



Засгийн газрын хэрэгжүүлэгч агентлаг
ГАЗАР ЗОХИОН БАЙГУУЛАЛТ,
ГЕОДЕЗИ, ЗУРАГ ЗҮЙН ГАЗАР

Геодези, зураг зүйн хэлтэс

МОНГОЛ ОРНЫ ХАМГИЙН НАМ ЦЭГИЙГ ШИНЭЧЛЭН ТОГТООСОН АЖИЛД ХЯНАЛТЫН ХЭМЖИЛТ ХИЙСЭН ТАЙЛАН

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Улаанбаатар хот 2020 он

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1. Оршил

2019 онд Газар зүй, гео экологийн хүрээлэн болон бусад байгууллагууд хамтран Монгол орны хамгийн нам цэгийг Говь-Алтай аймгийн Алтай сумын Говийн Их Дархан газрын Номингийн говийн Элст сайрын баруун салаанд /527 м/ байгааг шинэчлэн тогтоосон юм.

ГЗБГЗЗГ-ын ГЗЗХ Монгол орны хамгийн нам цэгийг шинэчлэн тогтоосон дээрх газарт хяналтын хэмжилтийг 2020 оны 8 дугаар сарын 14-21-нд хийж, үр дүнг боловсруулж, Газарзүй-геоэкологийн хүрээлэн шинэчлэн тогтоосон утгатай харьцуулав.

1.1. Цэг, тэмдэгтийн судалгаа, суулгалт, хээрийн хэмжилт, зураглал

1.1.1. Цэг, тэмдэгтийн судалгаа, суулгалт

Хяналтын хэмжилт хийх талбайд цэгийн судалгаа хийн Элст сайрын баруун салаанд шинээр геодезийн байнгын цэг, тэмдэгт суулгаж, тухайн цэгт тулгуурлан орчны хэмжилт, зураглалыг хийсэн.

Цэгийг бэлтгэхдээ 60 мм-ийн диаметртэй 1 м урттай төмөр яндан трубаны дээд хэсэгт 67024 дугаартай цэгийн толгойг гагнан цэг, тэмдэгтийг бэлтгэсэн.

Цэгийг газрын түвшнээс 1 метрийн гүнд бетоноор цутгаж, цэгийн толгойг газрын түвшинтэй тэнцүү байдлаар суулган газарт бэхлэн хэмжилтийг эхэлсэн.



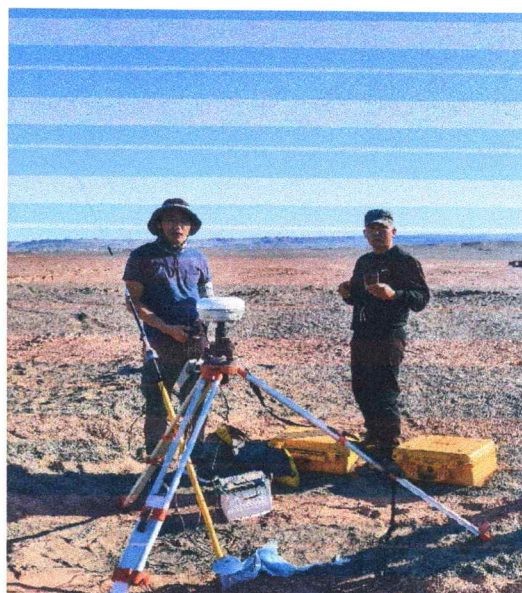
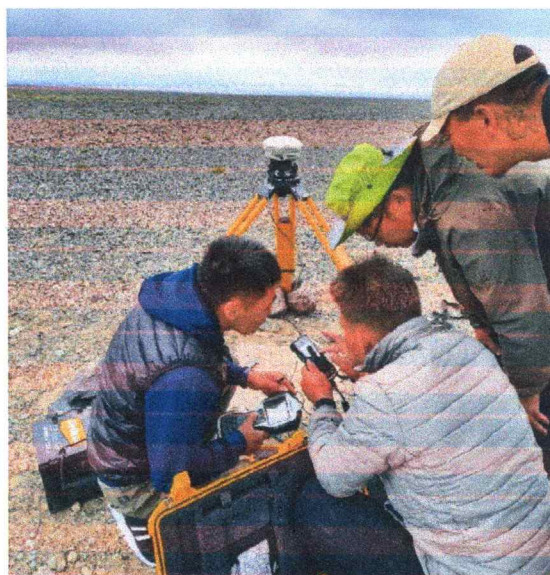
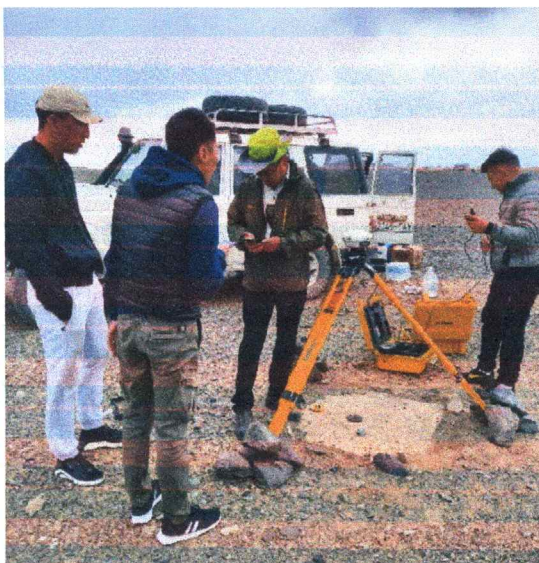
Зураг 1. Элст сайрын баруун салаанд геодезийн цэг суулгаж байгаа байдал

1.2. Хээрийн хэмжилт, зураглал

Шинээр суулгасан цэг, Алтай сумын гравиметрийн сүлжээний 027 цэгт ижил хугацаанд GNSS-ийн тасралтгүй 12-21 цагийн статик хэмжилтийг TrimbleR8 загварын GNSS-ийн 2 долгионы хүлээн авагчаар хийсэн.

Мөн газар орчны байршлыг харж хамгийн нам байх боломжтой цэгүүдэд GNSS-ийн бодит агшны хэмжилтийг байршилд хийсэн. Хэмжилтийн үр дүнг хавсралт1-д хавсаргав.

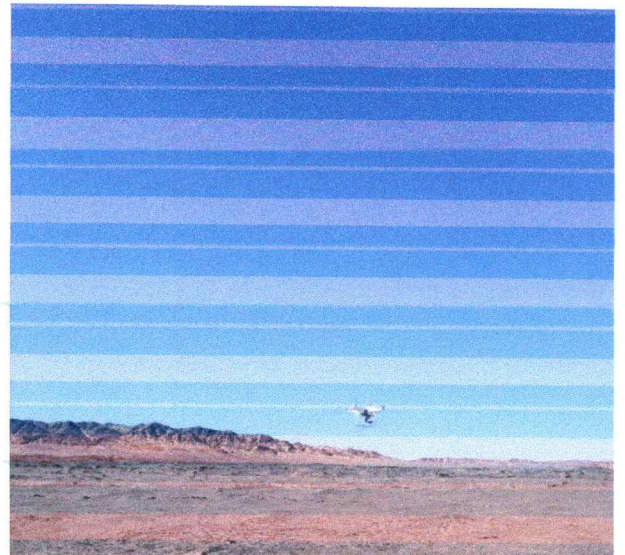
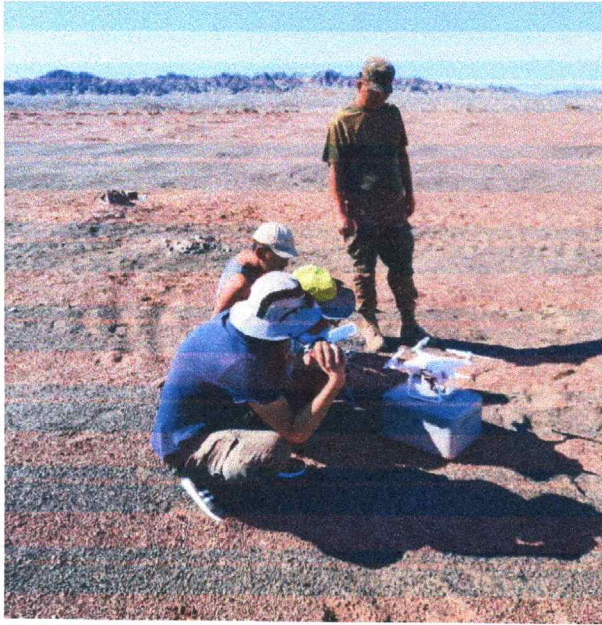
Нам цэгийн орчимд нисгэгчгүй нисэх төхөөрөмж ашиглан 1 га талбайд 1:500-ны масштабтай байр зүйн зураглал хийсэн.



Зураг 2. Алтай сумын 027 цэг дээр GNSS-ийн статик хэмжилт хийж байгаа байдал



Зураг 3. Нислэгийн талбайд газрын хяналтын цэгийг тэмдэгжүүлж байгаа байдал



Зураг 4. Нисгэгчгүй нисэх төхөөрөмжөөр зураглал хийж байгаа байдал

2. Тэгшитгэн бодолт, боловсруулалт

2.1. GNSS-ийн сүлжээний тэгшитгэн бодолт

GNSS-ийн статик хэмжилтийг “Gemit/Globk10.71” GNSS-ийн тэгшитгэн бодолтын хол зайн програм хангамж, Австрали Улсын “AUPOS” GNSS-ийн онлоайн боловсруулалтын програм, АНУ-ын “OPUS” GNSS-ийн онлоайн боловсруулалтын програм хангамжаар дундаж квадрат алдаа 0.003 м-ийн нарийвчлалтай тэгшитгэн бодож, үр дүнг хавсралт 2-д хавсаргав.

