Online GRF-TT

Geodetic Reference Frame Transformation Tool

User Manual

Version 2.0

07 November 2022

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AAA	Ain-Al-Abd datum
ARAMCO	Saudi Arabian Oil Company
CRS	Coordinate Reference System
GASGI	General Authority for Survey and Geospatial Information (former GCS), KSA
GCS	General Commission for Survey (name of GASGI before Sep 2020), KSA
GDMS	General Directorate of Military Survey, KSA
GNSS	Global Navigation Satellite System
GPS	Global Positioning System – one of GNSSs, belongs to USA Ministry of Defense
GRF	Geodetic Reference Frame
GRS	Geodetic Reference System
GUI	Graphical User Interface
ITRF	International Terrestrial Reference Frame
ITRF2000	ITRF2000 at epoch 1997.0 - one of realisations of ITRS
ITRF2014	ITRF2014 at epoch 2010.0 - one of realisations of ITRS
ITRF94	ITRF1994 at epoch 1993.0 -one of realisations of ITRS
ITRS	International Terrestrial Reference System
KSA	Kingdom of Saudi Arabia
KSA-GEOID21GASGI	Latest KSA Hybrid Geoid Model produced by GASGI, KSA in the year 2021
KSA-GRF	Geodetic Reference Frame for KSA
KSA-GRF17	First and latest realization of KSA-GRF. The number "17" reflects the last year of the GNSS observation data included in the computation.
KSA-VRF	Vertical Reference Frame for KSA
KSA-VRF14	Latest realisation of KSA-VRF produced by GCS
MOMRA	Ministry of Municipalities and Rural Affairs, KSA
MTRF2000	MOMRA's geodetic reference system
NGN	National Geodetic Network, KSA
Online GRF-TT	Online Geodetic Reference Frame Transformation Tool
PPM	Part Per Million
SANSRS	Saudi Arabia National Spatial Reference System
SCT	Source reference frame's Coordinate Type
SRF	Source Reference Frame
SRS	Spatial Reference System
TCT	Target reference frame's Coordinate Type
TRF	Target Reference Frame
TT	Transformation Tool
UTF-8	Unicode Transformation Format–8 bit - a variable-width character encoding
VRF	Vertical Reference Frame

INTRODUCTION

This document is the *User Manual* for the *Online GRF–TT* (*Geodetic Reference Frame Transformation Tool*) in its *GUI* (*Graphical User Interface*) version.

Online GRF-TT (Geodetic Reference Frame Transformation Tool) is web-based software developed by *GASGI* to transform *2D horizontal* (*geographical* or *UTM* projected) and *3D* (*horizontal* coordinates plus ellipsoidal height) coordinates from a few existing in the *KSA GRFs* (*Table 1*) to *KSA-GRF17* reference frame and to the *KSA-GEOID21GASGI* geoid's surface used as the reference for orthometric heights.

Standard *Helmert* parameters (*3* translations, 3 rotations and a scale factor) are used for coordinate transformation from the following geodetic reference frames:

- *ARAMCO (ITRF94)*
- *GDMS*
- *MOMRA* (*MTRF2000)*
- *WGS84* (according to its definition in the *CRS* transformation *EPSG-9383* from *KSA-GRF17* to *WGS84*).

A grid of *3D* transformation parameters is used for transformation from *ARAMCO (Ain-Al-Abd)* reference frame.

KSA-GRF17 ellipsoidal heights can be transformed to orthometric heights (referenced to the used geoid surface) by using a *1D* geoid height grid *KSA-GEOID21GASGI* derived by the fitting of the *Gravimetric Geoid KSA-GEOID21Grav* to geoid heights of *3522 GASGI GPS/Levelling* benchmarks from *National Vertical Network*.

The *Online* GRF-*TT* can be accessed and used from any *Internet Browser*.

KSA-GRF17 (*Technical Summary for Saudi Arabia National reference System (SANSRS)*) is unified geodetic reference frame for the *Kingdom of Saudi Arabia* (*KSA-GRF*), and it is defined in such a way that it

(1) coincides with *ITRF2014* at the epoch *2017.0* and

(2) is co-moving with the stable part of the *Arabian* tectonic plate.

KSA-GEOID21GASGI (*Technical Summary for Saudi Arabia National reference System (SANSRS)*) is the latest hybrid gravimetric geoid combining all available relevant data in the *Kingdom*, including ground, satellite and ship-borne gravity data, and fitted to geoid heights (in *KSA-VRF14*) of *3522 GASGI GPS/L*evelling benchmarks.

KSA-VRF14 (*Technical Summary for Saudi Arabia National reference System (SANSRS)*) is the latest realization of *National Vertical Reference System* (*NVRS*) that is defined on the base of satellite altimetry and satellite gravity data utilizing as well as in-situ terrestrial observations from *Tide Gauges*, leveled differences and gravity.

Before the use of *GNSS* technique, the geodetic frames were based on the observations in the *National Geodetic Network* (*NGN*) established in the 1960's, and the resulting frame was called *Ain-Al(el)-Abd* geodetic datum (*AAA*).

With the use of *GNSS* and other spatial techniques, and the introduction of the *International Terrestrial Reference System* (*ITRS*), the geodetic frames are national realizations of *ITRS* via global realizations called

International Terrestrial Reference Frames (*ITRF*) with added the last year of used data *ITRFyyyy* and fixed at a conventional epoch, and called *ITRFyyyy*@epoch. National realizations are biased relative to *ITRFyyyy@epoch* so one has to calculate transformations that are slightly (but assumed to be of significant value) different from the official transformations between global realizations of *ITRS*.

The geodetic reference frames, which were used in *KSA* (created by *General Directorate of Military Survey (GDMS)*, *The Ministry of Municipal and Rural Affairs (MOMRA), The Saudi Arabian Oil Company* (*Saudi ARAMCO*; formerly known as *Arabian-American Oil Company*) are listed in the *Table 1*.

The *EPSG* definition of *WGS84* (which is, actually, the *ITRF2014* at the epoch *2010.0* according to the *WGS84* definition in the *CRS* transformation *EPSG-9383* from *KSA-GRF17* to *WGS84*) is given in the *Table 1* too. Because of tectonic *Arabian* plate motion with velocity *4.5 cm/year*, the *1 cm* accuracy of this transformation deteriorates for the epochs different from *2017.0*, reaching 1 meter accuracy the epoch difference is ± 22 years.

Table 1. Geodetic Reference Frames existing in KSA

Organization	**Reference frame**	**Ellipsoid**	**Realization of ITRS (if applicable)**	**Name of the Option in the Online Tool**
GDMS	ITRF2000@2003.1998	GRS80	ITRF2000 at epoch 2003.1998	GDMS
GCS	KSA-GRF17	GRS80	ITRF2014 at epoch 2017.0	KSA-GRF17
MOMRA	MTRF2000	GRS80	ITRF2000 at epoch 2004.0	MOMRA (MTRF2000)
Saudi ARAMCO	WGS84	WGS84	ITRF94 at epoch 1998.0	ARAMCO (ITRF94)
Saudi ARAMCO	AAA(Ain-Al-Abd 1970)	Hayford 1909 (International 1924)	N/A	ARAMCO (Ain-Al-Abd)
EPSG	WGS84 in EPSG-9383	GRS80	ITRF2014 at epoch 2010.0	WGS84

Note: For all geodetic and surveying practical purposes, the *WGS84* and *GRS80* ellipsoids can be considered as identical.

Compared to the previous realizations of the *Kingdom*'s *GRF*, the *KSA-GRF17* is a modern and precise *GRF* for the development of which observations from major *CORS* networks in *KSA* have been used.

HOW TO USE ONLINE GRF-TT

To launch the *Online GRF-TT*:

- Launch any internet browser.
- Type the URL *https://gds.gasgi.gov.sa* in browser's address bar to access the *Geodetic Services* landing web page (*Figure 1*).
- In the web page, select *SANSRS Transformation Tools* → *Online GRF-TT* → *Start* button to launch *Online GRF-TT* transformation tool on the page *https://gds.gasgi.gov.sa/GRF17* (*Figure 3*).
- Perform the actions according to the steps described below.
- Otherwise, the tools can be accessed by clicking *Services* → *Tools* → *Geodetic Reference Frames* in the top right corner of the web page and selecting the tool from the drop-down menu (*Figure 2*).

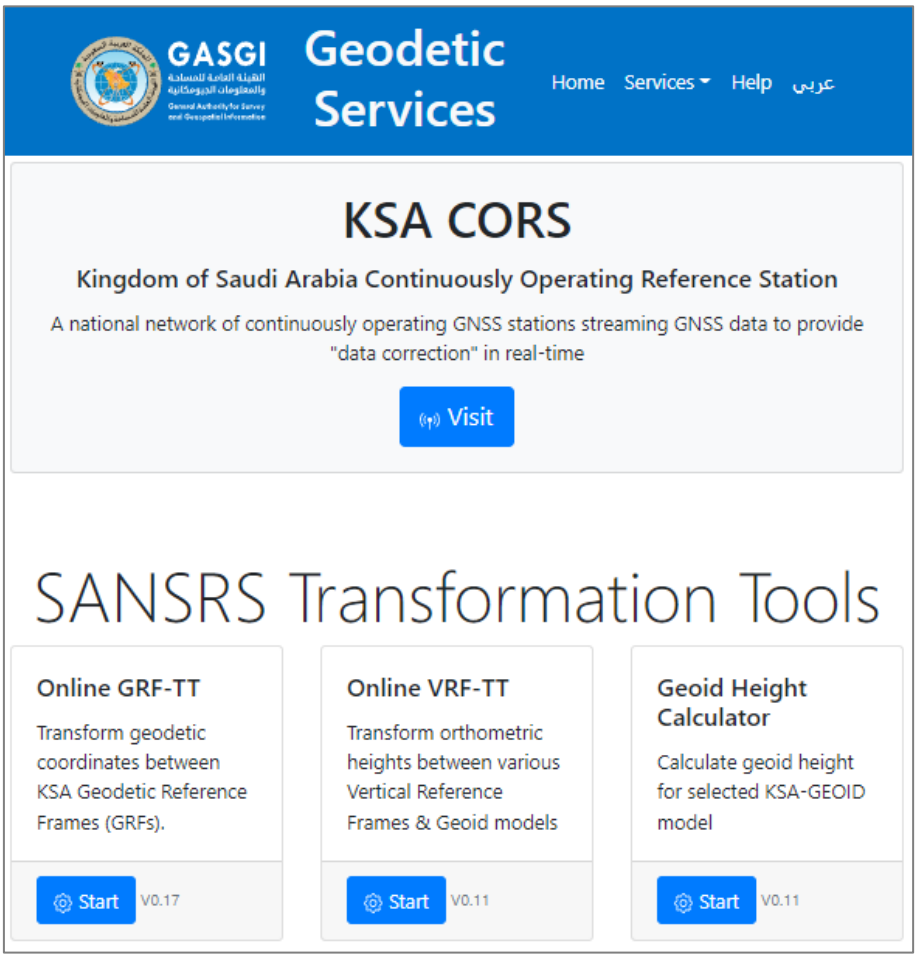

Figure 1. Geodetic Services landing web page

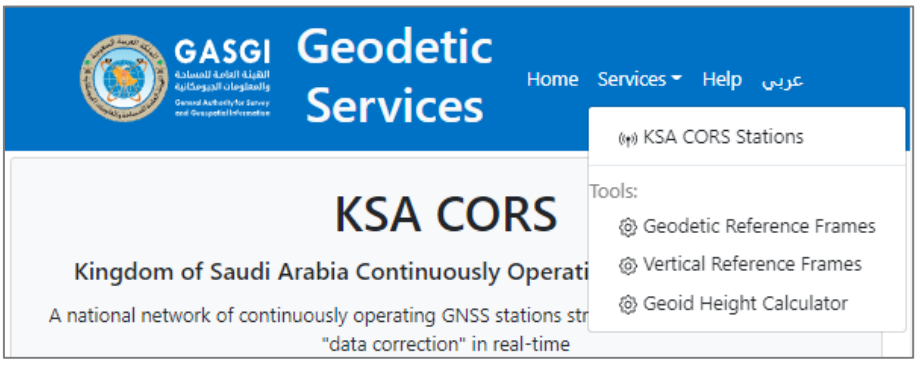

Figure 2. Service selection from the drop-down menu

STEP 1. SOURCE REFERENCE FRAME SELECTION

Type of the transformation can be selected from the drop-down menu in *Online GRF-TT GUI* (*Figure 3*).

