POLITECNICO DI TORINO

DIPARTIMENTO DI INGEGNERIA DELL'AMBIENTE, DEL TERRITORIO E DELLE INFRASTRUTTURE - DIATI

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Measurements of the RF Antenna pattern using a Unmanned Aerial Vehicle (UAV): test and results

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Overview

- UAV – Introduction
- Hexacopter – Our Experience
- How to do the measurements?
- Test and Results
- Conclusions

UAV – What is this?

An unmanned aerial vehicle (UAV), called drone, is an aircraft without a human pilot onboard.
Its flight is either controlled autonomously by computers in the vehicle, or under the remote control of a pilot on the ground.

There are several types and models of UAV, with are different for:

- **size**
- **range of flight**
- **weight**
- **type of vehicle (plane, helicopter, etc)**
- **payload**
- **duration of the flight time**
- **purposes**
- **type of TOL**
- **…**

UAV – Hexacopter experience

The geomatic group in 2010 has decided to bought a new low cost UAV system, but with a different structure: Hexacopter.

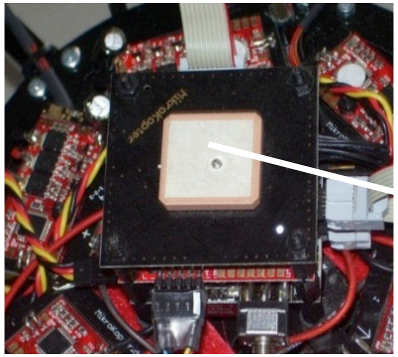
GPS-board Mikrocopter KGPS ver1.0 equipped with the u-blox 6S sensor.

http://www.mikrokopter.de

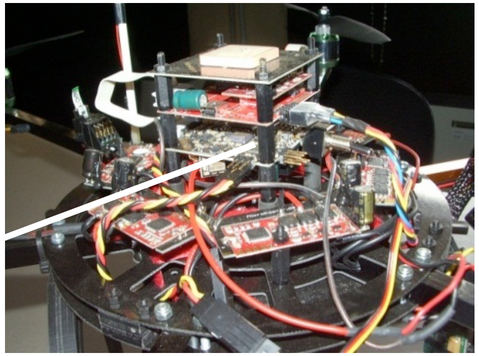
This is a commercial solution, where the single parts will be mounted by a ourselves. Engines and some electronic parts have been modified.

- **low cost (< 2500€)**
- **transportability**
- **no expert pilot is required**
- **no runways are required**
- **vertical and standing flight are allowed**
- **time of flight (5-15 mins)**
- **no autonomous TOL**

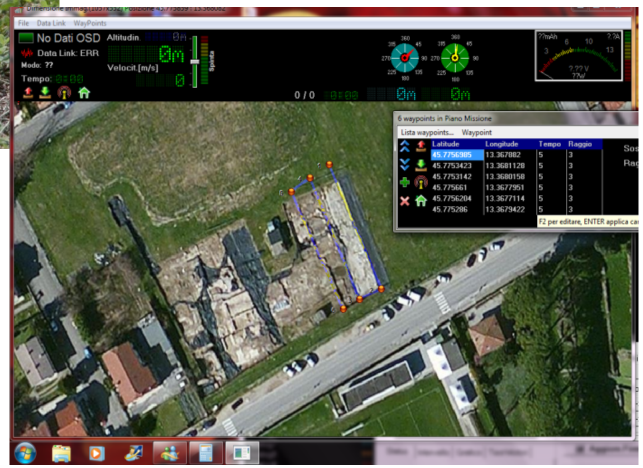
UAV – Hexacopter experience



GPS antenna



Navi control
(gyro, accelometers)



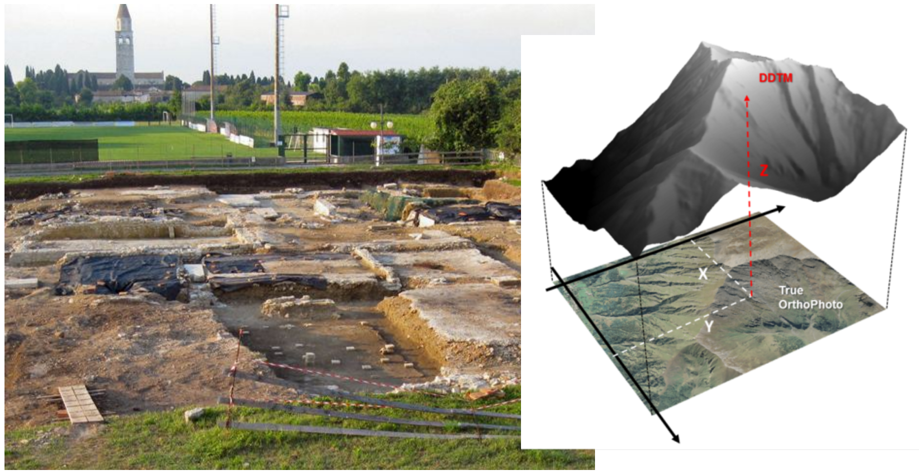
The UAV is able to do an autonomous fly, but the landing and take off have to be manually realized.

