2017 Elijah High-Altitude Balloon Launch Team Summer Proceedings Report

Quinlan J. Bock, Taylor L. Davitz, Josh J. Furey, and Tyler T. Rasmussen

[1]Lawrence University, [2]Milwaukee School of Engineering, and
[3]University of Wisconsin-Fox Valley

Abstract

The 2017 Wisconsin Space Grant Consortium Elijah High-Altitude Balloon Launch Team was comprised of one student from Lawrence University, two students from the Milwaukee School of Engineering, and one student from the University of Wisconsin – Fox Valley. This year, three members of the team had experience with high altitude balloon launches due to previous participation on either the Elijah Payload or Launch Team, or both. A training session was hosted by Dr. Farrow to familiarize or refresh the team with the physical setup of a launch train as well as how to run track predictions and how to read the jet stream charts. Launches were planned and carried out for the Elijah High-Altitude Balloon Payload Team. This launch was successful, reaching a peak altitude of over 35 km above mean sea level.

Introduction

The Wisconsin Space Grant Consortium (WSGC) Elijah Balloon Launch Program takes place yearly when four students from Wisconsin colleges and universities come together to plan, launch, and recover a high altitude balloon with a scientific payload. The launch team has various preflight planning responsibilities including: watching Jet Stream predictions, running flight predictions, and preparing flight materials. The launch team coordinates with the WSGC Elijah Balloon Payload design team on a launch date, and carries out the launch and recovery of the payload and tracking line so that the payload team can gather data from their experiments in a space-like environment.

Each of the launch team members experiences a large amount of organizational activity involved with coordinating and carrying out scientific experiments. This experience directly translates to school projects, other internships, and jobs.

Launch Planning

Team meetings. During the later parts of summer, the Elijah High Altitude Launch team meets regularly to train and plan. Meetings started as early as July 13th, when the teams meets for the first time and learns about the project. This meeting also leads into planning the preliminary prep and training portion of the project. Training took place on July 18th, it is required for learning and understanding how a launch should properly function. Remaining meetings then took place at weekly intervals. These meetings mainly dealt with the flight path planning and communication between the Launch and Payload teams. Prior to the launch date, July 29th, the Launch team meets one last time to inventory equipment and prepare for launch.

Flight predictions. All flight predictions created during this project were all created using an online software from Cambridge University Spaceflight. This system allowed the team to test theoretical balloon flights from any known position. Using locations that previous teams have launched from in previous years, allows the team to view the flight path the balloon should follow on a given day. Once the calculated flight path is found, the team can try and find specific

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launch sites that allow the balloon to stay out the path of undesired zones, undesired zones being: no fly zones, bad terrain, cities, and etc. Many locations previously used by launch teams had recently changed over the years and turned into undesired fly zones for the team. This caused the team to find new alternative launch locations that would suit this year's launch. After multiple locations being discussed and viewed by the team, it came down to a primary and secondary launch site, the primary launch site being Lake Mills, WI and the secondary site being Sun Prairie, WI. These sites were chosen due to how the modelled test flight paths arranged themselves over the terrain. Figure 1 below shows the modelled flight predictions of the payload balloon as launched from Lake Mills and Sun Prairie respectively. In both launches, it can be seen that the ideal launch starts in an open area and also lands in an open area outside of towns.

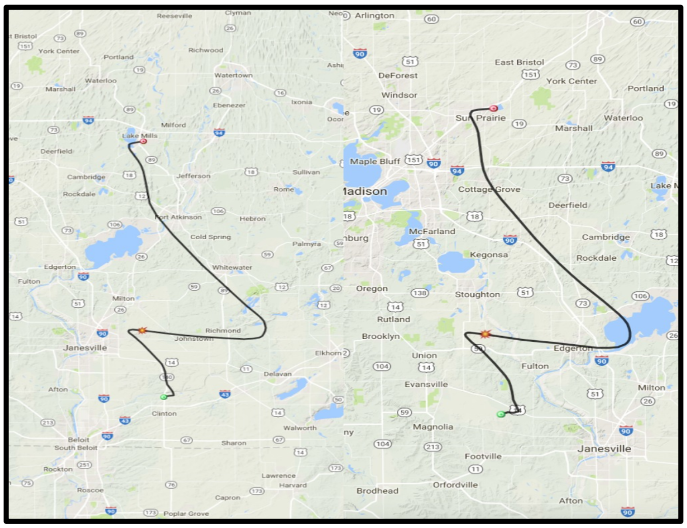

Figure 1: The flight path predictions of Lake Mills (Left) and Sun Prairie (Right) taken July 28th.

Weather forecasting. Weather forecasting is biggest thing that impacts where and when a launch happens, that is why weather forecasting starts a week before possible launches and is monitored daily until the launch is commenced. Jet streams and ground weather are the things the team watches daily to ensure a launch is good to go. When looking at jet streams, the important thing is to find days when the wind speeds are below 60 knots, anything over that is a no fly date. Once the winds are low enough, the local ground weather is also observed to make sure that there are no storms or foul weather that could damage the payload. Shown below in Figure 2. is an example of good jet streams, it is also the jet stream map modelled for July 29th Launch.

