Quality check of the accuracy of the WV-2 orthoimagery

Performed in the frame of the 2010 LPIS QA in Scotland"

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Introduction

1.1. Report objectives

1.1.1. The objective of the report is to assess the geometric quality of the WV-2 orthoimagery, produced for the LPIS QA in Scotland in 2010. The analysis of the spatial accuracy was focussed on the WV-2 orthoimage for LPIS control zone RS02 only.

1.1.2. The accuracy assessment was done on the base of the ground truth data collected during the field trip in the area of Kelso (Scottish Borders, Scotland), organized by the Scottish Administration in the frame of the mission of the GeoCAP team (W. Devos and P. Milenov), performed on 11-13.01.2011 (for more information see file://S:\FMPArchive\P\12571.doc).

2. Input data

2.1. Orthoimagery

2.1.1. The Worldview-2 images over LPIS control zone RS02 (about 600 sq.km.), were acquired on 22.05.2010 in one pass. The zone was covered with two scenes, acquired with elevation angles of 59 and 64 degrees and estimated cloud cover of 7% for the whole zone.

Id		Filename	Product	Progr.	Display Order	Description	Comment	Cloud Cover	Haze Flag	Elevation	Acquisition Date	Upload Date
13337	🖊	rs02.shp	PSH	priority	3			7.0	False	64.5	22/05/2010	25/05/2010
13336	🖊	WV200324110001A_000014232_Browse_0.tif	PSH	priority	2				False	64	22/05/2010	25/05/2010
13335	🖊	WV200324110001A_000014231_Browse_0.tif	PSH	priority	1				False	59	22/05/2010	25/05/2010

Fig. 1 Extract from LioDotNet system, showing the WV-2 acquisitions for RS02

2.1.2. Both scenes have a considerable overlap, which allows the identification of enough tie points to perform the geometric correction (orthorectification) using bundle block adjustment).

Fig. 2 Scene coverage over the LPIS control zone RS02

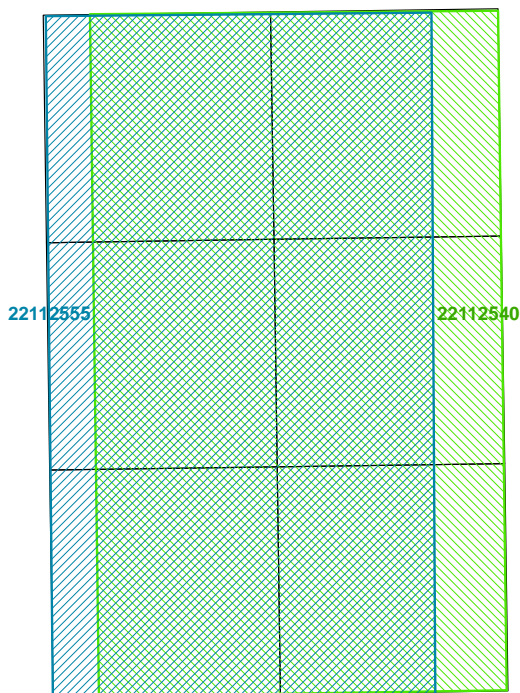2.1.1.   The Orthorectification was done by the image provider (European Space Imaging) with preliminary generated RPC and ancillary data (GCPs and DEM), provided by the Scottish Administration, through JRC. Due to specific processing workflow at EUSI, the ancillary data had to be delivered in Geographic (Lat/Lon, WGS84) reference projection. For that reason JRC had to further re-project part of the ancillary data from its original projection (Ordnance Survey Great Britain 1936 – OSGB36) to Geographic (Latitude/Longitude). The final product delivered was 4 channels pan-sharpened dataset at resolution of 0.5 meters.

2.2.   Ground control points

2.2.1.   The orthorectification was done with 5 ground control points (GCPs), acquired with differential GPS (real-time satellite), and expected accuracy of 0.2-0.3 meters. GCPs were located on corners of walls and fences. Reference coordinates of the points were provided in both OSGB36 National Grid and in Latitude/Longitude. The GPS points, which were initially captured in Geographic (Lat/Lon) using the ETRS89-based National GPS Network, were subsequently converted to Ordnance Survey GB grid using OSTN02 transformation. More information is available on:

http://www.ordnancesurvey.co.uk/oswebsite/gps/osnetfreeservices/about/surveying_osnet.html.

