DRONE AND GNSS FOR APPLICATIONS TO PROFESSIONAL SURVEYS

DGAP TEAM

PRIME

NAIS S.r.l.

PARTNERS

ITALFERR S.P.A.

AIVIEWGROUP S.R.L.

PEOPLETRUST S.R.L.

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DGAP TEAM

• Web Platform • Mobile App • Anomalies Detection • System Integration	• User Needs • BIM Generation	• UAV Mission Preparation • UAV Mission Execution • Digital Models Generation	• On-site sensors • Worker devices • Vehicle devices

WHAT ARE THE SERVICES ABOUT

Construction Sites represent sensitive areas to be daily managed and monitored

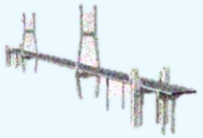
Access into the area has to be monitored and recorded

CSM needs to daily monitor the evolution of the infrastructure

Infrastructure anomalies has to be identified to ensure a proper level of quality

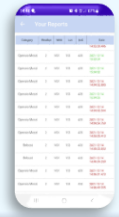
SERVICES TO SUPPORT CONSTRUCTION SITES DAILY MANAGEMENT

Survey Support Service

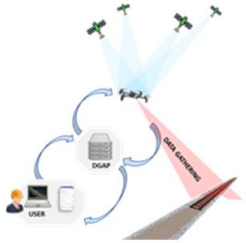


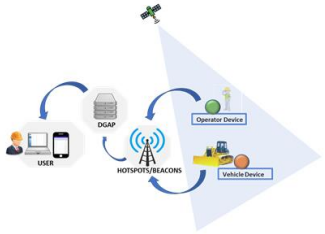
Daily Monitoring Service

Site Management & Service Fruition



DGAP SERVICES





Survey Support Service

- Generation of Digital Models
- Remote qualitative and quantitative analysis

Daily Monitoring Service

- Workers presence into the construction site area
- Vehicle status and presence into the construction site area

Site Management & Fruition Services

- Remote monitoring of infrastructure evolution to support SoW
- Automatic generation of Daily Report

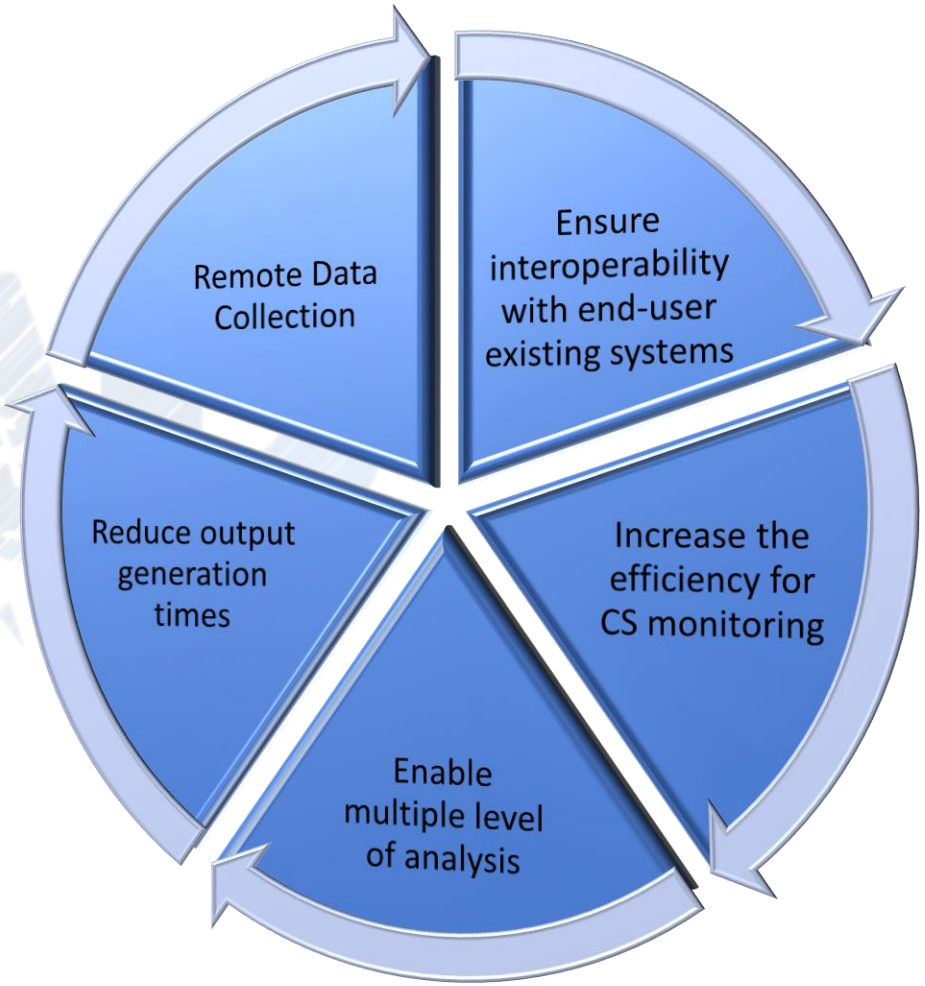
WHAT DGAP IS AIM TO

Foster the transition from traditional construction management to digital processes

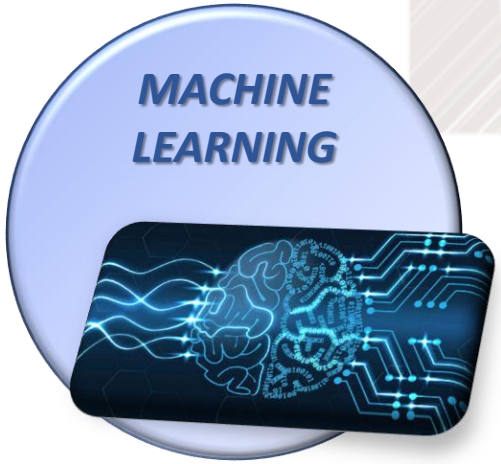
Support the involved actors in their daily and periodical activities

Enhance the activities related to the work progress

Daily monitoring of access to the construction sites



DGAP ENABLING TECHNOLOGIES



LOCALISATION IN THE CONSTRUCTION SITE AREA - TECHNOLOGIES

- The DGAP system architecture has been conceived to allow the localisation of persons and vehicles in the construction site area. It has been also conceived to localise generic "assets" such as construction materials, pre-fabricated parts, etc., although these features have not been actually implemented or exploited in the project as they were not included in the original requirements
- In order to cover both outdoor and indoor areas (e.g., tunnels under construction) as well as persons, vehicles, and generic assets, various localisation technologies have been combined:
  - GNSS (mostly for outdoor localisation of persons or vehicles)
  - Bluetooth Low-Energy by proximity (mostly for indoor localisation of persons or vehicles)
  - Bluetooth Low-Energy by multi-lateration (for more accurate localisation of persons or vehicles) [*]
  - LoRa by multi-lateration (for rough localisation of persons or vehicles when no other means are available) [*]
  - WiFi by multi-lateration (for rough localisation of persons or vehicles when no other means are available) [*]
  - RFID by proximity (mostly for localisation of "assets") [*]
  - RFID by multi-lateration (mostly for localisation of "assets") [*]

[*] Foreseen in the system architecture, but not actually implemented or exploited in DGAP

COMMUNICATION IN THE CONSTRUCTION SITE AREA - TECHNOLOGIES

- Communications are used to transfer localisation information to the DGAP backend for further processing (e.g., spatial resolution of proximity) and storage/presentation
- Two main communication modes are foreseen by the system architecture:
  - Direct communication from the tracking devices to the backend via GSM cellular network, when GSM coverage (at least 2G) is available over (most of) the construction site
  - Local communication via a “hotspot” plus backhauling to the internet when no GSM coverage is available over (most of) the construction site
- Local communication technologies foreseen: WiFi (primary, capable of larger traffic capacity) and LoRa (backup for areas not covered by WiFi, with limited traffic capacity)
- Backhauling communication technologies foreseen: ethernet (when a connection to the internet is available already on the construction site through other means); LTE cellular (when LTE cellular coverage is available at least at one place of the construction site where a hotspot can be installed); IRIDIUM satellite network (when no other backhauling communication means are available on the construction site) [*]

[*] Ethernet connectivity and an IRIDIUM modem for backhauling have been included in the hotspots, but not actually used in DGAP as backhauling through LTE cellular network was foreseen for the demonstration

DEPLOYED HARDWARE

THE DGAP HOTSPOTS

Each hotspot includes:

- WiFi hotspot
- LoRa Gateway
- Bluetooth direct and reverse beacon
- LTE cellular modem for backhauling
- IRIDIUM satellite modem for backhauling
- Ethernet connection for backhauling
- RFID reader for passive RFIDs [*]
- RFID reader for active RFIDs [*]
- GNSS receiver with RTK capabilities (for reference positioning)
- Hot-swappable batteries, providing several days of autonomy
- 220 – 240 V power supply, remote monitoring and control, light for maintenance operations when dark, tampering alarm, etc.
- Telescopic mast and foldable tripod to ease the transportation
- Rated for up to 100 Km/h wind, and up to 130 Km/h wind gusts
- 2 hotspots provided for DGAP

[*] Foreseen by the architecture but not actually equipped in DGAP

DEPLOYED HARDWARE

THE DGAP TRACKERS

- A common electronic design has been made for the “operator devices” (i.e., the trackers used to localise persons), for the “vehicle devices” (i.e., the trackers used to localise vehicles), and for the “beacons” (i.e., fixed devices used to localise trackers through proximity via Bluetooth Low Energy)
- Each tracker includes:
  - GNSS receiver
  - 2G GSM cellular modem
  - LoRa modem (including an autonomous GNSS receiver and a WiFi sniffer)
  - WiFi transceiver
  - System-On-Chip (SOC) including the main microcontroller and the Bluetooth Low Energy transceiver
  - Internal battery and power management circuitry
  - Direct communication from the tracking devices to the backend via GSM cellular network, when GSM coverage (at least 2G) is available in the construction site
  - Local communication via a “hotspot” + backhauling when no GSM coverage is available over the construction site
- Due to the well-known problems with long delivery time of electronic components following the COVID-19 pandemic, various versions of the DGAP trackers have been implemented (named Level 1, Level 2, and Level 3), so as to mitigate the problem and allow to proceed with the tests and the demonstration even though not all electronic components were immediately available

