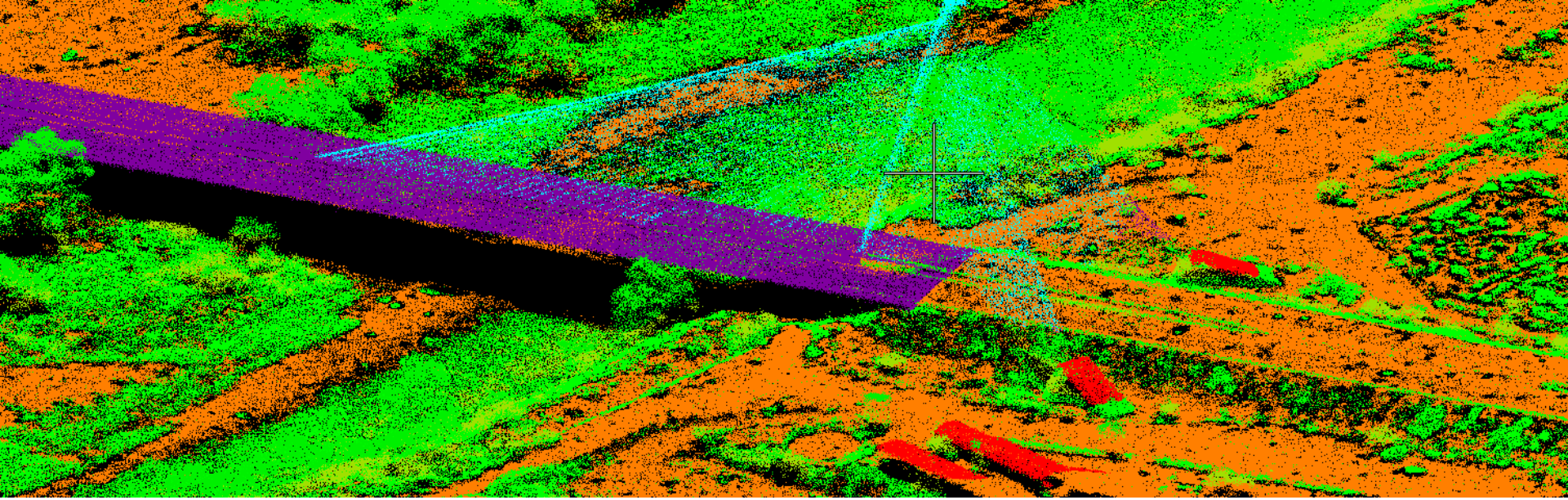




Víctor García, Tracasa

LiDAR Data capture with sensor SPL100 in the Region of Navarra

Workshop: Use of algorithms on big DEM's

Tønsberg, 4th April 2018



Company Presentation - Tracasa

TRACASA is a public company, owned by the Government of Navarre.

Founded in 1982: to create and establish the Cadastre of Navarre.

- | | |
|-----------------------------|------------------|
| ☑ Share Capital: 20 M€ | ☑ Revenue: 25 M€ |
| ☑ Annual R&D Budget: 0,7 M€ | ☑ Employees: 374 |



Two Production Departments:

Software Engineering, Information Systems and Cadastre (ISSI)

Territorial Information Systems and Cartography (TIS)

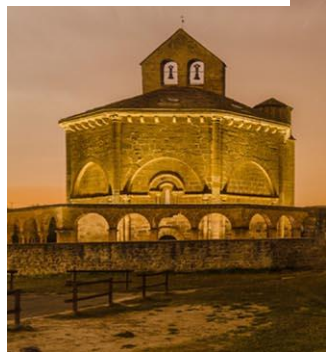
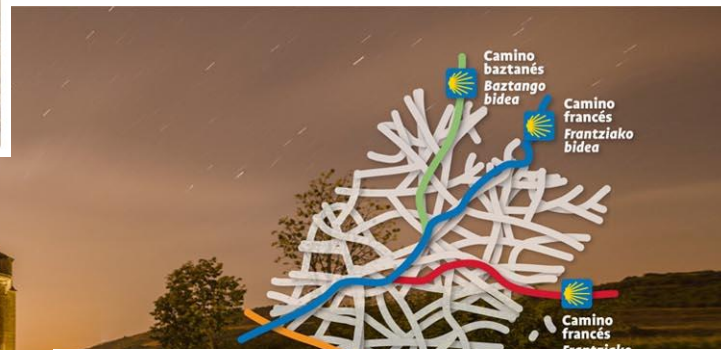
- Cartography
- Orthophoto
- LiDAR Data



Navarre, just a step away from the world



The essence of Navarre



SPL Navarra Project - Project's Roleplayers



Need: Update LiDAR Coverage from Navarra

Between 2011-2012

- 1 point/m²
- ALS60



SPL Navarra Project - Project's Roleplayers



Need: Update LiDAR Coverage from Navarra

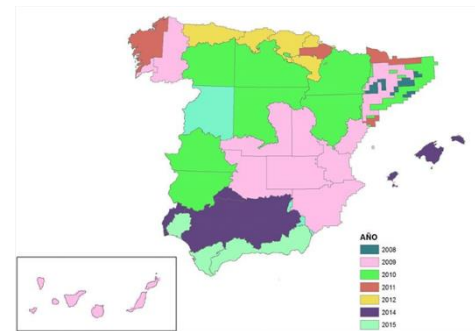
PNOA

**INSTITUTO
GEOGRÁFICO
NACIONAL**



(Plan Nacional de Ortofotografía Aérea)

Spanish Aerial Orthophotography National Plan



SPL Navarra Project - Project's Roleplayers



Nafarroako
Gobernua



Gobierno
de Navarra



tracasa



GRUP **AiRMed**



COWI

Leica
Geosystems

 tracasa

Nafarroako
Gobernua



Gobierno
de Navarra

SPL Navarra Project - Equipment



COWI

Leica
Geosystems

Beechcraft

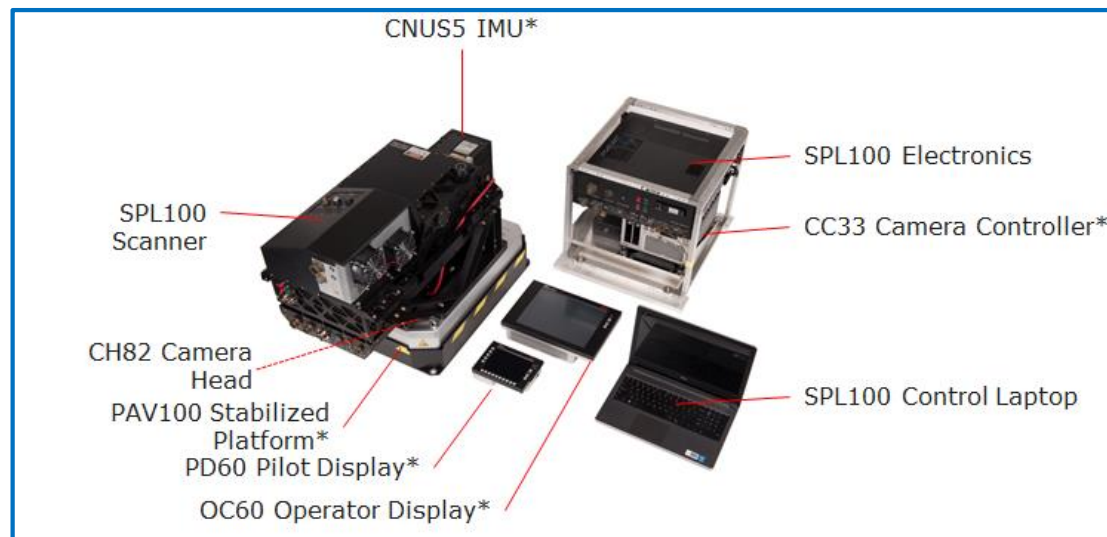
B200 King Air



Crew: 2 Pilots – 1 Airborne Sensor Operator



Single Photon LiDAR (SPL100)



SPL Navarra Project - Equipment



COWI

Leica
Geosystems

Single photon LiDAR is capable of detecting single particles of light (photons)

Laser output is split into a 10 x10 array of laser beamlets.

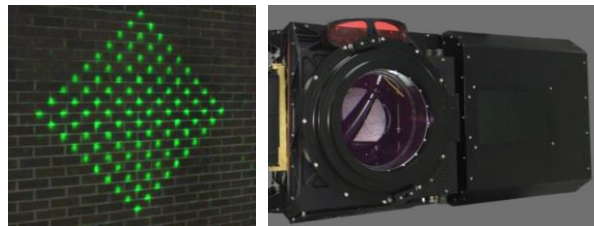
Each output beamlet is collected and input to an independent detector channel. This design allows SPL to operate like 100 LiDARs in parallel.

System records multiple returns per channel and per shot. Due to the fast recovery time (1.6 nanosecs), multiple returns with small vertical separation are detected (24 cm).

24/7 operation of SPL is possible without being blinded by sunlight returns.

Scanner produces a conical scan pattern and a large circular pattern (~1 to 3 km diameter) on the ground.

Currently working at 6.0 million points per second effective pulse rate.
Efficiency 6x linear sensor.

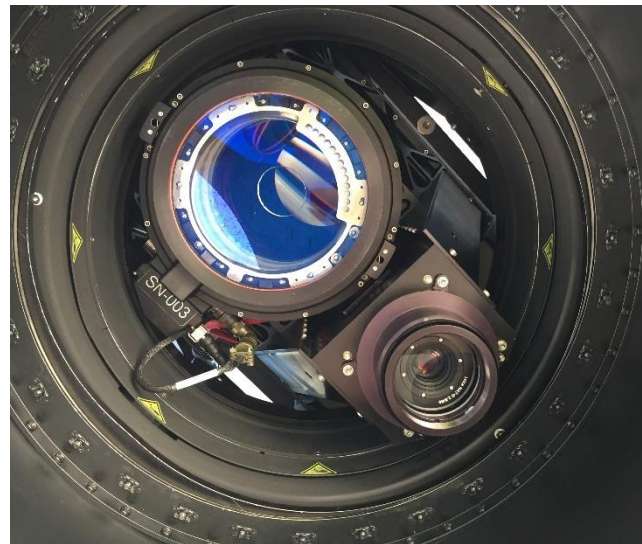
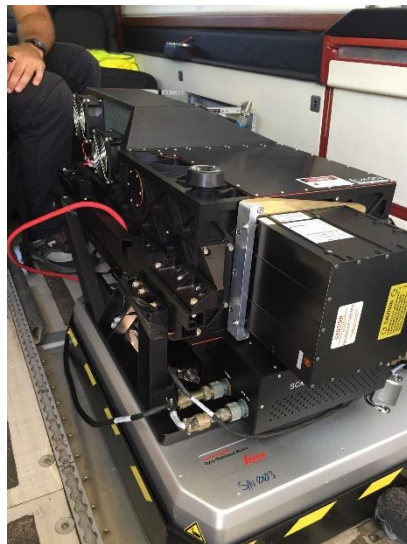


LIDAR UNIT

Beam configuration	10 x 10 array
Laser wavelength	532 nm
Laser divergence	0.08 mrad (1/e ² per beam, nominal)
Laser pulse width	400 psec
Laser optical output	5 W average
Eye safety	NOHD < 300 m
Pulse repetition frequency	60 kHz (6.0 MHz effective puls rate)
Return pulses	Up to 10 returns per channel per laser shot including intensity



SPL Navarra Project - Equipment



The pressurized optical window was removed



SPL Navarra Project - Equipment



Interference with the aircraft's transponders



SPL Navarra Project – Technical Specifications

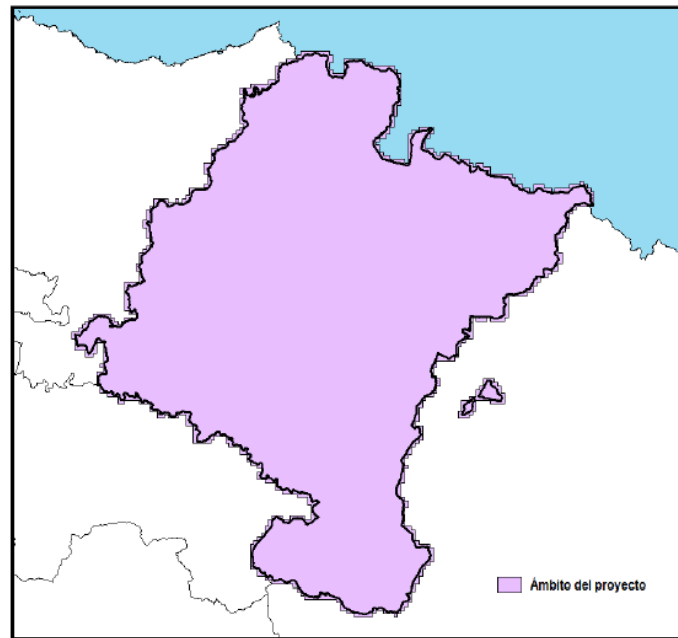
Navarra's Area 10.391 Km²

Point density: 10 points/m²

Overlap: 15%

Accuracy:

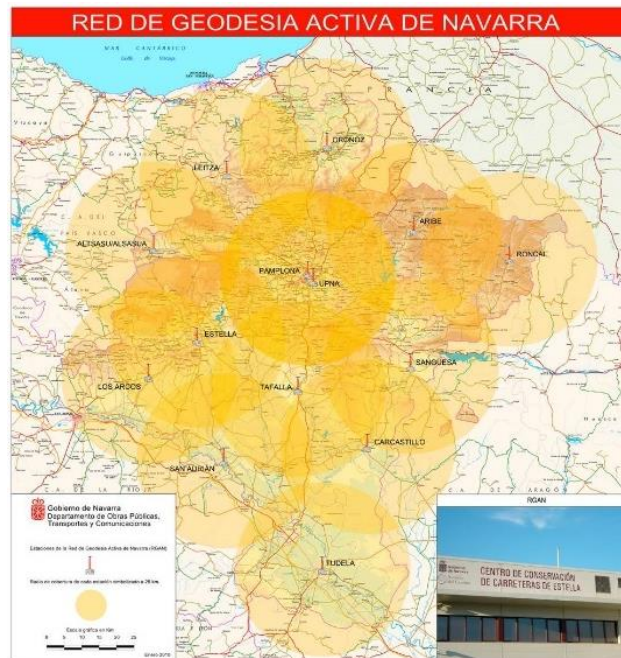
- XY: 20 cm
- Z: 15 cm



SPL Navarra Project – Information provided

Permanent GNSS Network Infrastructure : RGAN

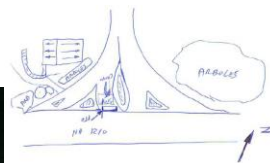
- Made out of 13 ground stations
- Distance between stations < 25 km
- Set up frequency: 2Hz