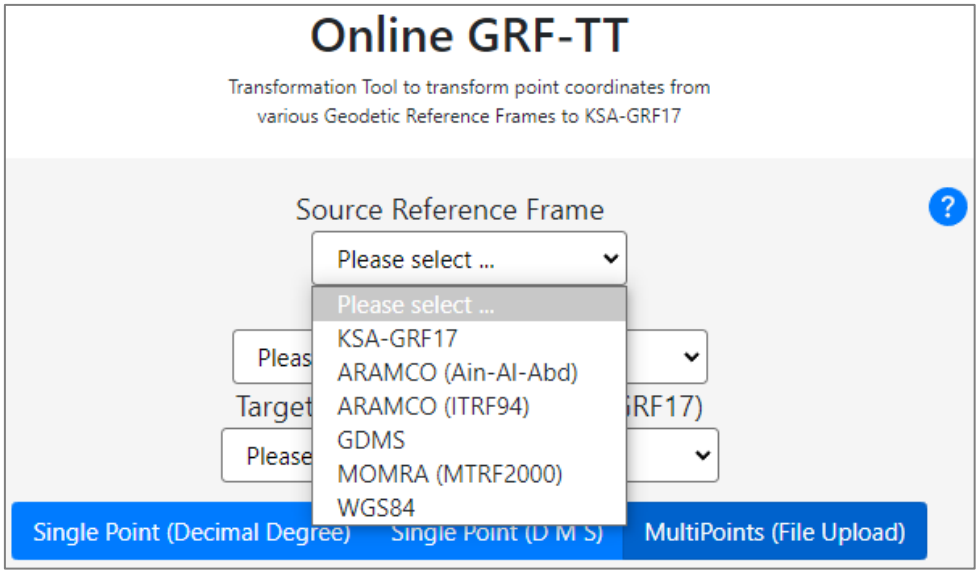

Figure 3. Selection of the source reference frame

In *Online GRF-TT*, there are the following *Source Reference Frames* (*SRF*) available:

- *KSA-GRF17* - coincides with *ITRF2014* at the epoch *2017.0*
- *ARAMCO (Ain-Al-Abd)*
- *ARAMCO (ITRF94)* – has as well the name ARAMCO_WGS84; coincides with *ITRF94* at the epoch *1998.0*
- *GDMS* - coincides with *ITRF2000* at the epoch *2003.1998*
- *MOMRA (MTRF2000)* - coincides with *ITRF2000* at the epoch *2004.0.*

KSA-GRF17 is the only *Target Reference Frame* (*TRF*) used in the tool. For more details on the reference frames, refer to *Technical Summary for Saudi Arabia National reference System (SANSRS)*.

By clicking the question mark or *Help* link (top right corner) in the *GUI* (*Figure 3*), you'll arrive to the *Help page* with links to the detailed information "How to use the our tools" (*Figure 4*).

Figure 4. Help page with "How to use our tools" links

STEP 2. SOURCE COORDINATE TYPE SELECTION

The next step is selection of the *Source* reference frame's *Coordinate Type* (*SCT*). The list of the drop-down menu options depends on the selected source *RF*. For *3D RFs* the list is shown in the *Figure 5*, and for the only one *2D RF – ARAMCO (Ain-Al-Abd)*, the option list is shown in the *Figure 6*. If projected coordinates have been selected, a user has to select the *UTM* (*Universal Transverse Mercator* projection) zone number (*Figure 7*) as well. The *UTM* zone boundaries for the *KSA* are presented in the *Table 2*.

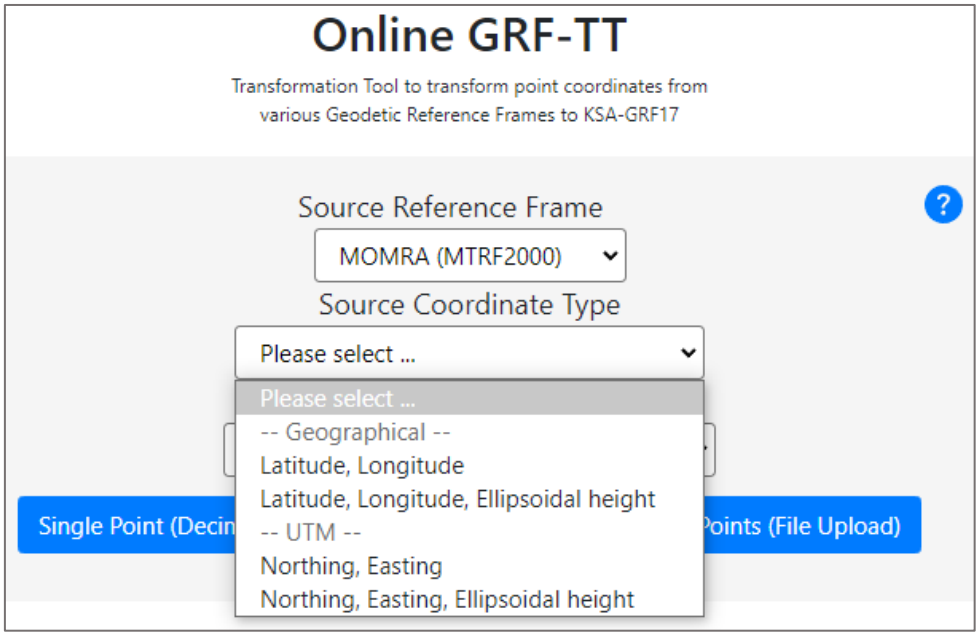

Figure 5. Selection of the source coordinate type for 3D RFs

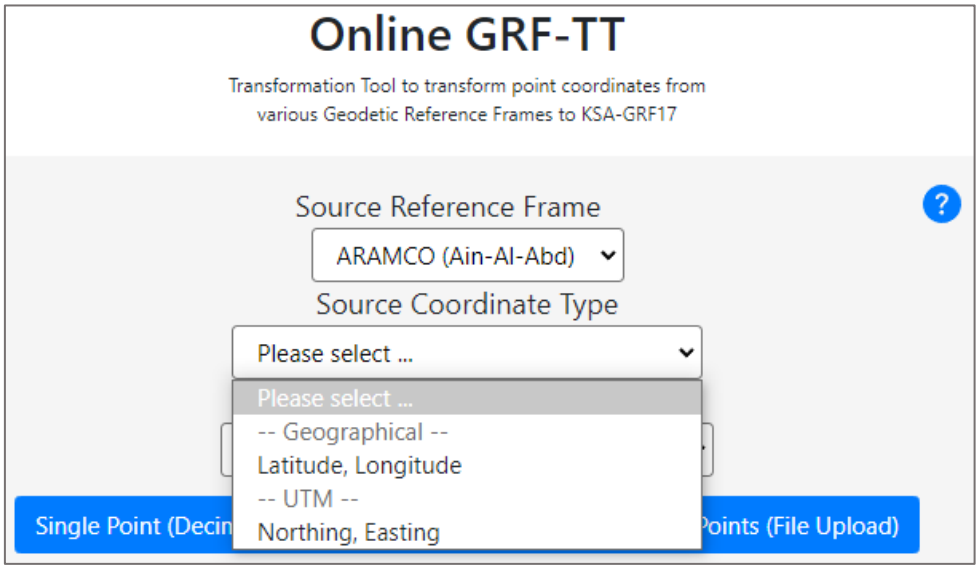

Figure 6. Selection of the source coordinate type for 2D RF – ARAMCO (Ain-Al-Abd)

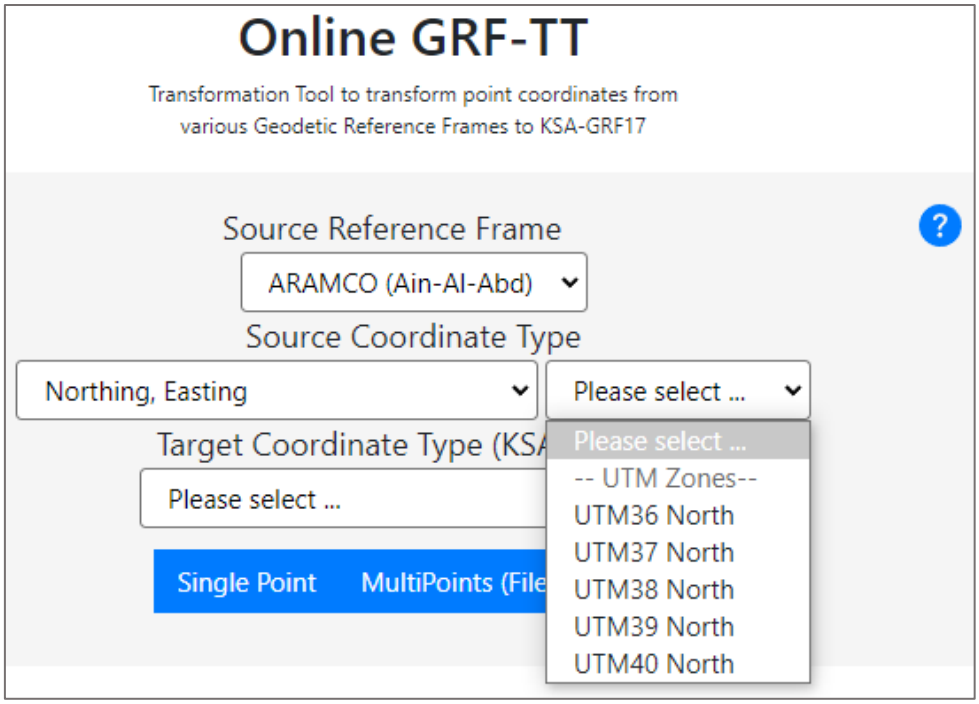

Figure 7. Selection of the source UTM zone

Table 2. UTM zone names and boundaries for KSA area

UTM Zone name	**East Longitude boundaries of zones**
UTM36 North	34° - 36°
UTM37 North	36° - 42°
UTM38 North	42° – 48°
UTM39 North	48° – 54°
UTM40 North	54° - 56°

STEP 3. TARGET COORDINATE TYPE SELECTION

The *Target Reference Frame* (*TRF*) is *KSA-GRF17* always. Therefore, the next step is the selection of the *Target* reference frame's *Coordinate Type* (*TCT*) for this default target frame (*Figure 8*). The drop-down menu option list for *TCT* depends on the selected *SCT* – was it *2D* or *3D* (when *ellipsoidal height* is present in the input). For the former case, the target list is shown in the *Figure 8*, in the latter case – in the *Figure 9*. Don't forget to select *UTM* zone number from the drop-down menu when using *UTM* coordinates as *SCT* or/and *TGT*. The tool makes transformation for the points from one (selected) *UTM* zone only, if you use *UTM* coordinates as input or output values.