DEPLOYED HARDWARE

THE LEVEL 1 TRACKERS

- The Level 1 trackers were the only type of tracker available when the preliminary test site survey was carried out (July 2021), as the delivery time of some electronic components for the Level 2 and Level 3 trackers was not compatible with the desired planning
- The Level 1 tracker includes:
  - GNSS receiver
  - 2G GSM cellular modem
  - main microcontroller
  - Internal battery and power management circuitry
- Very small and lightweight, Level 1 trackers may represent a good solution for construction sites where GSM coverage is available more or less throughout the site, and where no localisation is required indoor or in tunnels
- When Level 1 trackers are exclusively used, local communication coverage and backhauling using hotspots is unnecessary

DEPLOYED HARDWARE

THE LEVEL 2 TRACKERS

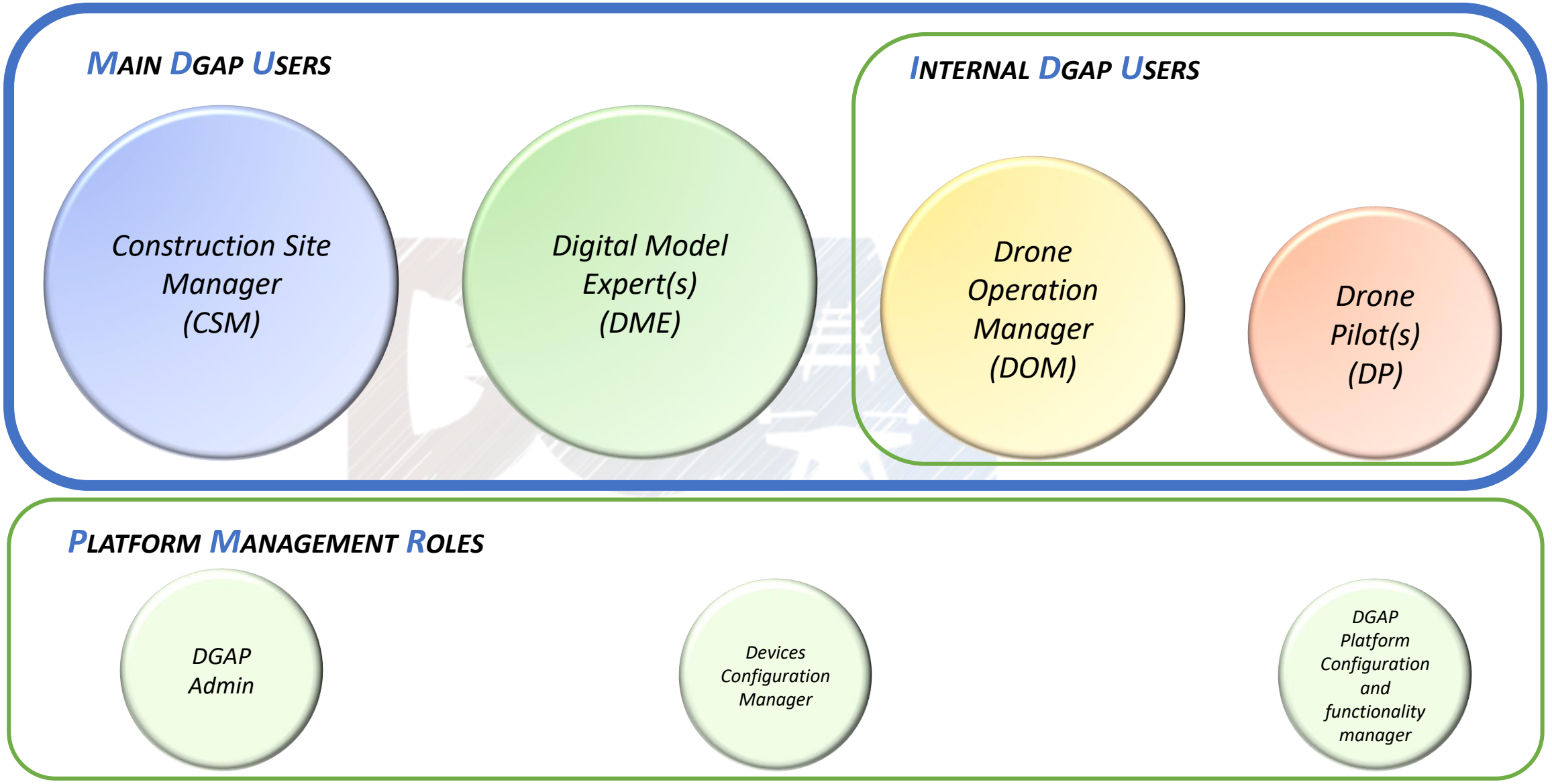
- The Level 2 trackers are fully featured, and they were used, in addition to Level 1 trackers, for on-site installation and setup (October 2021) as well as for the demonstration (December 2021)
- As a feedback gathered during the demonstration, interest was manifested for a version having a different form factor, which could be combined with an identification badge. This suggestion led to the realisation of the Level 3 trackers

DEPLOYED HARDWARE

THE LEVEL 3 TRACKERS

- The Level 3 trackers are also fully featured, and they were realised after the demonstration to show that the feedback gathered during the demonstration as a “lesson learned” could be actually implemented
- An enclosure for the Level 3 electronic board has been made using 3D printing techniques. It incorporates a holder for a standard size identification card, and rear clips to attach it to a pocket
- Future “Level 4” trackers may be further reduced in size and weight, and shaped for an optimum integration with the identification badge

