



Highlights of SAFEDRONE results

Increase safety level of drone operations



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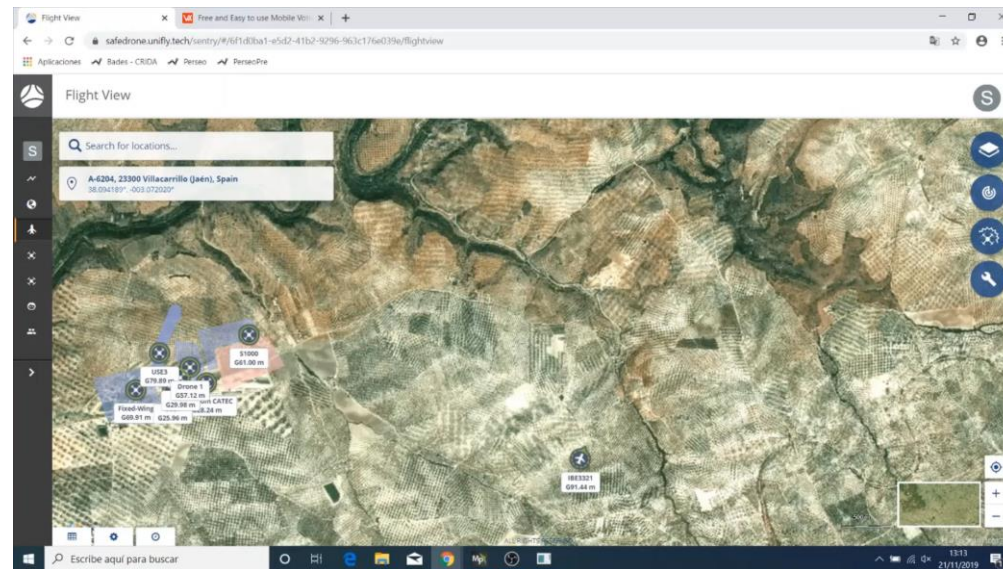
Ensure separation with manned aircrafts

- Separation between drones and manned aircraft is critical for long range flights.
 - Main risk and blocking point for market growth for drone applications in rural areas
 - Low density of people => low ground risk in case drone falls
 - Low density of drone flights => low probability to mid-air collision between drones
 - Risk of a mid-air collision with manned aircraft has to be safely managed
- SAFEDRONE has developed two strategies to ensure separation using U-space:
 - Based on aircraft equipment (ADS-B) or ATC communications.



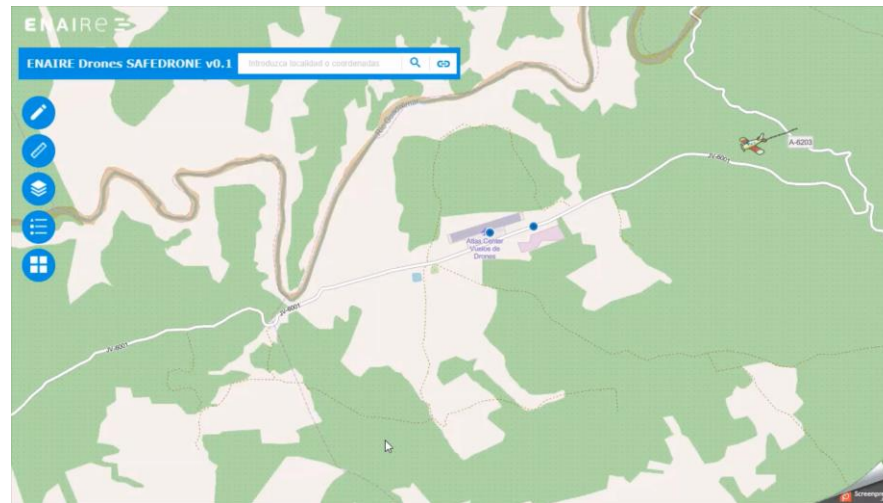
Ensure separation with manned aircrafts

- **When ADS-B is equipped:**
 - **Detection is automatic.**
 - **But a network of ADS-B receivers is needed**
 - **Automatic creation of a geofence surrounding the aircraft.**
 - **Geofence is dynamic (geofence *follows* the aircraft position).**
 - **Drone operators conflicting the geofence receive alerts and instructions.**
 - **Operation is safely performed.**



