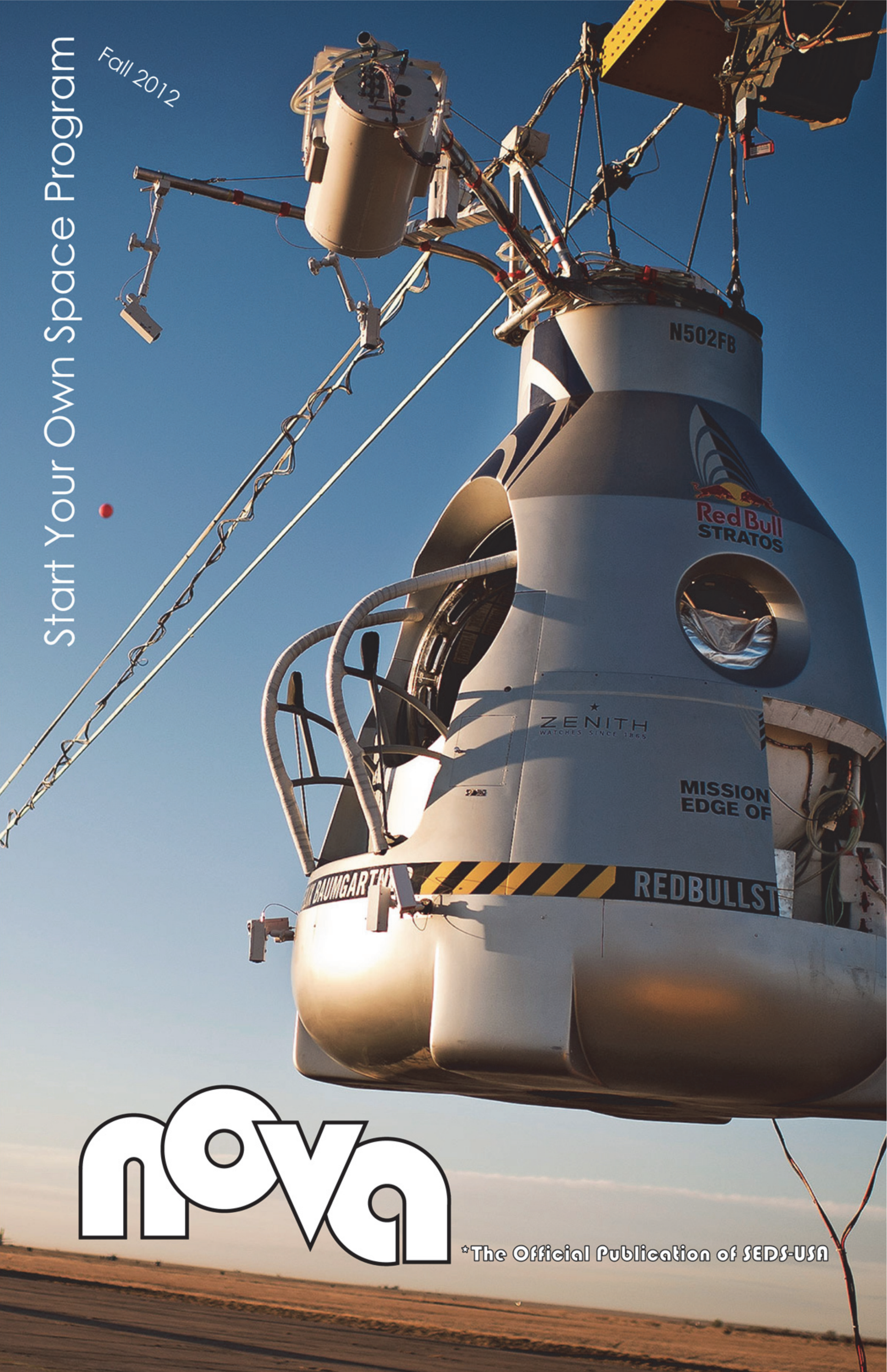

Start Your Own Space Program

Fall 2012

nova

*The Official Publication of SEDS-USA

In this issue

The Kármán line may be the traditional definition of space, but the 99% line (line below which you find 99% of the atmosphere) is only at 31 km. This begs the question, how far do you really want to go? Well in the case of our cover image, Felix Baumgartner - an Austrian skydiver, daredevil, and BASE jumper - ascended to just over 39 km and broke 3 or 4 world records when he stepped out of his gondola. That's one small step for a man and one giant leap for carbonated energy-drink ads! In this issue, we will look at ways to "cheat" and experience space either through zero-g flights (like in the case of some CU SEDS Members) or through high altitude ballooning. Then, when you're ready to take that next step, you can pitch your own space program at the Student NewSpace Business Plan Competition. Find out more inside.

Contents

Letter from the Chair

SEDS Members, Alumni, and friends,

As students finish their 9-5 internships, last minute summer vacations, and head back to the grind of school we welcome back current and new members alike to the joys of promoting the future - Space Exploration and Development - with SEDS. Chapters are ramping up their beginning of the school year efforts at bringing more students into the organization, and early signs are that record numbers are being seen! This is great news for the organization, and I hope to see even more growth this year. We currently have the highest number of college chapters in the history of SEDS! Each individual in the organization can help us keep these numbers up by bringing their friends into the organization; both at their own school and at others. With your help we can continue to grow and make the SEDS Network even bigger!

Since the last NOVA, we have seen a lot of great things happen in the Space industry. One of the most remarkable things we have seen is SpaceX successfully docking with the International Space Station in May, becoming the first private space vehicle to do such a thing. In August, the Commercial Crew Program made an award for commercial crew, the CCiCAP award. This award gives a set of objectives and milestones to produce a 'price per flight/seat' model for future human spaceflight. Three programs were awarded, the Boeing CST-100, the SpaceX Dragon Capsule, and Sierra Nevada's Dreamchaser. SEDS wishes the chosen programs success, and hopes that the models of those who were not chosen can be proven through operation - providing more routes to develop Space.

The Space industry is saddened as well by the recent lost of several of our own. Most prominent, we bid farewell to the first man to set foot on the moon, Astronaut Neil Armstrong. Neil will be remembered for both his great contribution to space exploration by leading humanity's way on our first steps into the cosmos, and for his quiet yet steady support of continued efforts in space exploration. SEDS also recently has lost one of our own. Darrell David Cain, who served between 2007-2008 as the Director of Chapter Affairs for SEDS-USA. Darrell was a firm supporter of the organization, and helped to bring a new wave of actively involved individuals into SEDS. He was also instrumental into helping us lay the foundations of the endowment and other pillars of the SEDS-USA organization. To remember Darrell's contribution to the organization, we are creating the Darrell David Cain Award of Excellence to remember him, and the contribution he made to SEDS-USA and opening the frontier for humanity in Space.

I'm pleased to say that SEDS-USA overall this year has been proactive in making great programs to benefit the members. Most prevalent, we hosted this year the second annual SEDS Rocketry Competition. While we have yet to announce the winners of the competition, overall I am pleased that the program has been able to bring chapters together in the pursuit of a goal. I hope we will be able to continue to grow this program in the future. We recently launched this year's Student NewSpace Business Plan Competition, and have several competitive, funded awards starting this year. The Business Plan competition (winners), Rocketry Competition, and awards will all be announced at our National conference, SpaceVision.

SpaceVision this year will be taking place in Buffalo, NY from November 8th through 11th at the Buffalo Niagara Convention Center. It is being hosted by the University at Buffalo Chapter, and should be an amazing event that you won't want to miss. With three NASA center directors, the founding NASA Chief Technologist (Robert Braun), the head of NASA's Commercial Crew Program, Ed Mango, and more; this year's program should be one of the most compelling yet. I strongly recommend you take part in one of the most important parts of SEDS. SpaceVision is a great opportunity for students to network with space leaders in person, see how the industry operates and how you can get involved. If you don't think you're able to afford to go, don't be afraid to work with your friends and other chapters to put something together to make it to the event, be it through coordinating fundraising, organizing your road trip, or room sharing.

Dan Pastuf accepting the University of Buffalo Engineering Council "Club of the Year" award on behalf of UB-SEDS.

Finally, I'm pleased to say we are constructing for the first time in many years a strategic plan for SEDS-USA. This plan will hopefully broaden SEDS view for the future, and lay the groundwork for growth. As the commercial industry grows and the interest in space follows suite, SEDS will continue to be ready to foster that growth towards the stars.

Ad Astra,

Dan Pastuf

Chair, SEDS-USA

Space Frontier Foundation

and

SEDS Present:

Student Business Plan Competition @ SpaceVision 2012

University of Buffalo

November 11, 2012

Grand Prize: $1k and entry into NewSpace Business Plan Competition

The Space Frontier Foundation (SFF) and the Students for the Exploration & Development of Space (SEDS) are proud to announce the 2nd annual Student NewSpace Business Plan Competition, taking place at SpaceVision on November 10th at the Buffalo Niagara Convention Center, Buffalo, NY. SpaceVision is an annual conference organized by SEDS-USA, attracting large numbers of students, professionals and enthusiasts from around the country.

This competition will require its participants to pitch their business model to a panel of investors experienced in the NewSpace industry and space entrepreneurship. The NewSpace industry is a growing sector of companies who share a bold vision of enabling the economic frontier of space development in areas such as space tourism, space manufacturing, resources harvesting, and commercial services in transportation and satellite infrastructure. The business plan must therefore revolve around a space-frontier-enabling technology or service idea. The plan need not entail a company that literally operates in space.