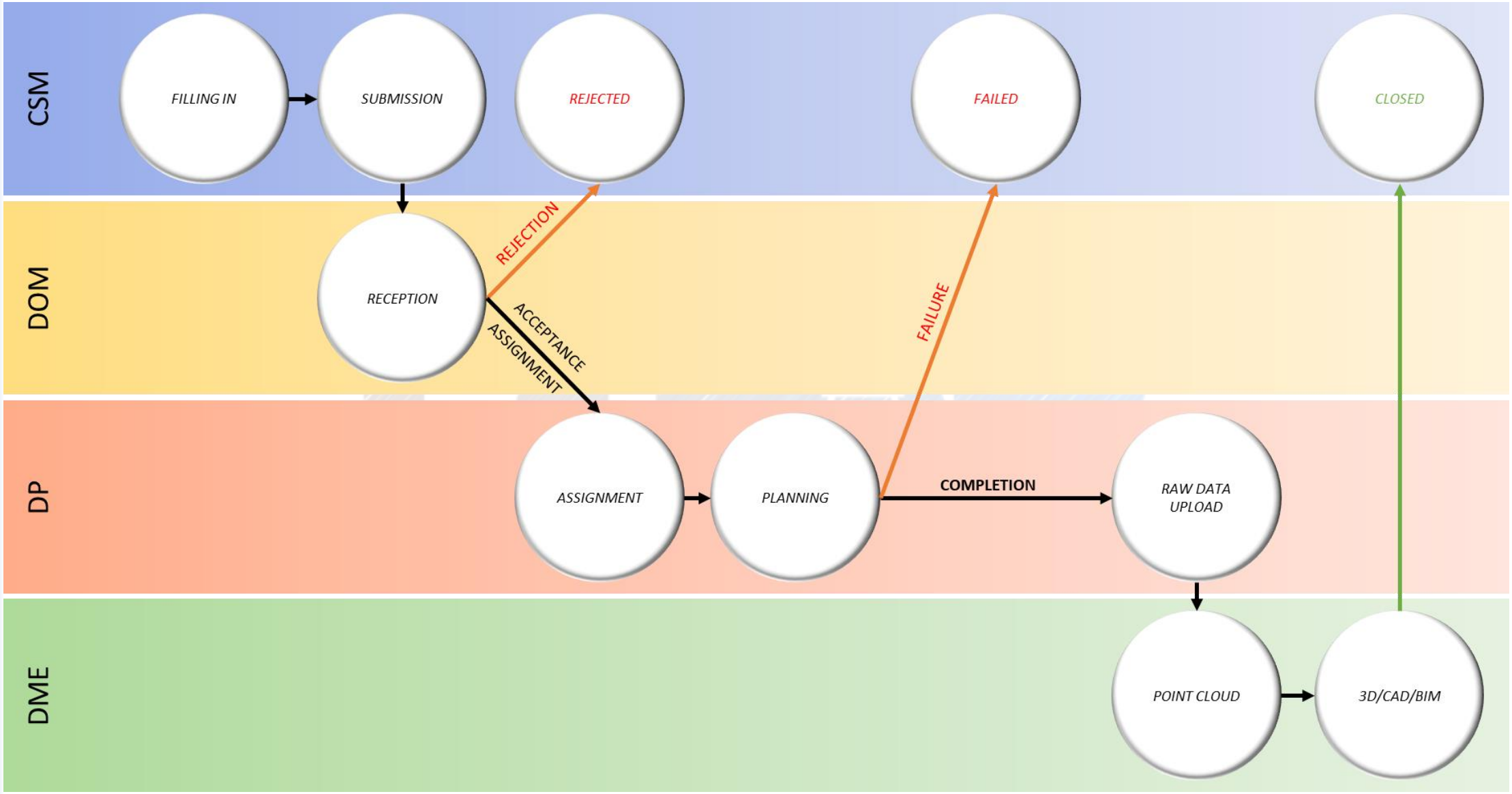
DGAP PLATFORM USERS



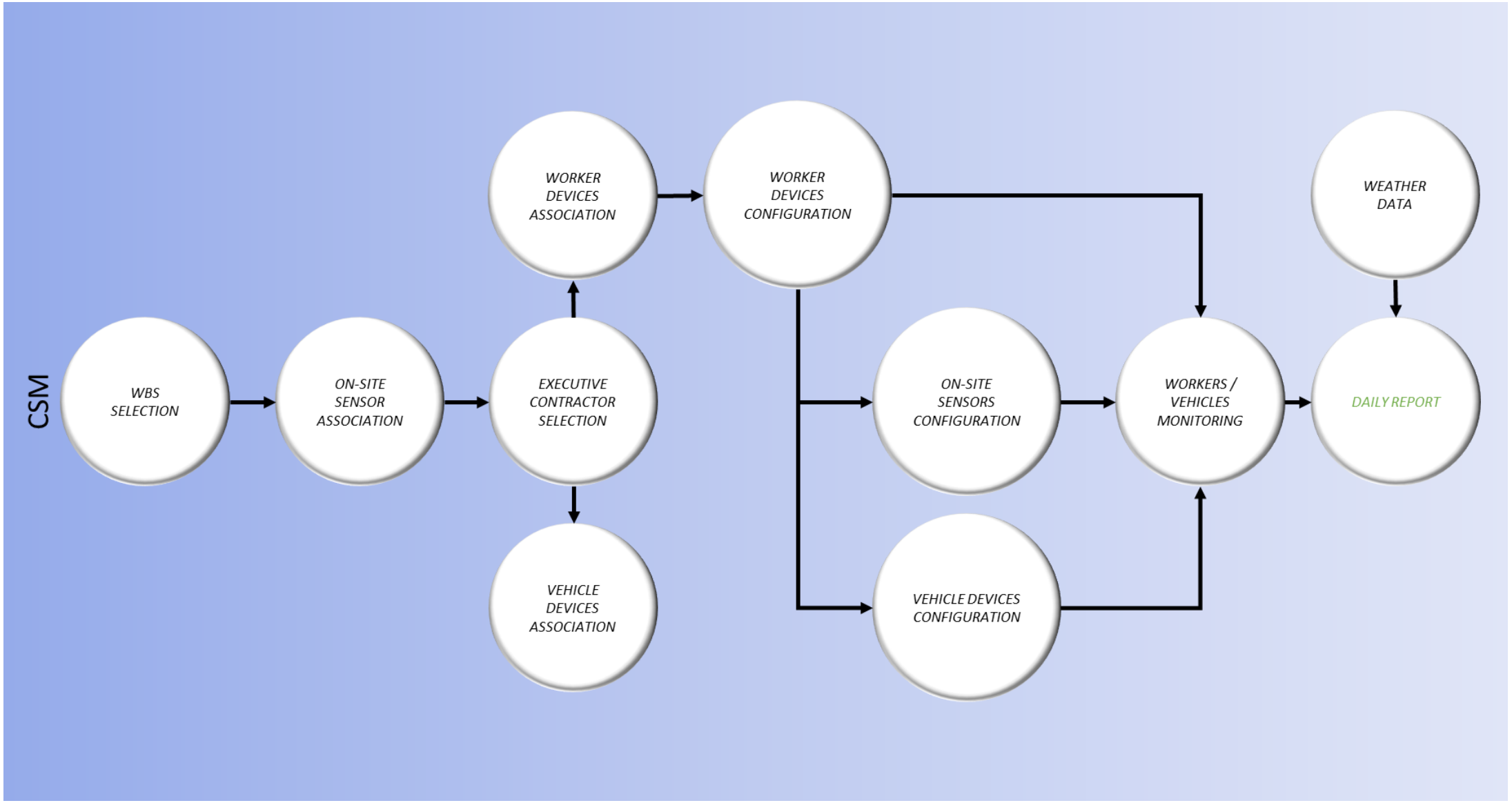
DGAP PLATFORM USERS

	Preliminary Platform Configuration Activities	*Survey Support Service*	*Daily Monitoring*
Construction Site Management	✓	✓	✓
Digital Models' Experts		✓	
Drone Operation Manager		✓	
Drone Pilot		✓	
Devices Configuration Manager	✓		✓
DGAP Web portal administrator		✓	✓

DGAP SET#1 OPERATIONAL FLOW



DGAP SET#2 OPERATIONAL FLOW



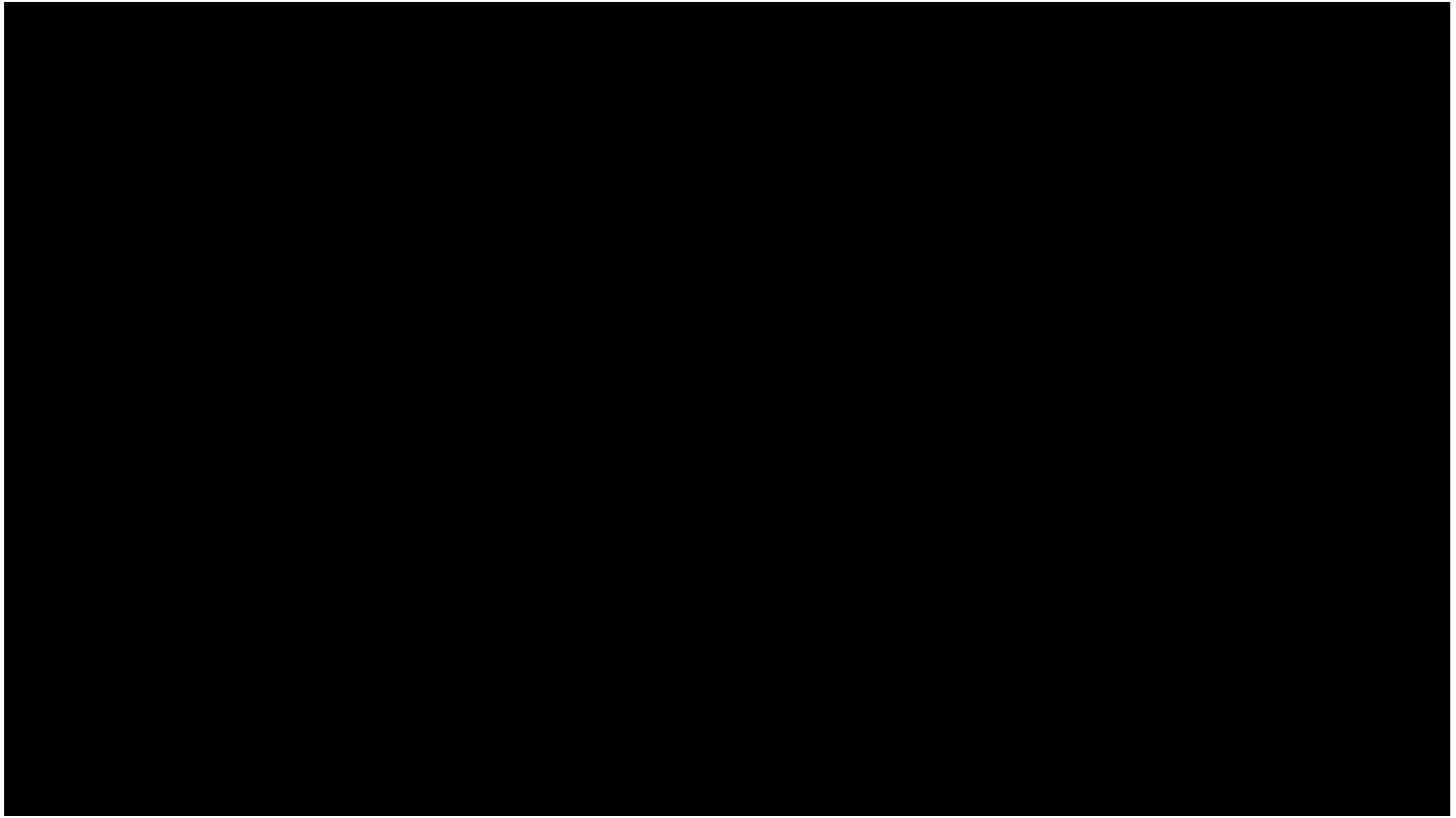
DEMONSTRATION SITES

DEMONSTRATION SITES

Survey Support Service (SET#1) Demo Site
GA03-Gallerodotto

Daily Monitoring (SET#2) Demo Site
VI01-Viadotto

DEMONSTRATION EXECUTION



UAV SURVEY (SET #1) – FIELD EQUIPMENT

DJI PHANTOM 4 ADVANCED UAV	
Type	Multirotor UAV (quadrotor)
Max Take-off Mass (MTOM)	1.5 kg
Max cruise speed	5 m/s
Endurance	30 min
Propulsion type	Electric
Positioning	GNSS receiver (GPS, GLONASS)
Sensor type and characteristics	RGB sensor CMOS 1/2.3" Effective pixels: 20M

STONEX S900A GNSS RECEIVER

Satellite Tracked	GPS: L1 C/A, L1C, L1P, L2C, L2P, L5 GLONASS: L1 C/A, L1P, L2C, L2P, L3 BEIDOU: B1, B2, B3 GALILEO: E1, E5a, E5b, Alt-BOC, E6 QZSS: L1 C/A, L1C, L2C, L5 SBAS: L1, L5
L-Band	Atlas H10 / H30 / Basic
Channels	600
Position Rate	5 Hz, optional 20Hz
Signal Reacquisition	< 1 sec
RTK Signal Initialization	Typically < 10 sec
Hot Start	Typically < 15 sec
Initialization Reliability	> 99.9 %
Internal Memory	8 GB
Micro SD Card	Expansion slot up to 32 GB

