THE FLOAT MISSION: PROMOTING TEAMWORK IN THE CLASSROOM

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Near space begins at an altitude of approximately 20 km and extends to the Kármán line at 100 km, where space is commonly accepted to begin. Weather balloons are capable of carrying small scientific payloads into near space, reaching stratospheric altitudes in the order of 30 km, and are a relatively cheap method of conducting experiments in space-like conditions. The Royal Military College of Canada (RMCC) recently incorporated a high altitude balloon mission into the Space Mission Analysis and Design (SMAD) course with excellent pedagogical results.

In 2009 the RMCC was approached by Defence Research and Development Canada (DRDC) with a research proposal : Can Automatic Dependent Surveillance - Broadcast (ADS-B)[1] transmissions be detected from near space? A potential solution for the accurate surveillance and tracking of aircraft anywhere in the world is through the monitoring of aircraft-transmitted ADS-B signals using satellite-borne receivers. An experiment demonstrating that ADS-B signals can be received in near space, well above commercial air traffic, would be the first step in developing a space based system.

In response to the DRDC proposal, RMCC space science students set out to design a high altitude balloon experiment that would investigate the reception of ADS-B signals in the near space regime. The ADS-B mission became the focus of the SMAD course, in which undergraduate and graduate students work as a team to design a unique space mission. The ADS-B experiment represented a significant change in philosophy from previous years, but it was decided that a stratospheric balloon mission would incorporate many of the same considerations that go into a satellite mission.

1. Payload: Commercially available ADS-B receiver / Aircraft updates provided once per minute
2. Communications: Radio downlink for payload data and balloon status, including position, altitude, as well as internal and external temperature
3. Navigation: Pre-launch track estimation / Continuous positional update to air traffic services / Balloon tracking and recovery
4. Data Handling: On-board computer / Data storage / Data downlink
5. Thermal control: Mitigate internal heat generated by electronics and stratospheric external temperatures as low as -60º C
6. Electric Power System: Power availability and distribution to payload and sub-systems
7. Attitude control: Ensure proper antenna pointing for payload, communications, and navigation (GPS)
8. Launch/Propulsion: Self-bursting meteorological balloon filled with helium
9. Structure: Overall mass not to exceed 3 kg / Withstand parachute landing / Watertight
10. Test and Evaluation: Assess airworthiness of balloon components prior to launch / Test descent parachute / Temperature and vacuum chamber testing
11. Operations: Balloon safety/Adherence to NAV CANADA regulations for unmanned balloon flights / Payload retrieval upon landing/Post flight data analysis
12. Ground Control: Launch site preparation / Data reception / Position monitoring

Between January and April the student team designed a mission called the Flying Laboratory for the Observation of ADS-B Transmissions (FLOAT). As in previous years, the course ended in April with a preliminary design review (PDR) of the mission. But unlike satellite missions, which cannot be developed, built and launched in an academic year owing to time and cost constraints, a balloon mission is achievable. Although the course was finished at the conclusion of the PDR, the class of 2009 set out to construct and launch FLOAT. With a budget of $2,000 the students purchased the materials and spent many hours during May integrating the components and testing the FLOAT payload.

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1. For those unfamiliar with the aviation industry, ADS-B is an alternate method to radar surveillance in which aircraft transmit their identity and GPS-derived navigational information. ADS-B messages are broadcast approximately six times per second on 1090 MHz with a transmitting power that ranges between 75 and 500 W, depending on the airframe. The ADS-B signals are received by ground stations and then relayed to air traffic services where this information is used to track aircraft with radar-like precision. Current radar surveillance cannot track aircraft over the ocean or remote areas, requiring air traffic to use inefficient procedural techniques to provide separation. Provision of continuous surveillance in this airspace would not only enhance air safety, but also allow aircraft to follow more direct routes, saving fuel and reducing engine emissions.

Fig. 1 FLOAT is shown a few minutes after launch. During the 2.4 hour flight all ADS-B equipped aircraft within a 200 km radius of the balloon were detected. A total of 2,076 unique messages were received by the payload.

On 26 May FLOAT-1 was launched from Wingham, Ontario near the eastern shore of Lake Huron. Unfortunately, communication with the balloon was lost at 22,000 ft and could not be re-established. A secondary tracking system allowed the payload to be recovered 55 km east of the launch site. Post mission analyses revealed that a malfunction of the on-board computer occurred 20 minutes after launch. The problem was attributed to either a disruption of the spinning hard disk as a result of turbulence or fluctuations of the power supply. Undaunted by the failure of FLOAT-1, the team returned to RMCC and prepared a second mission. Over the next two weeks the balloon payload was rebuilt to include a number of improvements such as a solid state hard drive, a more stable power supply and the ability to re-boot the computer during the flight in the event of temporary power loss. FLOAT-2 was launched on 12 June 2009. This time the payload successfully recorded data throughout the flight (Figure 1), reaching a maximum altitude of 92,950 ft (28.3 km) before coming to rest 90 km east of the launch site. The data collected as result of the tireless efforts of the FLOAT team (Figure 2) represented the first-ever collection of ADS-B data from a stratospheric balloon platform and proved that aircraft can be tracked from near space.

Fig. 2 Members of the FLOAT team following payload recovery. From left: Ron Vincent (Professor), Alex Cushley, Pascal Tremblay, Raymond Francis, Dan Desjardins. (Missing from picture: Matthew Wallace)

The data retrieved by FLOAT-2 led to a M.Sc. thesis [1], a conference paper [2] and a journal paper [3]. Analyses of the 1090 MHz signal propagation through the lower atmosphere and modeling of ionospheric effects indicates that ADS-B messages can be detected by a satellite in low Earth orbit. [1] Following the success of FLOAT-2, the SMAD course created a nano-satellite (10 × 10 × 30 cm, 3 kg) mission intended to demonstrate that ADS-B signals can be received from space. The Space ADS-B Receiver Experiment (SABRE) mission is designed to collect ADS-B trans-missions several times a day over the Hudson Bay region at 800 km altitude and subsequently downlink this data to RMCC for analysis. Hudson Bay is currently monitored by a series of ADS-B ground stations, so truth data will be available from NAV CANADA to determine the effectiveness of the system. The SABRE ADS-B payload and computer, which are significantly different from those used on FLOAT-2, will be tested on another high altitude balloon flight (FLOAT-3) in the spring of 2012.

The FLOAT program has created a number of opportunities for RMCC space science students in the field of space based ADS-B. The initial aim of the program was never to simply build a structure and send it into near space, but to conduct a meaning-ful scientific experiment. In this case the students showed remarkable forti-tude to obtain the required data and worked well beyond the expectations of the course to achieve a positive result. The success of the FLOAT program, combined with the enthusiasm expressed by Physics students to conduct further missions, is leading RMCC toward a path of future high altitude balloon experiments.

REFERENCES

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