SPL Navarra Project – Information provided

97 Ground Control Areas measured

- Between 9 and 16 Altimetric control points
- 1 Ground Control Point



RTK Method - Accuracy: 5 cm (XYZ)



SPL Navarra Project – Flight Planning

AOI: 16.500 km² - Divided 5 Blocks – 223 Flight lines

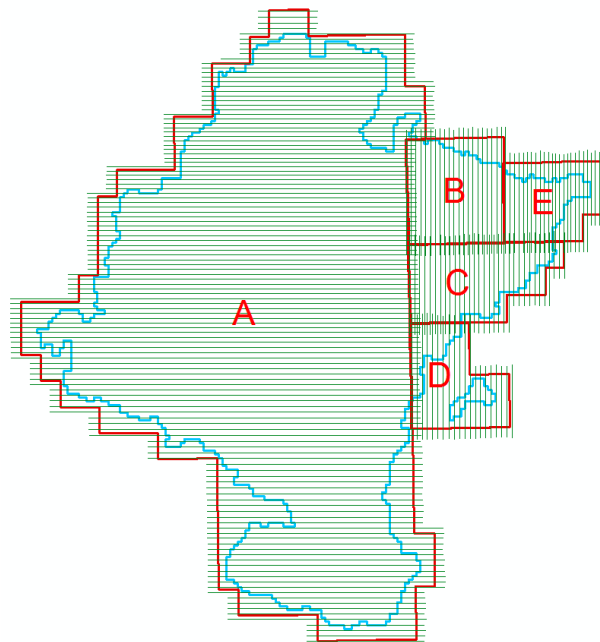
Flight Plan East-West and North-South

72 hours Data capturing planned

Flight Altitude: Between 9.500 and 15.600 feet AGL
2.850 and 4.680 m. AGL

Previous considerations:

- Weather - Schedule
- Rough topography (Height difference 2.400 m)



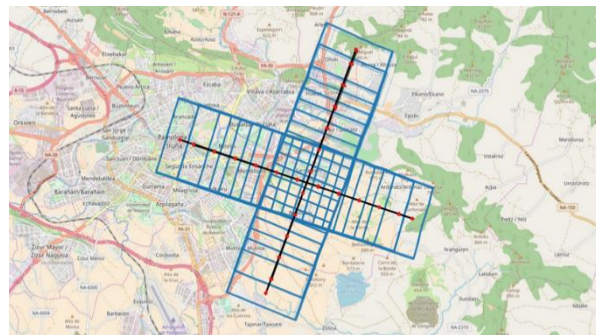
SPL Navarra Project – Calibration Flight

Before: Calibration flight in Reus to check the status of the equipment.

Parameter	Value
Roll [deg]	-0.0486784
Pitch [deg]	0.000890149
Heading [deg]	2.39171
Wedge angle [deg]	25.18
Wedge angle bias [deg]	-0.00652035
Coefficients_FM	-0.00017356 0.000167719 2.25243e-06 3.99377e-05 -1.49281e-05 4.11406e-06 3.85299e-06 -2.05025e-05 -6.18531e-07 -1.39936e-06

Parameter	Value
Roll [deg]	-0.052551
Pitch [deg]	-0.00161923
Heading [deg]	2.4059
Wedge angle [deg]	25.18
Wedge angle bias [deg]	-0.00311319
Coefficients_FM	-0.000156089 0.000197742 7.61207e-06 2.74423e-07 1.35138e-05 6.64237e-06 2.80943e-07 -1.43818e-05 -1.57677e-05 -8.16102e-07

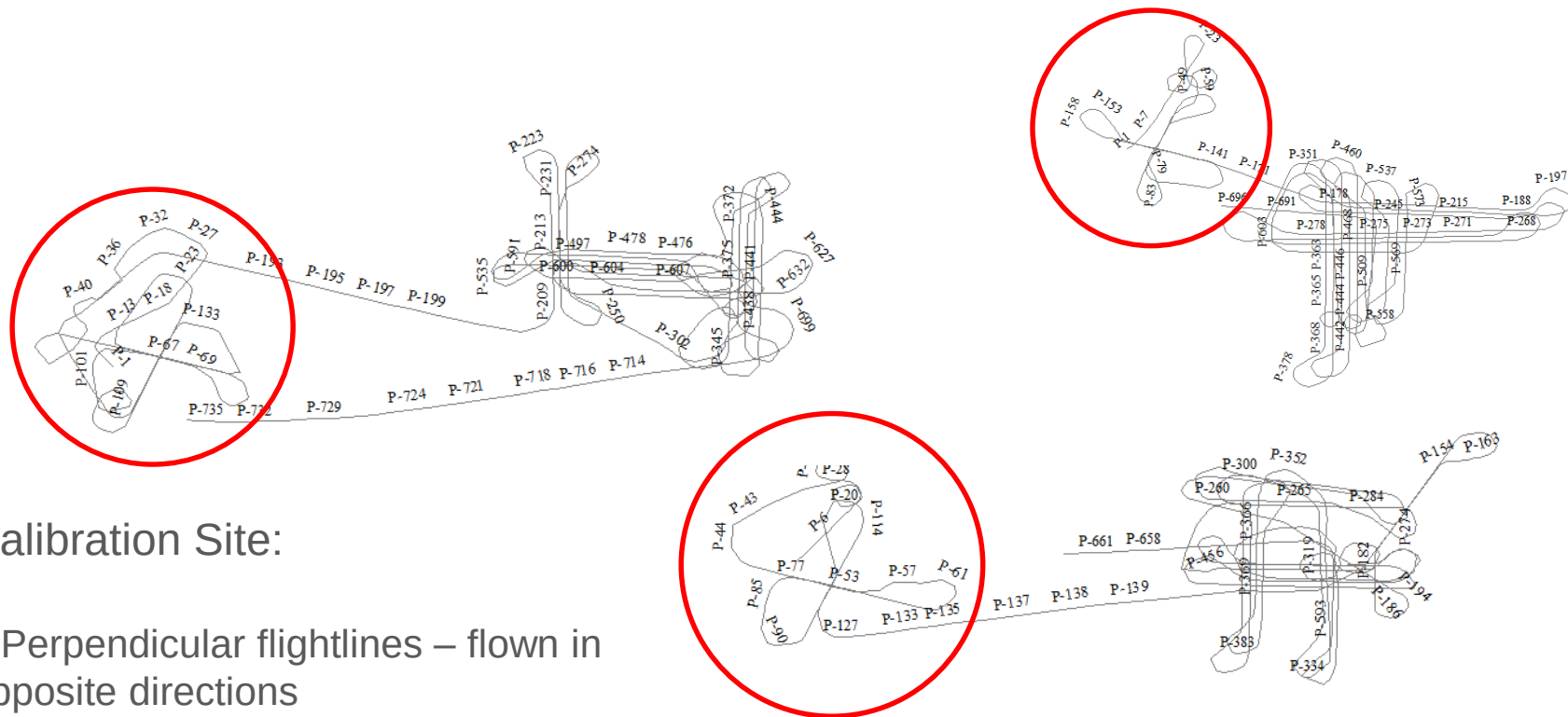
Parameter	Value
Roll [deg]	-0.0462453
Pitch [deg]	0.00148182
Heading [deg]	2.41637
Wedge angle [deg]	25.18
Wedge angle bias [deg]	-0.00558905
Coefficients_FM	-6.32627e-05 0.000160619 2.30935e-05 3.12538e-05 3.8469e-06 5.78865e-06 -5.59602e-06 -1.01458e-06 -6.19554e-06 5.52081e-06



Calibration per flight session:
Roll, Pitch, Heading, Wedge angle, Wedge angle bias, Coefficients Fourier (10)

Calculated with the data captured in the flight session.

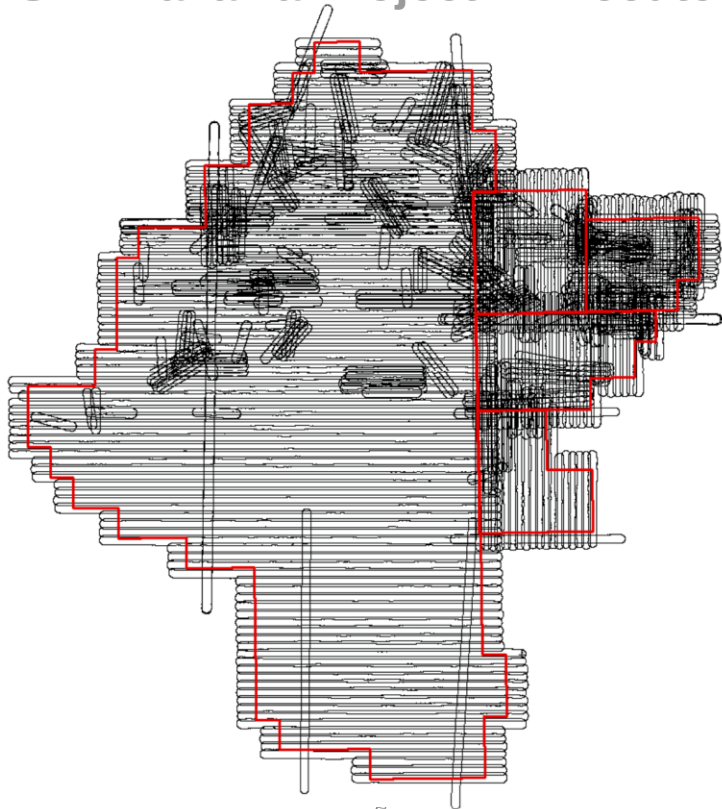
SPL Navarra Project – Calibration Flight



Calibration Site:

2 Perpendicular flightlines – flown in opposite directions

SPL Navarra Project – Executed Flight Plan



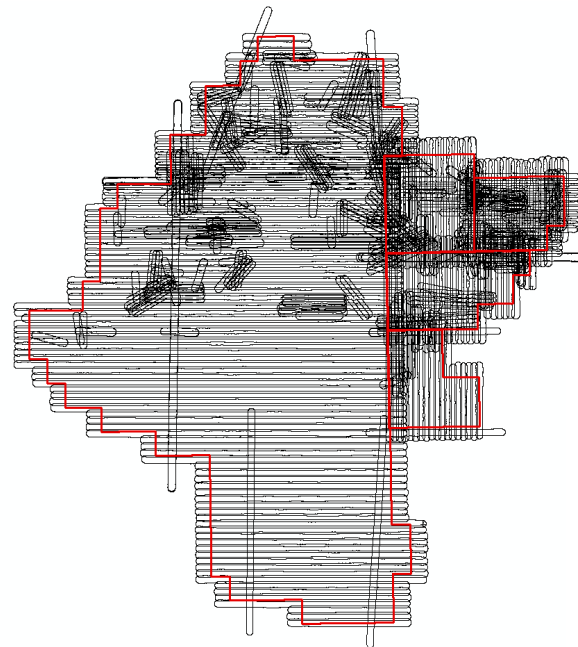
SPL100	Executed
Flight Lines	482
Total Length	16.000 km
Height (feet)	12.800 – 20.600 MSL
Swath (Average)	2300 m
Max. Length	110 Km
Point Density	14 points/m ²
Speed	200 Knots
Cross Strips	10
Sessions/Days	40 / 24

8th September - 16th November 2017

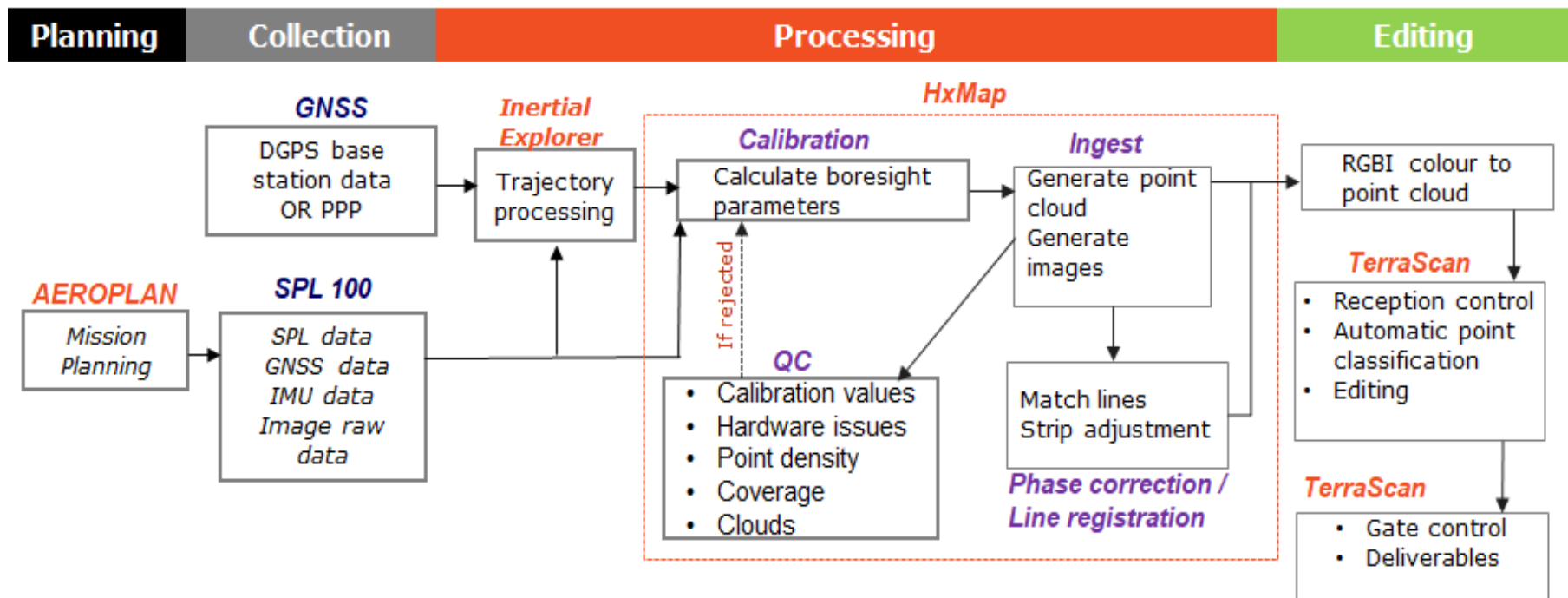
SPL Navarra Project – Executed Flight Plan