POSITIONING[1]	
HIGH PRECISION STATIC SURVEYING	
Horizontal	2.5 mm + 0.1 ppm RMS
Vertical	3.5 mm + 0.4 ppm RMS
CODE DIFFERENTIAL POSITIONING	
Horizontal	0.25 m RMS
Vertical	0.45 m RMS
SBAS POSITIONING[2]	
Horizontal	0.30 m RMS
Vertical	0.60 m RMS
REAL TIME KINEMATIC (< 30 Km) – NETWORK SURVEYING[3]	
Fixed RTK Horizontal	8 mm + 1 ppm RMS
Fixed RTK Vertical	15 mm + 1 ppm RMS

UAV SURVEY (SET #1) - DATA ACQUISITION PROCESS

Mission planning and preparation

Requirements analysis

Personnel selection

UAV and accessories selection

Field&Risk Assessment

Preparation for survey

GCP acquisition

UAV and sensor deployment

Flight Execution

Real-time monitoring

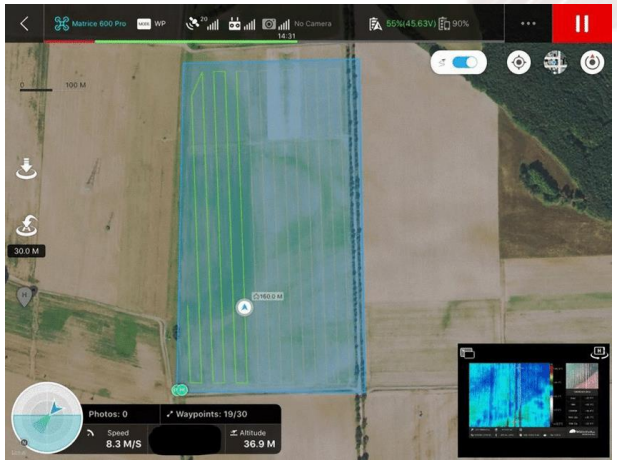
Post-flight

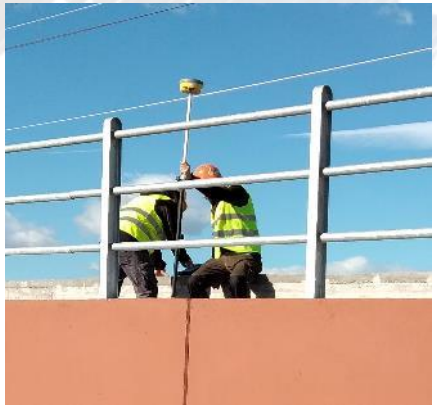
Verification of acquired data

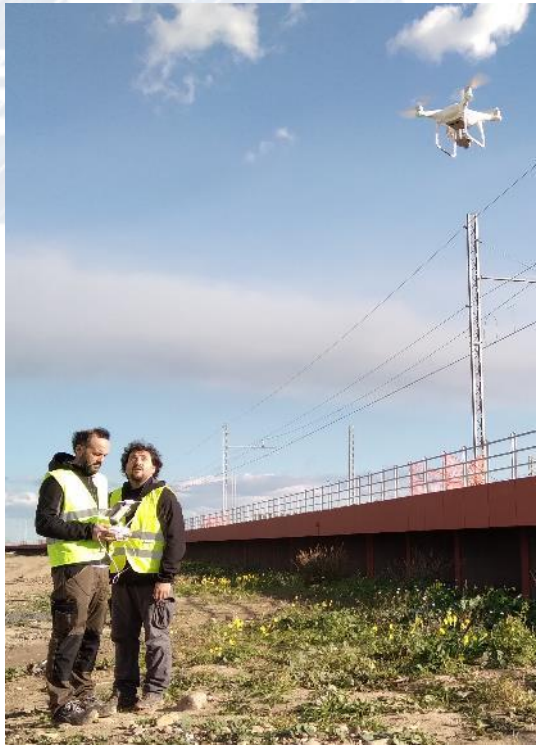
Eventual re-taking of missing data

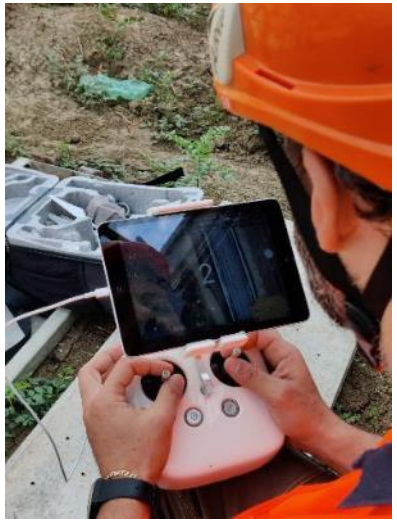
UAV and sensor check and storage

Upload of images on cloud









UAV SURVEY (SET #1) – POST-PROCESSING AND MODEL GENERATION

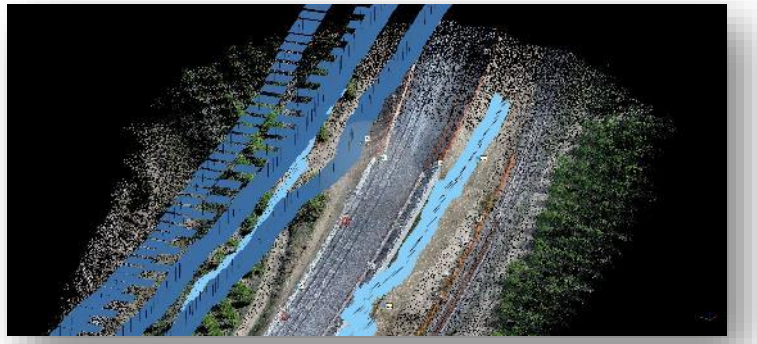
Image upload and alignment
- Sparse point cloud is generated

GCP coordinates input
- To increase overall model positioning accuracy

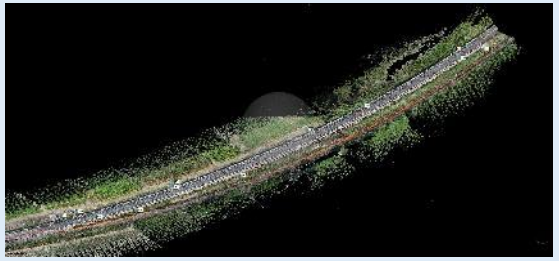
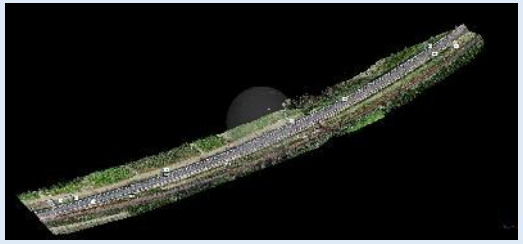
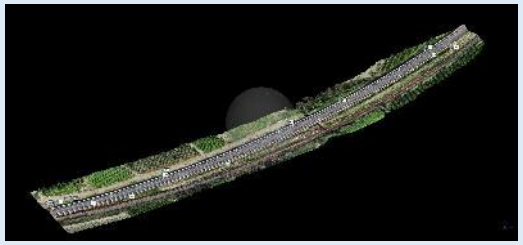
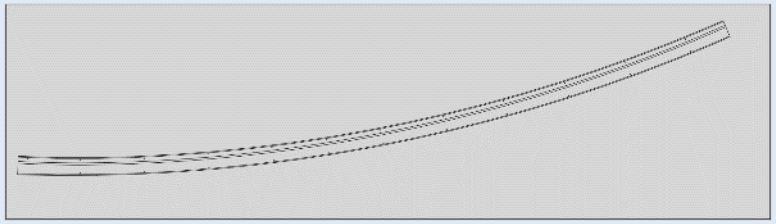
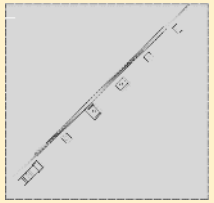
Densification
- Dense point cloud is generated