All undergraduate and graduate students affiliated with a US-based university are eligible to participate; however, students may be of any nationality. Teams are encouraged to be creative and draw parallels from other sectors and industries. Engineering and business students are encouraged to collaborate together to develop a strong business model. Students need not be members of SEDS but are encouraged to reach out to or start a local SEDS chapter at their institution.

The Grand Prize is a cash award and automatic entry into the more prestigious NewSpace Business Plan Competition, held at the NewSpace conference in Silicon Valley, July 2013. Additionally, one member from the winning team will be invited to the NewSpace Gala. Cash prizes will be awarded to second and third place teams as well. All cash prize amounts are TBA.

For more information on rules, procedures and deadlines, visit the competition website: **http://spacefrontier.org/projects/seds/student_bpc/**

SEDS is the world's largest student-run organization dedicated to space advocacy and development. Space Frontier Foundation is a non-profit corporation whose goal is to open the space frontier to space settlement through private sector development.

For more information contact:

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Email: sara.meschberger@spacefrontier.org
Phone: 623.271.2045

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Phone: 719.331.9104

Weightless Students Return to Earth

by Christopher Nie

University of Colorado SEDS members Mike Lotto, Kristyn Johnson, Kyle Shannon, Jared Yenzer, Andy Broucek, and Chis Nie lost a little weight over the summer for their microgravity project.

After testing their self-designed and constructed experiments on-board a gravity-defying aircraft, six students from the University of Colorado Students for the Exploration and Development of Space chapter are busy evaluating their data after experiencing weightlessness at NASA Johnson Space Center's Ellington Field in Houston.

CU SEDS members Mike Lotto, Kirstyn Johnson, Kyle Shannon, Jared Yenzer, Andy Broucek, and Chris Nie participated in NASA's Reduced Gravity Education Flight Program (RGEFP), which gives teams of undergraduate students from across the nation the opportunity to propose, design, build, fly and evaluate a reduced gravity experiment. The team was selected from over 60 proposals based on scientific merit and education outreach potential.

The team tested their experiment aboard NASA's "Weightless Wonder," a microgravity aircraft that can produce periods of weightlessness lasting 18 to 25 seconds at a time by flying a series of about 30 parabolas – a steep climb followed by a free fall – over the Gulf of Mexico.

"It was crazy, my mind didn't know what to do at first," said Johnson, saying that after the aircraft completed its first couple of parabolas the students were able to adjust to the feeling of weightlessness and conduct their experiment.

Nie added that "This project was an amazing way to pursue our interests outside of the classroom and get some hands-on experience. The Microgravity University is good about requiring the students to participate in the entire engineering process, from initial concepts, to project requirements, to actual building and testing the experiment. We're now in the process of writing a final science report to share our results. The past year has been an unforgettable experience and the flight was unbelievable. It's something that everyone should try and do."

The student team flew their experiment, Validating Unaddressed Levels of Convection At Null-gravity (VULCAN), at Ellington Field from July 16th to 20th, 2012. This experiment provided experimental data that suggested the validity of a theoretical convection correlation during their reduced gravity flights. The team will issue a final report to NASA two months after the flight analyzing the experiment's effectiveness, scientific findings, and the conclusions that were drawn from the results.

"The Reduced Gravity Program with NASA was something I wanted to do very badly ever since I first heard about the opportunity, which was the first day of college orientation," said Shannon. "Experiencing weightlessness was literally a dream come true."

For more information about the Reduced Gravity Education Flight Program, contact Rachel Kraft, NASA Johnson Space Center Public Affairs Office, at 281-792-7690 or visit the Web site at: **http://reducedgravity.jsc.nasa.gov/**

KR: Many of us were introduced to space and science in different ways. Tell us about your childhood experiences; your first exposure to space exploration as a kid that inspired you to dedicate your life to it.

RP: I have had an interest in space exploration for about as long as I can remember. Fortunately, my parents recognized and supported my interest, taking me to the local planetarium and signing me up for youth astronomy courses at the local community center. My mother, a former teacher, shared with me the newspaper clippings she had saved from the Apollo 11 moon landing and I was hooked.

RP: My interest in space grew into a passion though, after attending U.S. Space Camp. I ultimately went to the weeklong program six times between 1987 and 1993, between the ages of 11 and 17. The experience and encouragement I gained there convinced me I wanted to shape my career around space exploration, ideally as an astronaut but even when that wasn't possible, through the experiences I would have and make for myself as a web developer, marketing director, and journalist.

KR: What is your fondest memory of being a SEDS member?

RP: Though I had some great experiences on the national level, at the annual SEDS-USA conferences and running SEDS as chair, my fondest memories as a SEDS member are on the local level. I helped start the University of Maryland chapter, Maryland SEDS (MSEDS), and as a group we made annual trips to the National Radio Astronomy Observatory in Green Bank, West Virginia. Not only did we have the opportunity to make observations using one of the radio telescopes, but it also gave us a weekend to discuss and debate the future of space travel, stargaze in the secluded valley where the NRAO is located, and build friendships that have lasted well beyond college.

RP: From an outreach perspective, the experiences bringing astronauts (including Apollo 11 moonwalker Buzz Aldrin) to the university and helping to host NASA's first Human Exploration and Development Conference on campus were certainly rewarding and memorable.

KR: How important a tool do you think history is in developing a future in space in the most efficient manner?

RP: A good understanding of space exploration history is necessary for moving forward, if only to avoid repeating the mistakes of the past. But beyond that, history can serve as a strong motivator for pushing outward, so long as it doesn't become the yardstick by which everything is measured.

RP: Many Apollo program enthusiasts for example, have bemoaned the space shuttle and space station programs, pointing to the moon landings as a greater achievement. There's an appropriate time and place for such comparisons, but I think that each program needs to be considered and judged on their own merits.

Founder of collectSPACE

by Kaizad Raimalwala

KR: How best can we advocate the cause of space exploration to the general public?

RP: Find ways to make space interactive. Space exploration as a "spectator sport" can only hold the public's interest so long. There are many easy activities that can raise awareness on the local level.

RP: For example, it has been my experience that there is no greater way to get people excited about the work on the International Space Station than to show them the station as it flies overhead. As you're waiting for the pass, you can talk about the astronauts and cosmonauts who are there, what science they are working on, and why having a continuous human presence in space is important.

RP: Meeting an astronaut is still a source of excitement for the public, even if they are not immediately familiar with the astronaut's name or when/where s/he flew. For more than a decade, we have been tracking astronaut appearances on collectSPACE.com and I've heard over the years about the impact those meetings have had not just on kids, but business and community leaders and educators. If you can help organize or promote a local appearance, it can serve as a platform to expose more people to the past, present and future of space exploration.

KR: What other interests or passions do you hold besides space exploration?

RP: I have always been a collector. My focus today is space memorabilia and artifacts, but I have mini collections based on personal experience, including my travel and a family connection to Disney.

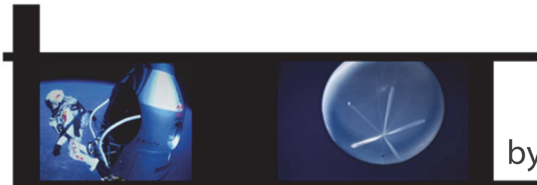
RP: I'm a bit of a tech geek, and definitely an early adopter when it comes to the latest gadgets. And through that I have grown passion for photography. I never had a film camera but have picked up digital photography from the early days of the Apple QuickTake through the current line of digital SLRs.

RP: And I have an interest in the culinary arts and have an admiration for the chefs that elevate food to an art form.

KR: Tell us about any upcoming/future projects you have in mind.

RP: I am working on writing my first book on a subject related to recent space history. And collectSPACE may soon be bridging into another medium that should help expose space history and its artifacts to a wider, different audience.


NearSpace /
[What does it take to get to space?]
Felix Baumgartner
ascended to 128,097 feet
stepped from this platform
[Wait. Wait. Wait.]
and fell.
4 mins + 20 sec
119,846 feet
833 miles per hour
[Is it really that easy?]
making him the first human
to break the sound barrier
unaided by a vehicle
[Can I do it too?]



by Harvey Elliott

You might be surprised, but you can reach space– or near space – with a few hundred bucks and weekend in the garage. It may not make you Felix Baumgartner, but hey, it's still pretty cool to space rate your phone... In the next few pages, I'll walk you through the process to start your very own space program. And Believe me, high altitude balloons are something you can do at every school and in every chapter so – **GET TO IT!**

This article will walk you through the design, build, and test of a high altitude balloon payload. In the case of full disclosure, you should start making some friends if you want to do this at home – this was a project I did with a team of students at the University of Michigan Student Space Systems Fabrication Lab (S3FL). Our payload, "NEMO" – short for Near Earth Measurements and Observations – consisted of several scientific instruments, GPS, comm system, two tracking units, and a flight termination unit. For the flight, we used a 1500 g high altitude balloon and filled it with helium until it was buoyant – then we used a scale to quantify the lifting force. Our calculations estimated that this balloon would rise at a rate of 1500 feet per minute to a maximum altitude of ~100,000 feet where it would burst and descend on target even in the event of a failure. For the descent, we used a 42" square parachute to slow the fall rate of our 7 pound payload.

