



Unmanned aerial vehicle

Tested in: Tunnel construction - La Ribera de Folgoso, León, Spain

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Autonomous Aerial Robots

Introduction

- A proven GNSS-denied autonomous navigation system based on algorithms for: localization (global and relative), real-time mapping, motion planning and control.
- Collaboration with Autonomous Wheel Loader on post-blasting tasks.

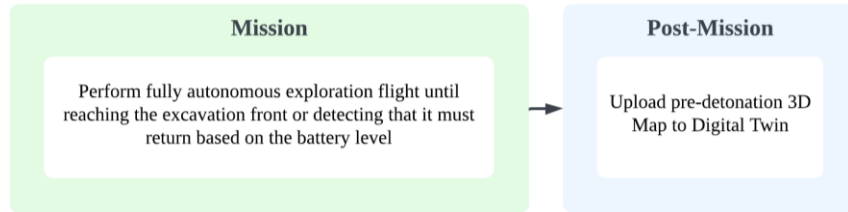


CADRIN Drone performing autonomous flight inside tunnel

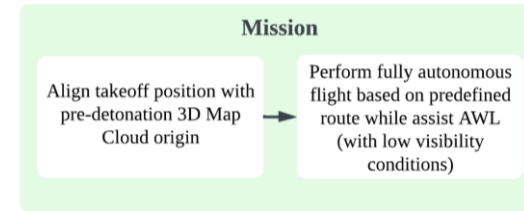
Autonomous Aerial Robots

Tunnel Contruction

- Main goals of the aerial robots in the case study:
 - Before carrying out the tunnel advance detonation, the aerial robot will explore the entire tunnel autonomously and create a 3D map of it.
 - After detonation, the aerial robot will support the autonomous wheel loader while it moves forward to the excavation front site.



Tunnel Contruction Case Study Workflow – Pre-Detonation Phase

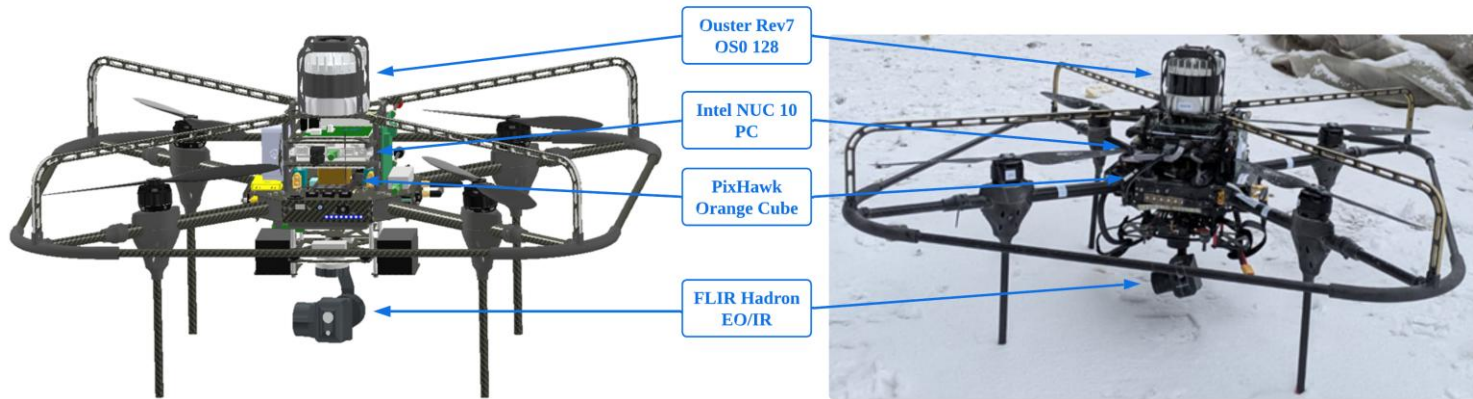


Tunnel Contruction Case Study Workflow – Post-Detonation Phase

Autonomous Aerial Robots

Tunnel Contruction

- Fully autonomous flights are carried out in tunnels with low visibility conditions where GNSS signal aren't available.
- Custom aerial vehicle has been designed and manufactured to fit the needs of the environment.