3D texturized model generation
- 3D model with texturized mesh is generated

CAD model
- On CAD generator module



UAV SURVEY (SET #1) – SUMMARY OF RESULTS

	GA03 «gallerodotto»	VA11
Sparse cloud		
Dense cloud		
3D textured mesh		
CAD		

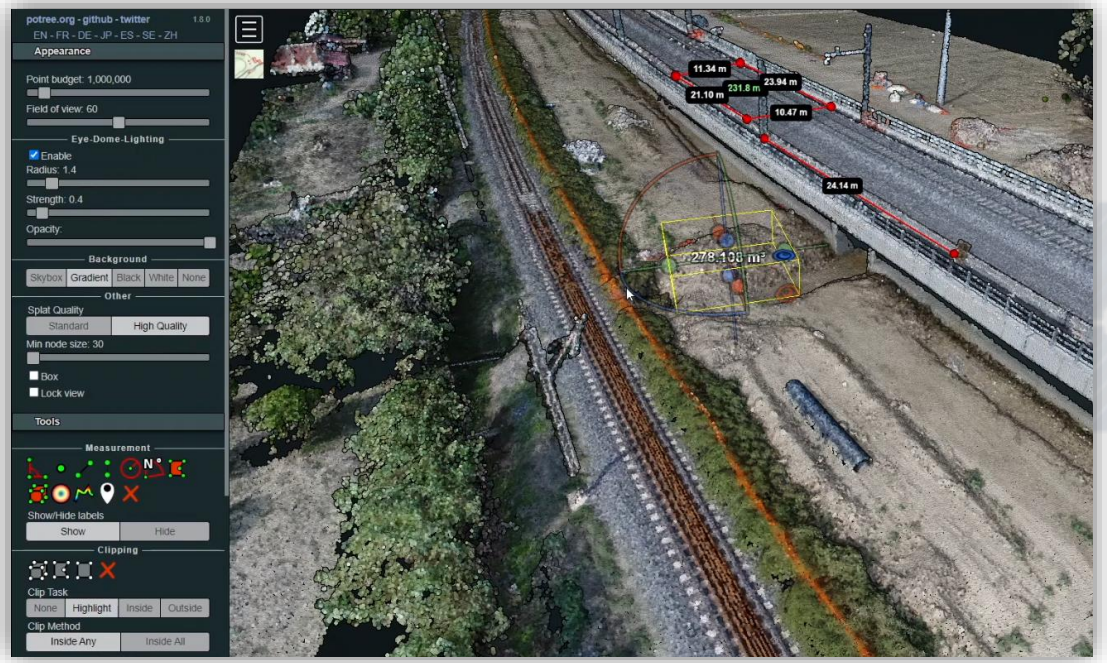
DGAP: DIGITAL SERVICES SUPPORTING CONSTRUCTION SITES ACTIVITIES

SET#1 – «Survey Support Service"	SET#2 – «Daily Monitoring»
SET#1 aims to support the Site Manager team in the periodic evaluation of the advancements of the linear construction site thanks to the use of drone and ad-hoc payload (e.g. RGB Camera, Lidar sensors, other sensors). The data gathered during the drone mission will be post-processed by a dedicated processor module in case correction processing is requested and will be sent to the Site Manager in a format compatible with existing client infrastructure (e.g. Point of Cloud, BIM Model, CAD Model, Other).	SET#2 provides continuous information to the Site Manager about any presence into the construction site together with additional weather information required for the daily monitoring. An ad-hoc operator device will be provided to each worker and a vehicle device will be installed on board of each vehicle operating into the work area while a third-party weather provider will be used to obtain any relevant information (e.g. weather condition, temperature, wind, other) in the interested area.
Quantitative and Qualitative measurements • volume of concrete used • number of reinforcing steels placed, • excavation volume • presence of honeycomb patterns or cracks • etc **Work progress analysis** by comparing: • data acquired and processed at T0 and T1; • data acquired on field with the design model	**Real time operation data – Live Report** • Presence, localization and typology of workers (technical employees, common worker, skilled workers, etc.) • Presence, localization and typology of vehicles • Weather condition **Interoperability with Piattaforma Costruzioni** (Constructions Platform) **Automatic compilation of the Daily Report**

3D POINT CLOUD MODELS FOR QUANTITATIVE MEASUREMENTS

The availability of point cloud models allows performing quick&smart quantitative measures in order to speed up on-sites monitoring activities to be performed by Italferr personels.

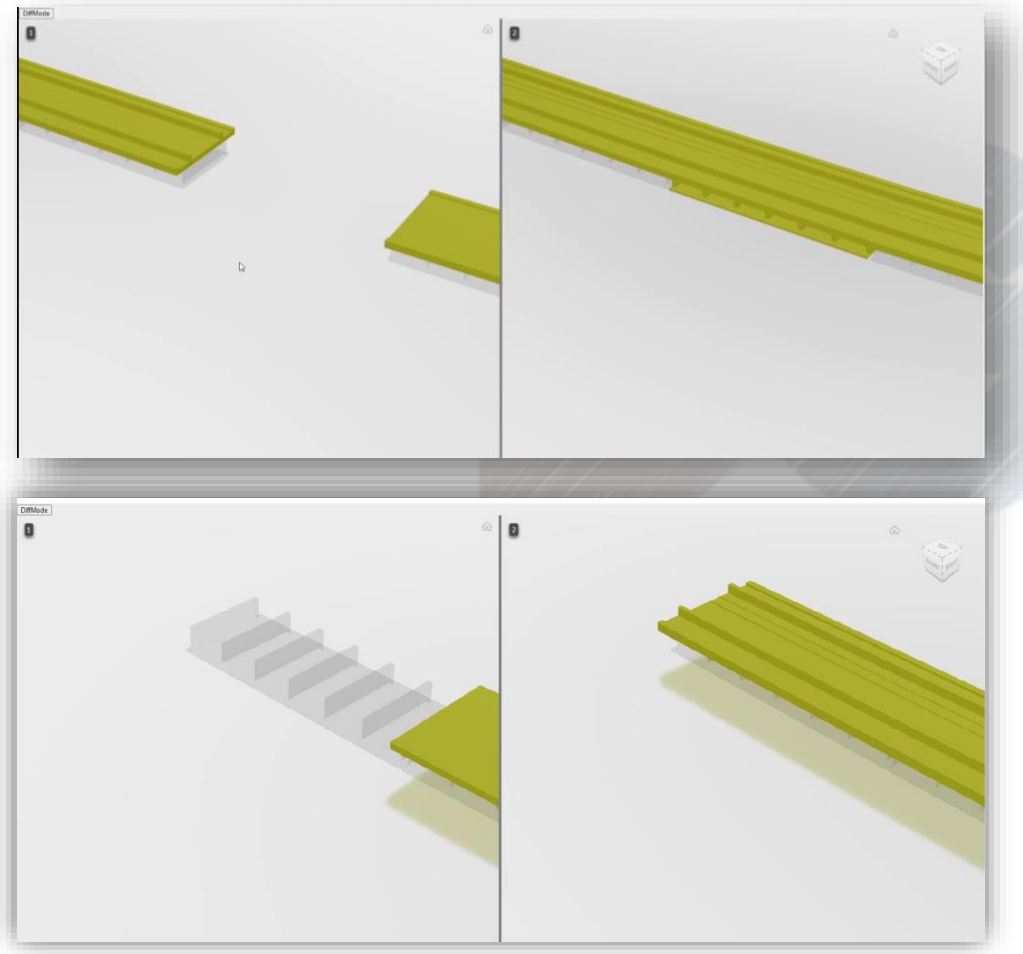
POTREE application integrated in the DGAP Platform, available also on mobile devices, allows to check on the point cloud models several relevant features needed to verify the correct realization of the works.



- ✓ length and surface measurements
- ✓ angle and curvature measurements
- ✓ volume measurements
- ✓ counting macro objects related to the project

BIM MODELS GENERATION SUPPORTING WORK PROGRESS ANALYSIS

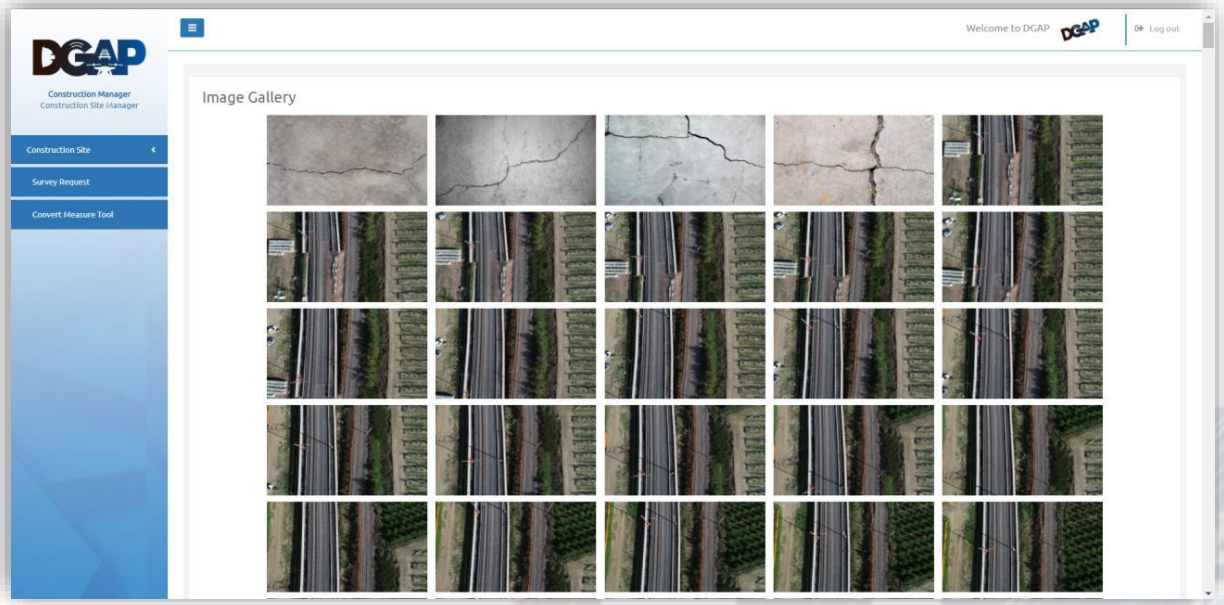
Starting from the point cloud model, Italferr BIM Specialist creates a 3D BIM Models, using Bentley ContextCapture software, which can uploaded in the DGAP platform and correctly visualized and managed using Autodesk FORGE application.

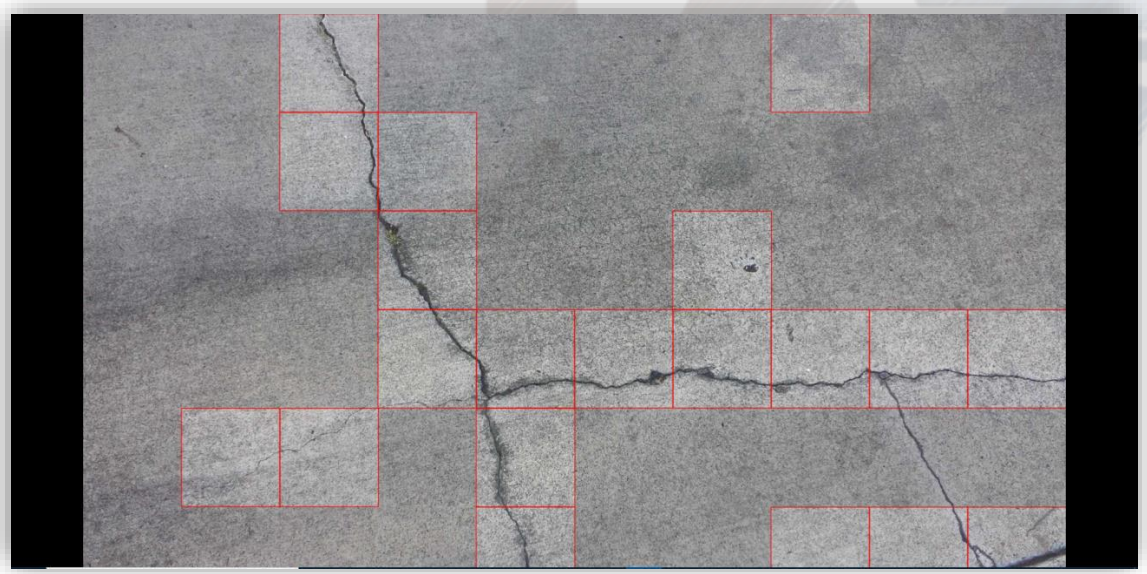


DGAP Platform can support Italferr specialists in carrying out project related activities such as:

- ✓ Quick analysis of works progress status by developing BIM models of structures using on-site data gathered at T0 and data collected a Tn+1
- ✓ Quick analysis of adherence with by comparing BIM on-site models developed from data collected on field with BIM models related to the design and planned construction activities

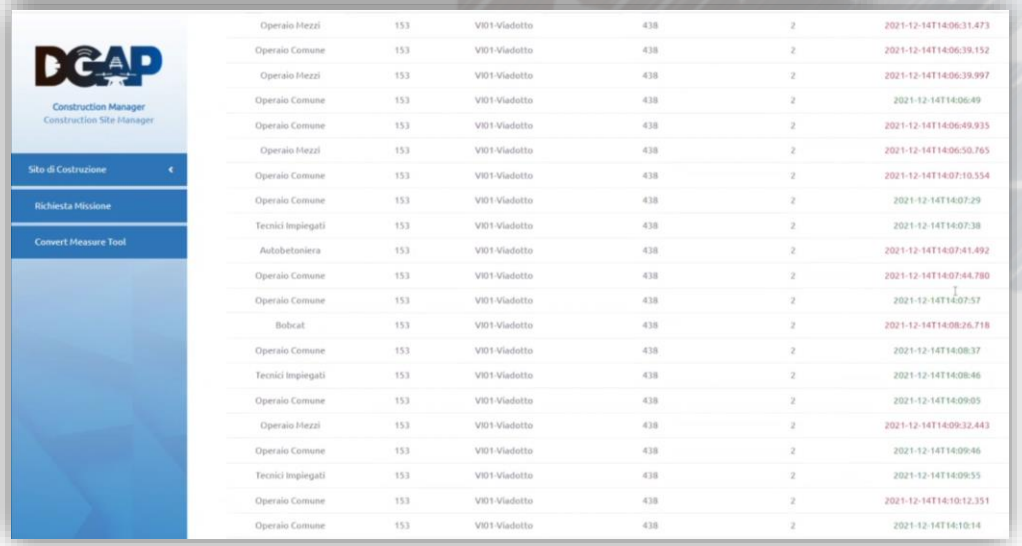
MACHINE LEARNING ALGORITHM FOR ANOMALIES DETECTION





- ✓ Anomalies detection in structures such as superficial anomalies in concrete (e.g. cracks, ecc) can be visually and automatically detected analyzing large quantities of pictures gathered on site. This functinality allows Italferr's Specialist to speed up monitoring activities, limiting the number of personnel to be used on site
- ✓ Anomalies pictures collection and recording is also useful for producing technical inspection forms including all the evidences from the inspection
- ✓ A register of the anomalies pictures can also be useful for legal issues with the Contractor in relation to the correct execution of works and related payments

CONSTRUCTION SITE DAILY MONITORING REPORT



- ✓ Ad hoc on-site communication equipment (hotspot, beacon) and tracker devices guarantee an optimal signal coverage (also in indoor areas)
- ✓ automatic and daily identification and positioning (IN/OUT) of operators and vehicles working on the construction site
- ✓ Automatic generation of daily monitoring report
- ✓ Potential interoperability with Italferr's "Construction Platform"

Autobetoniera	153	VI01-Viadotto	438	2	2021-12-14T14:07:41.492
Operaio Comune	153	VI01-Viadotto	438	2	2021-12-14T14:07:44.780
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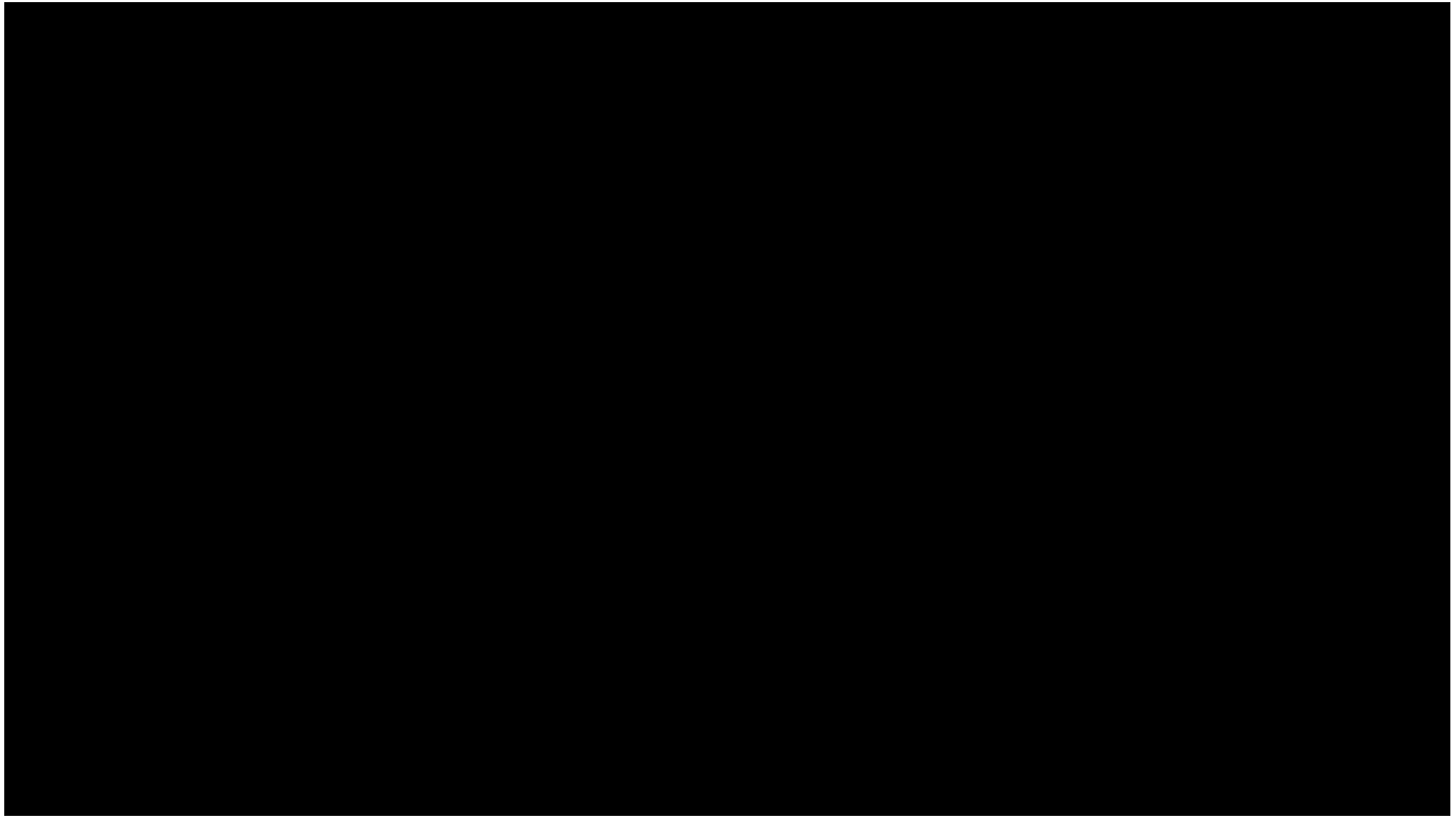
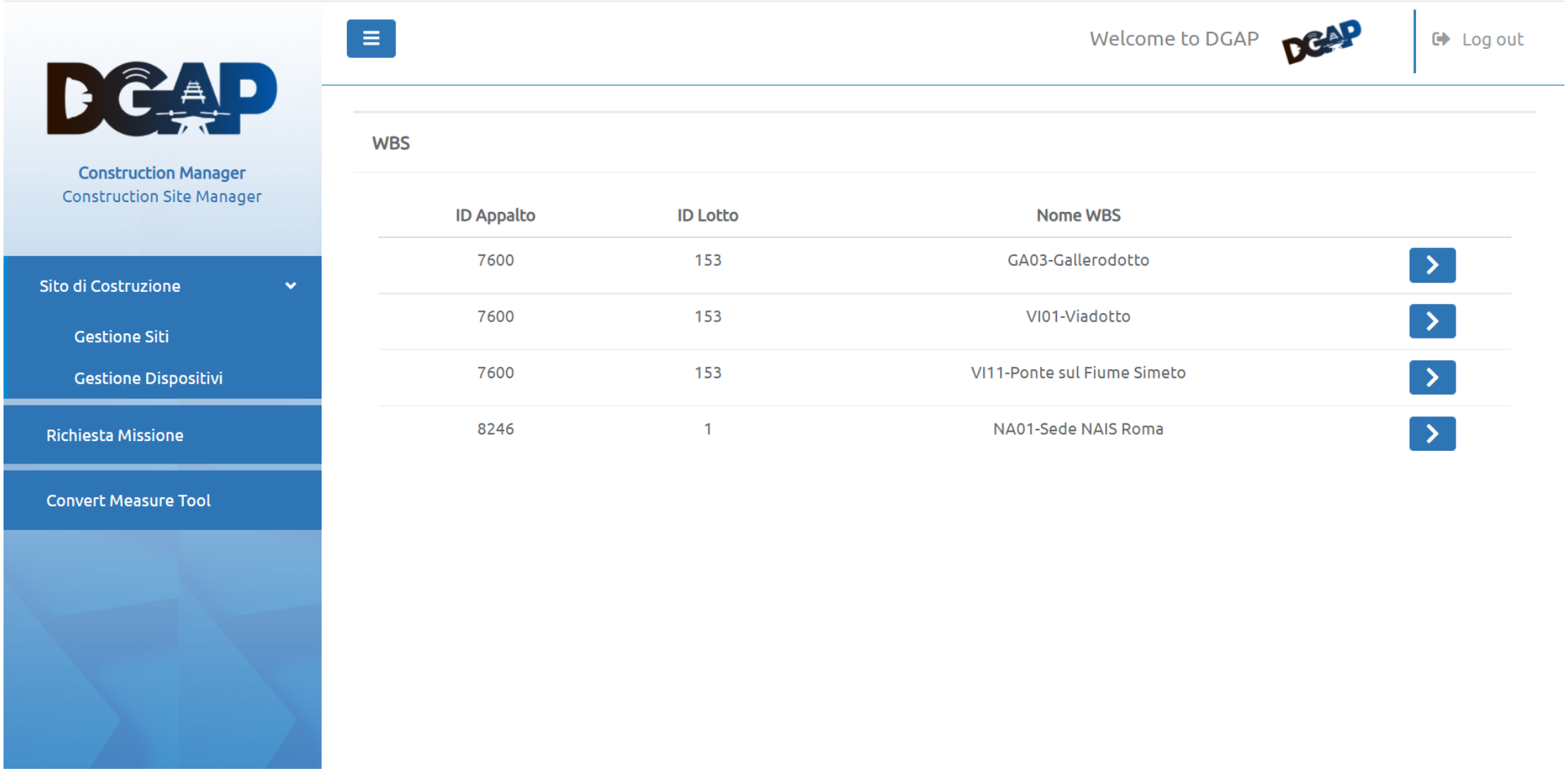
DEMONSTRATION OUTCOMES