Main Payload

This consisted of an Arduino Nano, Parallax data logger, Aerocomm, GPS, inertial measurement unit, and some environmental sensors. Aside from the sensors and antenna, all the electronic components for the main payload were placed inside of a hard, water proof plastic case and fixed in place using precisely fitted hard insulating foam. This was done to prevent any damage to the primary electronics and recorded data due to impacts, jostling, low temperatures, or water. The case was then placed inside of a stiff foam box which provided both thermal insulation and a structural platform for the cameras and external sensors. The hard case and full insulating housing can be seen below.

NEMO's hard case (left) and full insulating housing (right).

Micro-Trak

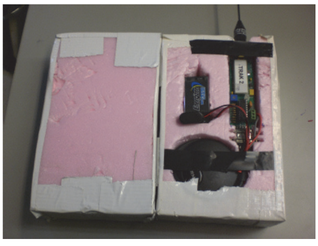
Even though we have a GPS and radio in the main payload, we wanted to make sure we would be able to recover the balloon in the case of failure. When launching things into space, you should always think about redundancy and what happens if "X" doesn't work! As a backup system, we included a Micro-Trak 300 transmitter operating on the standard frequency of 144.390 MHZ. This is connected to a Garmin 18x LVC GPS, a 15.5" SMA antenna, and two 9V batteries wired in series. When it is flipped on, the Micro-trak automatically transmit location and telemetry data to the APRS – Automatic Packet Report System – network. We found this system to be the most effective and reliable for tracking balloons during flight and would highly recommend it. The only downside I can see is that it uses the amateur radio frequencies and so if you don't have it already, you will need to get your license. You can find classes and exams at: **ARRL.org**

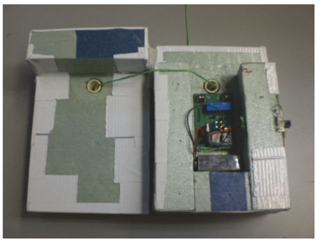
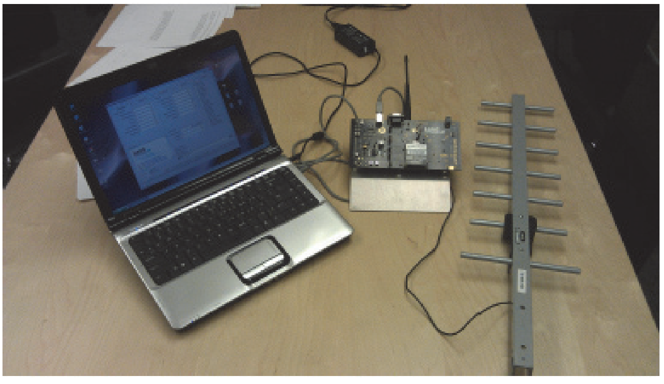
Cell Tracker

As a second backup system, we also flew an Android phone as a separate tracking payload. We used my Nexus S, but almost any cell phone can be modified to automatically text GPS coordinates and pictures. When it was time to fly, I started the application and taped the phone into a rigid foam case. When it landed, it was cold to the touch, but otherwise fine and worked surprisingly well over the course of the flight.

Flight Termination Unit

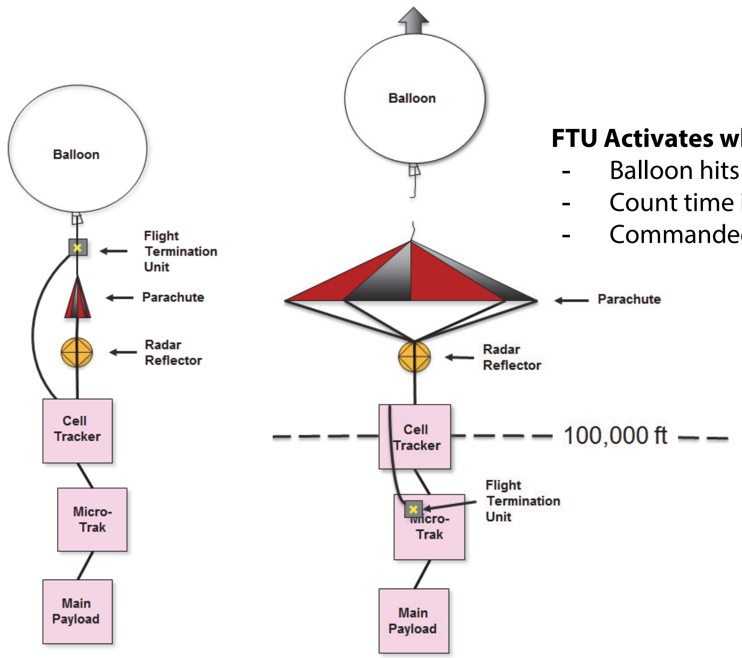
During our flight, we also tested a Flight Termination Unit (FTU) to disconnect the balloon from the payloads in the event the flight needed to end early for safety or control purposes. The FTU system consisted of an XBee radio connected to a relay with NiChrome wire – when the FTU receives the "kill" command, the relay is activated to heat the NiChrome, which subsequently cuts the nylon string. The FTU was attached to both the line connecting the balloon and parachute as well as the radar reflector below the parachute. This way, the FTU would hang below the parachute after severing the line connecting the balloon to the parachute. In order to avoid collisions with the FTU during descent, the line connecting the FTU to the radar reflector was sized so that the FTU would hang below the main payload after falling. The electronics of the FTU were contained in stiff insulating foam, which provided both a study lightweight platform for the components as well as thermal insulation.



Secondary payloads (from left to right): Micro-Trak, Cell Tracker, and Flight Termination Unit. (Below) Aerocomm ground station with omni/yagi antenna and laptop.

Payload Configuration and ConOps
The NEMO components were attached to the balloon in a payload train consisting of the: FTU, parachute, radar reflector, cell tracker, Micro-Trak, main payload. At the top, the balloon is filled with helium, zip tied, and duct taped all while being held down under a nylon blanket until the payload train is attached. For this, we use Velcro straps and brightly colored nylon kite string.



FTU Activates when:
- Balloon hits max altitude
- Count time is reached
- Commanded from ground station

Payload train on ascent (left) and descent (right).

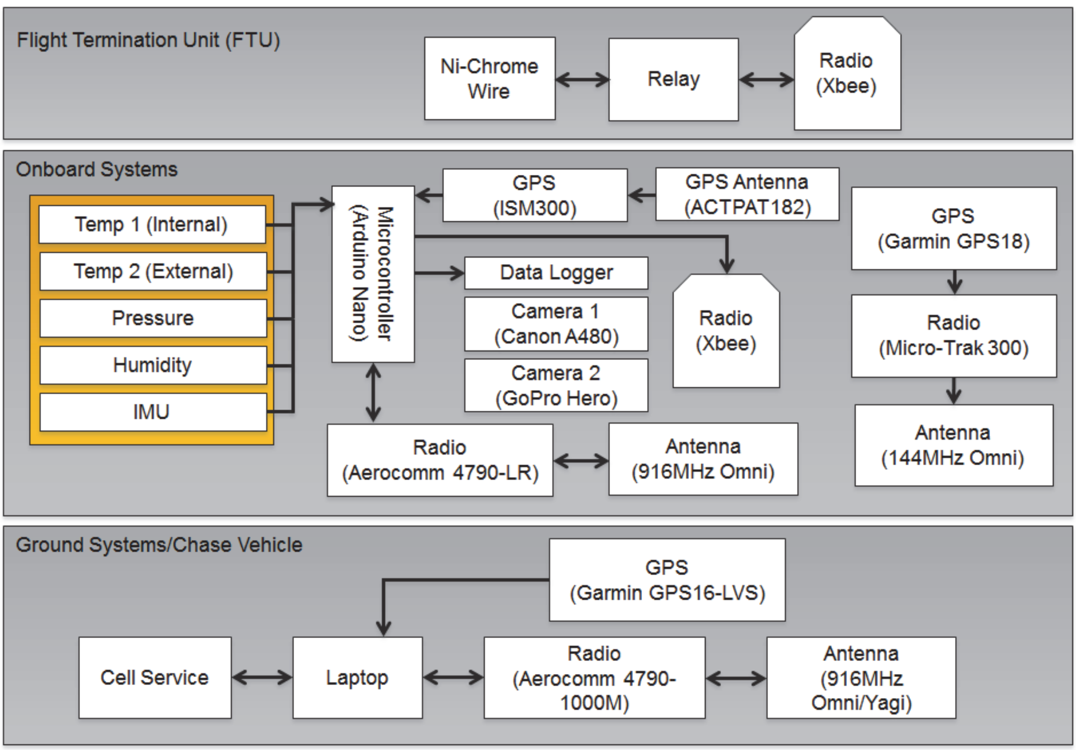
ConOps:

Preflight Check
- Assemble payloads and attach to string, activate strobe light, arm flight termination unit.
- Fill the tethered balloon; attach string once full, arm payload.
- Confirm Aerocomm and APRS telemetry, release tether.

Launch/Ascent
- Balloon is expected to gain altitude at ~1500 feet per minute.
- Use two chase vehicles with mobile ground stations to track via Aerocomm and APRS.
- Use omni-directional antennas until signal is lost, then switch to yagi (expected at ~20 mile range).
- Monitor payload health status, if weather conditions deteriorate or if further operation is deemed hazardous – send the kill command to activate the FTU.