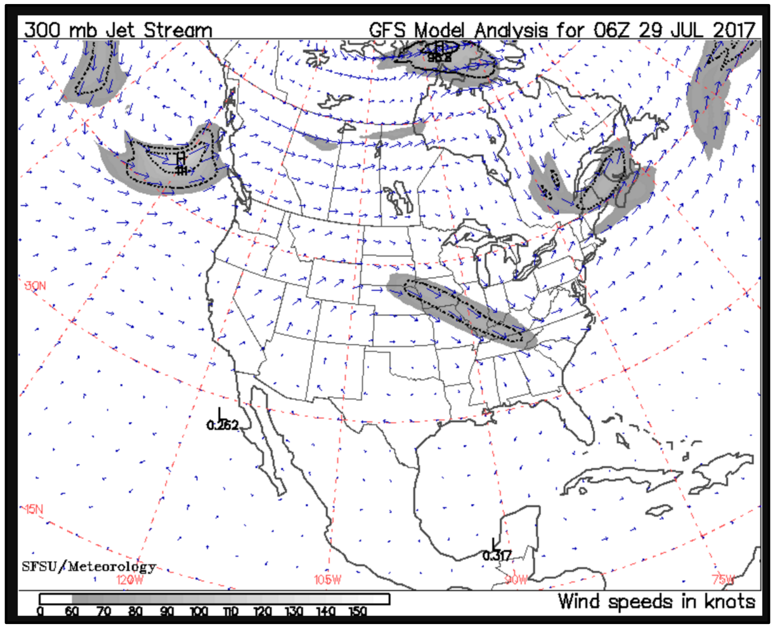

Figure 2: Jet Steam for 29 July 2017 - Launch Successful

Balloon and payload set-up.

In order to reach the goal of sending the science payload to around 100,000 ft, there is some flight hardware involved that makes this goal possible. One of the most important components is the balloon itself. The team used (size or weight) natural latex weather balloon with a custom made throat to be able to fill the balloon with Helium. Even though we were able to predict where the balloon was going to fly, to increase our chances of finding it, two tracking payloads were used. The primary tracking payload communicated directly to two computers on the ground in the chase vehicles and sent useful information such as altitude and GPS location of the payload. The secondary tracking payload used an APRS HAM radio network tracking system which transmits the payloads altitude and position which was viewed online. In order to slow the descent of the payload, a small parachute was also used. All of the flight components were attached to each other with two nylon strings and were assembled in a line. At the top was the balloon followed by the parachute, then the primary and secondary tracking payloads and finally the science payload.

The balloon train was set up in the following order starting with the top as seen in figure 3.

1. Balloon
2. Parachute
3. Primary Tracking Payload
4. Secondary Tracking Payload
5. Elijah Payload Team Scientific Experimental Payload

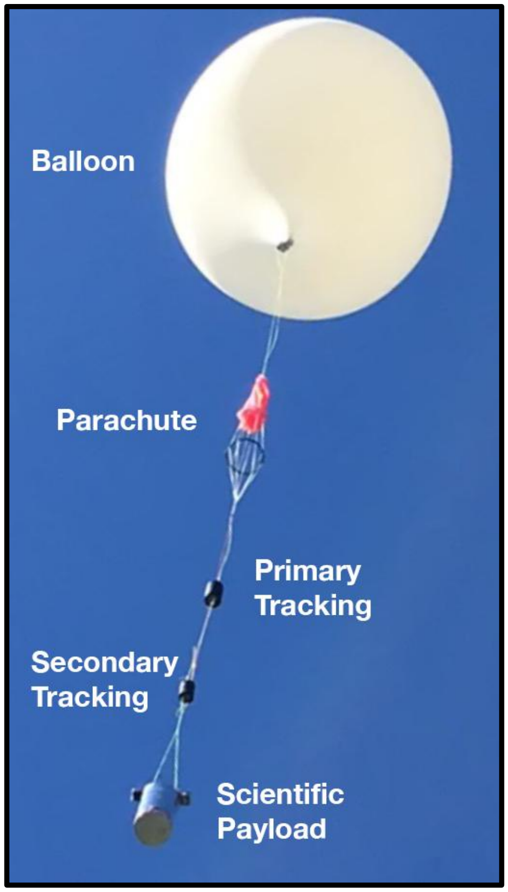

Figure 3: The balloon train as it ascended into the sky after launch

Launch

The Elijah Balloon Launch took place on July 29th 2017 in Lake Mills Wisconsin (43.07°, -88.90° latitude and longitude respectively). Both the launch team and the payload team left Milwaukee School of Engineering the morning of the 29th and drove to Lake Mills where the launch team proceeded to set up the balloon, and payload, primary, and secondary tracker line while the payload team ran final tests on the payload. The balloon launched at approximately 11:00. The two chase cars followed the balloon from the launch site to the predicted landing location while receiving real-time packets of information about the balloon's latitude, longitude and altitude. This data was used to further predict the landing location of the balloon.