	2011 - 2012	2017
Sensor	ALS60	SPL100
Point Density	1 point/m ²	14 points/m ²
Flight Lines	841	482
Height (feet)	7.000-14.500 MSL	12.800 – 20.600 MSL
Swath	1200 m	2300 m
Max. Length	80 Km	110 Km
Speed	130 Knots	200 Knots



SPL Navarra Project – Workflow



SPL Navarra Project – Deliverables

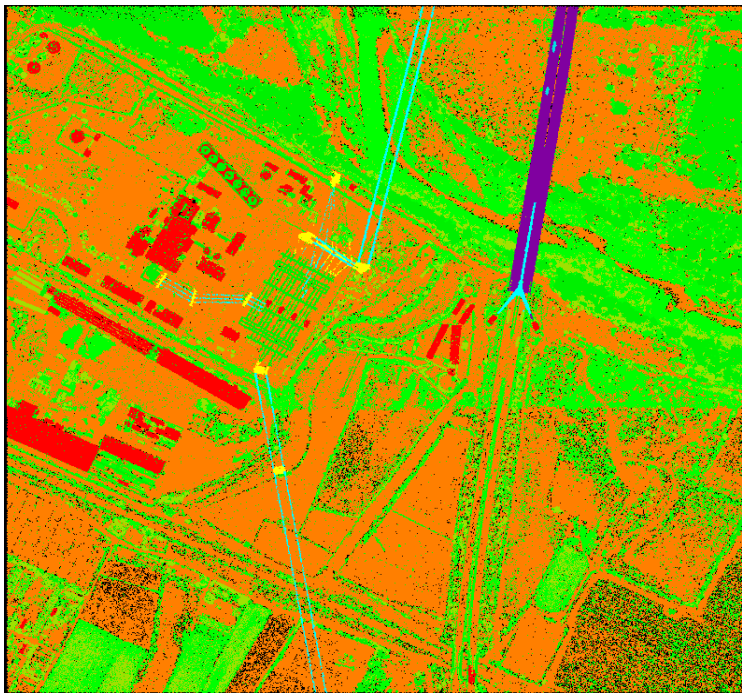
1x1 Km LAS 1.4 (~20 Tb) – LAZ 1.4 (~6 Tb)

- Automatic Classified
- Colorized point cloud RGBIr

ETRS89 UTM30N - Ellipsoidal Height

- Raw Data per Strip Adjusted
- RCD30 Images – RGBNlr
- Rapid Orthoimage - RGBNlr

