AMPERE (Asset Mapping Platform for Emerging CountRies Electrification)

a GNSS-based integrated platform for energy decision makers

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Despite global electrification rates are significantly progressing, the access to electricity in emerging countries is still far from being achieved. Indeed, the challenge facing such communities goes beyond the lack of infrastructure assets; what is needed is a holistic assessment of the energy demand and its expected growth over time, based on an accurate assessment of deployed resources and their maintenance status.

As an example, one big problem plaguing Dominican Republic is the precarious, often chaotic status of large part of the electricity distribution network (figure 1), which, besides making the service unreliable and sometimes dangerous, takes away from the simple beauty of the area.
The old lines are now being replaced with several dedicated interventions to make areas more appealing. Moreover, the electricity distribution companies experience serious problems with electricity leakages and were losing vast amounts of resources from illegal connections to the grid. Based on the above scenario, the AMPERE solution aims to support the decision-making process – including activities planning, data acquisition and final reporting - for investments and network maintenance, based on infrastructural and geomorphological assets mapping intended as a service provided by AMPERE consortium (figure 2).

The concept

The original need for AMPERE platform comes from issues related to operations performed by on-field surveyors to collect information about mapping and status of electrical assets. In this operational scenario, the surveyors have to operate in a time-efficient and safe way, using hand-held cameras and geomatic tools to collect data, which are then processed offline.
AMPERE provides an important contribution, being the survey also supported by Remotely Piloted Aircraft's (RPA's) performing operations in a semi-automated way, i.e., exploiting on-board sensors (optical/ thermal

cameras, LIDAR and GNSS receivers) to keep their trajectory as close as possible to the targets to be surveyed. electric assets, thus achieving high-resolution details while maintaining a safe distance to avoid collisions.
It is worth noting that the use of GNSS (GPS and Galileo) receivers allows not only a precise navigation of the drones, but also a highly accurate geo-referencing of the collected data. These features will be in the future further enhanced taking advantage of the soon operational Galileo High Accuracy Service (HAS).
AMPERE proposes a solution (figure 3) based on a GIS cloud mapping technology, collecting on field data acquired with optical/thermal cameras and LIDAR installed on board an RPA as well as other data captured with conventional sensors on ground. In particular, an RPA will be able to fly over selected areas performing semi-automated operations to collect optical and thermal images as well as 3D LiDAR-based reconstruction products. Such products are post processed at the central cloud GIS platform, allowing operators to perform planning and monitoring activities by means of different screen views. Analytic tools can resolve data accessibility issues and improve the decision-making process.

AMPERE system elements

RPA platforms

Two RPA typologies have been considered in AMPERE: Fixed Wing RPA's and Multirotor RPA's.
A Fixed Wing RPA, flying high and fast, is very suitable for a rapid inspection over a long power line, but it cannot observe small details (e.g., signs of deterioration)in electric towers, distribution boxes, wires and insulators. However, it can provide the general topology of the network by flying even 80 Km per flight (Beyond Visual Line of Sight, BVLOS), embarking an RGB camera and/or a thermal (IR) imager as payload.
The AMPERE fixed-wing RPA is based on the Believer 1960 mm Wingspan platform. This flight platform features a high portability, stability and durability, making it ideal for industry class aerial survey. The Fixed Wing RPA has been designed with active tracking antenna system (ATAS) needed for long range flight operations.
Figures 4 and 5 show, respectively, the fixed-wing drone and its portable control and communications system.
A multi-rotor aircraft is the most suitable choice to provide very detailed thermal and optical images by hovering in the air at close distance from the various components of the power line; moreover, it is suggested for rural as well as for sub-urban and urban

Figure 1: aerial power lines in Dominican Republic

environments. The only disadvantage of this type of drone comes from the relatively limited autonomy: about half an hour, working on batteries.
The main platform used for powerline inspections in AMPERE is the DJI MATRICE 300 RTK. It is a powerful industrial drone platform with an advanced

