	37	26	1,3,5,10,13,27,40,41,47,48,50,51,55,58, 61,62,65,68,69,70,71,82,83,86,87,93
0,25<ΔY:ΔX<0,50	19	17	1,2,5,13,27,30,38,40,48,57,65,67,82,83, 86,87,95
TOPLAM	66		

Table 34 HST M5(146)+DS(66) Hybrid Solution Statistics and seperation of Δy:Δx values to class intervals.

HYBRID SLTN.	Diff HST M5(146)		Diff DS(246) Surface		Diff From Positions	
EQC JGCPS:41	ΔY	ΔX	ΔY'	ΔX'	dΔY=Yi-Y'j	dΔX=Xi-X'j
MAXIMUM	0,118	0,284	0,123	0,278	0,018	0,077
MINIMUM	-0,292	-0,275	-0,290	-0,269	-0,091	-0,089
MEAN	-0,113	-0,026	-0,105	-0,024	-0,008	-0,002
m0	0,124	0,163	0,120	0,165	0,012	0,018

POINT AND GROUP BASED CLASSIFICATION			
CLASS INTERVAL	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	41	22	2,5,13,27,30,40,41,47,48,50,51, 58,61,65,67,69,70,82,83,86,87,95
TOPLAM	41		

Table 34 HST M5(146)+DS(66) Hybrid Solution EQC Statistics with 42 GCPs and seperation of Δy:Δx values to class intervals.

If Table 34 checked , Table 34 shows, if the GCPs accuracies are good enough, results of HST and DS are getting closer to each other. It means if we assume point position's are no error than both solution will give similar result and Hybrid solution will turn into HST or vice versa. As per the result of this evaluation; there is no longer differences bigger than Δy:Δx> 0.15m. So we can conclude if the distribution and accuracies of the GCPs used for Hybrid Transormation, EQC process will work exactly and success of the Hybrid solution will get better.

”C” Coded Process : In this approach ; GCPs lying in the outer boundry of the points formed with all points included in TKGM group's used for the HST. In total 357 points in 35 TKGM groups located in HST M5(146) transormation groups determined. After exclusion of 144 TKGM points used for HST M5(146) Hybrid Solution is executed with 213 JGCPs and result are given in Table 35.

HYBRID SLTN.	DIFF.(ED50)		ABS DIFF.(ED50)	
JGCPS:213	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	6,463	2,074	6,463	2,074
MINIMUM	-1,546	-0,464	0,005	0,001
MEAN	0,247	0,154	0,565	0,247
m0	0,685	0,248	0,675	0,196

POINT AND GROUP BASED CLASSIFICATION			
CLASS INTERVAL	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	19	8	3,14,33,49,57,58,89,95
0,15<ΔY:ΔX<0,25	76	25	1,3,5,13,14,27,33,40,41,47,48,49,50,57,58,62,65,71,85,86,87,89,93,101,107
0,25<ΔY:ΔX<0,50	96	27	1,2,3,5,13,14,27,30,33,38,40,41,43,44,47,48,49,50,57,65,71,77,86,87,90,95,101
0,50<ΔY:ΔX<0,85	5	4	47,65,77,90
ΔY:ΔX>1,0	17	2	8, 103
TOPLAM	213		

Table 35: HST M5(146)+DS(213) Hybrid Solution Statistics and seperation of Δy:Δx values to class intervals.

Cause of the points creating differences Δy:Δx> 0.40 are excluded from the JGCPs set and trials executed with 180 JGCPs set . Results are given in Figure 24 and Table 36. For EQC of this process,180 GCP divided to sub-set of transformation and EQC respectively as to inlude 94 and 86 points each. Results for transformation and EQC process are given in Table 37 and Figure 25/26.

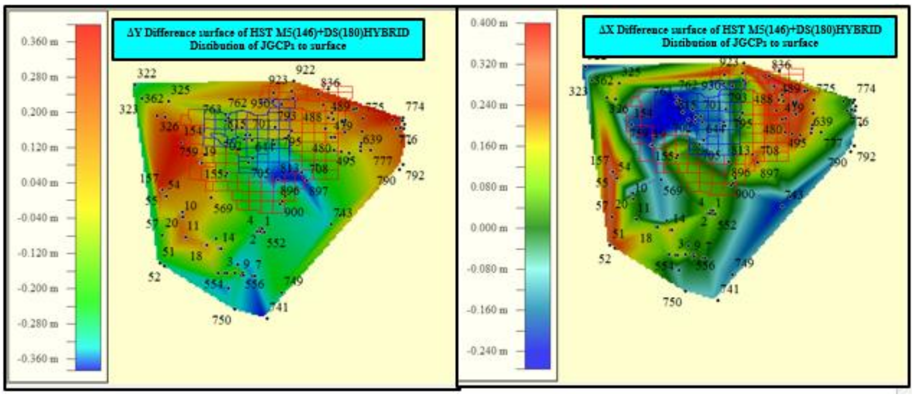


Figure 24 : Δy:Δx Surface for HST M5(146)+DS(180) Hybrid solution.