3 програм хангамжаар тэгшитгэн бодож, солбицол, өндрийн харьцуулалтыг хүснэгт – 1, 2-д үзүүлэв.

Gemit/Globk 10.71 програм хангамжаар бодсон солбицол, өндрийг хэмжилт, зураглалын тулгуур өгөгдөл болгон ашигласан.

Цэгийн эллипсодын өндрийг Монгол улсын геоидын өндрийн тоон загвар ашиглан ортометрийн өндөрт хөрвүүлсэн.

Алтай сумын гравиметрийн сүлжээний 027 цэгийн орос катологийн өндөр болон геоидын өндрийн тоон загвар ашиглан тодорхойлсон ортометрийн өндрөөс 1.09 м зөрүүтэй байна.

3. Байр зүйн зураглалын хэмжилт, боловсруулалт

Шинээр тодорхойлогдсон нам цэгийн орчинд 1 га газарт 1:1500-ны масштабтай байр зүйн зураглалыг нисгэгчгүй нисэх төхөөрөмж ашиглан гүйцэтгэсэн.

1 метрийн үеийн өндөртэй тоон байр зүйн зураглалыг autocad програм хангамж ашиглан боловсруулжсан.

Нам цэгийн орчинд боловсруулсан байр зүйн зургийн пикетийн өндөр 626.95-527.40 метр байна.

Байр зүйн тоон зураглалыг хавсралт 1, 2, 3-т хавсаргав.

ХҮСНЭГТ 1

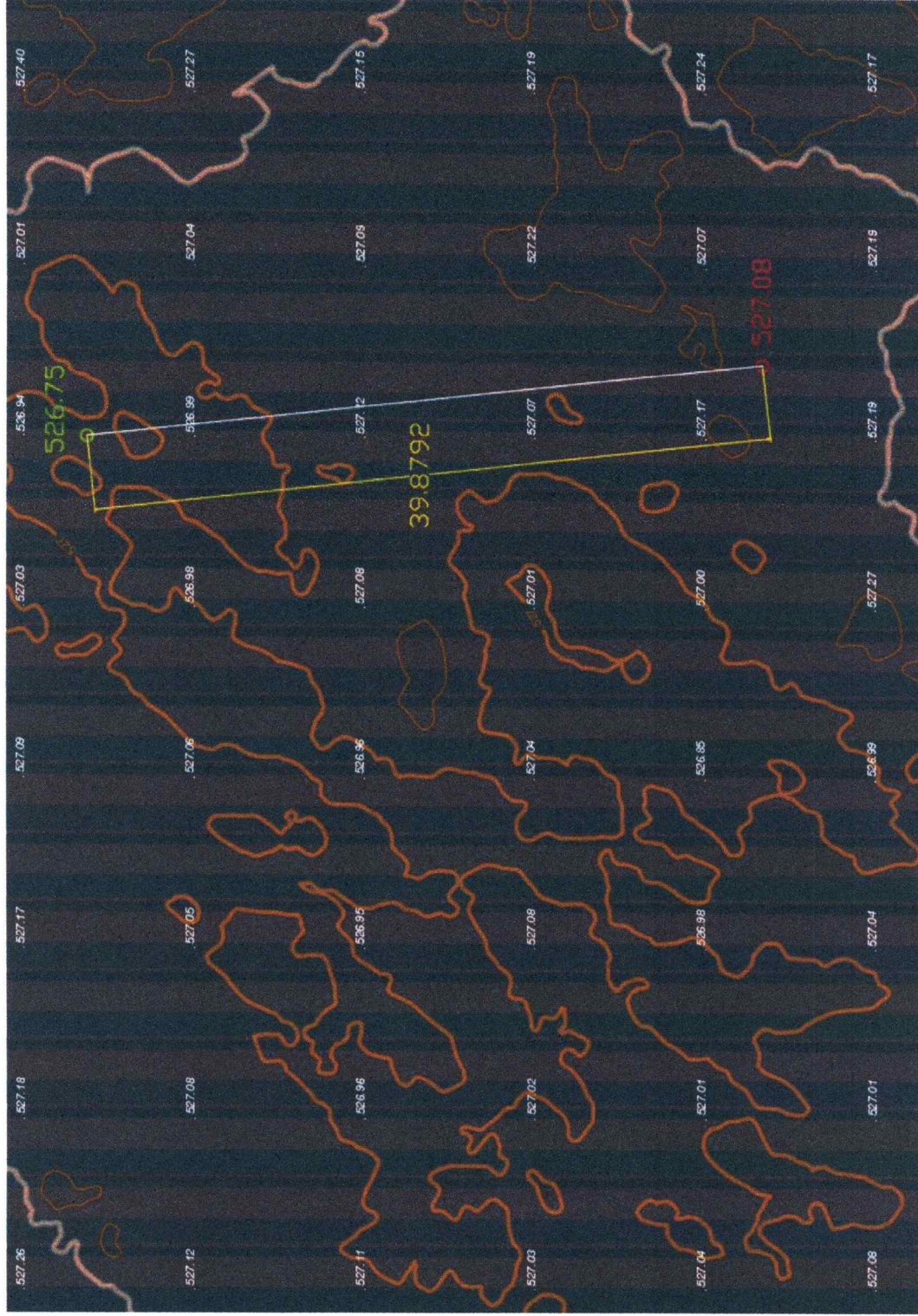
Цэг дугаар	GAMMIT				AUPOS				OPUS							
	X	Y	Z	H ellip	Hortho	X	Y	Z	H ellip	Hortho	X	Y	Z	H ellip	Hortho	
67024	-453727	4588660	4392612	478.7191	538.7711	-453727	4588660	4392612	478.657	538.566	538.709	453727	4588660	4392612	478.667	538.719
27	-390459	4531112	4458820	1398.092	1452.193	-390459	4531112	4458820	1398.09	1452.794	1452.191	-390459	4531112	4458820	1398.1	1452.201
	GAMMIT-OPUS				AUPOS-OPUS				GAMMIT-AUPOS							
	dX	dY	dZ	dH		dX	dY	dZ	dH	dX	dY	dZ	dH			
67024	-0.01613	0.0427	0.03298	0.052		0.005	-0.006	-0.008	-0.01	-0.01113	-0.0487	-0.04098	0.062			
27	-0.0179	0.00562	-0.00532	-0.008		0.002	-0.01	-0.005	-0.01	-0.0159	-0.00438	0.00032	0.002			

ХҮСНЭГТ 2

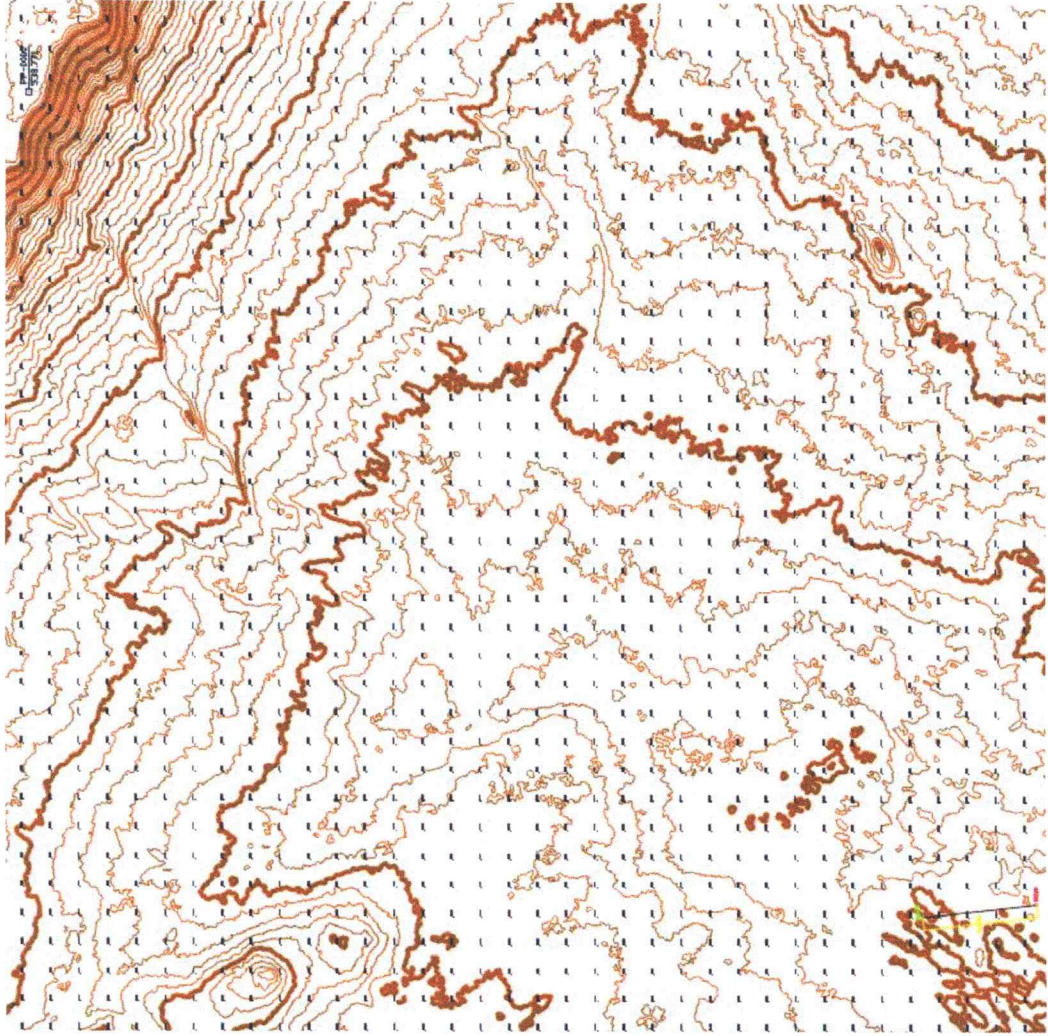
GAMMIT	LAT	LONG		N_UTM	E_UTM	H ellip	Hortho	B_degree	L_degree
		95	94						
67024	43	48	9.02787	4853344	712931.6	478.719	538.7711	43.80251	95.64706
27	44	37	32.39201	4943171	652718.2	1398.09	1452.193	44.62566	94.92517
OPUS	LAT		LONG	N_UTM	E_UTM	H ellip	Hortho	B_degree	L_degree
67024	43	48	9.02801	4853344	712931.7	478.667	538.719	43.80251	95.64706
27	44	37	32.39198	4943171	652718.3	1398.1	1452.201	44.62566	94.92517
AUPOS	LAT		LONG	N_UTM	E_UTM	H ellip	Hortho	B_degree	L_degree
67024	43	48	9.02796	4853344	712931.7	478.657	538.566	43.80251	95.64706
27	44	37	32.39207	4943171	652718.3	1398.09	1452.794	44.62566	94.92517
Catlogy	LAT		LONG	N_UTM	E_UTM	H ellip	Hortho	OROS	
27	44	37	32.3915	4943170	652717.7	1398.26	1452.361	1451.1	44.62566
									94.92517