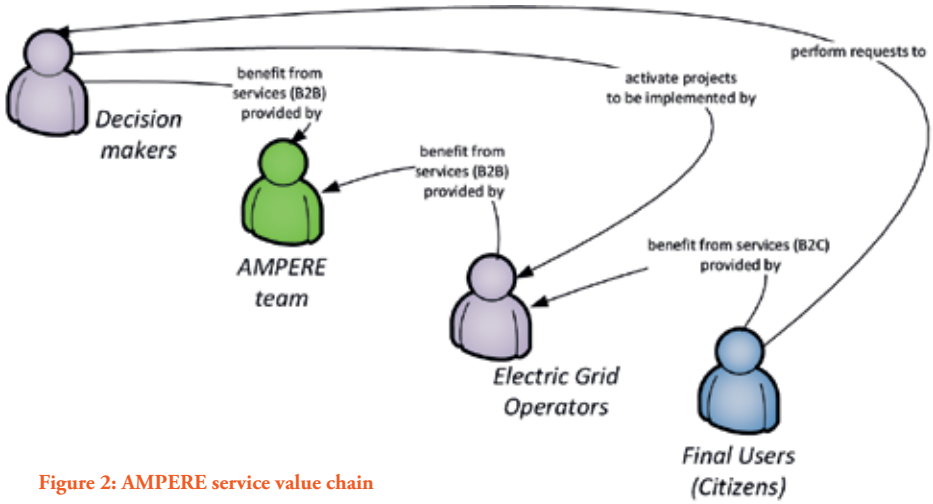


Figure 2: AMPERE service value chain

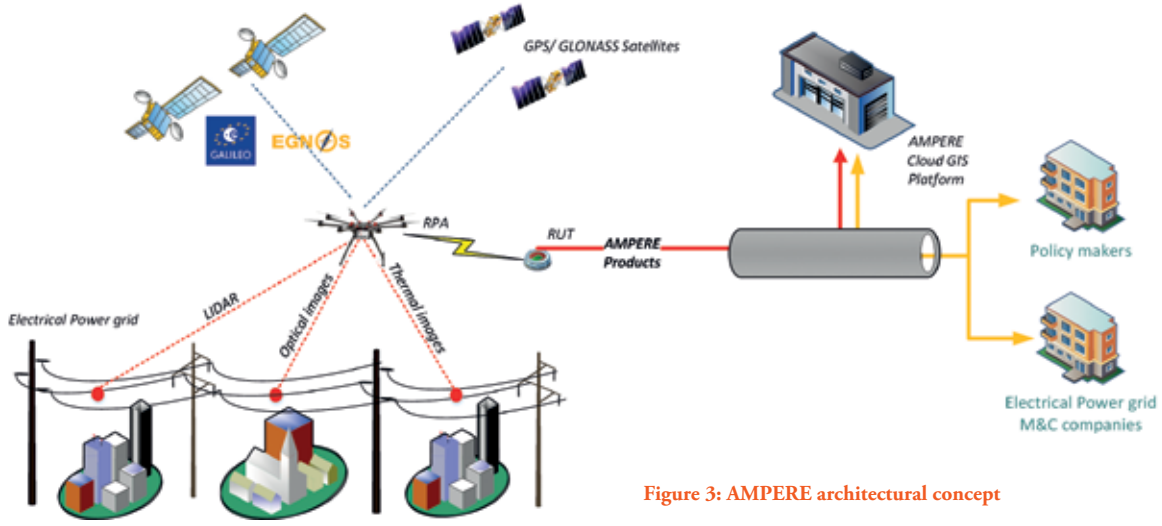


Figure 3: AMPERE architectural concept

flight controller system, 6 Directional Sensing, Positioning system and FPV camera. This system can implement semiautonomous operations, thanks to the high-end onboard sensors and sophisticated data fusion algorithms. Moreover, this platform has different mechanisms (SDK) to integrate specific third-party equipment. Specifically, in the AMPERE application the drone is equipped with a payload, including a LIDAR instrument, which implements a complete 3D Laser scanning, providing a high-resolution map of the power line, with a centimetric level resolution; a Synchronized Stereo Optical Camera and a Triple Frequency Multi-Constellation E-GNSS Receiver, used for georeferencing the acquired data and for they synchronization. Figures 6 and 7 show the main multi-rotor RPA and its multi-instrument payload. Finally, in addition to the fixed-wing and the main multi-rotor RPA's, a small multi-rotor drone with a Maximum Take-Off Mass (MTOM) of less than 250 g, including payload, will be used. The main advantage of this category is the possibility to fly over people not informed of drone operations, making it suitable to be employed even in crowded cities.

