Ascent: A community-based project to the stratosphere

by Bob Riddle

During the fall of 2011, a group of high school and community college engineering students from Kansas's Blue Valley School District, and Longview College got together to design and build a payload container that would be carried into the stratosphere by a high-altitude weather balloon. The payload consisted of data loggers for collecting light intensity and temperature; a GPS transmitter; several high-definition video cameras; and one 18-megapixel, digital, single-lens reflex (DSLR) camera with a fish-eye lens set to automatically take a picture every second. During the flight, one of the high-definition video cameras transmitted a live TV signal. Data from the flight can be downloaded and include the GPS and data-logger data in spreadsheet format; the flight paths are in Google Earth file format (see "Ascent balloon flight data" in Resources).

Students were involved through Ascent, a community-based project that was funded in part through a small grant from Kansas City's Spencer Museum of Art and the Charlotte Street Foundation. Known as Rocket Grants, these funds are available for innovative art and science projects in and around Kansas City. Our grant was written by Dark Matter, a group of musicians, scientists, and educators who collaboratively work on projects combining arts and sciences. As a community-based project, Ascent involved students from the Kansas City metropolitan area, local businesses, and educators.

While the Rocket Grant provided the funds for purchasing materials, it was really the combination of several resources that made for a successful project. We partnered with a local science/hobby store for a space to hold meetings and construct the payload container. Technical support included an aerospace engineering teacher, members of Make: KC (a local organization supporting art and technology), and the SABENS Group (a STEM initiative organization in New Hampshire). As with many projects, we had a group "MacGyver," a local business owner who is an electrical engineer and ham-radio operator.

Following a series of meetings spanning several weeks (during which students worked as a team, proposed payload designs, tested their designs, and then constructed and built the payload container), we were ready for flight day.

Flight 1

Our first flight day was on a sunny Sunday morning. With several hundred onlookers, students working

FIGURE 1 Ascent balloon release

PHOTOS COURTESY OF THE AUTHOR

in two teams prepared the payload and filled the balloon with helium. Unfortunately, while students were measuring the lift capability of the balloon with a spring scale, the balloon got away. So as we watched the balloon ascend out of sight, we discussed what went wrong and ways to make corrections, and planned to meet the following morning for another attempt.

The following morning, we were confident with the modifications students had worked out for securing the balloon to the payload, and for measuring its lift capability with the spring scale. Flight-day weather was absolutely perfect, with clear, blue, early autumn skies and no wind. Final preparations went well, and the balloon with parachute and payload attached was released on time (Figure 1). We lost the TV video signal almost immediately due to a loose connection; however, all cameras kept filming and storing video, eventually giving us close to 12 GB of high-definition footage. Unfortunately, we had unknowingly scratched the camera lens on the down-facing camera, resulting in a thumbprint-like blur on the entire video. We also had other camera problems: The DSLR camera stopped working at approximately 15,240 m (50,000 ft.) due to low temperatures and did not warm up on the way down until around 7,935 m (26,000 ft.). It took pictures very sporadically until impact, but still yielded nearly 4,000 images.

We followed the flight in real time using the GPS telemetry that was transmitted every minute or so over a ham-radio frequency using a borrowed ham call sign from a group member. This meant we could track the flight using GPS in a car, which we did, as well as track the flight path using a Google Earth display. By following the GPS signal, we were able to drive directly to where the last signal (from about 305 m [1,000 ft.] up) was received before landing. Knowing its direction of descent, we guesstimated its landing area and found its landing spot.

In addition to the easy recovery, what was really amazing about this flight was that we were able to watch the balloon right up to the moment it burst at around 29,261 m (96,000 ft.) (Figure 2). With virtually no wind, the balloon ascended in a spiral nearly straight up from release, appearing as a shiny, bright-white dot. Despite traveling a flight path of nearly 97 km (60 mi.), the payload container landed only 19 km (12 mi.) away from where it was released, just off a county road in a plowed field.

FIGURE 2 Kansas City from 29,261 m (96,000 ft.)

Flight 2

While the first flight was considered a success, the high-definition video was spoiled by a series of scratches on the lens that happened the morning of flight preparations. So we decided to replace the lens and try another flight, this time focusing on recording better video and taking additional images with the fish-eye lens. The second flight's payload package did not include the TV transmitter and antenna, and by decreasing the overall mass of the payload, we were able to include a third video camera facing upward to hopefully capture video of the balloon when it burst at high altitude. Unfortunately, the batteries ran out before the flight ended. However, by comparing the balloon's apparent size in the video at the beginning with its appearance at the end of the video, it is easy to see that the balloon had noticeably increased in size as it ascended.