DGAP PLATFORM PRESENTATION

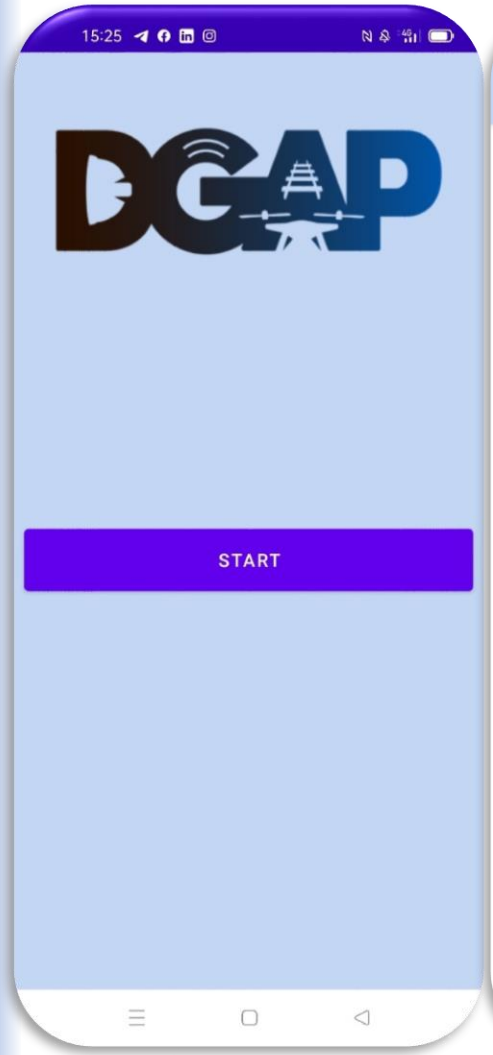
KEY RESULTS

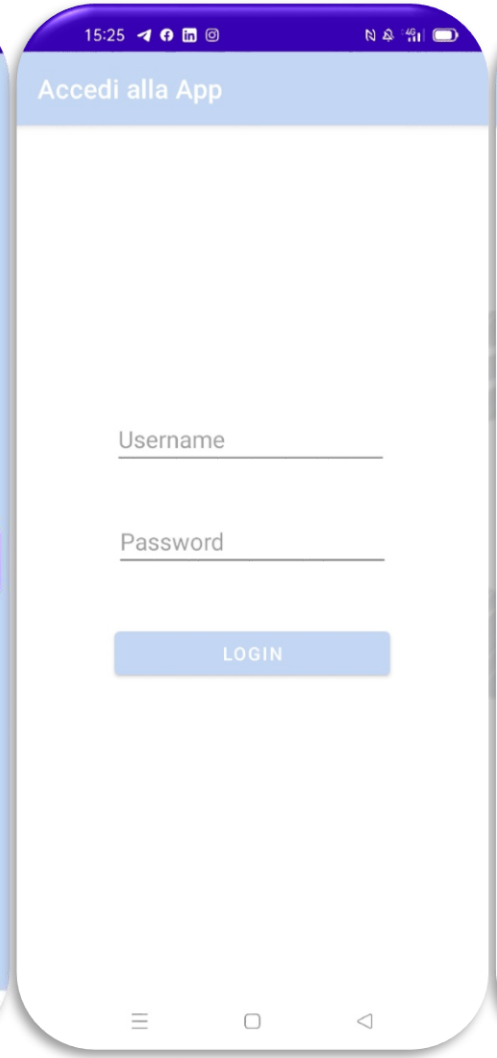
DGAP WEB PORTAL

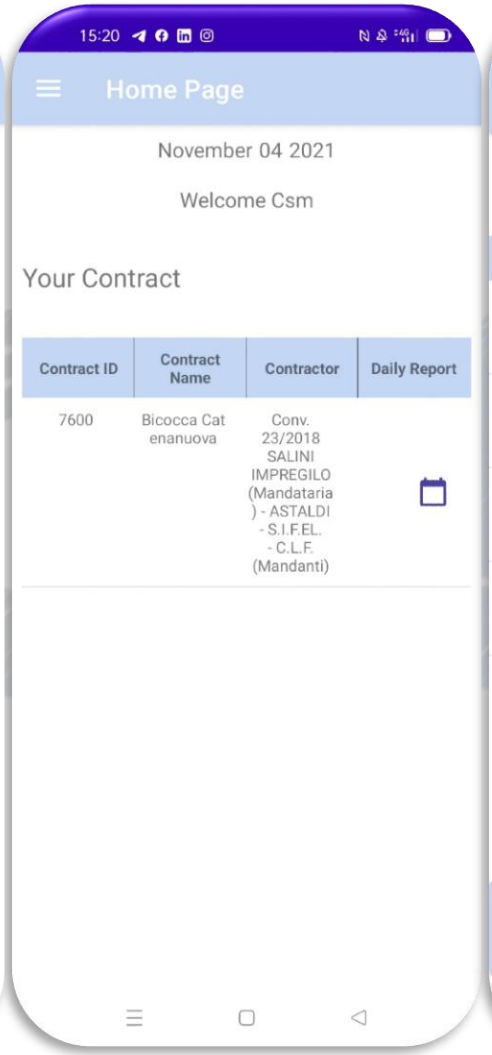


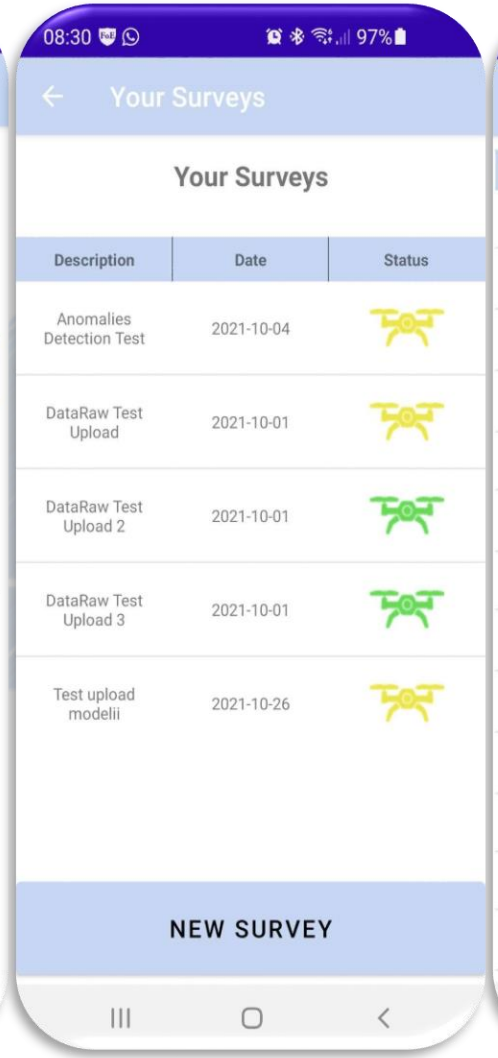
KEY RESULTS

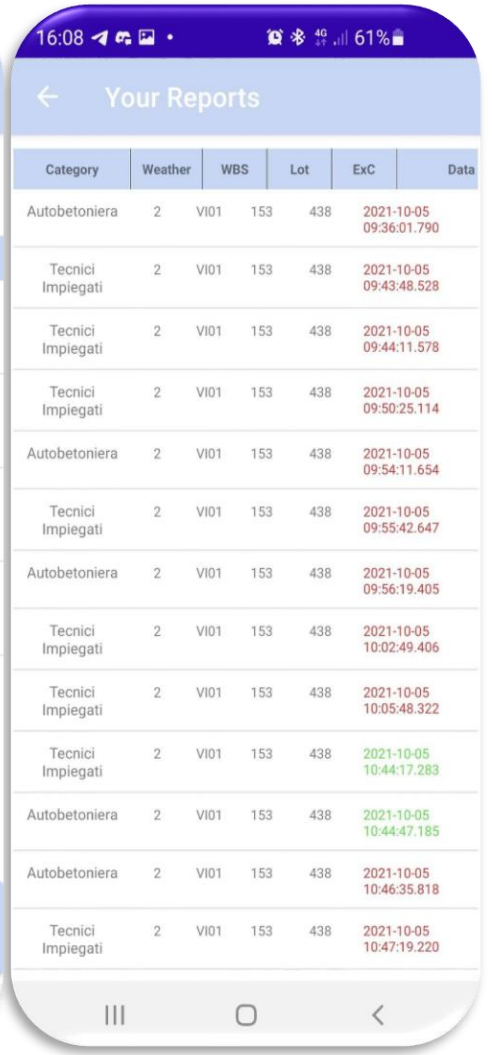
DGAP MOBILE APP





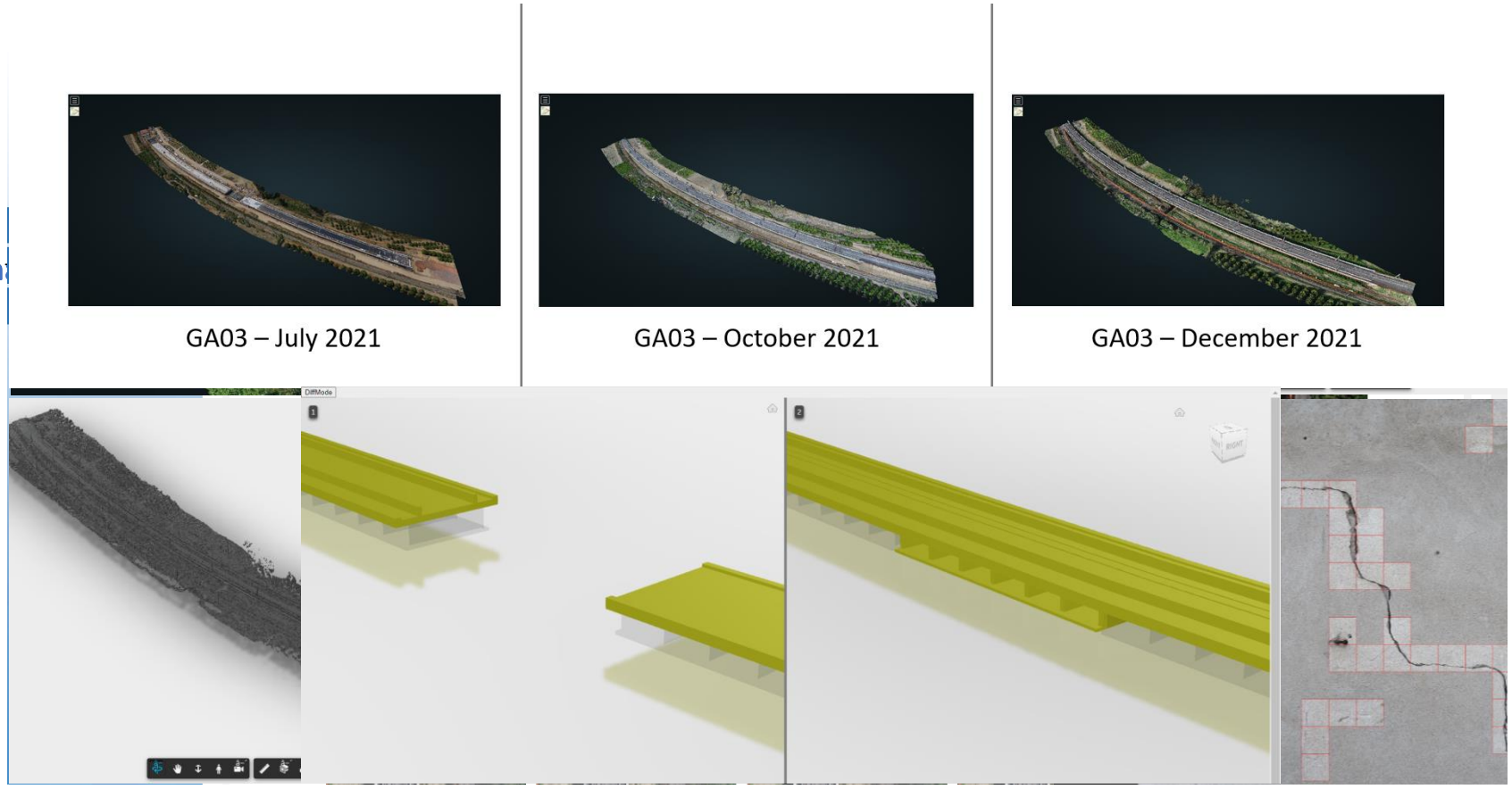






KEY RESULTS

SURVEY SUPPORT SERVICE (SET#1)



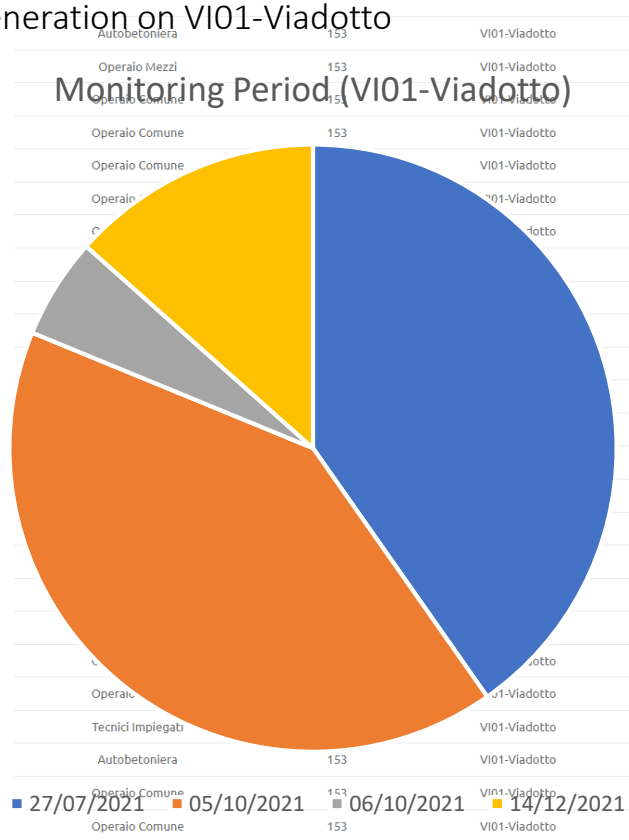
KEY RESULTS

DAILY MONITORING (SET#2)

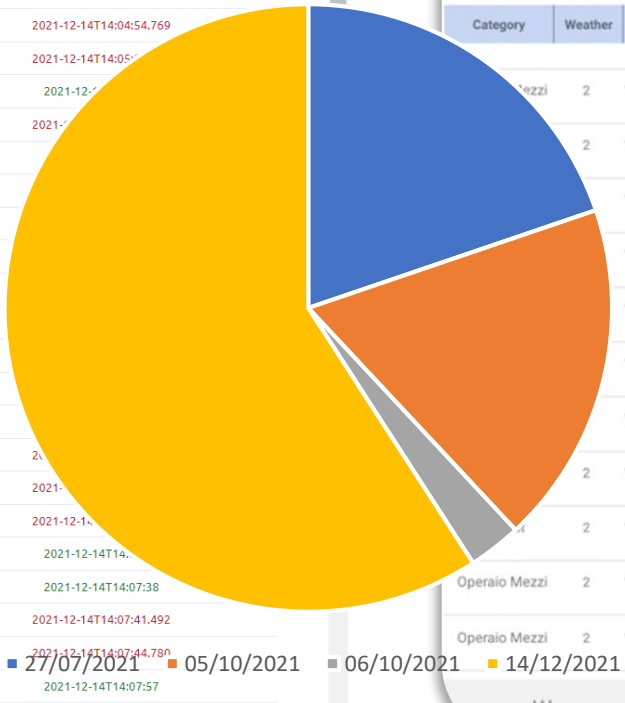
15 hours of monitoring period for Daily Report generation on VI01-Viadotto

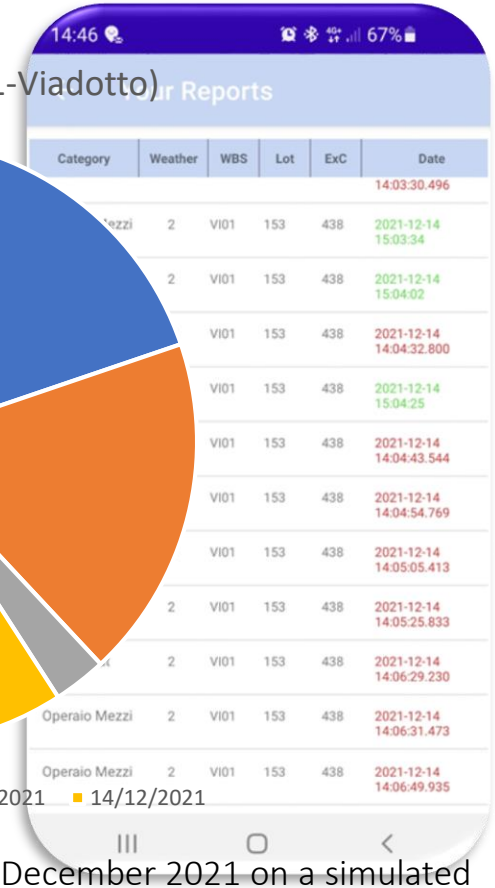
Corresponding to more than 450 records for the daily report generation

Monitoring Period (VI01-Viadotto)



Amount of Records (VI01-Viadotto)





In order to stress the platform, additional monitoring activities have been performed from 26th of October 2021 to 12th of December 2021 on a simulated construction sites cantered on NAIS Premises in Rome. For this simulated have been recorded more than 128 hours corresponding at more than 10900 records.

POTENTIAL IMPROVEMENTS

Direct Integration in existing Final User infrastructure

Automatic rescheduling of the survey

Devices Assignment

Anomalies identification improvement

GCP in challenging scenario

Devices improvement after user feedback

THANK YOU