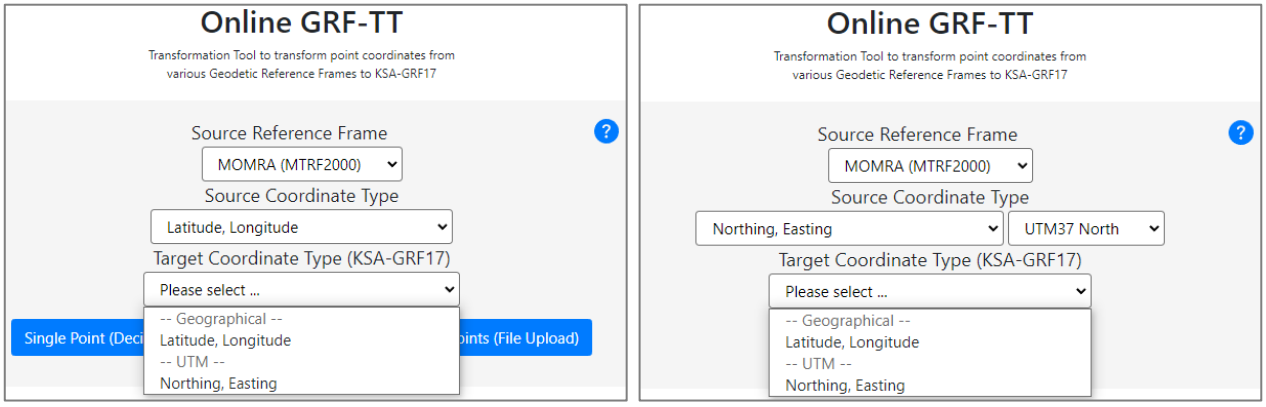

Figure 8. Selection of the target coordinate type: 2D source coordinate type cases

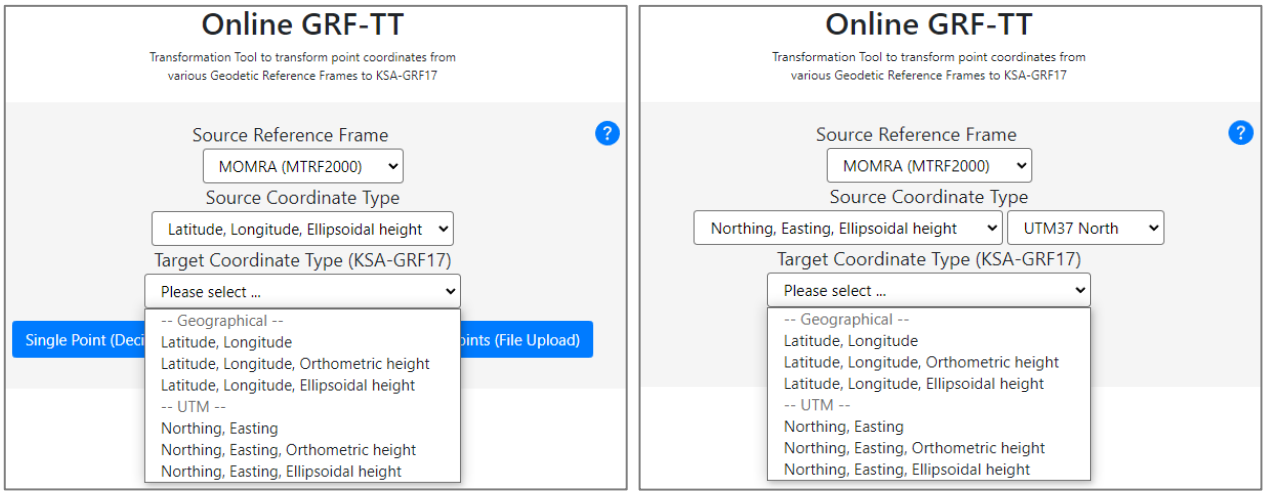

Figure 9. Selection of the target coordinate type: 3D source coordinate type cases

STEP 4. DATA INPUT, TRANSFORMATION AND RESULT OUTPUT

The input information should include values of *geographical angular* (*Latitude & Longitude*) or *UTM projection plane* (*Northing & Easting*) coordinates and, optionally, ellipsoidal *Height*. There are two modes of the data input:

- *Single Point* mode
- *MultiPoint* mode - multiple points (each point's own name for identification and coordinates are saved into *Input (Upload) File* where the same *Source Coordinate Types* (*SCT*) and data formats are used as in the *Single Point* mode except of the absence of *DMS* measurement units format and presence of point names (id) in the *MultiPoint* mode.

Online GRF-TT is able to transform data with the values which are only within the following ranges covering the *KSA* area (*Table 3*):

Table 3. Coordinate range values for KSA area

Coordinate	Range values
Latitude [°]	*16.02 – 33.00*
Longitude [°]	*34.00 – 56.00*
Ellipsoidal height [*m*]	Less than *3200 meters*
Northing [*m*]	*1660514 – 3655285*
Easting [*m*]	*177349 – 822651*

These value ranges are shown as well in the tool's *GUI* under input value fields.

If the input coordinates are out of these ranges the coordinates of such point will not be transformed and the user will see, in the ***Single Point*** mode, corresponding error indicators (* - red stars) above the data entry fields (*Figure 10*). In the ***MultiPoint*** mode, this error message will appear for all such points in the result output file.

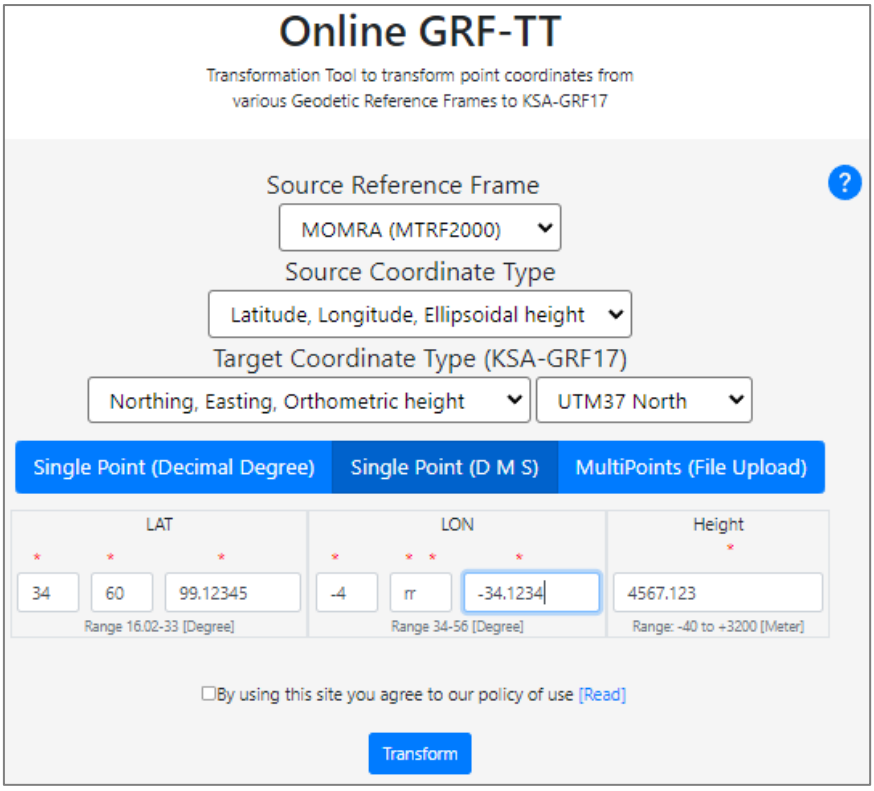

Figure 10. Degrees, Minutes and Seconds client-side detection of input errors

4.1 SINGLE POINT MODE: DATA INPUT

Single Point input mode is used when the user needs to transform *geographical* or *UTM* coordinates without or with *ellipsoidal height* for one point only. In this mode, the user should input the values in the proper fields of the *GUI* according to the selected *SCT*:

- Geographical coordinates (*Figure 11*): latitude *Lat* and longitude *Lon*, are presented either in
  - *decimal* degrees (*[°]* (float, up to *8 digits* after the decimal dot; the number *1* in the 8^{th} digit corresponds to *1 mm* on the *Earth's* surface) in *Single Point Degree* and *MultiPoint* modes, or in
  - *DMS* - angular *degrees* (*[°]* (integer), *minutes [']* (integer), *seconds ["]* (float, up to *5 digits* after the decimal dot; the number *1* in the 5^{th} digit corresponds to *0.3 mm* on the *Earth's* surface) in *Single Point DMS* mode.

  Optional ellipsoidal height is presented in *meters [m]*. Pay attention to the value ranges which are specified under each input field in the *GUI*.
- *UTM* projection coordinates (*Figure 12*): *Northing* and *Easting* in *meters* [*m*] (up to *3 digits* after the decimal dot) and, optionally, in *meters [m]* for ellipsoidal height. Pay attention to the value ranges which are specified under each input field in the *GUI*.

To select the required *Single Point* input mode, just click one of *three* (*Figure 11*) or *two* (*Figure 12*) input mode buttons highlighted with blue background.