2.2.2.   A supplementary visual assessment of the GCP positions in reference to the recently produced Ordnance Survey orthophoto, revealed a good positional fit between the two datasets (+/-0.5 m.). GCPs were evenly distributed over the LPIS control zone RS02, with 4 points at the corners and one point in the centre of the zone.

Fig. 3 Location of a GCP on the Ordnance Survey Orthophoto

Fig. 4 Distribution of the GCPs over the two scenes

2.3. Digital Elevation Model

2.3.1. DEM was provided by Ordnance Survey, as point shape file in reference coordinate system OSGB36 (Ordnance Survey Great Britain 1936). Vertical datum is ODN (Ordnance Datum Newlyn). Values for the height are referenced to the mean sea level (orthometric heights). More information is available on:

http://www.ordnancesurvey.co.uk/oswebsite/gps/osnetfreeservices/about/surveying_osnet.html.

2.3.2. DEM is subsequently converted to raster (10 m grid) using GDAL and re-projected to Geographic (LatLon), using ArcGIS. Reference projection parameters for the transformation of the DEM done in ArcGIS were as follows:

PROJCS["British_National_Grid",GEOGCS["GCS_OSGB_1936",DATUM["D_OSGB_1936",SPHEROID["Airy_1 830",6377563.396,299.3249646]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECT ION["Transverse_Mercator"],PARAMETER["False_Easting",400000.0],PARAMETER["False_Northing",- 100000.0],PARAMETER["Central_Meridian",- 2.0],PARAMETER["Scale_Factor",0.9996012717],PARAMETER["Latitude_Of_Origin",49.0],UNIT["Meter",1.0]]

2.3.3. The projection transformation used in ArcGIS, which provided the most accurate transformation, was "OSGB_1936_TO_WGS_1984_1 (Mean for UK (England, Scotland, Wales, and Isle of Man)". However, as the ArcGIS (v.9.3) doesn't possess with the exact parameters for the transformation from OSGB to ETRS89, a possible shift of 3-4 meters is introduced, from the use of approximate transformation.

2.3.4. In any case, as the vertical accuracy (expressed in RMSEz) of the DEM, measured on the base of 11 independent checkpoints was estimated to be less than 2 meters, such horizontal shift to the DEM is not expected to introduce a detectable error in the geometric model for the orthorectification (taking into account also that the imagery was acquired with relatively high elevation angles). Additional factors in favour to that assumption, were the relatively flat terrain of LPIS control zone RS02 (mean elevation of 153 m and $StDev_{1sigma}$ of 80 m) and the smoothing of the height values resulted from the performed interpolation[1] of the DEM point files to grid.

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[1] Nearest neighbour interpolation was used in order to derive the raster DEM from the point shapefile, as the grid size was 10 meters for both directions.

Fig. 5 Extract of the DEM over LPIS control zone RS02 (shown as painted relief)