Ensure separation with manned aircrafts

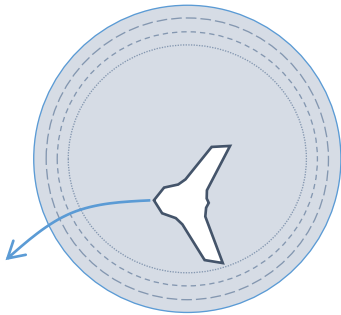
- **When ADS-B is NOT equipped (for example not uncommon in ultralights aircrafts):**
 - If manned aircraft is going to enter Very Low Level (below 500ft) for landing or for an emergency, pilot calls ATC.
 - ATC generates a large area of protection.
 - Geofence is static.
 - Drone operators in the area receive alerts and instructions.
 - Operation is safely performed.



U-space procedure demonstrations

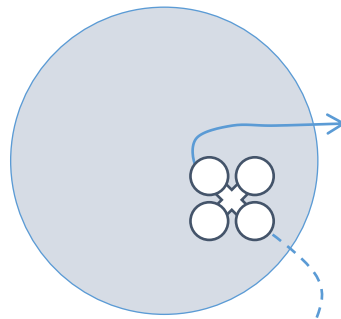
- **Demonstrations of different procedures related to No-Fly Zones (NFZ) under normal U-space operations:**

NFZ activation



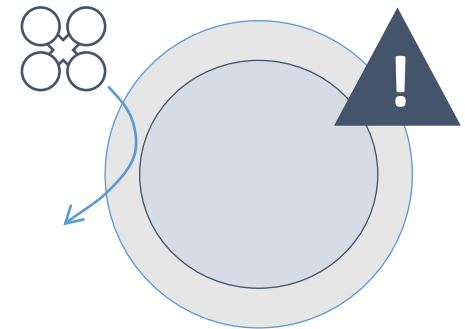
Procedures for leaving a No-Fly Zone which is activated in-flight

NFZ intrusion



Procedures for mitigating unintended intrusion of a No-Fly Zone

NFZ alert distance

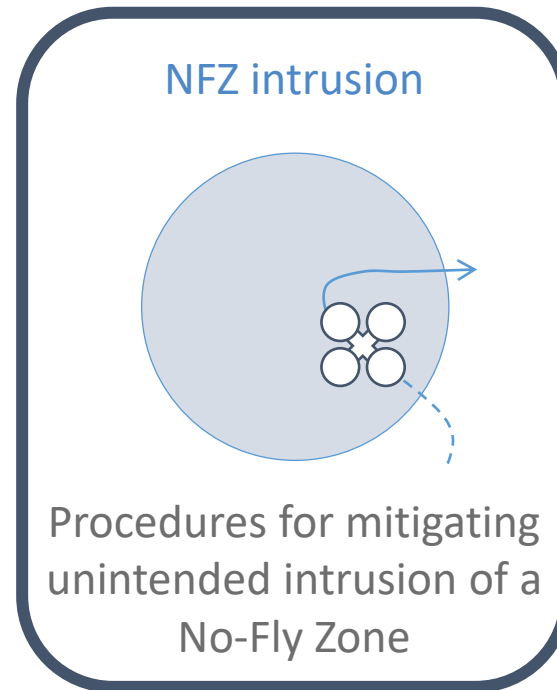


No-Fly Zone avoidance through proximity alerts



U-space procedure demonstrations

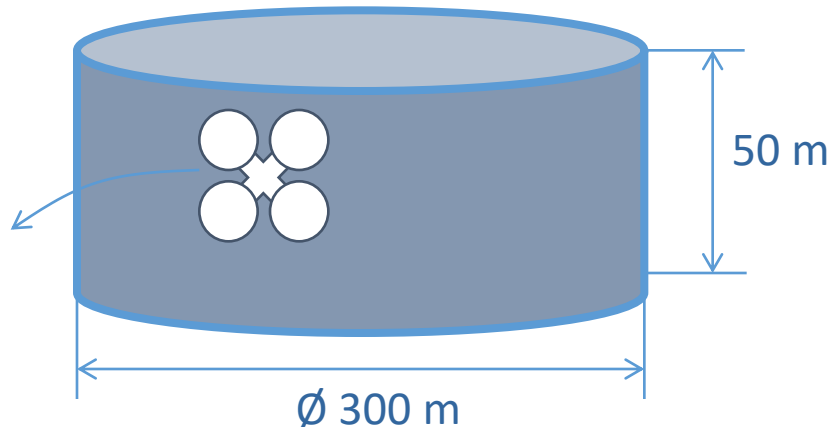
- **Demonstrations of different procedures related to No-Fly Zones (NFZ) under normal U-space operations:**



