Aerial Sensing Platform for Automated Detection of Atmospheric Gases

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Motivation

Measurments of trace gases such as methane, ammonia, and CO_2 are an important part of determining greenhouse gas and pollutant concetrations in the atmosphere. To reduce the impact gases have on the environment sources and sinks of gas must be discovered and dealt with accordingly. Unfortnatly, stationary measurements alone do not paint an accurate picture of emissions. Spatial and temporal measurements are necessary in order to truly understand sources and sinks of gas.

Overview

In order to take spatially and temporally accurate measurements, a platform that can move precisely in latitude, longitude, and altitude is necessary. With a mobile platform a three dimensional picture of an emissions plume can be created by using point measurements taken across an area. An example of this is shown in the figures below.

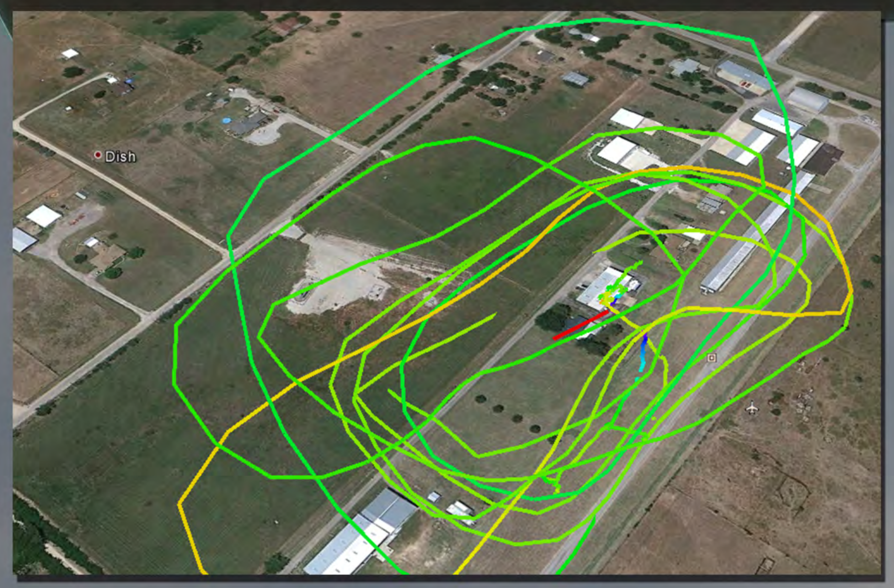

Fig 1. A trail of methane measurements created using point measurements from a aerial mobile sensing platform in Dish, Texas
Amir Khan - Princeton University

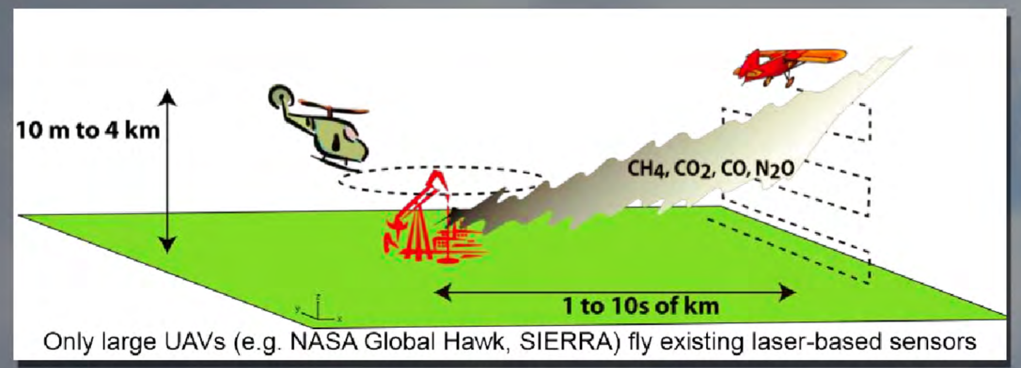

Fig 2. Sample flight patterns through a plume of trace gas emissions.
Mark Zondlo - Princeton University

Requirements

To function well as trace gas measurement platform the system must be able to:
- Carry an **8lb payload**
- Operate in sessions of at least **15 minutes**
- Be compact enough to fit in a **3' x 5' x 8'** box
- Take precise **spatial and temporal measurements**
- Be able to provide at least **100 watts** of power for the duration of each session