SLTN.	DIFF.(ED50)		ABS DIFF.(ED50)	
JGCPS:180	ΔY=Y-Y'	ΔX=X-X'	ΔY=Y-Y'	ΔX=X-X'
MAXIMUM	0,399	0,400	0,399	0,400
MINIMUM	-0,386	-0,275	0,005	0,001
MEAN	-0,058	0,057	0,177	0,153
m0	0,175	0,144	0,093	0,085

POINT AND GROUP BASED STATISTICS			
CLASS INTERVAL	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	19	8	3,14,33,49,57,58,89,95
0,15<ΔY:ΔX<0,25	76	25	1,3,5,13,14,27,33,40,41,47,48,49,50,57,58,62,65,71,85,86,87,89,93,101,107
0,25<ΔY:ΔX<0,50	85	27	1,2,3,5,13,14,27,30,33,38,40,41,43,44,47,48,49,50,57,65,71,77,86,87,90,95,101
TOPLAM	180		

Table 36: HST M5(146)+DS(180) Hybrid Solution Statistics and seperation of Δy:Δx values to class intervals.

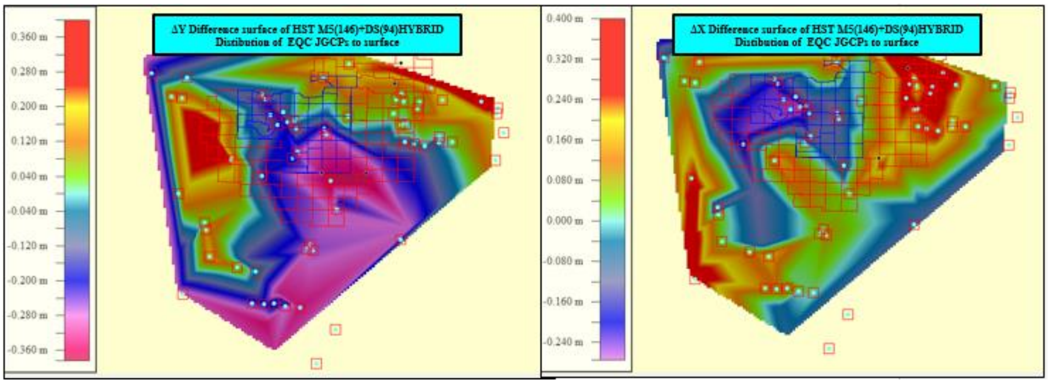


Figure 25: Δy:Δx Difference surfaces of HST M5(146)+DS(94) and EQC JGCPs on .

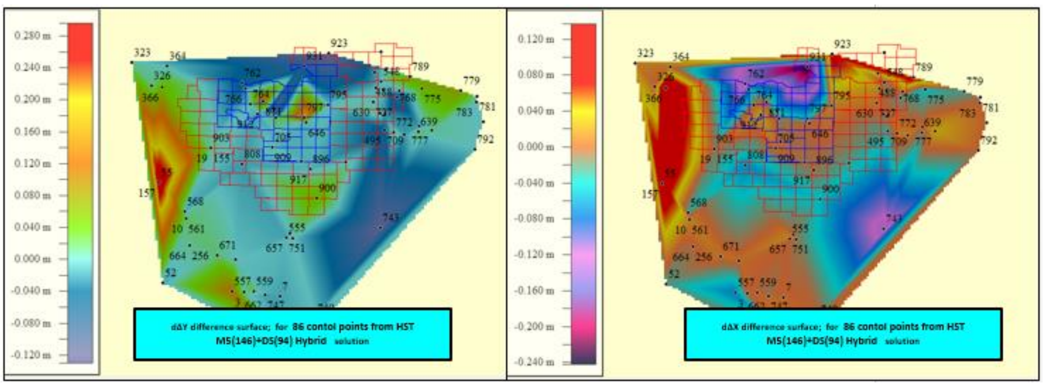


Figure 26: dΔy:dΔx Difference surfaces for the EQC of HST M5(146)+DS(94) Hybrid solution with 86 GCP.