This system has a payload up to 1 kg, and an autonomy about 8-10 minutes (depends on the battery). ⇧ **payload** ⇩**duration of fly**

UAV – Hexacopter experience

Our purpose was to use this UAV for photogrammetric applications. On the UAV bottom, a no-metrical camera (but calibrated) was housed and a dedicated support was used in order to preserve the camera attitude.

For example, this system over an archeological area has been used, in order to extract Digital Surface Model (DSM) and orthophothos.



Geomatics group and IEIIT

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AIMS

Know-how

According with IEIIT request (measurements of RF Antenna pattern), the UAV has been modified for this purpose.

Hexacopter for measurements of RF Antenna pattern

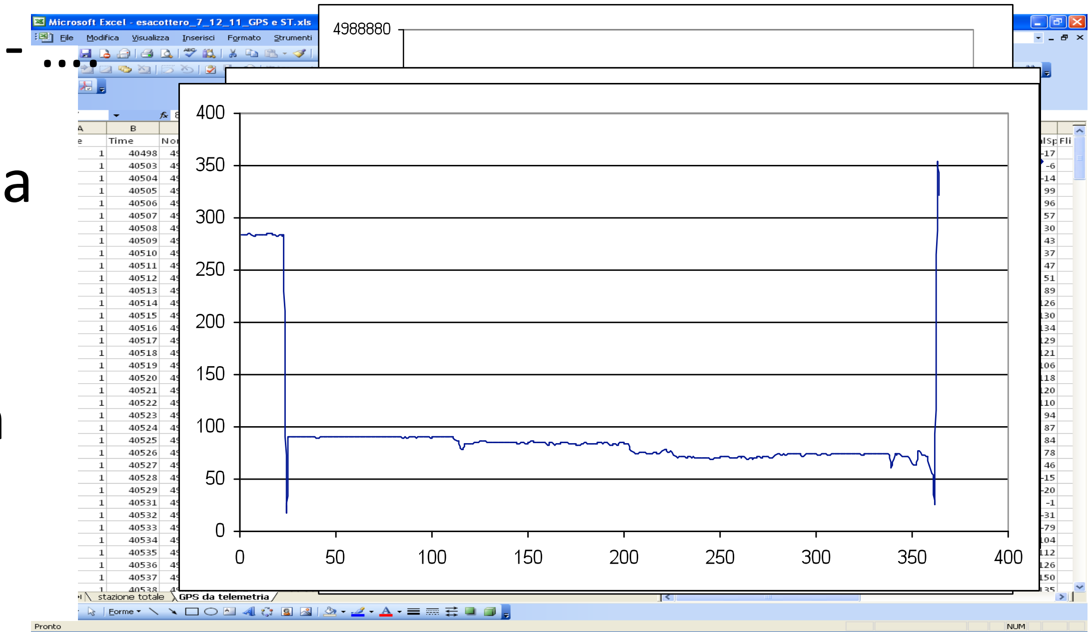
Skids: the metallic parts were removed to avoid interference, and they were substituted with wooden skewers.

Camera: it was removed and a dedicated antenna (Bow-tie dipole antenna) was housed .

Hexacopter for measurements of RF Antenna pattern

The UAV acquires several data in the internal memory, as:

- Position (in PVT)
- # Satellite
- Attitute (roll, pitch, yaw)
- Voltage
- ....