SPL Navarra Project – Real Data

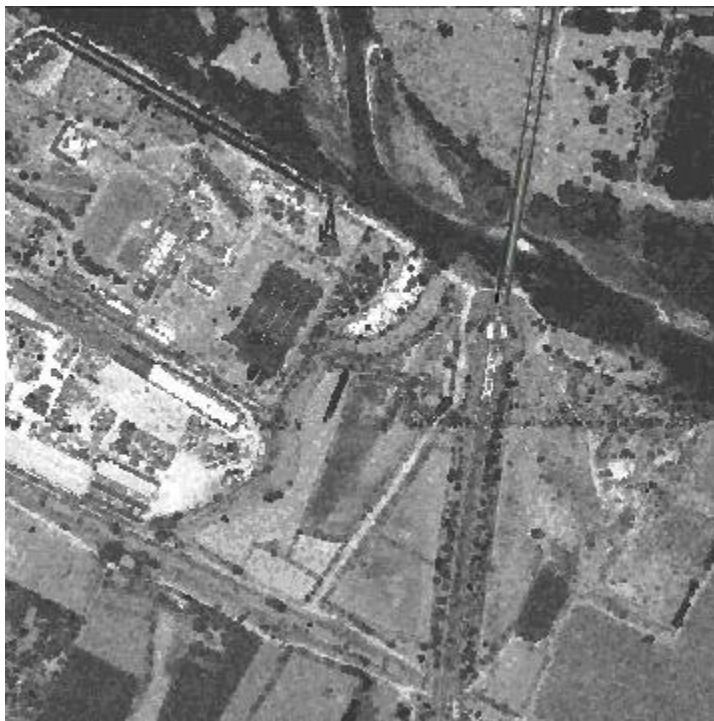


Class



RGB

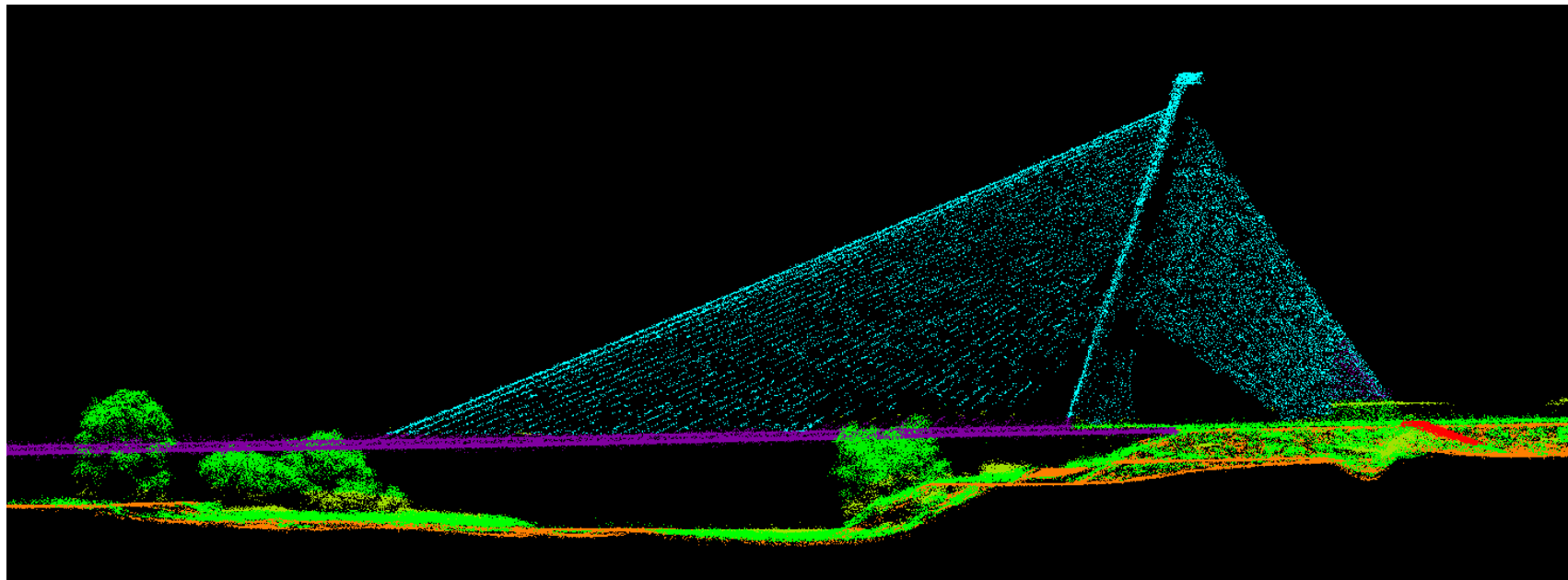
SPL Navarra Project – Real Data



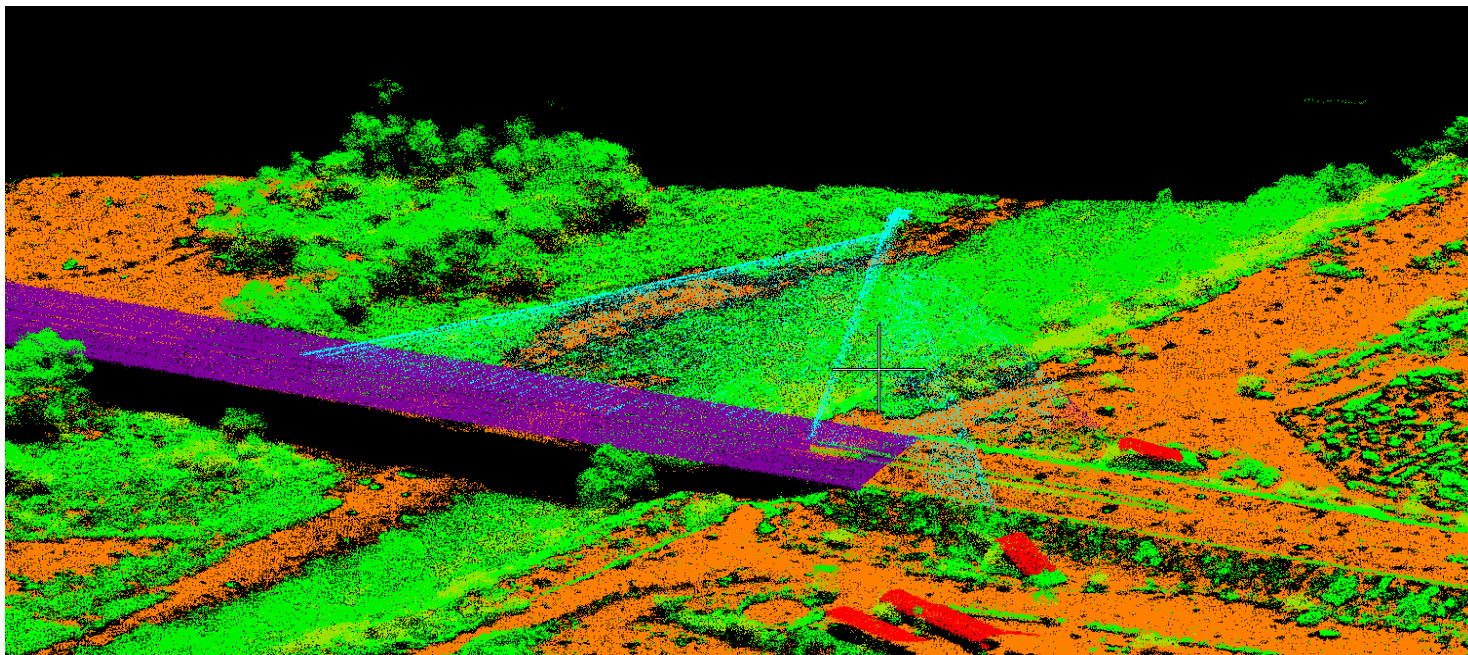
Intensity



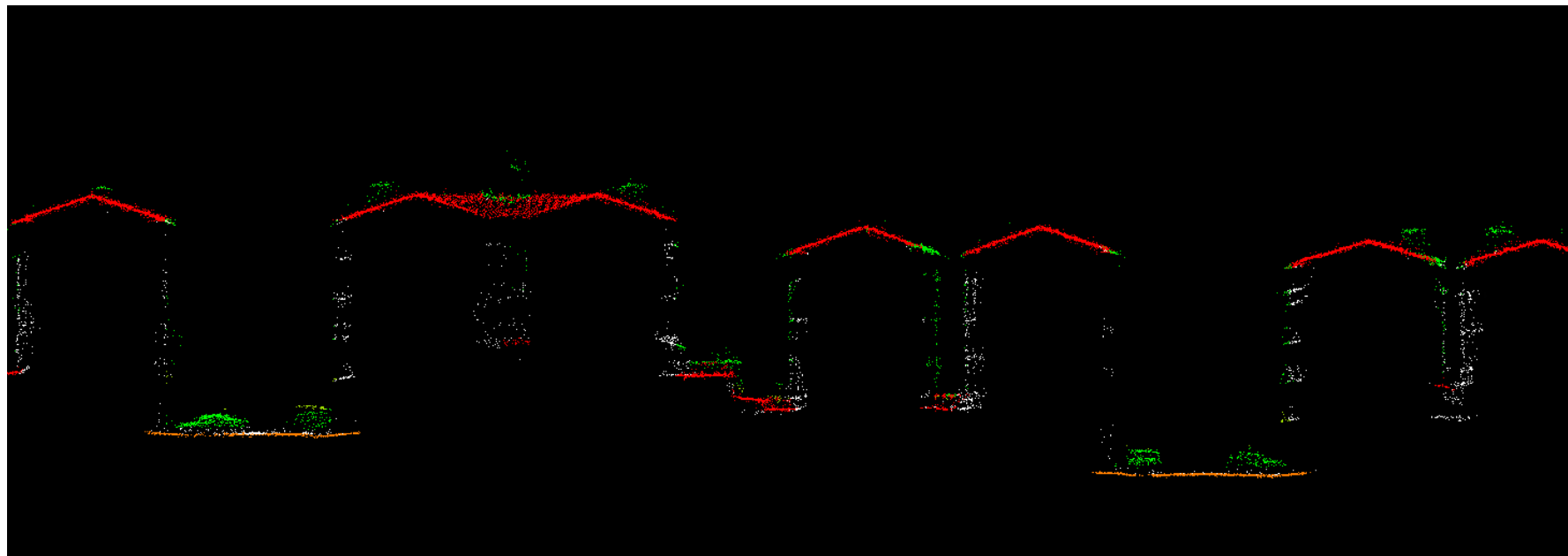
SPL Navarra Project – Real Data



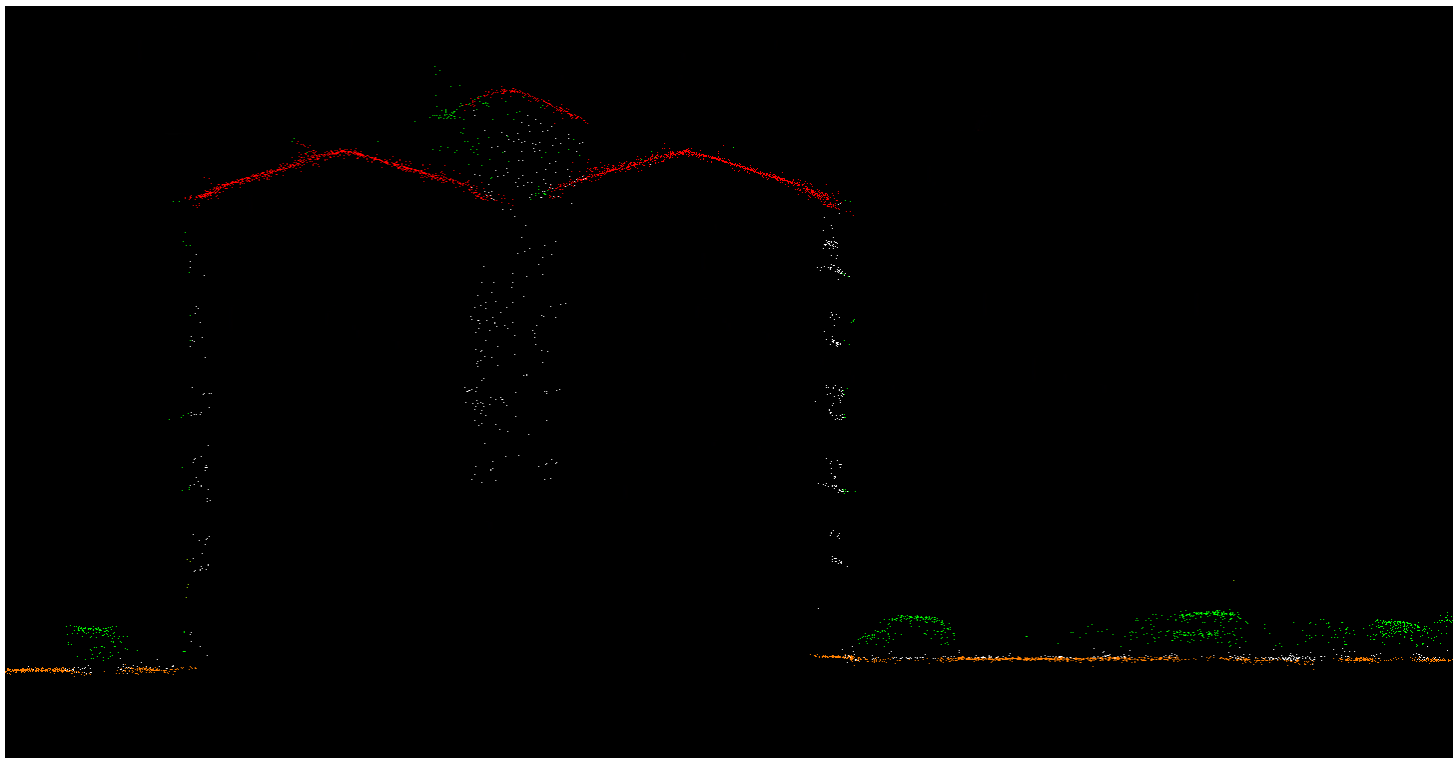
SPL Navarra Project – Real Data



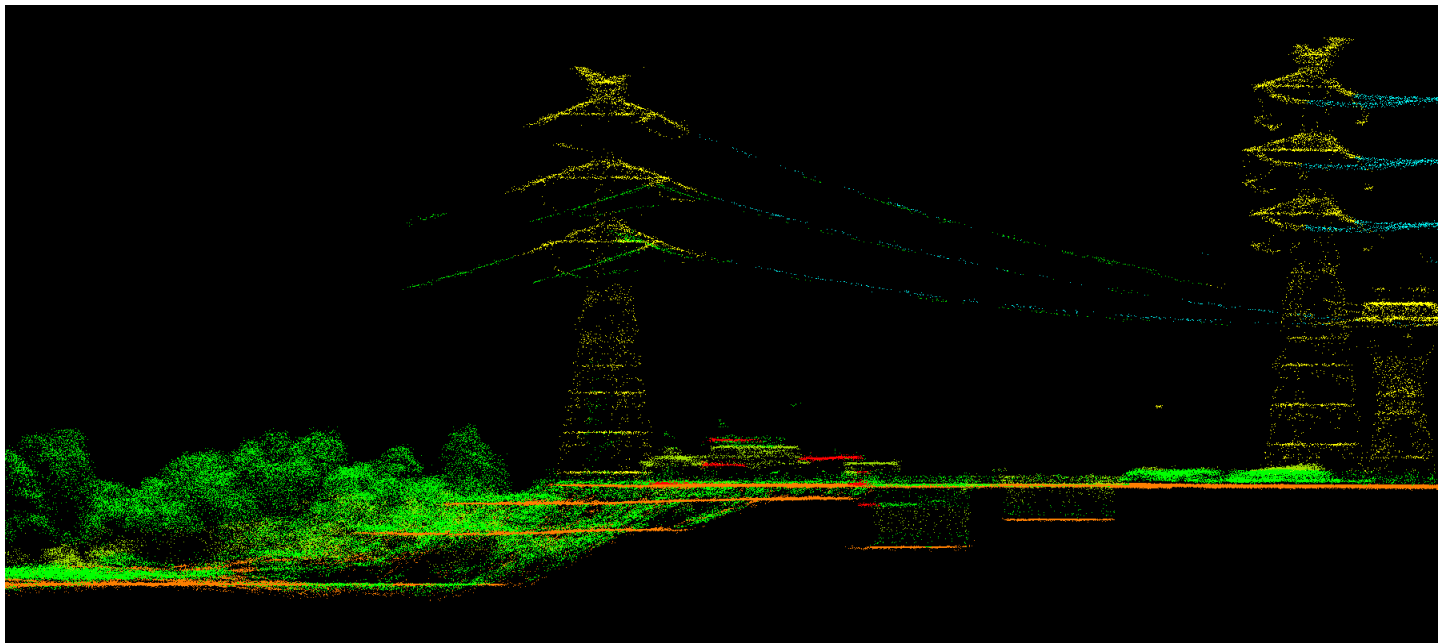
SPL Navarra Project – Real Data



SPL Navarra Project – Real Data

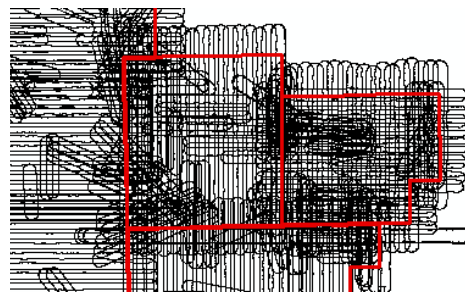
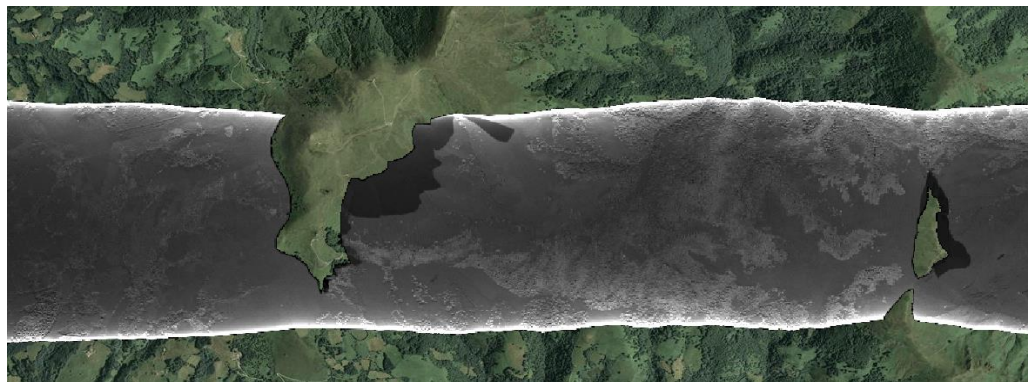
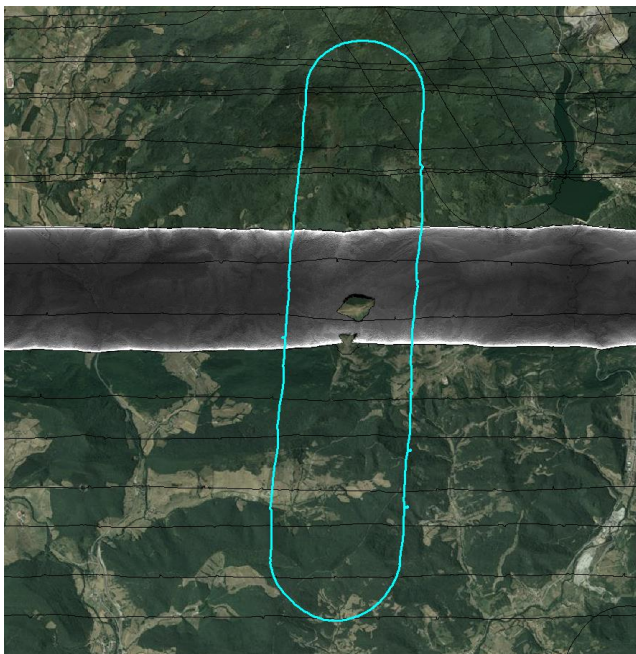