4. Хавсралтууд

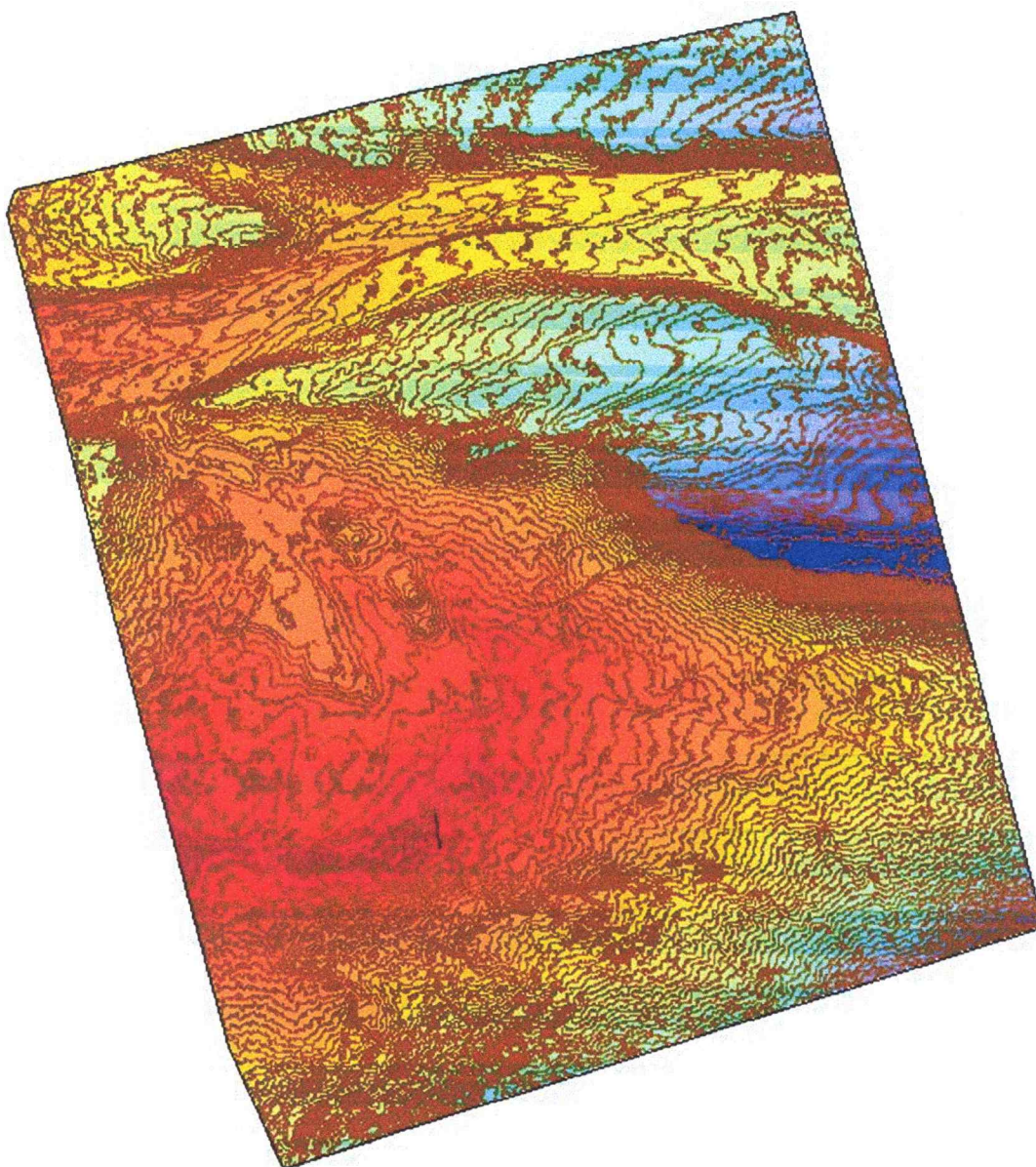
Хавсралт 1



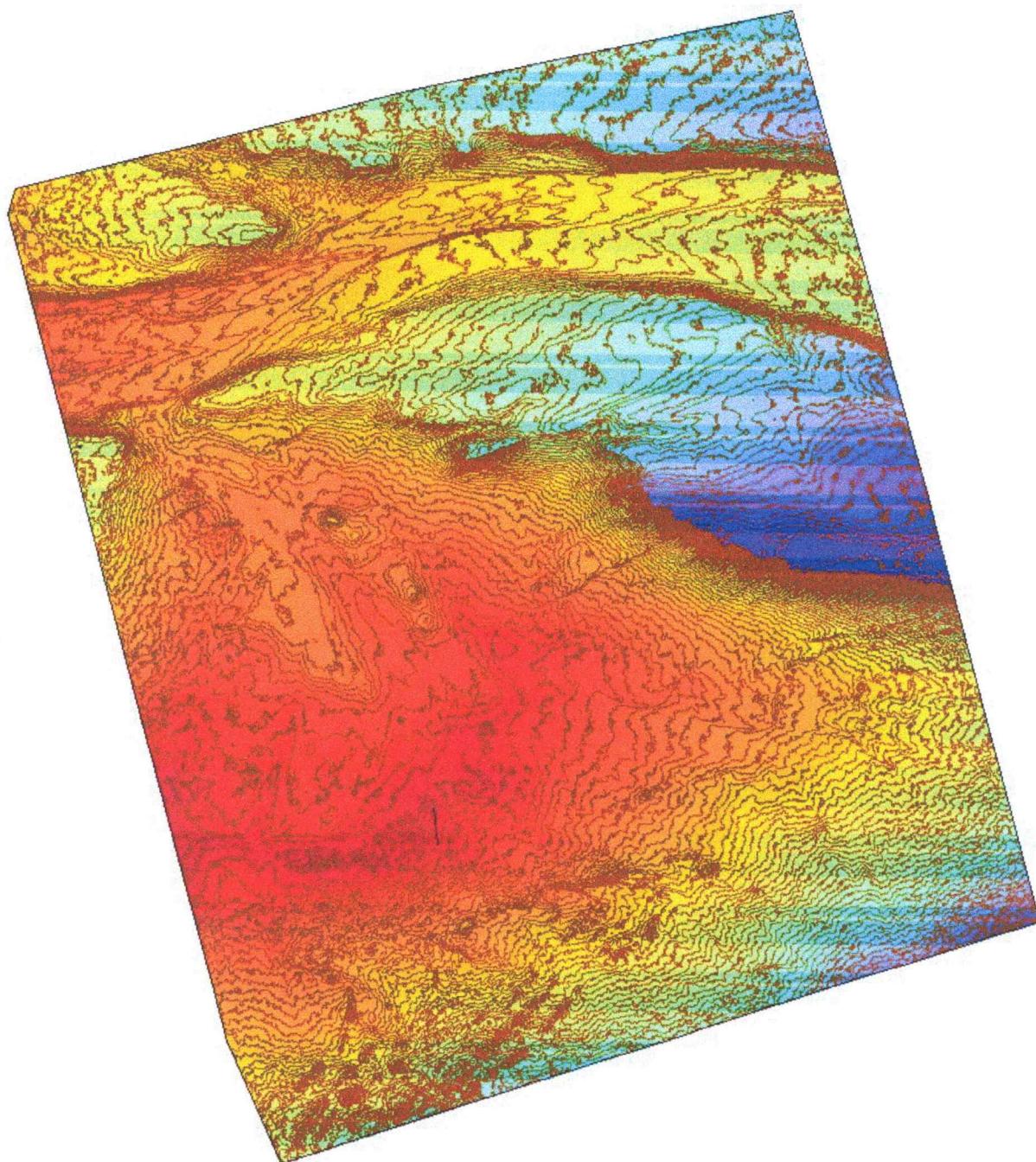
Байр зүйн зураг - 1



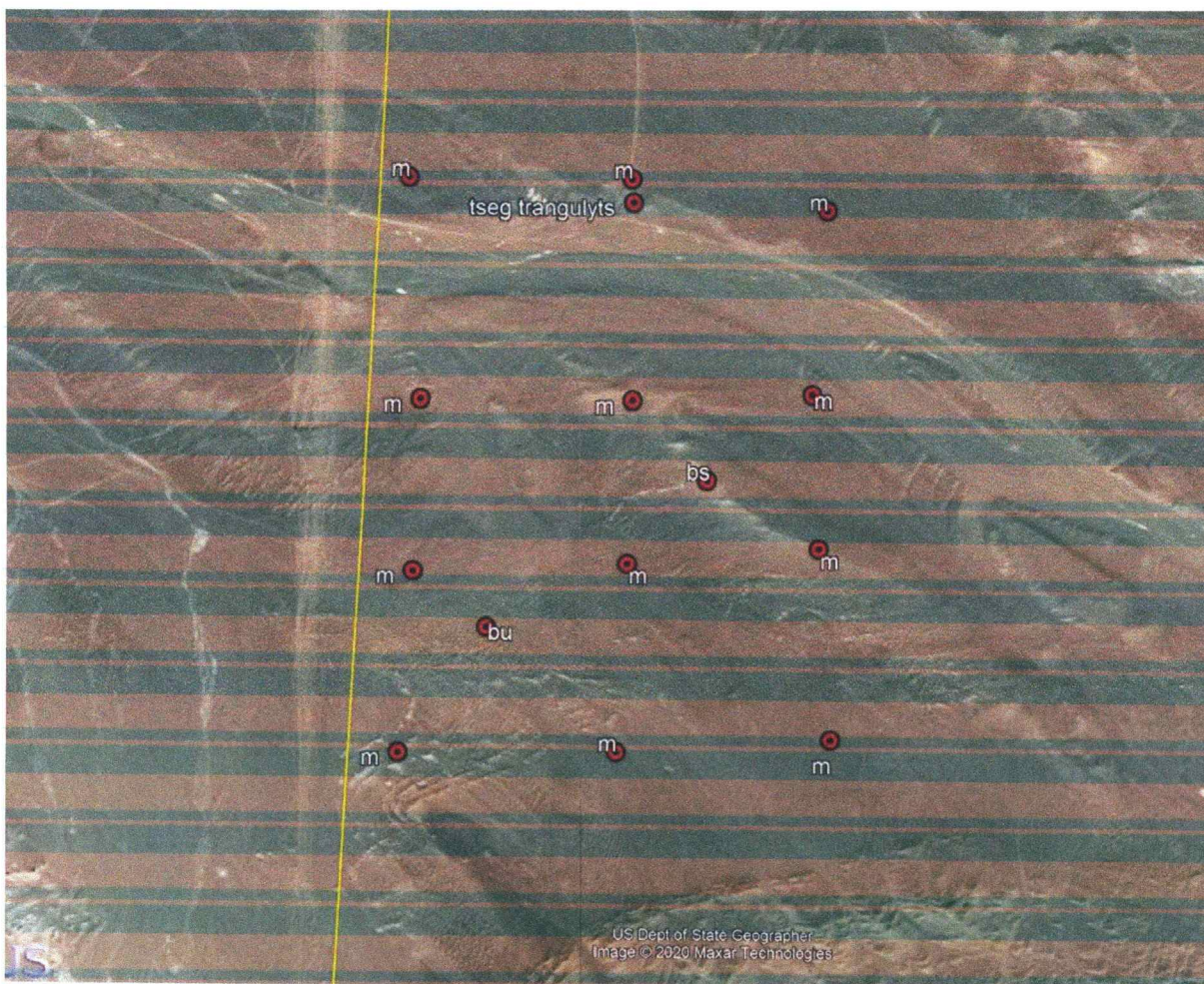
Байр зүйн зураг - 2



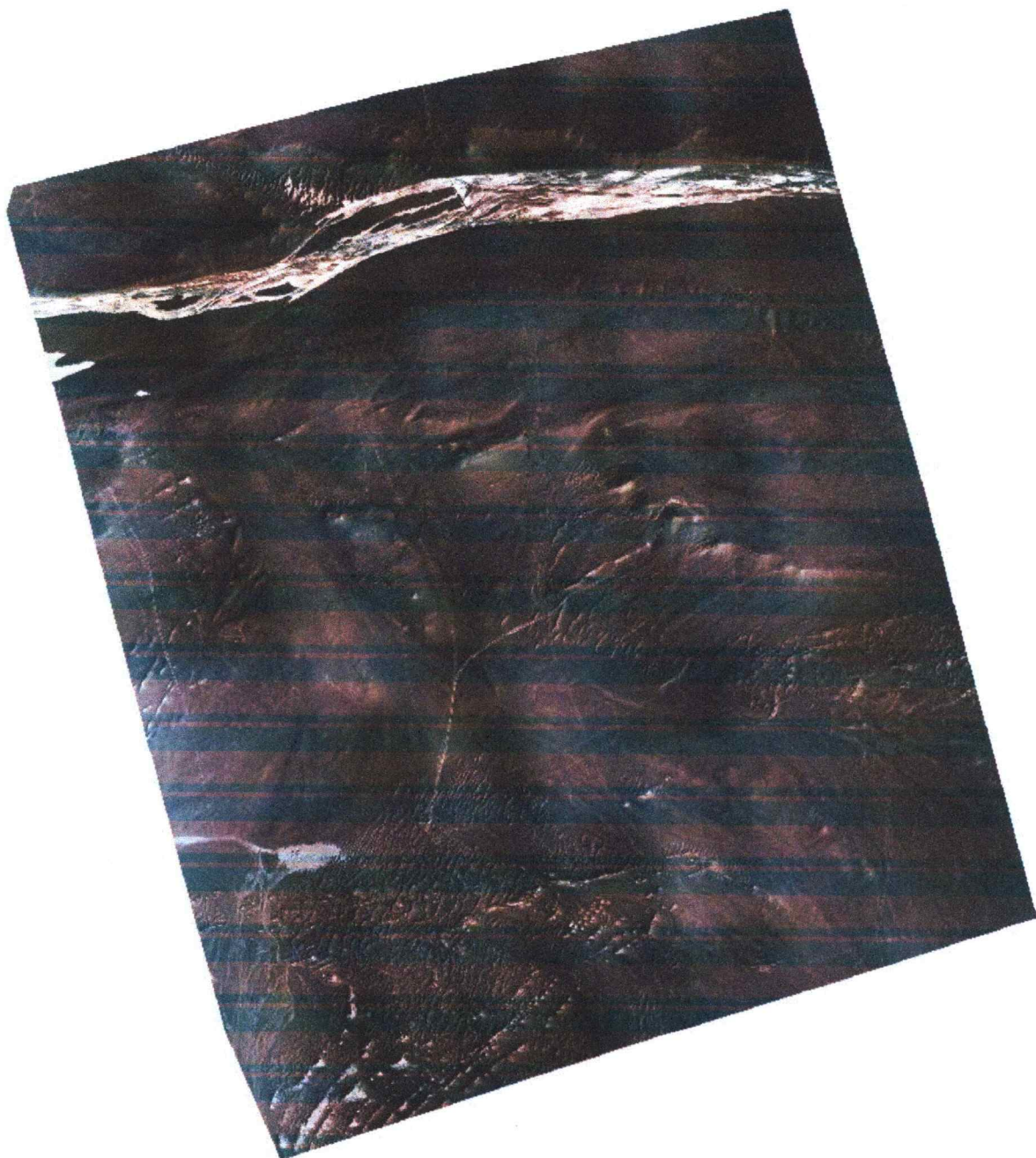
DEM зураг 1



DEM зураг 2



Зураг 5. Газар дээр агаарын зураг хийхдээ холболт хийсэн байдал



Зураг 6. Ортофото зураг

OPUS solution : 43312280.20o OP1598838826795 Inbox X



opus <opus@ngs.noaa.gov>
to me *

FILE: 43312280.20o OP1598838826795

NGS OPUS SOLUTION REPORT

=====

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: mopgi91@gmail.com DATE: August 31, 2020
RINEX FILE: 43312280.20o TIME: 01:49:16 UTC

SOFTWARE: page5 1801.18 [master97.pl](#) 160321 START: 2020/08/15 11:57:00
EPHEMERIS: igr21186.eph [rapid] STOP: 2020/08/16 00:24:00
NAV FILE: brdc2280.20n OBS USED: 28346 / 28643 : 99%
ANT NAME: TRMR8-4 NONE # FIXED AMB: 85 / 94 : 90%
ARP HEIGHT: 1.185 OVERALL RMS: 0.016(m)

REF FRAME: ITRF2014 (EPOCH 2020.6223)

X: -453727.499(m) 0.016(m)
Y: 4588660.010(m) 0.019(m)
Z: 4392611.917(m) 0.023(m)

LAT: 43 48 9.02801 0.011(m)
E LON: 95 38 49.41622 0.016(m)
W LON: 264 21 10.58378 0.016(m)
EL HGT: 478.667(m) 0.028(m)

UTM COORDINATES

UTM (Zone 46)

