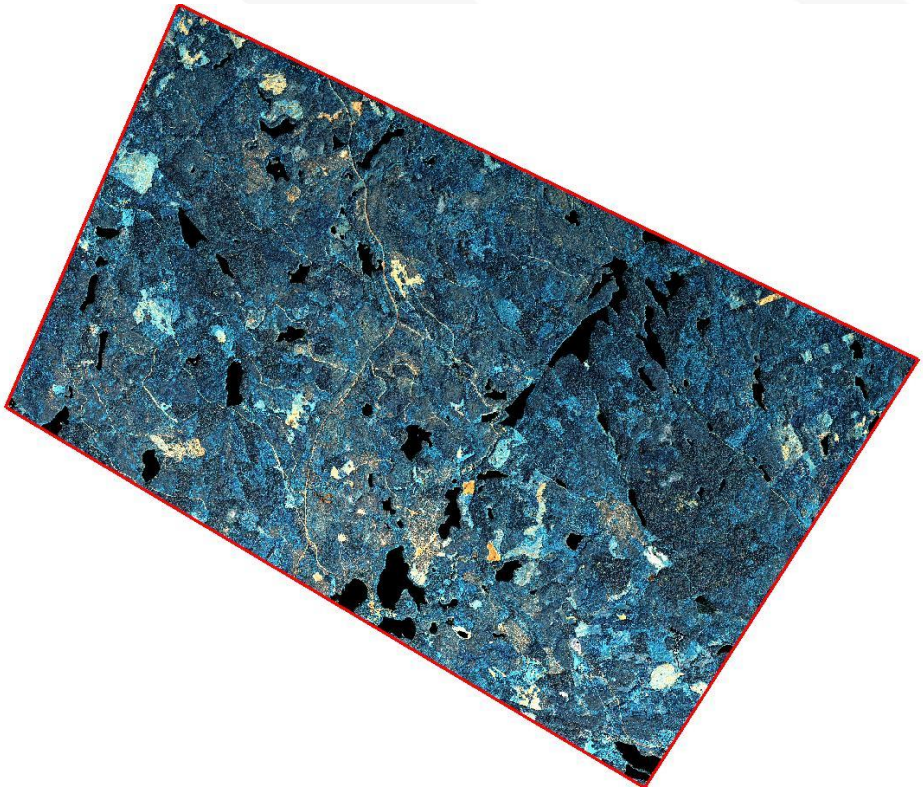
REPORT FOR HYPERSPECTRAL DATA CAPTURE

L40925 SYKE HySpex



terratec

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Report prepared,

terratec

Oslo, Norway, 18.09.2018

Vetle Jonassen

Project manager

1 General Project Information

1.1 Client

Name:	Blom Kartta OY
Address:	Esterinportti 2, 00240 Helsinki, Finland
Project manager:	Lasse Turunen
Project reference:	18068_AP

1.2 Project

Name:	SYKE HySpex
County:	Finland

1.3 Contractor

Name:	TerraTec AS
Address:	Vækerøveien 3, 0281 Oslo
Project manager:	Vetle Jonassen
Project reference:	8739

1.4 Project Content

The project included georeferenced and orthorectified hyperspectral image cubes with radiance values and a resolution of 0.5 meters for the HySpex VNIR sensor and 1 meter resolution for the HySpex SWIR sensor. Ordered area coverage was a total of 82.94 km^2.

1.5 Quality Checks

The area of interest was controlled during data acquisition to ensure coverage as described in the flight plan. The sensor operator in the aircraft controlled the images so that they had the right saturation, and so that they did not contain errors, such as shadows or clouds, beyond thresholds. The overall image quality and possible errors registered by the operator were checked after data capture. GNSS/INS data were ensured to be correctly captured as well. GNSS data and a final quality check of the resulting georeferencing were carried out in the end.

2 DATA ACQUISITION

2.1 Execution

TerraTec AS has carried out the hyperspectral data acquisition in the following operations:

Line number:	Operators	Date
1-27	Vetle Jonassen and Markus Unt	2018.07.16

2.2 Flight Plan

The hyperspectral system consisted of two sensors. Both sensors were mounted in a gyro frame, and the flight plan was made to meet the maximum field of view of the HySpex SWIR sensor, i.e. 16 degrees.