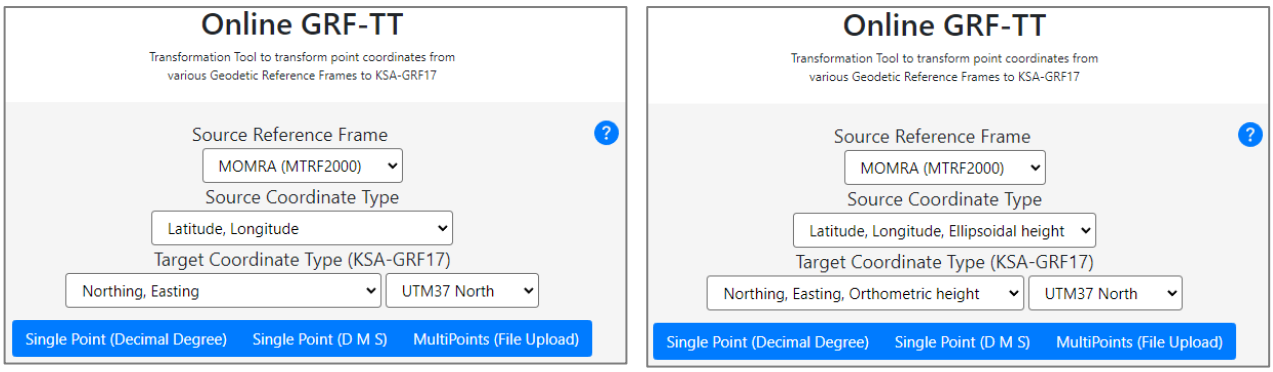

Figure 11. Selection of input mode for geographical SCT

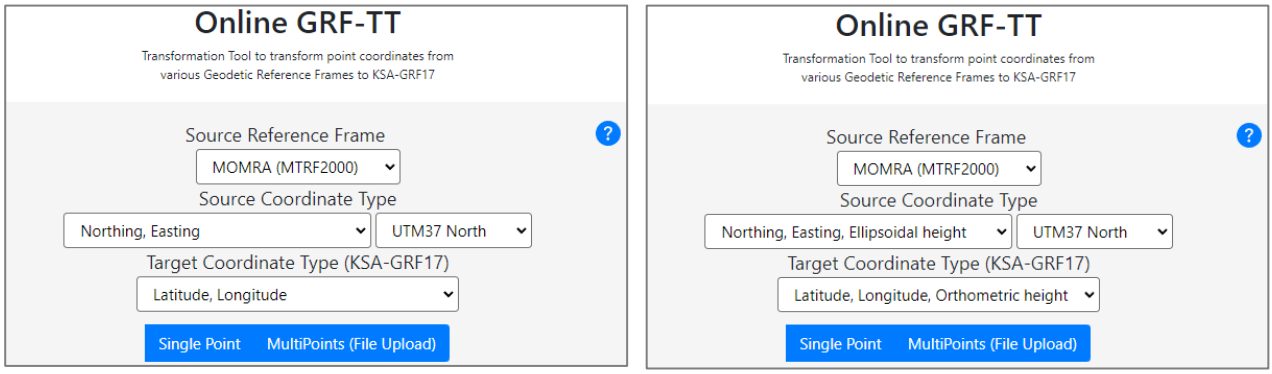

Figure 12. Selection of input mode for UTM SCT

After selection the *Single Point (Decimal Degree)* input mode for geographical coordinates, the data input window will open as shown in the *Figure 13*. Enter required values for coordinates (*Figure 14*).

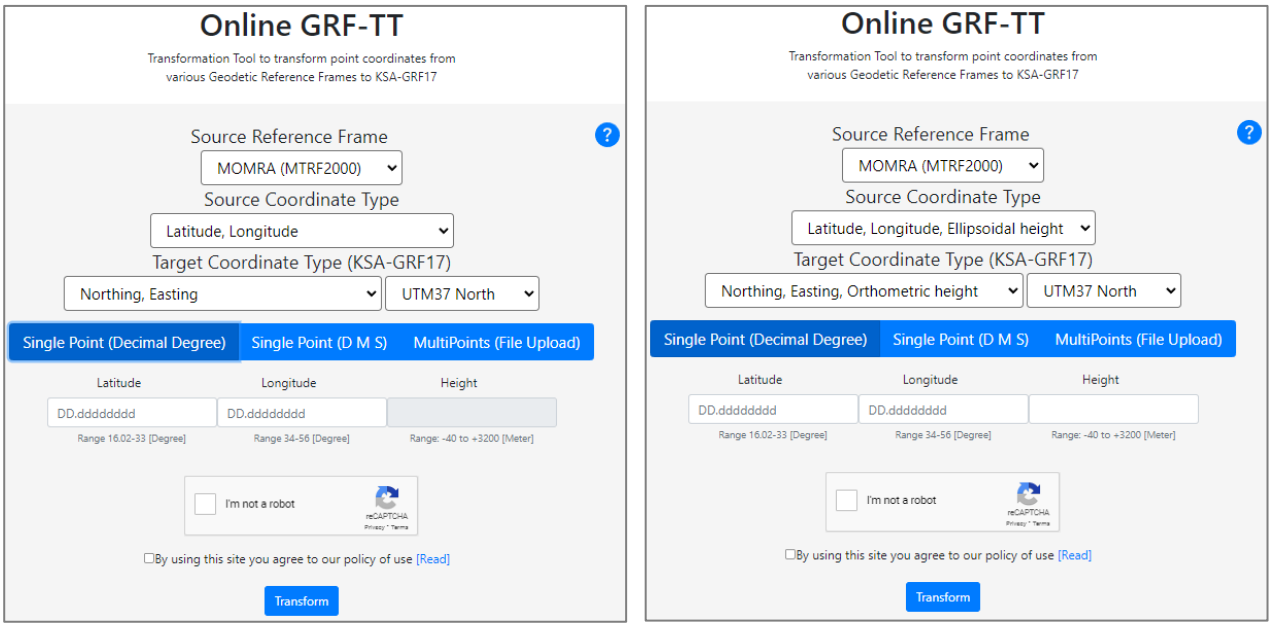

Figure 13. Single Point (Decimal Degree) input window for geographical SCT

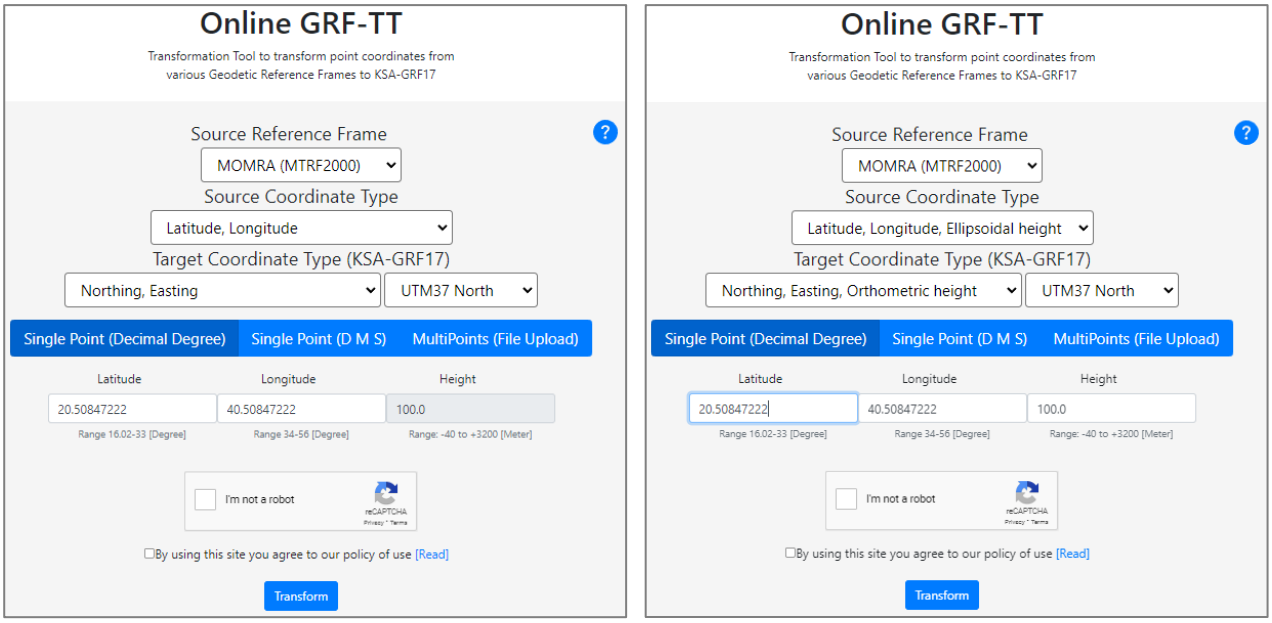

Figure 14. Input of geographical SCT coordinate values in the Single Point (Decimal Degree) mode

After selection of *Single Point (D M S)* input mode for geographical coordinates, the data input window will open as seen in the *Figure 15*. Enter required values for coordinates (*Figure 16*).