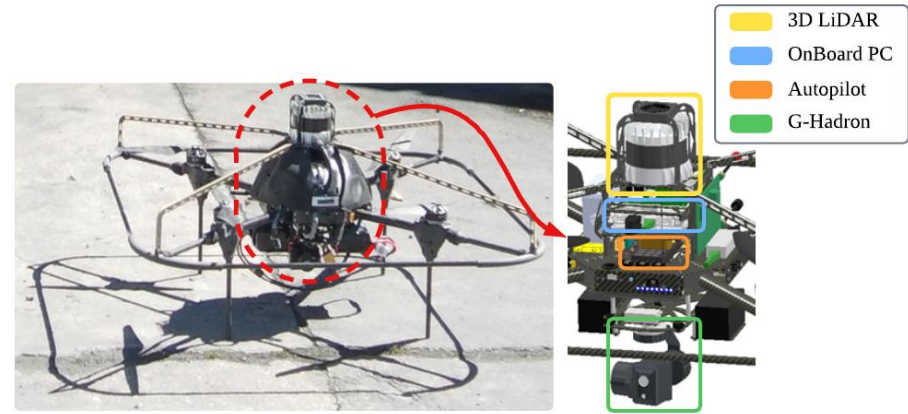


CADRIN Drone CAD and real with onboard sensors

Autonomous Aerial Robots

Tunnel Contruction

- Protective fairing to insulate equipment from dust or moisture.
- Weight: 5.5 Kg
- Operational Endurance: 14 min
- Diameter x height: 1025 x 425 mm
- Cruise speed in Auto mode: 1-5m/s.

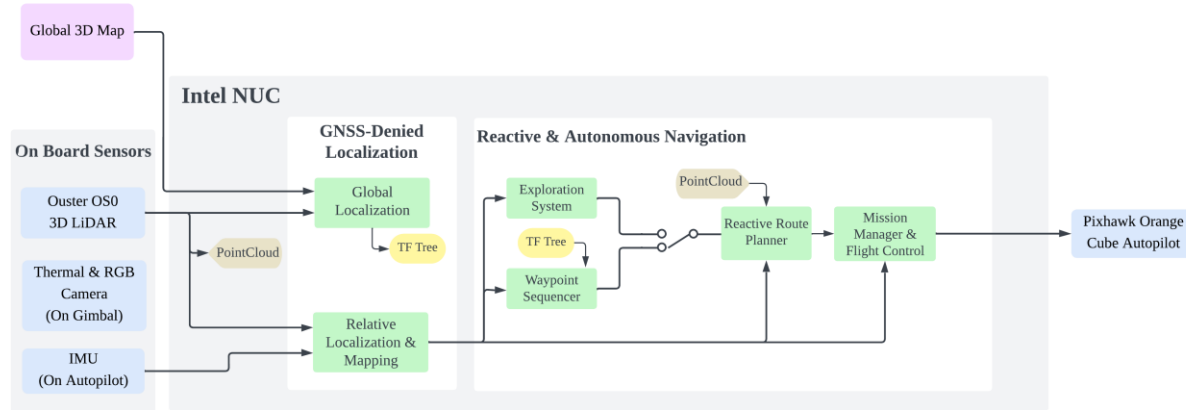


CADRIN Drone CAD and real with onboard sensors

Autonomous Aerial Robots

Tunnel Construction

- The whole computing is performed on the onboard computer of the robot.
- Modular and interchangeable software architecture with two main components: GNSS-Denied Localization system and reactive navigation system with static and dynamic obstacle avoidance and exploration system (interchangeable with a waypoint sequencer depending on the phase it is in).



CADRIN Drone software architecture in tunnel construction case study

Autonomous Aerial Robots

Tunnel Contruction

- Fully Autonomous Exploration with simulated smoke (post-blasting phase).



Autonomous exploration execution – Sensors Point-Of-View

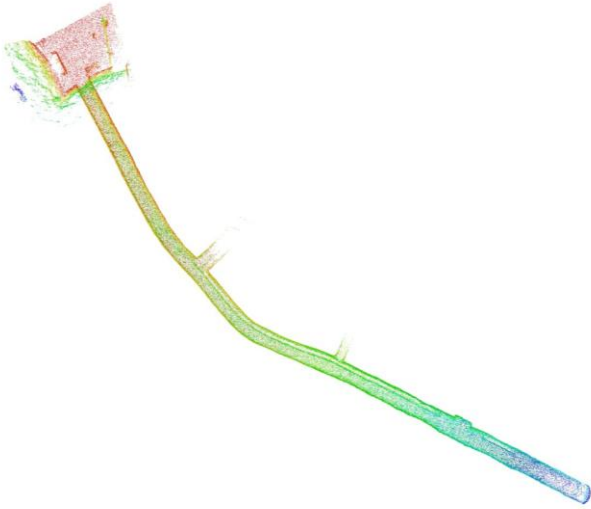


Autonomous exploration execution – Outdoor Point-Of-View

Autonomous Aerial Robots

Tunnel Contruction

- As a result of the exploration, the aerial robot will report the 3D map generated of the tunnel.