2.4.   Independent Check Points

2.4.1.   11 checkpoints have been collected on the field on 12.01.2011, using Trimble GPS in carrier mode. The raw data was post-processed using differential corrections (base station located 18 km from Kelso). The planimetric accuracy was estimated to be in the range of 20 to 40 cm., while the vertical accuracy was estimated to be within 50 cm. Most of the points were taken at the corner or the end of fences. One of the checkpoints was skipped from the subsequent analysis, as it coincided with a GCP used for the orthorectification (both measurements were found to be within 20 cm. one from another).
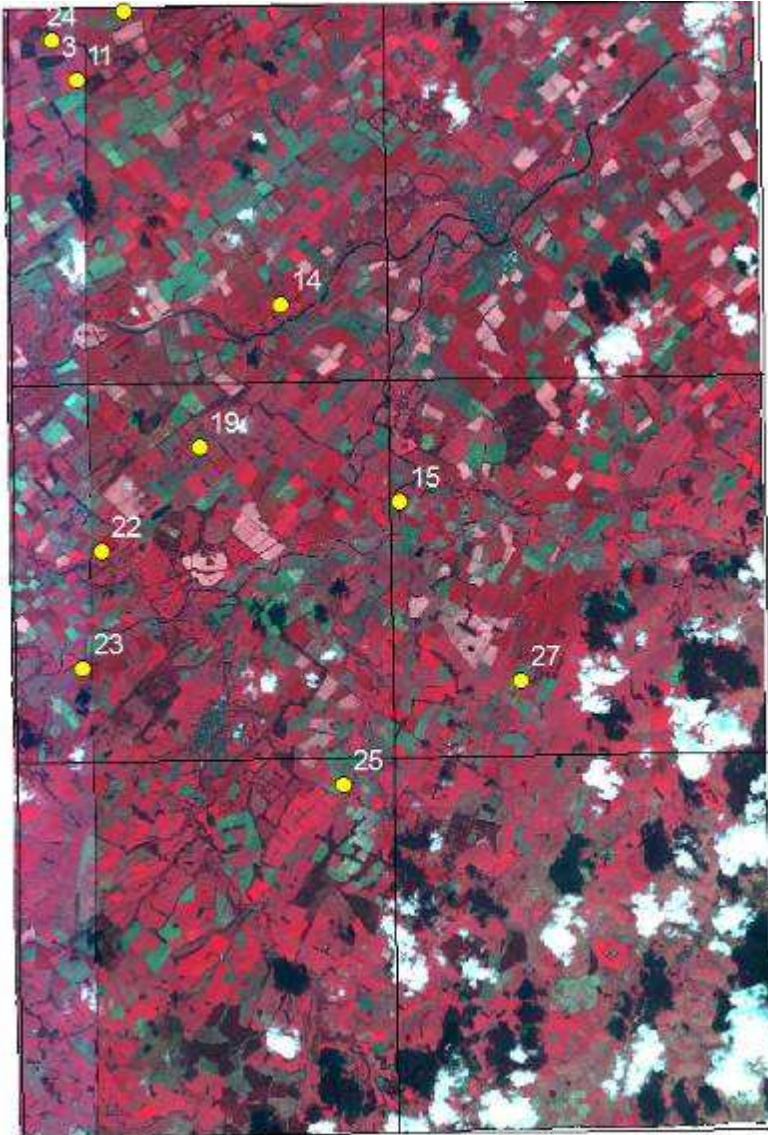
Fig. 6 Distribution of the Independent Check Points over the two scenes

3.   Results

3.1.1.   The accuracy assessment was done in ArcGIS. Checkpoints were displayed and they position against the orthoimage further adjusted, after visual inspection. The relevant image coordinates and the reference coordinates from the ground measurements were compared in Excel. The RMSE was calculated following the "Guidelines for Best Practice and Quality Checking of Ortho Imagery, v 3.0" of JRC, available on: http://mars.jrc.ec.europa.eu/mars/Bulletins-Publications/Guidelines-for-Best-Practice-and-Quality-Checking-of-Ortho-Imagery-v-3.0.

3.1.2.   The results of the accuracy check are given in the Table 1. Figure 7 shows the scattered (XY) chart of the residuals.