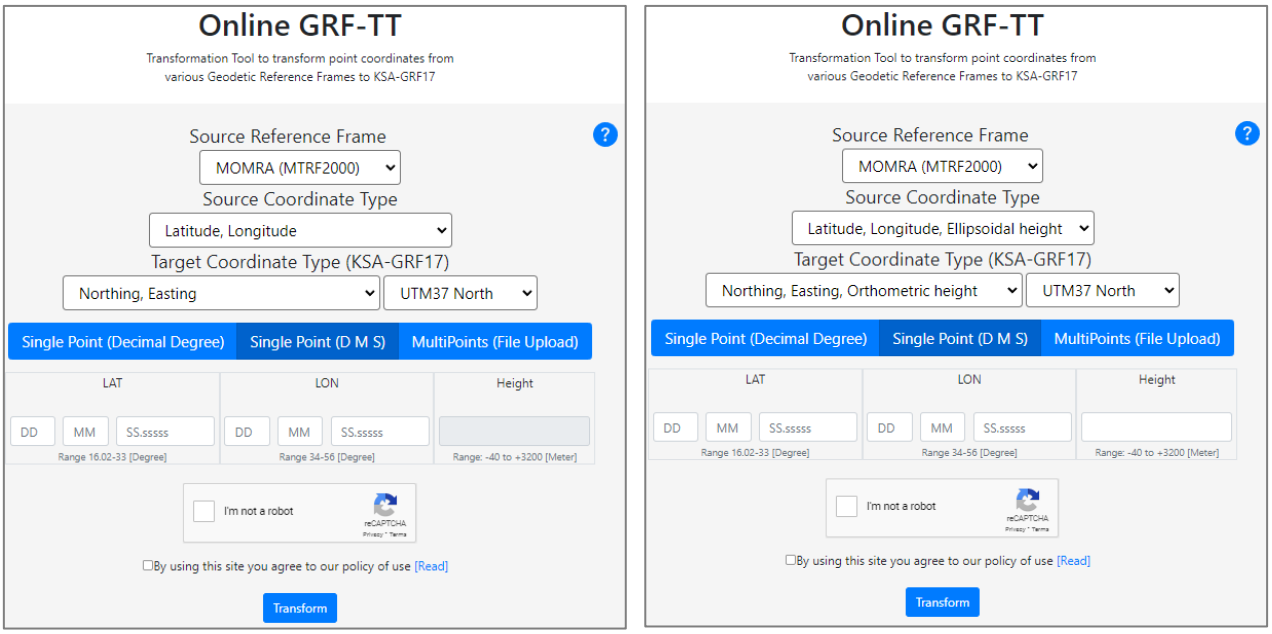

Figure 15. Single Point (D M S) input window for geographical SCT

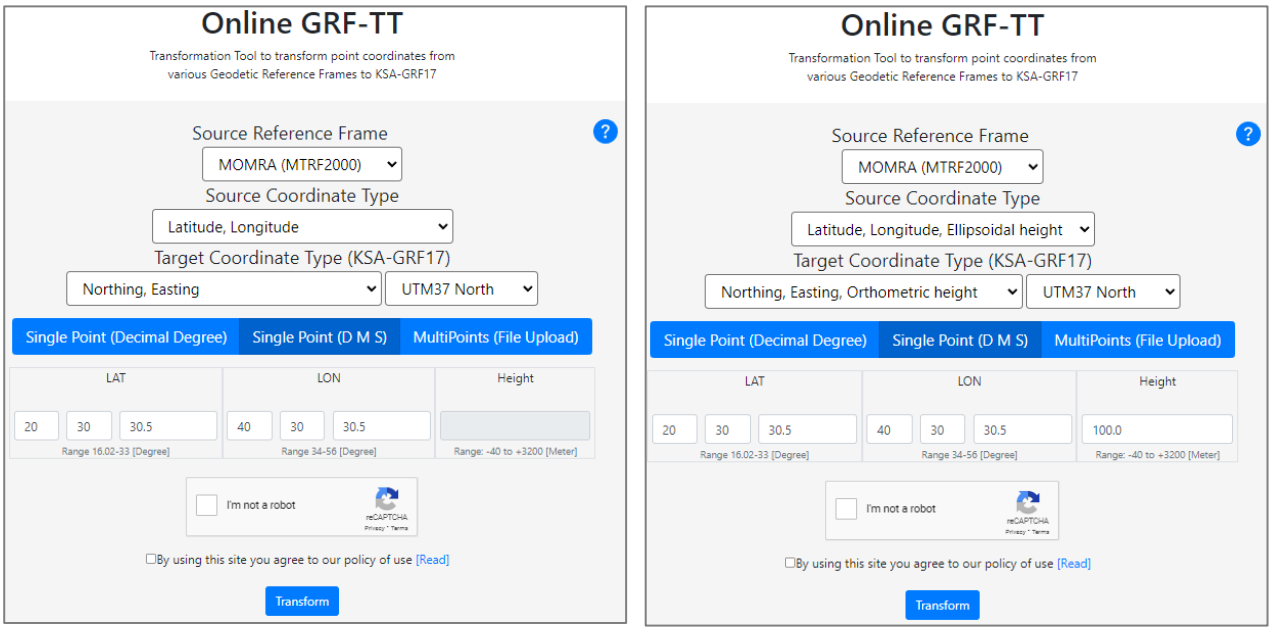

Figure 16. Input of geographical SCT coordinate values in the Single Point (D M S) mode

After selection of *Single Point (UTM)* input mode, the data input window will open as seen in the *Figure 17*. Enter required coordinates (*Figure 18*).

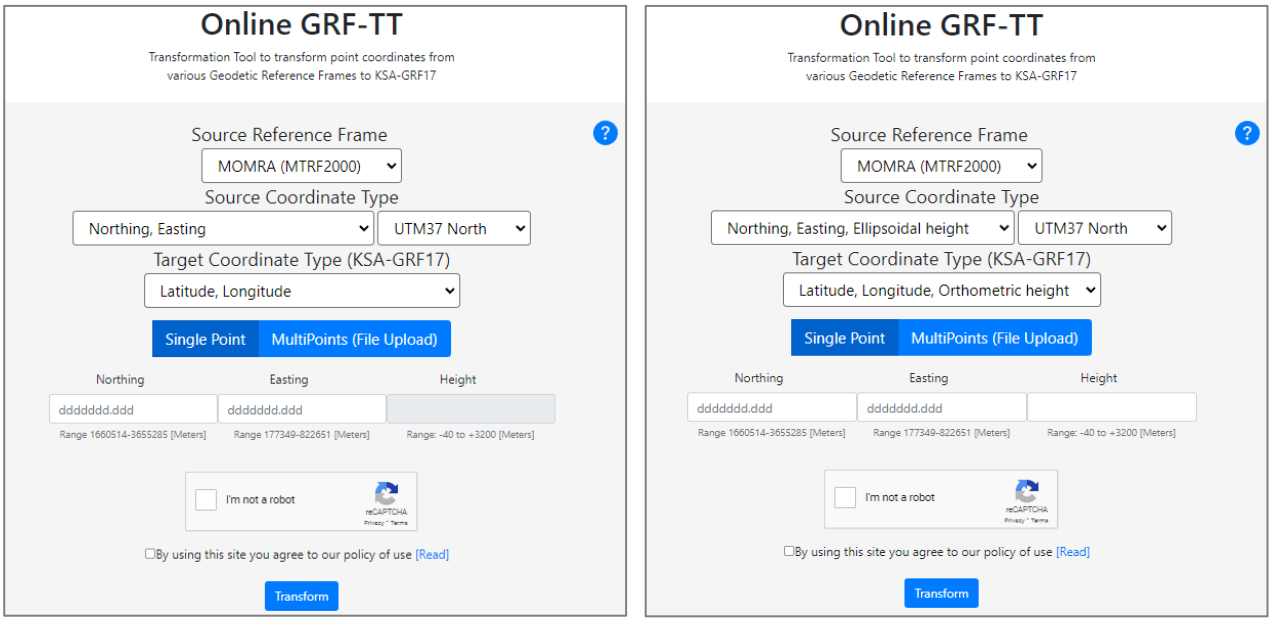

Figure 17. Single Point input window for UTM SCT

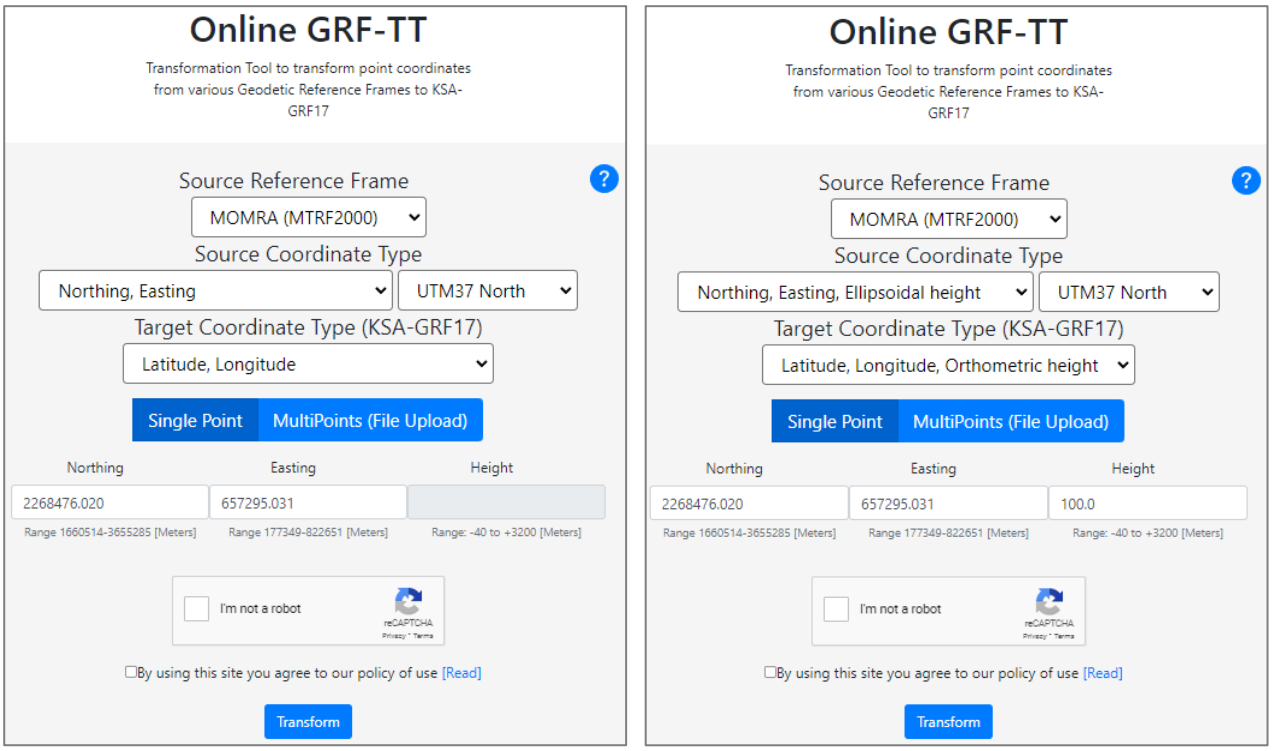

Figure 18. Input of UTM SCT coordinate values in the Single Point mode

4.2 SINGLE POINT MODE: TRANSFORMATION AND RESULT OUTPUT

Next, to transform the entered coordinates, the user should check the box 

in the *Captcha* test in the *GUI*, then, optionally, read the *Software Use Policy* document (Read link) before the use of the tool, check the "*By using this site you agree to our policy*" checkbox, and click the Transform button, e.g. with selected options shown in the *Figure 14*.

The tool will display the resulting coordinates in the *Result* window (*Figure 19*).

To make computation with other *GUI* options or coordinate values, select required options and update coordinates if required. This time, the *Captcha* test checkbox will not be available for a certain time. Check the box "*By using this site you agree to our policy*" of the tool use checkbox and click the Transform button. The new result will appear in the *Result* window.

The copy button is used to copy the resulting values of the coordinates to the computer memory buffer.

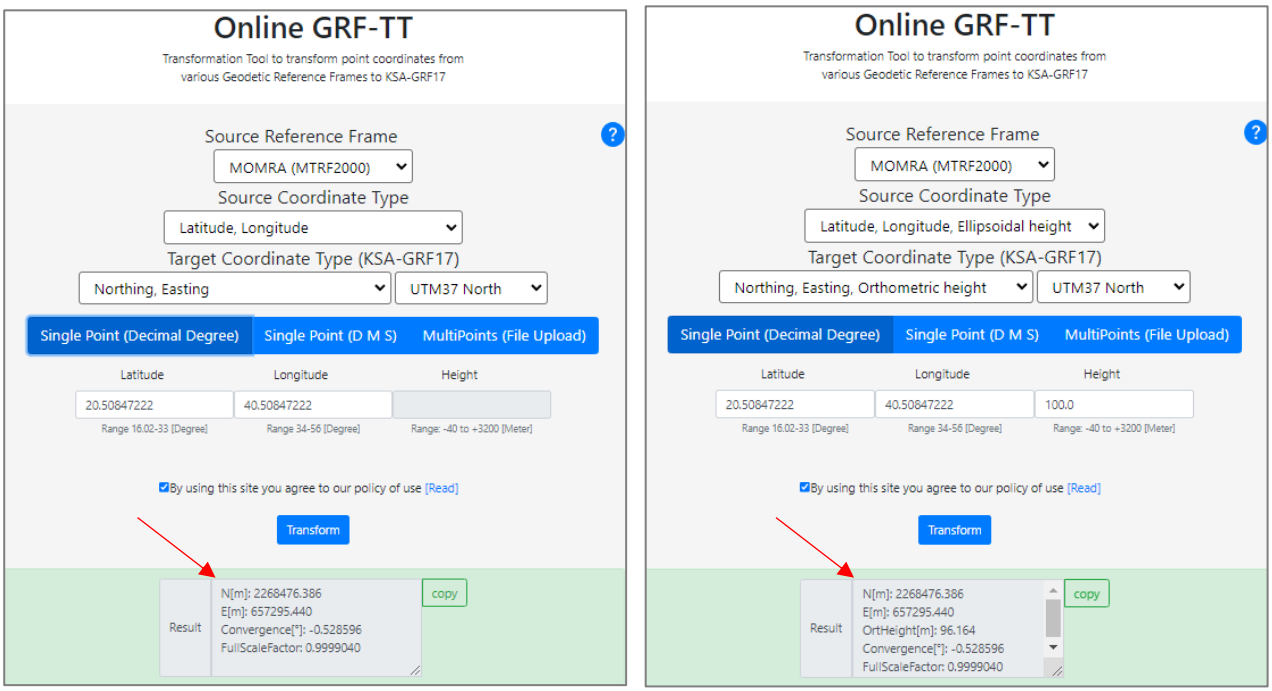

Figure 19. Transformation result in the Single Point mode for the UTM TCT coordinates

The example of results output in the case of geographical *TCT* coordinates is shown in the *Figure 20*.