Top View of the 3D Map of the tunnel

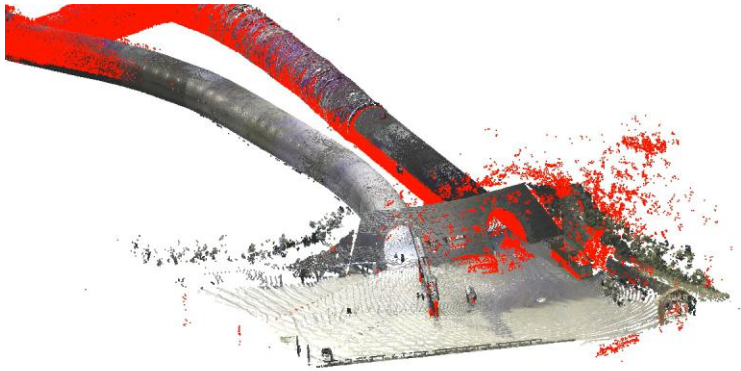


Perspective View of the 3D Map of the tunnel

Autonomous Aerial Robots

Tunnel Contruction

- As a result of the exploration, the aerial robot will report the 3D map generated of the tunnel.



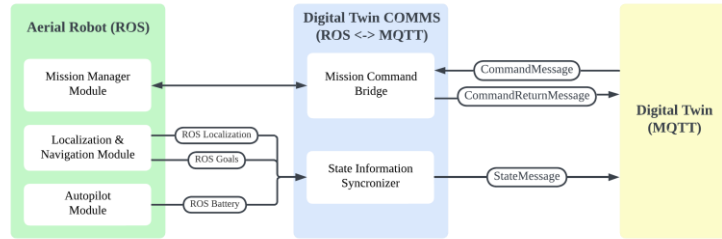
	Classic Method	CATEC UAV
Time taken to create the 3D model	2 days	480 seconds
	Distance between points	Standard Deviation
Quality metrics for the generated 3D model	0.3885m	0.9362m

Comparison between the map produced using traditional methods (coloured) by ACCIONA and the one generated by the UAV (in red)

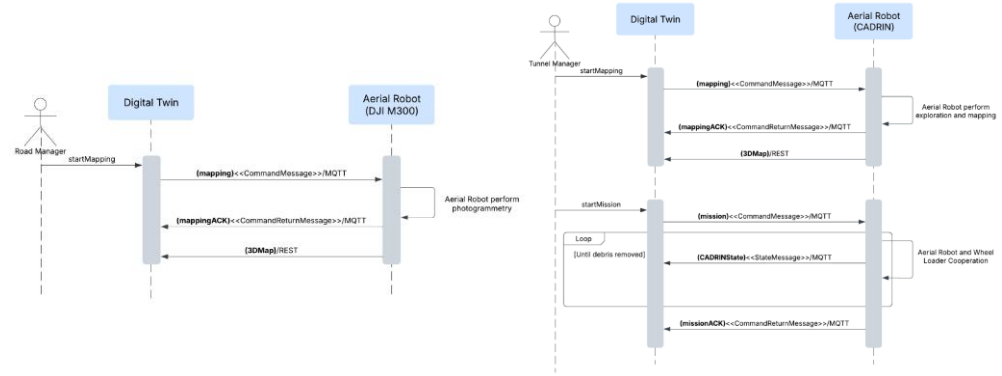
Autonomous Aerial Robots

Digital Twin Integration

- Mission Control & Monitoring → MQTT Communications.
- Upload generated data (maps and recorded videos) → REST-API



Communication Diagram Between Aerial Robots and Digital Twin



Examples of refined UML Communication Diagram (Left: Road Construction; Right: Tunnel Construction)