El Oro

Actualización del catastro de usuarios de los sistemas de riego y drenaje en los territorios de la Provincia de El Oro: características innovadoras en la toma y gestión de datos fotogramétricos y LiDAR

Update of the cadastre of users of irrigation and drainage systems in the territories of the Province of El Oro: innovative features in the collection and management of photogrammetric and LiDAR data.

2.da Semana Geomática – Lima – 14 noviembre 2018

MEDS AMSTERDAM

Summary

A Project to optimize agricultural development, equalize the tax system and build a base for territorial planning.

The Reasons of the Project

For over 60 years, Del Oro Decentralized Provincial Government, committed to the agro-productive development of the Province, has promoted the construction, management and maintenance of a network of irrigation and drainage canals, supporting investments in the agro-productive sectors which generate employment and foreign currency, thus contributing to wealth creation in the Province.

In this context, to improve the efficiency of water resources management, the Government set itself the target of updating the users' register and the technical and economic assessment of irrigation and drainage systems in the "Pasaje - Machala", “Pasaje - El Guabo - Barbones" and "Santa Rosa" territories, in order to identify the number of actual users of irrigation systems, quality of service, use and occupation of land, types of crops and type of irrigation system installed.

It is estimated that the area cultivated by the users of irrigation and drainage systems is equal to about 20,000 ha and 1,500 plots, with a ratio of 2 users per plot, for a total of about 3,000 users.

The cartographic basis produced, has the following purposes:

- allow agricultural development through optimization of irrigation and canal management systems;
- optimize property taxes, implementing fiscal equalization mechanisms;
- consentire provide a significant basis for territorial planning (irrigation, viability, urban expansions, and prevention of hydro-geological instability …)

Areas of intervention

The work organization: integration between sensors

Only the integration of the best sensors available today in the field of Geomatics has allowed us to meet the stringent requirements of the notice and at the same time shorten run times.

The cartographic basis, completed by arranging a set of information structured into a *GIS (Geographical Information System)* system, was defined by a photogrammetric survey integrated by a LiDAR (Light Detection and Ranging) sensor, both geometrically localized through a GNSS + IMU system for geo-referencing the images taken.

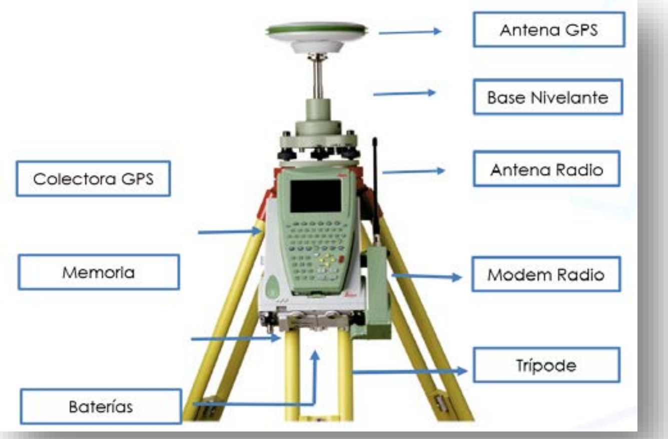
The Bell 206helicopter used in the survey and onboard instrumentation

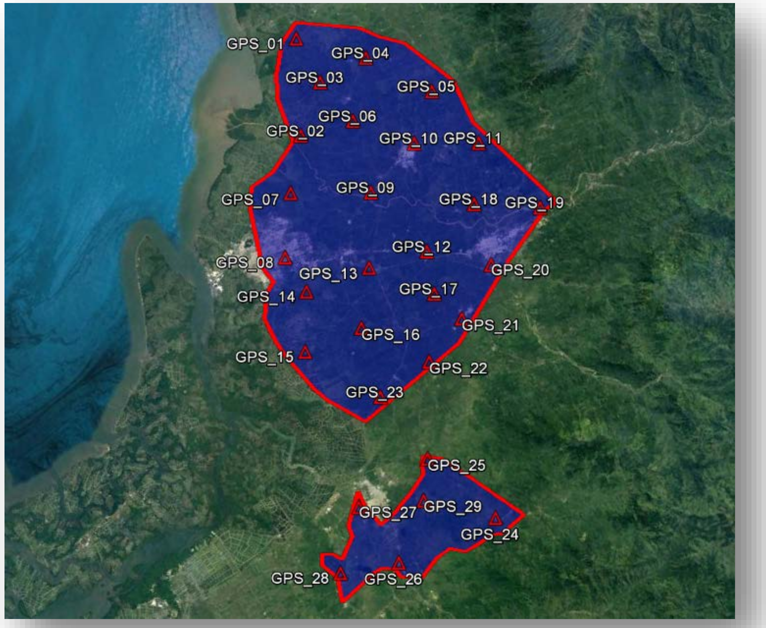
Topographic operations

The creation of a network of topographic points, useful for determining an improvement in the geo-referencing of images and point clouds and, simultaneously, to allow the verification of the overall accuracy obtained, is a prerequisite to any photogrammetric and LiDAR work.