SPL Navarra Project – Real Data



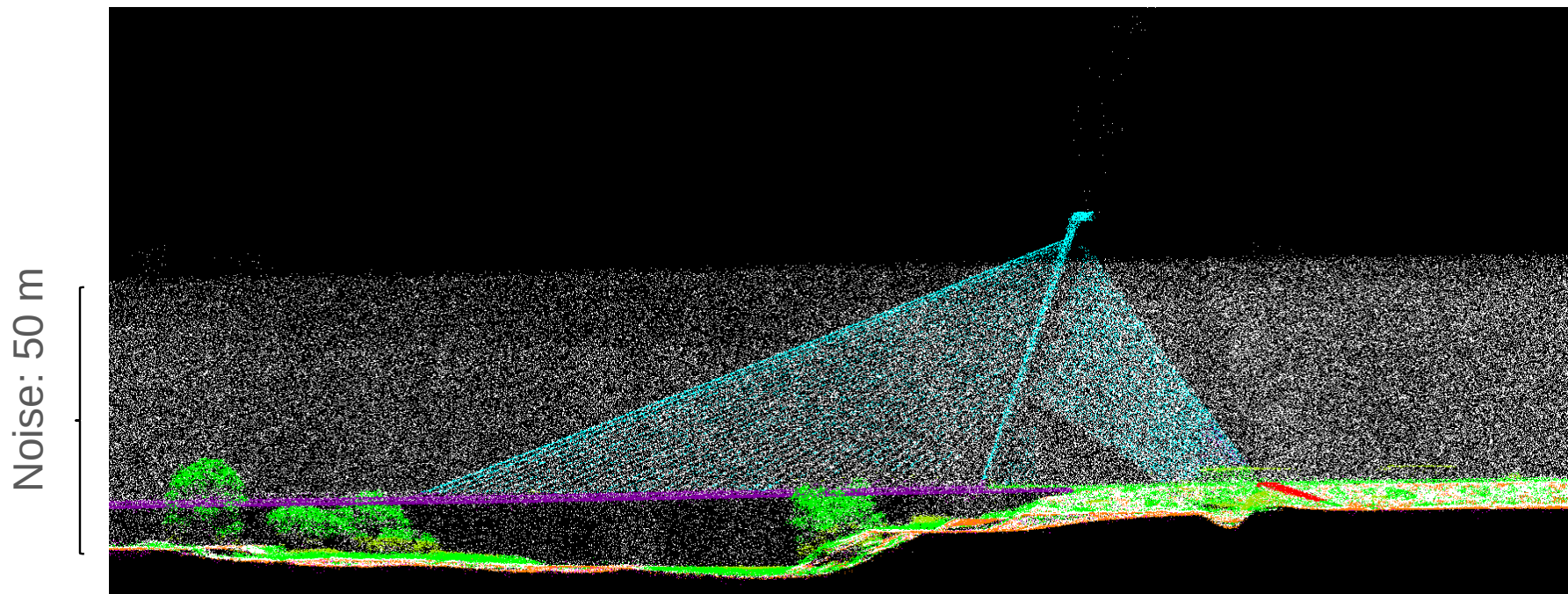
SPL Navarra Project

Gaps – New Flight lines

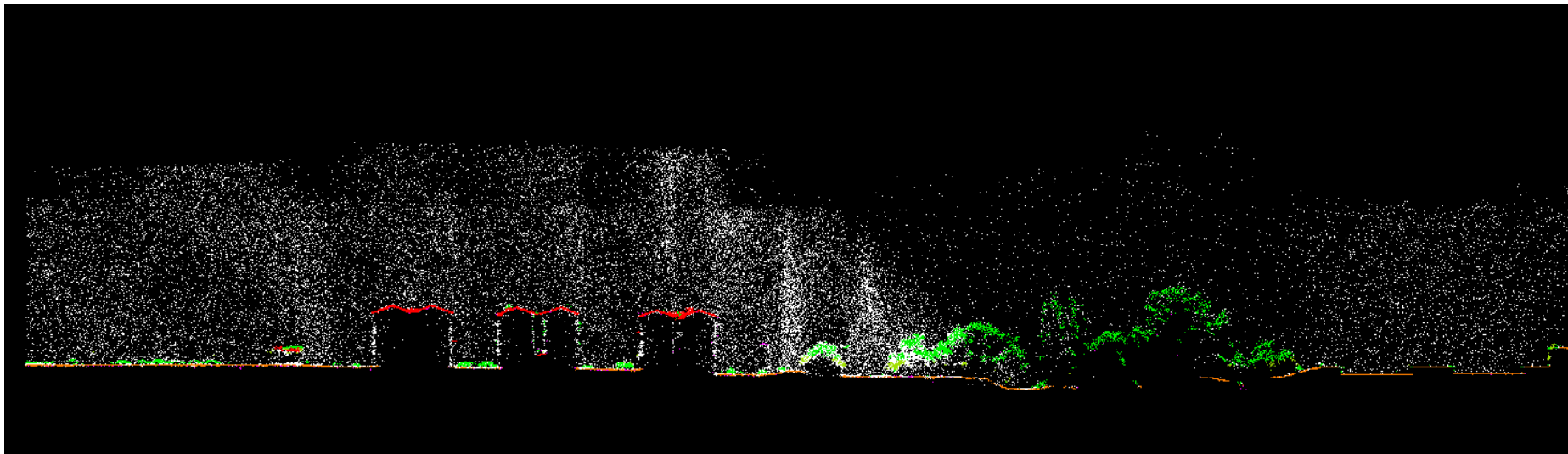


Manual range gate control in-flight

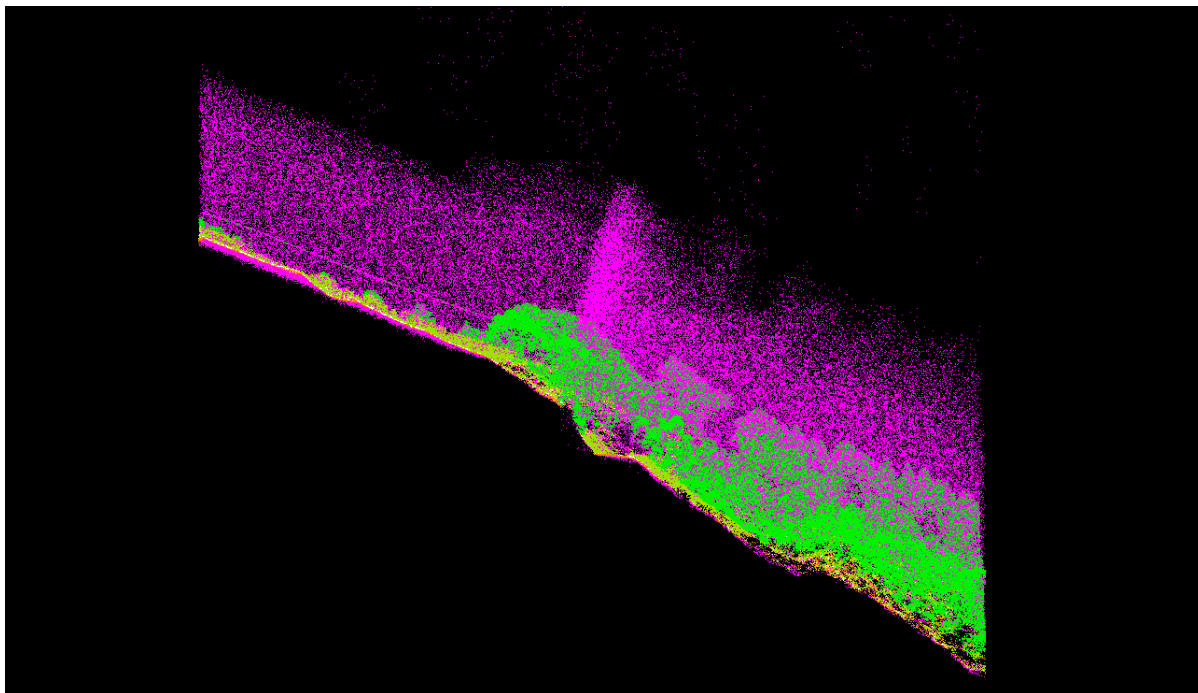
SPL Navarra Project - Noise



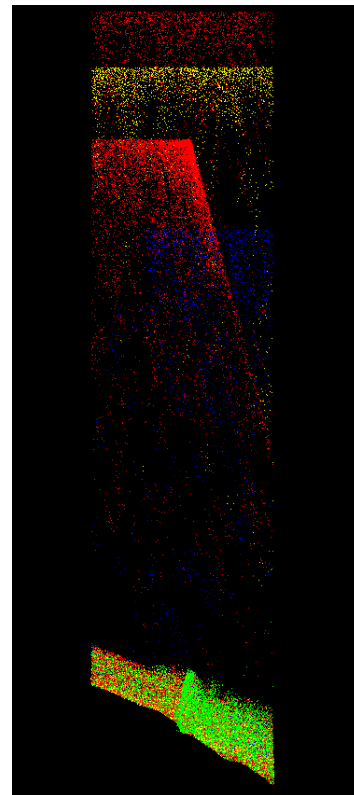
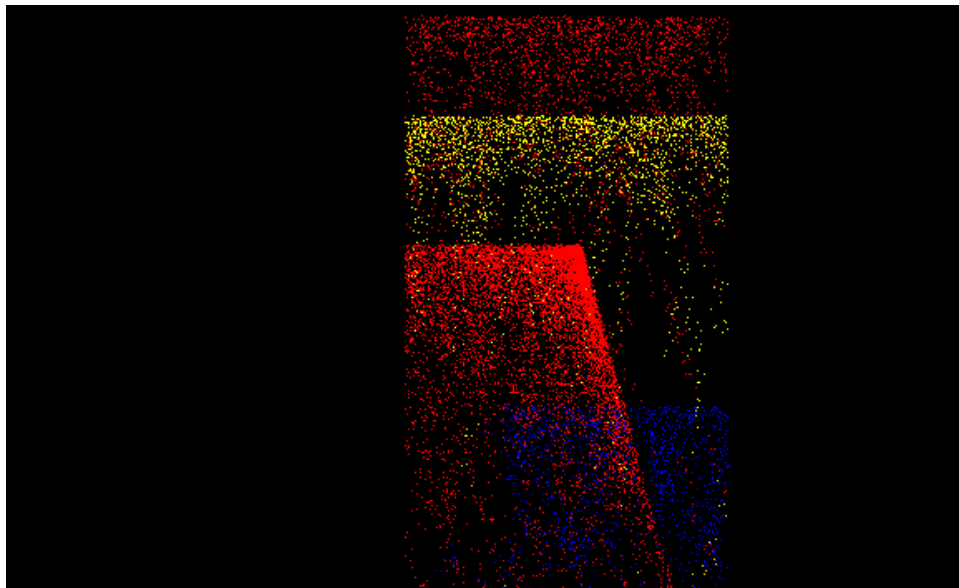
SPL Navarra Project - Noise