Flight day was windy, with gusts out of the southwest averaging around 20 miles per hour. The balloon

FIGURE 3 Balloon data

	Maximum altitude	Altitude at last GPS signal	Straight-line distance to recovery site	Total flight distance
Flight 1	29,238 m (95,926 ft.)	627 m (2,058 ft.)	18.44 km (11.46 mi.)	83.2 km (51.7 mi.)
Flight 2	26,608 m (87,298 ft.)	1,000 m (3,280 ft.)	359.44 km (223.35 mi.)	426.47 (265 mi.)

release went well, with a major difference from the first one: On a windy day, the balloon does not rise vertically faster than its horizontal motion. In other words, the balloon rose at a low angle, was immediately caught in the blowing winds, and quickly blew out of sight. Our initial concern was how low it appeared to be as it traveled over the southeastern part of the Kansas City metropolitan area, but the rate of ascent carried it above any potential obstacles.

Based on the online program we used to calculate its flight path (see Resources), we at first thought the balloon would land about 161 km (100 mi.) to the east near Boonville, Missouri. However, as we continued monitoring the balloon's flight and recalculating its flight path, it became obvious that the balloon was on a multistate course, taking it and our payload from eastern Kansas across Missouri to a landing on the other side of the Mississippi River in Illinois. We knew the camera batteries would not last for the duration of what looked to be a long flight. However, the GPS transmitter had a backup battery, giving it an additional 10 hours of transmitting time. The camera batteries ran out after nearly three hours, shortly before sunset and about an hour before the balloon burst at around 26,518 m (87,000 ft.) over the Mississippi River.

The recovery team, which was Fred (aka "MacGyver") and I, followed the balloon's GPS signal across Missouri and into western Illinois using an internet-connected cell phone, Fred's dashboard GPS, his wife on a computer at home, and map gazetteers for Missouri and Illinois. With a bit of ingenuity and luck, the payload package, parachute, and what was left of the balloon were successfully recovered late that night by moonlight in Illinois from a tree leaning over a ravine at the edge of a farm field about one-quarter mile west of the Illinois River.

Flight data

The data we collected from the balloon flights are pretty typical of data collected from any ascending balloon (Figure 3). With these data students could, for example, determine the approximate altitude of the bottom of the ozone layer within the stratosphere. Data from our data loggers included time, light intensity, outside temperature, and motion of the payload package. Data from the GPS included time, temperature within the payload package, latitude and longitude, direction of travel, altitude, and relative ground speed. The data files are all in Excel spreadsheet format. Additionally, two data files are in KMZ format and are intended for use with Google Earth (See "Ascent balloon flight data" in Resources). These KMZ files, once loaded into Google Earth, display the entire flight path for each balloon flight along with indicators showing the points where GPS telemetry was transmitted. By selecting to display the "elevation profile," students can easily trace along the profile and follow the flight of the balloon. Zooming in on the Google Earth map display will provide the opportunity to see the type of geography and populated areas the balloons flew over.

Data from the GPS were transmitted and recorded at approximately one-minute intervals, so the last GPS signal was sent up to a minute before landing. This had us estimating the final flight path and landing spot. For the first flight, the last signal was over a small lake; however, the payload drifted a few hundred feet farther across a road and landed in a plowed field. The landing was in a typical Great Plains setting; that is, a relatively level farming area common to eastern Kansas and western Missouri. The second flight carried the payload into a very heavily wooded and hilly farming area of western Illinois about 20 miles east of the Mississippi River and very near to the Illinois River. The latter recovery was more challenging given the distance we traveled; that the last GPS signal was from 975 m (3,200 ft.) up; the hilly, wooded terrain; that it was after sunset; and that the payload landed about 6 m (20 ft.) up in a tree. Guess who lost the coin toss and did the tree climbing?

The *Forrest Gump* law of balloon projects

From our experiences, we learned that flying a high-altitude balloon is somewhat like a box of chocolates—you never know what you will get. Despite the challenges and missteps we made along the way, both flights were a success, with good imagery and data, and student and community involvement. Additionally, students felt a real sense of ownership in the project, as they designed, built, and flew the balloon, and analyzed data from their flight.

Our sense of community was greatly extended when we were invited to do a balloon release at what is billed as the world's largest live science event. Called "School Day at the K," it is an hour-long, tightly scripted event featuring the weather team from a local TV station, WDAF-TV Fox 4. They conduct and introduce a variety of demonstrations and experiments to an audience of 10,000 to 15,000 students at the Royals baseball team's Kauffman Stadium. For our part, Balloon Kam, we released a balloon from third base with a payload that included a camera to broadcast a TV signal. Using an aimable antenna, our team followed the balloon's ascent. Periodically during the rest of the event, the Jumbotron screen would display the Balloon Kam view (Figure 4).