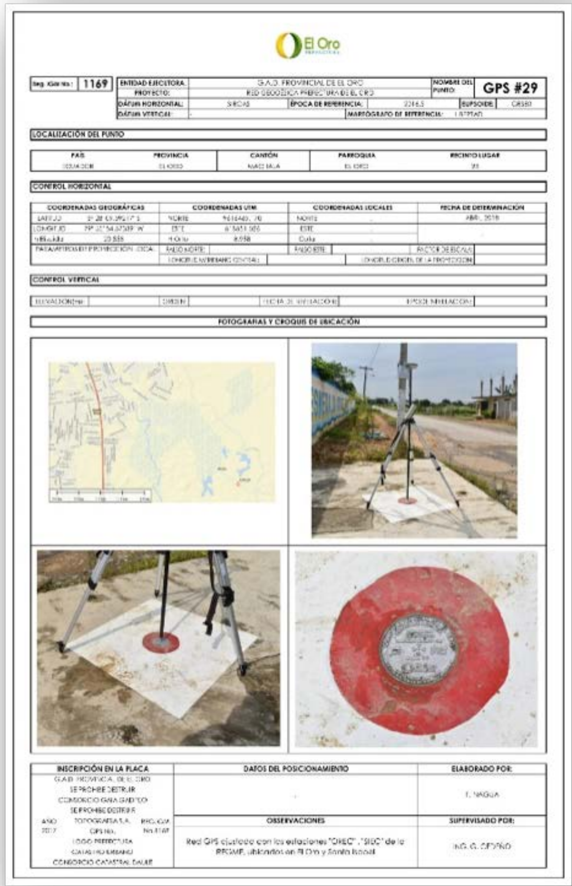
The LiDAR and photogrammetric survey was based on a network, built according to IGM specifications (*Instituto Geográfico Militar*) of Ecuador regarding the following aspects:

- location of stations;
- artefact construction mode;
- observation times in static GNSS mode;
- processing and generation of monographs.





For the survey of the vertices, 4 double-frequency Leica 1200 GPS instruments were used, with reception of the GPS and GLONASS constellations; in all, 29 vertex monumentations were performed.


El Oro
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ENTIDAD EJECUTORA:
PROYECTO:
NOMBRE DEL PUNTO:
GPS #29
DÁTUM HORIZONTAL:
ÉPOCA DE REFERENCIA:
ELIPSOIDE:
DÁTUM VERTICAL:
MAREÓGRAFO DE REFERENCIA:
LOCALIZACIÓN DEL PUNTO
PAÍS
PROVINCIA
CANTÓN
PARROQUIA
RECINTO/LUGAR
CONTROL HORIZONTAL
COORDENADAS GEOGRÁFICAS
COORDENADAS UTM
COORDENADAS LOCALES
FECHA DE DETERMINACIÓN
CONTROL VERTICAL
FOTOGRAFÍAS Y CROQUIS DE UBICACIÓN
INSCRIPCIÓN EN LA PLACA
DATOS DEL POSICIONAMIENTO
ELABORADO POR:
OBSERVACIONES
SUPERVISADO POR:

At the end of the compensation calculation, performed with the *Leica Geo Office rel 7.0* software, the calculation reports showed that the overall accuracy was below half a centimetre in plan and a maximum of one centimetre in altimetry.

During the execution of aerial shots, the acquisition of a GNSS receiver was activated on a vertex of the previous ones, identified in such a way as to occupy a barycentric position with respect to the area subject to overflight, with a sampling interval of 2 Hz, active at least one hour before and one hour after the flight period.

Shooting and photogrammetric processing

A medium-format camera property of SwissLiDAR company was used, Leica RCD30 with 53mm focal length, resolution of 8956 x 6708 pixels and pixel-size of 6 microns for the visible, resolution of 4478 x 3654 pixels and pixel-size of 12 micron for NIR, with sensor characterized by the following spectral bands:

Spectral band	**λ nm**
Blue	435 - 495
Green	530 - 580
Red	610 - 660
Near-infrared	840 - 900

The camera integrates a dual frequency L1 / L2 NovAtel SPAN GNSS receiver active in the GPS and GLONASS constellations, and an IMU sensor rigidly integral to the machine body.