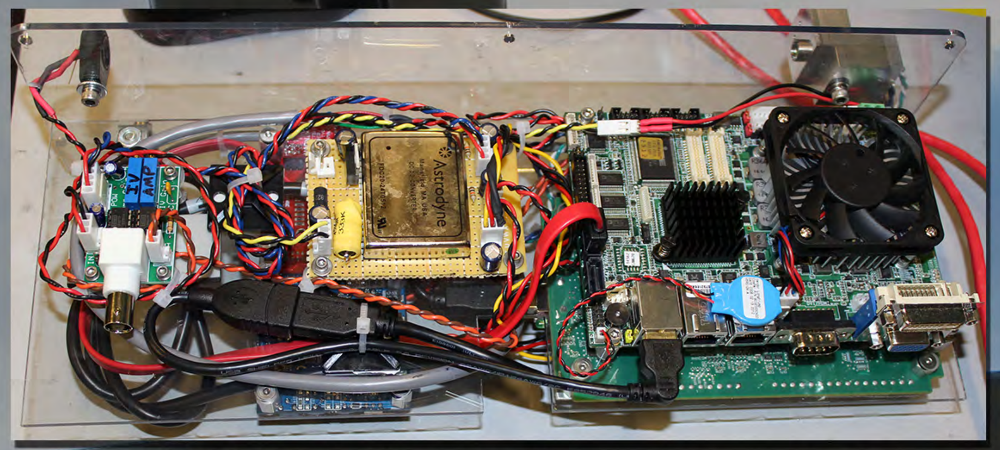

Fig 3. VCSEL based water vapor sensor used as a sample payload, The payload weighs about 3 lbs and records 1Hz water vapor measurements on a solid state drive. It receives it's power from on-board aircraft batteries.

Design Decisions

An airplane was chosen as the basic platform for the project. Fixed wing aircraft can carry large payloads, are more energy efficient than multi-rotors, and are more compact than lighter-than-air craft.

Fig 4. A 1m wingspan piper cub model used in preliminary platform tests. This model was used to prototype autopilot functions.

Construction

In order to create a more stable platform that can fly accurate grid patterns, an autopilot was integrated into the aerial platform. The autopilot was tested in a small airplane platform before being integrated into larger airframes. First the model plane shown in figure 4 was constructed and tested for flight worthiness. Once the platform was satisfactory for manual flight an autopilot was installed and tested. This created a basic procedure that could be followed while constructing the larger platforms seen in figures 6 and 9. Unlike the smallest platform, which was flight ready from purchase, the larger planes needed to be assembled before they could be flown.

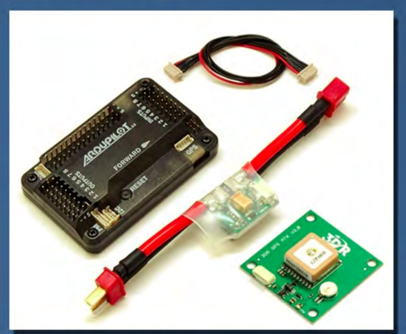

Fig. 5 APM 2.5 autopilot used to stabilize the airplane platform, and navigate between points in a grid.

Fig. 6 Medium sized 2.2m wingspan X8 platform.

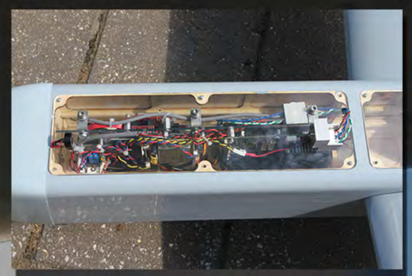

Fig. 7 Test electronics installed onto the Hugin platform.

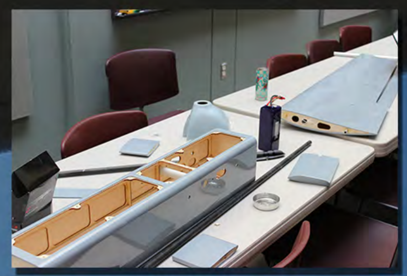

Fig. 8 Unconstructed Hugin fuselage

Fig. 9 Large 2.6m wingspan Hugin platform

Conclusion

Hugin
- -Largest payload capacity and volume
- -Stable flight in winds
- -More speed is needed for flight than other planes

X8
- -Also has a large payload capacity
- -less payload volume than Hugin
- -Easiest to assemble

Super Cub
- -Easiest to fly
- -Unstable in wind
- -Very Low Payload Capacity

Fig 10. Hugin platform mid-flight

Future Work
- -More Care Should be taken when measuring the plane's center of gravity
- -Landing gear should be reinforced for takeoffs and landings from grass runways
- -Larger motor for faster takeoff

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