Descent/Recovery
- After activation of the FTU or failure of the balloon envelope, the payload is expected to lose altitude quickly until the parachute inflates
- Once the parachute inflates, the payload is expected to lose altitude at ~200 feet per minute.
- Try to place chase vehicles ahead of the payload path
- Try to regain comm if signal was lost, and at 40,000 ft begin visual search
- Once landed, attempt to get permission of property owner and recover payload

System Overview
To collect telemetry and data from our sensors, we flew an Arduino Nano microcontroller with Parallax Memory Stick Datalogger. We collected data on eight unique parameters during flight: GPS location (position and altitude), acceleration (X, Y, and Z components), external pressure, external humidity, internal temperature, and external temperature. GPS coordinates were taken using an Inventek Systems ISM300F2-C5-V0004 GPS receiver and ACTPAT182-01-IP GPS antenna. Acceleration measurements were taken with an ADXL335 triple axis accelerometer which was mounted internally on the main circuit board. Humidity measurements were taken with an HIH4030 humidity sensor which was mounted externally. Temperature measurements were taken with two LM335A temperature sensors. One was mounted on the main circuit board and the other was left outside the enclosure to measure the atmospheric conditions. Pressure measurements were taken with an MPX5100A pressure sensor, which was also mounted externally. All of these sensors can be found online with a simple Google search or through SparkFun Electronics. A system level block diagram for the payload can be seen below.



NEMO system level block diagram with interfaces shown for main payload, FTU, and ground station.

To send and receive information from the ground station, we used a Laird Technologies Aerocomm AC4790-1000M 900 MHz Transceiver with a 1/4 wave omni-directional antenna mounted externally to the main payload. To track the balloon at the ground station, the Arduino was programmed to transmit the GPS coordinates over the Aerocomm every 20 seconds. This signal would then be received by the ground station and plotted on Google Earth. Once every minute, the Arduino would then switch into listen mode for 5 seconds and monitor the channel for commands from the ground station. This would be one of the methods we could use to send the kill or reset commands.

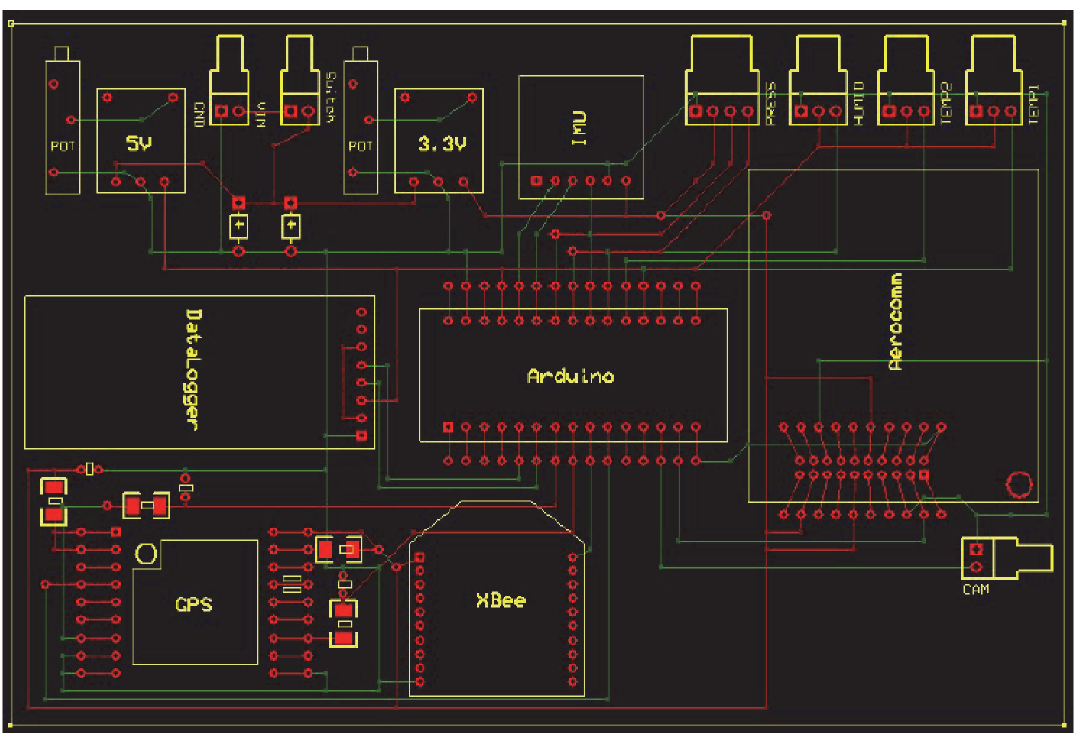
An XBee transceiver was also configured as a transmitter and integrated with the Arduino to send the termination command to the (FTU) circuit. The main components of the FTU circuit consisted of an XBee configured as a receiver, a OMR-C-105H relay switch, a NiChrome wire, and various components to regulate the power and operate the relay switch. When the Arduino sent a termination command to the transmitting XBee, a wireless signal was sent to the receiving XBee which activated the relay switch, sending power from the 9V battery to the NiChrome wire. The

NiChrome wire then heated up until it was hot enough to cut the nylon string between the balloon and the rest of the payload. This termination command was sent when one of three criteria was met:

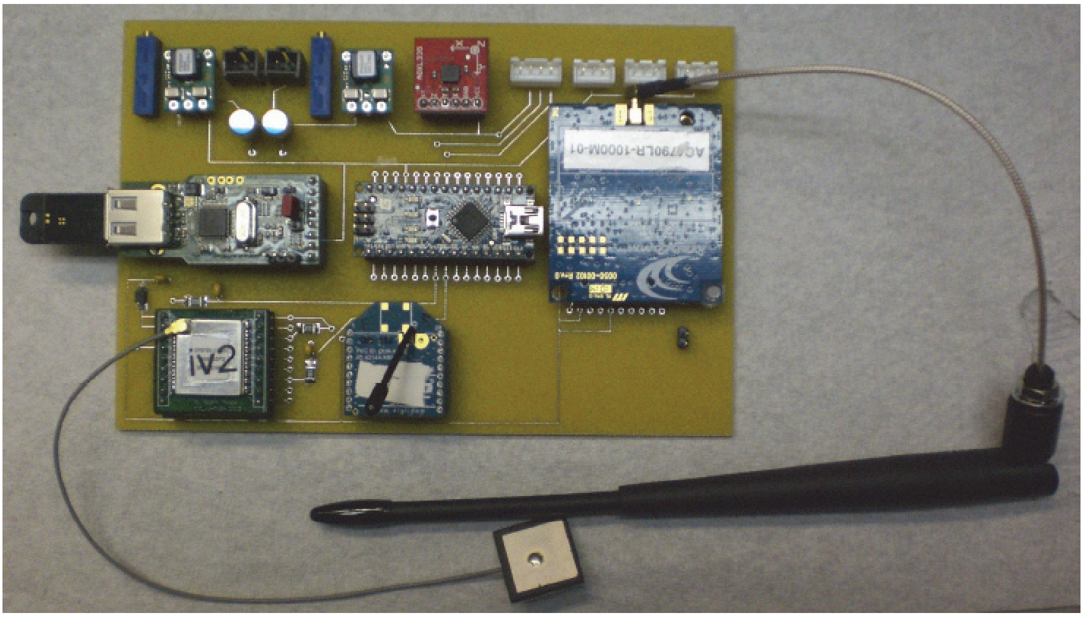
1. The altitude reached or exceeded 100,000 feet
2. The mission time reached or exceeded 90 min
3. A kill command sent from the ground station was received by the Aerocomm

The completed FTU system was successfully tested three times before the flight. On each occasion, a signal was sent to the transmitting XBee, received by the FTU circuit, and the string supporting the FTU unit was cut. These tests confirmed the circuit would work under the expected tension in the string and at the expected range between the XBee transceivers.

A printed circuit board (PCB) was fabricated to connect all of the electrical components to the Arduino and provide the necessary power regulation and protection circuits. The layout of this PCB is shown in the figure below, with the electrical traces on the top face of the board colored in red and the traces on the bottom face of the board colored in green. During the design, the configuration was tested using breadboards to verify the components were wired properly. Breadboarding the components also allowed us to program the Arduino and preform preliminary testing while the PCB was being fabricated and assembled. Pin sockets were used to attach all electrical components so they did not need to be permanently soldered to the circuit board. Upon assembly of the PCB, two small mistakes were found. The first was the 5V power line to the Arduino, this had to be cut and re-routed to the VIN pin. The second was the TX pin on the XBee, please check these before you send your schematic off for fabrication. The other word of caution I have is to make sure you have clearance between plugs and interfaces. The USB ports on the Arduino and data logger were not exactly in optimal locations. Also, the antenna port of the Aerocomm was a little too close to the sensor sockets and I would suggest rotating this 180 degrees. The finished circuit board with all electrical components and antennas attached is shown in the figure below.



NEMO main circuit board with the electrical traces on the top face in red and on the bottom face in green.

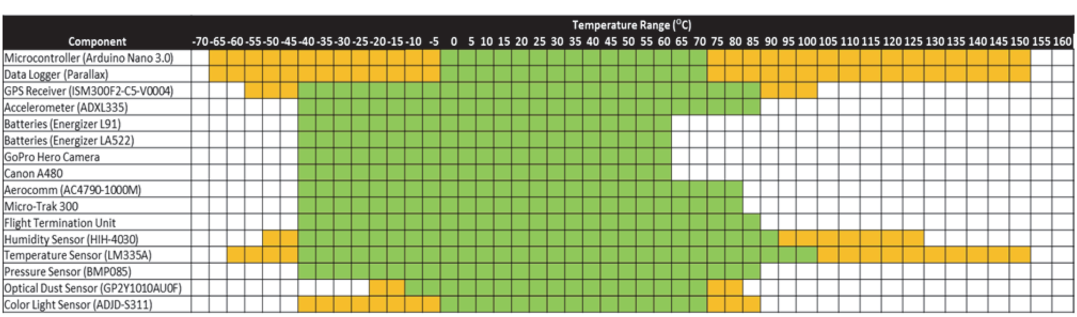


Finished circuit board with components installed.