Figure 4: Fixed wing drone developed in AMPERE project

AMPERE Cloud GIS Platform (ACGP)

Electric utility companies need accurate information on their asset inventory, basically based on two types of geographical information: (i) asset mapping of the distribution network, containing crucial technical information and locations of infrastructural assets as poles, power lines, lights, circuits, equipment, facilities etc.; and (ii) information about the customers, including their locations and consumption details to determine the areas for potential new customers and network expansion.. Indeed, the biggest problem electric utilities are facing is storing the historical data and updating it due to the real-time changes on the field.

Accordingly, AMPERE Cloud GIS solution provides utilities with an overview of the entire process visualized on a map from campaign planning, execution, acquisition and processing to generate a final automated report (figures 8 and 9).
AMPERE Cloud GIS platform is a multi-sensor mapping system, featuring both 3D reconstruction capabilities (based on LiDAR) and vision-based products (based on RGB/thermal cameras), that are already geo-referenced for their straight-forward use by end-user platforms in AMPERE. Moreover, AMPERE foresees co-registration and combination of RGB images and LiDAR point clouds. The key concept is that the LiDAR point cloud can provide 3D information to image data, while in an inverse fashion, LiDAR points can be associated to image windows where these points are observed, thus supporting visual inspection.
The greatest benefit is the real-time collaboration between top management and field operators where maps and layers can be shared with different levels of access. Moreover, AMPERE Cloud GIS solution can be used with no need for extensive education of operators: the solution is implemented in a process workflow immediately and it is suitable for non-GIS users as well as for professionals. The option to collect line features in the field with high GNSS accuracy and to store them in the database can increase time and cost efficiency of the entire organization as it offers a more convenient way to collect data.

As such, in the context of AMPERE, Galileo – the European GNSS system - is a key enabler, especially when leveraging its unique features: a free-of-charge High Accuracy Service (HAS) and highly precise E5 AltBOC code measurements. These features are of great benefit for the industry of mapping in general -and electric utilities in particular-, as they simplify the mapping methodology (less supporting infrastructure needed) and therefore increase time and cost efficiency, offering a more convenient way to manage energy distribution. The core component in this task is GeoNumerics' NEXA, a robust non-linear least-squares generic sequential estimation engine to compute trajectories of any type. NEXA has been designed to be extensible and adaptative, provided with the appropriate plug-and-play toolboxes (GNSS, or GNSS/INS, or GNSS/INS plus other sensors).