Northing (Y) [meters] 4853344.048
Easting (X) [meters] 712931.660
Convergence [degrees] 1.83291389
Point Scale 1.00015770
Combined Factor 1.00008263

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
	CHUM		1685849.8	
	IRKJ		1134434.2	
	NVSK		1515229.0	

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

OPUS solution : 40122281.20o OP1598838777019 Inbox X



opus <opus@ngs.noaa.gov>
to me *

FILE: 40122281.20o OP1598838777019

NGS OPUS SOLUTION REPORT

=====

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: <https://www.ngs.noaa.gov/OPUS/about.jsp#accuracy>

USER: maggi91@gmail.com DATE: August 31, 2020
RINEX FILE: 4012228e 20o TIME: 01:48:55 UTC

SOFTWARE: page5 1801.18 [master55.pl](#) 160321 START: 2020/08/15 04:10:00
EPHEMERIS: igr21186 eph [rapid] STOP: 2020/08/16 02:41:00
NAV FILE: brdc2280.20n OBS USED: 45679 / 46080 : 99%
ANT NAME: TRMR8-4 NONE # FIXED ANTS: 120 / 142 : 85%
ARP HEIGHT: 1.130 OVERALL RMS: 0.017(m)

REF FRAME: ITRF2014 (EPOCH: 2020.6219)

X: -390458.836(m) 0.008(m)
Y: 4531112.349(m) 0.001(m)
Z: 4458819.574(m) 0.007(m)

LAT: 44 37 32.39198 0.005(m)
E LON: 94 55 30.62370 0.008(m)
W LON: 265 4 29.37630 0.008(m)
EL HGT: 1398.100(m) 0.005(m)

UTM COORDINATES

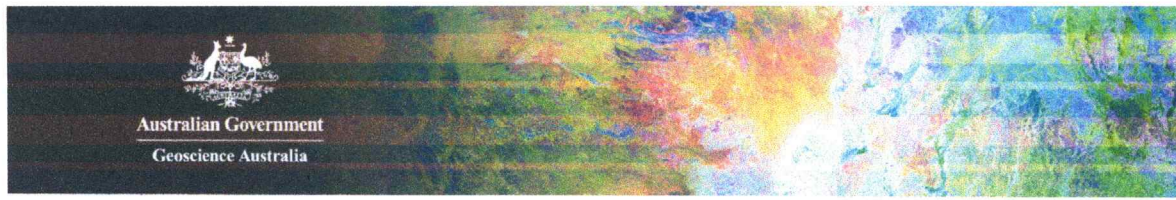
UTM (Zone 48)

Northing (Y) [meters] 4943170.518
Easting (X) [meters] 652718.256
Convergence [degrees] 1.35264167
Point Scale 0.99988681
Combined Factor 0.99966767

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
POL2		1637898.8		
CHUM		1624858.4		
BADG		960651.4		

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.



AUSPOS GPS Processing Report

August 31, 2020

This document is a report of the GPS data processing undertaken by the AUSPOS Online GPS Processing Service (version: AUSPOS 2.4) . The AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products (final, rapid, ultra-rapid depending on availability) to compute precise coordinates in International Terrestrial Reference Frame (ITRF) anywhere on Earth and Geocentric Datum of Australia (GDA) within Australia. The Service is designed to process only dual frequency GPS phase data.

An overview of the GPS processing strategy is included in this report.

Please direct any correspondence to geodesy@ga.gov.au

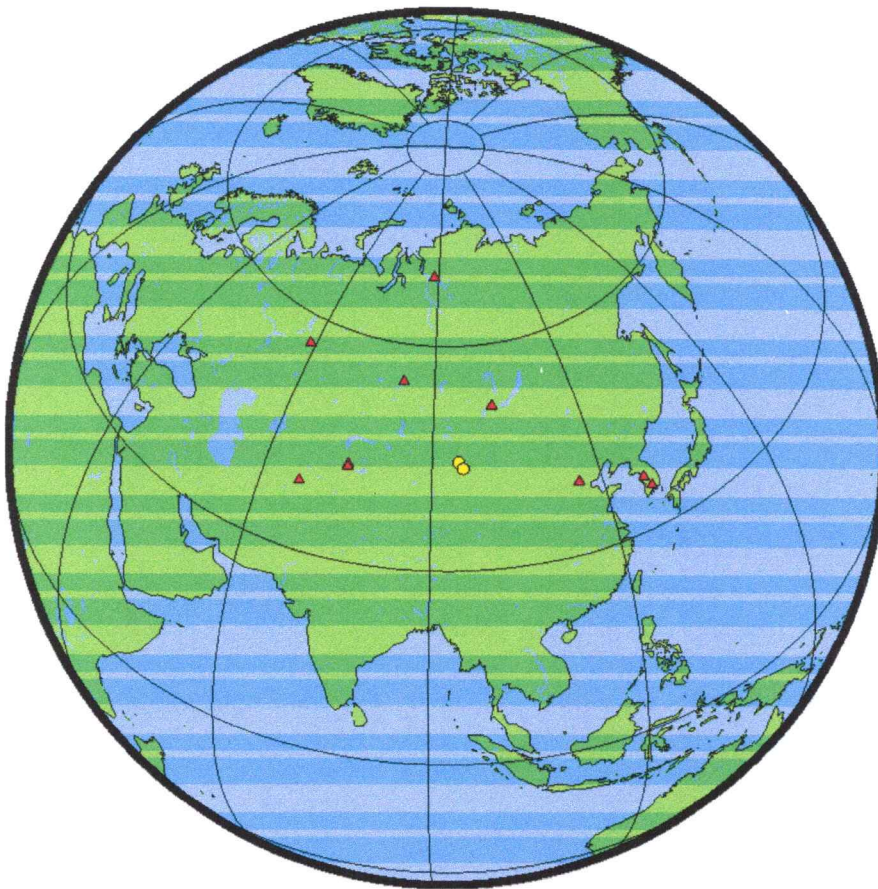
Geoscience Australia
Cnr Jerrabomberra and Hindmarsh Drive
GPO Box 378, Canberra, ACT 2601, Australia
Freecall (Within Australia): 1800 800 173
Tel: +61 2 6249 9111. Fax +61 2 6249 9929
Geoscience Australia
Home Page: <http://www.ga.gov.au>

1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

Station (s)	Submitted File	Antenna Type	Antenna Height (m)	Start Time	End Time
6702	43312280.20o	TRMR8-4 NONE	1.185	2020/08/15 11:57:30	2020/08/16 00:49:30
R000	40122281.20o	TRMR8-4 NONE	1.130	2020/08/15 04:10:30	2020/08/16 02:41:30

2 Processing Summary



Date	User Stations	Reference Stations	Orbit Type
2020/08/15 04:10:30	6702 R000	ARTU BADG BJFS CHUM GAMG KITG NOVW NRIL OSN3 POL2	IGS rapid

3 Computed Coordinates, ITRF2014

All coordinates are based on the IGS realisation of the ITRF2014 reference frame. All the given ITRF2014 coordinates refer to a mean epoch of the site observation data. All coordinates refer to the Ground Mark.

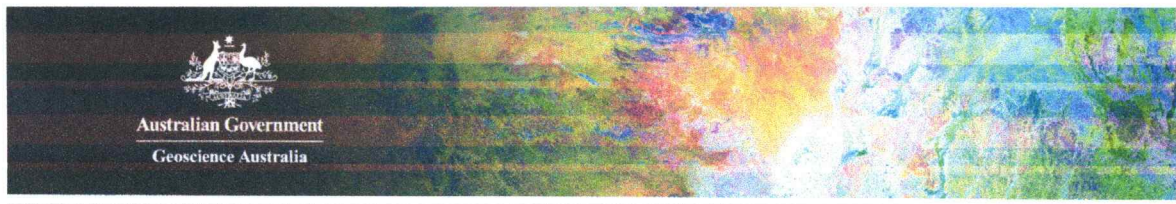
3.1 Cartesian, ITRF2014

Station	X (m)	Y (m)	Z (m)	ITRF2014 @
6702	-453727.494	4588660.004	4392611.909	15/08/2020
R000	-390458.834	4531112.339	4458819.569	15/08/2020
ARTU	1843956.341	3016203.254	5291261.792	15/08/2020
BADG	-838282.086	3865777.320	4987624.571	15/08/2020
BJFS	-2148744.578	4426641.164	4044655.806	15/08/2020
CHUM	1228950.369	4508080.003	4327868.539	15/08/2020
GAMG	-3191607.979	4096899.788	3691839.205	15/08/2020
KITG	1944879.622	4556783.820	4004205.960	15/08/2020
NOVM	452260.692	3635877.604	5203453.340	15/08/2020
NRIL	64536.840	2253782.911	5946363.518	15/08/2020
OSN3	-3068341.240	4066863.816	3824756.880	15/08/2020
POL2	1239970.940	4530790.163	4302578.873	15/08/2020

3.2 Geodetic, GRS80 Ellipsoid, ITRF2014

Geoid-ellipsoidal separations, in this section, are computed using a spherical harmonic synthesis of the global EGM2008 geoid. More information on the EGM2008 geoid can be found at <http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/>.