U-space procedure demonstrations

No-Fly Zone intrusion (1/2)

- Testing of procedures to leave No Fly Zones which were inadvertently flown into.
- Focus on different recovery methods:
 - Manual flight: manual take-over of controls
 - Return To Launch: use of the RTL function
 - Waypoint: placement of additional waypoint for the drone to navigate to

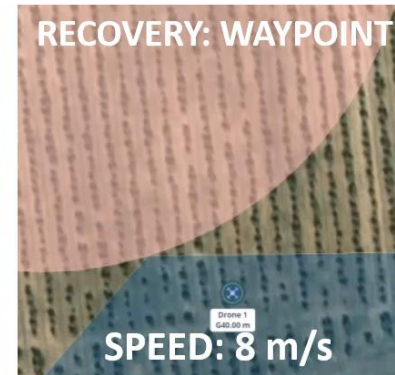
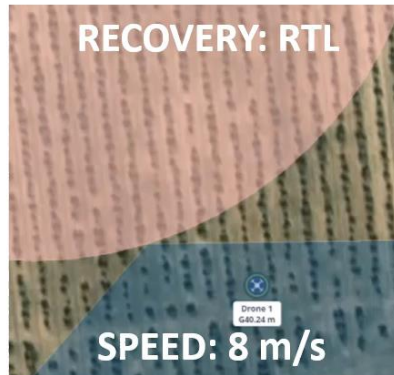
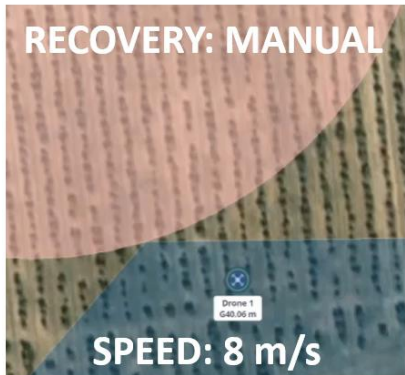
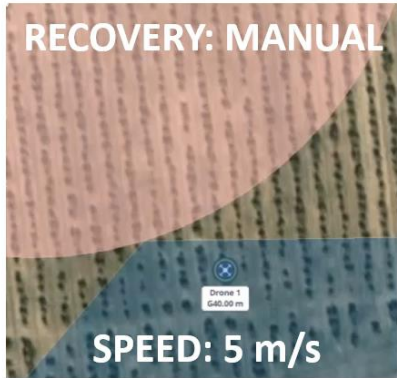


Test Parameters	
Drone type	Multi rotor
Flight altitude	40m
Speed	5 m/s - 8 m/s
Flight execution	Guided
Manoeuvre	Guided, Manual

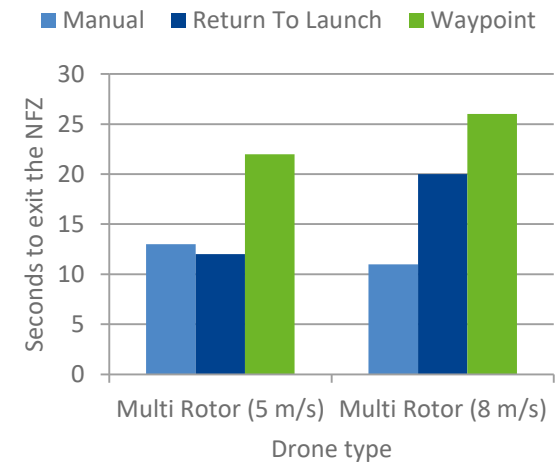


U-space procedure demonstrations

No-Fly Zone intrusion (2/2)