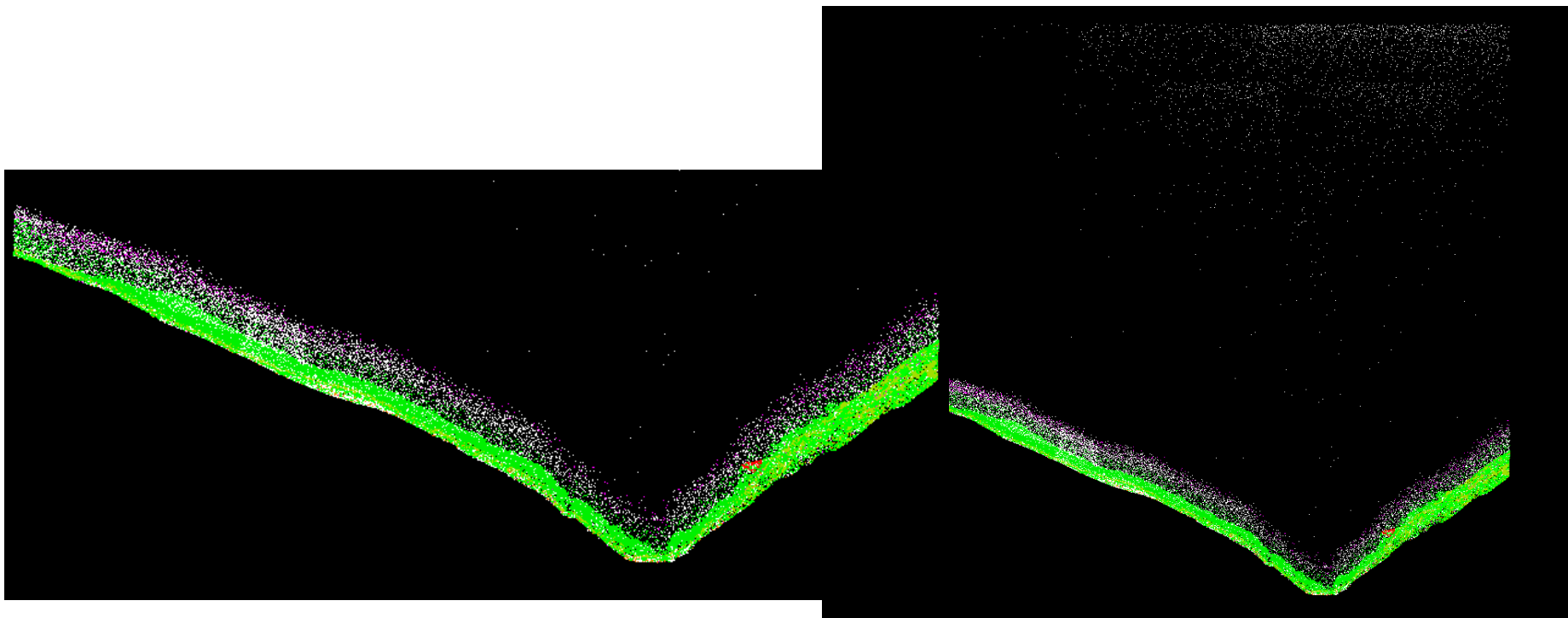
SPL Navarra Project - Noise



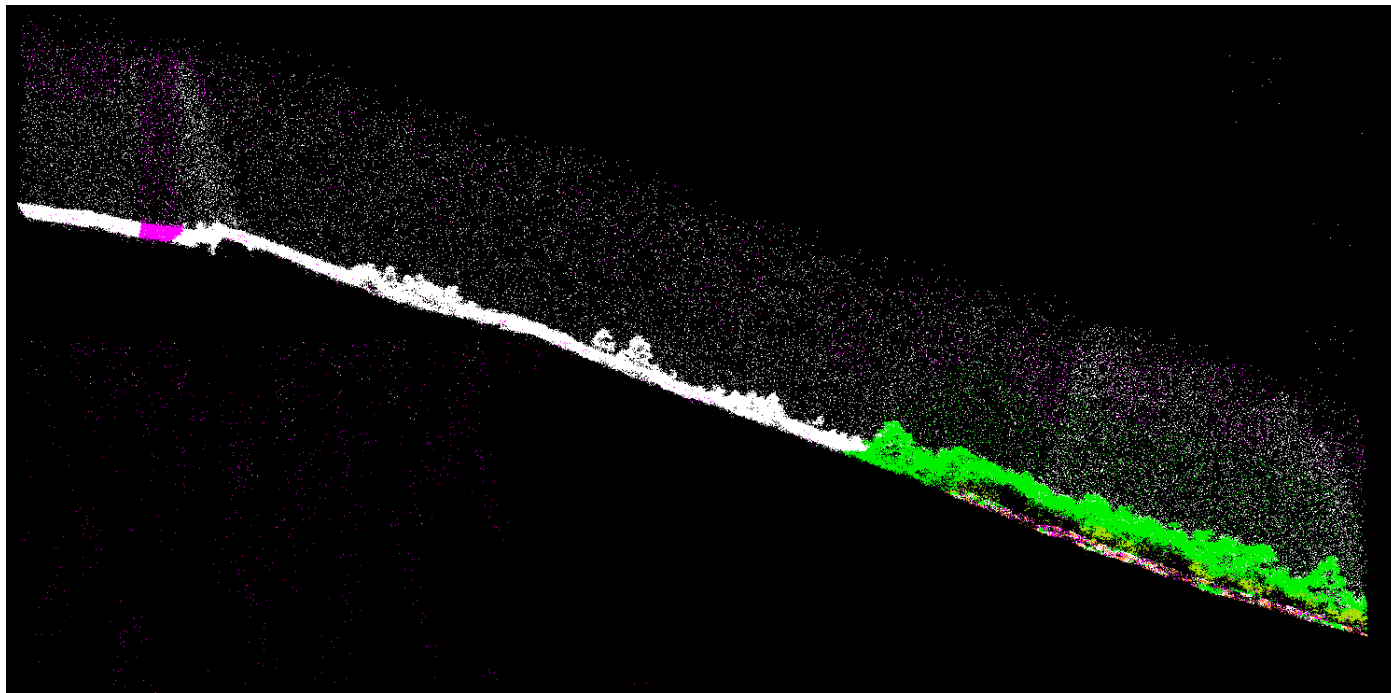
SPL Navarra Project - Noise



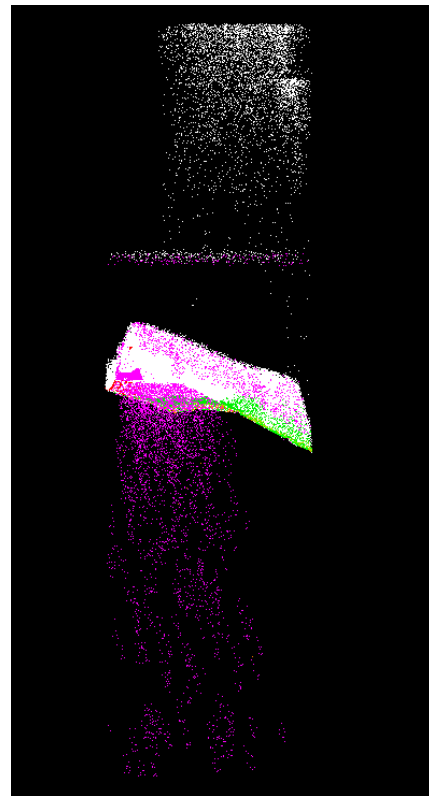
SPL Navarra Project - Noise



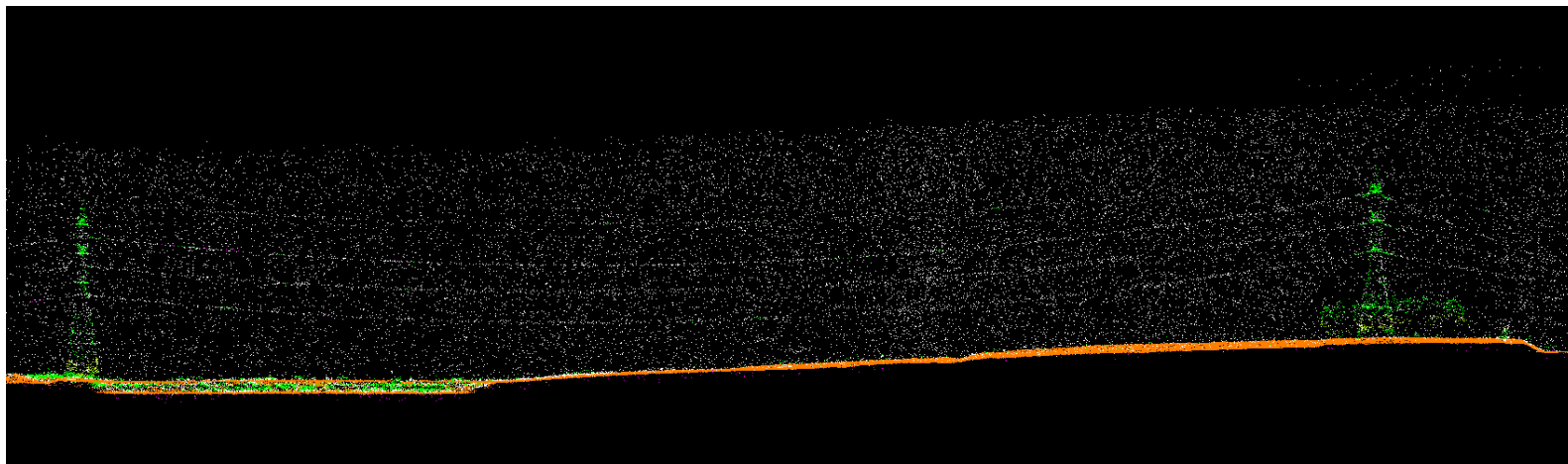
SPL Navarra Project - Noise



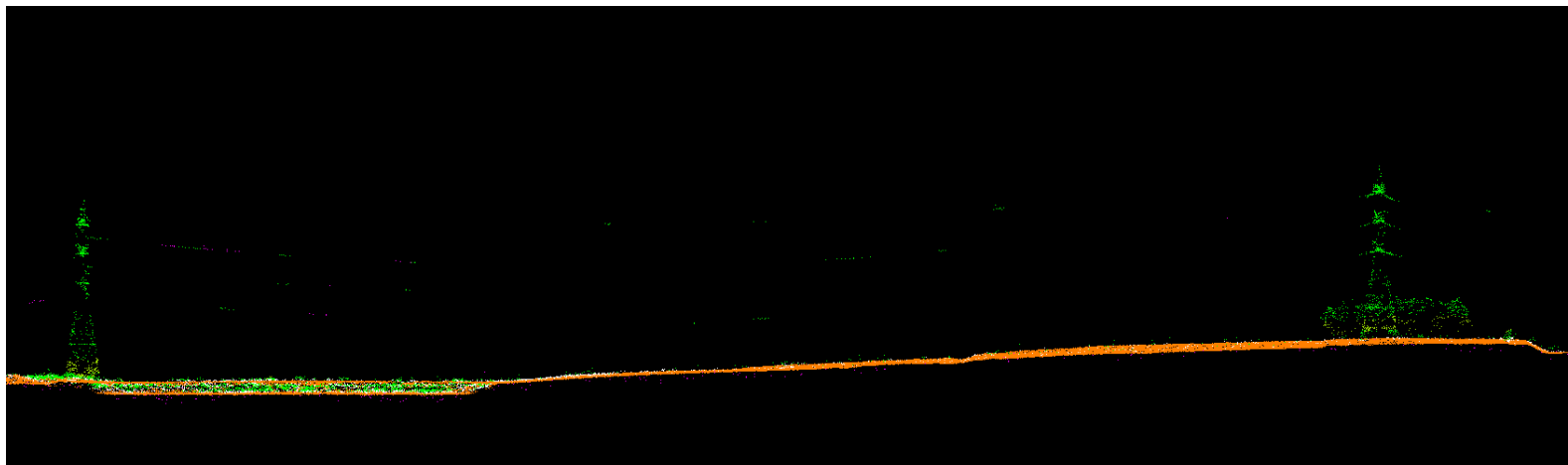
SPL Navarra Project - Noise



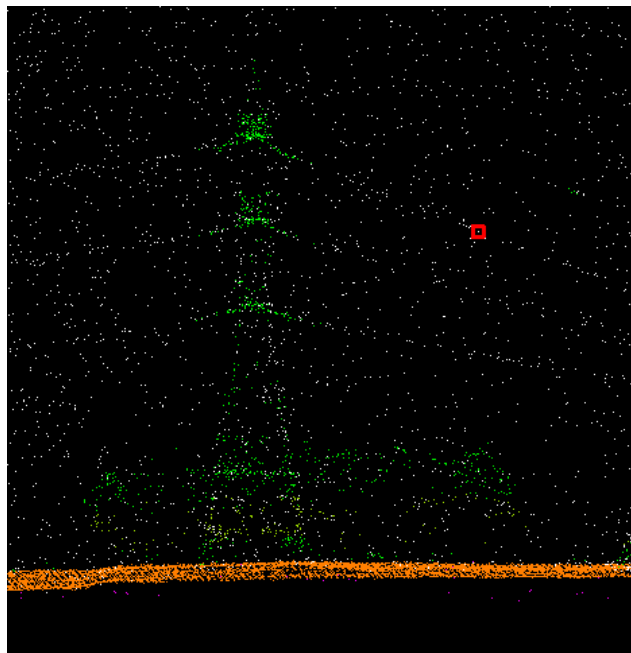
SPL Navarra Project - Noise



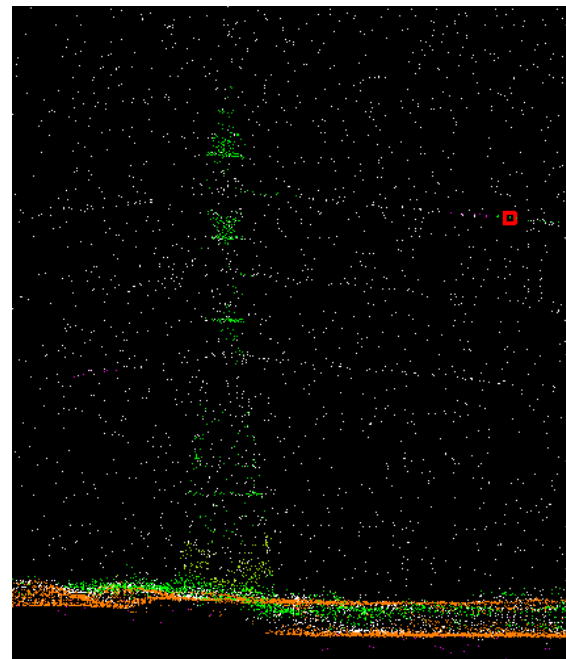
SPL Navarra Project - Noise



SPL Navarra Project - Noise



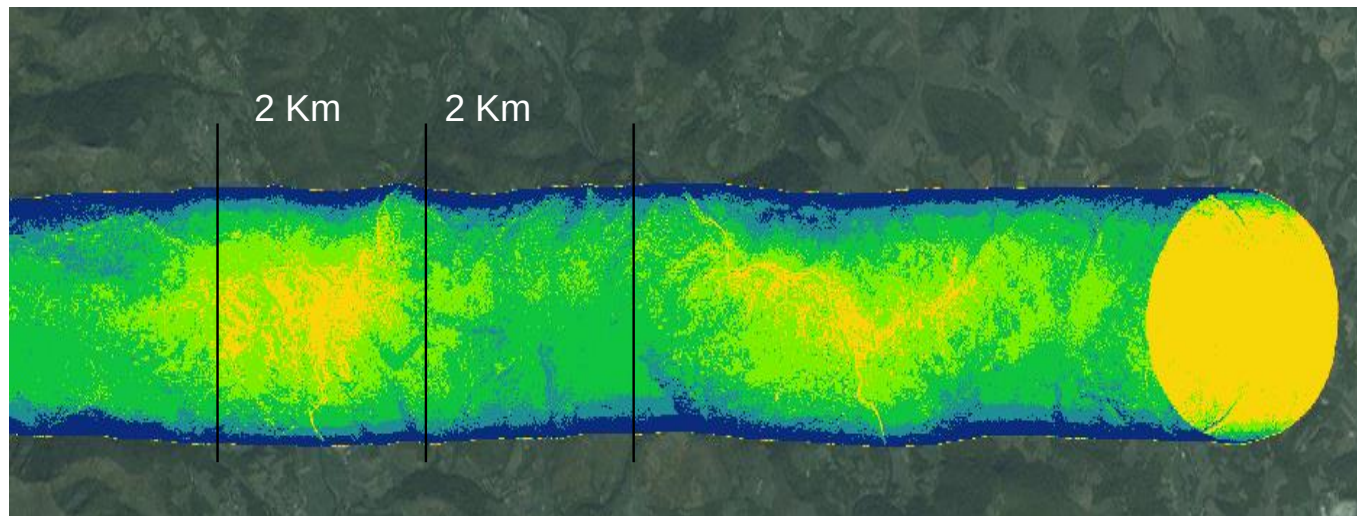
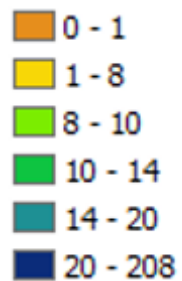
Intensity: 5 - 20