Table 1. Accuracy of the WV-2 orthoimage, expressed in $RMSE_x$ and $RMSE_y$

| X_o	Y_o		X_{ref}	Y_{ref}		d_X	d_Y	d_X^2	d_Y^2
6166550,6	524161,0	1,0	6166552,1	524162,0		-1,5	-0,9	2,2	0,9
6166557,9	524157,7	1,0	6166559,1	524158,9		-1,1	-1,2	1,3	1,4
6165481,6	524817,1	1,0	6165480,4	524817,2		1,2	-0,1	1,4	0,0
6159526,1	530244,6	1,0	6159526,6	530244,4		-0,5	0,2	0,2	0,1
6154296,9	533396,7	1,0	6154294,8	533396,4		2,2	0,3	4,6	0,1
6155751,1	528080,0	1,0	6155750,7	528078,6		0,4	1,4	0,2	1,9
6152979,1	525455,9	1,0	6152979,8	525454,8		-0,7	1,1	0,6	1,3
6149853,6	524980,5	1,0	6149851,6	524979,4		2,0	1,1	3,8	1,2
6146808,7	531890,9	1,0	6146808,3	531890,1		0,5	0,8	0,2	0,6
6149555,1	536608,6	1,0	6149555,0	536608,3		0,1	0,2	0,0	0,0
	Number of Checkpoints 10							14,60	7,37
								9,00	9,00
								1,27	0,90
								$RMSE_x$	$RMSE_y$
								1,27	**0,90**
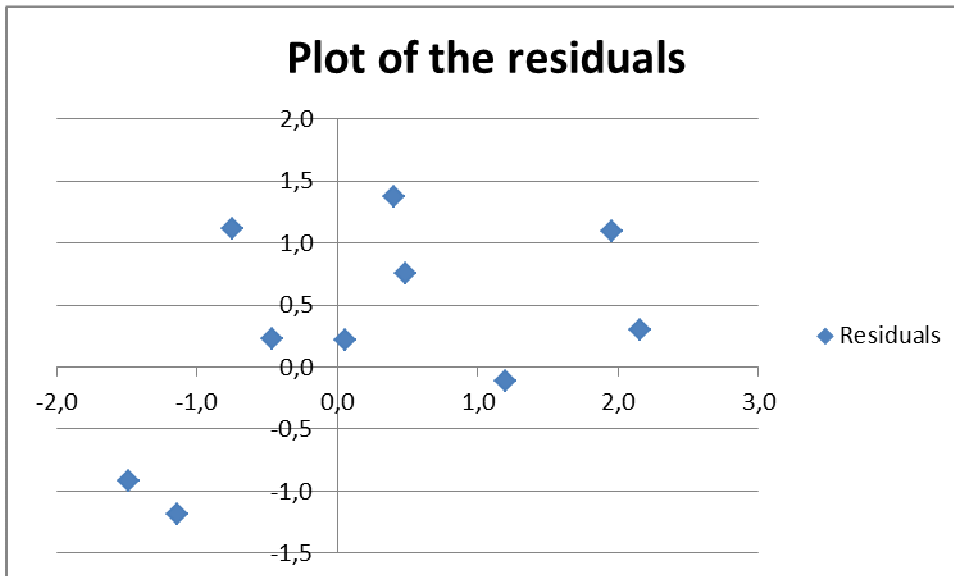
Figure 7. The scattered chart of the residuals.

3.1.3.   The value of the $RMSE_x$ is 1.27 meters, while the value of the $RMSE_y$ is 0.9 meters. The axis of the standard error ellipse are e0 = 2.41m and e1 = 0.44m. The azimuth of the orientation of the major error axis is 212 degrees east.

4.   **Conclusions**

4.1.1.   The quality of the WV-2 orthorectified product, delivered for the LPIS QA in Scotland is well inside the JRC specifications for geometric quality of orthoimagery used for the CwRS and LPIS update. The resulted RMSE is twice less the maximum $RMSE_{1d}$ of 2.5 meters allowed.