Survey has been designed to respect the dimensions foreseen for the GSD (*Ground Sample Distance*) on the ground, carrying out the flight operations in the hours straddling the noon, in order to limit the shadows.

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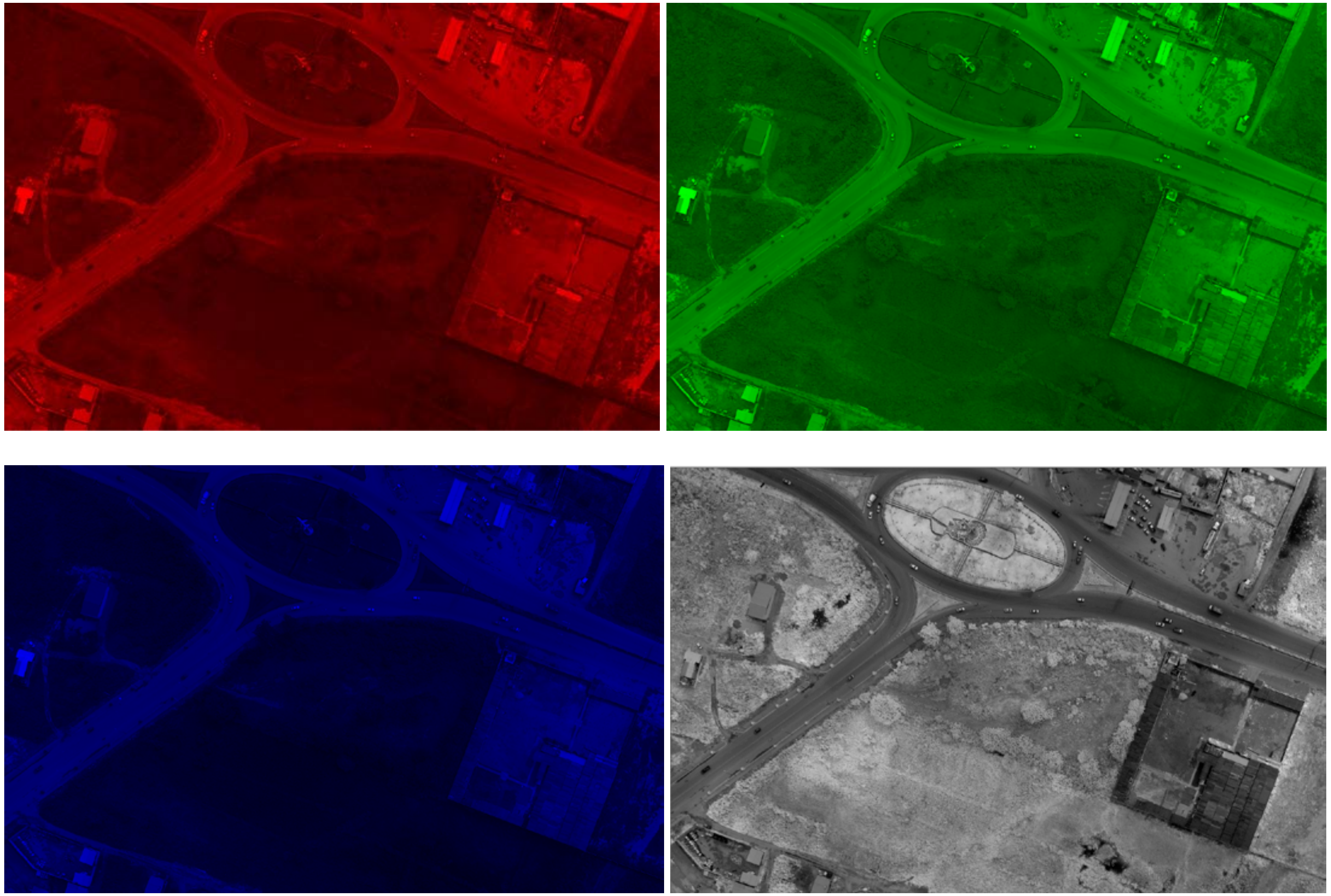


Scheme with the acquisitions of the 4 RGB+NIR bands

Photogrammetric operations involve the connection between all frames taken (matching), so as to optimize the shooting position of every frame in relation to the position of other frames and to the known positions of the points on ground (*Air Triangulation*).