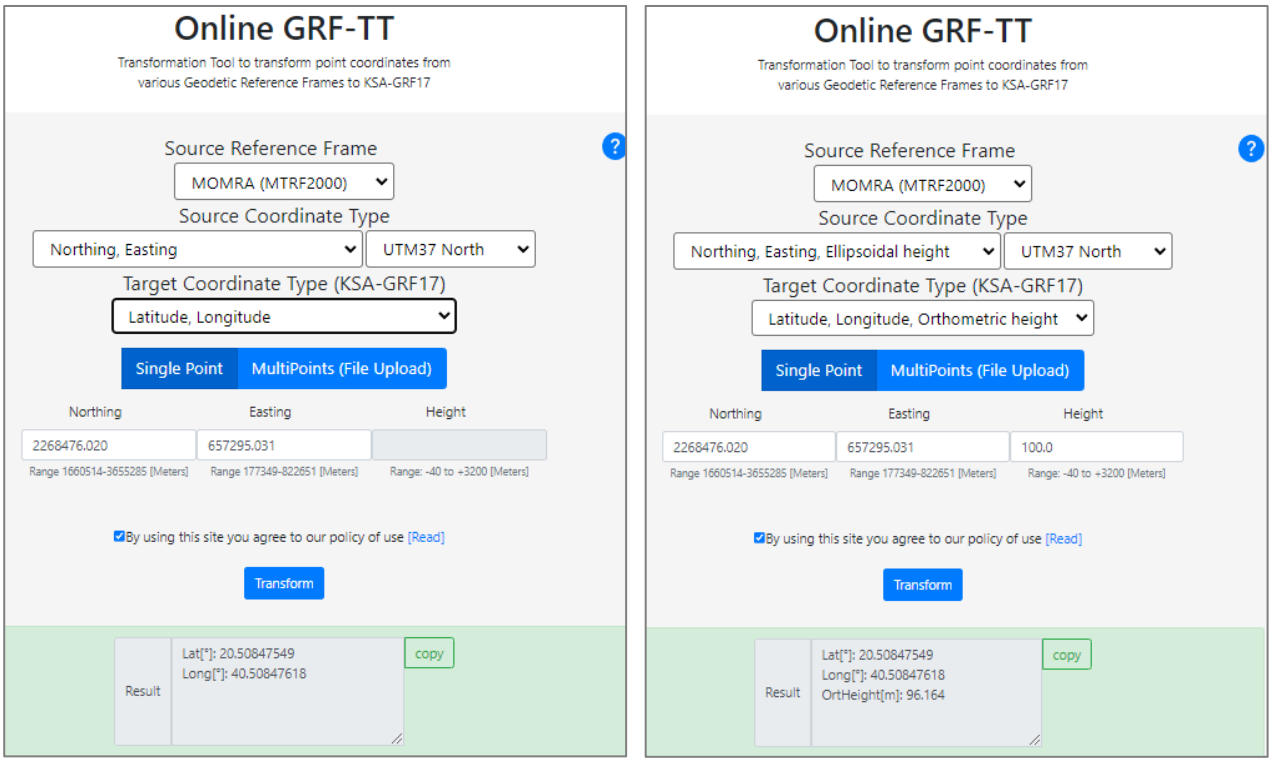

Figure 20. Transformation result in the Single Point mode for the geographical TCT coordinates

4.3 MULTIPOINT MODE: DATA INPUT

MultiPoint input is designed to transform heights of a number of points simultaneously. To do that, the user should compile the input data in *UTF-8* code text file (with *MS Windows* system *CR/LF* or *LINUX/UNIX* system *LF* character at the end of each record line; *Macintosh* operational system uses a character *CR*, therefore, you have to use *Edit → EOL Conversion* option in *Notepad++* text editor to replace *CR* with *CR/LF* otherwise, the transformation will be made for the first point only) with extension **.txt*. To select *MultiPoint* mode, click the "*MultiPoints (File Upload)*" option (*Figure 21*). The area to select and upload the input coordinates file will appear (*Figure 22*).

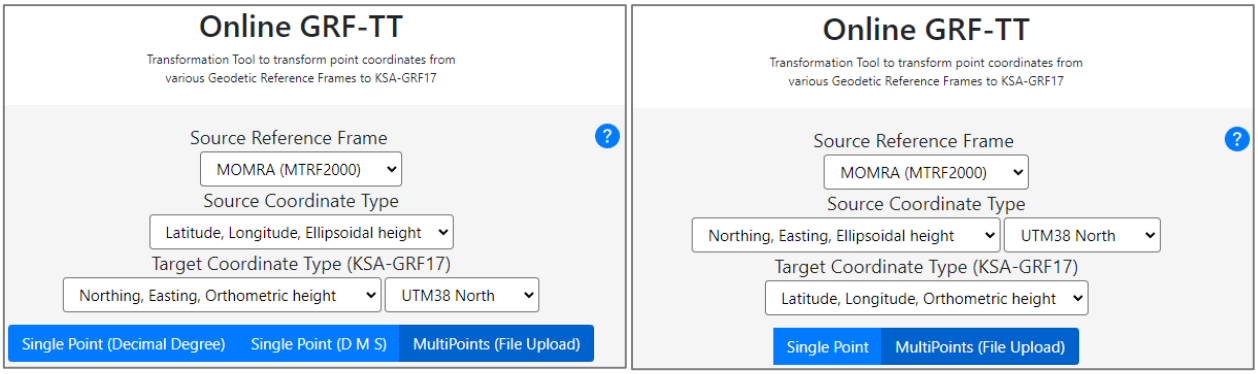

Figure 21. Selection of MultiPoints (File Upload) option for MultiPoint mode

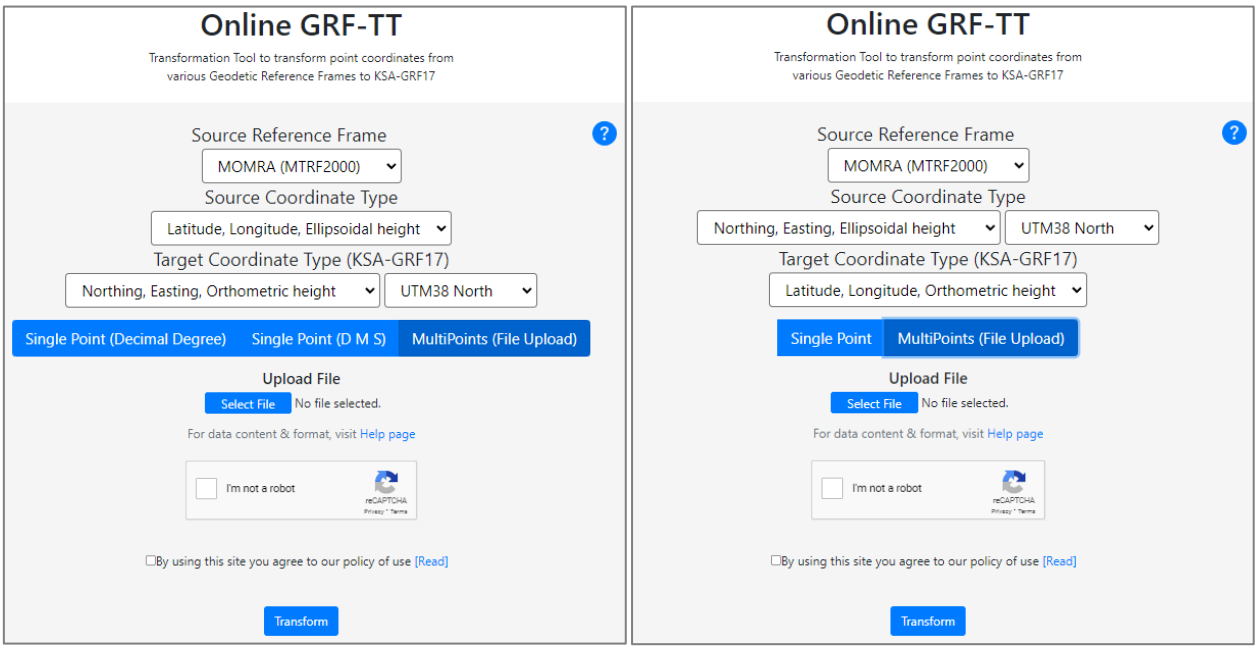

Figure 22. Selection of input file in the MultiPoint mode

Input File to upload has to have *3* (with no point's height) or *4* (with point's height) values in each record line depending on the *Source Coordinate Type*. The range value requirements described for the ***Single Point*** mode input data must be applied to the *Input File* data too. The values must be separated with at least *one space*. Point *id* can contain the sequence of numbers, letters and other symbols, but without spaces between them. The ***Input File*** must have *one empty line* at the very end of the file. No comment texts or lines are allowed.

This information is provided as well in the "*Geodetic Reference Frames*" web frame for *Online GRF-TT* in *Help* web page "*How to use our tools*" at the link *https://gds.gasgi.gov.sa/About*

Some other examples of the input file record lines are given in the *Table 4*.

Table 4. Examples of input file record lines (comment lines are shown for clarity only)

***id Lat [°] Lon [°]** AB01 23.123456 46.12345678 AB02_3 28.12345678 48.12345678
***id Lat [°] Lon [°] Height [m]** AB01 23.123456 46.12345678 100.123 AB02_3 28.12345678 48.12345678 101.12
***id Northing [m] Easting [m]** AB01 2557629.352 615033.727 AB02_3 3114223.837 217427.586
***id Northing [m] Easting [m] Ell.Height [m]** AB01 2557629.352 615033.727 100.123 AB02_3 3114223.837 217427.586 101.12

To upload the input data file to the server, click Select File button (*Figure 22*), select the required file, click *Open*, and the input file name, e.g., "*idNEl_38N.txt*" (with point *id*, *Northing, Easting*) or "*idNEHell_38N.txt*" (with point *id*, *Northing, Easting, Ellipsoidal Height*) will appear instead of "*No file selected*" text in the *GUI* (*Figure 23*).