4.1.2.   As the number of the checkpoints was limited and their location not evenly distributed over the orthoimagery, it is suggested to perform a complementary assessment of the positional accuracy using the Ordnance Survey aerial orthophoto (having spatial resolution of 25 cm) as a reference.
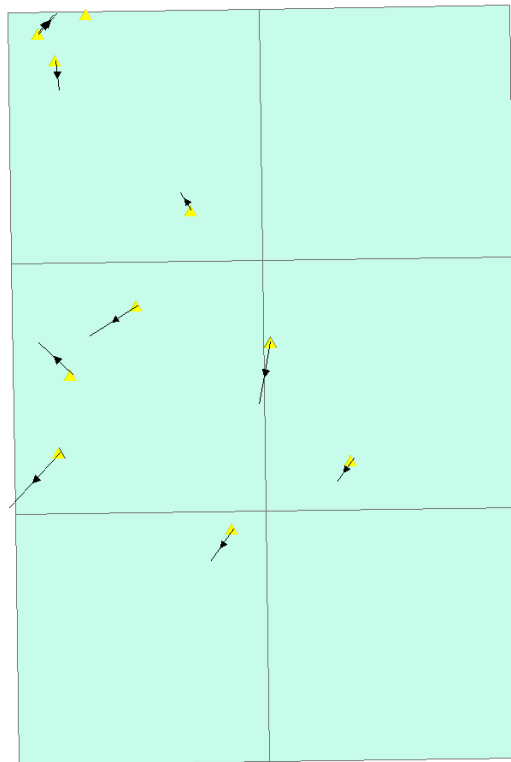
Figure 8. Residual plot, showing the direction of the errors.

5. References

- DigitalGlobe: DigitalGlobe Imagery Products Format Specifications
- Kapnias, D., Milenov, P., Kay, S., 2008. 'Guidelines for Best Practice and Quality Checking of Ortho Imagery' Issue 3.0. EUR 23638 EN – 2008.
- Calculation of Error Ellipses, University of Melbourne, http://www.geom.unimelb.edu.au/nicole/surveynetworks/02a/notes09_01.html
- Surveying with the free OS Net services, Ordnance Survey: http://www.ordnancesurvey.co.uk/oswebsite/gps/osnetfreeservices/about/surveying_osnet.html.
- ETS Scotland, January 2011 - Mission Report, JRC IPSC/G03/P/PMI/pmi D(2011)(12571), file://S:\FMPArchive\P\12571.doc
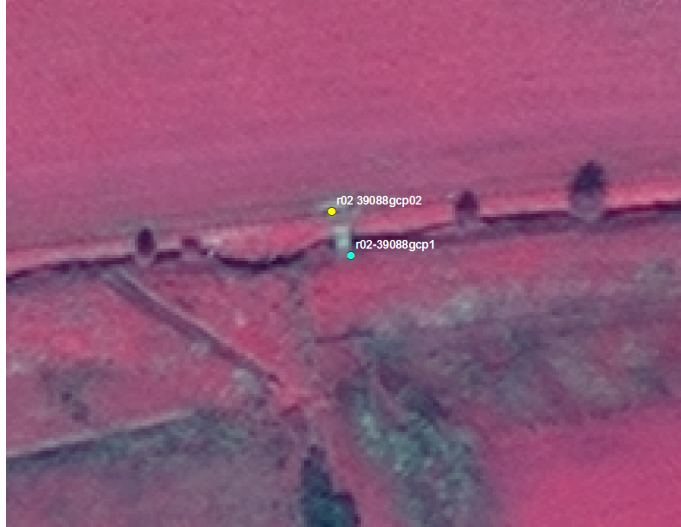
6.   Annexes
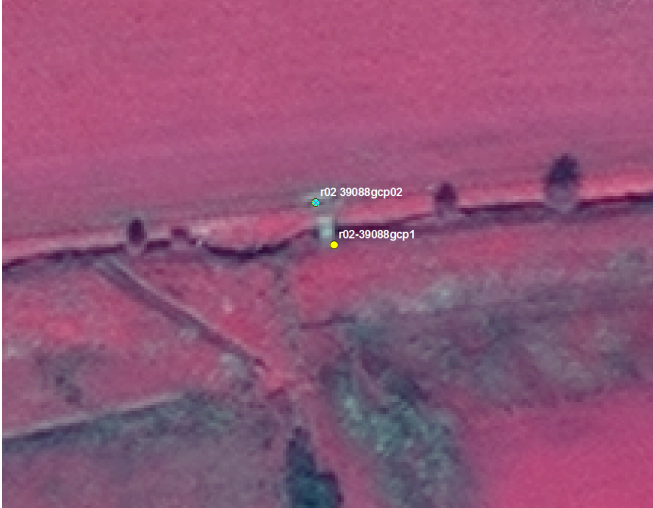
6.1.   Annex I – Accuracy assessment of the DEM over zone RS02
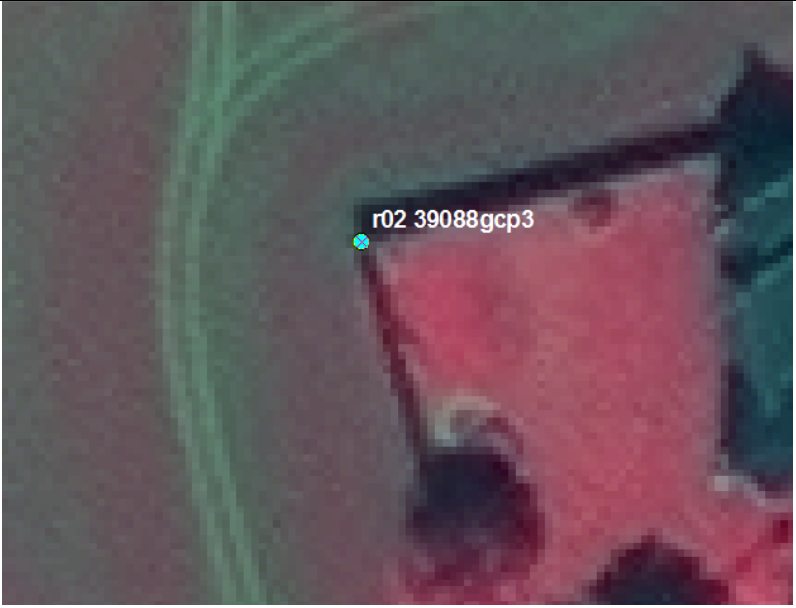
Point_ID	Comment	DEM Height (MSL)	GPS heght (MSL) OSGM02	Difference (m)	Diff^2 (m2)
2,000	r02-39088gcp1	134,000	131,240	2,760	7,618
4,000	r02 39088gcp02	134,000	131,670	2,330	5,429
8,000	r02 39088gcp3	188,000	190,028	-2,028	4,113
11,000	r02 37914 - gcp4	156,000	157,350	-1,350	1,822
14,000	r02-32201 - gcp5	60,000	60,173	-0,173	0,030
15,000	r02-26787- gcp6	60,000	61,845	-1,845	3,404
19,000	ro2-28389- gcp7	113,000	112,550	0,450	0,203
22,000	r02-25914 - gcp8	120,000	121,998	-1,998	3,992
23,000	r02-22464- gcp9	78,000	77,236	0,764	0,584
25,000	r02-19193 - gcp10	139,000	139,285	-0,285	0,081
27,000	r02-22193 - gcp11	186,000	185,132	0,868	0,753
				RMSEz in meters	**1,674**