HYBRID SLTN. EQC JGCPS:84	Diff HST M5(146)		Diff DS(246) Surface		Diff From Positions	
	ΔY	ΔX	ΔY'	ΔX'	dΔY=Yi-Y'j	dΔX=Xi-X'j
MAXIMUM	0,378	0,391	0,303	0,301	0,296	0,137
MINIMUM	-0,386	-0,275	-0,380	-0,263	-0,130	-0,242
MEAN	-0,049	0,051	-0,064	0,067	0,006	-0,005
m0	0,168	0,145	0,149	0,134	0,035	0,027

POINT AND GROUP BASED CLASSIFICATION			
CLASS INTERVAL	NOP	NOG	GROUP ID
ΔY:ΔX=<0,15	76	30	1,2,3,5,13,14,27,30,33,38,40,41,43,47,48,49, 50,57,58,62,65,71,85,86,87,89,90,93,101,107
0,15<ΔY:ΔX<0,25	2	2	58,95
0,25<ΔY:ΔX<0,50	2	2	44, 71
Yüzey dışı	6		
TOPLAM	86		

Tablo 37: HST M5(146)+DS(94) Hybrid Solution EQC Statistics and seperation of Δy:Δx values to class intervals.

Here it is clear this result is achieved since for points in second and thir class interval and process is ended without any other further computation .

8. CONCLUSIONS

Till now ; three datum transformation method namely Helmert Similarity Transformation,Direct Solution and Hybrid Solution are discussed together with implementations, alternative solutions and external quality methods . During Transformation process two basic criteria of Δy:Δx<0.15m ve m_0<0.10m considered which are foreseen in governing regulation.

Cause there is not any explicit External Quality Control arrangement exist , Via using "0,A,B,C" Coded applications it is tested which limits or rules can be used for transformation and EQC processes. Based on the used approach and trials differences ranging from 0.0 m to 7 m were encountered.

Results achieved with this studay are summarized below :

- When ED50 datum is being defined; Plate Tectonics, Velocity field, Standart Epoch, Observation Epoch, Frame,Velocity field, Displacement and so on. current concepts were not available. For this reason, all coordinates specified in this datum have been used statically, since the ED50 datum has been accepted.
- With the introduction of ITRF96 datum in 2005 for positioning and in the comparison of the point positions, Plate and intra-Plate movements, epoch, standart epoch and similar concepts has enabled the widespread use of the concepts.
- This facts, seriously effected the critisms in a positive manner which discussed in the past for the accuracy assesment of Turkish National Horizontal Control Network
- So In this study we have to keep in mind that , datum transformations to be executed in between ITRF96 and ED50 datums we are working by two sets of GCPs which are common but not homogeneous with each .
- As a matter of fact,in the process of transformation and EQC made in this matter, the existence of points or groups that differ by 1m and above during these transactions were observed.
- In this study, although the points or groups having greater 1 m differences after transformations are extracted from the JGCPs Set , if only the post seismic velocity field considered this range of differences are quite normal.
- However, taking into account the provisions of the regulation, the evaluation of differences over 1.0m was left to another study, External Quality Controls and evaluations are realized with the points having with different classification less than 1.0m.grades were audited and interpreted in place.
- Now, after this general explanation, we can summarize the necessary points and lessons learnt to be taken into account in the course of this study.
    - The points used in transformation and EQC should cover the project area very well ,Bu bakımdan özellikle dönüşüm noktaları kümesi proje sahasını taşan bir yapıda olmalıdır ki Dış Kalite Kontrol işlemlerinde proje sahası içi ile ilgili güvenilir sonuçlara ulaşılabilsin.
    - In this regard, especially the set of JGCPs set should be in a structure that extending beyond the project area boundry so that you can reach reliable results about the inside of the project area in the External Quality Control operations.
    - For presize works ; External Quality Control points should be used if they are available and the transformation should be subject to EQC process.
- It should be keep in mind that , Following transformation and EQC, the Δy:Δx differences achieved in common points; in addition to the positional accuracy of the points, it carries very important information about the active tectonics of the zone.

- At the end of this report, which method is better is not discussed. This is because depends on ;
    - Requirements of the project ,
    - Dispersion and sufficiency of the ED50 points that can be found in the region,
    - Possible positional accuracy of known Points and many parameters that we might not think of here.
- For these reason the decision is left to the practitioner.
- But at least we can say ;
  - Where Helmert Similarity Transformation is not enough especially for the complex solutions,
  - Direct and Hybrid solutions will be effective without any doubt.

REFERENCES

Ayhan,M.E. and et.al. Türkiye Ulusal Temel GPS Ağı-1999 (TUTGA-99), Teknik Rapor, Hrt.Gn.K.lığı, Ankara 2001

Gürkan, O. Astrojeodezik Ağların Deformasyonu ve Türkiye I.Derece Triangülasyon Ağı, KTÜ, 1979.

Kılıçoğlu, A. 3 Boyutta Benzerlik Dönüşümü Parametrelerinin Hesaplanması. HGK İç rapor No:JEOF-94-1,

Demirkol,Ö.E and et.al Bursa Metropoliten Municpality Geodesy Report 2018 .

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