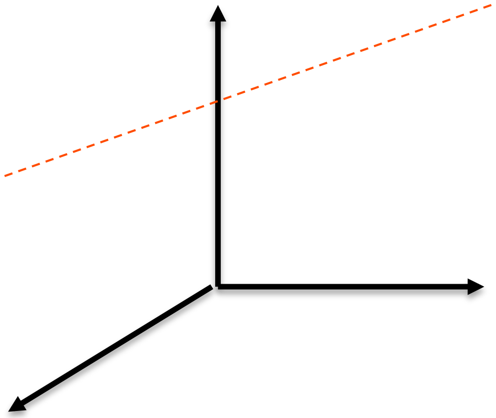


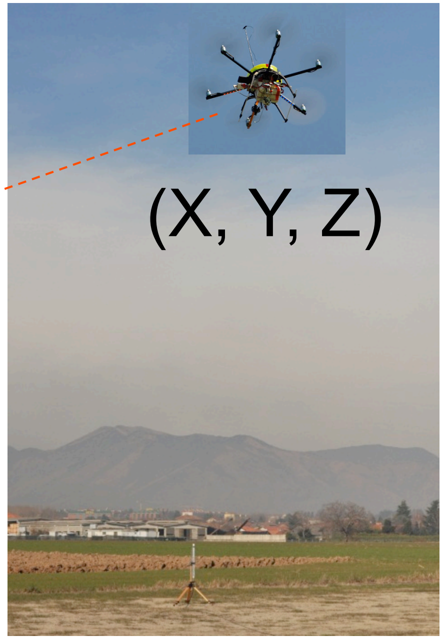
The position of UAV is controlled by means the internal GPS, with a metrical accuracy. In order to increase the accuracy and precision of the UAV position, an alternative method has been adopted.

UAV position: an alternative solution

In order to define the absolute position of the UAV, a topographic tracking has been realize using a motorized total station (MTS). It was possible thanks to a dedicated retroreflector installed on the bottom of the UAV.

The real position is defined by means MTS with a rate ≅ 3-6 Hz.