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
6702	43 48 09.02796	95 38 49.41604	478.657	538.566
R000	44 37 32.39207	94 55 30.62361	1398.090	1452.794
ARTU	56 25 47.36068	58 33 37.66746	247.574	253.898
BADG	51 46 10.93590	102 14 05.96230	811.421	850.189
BJFS	39 36 30.95936	115 53 32.96762	87.468	97.509
CHUM	42 59 54.60551	74 45 03.97383	716.341	759.331
GAMG	35 35 24.25269	127 55 10.78195	927.963	900.295
KITG	39 08 00.19152	66 53 12.26219	620.650	657.744
NOVM	55 01 49.80342	82 54 34.17831	150.086	186.317
NRIL	69 21 42.59906	88 21 35.24219	47.944	62.038
OSN3	37 04 57.68047	127 02 00.91744	64.468	40.955
POL2	42 40 47.17450	74 41 39.37312	1714.212	1754.278



3.3 UTM Grid, GRS80 Ellipsoid, ITRF2014

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived Above Geoid Height(m)
6702	712931.657	4853344.047	46	478.657	538.566
R000	652718.254	4943170.521	46	1398.090	1452.794
ARTU	596235.165	6255011.357	40	247.574	253.898
BADG	309225.307	5739041.824	48	811.421	850.189
BJFS	404924.707	4384902.965	50	87.468	97.509
CHUM	479712.387	4760678.445	43	716.341	759.331
GAMG	402128.377	3939019.836	52	927.963	900.295
KITG	317344.627	4333705.272	42	620.650	657.744
NOVM	622047.112	6099852.356	44	150.086	186.317
NRIL	553484.934	7695302.994	45	47.944	62.038
OSN3	325216.604	4105854.291	52	64.468	40.955
POL2	474951.448	4725300.179	43	1714.212	1754.278

3.4 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2014

Station	Longitude(East) (m)	Latitude(North) (m)	Ellipsoidal Height(Up) (m)
6702	0.006	0.005	0.013
R000	0.005	0.004	0.011
ARTU	0.006	0.004	0.011
BADG	0.005	0.004	0.008
BJFS	0.006	0.004	0.010
CHUM	0.005	0.004	0.008
GAMG	0.006	0.005	0.011
KITG	0.006	0.004	0.011
NOVM	0.005	0.004	0.008
NRIL	0.005	0.005	0.010
OSN3	0.006	0.005	0.011
POL2	0.005	0.004	0.008

4 Ambiguity Resolution - Per Baseline

Baseline	Ambiguities Resolved	Baseline Length (km)
GAMG - OSN3	80.4 %	183.750
CHUM - POL2	89.7 %	35.732
BADG - R000	87.3 %	960.651
ARTU - NRIL	51.7 %	2043.716
CHUM - NOVМ	89.8 %	1459.669
R000 - 6702	94.3 %	108.158
CHUM - KITG	79.3 %	787.200
NOVM - NRIL	94.5 %	1616.302
BADG - NOVМ	88.7 %	1328.509
BJFS - GAMG	89.3 %	1149.249
BADG - GAMG	43.5 %	2696.409
AVERAGE	80.8%	1124.486

Please note for a regional solution, such as used by AUSPOS, ambiguity resolution success rate of **50%** or better for a baseline formed by a user site indicates a reliable solution.

5 Computation Standards

5.1 Computation System

Software	Bernese GNSS Software Version 5.2.
GNSS system(s)	GPS only.

5.2 Data Preprocessing and Measurement Modelling

Data preprocessing	Phase preprocessing is undertaken in a baseline by baseline mode using triple-differences. In most cases, cycle slips are fixed by the simultaneous analysis of different linear combinations of L1 and L2. If a cycle slip cannot be fixed reliably, bad data points are removed or new ambiguities are set up. A data screening step on the basis of weighted postfit residuals is also performed, and outliers are removed.
Basic observable	Carrier phase with an elevation angle cutoff of 7° and a sampling rate of 3 minutes. However, data cleaning is performed at a sampling rate of 30 seconds. Elevation dependent weighting is applied according to $1/\sin(e)^2$ where e is the satellite elevation.
Modelled observable	Double differences of the ionosphere-free linear combination.
Ground antenna phase centre calibrations	IGS14 absolute phase-centre variation model is applied.
Tropospheric Model	A priori model is the GMF mapped with the DRY-GMF.
Tropospheric Estimation	Zenith delay corrections are estimated relying on the WET-GMF mapping function in intervals of 2 hour. N-S and E-W horizontal delay parameters are solved for every 24 hours.
Tropospheric Mapping Function	GMF
Ionosphere	First-order effect eliminated by forming the ionosphere-free linear combination of L1 and L2. Second and third effect applied.
Tidal displacements	Solid earth tidal displacements are derived from the complete model from the IERS Conventions 2010, but ocean tide loading is not applied.
Atmospheric loading	Applied
Satellite centre of mass correction	IGS14 phase-centre variation model applied
Satellite phase centre calibration	IGS14 phase-centre variation model applied
Satellite trajectories	Best available IGS products.
Earth Orientation	Best available IGS products.

5.3 Estimation Process

Adjustment	Weighted least-squares algorithm.
Station coordinates	Coordinate constraints are applied at the Reference sites with standard deviation of 1mm and 2mm for horizontal and vertical components respectively.
Troposphere	Zenith delay parameters and pairs of horizontal delay gradient parameters are estimated for each station in intervals of 2 hours and 24 hours.
Ionospheric correction	An ionospheric map derived from the contributing reference stations is used to aid ambiguity resolution.
Ambiguity	Ambiguities are resolved in a baseline-by-baseline mode using the Code-Based strategy for 180-6000km baselines, the Phase-Based L5/L3 strategy for 18-200km baselines, the Quasi-Ionosphere-Free (QIF) strategy for 18-2000km baselines and the Direct L1/L2 strategy for 0-20km baselines.

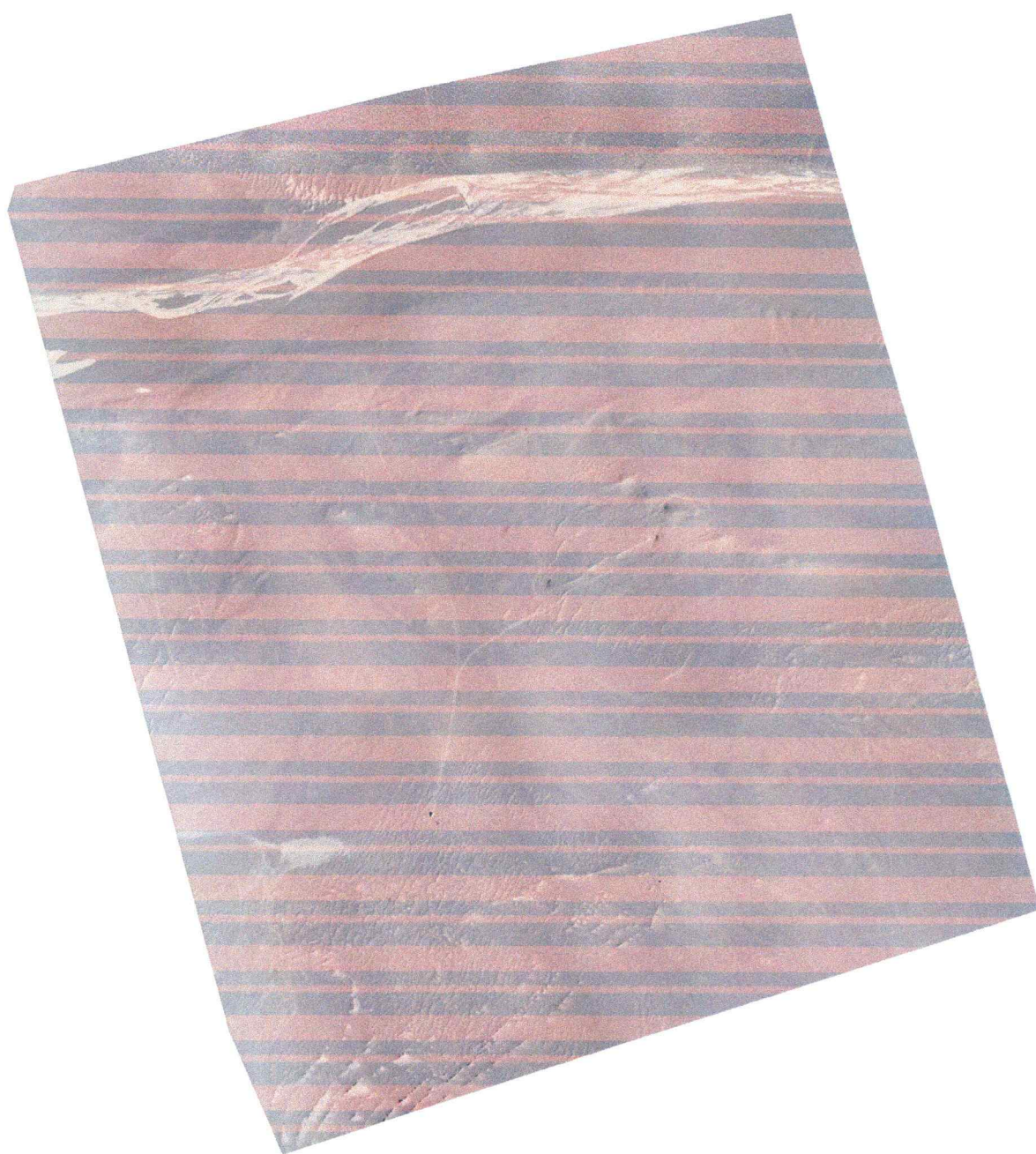
5.4 Reference Frame and Coordinate Uncertainty

Terrestrial reference frame	IGS14 station coordinates and velocities mapped to the mean epoch of observation.
Australian datums	GDA2020 and GDA94.
Derived AHD	For stations within Australia, AUSGeoid2020 (V20180201) is used to compute AHD. AUSGeoid2020 is the Australia-wide gravimetric quasigeoid model that has been a posteriori fitted to the AHD. For reference, derived AHD is always determined from the GDA2020 coordinates. In the GDA94 section of the report, AHD values are assumed to be identical to those derived from GDA2020.
Above-geoid heights	Earth Gravitational Model EGM2008 released by the National Geospatial-Intelligence Agency (NGA) EGM Development Team is used to compute above-geoid heights. This gravitational model is complete to spherical harmonic degree and order 2159, and contains additional coefficients extending to degree 2190 and order 2159.
Coordinate uncertainty	Coordinate uncertainty is expressed in terms of the 95% confidence level for GDA94, GDA2020 and ITRF2014. Uncertainties are scaled using an empirically derived model which is a function of data span, quality and geographical location.