This operation, which is fundamental for the subsequent phases, allows the assessment of the overall accuracy of the work. The synthetic parameters obtained are shown below:

```
number of observations     1518954
  number of unknowns          557181
  redundancy                  961773

  RMS automatic points in photo (number: 759341)
          x           2.4 micron
          y           3.3 micron

  RMS   control and manual points in photo (number: 103)
          x           1.9 micron
          y           3.1 micron

  RMS control points with default standard deviation set (number: 22)
          x         0.017 [meter]
          y         0.019 [meter]

  RMS control points  with default standard deviation set (number: 22)
          z         0.006 [meter]

Sigma naught :     4.2 [micron] =    0.7 [pixel]
```

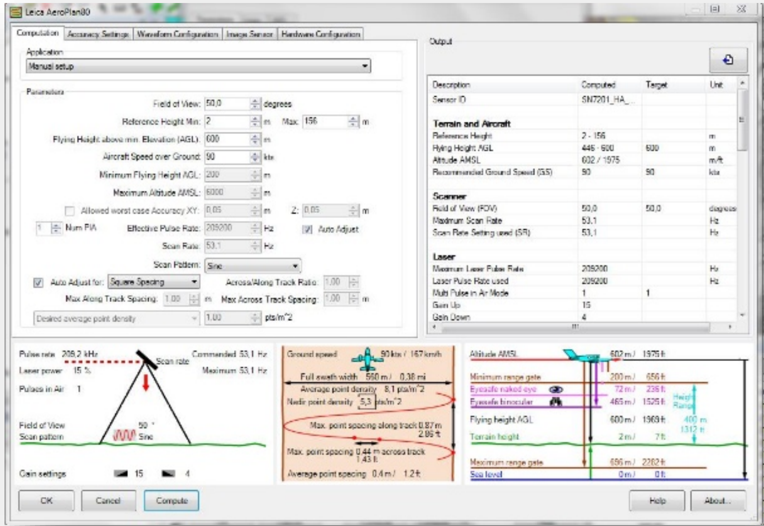
Shooting and LiDAR processing

A Leica ALS70 LiDAR sensor, property of Swiss LiDAR Company was used, characterized by the following parameters:

frequency 250,000 points/sec

height accuracy lower than 10 cm (1σ)

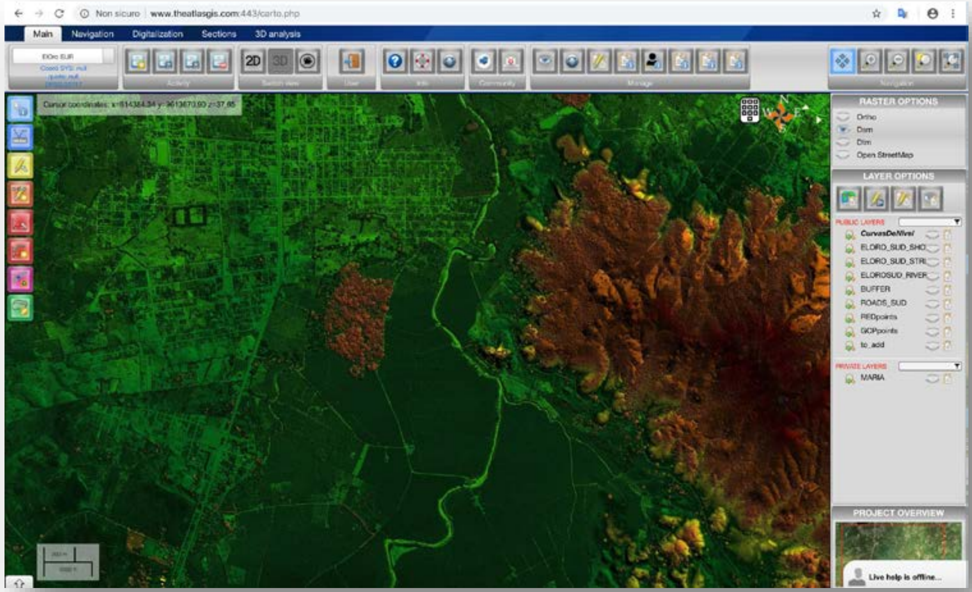
The planning of shooting allowed to obtain the stability density of 6 points / sqm.



Every strip was mosaicked, to verify correct alignment between them and the points on ground, and obtain a dense cloud of points of high quality and resolution, compatible with specifications and with the requisites normally reported in international literature.