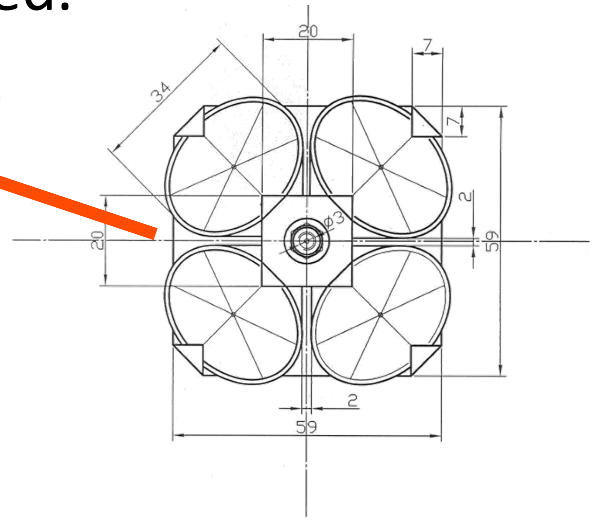


Leica TPS 1200+, TCRP 1201 - R300

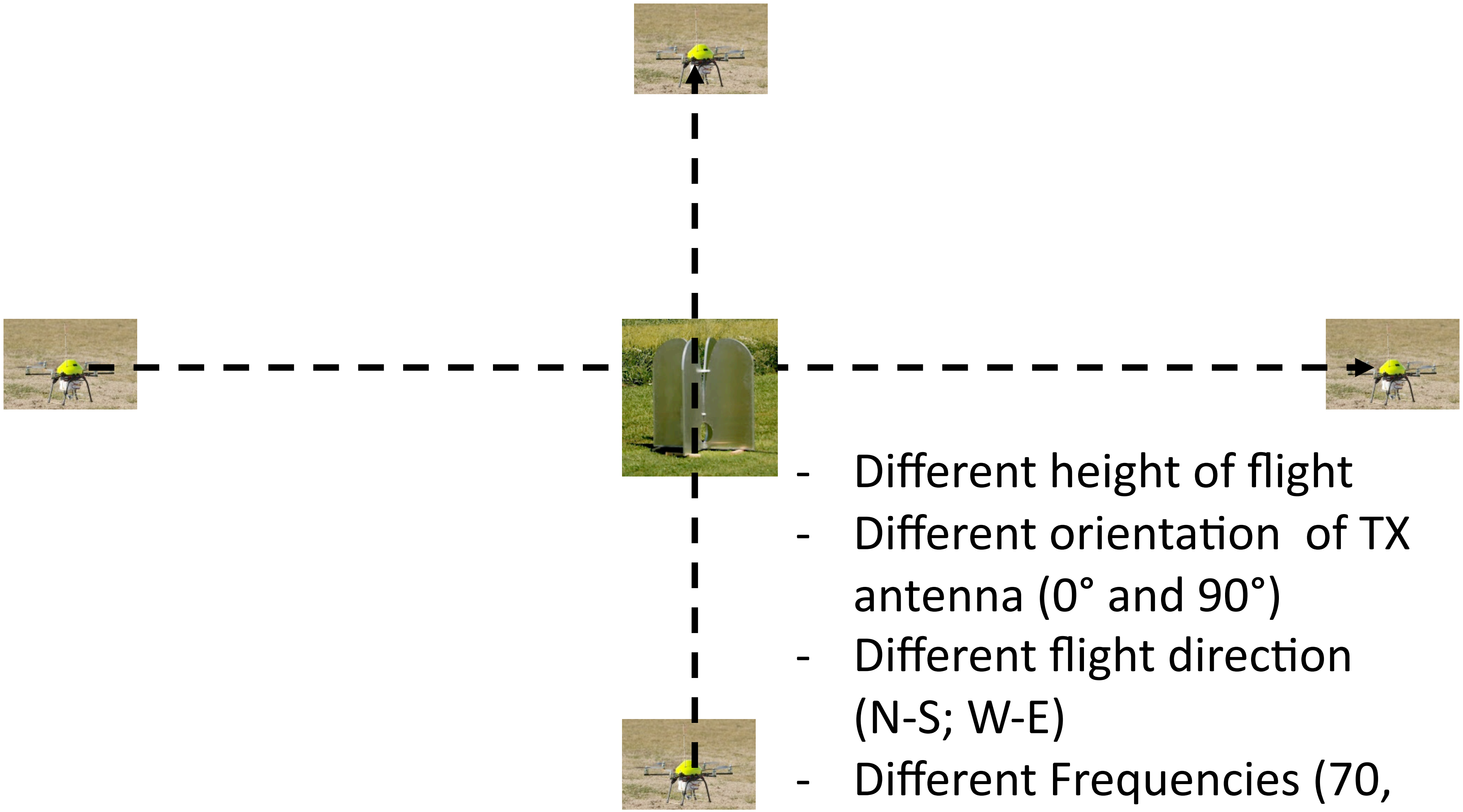
nominal distance and angle accuracies of 3mm + 1.5ppm and 1 arcsec, respectively, within a 1 km operative range

UAV position: an alternative solution

The pyramid of retroreflector has been designed and realized by ourselves, in our laboratory. Using 4 topographic retroreflector, a dedicated support and system has been realized.