6.1. Annex II – Technical details for the checkpoints collected

Point Name	Max_PDOP	Max_HDOP	Corr_Type	GPS_Date	GPS_Time	GPS_Second	GPS_Height	Vert_Prec	Horz_Prec	Std_Dev	Northing	Easting	Point_ID
r02-39088gcp1	2,0	1,2	Postprocessed Carrier Float	12/01/2011	09:23:00am	292994,000	182,849	0,2	0,2	0,0	6166550,6	524161,0	2
r02 39088gcp02	2,0	1,2	Postprocessed Carrier Float	12/01/2011	09:27:59am	293293,000	183,288	0,3	0,3	0,0	6166557,9	524157,7	4
r02 39088gcp3	2,7	1,4	Postprocessed Code	12/01/2011	10:22:01am	296535,000	241,552	0,4	0,3	0,1	6167336,9	526045,6	8
r02 37914 -gcp4	2,2	1,0	Postprocessed Carrier Float	12/01/2011	11:06:52am	299226,000	208,944	0,3	0,2	0,0	6165481,6	524817,1	11
r02-32201 - gcp5	2,1	1,1	Postprocessed Carrier Float	12/01/2011	11:44:18am	301472,000	111,566	0,5	0,4	0,0	6159526,1	530244,6	14
r02-26787-gcp6	1,9	1,1	Postprocessed Carrier Float	12/01/2011	12:23:00pm	303794,000	113,187	0,2	0,2	0,0	6154296,9	533396,7	15
ro2-28389-gcp7	5,3	2,8	Postprocessed Carrier Float	12/01/2011	01:43:57pm	308651,000	164,098	0,5	0,4	0,0	6155751,1	528080,0	19
r02-25914 - gcp8	1,8	0,9	Postprocessed Carrier Float	12/01/2011	02:30:21pm	311435,000	173,684	0,3	0,2	0,0	6152979,1	525455,9	22
r02-22464-gcp9	3,7	1,8	Postprocessed Code	12/01/2011	02:49:13pm	312567,000	128,988	0,3	0,2	0,0	6149853,6	524980,5	23
r02-19193 - gcp10	2,7	1,3	Postprocessed Carrier Float	12/01/2011	03:17:48pm	314282,000	190,836	0,3	0,2	0,1	6146808,7	531890,9	25
r02-22193 - gcp11	4,0	2,8	Postprocessed Carrier Float	12/01/2011	04:05:12pm	317126,000	236,460	0,3	0,2	0,2	6149555,1	536608,6	27