The processing of LiDAR strips georeferencing was carried out by the Prometheus software, property of MEDS Amsterdam, which operates through the search of the homologous points on the overlap of strips and around them, to assess the best translation aimed at reducing geometry inconsistencies:

- average planimetric morphing en bloc (5 iterations)
- punctual morphing at height (1 iteration)



The LiDAR cloud of points was then classified, using automated techniques that exploit complex algorithms developed for this case, to identify what belongs to the "ground" and what is instead, relative to the above ground (vegetation, buildings ...).

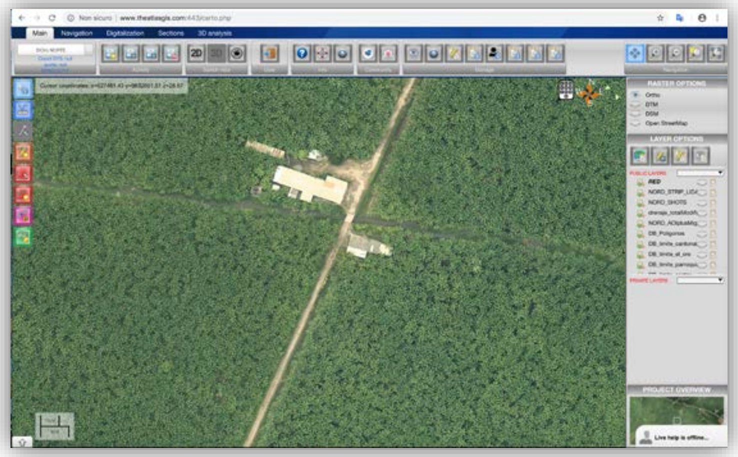
The extraction of the LiDAR points cloud, in the "ground only" version required particular attention, given the challenge of classifying areas destined to very intense crops, due to the required aims, i.e. to extract canals with almost fully automated techniques and, as much as possible, their geometric characteristics.

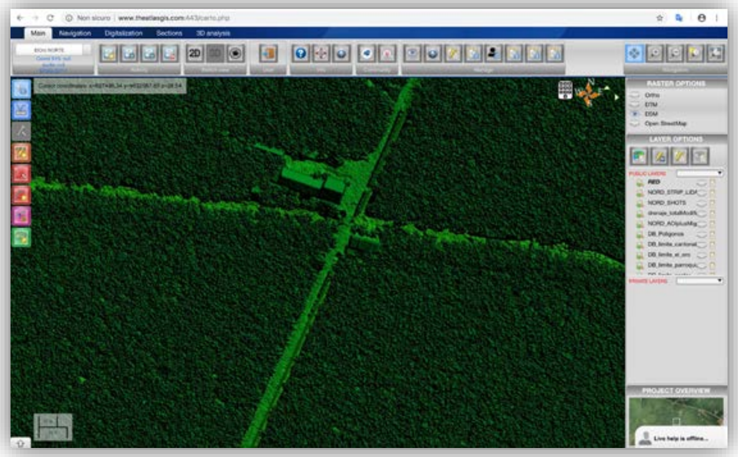
To generate this classification, a special algorithm has been implemented on the Prometheus software of MEDS Amsterdam, where in summary, the following steps take place:

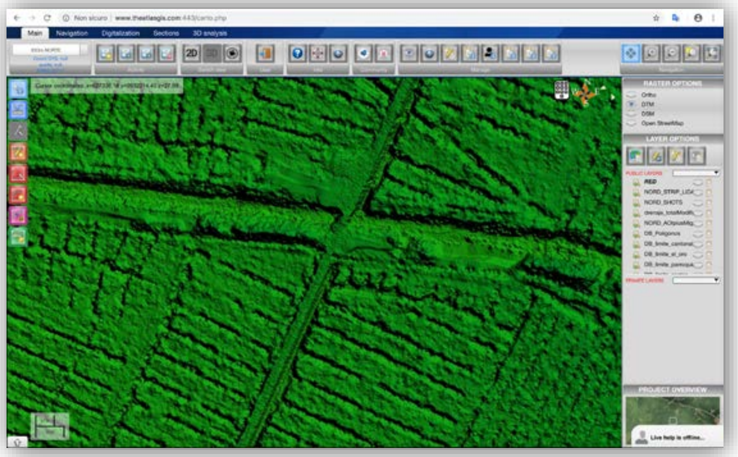
a. the whole cloud of points is automatically subdivided based on the chorographic characteristics, such as urban areas, agricultural entropized areas, tree plantations, etc.;
b. search for isolated points;
c. by means of iterative algorithms, search for objects with special geometries, like buildings;
d. generation of a mesh of points that undoubtedly belong to the ground and, through successive iterations, mesh reinforcement with all the "ground" points;
e. search for canals and extraction.