UAV – Flight strategies

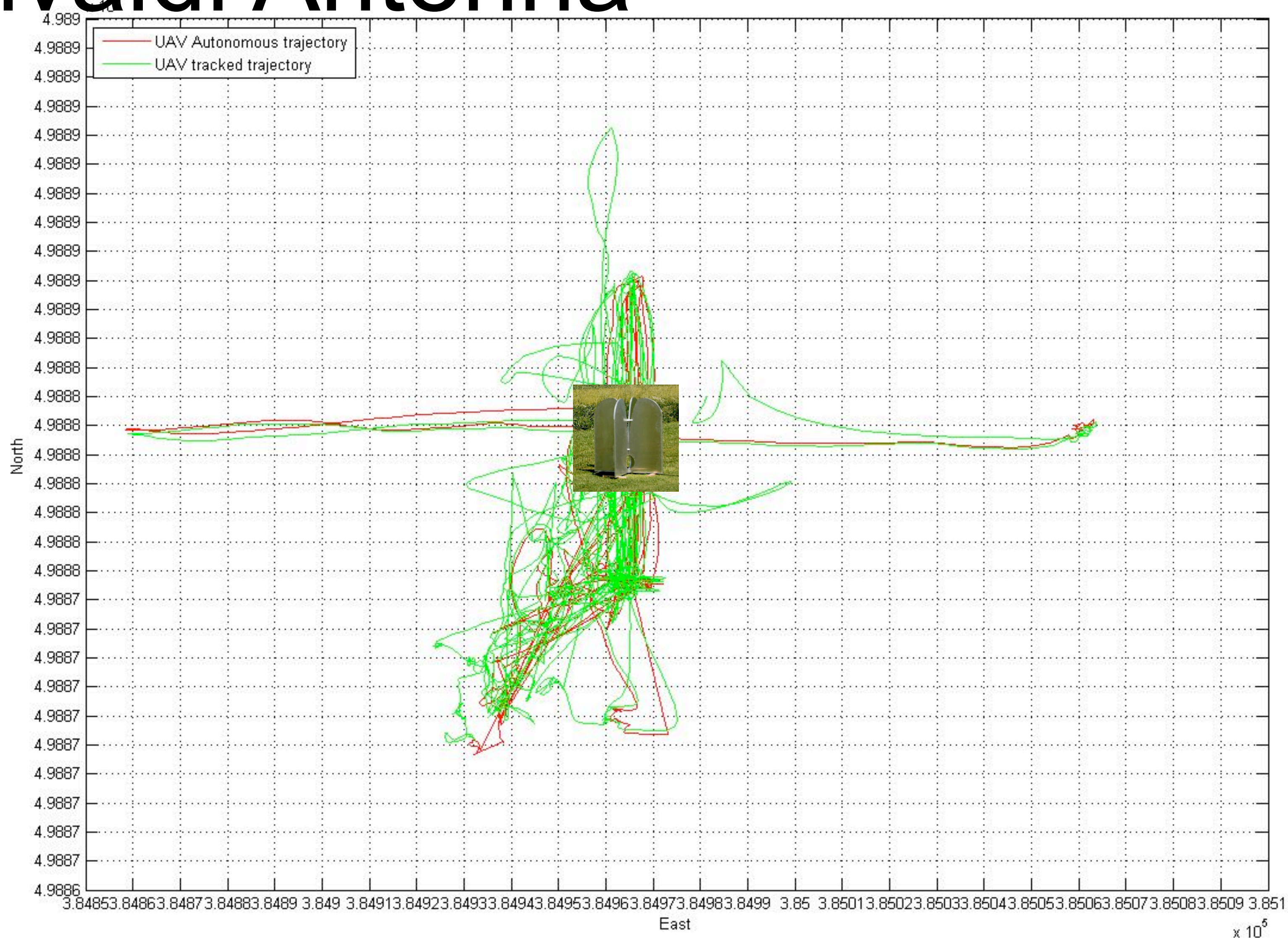


- Different height of flight
- Different orientation of TX antenna (0° and 90°)
- Different flight direction (N-S; W-E)
- Different Frequencies (70, 150, 300 and 450 MHz)

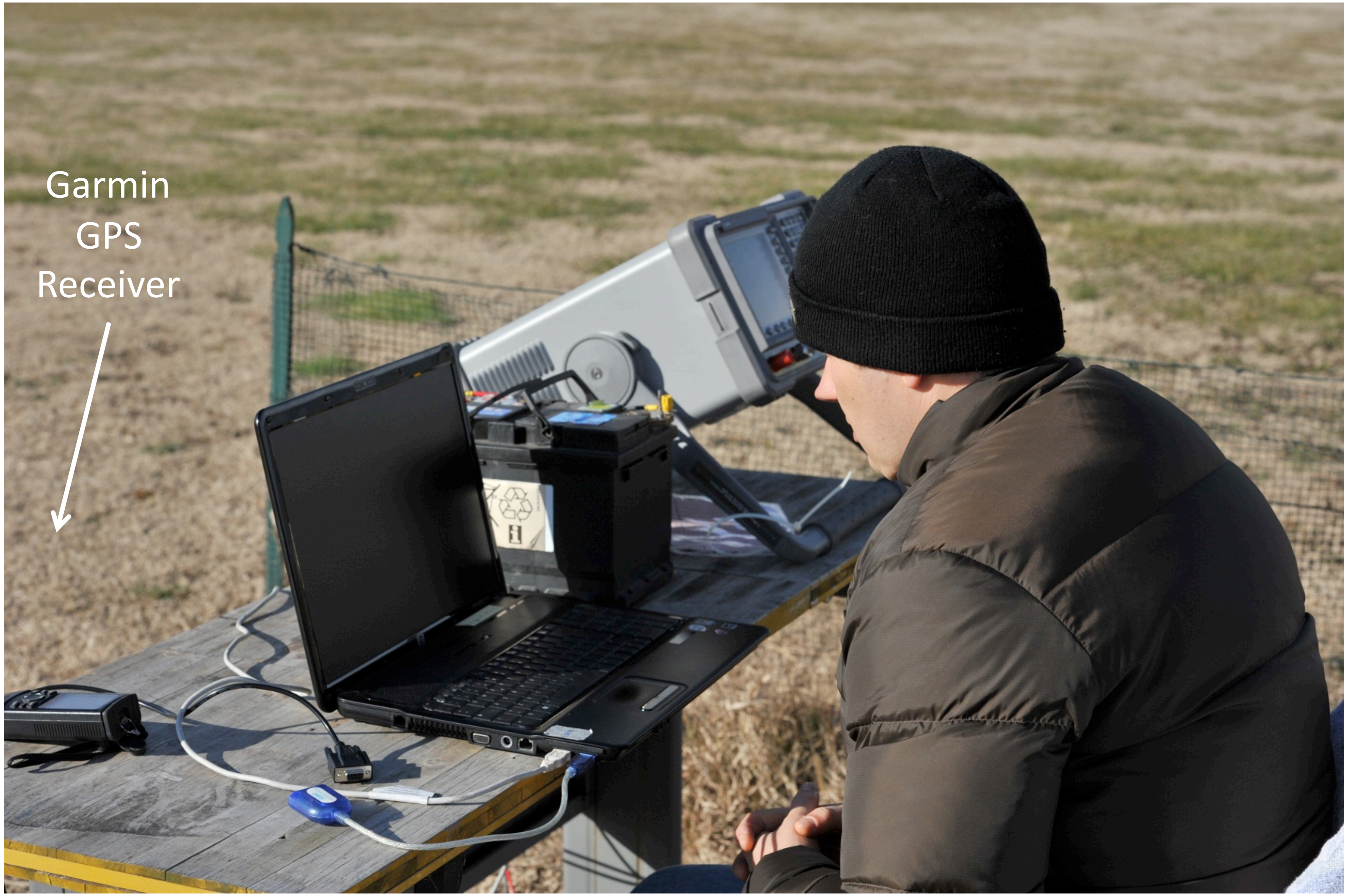
UAV – First test and results with Vivaldi Antenna