Finally, in addition to the sensors and comm systems, we flew three cameras with our payload. You might have noticed that we included an electronic trigger for a camera on our circuit board. This ultimately proved unnecessary as we were able to flash the firmware on two Canon A480 digital cameras to automatically take pictures every 30 seconds. We mounted these cameras vertically on the main payload - one facing out the top and the other out the bottom. For the third camera, we chose to include a GoPro Hero with no modifications. This camera would face horizontally out of the main payload and record a video of the flight facing the horizon with its fisheye lens.

Thermal Constraints

Referring to the US Standard Atmosphere, we expect the temperature to drop rapidly as the balloon rises between the planetary boundary layer and the tropopause. From these tables, we can infer that the minimum temperature our payload is likely to experience is around -60°C and this is certainly going to pose a problem for some systems. Below you will find the specified thermal range of our components taken directly from the spec sheets. Since most of our components are only specified down to -40 °C you might suspect that we need some insulation from the environment. We have found that the standard hard Styrofoam insulation (available at Home Depot) covered in white duct tape works quite well for this purpose. My final word of warning is that you should also be careful to avoid over insulating the package, especially if it is a dark color. Even if it is -60°C during some points of the fight, it is very easy to go to the other extreme and fry your components as the balloon is gaining altitude. Take your time, think critically about this, and perform lots of testing!



Specified thermal range of our components, with operating temperature shown in green and survival temperature in yellow.

Mass Budget

To meet Federal Aviation Administration (FAA) requirements, the total weight of the balloon system must be less than 5.4 kg with no single piece being more than 2.7 kg in mass. As flown, our total payload was 3.07 kg with most of that being dedicated to the "NEMO" package. A breakdown of each component's mass can be seen in below.

Component	Qty	Mass/Unit (g)	Mass (g)
C&DH			
Microcontroller (Arduino Nano 3.0)	1	6.3	6.3
Data Logger (Parallax)	1	7.5	7.5
PCB Board (Estimated)	1	100.0	100.0
Cords (Estimated)	1	50.0	50.0
ADCS			
GPS Receiver (ISM300F2-C5-V0004)	1	3.5	3.5
GPS Antenna (ACTPAT182-01-IP)	1	7.2	7.2
GPS Rec/Ant (Garmin GPS 18)	1	75.4	75.4
Accelerometer (ADXL335)	1	1.0	1.0
Power			
Batteries (Energizer L91 - AA)	4	14.5	58.0
Batteries (Energizer LA522 - 9V)	4	33.9	135.6
4 Cell Battery Holder	1	13.2	13.2
Cameras			
GoPro Hero Camera	1	94.5	94.5
Canon A480	2	157.7	315.4
Communications			
Aerocomm (AC4790LR-1000m-01)	1	13.2	13.2
Aerocomm Antenna	1	22.2	22.2
Micro-Trak 300	1	37.9	37.9
Micro-trak Antenna	1	14.3	14.3
Flight Termination Unit (XBee WRL-08665)	2	5.3	10.6
Instrumentation			
Humidity Sensor (HIH-4030)	1	1.0	1.0
Temperature Sensor (LM335A)	2	1.0	2.0
Pressure Sensor (BMP085)	1	1.0	1.0
Structure			
B&W Type 05 Box	1	226.0	226.0
Foam Box (Estimate)	1	411.3	411.3
Non Payload			
Radar Reflector	1	226.0	226.0
Parachute	1	542.0	542.0
		Payload Total:	**2375.1**
		Payload + 30% Contingency:	**3087.5**

Preliminary mass budget for NEMO balloon payload.

Power Budget and Batteries

A power budget was prepared to determine the minimum power needed to operate all the electrical components for a total duration of 2 hours. With a 30% contingency, we estimated the payload power consumption to be about 13.2 W-Hr and therefore four Energizer L91 lithium ion batteries should be sufficient for our flight. During testing this was later changed to 8 Energizer lithium ion AA batteries due to issues with the voltage regulators. After we made this change, multiple endurance tests were performed to prove that the payload would operate for well over 2 hours, even in the cold and hostile environment at 100,000 feet. The preliminary power budget and battery trade studies are shown below.

Component	Qty	Voltage (V)	Current (mA)	Power (W)	Run Time (Hr)	Duty Cycle (%)	Power (W-Hr)
C&DH							
Microcontroller (Arduino Nano 3.0)	1	12	150	1.8	2	1	3.60
Data Logger (Parallax)	1	5	25	0.125	2	1	0.25
ADCS							
GPS Receiver (ISM300F2-C5-V0004)	1	5	29	0.145	2	1	0.29
Accelerometer (ADXL335)	1	3.6	0.375	0.00135	2	1	0.01
Communications							
Aerocomm (AC4790-10000m)	1	5.5	1300	7.15	2	0.1	1.43
Micro-Trak 300	1	12	1700	22.1	2	0.1	4.42
Flight Termination Unit (XBee WRL-08665)	1	3.3	50	0.165	0.1	1	0.02
Instrumentation							
Humidity Sensor (HIH-4030)	1	5.8	0.5	0.0029	2	1	0.01
Temperature Sensor (LM335A)	2	5	5	0.05	2	1	0.10
Pressure Sensor (BMP085)	1	3.6	0.005	0.000018	2	1	0.01
Cameras							
Hero Camera	1			Internal	2	0.03	N/A
Canon A480	2			Internal	2	0.03	N/A
						Total:	**10.14**
						Total + 30% Contingency:	**13.18**
Batteries							
Energizer L91	4	1.5		4	2	1	**16**

Preliminary power budget for NEMO balloon payload, we calculated an expected draw of 13.18 W-Hr and used this estimate to size our batteries.

Battery	Weight (g)	Lifetime(mAh) @500mW	Temp Min (C)	Temp Max (C)	Flight Heritage
Energizer L91 Ultimate Lithium	14.5	3700	-40	60	+
Energizer EA91 Advanced Lithium	14.5	2500	-40	60	-
Duracell Ultra Power (Alkaline)	24	2900	-20	54	-
TekCell Lithium	16	2400	-55	85	-
Saft LS 14500C (Lithium)	16.2	2700	-60	70	-

Battery trade study for NEMO balloon payload.

Communications

Communications between the ground and NEMO relied primarily on a pair of Aerocomm AC4790-1000M 900MHz transceivers, from Laird Technologies, operating with a 9600 baud rate. The Aerocomm chip is operated by sending it a serial signal containing ASCII text, which it then broadcasts to all receiving radios. The Aerocomm on the ground was connected to a computer via the board provided in the Developer Kit and used either the antenna provided by the developer kit or a yagi antenna which was manually pointed towards the balloon during flight. Unfortunately, communication with the balloon via the Aerocomm was lost when the balloon reached ~20,000 feet. Attempts were made using both the yagi and standard antennas, but contact with the balloon was never re-established.

Our backup system, the Micro-Trak, worked flawlessly and relayed quality data throughout the flight. Since effective line-of-sight is required to receive messages, it stopped working near landing, and the last reading we got was from 550 meters above sea level. This means there was a small difference in the last reading and the landing spot of the balloon, but we were able to arrive as the balloon was descending and seeing it on the way down made recovery easy.

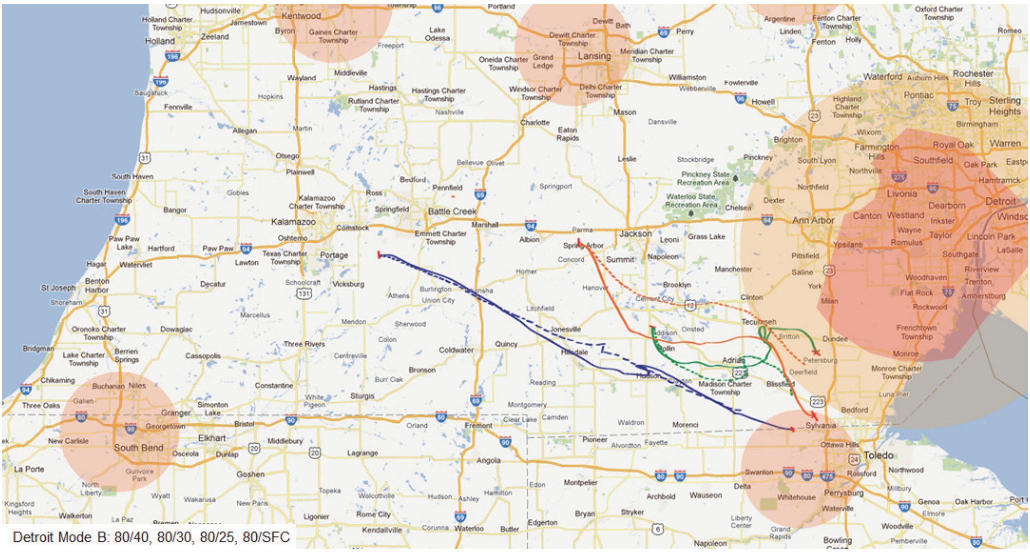
The second backup system, a Nexus S cell phone with custom tracking application also worked well. This phone would periodically text the coordinates of the balloon to a phone on the ground. These coordinates came from GPS when available, or from cell towers, which provide a less accurate position of the phone. We chose to use text messages because we knew that rural areas in Michigan would have minimal network coverage and we did not want to rely on the phone being able to establishing a data connection. The on-board phone was able to text coordinates during pre-flight and initially during ascent; the last altitude received was 9,678 feet. Connection was not reestablished until the payload was on the ground, at which time text messages resumed. However, at this time the phone was not able to get a lock on GPS coordinates, so it was sending the location of the cell tower it was connecting to. This meant the coordinates were not exactly at the landing site, but at the location of the cell tower, which was about a mile away. The phone was able to handle the high-altitude environment without issues and once it regained signal, it resumed communications with the ground station. This suggests there is great potential for using a phone as the main computer. This design would reduce complexity and increases dependability, as the phone has an integrated CPU, camera, GPS receiver, and on-board storage.