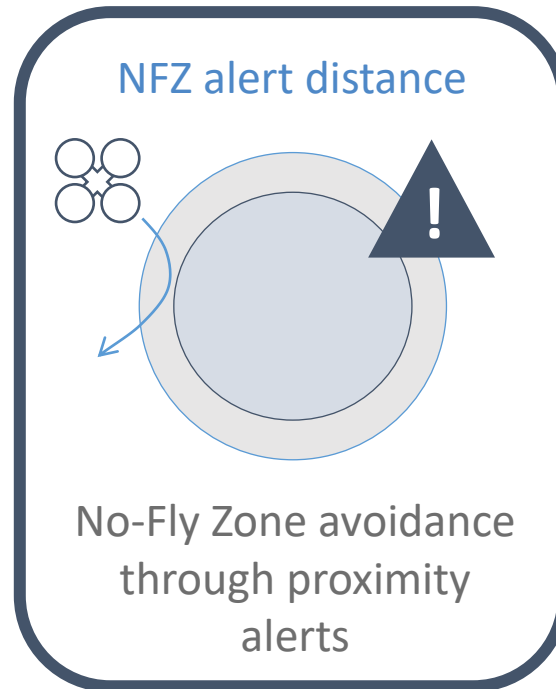


NFZ intrusion results



U-space procedure demonstrations

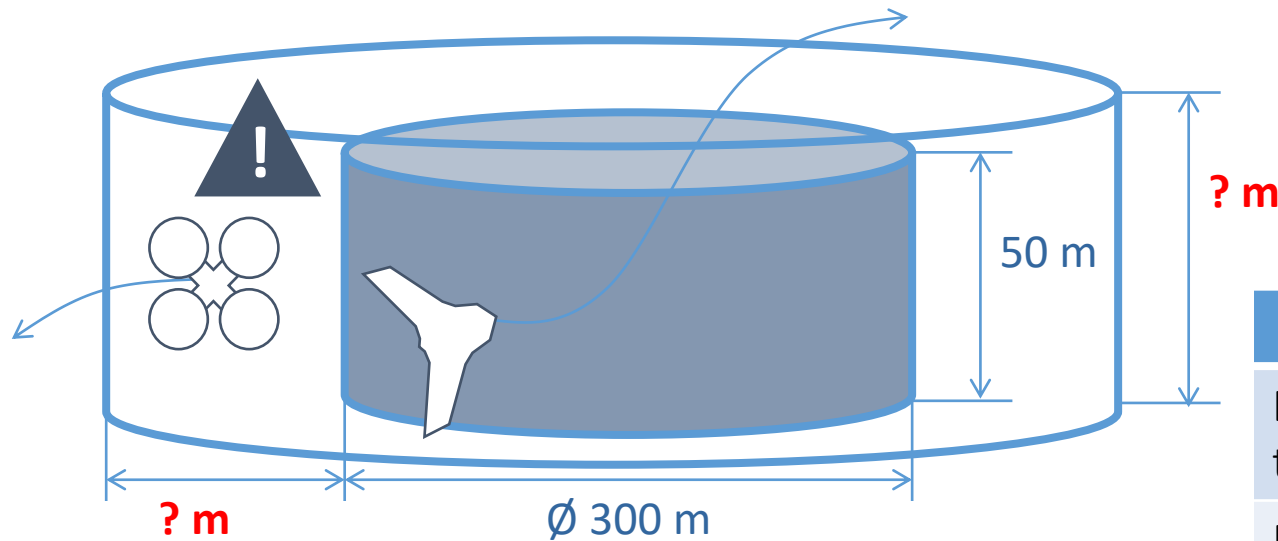
- **Demonstrations of different procedures related to No-Fly Zones (NFZ) under normal U-space operations:**



U-space procedure demonstrations

No-Fly Zone alert distance (1/2)

- Testing of procedures to avoid entering circular No Fly Zones with additional “alert buffer zones”.