A calibration of the system (gyro, accelerometers and compass) is needed in order to improve the quality of autonomous flight and the UAV trajectory.

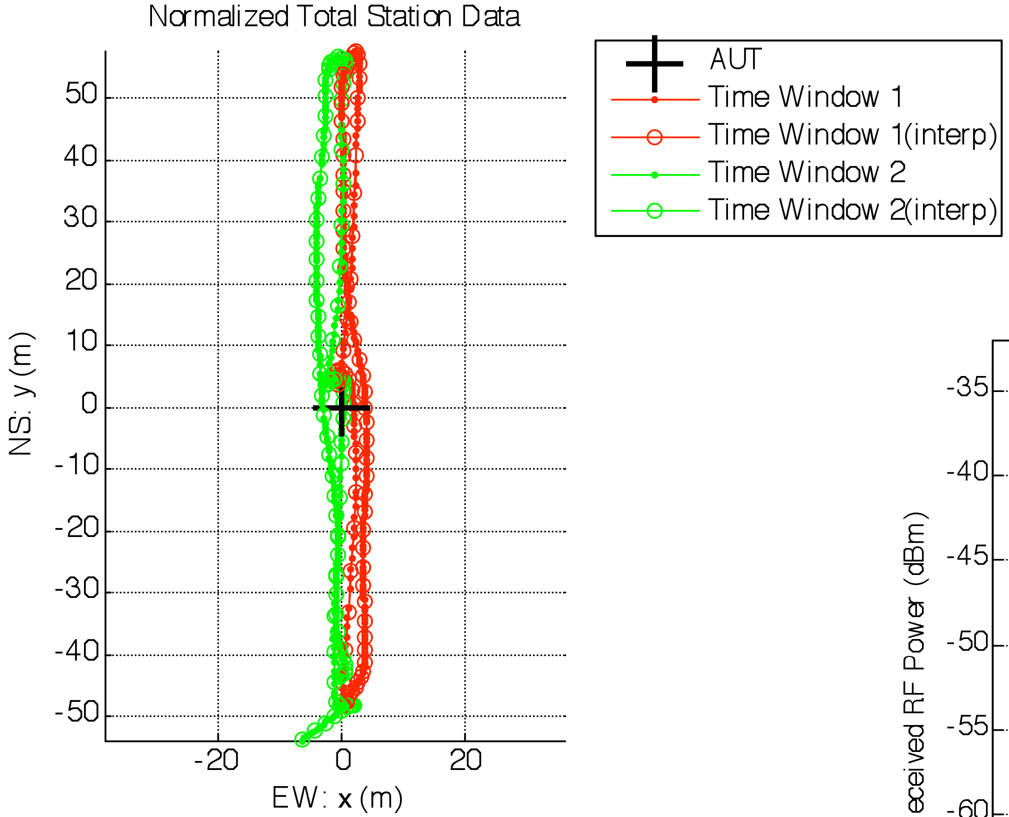
UAV – First test and results with Vivaldi Antenna