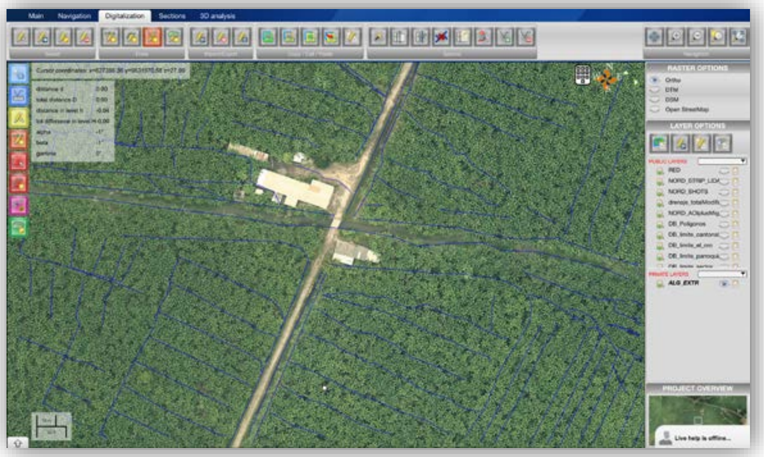
The following figures show this sequence:

1. visibility of the main irrigation canals on the orthophotos;
2. DSM, on which only the main canals are visible;
3. canals visible on DTM downstream filtration and therefore elimination of vegetation and built-up;
4. vector extraction of irrigation canals based on the altitudinal discontinuities detected on DTM.









Due to the section obtained by activating the "Profile" mode on AtlasGIS and relative arrangement of canals, a semi-automated classification of the same has been performed, distinguishing them in 3 hierarchical orders.

The final deliverables: DSM, DTM and Orthophotos

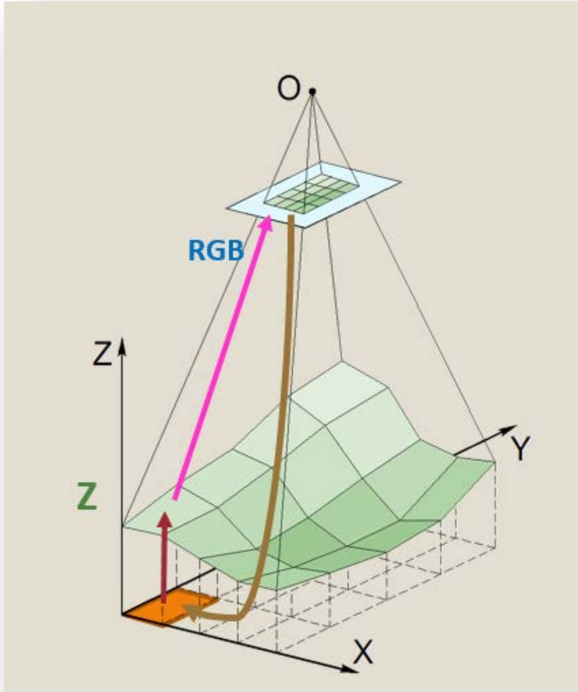
Starting from the processing of survey phases, the following deliverables have been produced:

cloud of LiDAR points, both in overall and in "ground only" version;