Intensity: 5500 - 6700

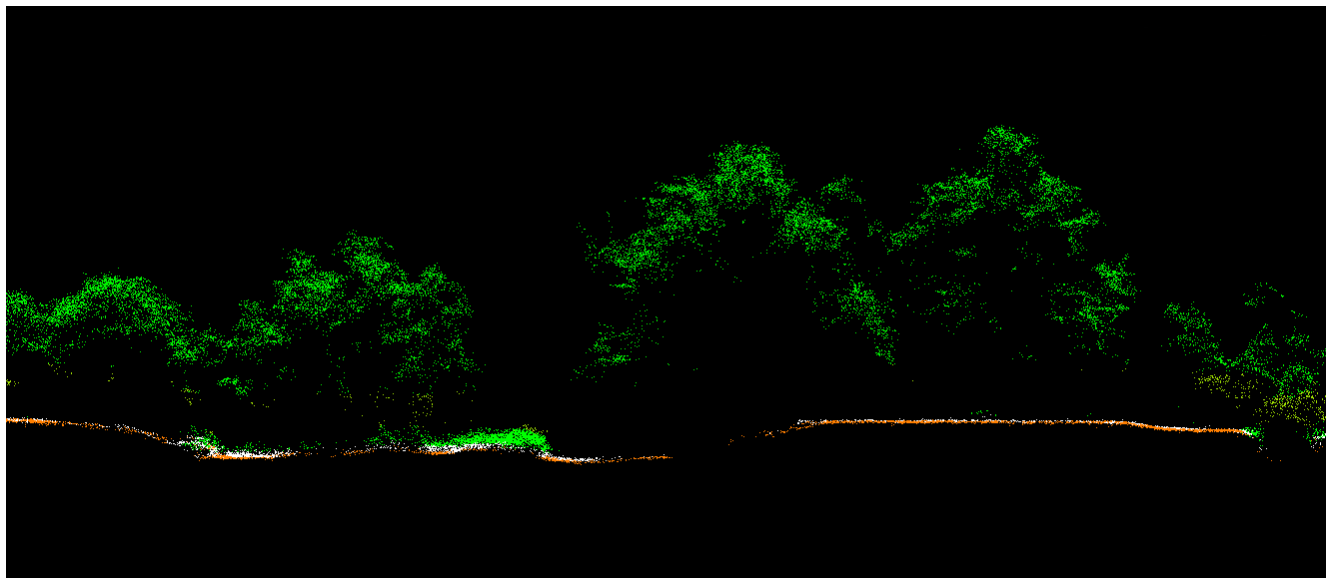
SPL Navarra Project – Point Density

Point Density



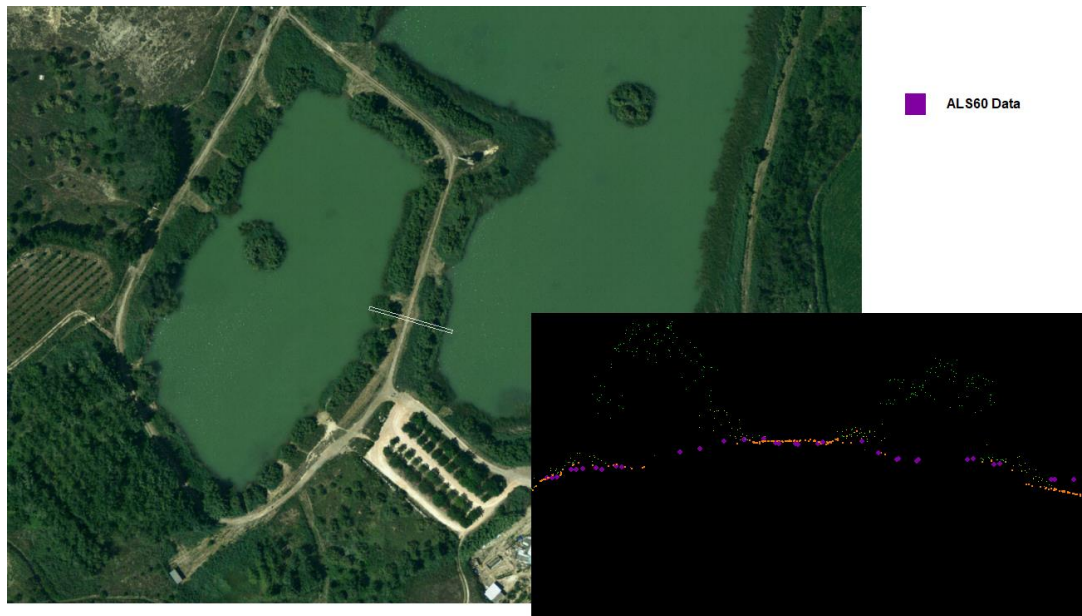
SPL Navarra Project

Vegetation penetration



SPL Navarra Project

Vegetation penetration

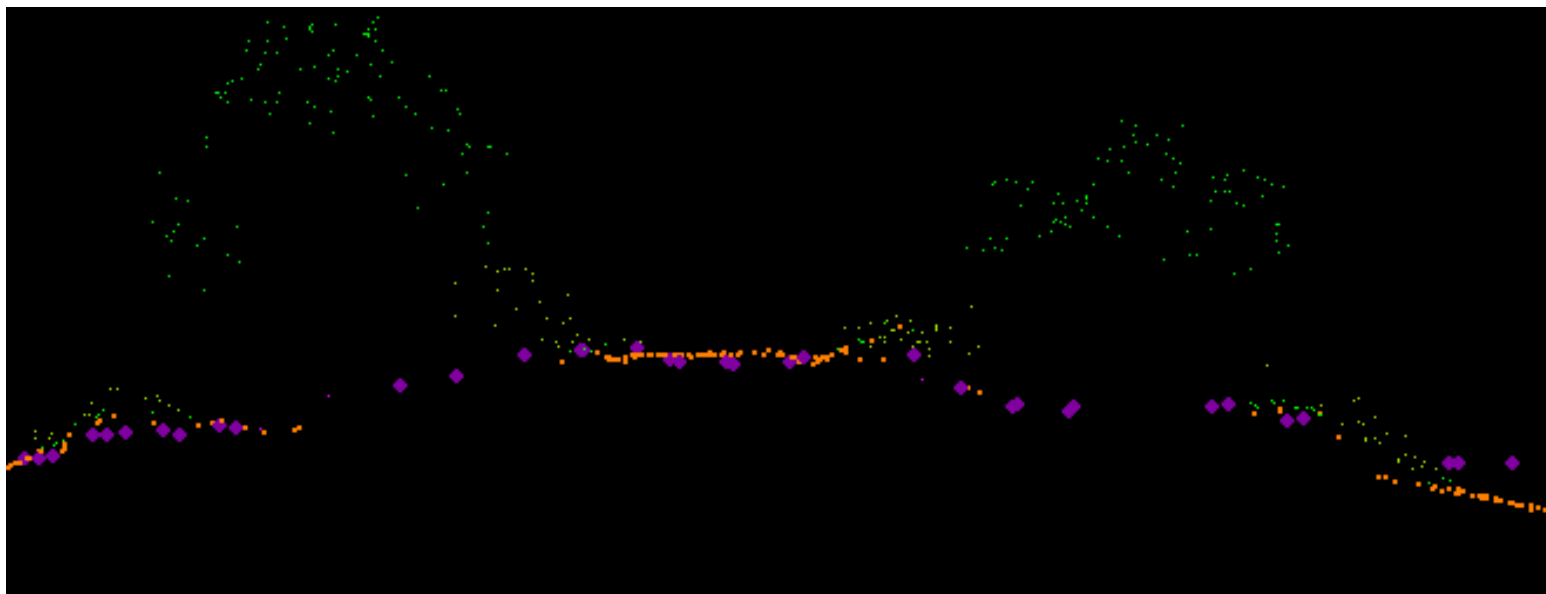


SPL Navarra Project

Vegetation penetration: SPL100 – ALS60

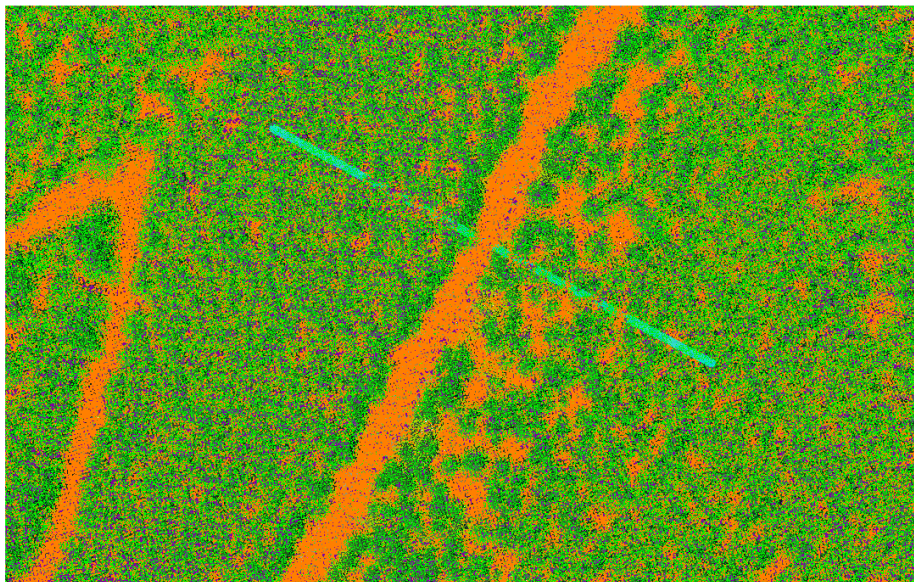


ALS60 Data

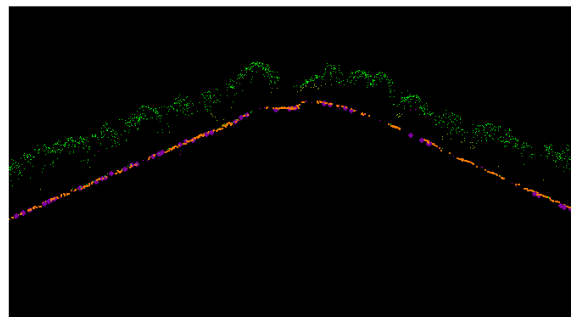


SPL Navarra Project

Vegetation penetration

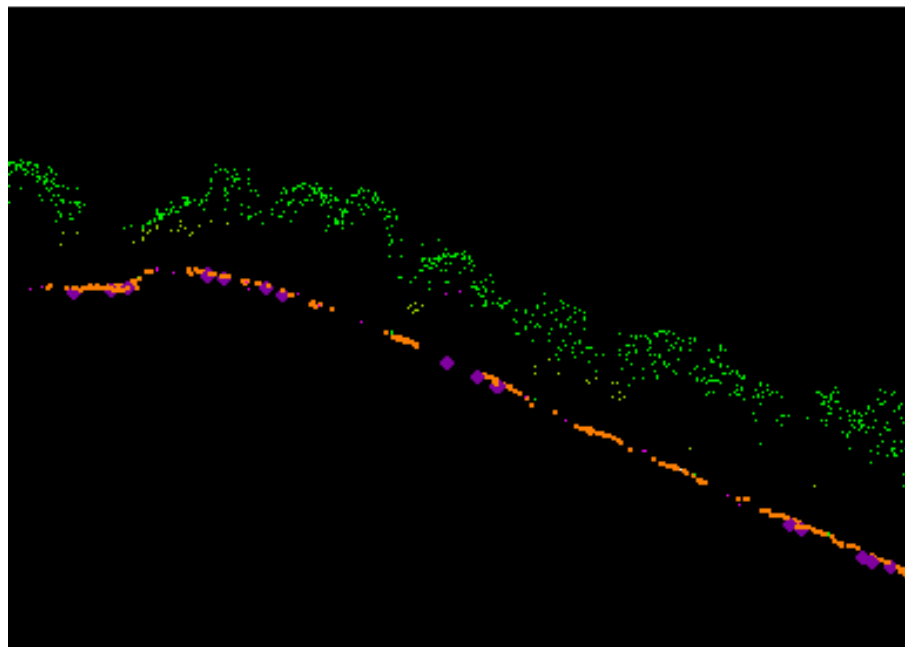


■ ALS60 Data



SPL Navarra Project

Vegetation penetration: SPL100 – ALS60



ALS60 Data

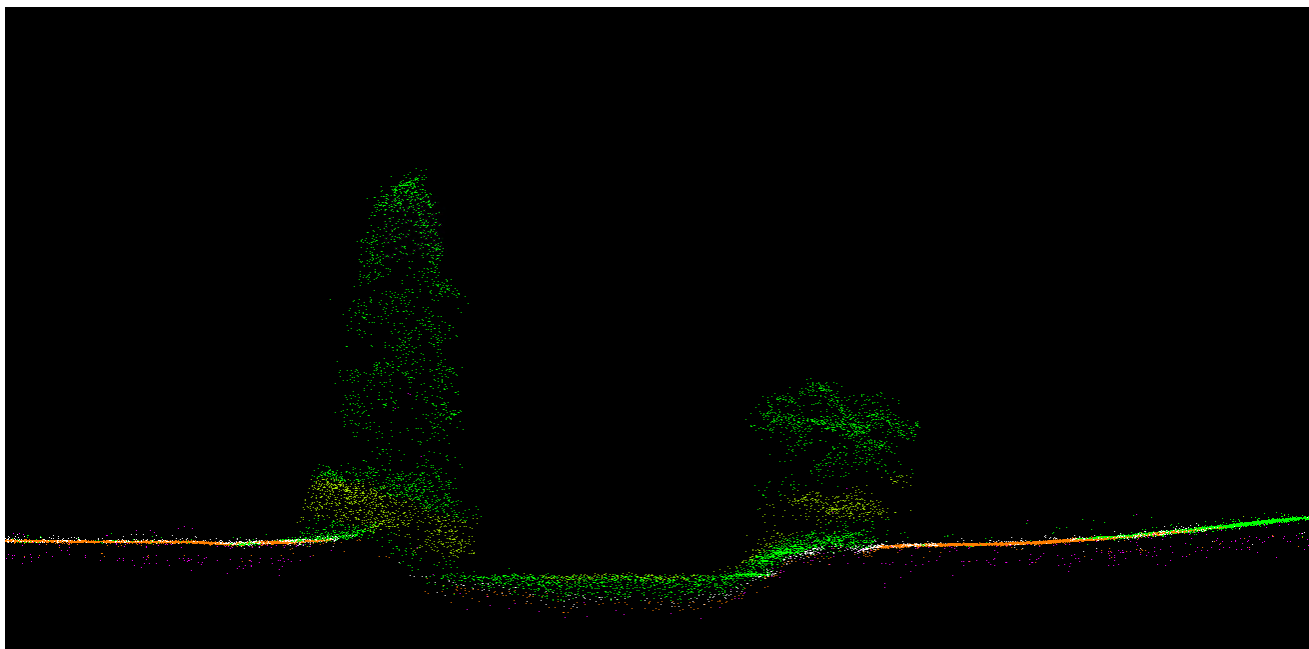
SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



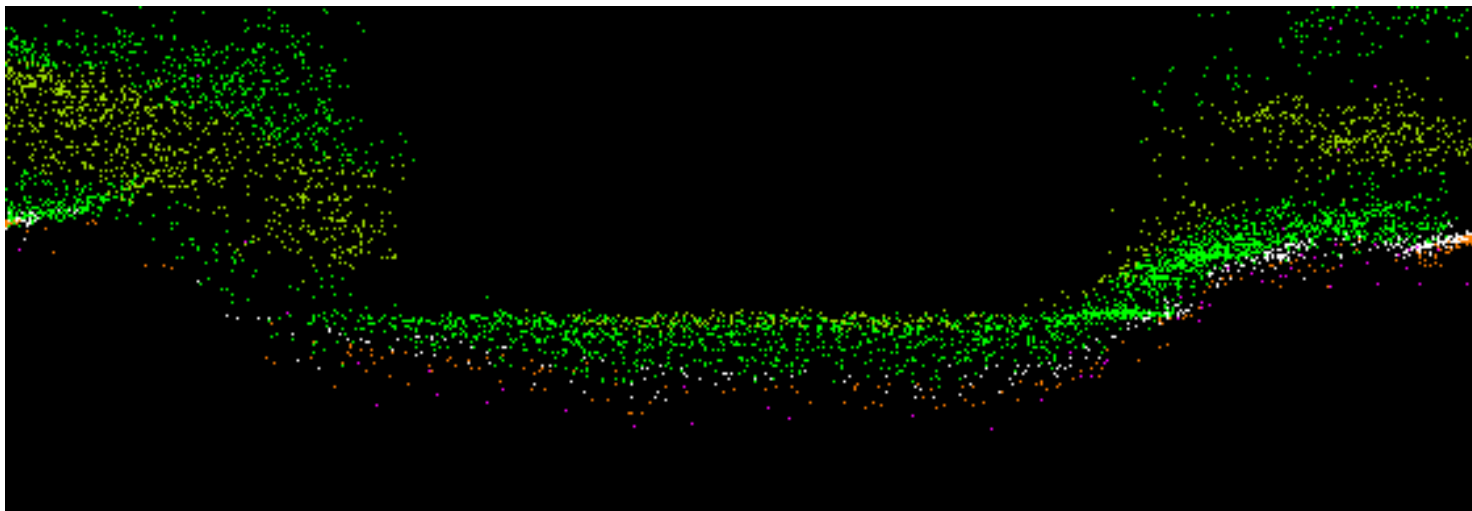
SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