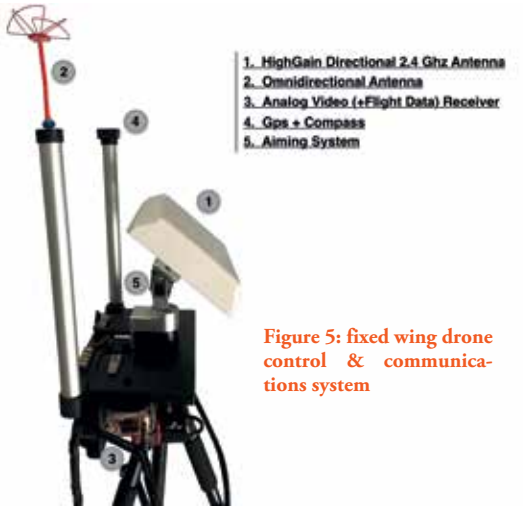


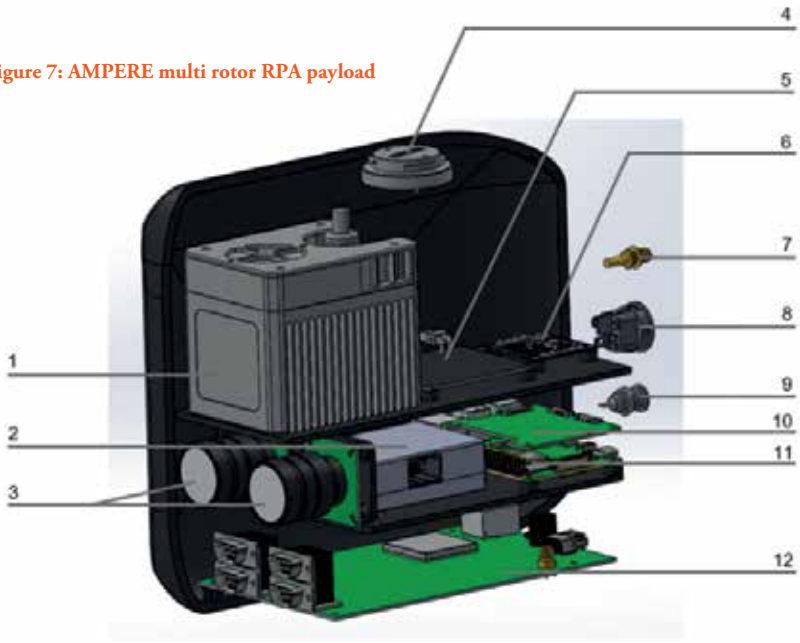
Figure 5: fixed wing drone control & communications system

Future works and conclusions

The AMPERE system is being tested in Europe. After on factory tests performed at partners' premises in Italy and Spain, a dedicated campaign covering technical (accuracy of sensors installed on the drone) and operational (user experience) aspects is planned in September 2021 for the complete system acceptance.

Figure 6: AMPERE multi-rotor RPA

Figure 7: AMPERE multi rotor RPA payload



1. Lidar Livox Mid-40
2. Livox Converter
3. Synchronized Stereo Camera
4. Skyport V2
5. Payload SDK board
6. Power distribution board
7. SMA connector
8. Power Button
9. Status LED
10. Arducam HAT
11. Raspberry Pi 4 Model b
12. Septentrio Mosaic Development board