Cost and Expenses

We were able to build our main payload and fly it - all for about $400, but it should be noted that we already had the Aerocomm developer's kit ($200), Micro-Trak ($105), cell tracker ($100), cameras ($330), parachute ($40), and radar reflector ($30). That means if you are starting from scratch and using this guide, you should probably budget about $1000. Now, if you cannot afford $1000, you still have options. We used a 1500 g balloon ($120) and 2x224 CF tanks of helium ($65 ea) to fly a relatively large payload. A smaller payload could use a smaller balloon and have a smaller price tag. Say you flew an Arduino on a breadboard with some sensors, a camera, and a Micro-Trak. The cost for that system would be more on the order of $220. That is a lot easier to swallow for a small chapter and you know what, you get the same picture of black sky!

Flight Path Prediction and Preparing for Flight

For your reference, on the following pages I have included some example checklists for testing and pre-flight preparations as well as an example NOTAM to be filed with the FAA Flight Standards District Offices. For flight path prediction, we developed our own in house software that takes the launch time and location as inputs and then uses the current National Weather Service forecast to predict the balloon flight path and burst altitude. The nice thing about this software is that it can be updated real time, as we receive telemetry from the balloon, and this allows us to very accurately predict the landing site. The predicted (dashed) and actual (solid) flight paths of three balloons are plotted in the following figure. Note that the shaded areas represent restricted airspace. I highly recommended that you review the FAA Sectional Charts for your area before planning a flight – flying through Class C airspace is very bad, flying through Class B airspace is probably going to earn you a visit from your local men in blue. Track your balloon, notify nearby airports, and if you think there's potential for your balloon to drift into restricted airspace, activate the FTU. While I can't share our software through the NOVA, you can get started by using the flight prediction software available online from Near Space Ventures, Inc. (see Pre-Flight Checklist).



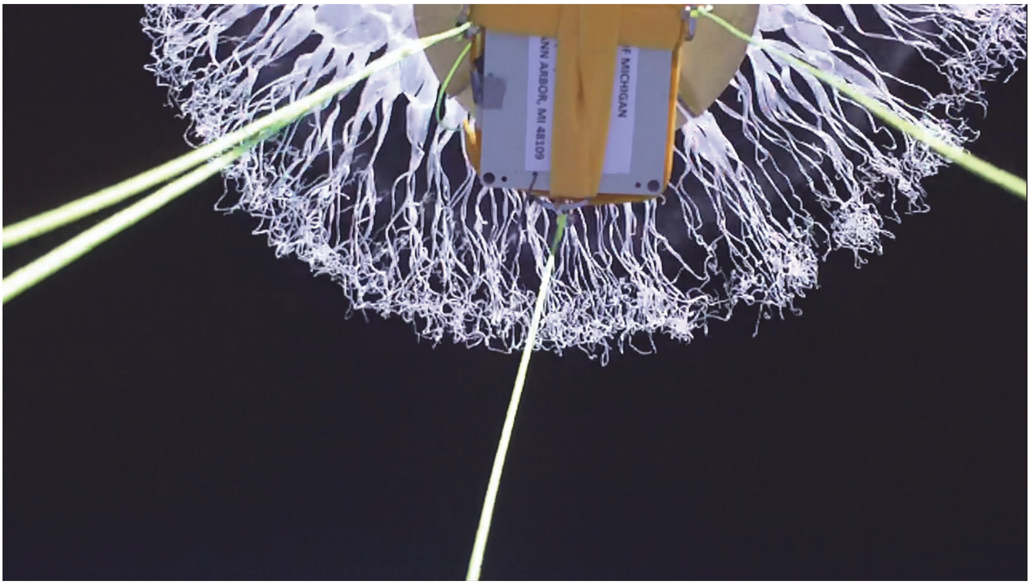
Flight path (solid line) and prediction (dashed line) for three University of Michigan balloon payloads.

Flight and Results

We launched NEMO from an open field near Mason, MI, on April, 13, 2012 at 9:56 am. The general shape of the flight path closely followed the prediction, but our true ascent rate was slower than estimated. This in turn prolonged our time in the jet stream and caused us to land farther downwind.


Balloon and payload train just seconds before launch.

Our payload reached a maximum altitude of 85,823 feet where the balloon popped and our payload began its descent. Initially, the payload was spinning and falling at a rate of 17,700 feet per minute – that's over 200 miles per hour! As the altitude dropped, the air became thicker and the parachute began to inflate. By the time the payload finally reached the surface, the speed had abated to about 1200 feet per minute. This is still fast, but a more reasonable speed of impact.



Black sky as NEMO starts its descent from 85,823 feet.

After falling for 20-25 minutes, we found NEMO southeast of Deerfield, MI at 11:19am. Our sensors survived the fall and there was no damage to the payload, but the FTU's NiChrome wire snapped at some point during the flight. As a result, the balloon never separated from the payload train and this prevented the parachute from fully inflating. Looking at the data, the accelerometer recorded an impact of 3-4 g's on landing so it is certainly not something you would want to land on your head. Luckily, NEMO made a nice little divot in a cornfield and we have since developed a more reliable mechanical actuator for flight termination. Over the course of the flight we captured over 605 images of the balloon and the ground along with a dizzying full length movie from the GoPro.

The NEMO team after recovery (from left to right) Lanre Oyebo, Harvey Elliott, Schuyler Cohen, Michael Ramirez, Denar Van Drasek, Nathan McKay.

Testing Checklist

1. Arduino working with sensors.

2/09	Temperature Sensor
2/09	Humidity Sensor
3/19	Pressure Sensor
2/28	Accelerometer

2. Arduino writing sensor data to data logger.

2/09	Data output to Serial Port
2/13	Data saved to EEPROM
2/29	Data saved to Data Logger

3. Arduino working with GPS.

3/19	GPS data received by Arduino
3/22	GPS data saved to Data Logger
4/11	GPS data converted to ".kml" file and plotted on Google Earth

4. Microtrak working.

1/24	ARRL License
2/22	Microtrak transmitting call sign
2/22	Microtrak appears on APRS.fi
4/10	Proof that Microtrack works

5. Arduino working with Aerocomm

3/16	Aerocomm talking to Aerocomm (Computer to Computer)
3/19	Arduino writing data to Aerocomm (Arduino to Computer)
3/22	Arduino writing GPS to Aerocomm (Sending GPS data to "ground station")
3/23	Arduino listening to Aerocomm (Computer to Arduino)

6. FTU Test

2/21	Arduino communicating to Xbee
4/06	Flight termination unit working with Xbee
4/09	Flight termination unit working with Arduino/Aercomm

7. System Integration

3/19	Individual sensors tested with Arduino
3/23	Integrated Testing/Sensors integrated into breadboard prototype
4/02	Integrated Testing/Sensors integrated into flight board

8. Thermal Test

4/10	Camera verified to work
4/10	GoPro verified to work
4/10	Sensors verified to work

9. Drop Test

4/10	Camera verified to work
4/10	GoPro verified to work
4/10	Sensors verified to work

Day-of-Flight Checklist

Check Weather

4. Go to Weather Underground and look up the weather for your intended launch location:
   http://weatherunderground.com
5. Make sure the cloud cover is at or below 50%.
6. If the cloud cover is over 50%, you cannot launch with a payload above 12 lbs
7. If the cloud cover is over 50% and your payload is below 12 lbs, try to reschedule for a day with clearer skies if possible.