GCP	r02-39088gcp1 (Point ID 2)	Location: Right edge of the small bridge
VHR Imagette		
Pictures from the ground		

GCP	r02 39088gcp02 (Point ID 4)	Location: Left end of the metal door
VHR Imagette	r02 39088gcp02 / r02-39088gcp1	r02 39088gcp02 / r02-39088gcp1
Pictures from the ground		

GCP	r02 39088gcp3 (Point ID 8)	Location: Corner of the stone wall
VHR Imagette		

GCP	r02 37914 -gcp4 (Point ID 11)	Location: Junction (corner) of fence
VHR Imagette		
Pictures from the ground		

GCP	r02-32201 -gcp5 (Point ID 14)	Location: End of fence
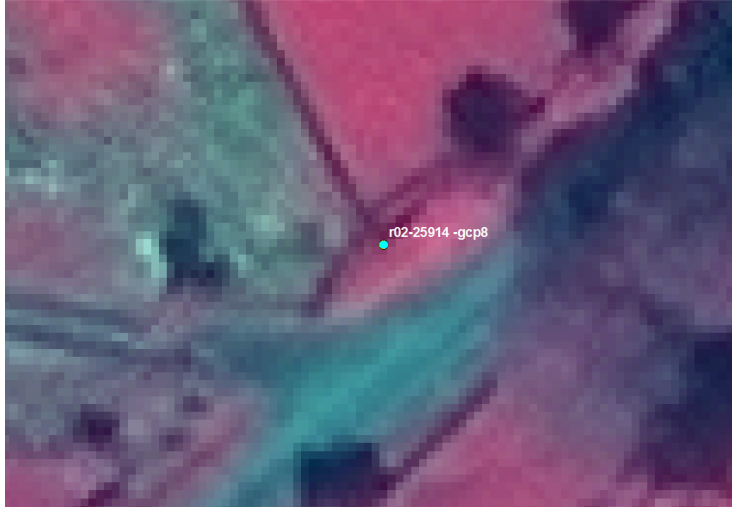
VHR Imagette		
Pictures from the ground		

GCP	r02-26787-gcp6 (Point ID 15)	Location: Base on an electric pole
VHR Imagette		
Pictures from the ground		

GCP	ro2-28389-gcp7 (Point ID 19)	Location: Corner of the fence (next to the door)
VHR Imagette		

GCP	r02-25914 -gcp8 (Point ID 22)	Location: Junction (corner) of a fence
VHR Imagette		
Pictures from the ground		

GCP	r02-22464-gcp9 (Point ID 23)	Location: Junction (corner) of a fence
VHR Imagette		
Pictures from the ground		

GCP	r02-19193 -gcp10 (Point ID 25)	Location: Junction (corner) of a fence
VHR Imagette		
Pictures from the ground		

GCP	r02-22193 -gcp11 (Point ID 27)	Location: End of a stone wall
VHR Imagette		
Pictures from the ground		

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