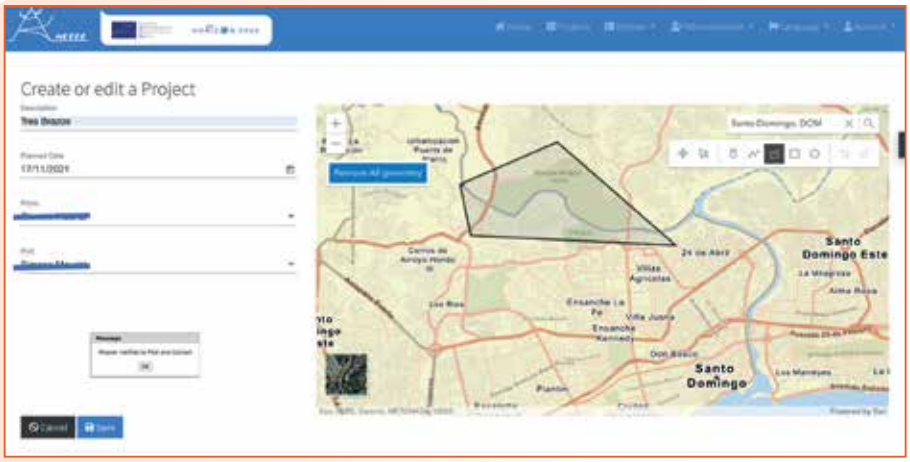


Figure 8: ACGP. Project creation for campaign planning

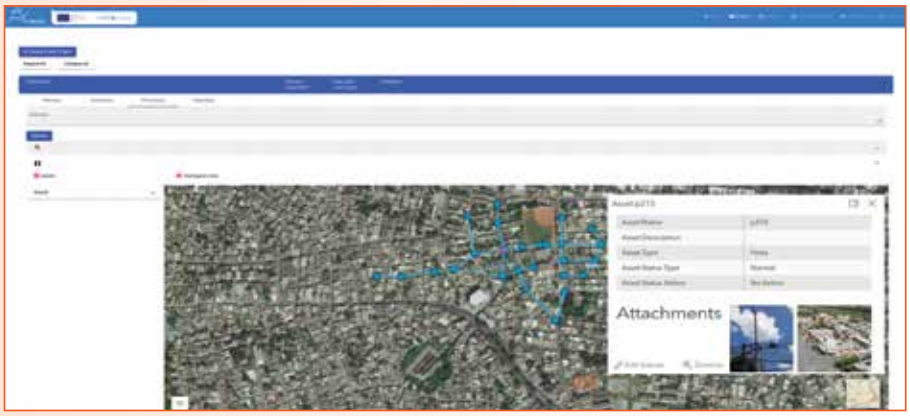


Figure 9: ACGP. Network assets topology acquisition with attached products

Furtherly, a validation campaign with Stakeholder's involvement will be conducted in Santo Domingo, in November 2021. The sessions will measure the benefit of the AMPERE solution in terms of time of operations and accuracy of collected data when compared to traditional state-of-the-art approaches based on the usage of geodetic GNSS receivers.
The area is already selected after agreement with Corporation Dominicana de Empresas Eléctricas Estatales (CDEEE), also supporting with formal interest the consortium together with Instituto Dominicano de Aviación Civil (IDAC).
The AMPERE solution will be used to map "Los Tres Brazos" sector, eastern side (ML69-02 EDEESTE) circuit, in a popular district of Santo Domingo.. The campaign in Santo Domingo, with involvement of the above mentioned stakeholders, will be an important pillar for qualification review also from a market perspective, providing necessary feedbacks upon the maturity of the envisaged business models (figure 10):

- AMPERE as a Product (AaaP): This option includes the provision of the overall needed fleet of drones (already tested and integrated with the payload), a training session (in which installation activities will be performed), the maintenance and post-sales service (for both physical assets – e.g. drones and payloads - and platform customer care/updates);

- AMPERE as a Service (AaaS): This option includes the provision of the overall service, meant as gridline mapping and inspection and production of reports and management of the ACGP.

As a final output the client would get a detailed report of the As-Is situation of the network, based on the surveys made by an allocated team of engineers and drone operators.

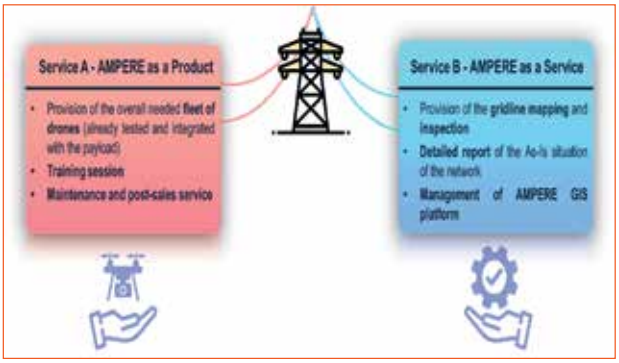


Figure 10: AMPERE business models

METAKEYS

Galileo, Copernicus, Powerlines, Electrical Asset Mapping, Emerging Countries

ABSTRACT

The purpose of the AMPERE (Asset Mapping Platform for Emerging countRies Electrification) project is to provide a dedicated solution for electrical power network information gathering: AMPERE will support decision making actors (e.g. institutions and public/ private companies in charge to manage electrical network) to collect all needed info to plan electrical network maintenance and upgrade. AMPERE solution is based on a GIS Cloud mapping technology, collecting on field data acquired with optical/thermal cameras and LIDAR installed on board a Remote Piloted Aircraft (RPA).

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