Монгол Улсын Нам цэг орчмын агаарын зураглал

Боловсруулалтыг Спэйшл моделинг ХХК-ийн инженер, Агаар зураглал,
боловсруулалтын Зөвлөх Инженер Ц.Дашзэвгэ гүйцэтгэв.

25 September 2020



Survey Data

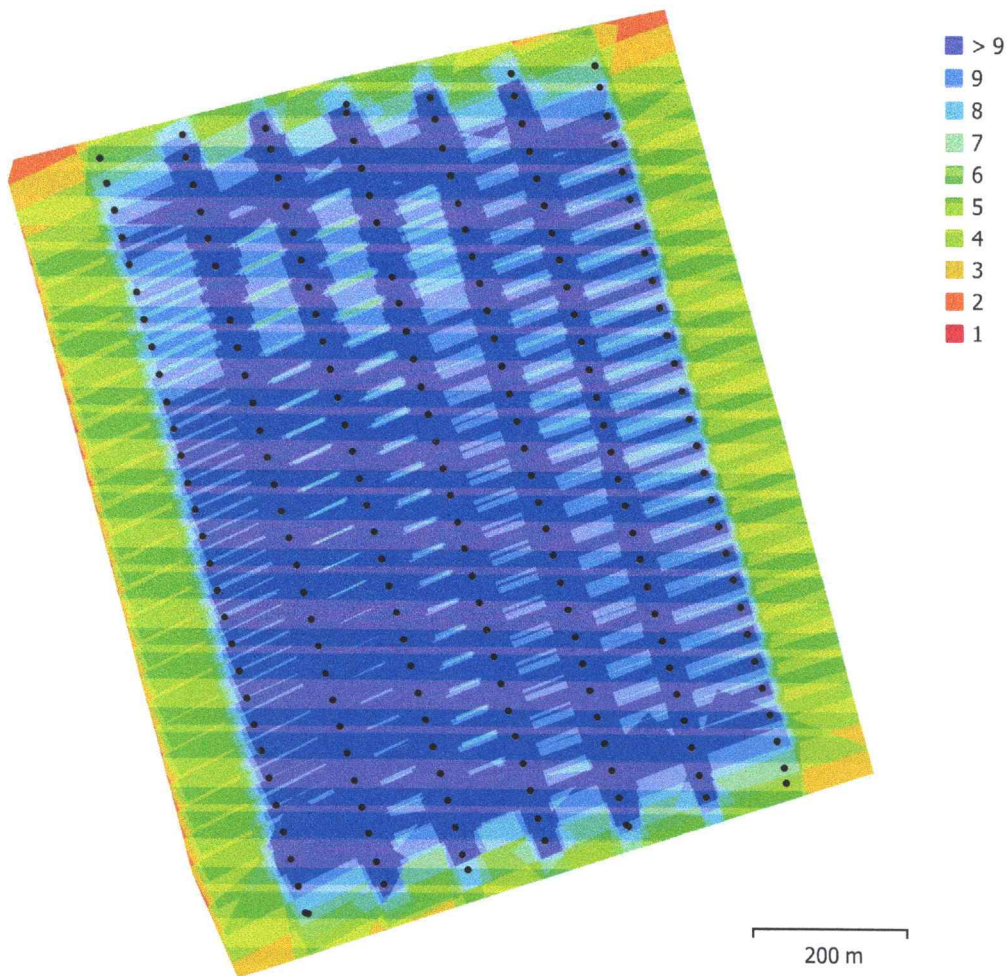


Fig. 1. Camera locations and image overlap.

Number of images:	200	Camera stations:	200
Flying altitude:	188 m	Tie points:	155,692
Ground resolution:	4.66 cm/pix	Projections:	799,304
Coverage area:	0.938 km ²	Reprojection error:	0.571 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC6310 (8.8mm)	5472 x 3648	8.8 mm	2.41 x 2.41 μ m	No

Table 1. Cameras.

Camera Calibration

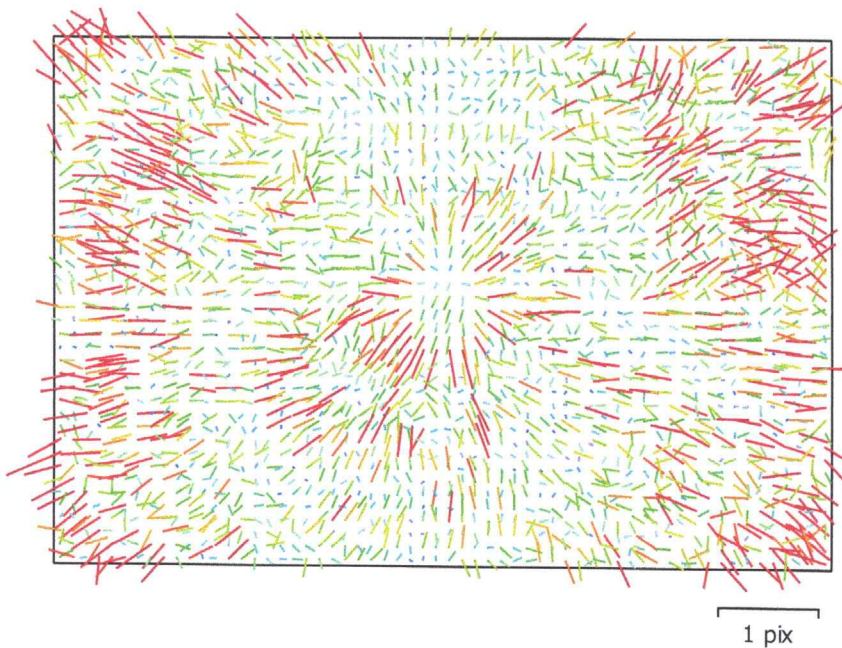


Fig. 2. Image residuals for FC6310 (8.8mm).

FC6310 (8.8mm)

200 images

Type
Frame

Resolution
5472 x 3648

Focal Length
8.8 mm

Pixel Size
2.41 x 2.41 μm

	Value	Error	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	3648											
Cx	-8.23486	0.12	1.00	-0.06	-0.09	-0.10	0.01	-0.01	0.01	-0.01	0.13	0.02
Cy	-0.839719	0.11		1.00	0.11	-0.06	-0.00	0.00	-0.00	0.00	-0.03	0.09
B1	-0.997783	0.009			1.00	0.03	0.02	-0.03	0.03	-0.02	-0.00	-0.00
B2	0.522686	0.0087				1.00	-0.01	0.00	-0.00	-0.00	0.01	0.01
K1	0.0122394	4.9e-05					1.00	-0.97	0.92	-0.87	0.00	-0.00
K2	-0.0588449	0.00023						1.00	-0.99	0.95	-0.01	0.00
K3	0.105643	0.00044							1.00	-0.99	0.01	-0.00
K4	-0.0626351	0.00029								1.00	-0.01	0.00
P1	-0.000540523	1.9e-06									1.00	-0.09
P2	-0.000683474	1.8e-06										1.00

Table 2. Calibration coefficients and correlation matrix.