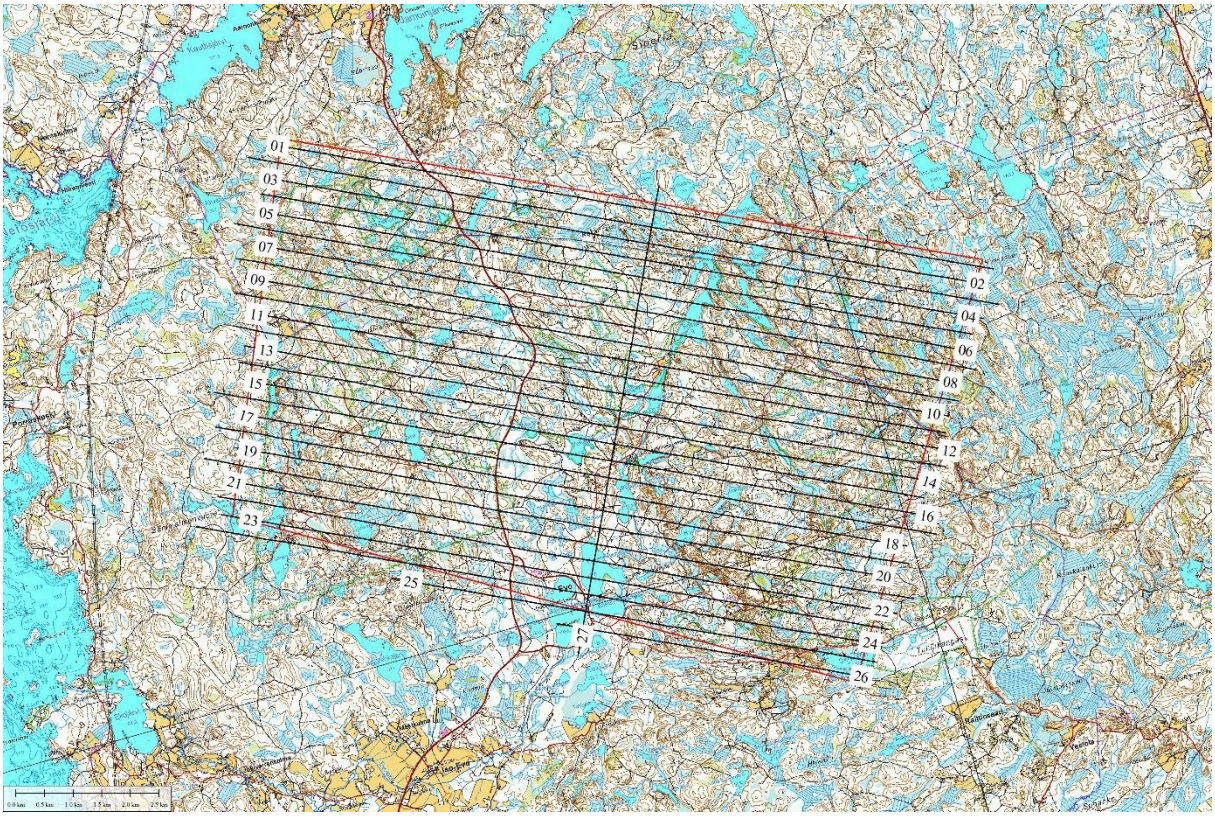

Figure 1: Center lines of acquired data.

2.3 Equipment Specifications

Hyperspectral sensors:	HySpex SWIR-384 and HySpex VNIR-1800
IMU:	Micro IRS IE-IPAS-uIRS
GNSS receiver:	Topcon Legacy E
Platform:	FW (LN-TTC)
Maximum altitude above terrain:	1500 m
Maximum flight speed:	130 kt
Field of view:	±8 degrees for SWIR
	±8,5 degrees for VNIR
Side overlap:	ca 23 % for SWIR
	ca 23 % for VNIR

2.4 Calibration

2.4.1 Factory Calibration

Calibration parameters of the hyperspectral sensors are given by Norsk Elektro Optikk AS. The calibration report and system parameter set were delivered along with the sensor. Factory calibration was also performed after repairs/upgrades and periodically according to service and maintenance plan.