UAV – First test and results with Vivaldi Antenna

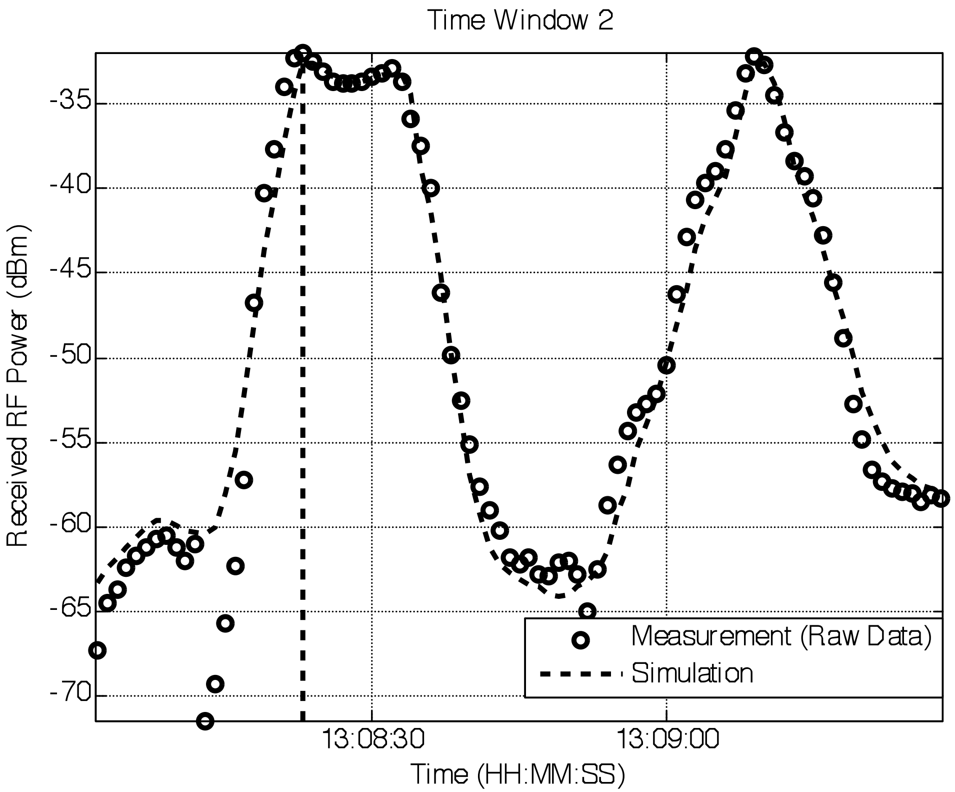


UAV – First test and results with Vivaldi Antenna



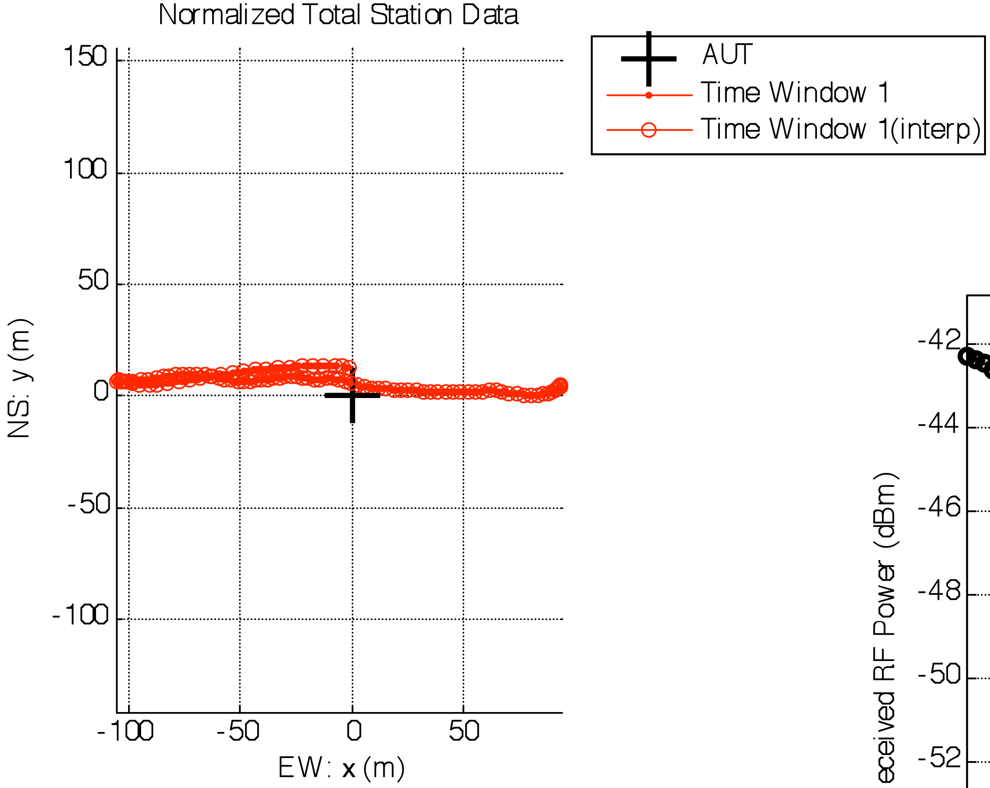
Quasi E-plane scan

Height ≅ 27 m



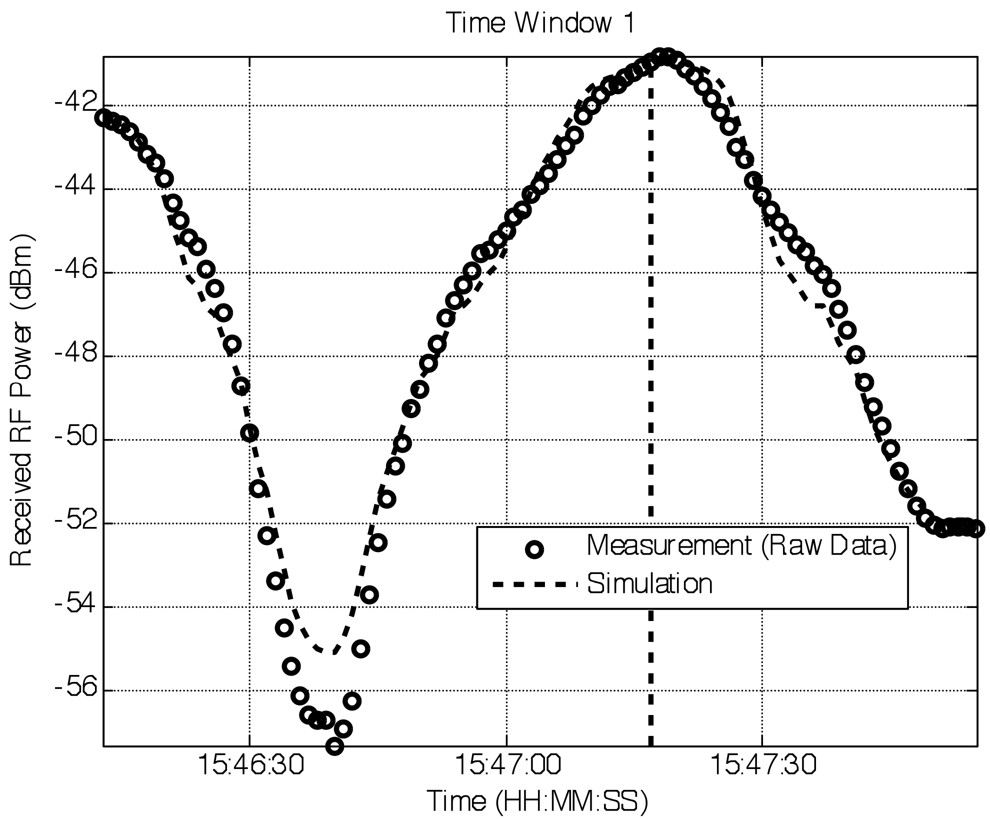
Fitting of the RF Data with Simulations : Antenna over Soil C (5 m cube)

UAV – First test and results with Vivaldi Antenna



Quasi H-plane scan

Height ≅ 60 m



Fitting of the RF Data with Simulations : Antenna over Soil C (5 m cube)

Conclusions

At the moment, this solution has carried out encouraging results, but more work have to be done.

In particular the research has to be focused on:

- **Obtaining an autonomous solution without MTS, using a dual frequency GNSS receiver.**

- **Improvement of the quality of electronic integration between the sensors.**

- **Developing a system devoted to assist the pilot during the flight (comparison of position with respect the alignment).**