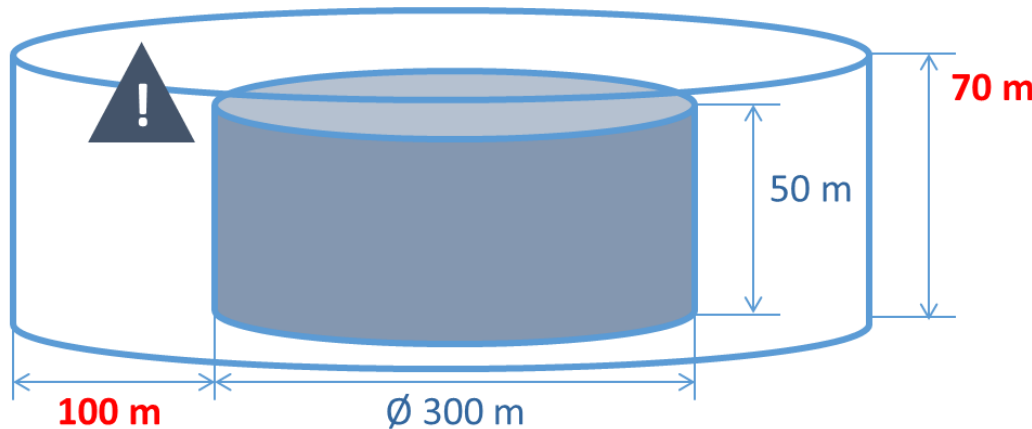


Test Parameters		
Drone type	Fixed wing	Multi rotor
Flight altitude	30m	30m
Speed	12 m/s	8 m/s



U-space procedure demonstrations

No-Fly Zone alert distance (2/2)

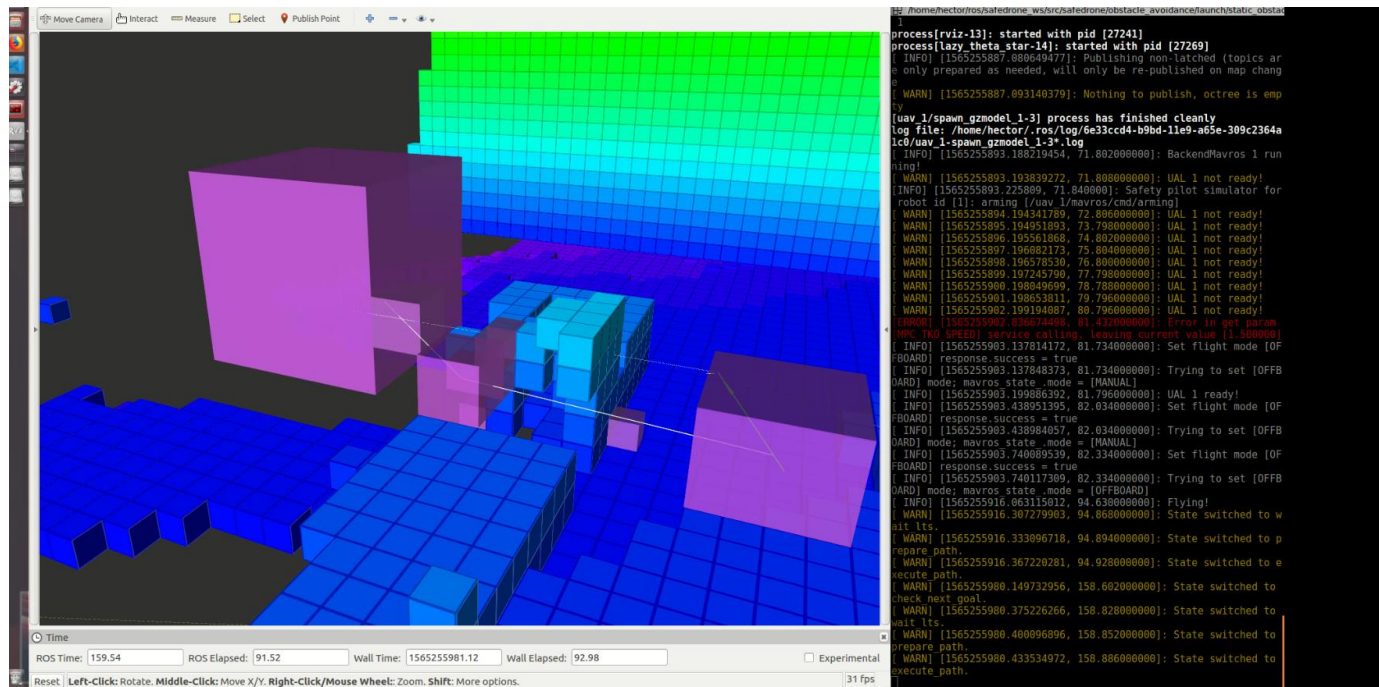


- A total of 16 individual runs were performed to test:
- Horizontal avoidance: avoid the NFZ via a horizontal turn whilst maintaining altitude.
- Vertical avoidance: avoid the NFZ via a vertical climb