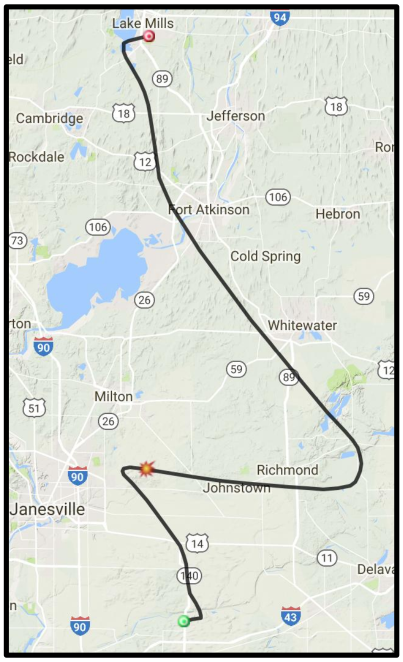

Figure 4

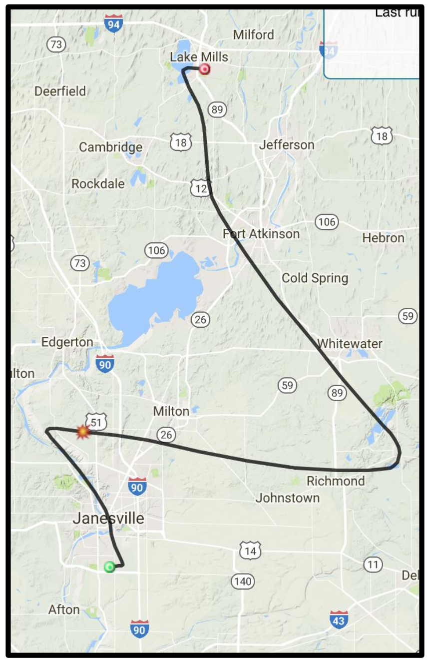

Figure 5

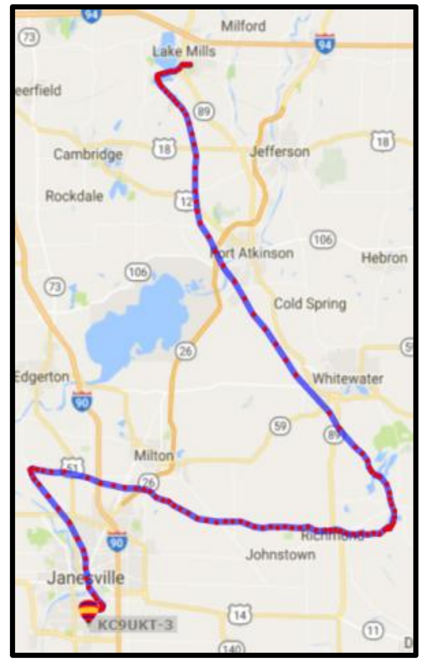

Figure 6

The original flight prediction run the morning of the flight before leaving Milwaukee is shown in *Figure 4*. Halfway through the chase the second chase car decided to run a new prediction once they realized the balloon was going to have a higher than expected burst altitude. *Figure 5* shows the flight prediction run during the chase with the higher burst altitude of 35,000 meters as opposed to the 30,480 meters used in the first prediction. The actual peak altitude reached by the balloon was approximately 36,800 meters. Finally, *Figure 6* shows the actual flight path of the balloon as depicted by the Automatic Packet Reporting System (APRS) software and our secondary tracking device. The flight paths are very similar. The variance between the predicted and actual flight paths can be attributed to unpredictable ground winds and the higher than expected burst altitude. The payload and tracking devices were recovered successfully after landing in the abandoned GM plant in Janesville, and the payload team was able to recover their data.

Flight data analysis. As experienced in previous years, the final tracking data from both tracking payloads was highly fragmented and/or contained corrupted and duplicated data points. Last year, it was discovered that the raw data packets were required to filter out extraneous data, however, these data packets were removed from the APRS archives three days after their creation. This year, the raw data packets were retrieved before the APRS archives automatically deleted them. The data was downloaded in excel format, then corrupt data points were manually removed. After the proper formatting for conversion into Google Earth was achieved, the data was saved as a CSV (comma separated values) file, and converted into the proper KML (keyhole markup language) file for Google Earth. The APRS data was prefered, because data from the primary tracking payload was extremely fragmented and little is known of the condition of these files. Future years could work on developing an automated system to convert the raw data packets into KML files for either the primary or secondary tracking payloads, or both.

Cancellations. Flight cancellations are predominantly due bad weather and Jet Stream. In the duration leading up to the launch completed on July 29th, there was only one cancellation (July 23rd). This was due to the fact that payload team did not complete their flight readiness tests by this date and needed more time to make final modifications. The flight was then postponed till the next weekend; the weather was clear and there wasn't any strong Jet Stream overhead so the balloon was set to launch on this date. A successful flight ensued that weekend.

Conclusion

Overall the launch of the Project Elijah Science payload on July 29th was successful and the payload was recovered. The extensive planning for the launch and team meetings aided in the launch with few problems. Even though the balloon burst 15,000 ft higher than expected, the team was able to readjust for the new flight path and recover the payload safely.

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