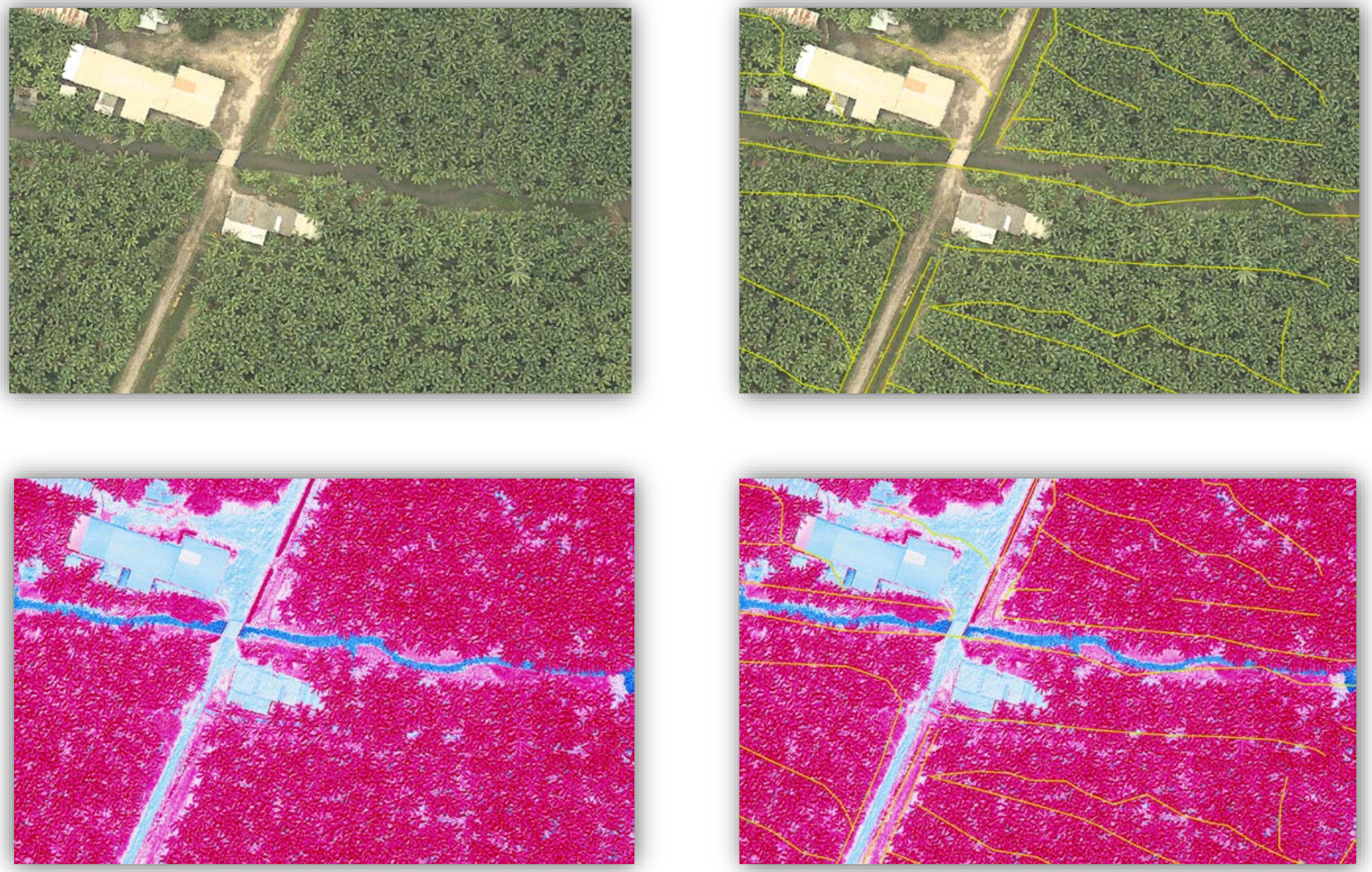
digital terrain model with a resolution of 20 cm, represented both in DSM (*Digital Surface Model*, relative to the terrain + any construction on it), and in DTM (*Digital Terrain Model*, i.e. terrain only);

level curves, with equidistance of 10 m;

RGB ortho-image with 10 cm resolution and CIR (*Colour Infra-Red*) ortho-image and NDVI (*Normalized Difference Vegetation Index*) with a resolution of 20 cm.



The following images highlight the contribution of the NIR band to the understanding of the territory.



Publication on AtlasGIS

ATLAS ATLAS is a server solution that allows users to access information through their web browser. No specific plug-ins are necessary to access the basic functions of the project, and the operating system is not a hindrance.