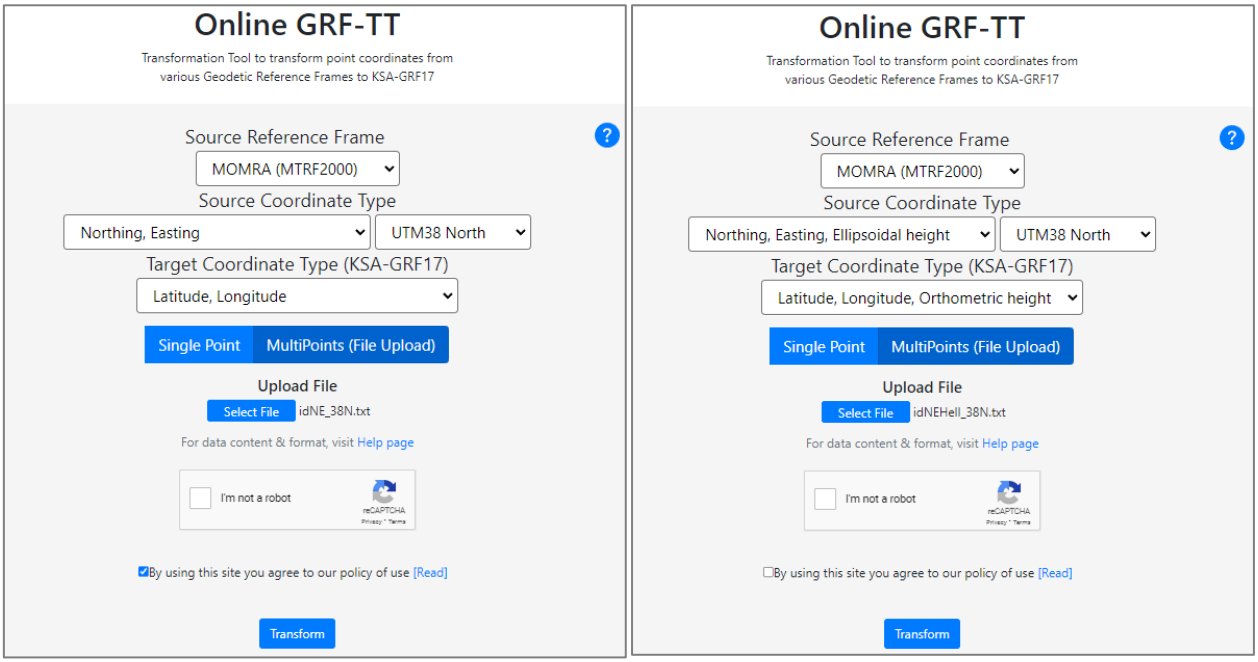

Figure 23. MultiPoint mode transformation window: input file has been uploaded

4.4 MULTIPOINT MODE: TRANSFORMATION AND RESULT OUTPUT

After uploading the input data file, check the box in the *Captcha* test in the *GUI* and, after optional reading of our *Software Use Policy* (Read link), check the "*By using this site you agree to our policy*" checkbox, click Transform button (*Figure 24*).

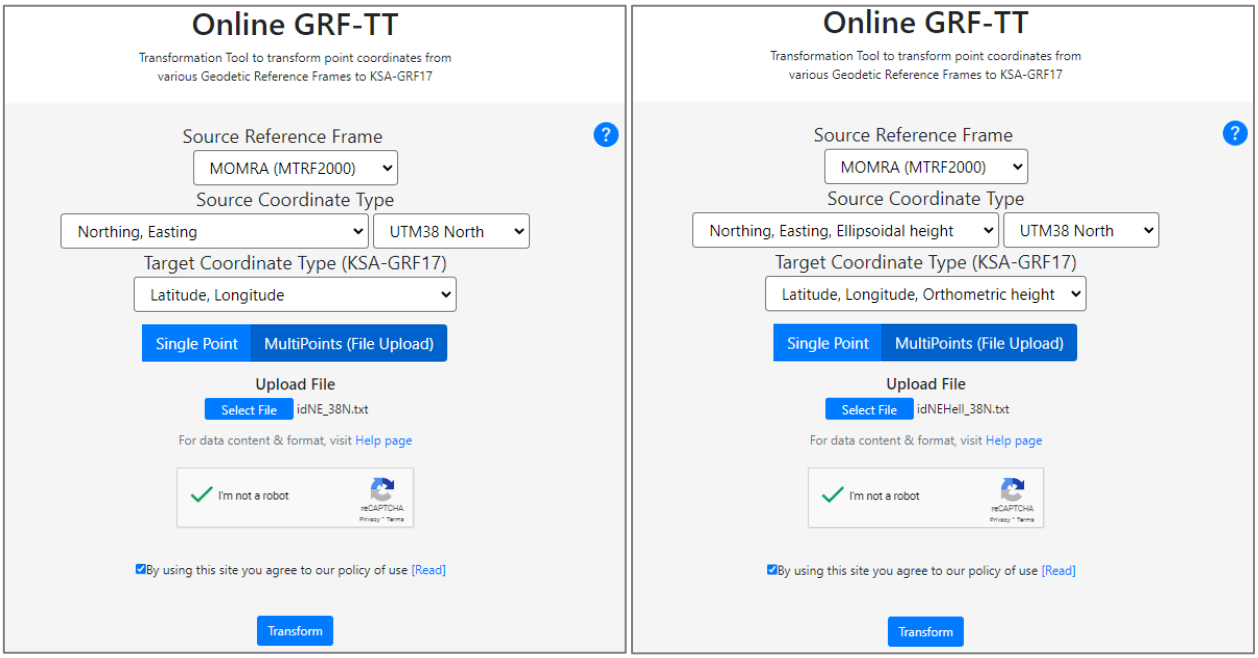

Figure 24. MultiPoint mode transformation window: "Transform" command

Online GRF-TT will transform the data and generate output *UTF-8*-encoded text file with extension **.txt*. By clicking the link "Download" (*Figure 25*), the user can download the `output_*.txt` file to the folder `C:\Users\<username>\Downloads\` on his computer, and inspect it.

Note, please, that immediately after the "***Download***" link appears, all options in *GUI* are reset (*Figure 25*).

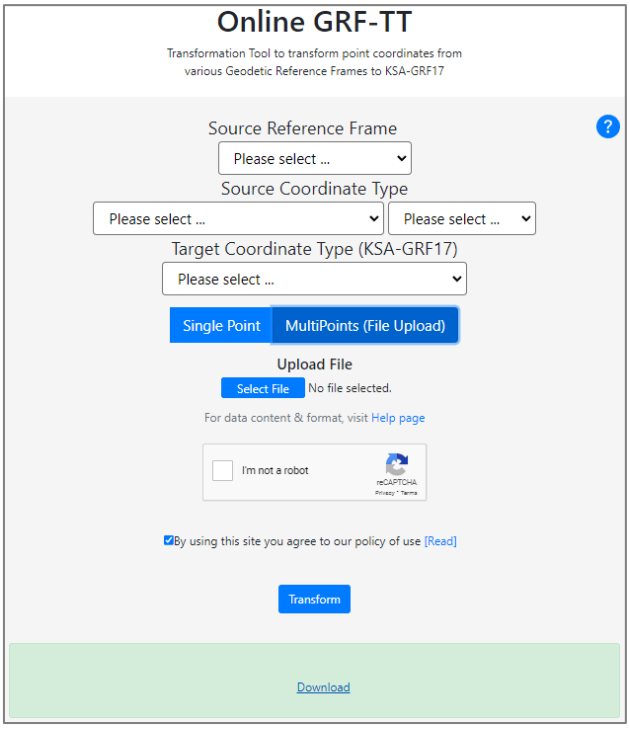

Figure 25. Multi Point mode: download link to the file with transformation results

For geographic *TCT* coordinates, the ***Output File*** to download has *5* (without point's height) or *7* (with point's height) values in each record line depending on the selected *TCT*. Each line contains point *id*, *Latitude* ([*Degrees*]), *Longitude* ([*Degrees*]), optional *Height* ([m], *ellipsoidal* or *orthometric*), optional information on the *Vertical Reference Surface*, information on *Geodetic* and *Vertical Position Precision* values.

For *UTM TCT* coordinates, the ***Output File*** to download has 7 (without point's height) or *9* (with point's height) values in each record line depending on the selected *TCT*. Each line contains point *id*, *Northing* [m], *Easting* [m], optional *Height* ([m], *ellipsoidal* or *orthometric*), meridian *Convergence* ([*Degrees*]), *Full Scale Factor* [unitless], optional information on the *Vertical Reference Surface, Geodetic* and *Vertical Position Precision* values.

At the top of the file, there is information about *Source Input File* name, *Source* and *Target Coordinate Reference Systems*, types of coordinates - *geographic* or *projected*, and measurement units – for *geographic* coordinates and meridian *convergence*, if available.

The output file will be created with *MS Windows* system's *CR/LF* characters at the end of each line. Don't forget to perform *EOL* (*End Of Line*) file conversion to the operational system of your computer with, e.g., *Notepad++* text editor, to replace *CR/LF* character with *CR* character for *Macintosh* and with *LF* character for *LINUX/UNIX* systems.

4.5 MULTIPOINT MODE: EXAMPLES OF INPUT AND RESULT OUTPUT FILES

Let's create two examples of output file for two input data files with values presented in the *Table 5* and *Table 6*. Note, that the input files don't have any indication about *UTM* zone number because the *Online GRF-TT* can transform *geographic* and *UTM* coordinates only for the points located within one *UTM* zone selected in the tool's *GUI*. Remember, the last line in the input file must be empty.

Table 5. Example of input UTM zone 38N data without heights – file idNE_38N.txt

```
01  1885645.756  719968.629
02  1868792.649  238558.461
03  2650221.341  294749.314
04  2024723.294  246263.786
05  2416978.992  644342.837
06  2737669.058  670074.026
07  3253779.002  393076.308
08  2410854.445  346422.637
09  2939906.270  535237.718
10  3155698.256  556070.103
11  2860662.354  244649.052
12  2426456.072  518935.246
13  1933827.535  627483.009
14  2737485.754  670282.507
15  2259043.430  730385.123
```

Table 6. Example of input UTM zone 38N data with ellipsoidal heights – file idNEHell_38N.txt

```
01  1885645.756  719968.629   -0.606006
02  1868792.649  238558.461    0.713314
03  2650221.341  294749.314    0.819051
04  2024723.294  246263.786    0.753967
05  2416978.992  644342.837   -0.519979
06  2737669.058  670074.026   -0.704108
07  3253779.002  393076.308    0.541227
08  2410854.445  346422.637    0.551687
09  2939906.270  535237.718   -0.158331
10  3155698.256  556070.103   -0.273690
11  2860662.354  244649.052    1.111071
12  2426456.072  518935.246   -0.068521
13  1933827.535  627483.009   -0.360855
14  2737485.754  670282.507   -0.704917
15  2259043.430  730385.123   -0.770505
```

The examples of two output files with results of transformation of coordinates from *Table 5* and *Table 6* are given in the *Table 7* and *Table 8* correspondingly for *GUI* transformations options shown in the *Figure 24* : to transform from *UTM* coordinates (without and with *ellipsoidal* heights) in *MOMRA(MTRF2000) r*eference frame to *geographic* coordinates (without heights and with *orthometric* heights *H* referenced to *KSA-GEOID21GASGI* geoid surface) in *KSA-GRF17* reference frame. Keep in mind, that output *ellipsoidal* height has notation ***he*** in the parameters header line in output files, whereas *orthometric* height has notation ***H***.

