Remote Operated Sample Extraction ROSE

Introduction

Project ROSE began when the Desert Research Institute's (DRI) cloud seeding weather modification (WxMod) team found the need for a remote sampling device. The system has been built for the cloud seeding team's specific needs, but can be adapted to other fields in the future to reduce risks taken by field researchers during all types of sample collection.

Overview

We aimed to create a reliable, remote operated, sample collection system to be deployed via UAV into areas that pose a potential risk to personnel. The system collects a snow sample via drop tube and retrieves the sample using a payload wench. The system has been built as a research tool for the cloud seeding project for which they use it to measure the levels of silver compounds present in precipitation cycles. This tool can help reduce the risks associated to field personnel and on-site sample collection. This device helps the Reno DRI WxMod crew verify the effects of their cloud seeding, proving its use. In the future this technology can make all sorts of sampling that was previously impossible, possible. Possible applications are samples of ocean water, high mountain snow , soil in remote regions, and many more.
The device was developed by the ROSE team, three college students and recent graduates, with assistance from the WxMod crew and advice from industrial engineers.

Method

Using what was learned from market research, we began by breaking down the problem into 3 sections: deployment, sample acquisition, and retrieval. After some deliberation and input from the WxMod team it was determined that the system would drop a hollow cylinder mounted from underneath the UAV. The force of impact would fill the drop tube with snow and the sample could be recovered using a winching system mounted to the chassis of the UAV. The sample tube needed to be able to accomplish three objectives: collect a recommended sample size of 100mg, collect reliably, and protect against sample contamination. 2" stock steel tubing was selected to act as the fuselage because it could get a big enough sample, be easily sterilized, and would carry enough inertia to reliably collect a sample. Next we designed tail fins and a nose cone for the tube so that it could be dropped straight and recover a sample. The nose cone was made from 6061 aluminum and had a silicone duckbill one way valve inside to contain the sample after collection.

The winching mechanism is a modified fishing reel powered by a DC motor. We opted for a 2-1 belt drive to span the distance from the crank to the motor. The fishing reel itself has a 5-1 gear reduction to increase torque on the bobbin. The reel release was designed to be servo activated and the bobbin ratchet was reactivated during retrieval. An servo activated emergency release was also added to the body of our winching mechanism so that the sample line could be cut if the tube got caught and was unable to be retrieved. The Matrice 600 has a payload capacity of about 13lbs in static conditions so it was assumed that the tube could be dropped and recovered with a 30lb braided fishing line.

Results

Our current prototype system is still in development and has not completed a successful retrieval in the field. The system went through 2 rounds of lab testing and one round of testing in the field. Deployment and collection were successful, the UAV can be piloted to the target area to deploy the sample tube remotely. The sample tube also had a good collection rate. We conducted multiple drop tests from 25ft, 50ft, and 100ft. At 25ft the tube struggled to gain balanced flight and collected snow 50% of the time. At 50ft the tube achieved a more stable drop and had successful collection at a rate of 60% and from 100ft collection rate declined to 25% from our drop tests. There were no malfunctions in the drop mechanism or the sample collection tube at any point during testing.
Currently, the prototype struggles to produce enough torque to retrieve a fully loaded sample tube. We learned from tests that our current model needs a bigger motor or larger gear reduction to achieve a successful recovery. Cutting weight from the drop tube or using a smaller diameter could allow for better efficiency.

Conclusion

Although we were unable to complete a fully functional snow retrieval system, good preliminary prototyping was completed. The current system may not fulfill the complete mission objective but within a few iterations the outlooks is good. Things to look forward to with future designs is streamlining the device increasing torque and reducing weight also improving accuracy and collection rates.