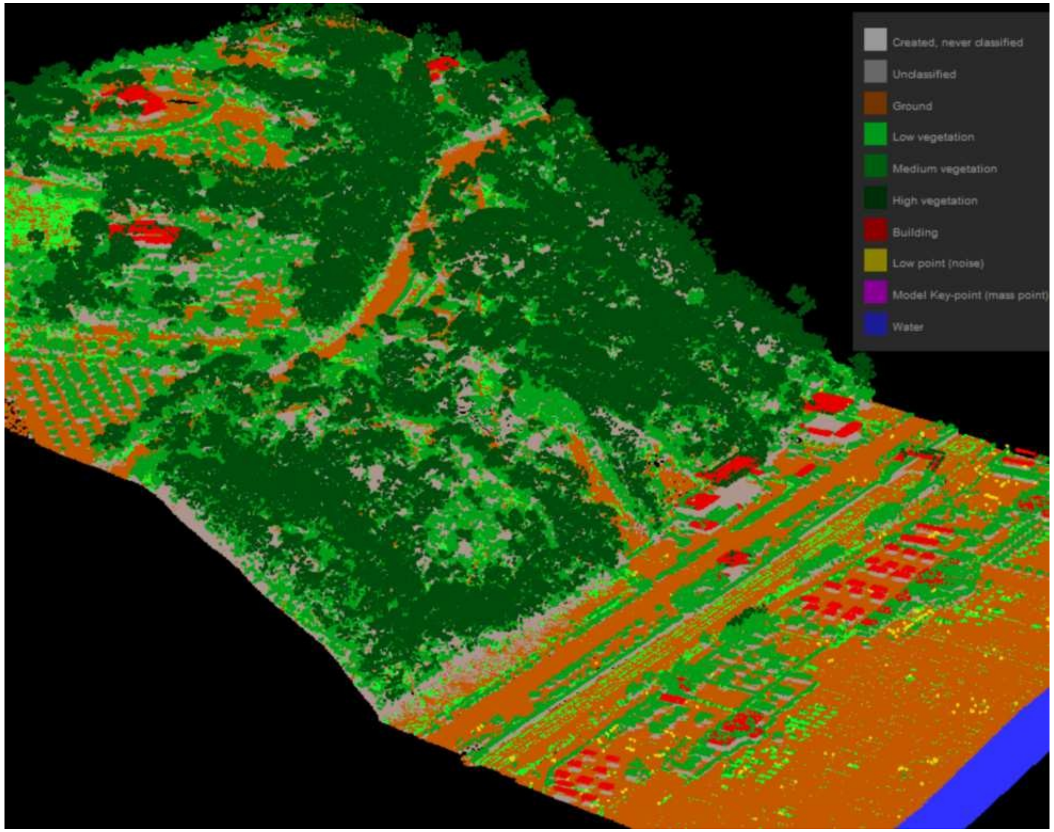
On the client side, any operating system can be used. The protocols are better in open standard languages, so that practically all the support devices of a browser (and 3GL for 3D visualization) have access to the project information.

The key of the infrastructure is the intelligence hosted on the DB space server and on the data server: the updating of components (organized by the software house) and the new functions are immediately available to all users. Therefore, clients do not have to "update" the software, as the interface is network-based, so that each new functionality is readily activated in real time.

The ATLAS architecture is more than a client-server infrastructure: its structure facilitates the distribution of data sets on different servers, to balance the load of requests and find the fastest repository to obtain data.

All data in this project have been uploaded to Atlas, with the following advantages:

- easily managed large volumes of data;
- simple interface designed on the needs of users;
- consult and view data through custom sections in areas of interest, see the 3D point cloud, calculate land movements, perform hydrogeological analyses, advanced 3D measurements, etc.;
- creation and import of levels and attributes;
- full accessibility from any standard browser;
- export of 3D point cloud, models and vector files.



Example of 3D visualization of LiDAR data

Results obtained

The project involved a total area of approximately 54,900 ha, covered by about 15,000 ha of known irrigated land, served by about 200 km of canals.

Through the analysis of the land morphology, obtained thanks to the extreme accuracy of the LiDAR survey, it was possible to identify, with almost completely automated techniques and with a very low error rate, an additional 400 km of canals.

The irrigated and therefore taxable surface has increased to over 37,000 ha, with a significant advantage in terms of eligible land.

The comparison with the actual situation of irrigated land was possible through the use of NDVI images, through which the actual use of irrigation water could be assessed by analysing the vegetation status and water stress of planted areas.

We can roughly estimate that the entire survey operation was fully paid up in the first year of new taxation, leaving to the following years an economic return or equalization from the point of view of taxation.

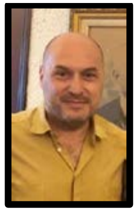
Future developments

The database created is undoubtedly an effective tool for territorial management both from a technical and an administrative point of view. It allows the activation of efficient procedures for the planning of territorial interventions and implementation of methods for managing territorial-based economic units, to allow equalization mechanisms from a fiscal and land-based point of view.

Specifically, in addition to the very objectives for which the project was financed, the following developments can be highlighted:

- use of geometric data bases (digital models and ortho-imaging) to improve knowledge from the hydrogeological point of view and allow mitigation of significant issues affecting the area, through modelling using predictive rainfall models based on the prepared geometric models integrated with geological and agronomic properties of the land;
- knowledge of the infrared band has allowed to identify and highlight the vegetated areas, information that can now become a basis for subsequent multi-temporal analysis, with the subsequent shots.

Contact information



Giovanni RIGHETTI
LiDAR Especialist
g.righetti@medsamsterdam.eu
www.medsamsterdam.eu

Gabriele GARNERO
Professor in Geomatic
gabriele.garnero@unito.it
http://www.dist.polito.it/

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