Ground Control Points

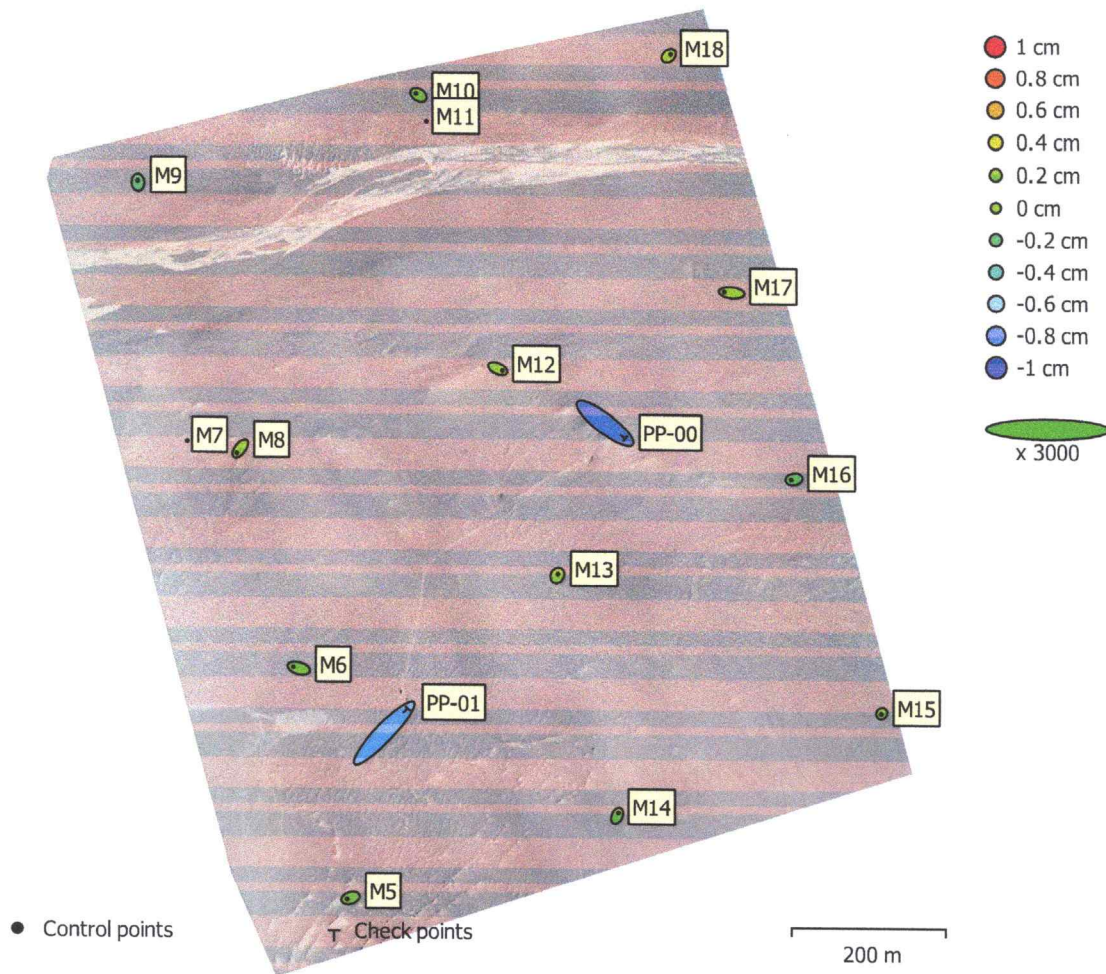


Fig. 3. GCP locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.
 Estimated GCP locations are marked with a dot or crossing.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
12	0.304275	0.166489	0.143384	0.346845	0.375314

Table 3. Control points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
2	1.89388	1.76402	0.793695	2.58815	2.70712

Table 4. Check points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
M5	-0.288156	-0.0905487	0.158789	0.341243	0.420 (8)
M6	-0.466909	0.116218	0.160618	0.507257	0.463 (10)
M7					
M8	-0.295714	-0.372066	0.0307937	0.476265	0.429 (10)
M9	-0.0147931	0.174892	-0.244859	0.301268	0.633 (7)
M10	-0.21489	0.132646	0.145761	0.29158	0.410 (6)
M11					
M12	0.403645	-0.162855	-0.0280196	0.43616	0.348 (9)
M13	0.0550275	0.114414	0.273255	0.301309	0.532 (9)
M14	0.117462	0.249572	-0.0495697	0.280251	0.296 (8)
M15	-0.02939	-0.0438393	-0.0413864	0.0670708	0.311 (4)
M16	-0.243914	-0.0455288	-0.135327	0.282631	0.460 (4)
M17	-0.642528	0.0583927	0.0584817	0.647821	0.801 (5)
M18	0.152191	0.122475	0.110398	0.224388	0.613 (3)
Total	0.304275	0.166489	0.143384	0.375314	0.480

Table 5. Control points.
X - Easting, Y - Northing, Z - Altitude.

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
PP-00	1.7396	-1.2916	-0.856386	2.32977	1.194 (9)
PP-01	2.0365	2.13431	-0.725606	3.03795	0.511 (10)
Total	1.89388	1.76402	0.793695	2.70712	0.902

Table 6. Check points.
X - Easting, Y - Northing, Z - Altitude.

Digital Elevation Model

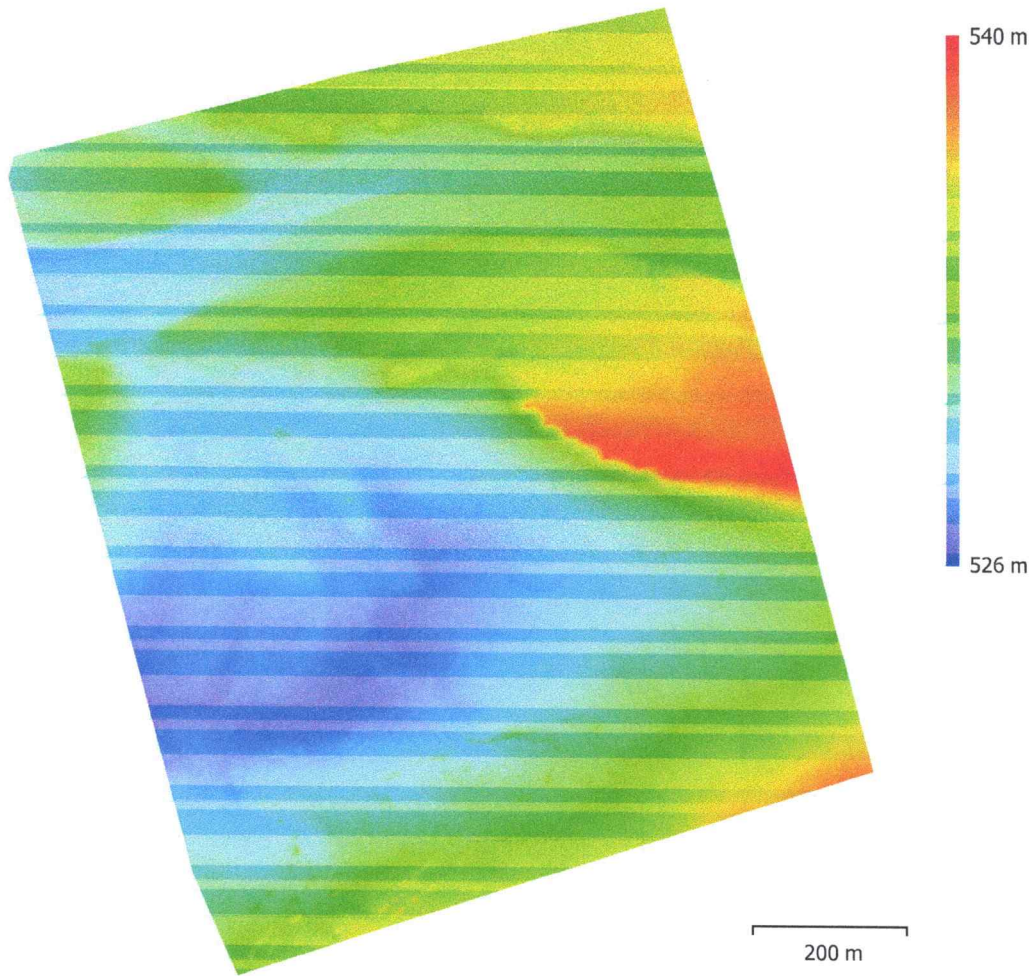


Fig. 4. Reconstructed digital elevation model.

Resolution: 18.7 cm/pix
Point density: 28.7 points/m²

Processing Parameters

General

Cameras	200
Aligned cameras	200
Markers	16

Shapes

Polylines	454
Polygons	17812
Coordinate system	WGS 84 (EPSG::4326)
Coordinate system	WGS 84 / UTM zone 46N (EPSG::32646)
Rotation angles	Yaw, Pitch, Roll

Point Cloud

Points	155,692 of 164,595
RMS reprojection error	0.213822 (0.57137 pix)
Max reprojection error	0.733928 (12.8296 pix)
Mean key point size	2.69591 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	5.23931

Alignment parameters

Accuracy	High
Generic preselection	No
Reference preselection	Source
Key point limit	40,000
Tie point limit	4,000
Guided image matching	No
Adaptive camera model fitting	Yes
Matching time	1 hours 14 minutes
Matching memory usage	295.30 MB
Alignment time	7 minutes 5 seconds
Alignment memory usage	84.36 MB

Optimization parameters

Parameters	b1, b2, cx, cy, k1-k4, p1, p2
Adaptive camera model fitting	No
Optimization time	7 seconds
Software version	1.6.3.10723

Depth Maps

Count	200
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Depth maps generation parameters

Quality	Medium
Filtering mode	Mild
Processing time	43 minutes 39 seconds
Software version	1.6.1.10009

Dense Point Cloud

Points	29,816,737
Point colors	3 bands, uint8

Depth maps generation parameters

Quality	Medium
Filtering mode	Mild
Processing time	43 minutes 39 seconds

Dense cloud generation parameters

General

Processing time 13 minutes 56 seconds
Software version 1.6.1.10009

DEM

Size 9,895 x 10,738
Coordinate system WGS 84 / UTM zone 46N (EPSG::32646)

Reconstruction parameters

Source data Dense cloud
Interpolation Enabled
Processing time 2 minutes 8 seconds
Software version 1.6.1.10009

Orthomosaic

Size 24,651 x 28,251
Coordinate system WGS 84 / UTM zone 46N (EPSG::32646)
Colors 3 bands, uint8

Reconstruction parameters

Blending mode Mosaic
Surface DEM
Enable hole filling Yes
Processing time 12 minutes 24 seconds
Software version 1.6.1.10009

System

Software name Agisoft Metashape Professional
Software version 1.6.1 build 10009
OS Windows 64 bit
RAM 31.93 GB
CPU Intel(R) Core(TM) i7-4700MQ CPU @ 2.40GHz
GPU(s) GeForce GTX 770M