Based on our experiences, I would recommend doing a balloon project. A great place to learn more about high-altitude balloon flights is the Amateur Radio High Altitude Ballooning organization website. For classroom ideas and activities, use the outreach link on NASA's Balloon Program Office website (see Resources).

Celestial events

Several events are worth noting this month. Watch for a few shooting stars from the Leonid meteor shower, which will peak on the morning of November 17. The full Moon of November 28 is the counterpart of the Super Moon from last May, as it will be the smallest full Moon of the year—a super-mini-Moon, if you will. The last pair of eclipses for this year will occur this month, with the solar eclipse not visible from the continental United States and the lunar eclipse visible only from the

FIGURE 4 A Jumbotron image of the Kansas City Royal's Kauffman Stadium from 3,048 m (10,000 ft.)

western half of the United States as the full Moon is setting. On November 13, the new Moon will pass between the Earth and the Sun, setting up conditions for a solar eclipse. The path of totality will travel across the South Pacific Ocean north of New Zealand and Australia. A penumbral lunar eclipse will be two weeks later, on November 28, when the Moon passes through the Earth's outer and fainter penumbral shadow. While not as noticeable as when the Moon passes through the umbral shadow, there will be a slight darkening on the Moon during mid-eclipse. Check your local times for sunrise or moonset, as this lunar eclipse will be in progress at around moonset local time for the western half of the United States. ■

Visible planets

Mercury will be visible over the western horizon at sunset for the first week of the month, and then reappears as a morning planet at the end of the month.

Venus will be visible, shining brightly over the southeastern horizon at sunrise.

Mars will be visible over the western horizon at sunset this month, setting a couple hours after the Sun.

Jupiter will rise around sunset and will be visible all night.

Saturn will be visible over the eastern horizon at sunrise this month.

November

1	Moon at apogee: 406,100 km (253,339 mi.)
	Waning gibbous Moon near Jupiter
4	End daylight saving time—"fall back"
6	Mercury near Antares
	Last quarter Moon
11	Thin waning crescent Moon near Venus and Spica
13	New Moon
	Total solar eclipse
	Cassini Titan flyby
14	Moon at perigee: 357,400 km (222,078 mi.)
15	Moon near Mars
17	Leonid meteor shower
	Mercury at inferior conjunction
18	Venus near Spica
20	First quarter Moon
21	Sun enters astrological sign of Sagittarius
22	Sun enters astronomical sign of Scorpius
26	Venus near Saturn
	Mars near Pluto
28	Full Moon (smallest for 2012)
	Penumbral lunar eclipse
	Moon at apogee: 406,400 km (252,525 mi.)
	Moon near Jupiter
29	*Cassini* Titan flyby
	Sun enters astronomical sign of Ophiuchus

Resources

Amateur radio high altitude ballooning—*www.arhab.org*

AMSAT & high altitude balloons—*www.amsat.org/amsat/balloons/balloon.htm*

Ascent balloon flight data—*http://sdrv.ms/OZHnqL*

Blue Valley School District Center for Advanced Placement Studies—*www.bvcaps.org/s/1403/start.aspx*

Cassini Solstice Mission—*http://saturn.jpl.nasa.gov*

Dark Matter Ascent performance videos—*http://darkmatterkc.com/blog*

Daylight saving time—*wwp.greenwichmeantime.com/time-zone/rules/usa*

Flight prediction and ascent-rate calculator—*http://nearspaceventures.com*

H.M.S. Beagle—*http://hms-beagle.com*

Leonid meteor shower—*http://meteorshowersonline.com/leonids.html*

Longview Community College—*http://mcckc.edu/explore/campuses/longview/welcome.asp*

Make: KC—*www.makekc.org*

Moonglow Technologies—*http://moonglowtech.com*

NASA Balloon Program Office—*http://sites.wff.nasa.gov/code820*

Penumbral lunar eclipse—*http://eclipse.gsfc.nasa.gov/OH/OHfigures/OH2012-Fig06.pdf*

Rocket Grants—*http://rocketgrants.org/*

SABENS Group—*stemconnector.org/state-by-state/new-hampshire*

School day at the K—*http://sdrv.ms/J5NbdE*

Total solar eclipse of 2012—*http://eclipse.gsfc.nasa.gov/OH/OHfigures/OH2012-Fig04.pdf*

WDAF-TV Fox 4—*http://fox4kc.com*

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