Run a Balloon Prediction

1. Go to the balloon prediction website provided by Near Space Ventures, Inc.
   http://nearspaceventures.com/w3Baltrak/
2. Fill out the fields:
   - Launch Date – YYYY-MO-DA
   - Estimated launch time – HH:MM:SS
   - Call sign (amateur radio)
   - Latitude – decimal form (i.e. 41.92), length of decimal not important
   - Longitude – decimal form in the negative (i.e. -84.54), length of decimal not important
   - Elevation – estimate based on area (usually ~1000 feet)
   - Ascent rate – The ascent rate depends on the weight of your payload, the type of balloon you plan to fly, and the amount of helium you put in the balloon. Heritage ascent rates: 1300-1600 fpm.
   - Descent rate – The descent rate is harder to estimate because it will start at a high value after burst where the air pressure is minimal and then increase significantly as it reaches lower altitudes. Usually an estimate of 1200-1500 fpm is sufficient.
   - Burst altitude – Also variable depending on payload mass, balloon type, and amount of helium. Most balloon flights have gone around 90,000 to 100,000 feet.
   - WX Station – Look at the station list to find the weather station closest to the launch location. Most flights have been close to Jackson, MI (JXN).
   - GFS Model – Be sure to pick the model that corresponds with when you expect to launch. If making the prediction a day or two before launch, choose the 0- 180 hour model.
3. Click Submit
4. Pick the correct date & time for the forecast period. Note the time is in UTC, which is -4 hours for EDT (summer) and -5 hours for EST (winter). For example, a 12:00 launch is 16:00 UTC in the summer or 17:00 UTC in the winter.
5. Click "go to 'Enter Data' page"
6. Copy and paste the GFS sounding data from the left window into the right window.
7. Click "submit"
8. Click "Plot Track on Google Maps"
9. A new tab will open that shows the flight prediction in Google Maps

File FAA Notification

1. If your payload meets one of the criteria (from FAR Part 101.14), advise the Detroit Flight Standards District Offices:
   http://www.faa.gov/about/office_org/field_offices/fsdo/dtw/
2. Make a HiBal Prelaunch Notification.
3. Even if your payload does not meet one of the criteria, it is wise to file a HiBal Notice to All Airmen (NOTAM) with the FAA Flight Services within 24 hours of launch.
4. The NOTAM will require mostly the same information as the HiBal Prelaunch Notice
5. Call the FAA Flight Services office at 1.877.487.6867
6. Ask for the Michigan office.
7. Tell the representative that you want to file a "HiBal NOTAM"

NOTAM

Filing Date: 12 APR 12 No. Pages: 1

TO: Nashville Flight Data
FAX: 571-223-1593

FROM: Harvey Elliott, University of Michigan
2455 Hayward St. Ann Arbor, MI 48109
TEL: (734) 647 0000, harvey.elliott@umich.edu

FAR 101 HIBAL PRELAUNCH NOTICE

1. Balloon Identification: **KD8ROJ**
2. Planned date/time of launch: **Fri 13 APR 2012 @ 1400Z**
3. Location of launch site: Mason Jewett Field (KTEW), Mason, MI: N42°34.13'
4. W84°25.45' (**LAN 132 015**)
5. Max altitude: 100,000 MSL.
6. Forecast trajectory to FL 600: 1500Z 148/021 NM re launch site.
7. Balloon and payload data:
    A) Balloon Type & fill: 1500 gm white latex weather balloon, He fill for 1500 fpm ROA, 100K MSL cutdown; 4.5' orange/blue parachute descent.
    B) Payload: 4 packages. Total Weight: 6.75 lbs
    C) Payload train length: 30 ft.
8. Estimated flight duration: 1 h, 50 min.
9. Forecast landing: 1600Z, 146/50 NM re launch site.

Notes:
1. Launch site cell phone number: (734) 646 1334 after 1300Z launch day.
2. In-flight GPS/APRS tracking available at aprs.fi call sign KD8ROJ
3. Launch and landing notifications will be called in.
4. Please email Special Provisions to originator by 12 Apr 12.

Pre-Flight Checklist

10. Activate FTU

- [ ] Insert 1 x 9V battery into FTU
- [ ] Flip FTU power switch to “On” position
- [ ] String balloon line through FTU enclosure and around nichrome wire
- [ ] Tape and Velcro FTU enclosure
- [ ] Attach to line

11. Activate Microtrak

- [ ] Insert 2 x 9V batteries into Microtrak
- [ ] Verify Microtrak is showing up on APRS.fi
- [ ] Tape and Velcro Microtrak enclosure
- [ ] Attach to line

12. Activate Cell Tracker

- [ ] Turn off Wifi, Bluetooth, and brightness adjustment
- [ ] Turn on GPS
- [ ] Start “balloon” application
- [ ] Verify receipt of GPS packets on second cell phone
- [ ] Tape and Velcro Cell Tracker enclosure
- [ ] Attach to line

13. Activate Camera 1

- [ ] Insert SD card into camera
- [ ] Insert 2 x AA batteries into camera
- [ ] Turn on Canon A480 Camera by pressing the “Playback” button.
- [ ] Press “Menu”
- [ ] Scroll down to “Firm Update…” and select using the “func set” button.
- [ ] Select “Ok”
- [ ] After the chdk logo pops up, click the “mode” button (bottom left button)
- [ ] Click the “menu” button (bottom right button) in order to access the CHDK menu
- [ ] Scroll down and select “scripting parameters” then select “Load script from file…”
- [ ] Scroll down and select “inverval.bas”
- [ ] Scroll down to the bottom and set the desired amount of time between pictures
- [ ] Click “Menu” to exit the menu, and then take a picture to trigger the program
- [ ] Plug in a pair of headphones to turn the screen off
- [ ] Insert Camera into bottom of structure

14. Activate Camera 2

- [ ] Insert SD card into camera
- [ ] Insert 2 x AA batteries into camera
- [ ] Turn camera on by pressing the “Playback” button.
- [ ] Press “Menu”
- [ ] Scroll down to “Firm Update…” and select using the “func set” button.
- [ ] Select “Ok”
- [ ] After the chdk logo pops up, click the “mode” button (bottom left button)
- [ ] Click the “menu” button (bottom right button) in order to access the CHDK menu
- [ ] Scroll down and select “scripting parameters” then select “Load script from file…”
- [ ] Scroll down and select “inverval.bas”
- [ ] Scroll down to the bottom and set the desired amount of time between pictures
- [ ] Click “Menu” to exit the menu, and then take a picture to trigger the program
- [ ] Plug in a pair of headphones to turn the screen off
- [ ] Insert Camera into top of structure

15. Activate GoPro

- [ ] Insert SD card into GoPro
- [ ] Insert li-ion battery into GoPro
- [ ] Turn on GoPro by pressing POWER/MODE button (GoPro will beep 3 times)
- [ ] The GoPro will power on in VIDEO mode as the default
- [ ] If not in VIDEO mode, press and hold the POWER/MODE, until you reach 
- [ ] Press shutter button to begin recording video. (GoPro will beep once)
- [ ] Red LED light on front of the GoPro will blink while video is recording
- [ ] Place GoPro in waterproof case, insert into side of structure

16. Activate NEMO Payload

- [ ] Insert memory stick into Data Logger
- [ ] Insert 8 x AA batteries into power pack
- [ ] Wait 10 seconds, insert USB cable
- [ ] Verify Arduino is printing data to serial port
- [ ] Verify Aerocomm/Ground Station is receiving GPS updates
- [ ] Seal black box
- [ ] Insert NEMO Payload into structure
- [ ] Tape and Velcro foam enclosure
- [ ] Attach to line

17. Ready for flight?

- [ ] Is NEMO Payload connected to Cell Tracker?
- [ ] Is Cell Tracker connected to Microtrak?
- [ ] Is Microtrack connected to Radar Reflector?
- [ ] Is Radar Reflector connected to Parachute?
- [ ] Is FTU installed on balloon line?
- [ ] Is second FTU line connected to Radar Reflector?
- [ ] If yes, attach payload train to balloon.
- [ ] Go!

Chapter Updates

University of Central Florida

Update: 6/03/12

Being that it's summer SEDS-UCF has been significantly less active than the rest of the year. However, we are still in the process of planning projects for the upcoming fall and spring semesters, and we are attending various UCF club fairs to recruit new members.

Update: 5/13/12

For the past month SEDS-UCF has been fairly quiet. We finished our hybrid rockets this year, but were unable to launch due to problems with ground support equipment. We also held a successful Yuri's night complete with a screening of *Apollo 13.* Four of our members were able to attend a private tour of the Kennedy Space Center and were lucky enough to visit the VAB, Launch Pad B, and Orbiter Processing Facilities building 1. We have two goals for the summer: project planning (mainly hybrid rockets and ground support equipment) and recruitment.

Update: 4/10/12

Since our last update, UCF-SEDS has been busy. We recently held elections and our proud to have our new president, Corey Marks, and vice president, Anderson Duran taking us to new heights. We are currently working on the Mini Hybrid Competitions (both closest to 2000ft and max altitude), Experimental Standing Rocket Competition, and will finish the L-1 Certification Program with launch day on April 14th. We are also looking for project leads for the Zero-G Experimental Payload Project, the USLI Rocket Team, and SEDS-National 10k Rocket Competition. We recently hosted a carbon fiber workshop on Saturday, March 24th and will be hosting a LabVIEW Workshop in the near future. Our last meeting of the semester will be on April 13th. Later that day we will also have a few members participating in Relay for Life. Our previous external affairs officer Gillian Smith is also currently trying to assemble a SEDS Recruitment Team. Our main goals for the upcoming semester are to recruit new members and continue to provide exciting projects for SEDS enthusiasts.

George Washington Space Society

Update: 5/13/12

This semester the George Washington Space Society (GWSS SEDS) hosted Lynn Cline, NASA Deputy Administrator for Human Exploration and Operations. Ms. Cline shared stories from her time as NASA's lead negotiator for the ISS collaboration and discussed current issues facing NASA. GWSS also hosted a movie and pizza night. GWSS members attended the International Space University Symposium in Strasbourg, France February 21-23, participated in the Space Exploration Alliance Legislative Blitz February 27-28, attended the Space Generation Fusion Forum in Colorado Springs April 15-16, and volunteered for the Space Foundation at the National Space Symposium in Colorado Springs April 16-19.

We Want Our Future!