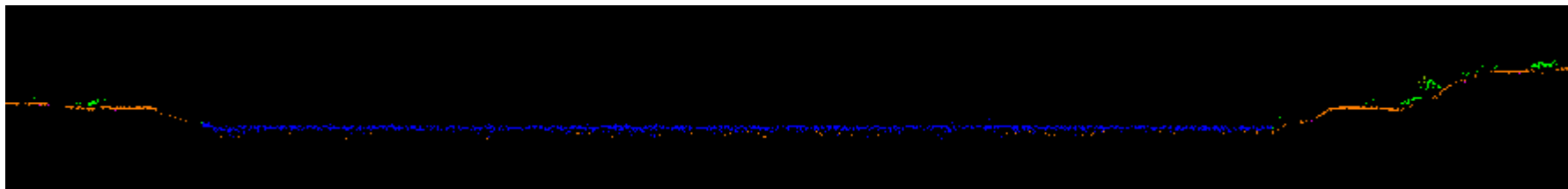
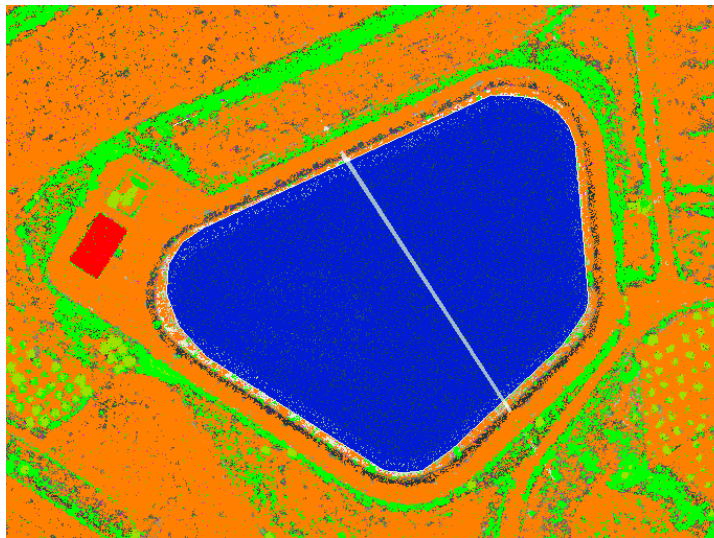
SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



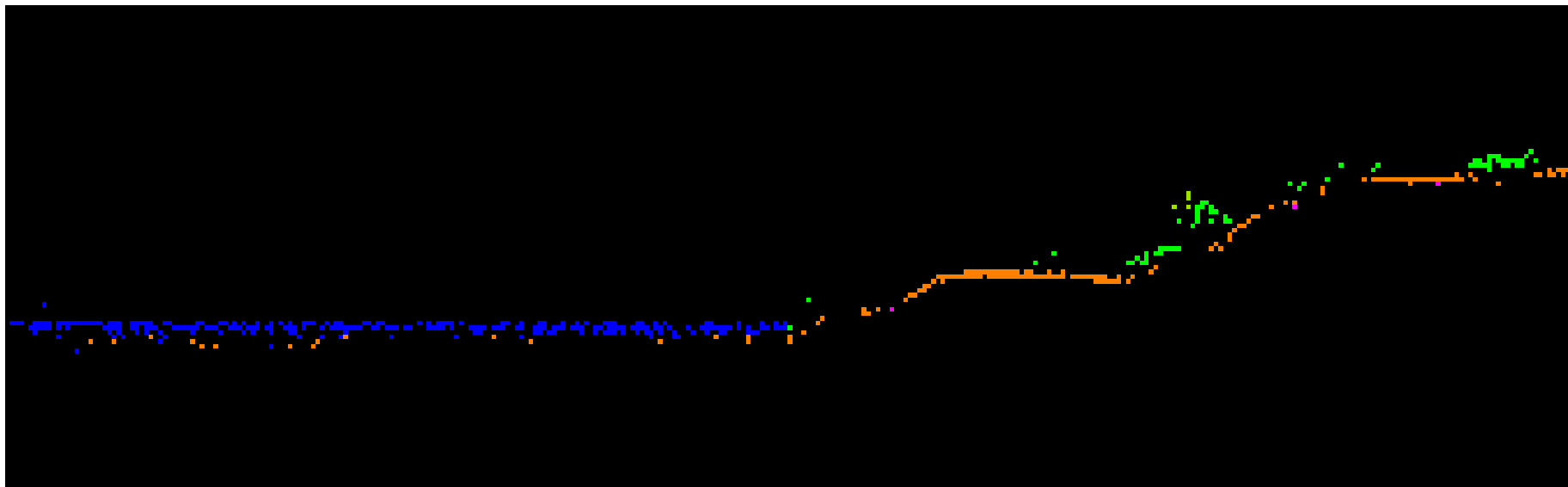
SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



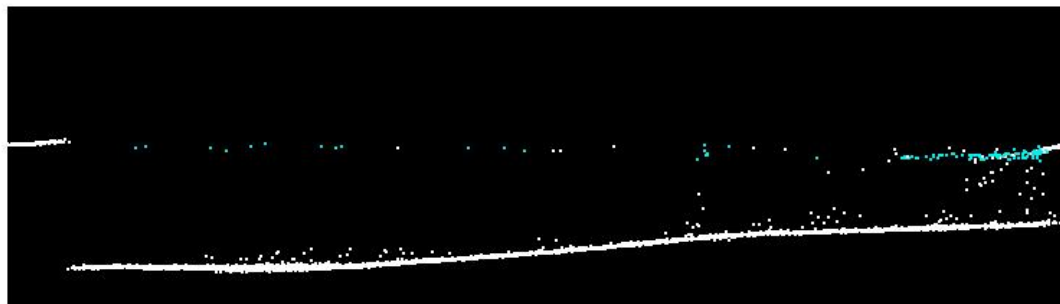
SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



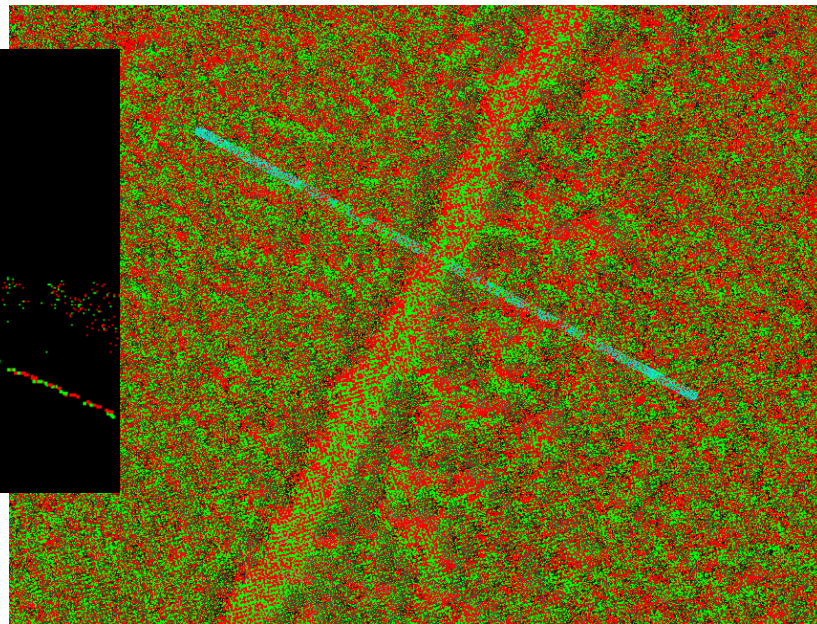
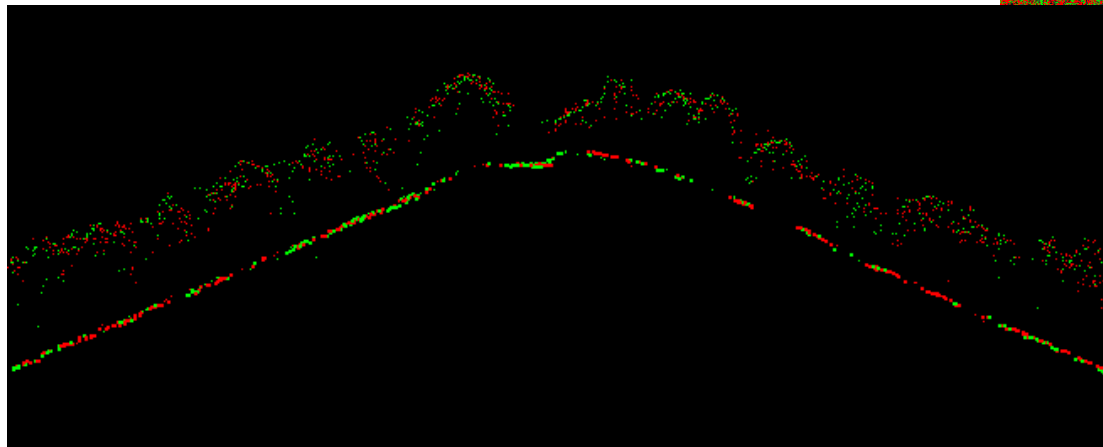
SPL Navarra Project – Water bodies

Able to capture surface and penetrate.



SPL Navarra Project

Very good result matching flight lines: 5 - 10 cm



Final error: 20 - 15 cm XY - Z

SPL Navarra Project

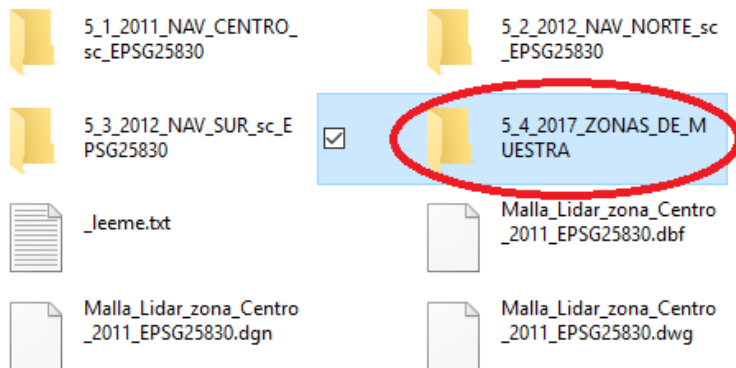
Next step: Improve Classification using the RGB – NIr info from RCD30

Applications:

- DSM – DTM – Update Relief information
- Update Cartography: Automated feature extraction
- Forestry
- Flooding – Hidrology
- Multi-temporal Analysis (2011/12 – 2017)

SPL Navarra Project – Real Data

<ftp.cartografia.navarra.es>



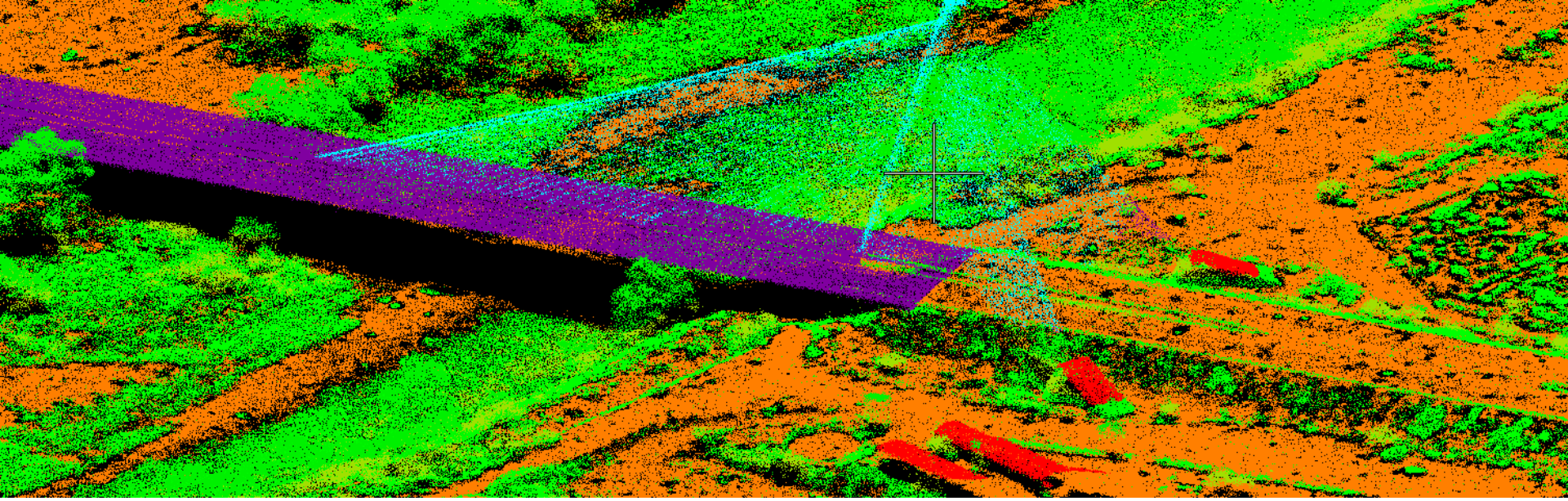
Sample Data:

ftp.cartografia.navarra.es/5_LIDAR/5_4_2017_ZONAS_DE_MUESTRA/

Software: Transform Heights, filter points by class, change LAS/LAZ version

SPL Navarra Project – Final remarks and considerations

- Water bodies: Penetration – Hydrological studies
- Vegetation: Irregular penetration – Medium vegetation
- Roughness surface
- Vast amount of information
- Irregular: Point density and data distribution
- The “noise” is almost the half of the total data.
- Challenge – Doubts
 - Initial problems with the set up of the system
 - Flightplan – Manual range gate control – Solved with new firmware/software version
- Free distribution of the whole dataset
- Now start the project



Víctor García, Tracasa

LiDAR Data capture with sensor SPL100 in the Region of Navarra

Workshop: Use of algorithms on big DEM's

Tønsberg, 4th April 2018