2.4.2 Calibration of Installed System

A calibration was performed at first time installation in aircraft, with changes in factory calibration or changes in the physical installation. In this calibration, angle differences between components were solved and lever arms between GNSS antenna, IMU- and hyperspectral sensors were estimated.

A last correction in offset to heading, roll and pitch was done by manually selecting natural ground control points between two crossing flight lines.

Boresight corrections are given in the table below:

Sensor	Heading correction	Roll correction	Pitch correction
SWIR-384	0,417°	0,498°	0,358°
VNIR-1800	-0,560°	-0,648°	0,283°

Boresight corrections of the respective sensors were based on the following ground control points:

Sensor	X mean (m)	Y mean (m)	X standard deviation (m)	Y standard deviation (m)
SWIR	0.00	0.14	1.02	0.58
VNIR	0.00	0.00	0.73	0.41

2.5 Datum and Projection

Horizontal: WGS84 UTM zone 35

2.6 Transformations

GNSS calculations are carried out in TerraPOS using WGS84. Transformation is done for delivery in the agreed datum for this project:
Transformation WGS84 UTM35

2.7 Challenges in Data Acquisition

The area of interest was in a geographical area with rapidly changing weather. This offered challenges as hyperspectral data over a desired area should preferably be gathered in the same day, under the same atmospheric conditions, with as little shadows and clouds as possible, and with a dry ground surface. The day of data capture offered cloud free conditions with a sun angle varying from 26 degrees to 44 degrees.

2.8 Mosaicking

The resulting hyperspectral data cubes were mosaicked using bilinear interpolation. Further, the mosaics were then tiled into 500 x 500-meter tiles for easier data handling.

3 PROCESSING

3.1 Calculations and Editing

The software used for data processing and their functionalities are listed in the table below:

Software/version	Producer	Function
MissionPro	Leica Geosystems	Flight planning
TerraPOS	TerraTec	GNSS processing
IPAS Pro	Leica Geosystems	GNSS/INS integration
HySpex_NAV	Norsk Elektro Optikk	GNSS/IMU resampling
HySpex_RAD	Norsk Elektro Optikk	File conversion to spectral intensity
ENVI 5.5	Harris Geospatial Solutions	Quality check of hyperspectral data
Parge 3.4	ReSe	Georeferencing, orthorectification and mosaic generation.

3.2 GNSS/INS Calculations

Blending of GPS and IMU data has been done using kalman filter in Leica's software IPAS-PRO v 15.

3.3 Orthorectification of Hyperspectral Image Cubes

The hyperspectral image cubes were orthorectified in Parge 3.4 based on a 50 cm resolution digital surface model made from a simultaneous laser scan captured by an ALS70 laser scanner 16.07.2018. The georeferencing and orthorectification was done using a fast-nearest neighbor interpolation.

4 DELIVERY

4.1 Delivery Content

The hyperspectral data tiles follow the naming:
*Sensor_name*_C*Tile_column_number*_R*Tile_row_number*.tif

File format	Description
#.tif	Georeferenced and orthorectified hyperspectral data
#.shp, #.shx, #.dbf, #.prj	Overview of the data tile borders
#.txt	Additional metadata file containing wavelengths

In addition, full mosaics of each of the respective VNIR and SWIR sensors have been zipped and delivered in .tif-format.

4.2 Tiling, Naming and File Storage

Delivery files for hyperspectral data are mosaicked and tiled for each of the HySpex SWIR and VNIR sensors in TIFF format. Full image cube mosaics of both VNIR and SWIR datasets have also been delivered. Band wavelength information is not a defined header tag in the requested TIFF format used in this delivery. Thus, an overview of the wavelengths of the ascending bands can be found in the "*sensor*_wavelengths.txt" files and in the Appendix.

Data has been shipped from Oslo, Norway to client on an external hard drive 18.09.2018.

APPENDIX

Following are the band numbers and respective wavelengths for the respective VNIR and SWIR sensors.