Table 7. Example of result output file for transformation from MOMRA (MTRF2000) UTM Zone 38N (no heights) to KSA-GRF17 geographic coordinates (no heights)

```
*!SOURCE: D:/Test_Web_GRF-TT/idNE_38N.txt
*!CODE: MOMRAMTRF2000UTM38N.
*!GEODETIC FRAME: MOMRA_MTRF2000 (ITRF2000 ep. 2004.0)
*!COORDINATES: projected
*!ELLIPSOID: GRS 1980
*!PROJECTION: UTM 38 North
*!
*!TARGET:
*!CODE: KSA-GRF17G.
*!GEODETIC FRAME: KSA-GRF17 (ITRF2014 ep. 2017)
*!COORDINATES: geographic
*!ELLIPSOID: GRS 1980
*!UNIT: degrees
*!
*!      id          Latitude       Longitude     geod.prec.  vert.prec.
01                  17.04454592    47.06665402   5 / 10 cm     no info
02                  16.88800605    42.54592633   5 / 10 cm     no info
03                  23.95057724    42.98307715   5 / 10 cm     no info
04                  18.29708483    42.59967509   5 / 10 cm     no info
05                  21.85090526    46.39683637   5 / 10 cm     no info
06                  24.74420546    46.68178856   5 / 10 cm     no info
07                  29.40876254    43.89789528   5 / 10 cm     no info
08                  21.79480892    43.51440112   5 / 10 cm     no info
09                  26.57946010    45.35386043   5 / 10 cm     no info
10                  28.52683408    45.57307722   5 / 10 cm     no info
11                  25.84200523    42.45239928   5 / 10 cm     no info
12                  21.94234269    45.18337387   5 / 10 cm     no info
13                  17.48696166    46.20073784   5 / 10 cm     no info
14                  24.74252754    46.68382714   5 / 10 cm     no info
15                  20.41580024    47.20786866   5 / 10 cm     no info
```

Table 8. Example of result output file for transformation from MOMRA (MTRF2000) UTM Zone 38N (with ellipsoidal heights) to KSA-GRF17 geographic coordinates (with orthometric heights H)

```
*!SOURCE: D:/Test_Web_GRF-TT/idNEHell_38N.txt
*!CODE: MOMRAMTRF2000UTM38N.
*!GEODETIC FRAME: MOMRA_MTRF2000 (ITRF2000 ep. 2004.0)
*!COORDINATES: projected
*!ELLIPSOID: GRS 1980
*!PROJECTION: UTM 38 North
*!
*!TARGET:
*!CODE: KSA-GRF17G.AUTHORITATIVE
*!GEODETIC FRAME: KSA-GRF17 (ITRF2014 ep. 2017)
*!COORDINATES: geographic
*!ELLIPSOID: GRS 1980
*!UNIT: degrees
*!
*!      id          Latitude       Longitude       H        [ vert.info. ]                 geod.prec.  vert.prec.
01                  17.04454592    47.06665402    15.353   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
02                  16.88800605    42.54592633     4.590   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
03                  23.95057724    42.98307715    -4.147   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
04                  18.29708483    42.59967509    -2.348   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
05                  21.85090526    46.39683637    11.362   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
06                  24.74420546    46.68178856     6.223   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
07                  29.40876254    43.89789528    -0.164   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
08                  21.79480892    43.51440112     0.327   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
09                  26.57946010    45.35386043     1.928   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
10                  28.52683408    45.57307722     4.524   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
11                  25.84200523    42.45239928    -5.909   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
12                  21.94234269    45.18337387     4.955   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
13                  17.48696166    46.20073784    13.541   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
14                  24.74252754    46.68382714     6.236   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm   no info
15                  20.41580024    47.20786866    19.457   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] 5 / 10 cm
```

More examples of output file's record line formats for a point coordinates are presented in the *Table 9*.

Table 9. Four examples of result output file record line format (without or with ellipsoidal heights)

#	Example
1	***id Lat** [°] **Lon** [°] **GeodeticPrecision VerticalPrecision** 01 23.43546534 46.42938473 < 5 cm no info
2	***id Lat** [°] **Lon** [°] **he** [m] **GeodeticPrecision VerticalPrecision** 01 23.43546534 46.42938473 347.483 < 5 cm no info
4	***id Northing** [m] **Easting** [m] **Convergence** [°] **FullScale GeodeticPrecision VerticalPrecision** 01 2211793.556 604609.324 -0.606006 1.0001945 < 5 cm no info
3	***id Northing [m] Easting [m] he [m] Convergence [°] FullScale GeodeticPrecision VerticalPrecision** 01 2211793.556 604609.324 347.483 -0.606006 1.0001945 < 5 cm no info

4.6 MULTIPOINT MODE: ERROR AND WARNING INDICATORS AND MESSAGES

Let's use the *Table 10* of geographical coordinates for demonstration of error and warning messages in the output file. The cyan-highlighted values for the first four points in the table are wrong because they are outside the range zone described in the *Table 3*.

Table 10. Example of input data with geographical coordinates (ellipsoidal heights) with out of range coordinates

* id	Lat [°]	Lon [°]	Ell.Height [m]
01	7.04454261	47.06664975	820.397
02	16.88800281	2.54592222	50.974
03	18.69564183	61.39374822	29.586
04	40.49095681	61.81728828	86.372
05	25.05817208	37.31601878	95.013
06	26.54368436	36.31480961	54.155
07	27.96853067	35.29034811	63.057
08	29.26529653	34.94071406	46.180
09	29.14275394	36.16109678	705.996

Example of the result output file for transformation from input *geographic* coordinates from the *Table 10* in *ARAMCO(ITRF94)* reference frame to *UTM* coordinates (with *orthometric* heights referenced to *KSA-GEOID21GASGI* geoid surface) in *KSA-GRF17* reference frame is given in the *Table 11*.

Table 11. Example of result output file for transformation from ARAMCO (ITRF94) geographic coordinates (with ellipsoidal heights) to KSA-GRF17 UTM 37N projection coordinates (with orthometric heights H)

```
*!SOURCE: D:/Test_Web_GRF-TT/idLaLoHeDe - out of zone points.txt
*!CODE: ARAMCO_WGS84G.
*!GEODETIC FRAME: ARAMCO_WGS84 (ITRF94 ep. 1998.0)
*!COORDINATES: geographic
*!ELLIPSOID: GRS 1980
*!UNIT: degrees
*!
*!TARGET:
*!CODE: KSAGRF17UTM37N.AUTHORITATIVE
*!GEODETIC FRAME: KSA-GRF17 (ITRF2014 ep. 2017)
*!COORDINATES: projected
*!ELLIPSOID: GRS 1980
*!PROJECTION: UTM 37 North
*!UNIT(Convergence): degrees
*!
*! id    N          E       H     Convergence Scale Factor   [ vert.info. ]                                                geod.prec.  vert.prec.
*Point is outside source geodetic CRS
*Point is outside source geodetic CRS
*Point is outside source geodetic CRS
*Point is outside source geodetic CRS
05 2772447.058 330134.806   84.368  0.713397 0.9999545  [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm     no info
06 2938699.113 232462.754   41.699  1.200659 1.0004795  [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm     no info
*Point is outside target geodetic CRS in target geodetic frame
*Point is outside target geodetic CRS in target geodetic frame
09 3227136.044 223812.477  688.315  1.383371 1.0005373  [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm     no info
```

The transformations haven't been performed for the first four points and the message

```
*Point is outside source geodetic CRS
```

has been placed in the point's record line in the output file (*Table 11* and *Table 12*).

If the input point is found to be outside (yellow highlighted values in the *Table 10*) the selected *TRF's* (target *CRS*) zone (*UTM 37N* in our case, what corresponds to the longitude range from *36°* to *42°*), next message appears for this point in the output file (*Table 11*):

```
*Point is outside target geodetic CRS in target geodetic frame
```

The message

```
*Point is outside CRS type definition domain
```

appears in the output file if the input data values are wrong for the selected *CRS*. For instance, if the *SCT* "*Latitude, Longitude*" option has been selected but, by mistake, the input file contains "*Latitude Longitude HeightEllipsoidal*" instead of "*id Latitude Longitude*", the tool will read *HeightEllipsoidal* values as values for the *Longitude*, and if *360 < HeightEllipsoidal < -360*, the tool sends the warning message because the *Longitude* can't be larger than *360°* and smaller than *-360°.* Pay attention to the data content and format in the input file when selecting the file.

Example of the result output file for transformation from input *geographic* coordinates from the *Table 10* in *ARAMCO (ITRF94)* (named *ARAMCO_WGS84* as well) reference frame to *geographic* coordinates (with *orthometric* heights referenced to *KSA-GEOID21GASGI* geoid surface) in *KSA-GRF17* reference frame is given in the *Table 12*.

Table 12. Example of result output file for transformation from ARAMCO (ITRF94) geographic coordinates (with ellipsoidal heights) to KSA-GRF17 geographic coordinates (with orthometric heights H)

```
*!SOURCE: D:/Test_Web_GRF-TT/idLaLoHeDe - out of zone points.txt
*!CODE: ARAMCO_WGS84G.
*!GEODETIC FRAME: ARAMCO_WGS84 (ITRF94 ep. 1998.0)
*!COORDINATES: geographic
*!ELLIPSOID: GRS 1980
*!UNIT: degrees
*!
*!TARGET:
*!CODE: KSA-GRF17G.AUTHORITATIVE
*!GEODETIC FRAME: KSA-GRF17 (ITRF2014 ep. 2017)
*!COORDINATES: geographic
*!ELLIPSOID: GRS 1980
*!UNIT: degrees
*!
*! id Latitude    Longitude       H       [ vert.info. ]                                                  geod.prec.  vert.prec.
*Point is outside source geodetic CRS
*Point is outside source geodetic CRS
*Point is outside source geodetic CRS
*Point is outside source geodetic CRS
05 25.05817672    37.31602426    84.368   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm      no info
06 26.54368892    36.31481496    41.699   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm      no info
07 27.96853514    35.29035333    48.224   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm      no info
08 29.26530096    34.94071917    30.332   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm      no info
09 29.14275844    36.16110193   688.315   [ KSA-GEOID21GASGI geoid surface via KSA-GEOID21GASGI_NW2SE ] < 5 cm      no info
```