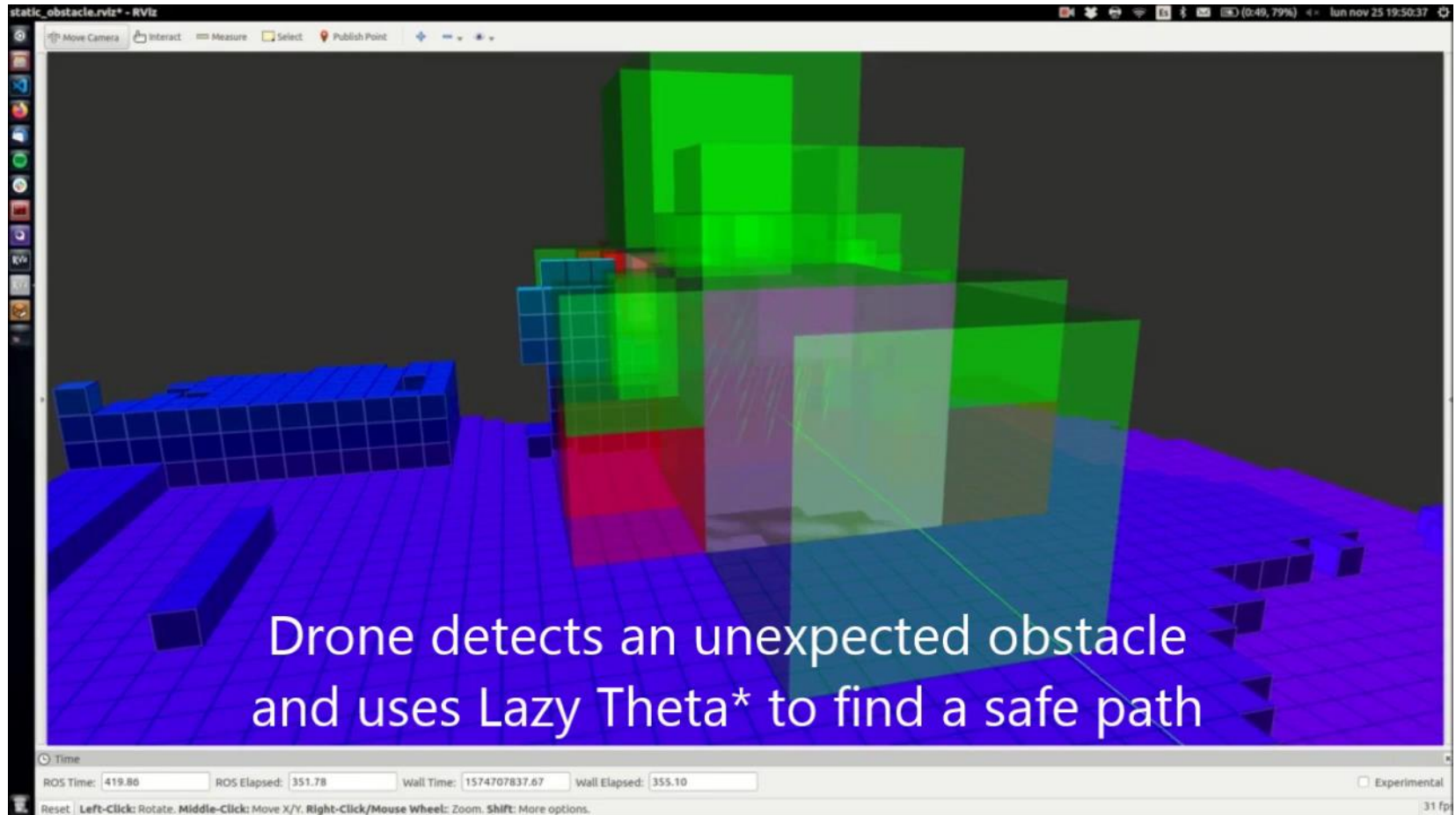


Detect and avoid of unexpected obstacles

- Integration of DAA within U-space solution (UNIFLY)



Detect and avoid of unexpected obstacles



Conclusions

- **SAFEDRONE has developed strategies to ensure separation between drones at VLL and manned aircrafts (general aviation and sport aviation), considering:**
 - Aircrafts equipped with ADS-B
 - Aircrafts NOT equipped with ADS-B
 - Through ATC communications
- **Experiments performed to gain experimental insights about U-space procedures with respect to No Fly Zones:**
 - A. NFZ activation
 - B. NFZ intrusion
 - C. NFZ alert intrusion
 - A. 100m horizontal alert distance
- **Non-cooperative DAA of unexpected obstacles and integration with U-space services**





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