VNIR Band Wavelengths:

Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavlength (nm):
1	405.954	40	530.210	79	654.467	118	778.723	157	902.980
2	409.140	41	533.396	80	657.653	119	781.909	158	906.166
3	412.326	42	536.583	81	660.839	120	785.095	159	909.352
4	415.512	43	539.769	82	664.025	121	788.281	160	912.538
5	418.698	44	542.955	83	667.211	122	791.467	161	915.724
6	421.884	45	546.141	84	670.397	123	794.654	162	918.910
7	425.070	46	549.327	85	673.583	124	797.840	163	922.096
8	428.256	47	552.513	86	676.769	125	801.026	164	925.282
9	431.442	48	555.699	87	679.955	126	804.212	165	928.468
10	434.629	49	558.885	88	683.141	127	807.398	166	931.654
11	437.815	50	562.071	89	686.327	128	810.584	167	934.840
12	441.001	51	565.257	90	689.513	129	813.770	168	938.026
13	444.187	52	568.443	91	692.700	130	816.956	169	941.212
14	447.373	53	571.629	92	695.886	131	820.142	170	944.398
15	450.559	54	574.815	93	699.072	132	823.328	171	947.585
16	453.745	55	578.001	94	702.258	133	826.514	172	950.771
17	456.931	56	581.187	95	705.444	134	829.700	173	953.957
18	460.117	57	584.373	96	708.630	135	832.886	174	957.143
19	463.303	58	587.559	97	711.816	136	836.072	175	960.329
20	466.489	59	590.746	98	715.002	137	839.258	176	963.515
21	469.675	60	593.932	99	718.188	138	842.444	177	966.701
22	472.861	61	597.118	100	721.374	139	845.631	178	969.887
23	476.047	62	600.304	101	724.560	140	848.817	179	973.073
24	479.233	63	603.490	102	727.746	141	852.003	180	976.259
25	482.419	64	606.676	103	730.932	142	855.189	181	979.445
26	485.606	65	609.862	104	734.118	143	858.375	182	982.631
27	488.792	66	613.048	105	737.304	144	861.561	183	985.817
28	491.978	67	616.234	106	740.490	145	864.747	184	989.003
29	495.164	68	619.420	107	743.677	146	867.933	185	992.189
30	498.350	69	622.606	108	746.863	147	871.119	186	995.375
31	501.536	70	625.792	109	750.049	148	874.305		
32	504.722	71	628.978	110	753.235	149	877.491		
33	507.908	72	632.164	111	756.421	150	880.677		
34	511.094	73	635.350	112	759.607	151	883.863		
35	514.280	74	638.536	113	762.793	152	887.049		
36	517.466	75	641.723	114	765.979	153	890.235		
37	520.652	76	644.909	115	769.165	154	893.421		
38	523.838	77	648.095	116	772.351	155	896.608		
39	527.024	78	651.281	117	775.537	156	899.794		

SWIR Band Wavelengths:

Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavlength (nm):
1	956.614	40	1169.680	79	1382.740	118	1595.800	157	1808.860
2	962.080	41	1175.140	80	1388.200	119	1601.270	158	1814.330
3	967.543	42	1180.600	81	1393.670	120	1606.730	159	1819.790
4	973.006	43	1186.070	82	1399.130	121	1612.190	160	1825.250
5	978.469	44	1191.530	83	1404.590	122	1617.650	161	1830.720
6	983.932	45	1196.990	84	1410.060	123	1623.120	162	1836.180
7	989.395	46	1202.460	85	1415.520	124	1628.580	163	1841.640
8	994.858	47	1207.920	86	1420.980	125	1634.040	164	1847.110
9	1000.320	48	1213.380	87	1426.450	126	1639.510	165	1852.570
10	1005.780	49	1218.850	88	1431.910	127	1644.970	166	1858.030
11	1011.250	50	1224.310	89	1437.370	128	1650.430	167	1863.500
12	1016.710	51	1229.770	90	1442.830	129	1655.900	168	1868.960
13	1022.170	52	1235.240	91	1448.300	130	1661.360	169	1874.420
14	1027.640	53	1240.700	92	1453.760	131	1666.820	170	1879.880
15	1033.100	54	1246.160	93	1459.220	132	1672.290	171	1885.350
16	1038.560	55	1251.630	94	1464.690	133	1677.750	172	1890.810
17	1044.030	56	1257.090	95	1470.150	134	1683.210	173	1896.270
18	1049.490	57	1262.550	96	1475.610	135	1688.680	174	1901.740
19	1054.950	58	1268.010	97	1481.080	136	1694.140	175	1907.200
20	1060.420	59	1273.480	98	1486.540	137	1699.600	176	1912.660
21	1065.880	60	1278.940	99	1492.000	138	1705.060	177	1918.130
22	1071.340	61	1284.400	100	1497.470	139	1710.530	178	1923.590
23	1076.810	62	1289.870	101	1502.930	140	1715.990	179	1929.050
24	1082.270	63	1295.330	102	1508.390	141	1721.450	180	1934.520
25	1087.730	64	1300.790	103	1513.860	142	1726.920	181	1939.980
26	1093.190	65	1306.260	104	1519.320	143	1732.380	182	1945.440
27	1098.660	66	1311.720	105	1524.780	144	1737.840	183	1950.910
28	1104.120	67	1317.180	106	1530.240	145	1743.310	184	1956.370
29	1109.580	68	1322.650	107	1535.710	146	1748.770	185	1961.830
30	1115.050	69	1328.110	108	1541.170	147	1754.230	186	1967.290
31	1120.510	70	1333.570	109	1546.630	148	1759.700	187	1972.760
32	1125.970	71	1339.040	110	1552.100	149	1765.160	188	1978.220
33	1131.440	72	1344.500	111	1557.560	150	1770.620	189	1983.680
34	1136.900	73	1349.960	112	1563.020	151	1776.090	190	1989.150
35	1142.360	74	1355.420	113	1568.490	152	1781.550	191	1994.610
36	1147.830	75	1360.890	114	1573.950	153	1787.010	192	2000.070
37	1153.290	76	1366.350	115	1579.410	154	1792.470	193	2005.540
38	1158.750	77	1371.810	116	1584.880	155	1797.940	194	2011.000
39	1164.220	78	1377.280	117	1590.340	156	1803.400	195	2016.460

Band #:	Wavlength (nm):	Band #:	Wavlength (nm):	Band #:	Wavelength (nm):
196	2021.930	235	2234.990	274	2448.050
197	2027.390	236	2240.450	275	2453.510
198	2032.850	237	2245.910	276	2458.980
199	2038.320	238	2251.380	277	2464.440
200	2043.780	239	2256.840	278	2469.900
201	2049.240	240	2262.300	279	2475.370
202	2054.700	241	2267.770	280	2480.830
203	2060.170	242	2273.230	281	2486.290
204	2065.630	243	2278.690	282	2491.750
205	2071.090	244	2284.160	283	2497.220
206	2076.560	245	2289.620	284	2502.680
207	2082.020	246	2295.080	285	2508.140
208	2087.480	247	2300.550	286	2513.610
209	2092.950	248	2306.010	287	2519.070
210	2098.410	249	2311.470	288	2524.530
211	2103.870	250	2316.930		
212	2109.340	251	2322.400		
213	2114.800	252	2327.860		
214	2120.260	253	2333.320		
215	2125.730	254	2338.790		
216	2131.190	255	2344.250		
217	2136.650	256	2349.710		
218	2142.110	257	2355.180		
219	2147.580	258	2360.640		
220	2153.040	259	2366.100		
221	2158.500	260	2371.570		
222	2163.970	261	2377.030		
223	2169.430	262	2382.490		
224	2174.890	263	2387.960		
225	2180.360	264	2393.420		
226	2185.820	265	2398.880		
227	2191.280	266	2404.340		
228	2196.750	267	2409.810		
229	2202.210	268	2415.270		
230	2207.670	269	2420.730		
231	2213.140	270	2426.200		
232	2218.600	271	2431.660		
233	2224.060	272	2437.120		
234	2229.520	273	2442.590		