A grassroots space-based outreach initiative run by students, for students

"We Want Our Future exists to inspire participants to value science, technology, engineering, and math in order to support the sustainable exploration of space."

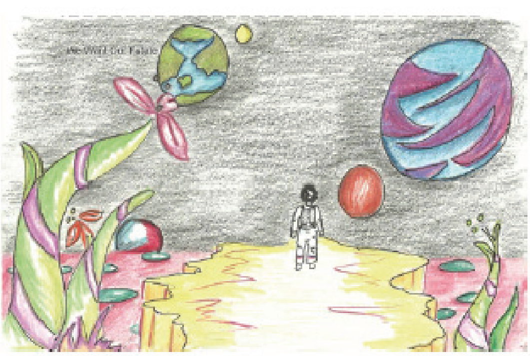
We Want Our Future (WWOF) is a student non-profit organization that:

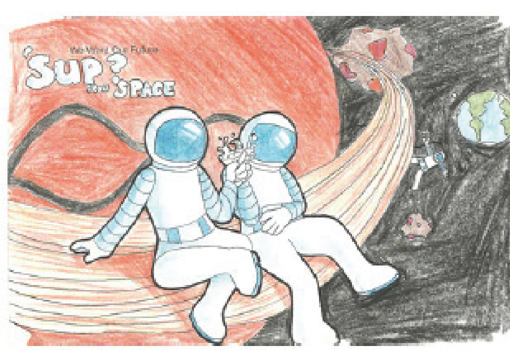
- Provides open source curriculum
- Portrays STEM through the thematic expression of exploration to increase accessibility
- Disseminates submissions for student-drawn postcards and provides a forum for participant visions

WWOF recognizes that space exploration is critical to the future of humanity and a fundamentally inspirational endeavor. Furthermore, WWOF acknowledges that without educated and inspired future generation, future exploration is not possible. Therefore, WWOF's mandate is to work with partner organizations and volunteers to engage 100,000 participants living both domestically and abroad. This is done in-part through the WWOF post-card program. The postcard program inspires students to imagine their future in space exploration by drawing this vision on a postcard. WWOF further achieves their mandate by providing no-cost outreach materials for teachers, students, and youth leaders across the United States and internationally.

To Get Involved or to receive more information:

- Go to the WWOF website: **www.WeWantOurFuture.org**
- Perform WWOF activities or volunteer with WWOF using suggested materials as a guide
- Submit completed postcards : *Attn: Brad Cheetham / Bruce Davis, We Want Our Future Initiative 431 UCB, ECNT 323, University of Colorado at Boulder, Boulder, CO 80309*
- Please contact us at: **info@wewantourfuture.org**





In Remembrance

Darrell David Cain

Aug. 25, 1985 - July 30, 2012

We mourn the passing of one of our greatest leaders and alumni, Darrell Cain, after a long fight with cancer. As an MIT SEDS leader, Todd B. Hawley Leadership Award recipient, former SEDS USA Executive Board member, and most importantly a friend, Darrell will be missed by all.

No words could even begin to describe the impact Darrell had on this world. His enthusiasm for life and passion for space influenced countless students and professionals during his 27 years. Darrell was one of the most intelligent people you could meet and put 110% into everything that he did.

Former SEDS USA Chairman Joshua Nelson said, "Darrell was the glue that held us all together. He was the reason people came to meetings, solved their differences, and made each and every one of us know we were part of something special."

Darrell began his experience in SEDS at the Massachusetts Institute of Technology, and served as a leader of his chapter throughout his tenure. His efforts with his chapter were vital to the successful re-establishment of the national organization, the MIT chapter, and the SpaceVision national conferences. He was elected to the position on the board as Director of Chapter Affairs, where he served for a year, re-invigorating the chapters and serving as a catalyst for building new ideas and programs across the country. He continued his work at Stanford University, influencing even more students there. True to Darrell's form, even sickness couldn't prevent him from being actively involved, attending conferences, participating in SEDS-USA discussions and impacting the organization until the very end.

In honor of Darrell's service and commitment to the next frontier, today we are establishing the Darrell Cain Award of Excellence. This award will honor Darrell, who was able to impact many through his efforts and inspire others to pursue the cause of space exploration. In keeping with Darrell's efforts, this award will be given each year in memory to an individual whose efforts have served to inspire students to be involved and promote our goal of becoming a spacefaring civilization.

SEDS would like to extend our condolences to the Cain family and offer our support in this time of mourning.

Neil Alden Armstrong

Aug. 5, 1930 – Aug. 25, 2012

Dr. Neil Armstrong, the first human to set foot on the moon, passed away this last August following complications resulting from cardiovascular procedures. He was 82 years old.

"Many Students first learn about Space exploration through the great accomplishments of the past, like Armstrong's historic and heroic landing on the Moon. This was a journey that he himself said only had a 50-50 chance of success" SEDS Executive Board Chairman Dan Pastuf said, "Because of the groundwork Armstrong laid down, young people have been inspired throughout the world to pursue the limits of where we can explore."

Armstrong joined the Astronaut corps in 1962 as part of "the New Nine", the second group of Astronauts selected by NASA. He first flew in space on Gemini 8, which included a rendezvous and docking, the most complex space mission up to that point. The mission almost resulted in disaster when the Gemini and its docking target began an uncontrolled roll, as a result of a thruster on the Gemini capsule being stuck in the on position. Armstrong was able to disconnect the vehicles maneuvering system, by shutting down the errant thruster but the vehicle was left almost completely uncontrollable forcing the mission to be shortened. He returned to space for the historic Apollo 11 flight, taking humanities first steps on another world at Tranquility Base on the Moon on Monday, July 21, 1969.

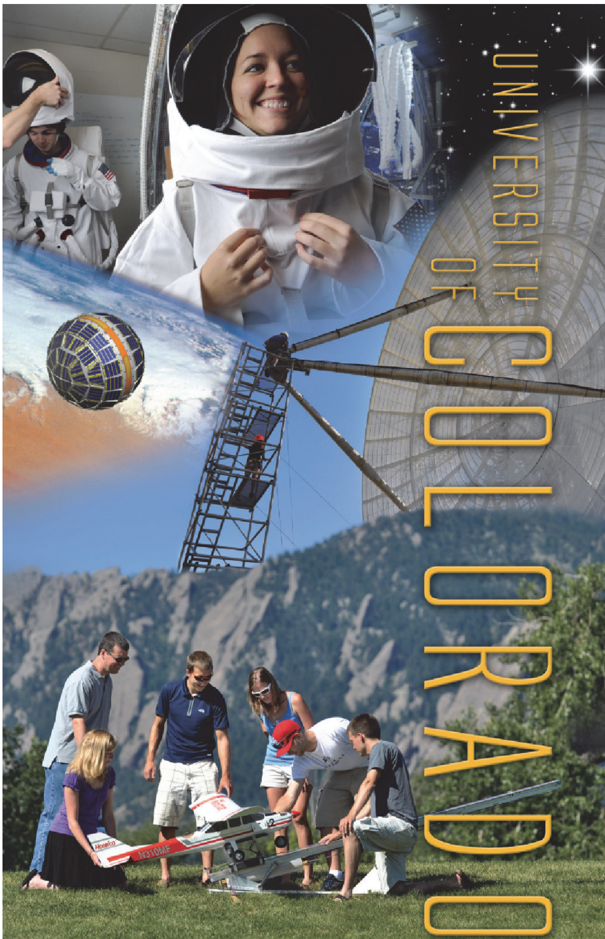
After his return from the Moon, he announced his intention not to fly in space again. He was appointed as the Deputy Associate Administrator for aeronautics for what would become the Defense Advanced Research Projects Agency, then retired from both it and NASA in 1971. He went on to become a professor at the University of Cincinnati, teaching students for over eight years before retiring in 1979. Armstrong throughout his life was able to act and inspire students.

"Neil Armstrong has always greatly motivated me, and shaped my steps towards my college career," said Board Member Daniel Zhou, a current student of Armstrong's Alma Mater, Purdue University, "Today marks a sad day for all Boilermakers in the US, and abroad and across Purdue alumni family. As we all mourn Armstrong's passing, we must also remember his past achievements and accomplishments. Not only did he pave the way for space exploration for the United States, he will always be a source of inspiration for our generation, and for the generations to come, as we ask ourselves, 'why explore space?'"

"There are some people that do the 'impossible' things and challenge us to go beyond reasonable expectations. Neil Armstrong has not only given us this challenge and inspired us to reach beyond the stars," SEDS Executive Board Vice Chair Sara Meschberger said, "but he through his life and passion he has given us hope to achieve 'impossible' dreams for generations to come."

Armstrong leaves a legacy of being the first man to step on the face of another world. NASA and Armstrong's work is one of the greatest technological accomplishments in the history of mankind.

"While many see the landing of Apollo as the conclusion of the great challenge set in front of us by President Kennedy, it was only the beginning," Pastuf said "the trailblazing efforts lead by Neil Armstrong and others must be continued as we reach farther into cosmos and return to the Moon and beyond."



AT BOULDER

The place for aerospace

DEPARTMENT OF AEROSPACE ENGINEERING SCIENCES

The Department of Aerospace Engineering Sciences at the University of Colorado at Boulder offers graduate students the opportunity to:

- collaborate with outstanding faculty on research supported by NASA, JPL, the Department of Defense and National Science Foundation
- work with engineers from space industry leaders such as Ball Aerospace, Boeing, Lockheed Martin, Northrop Grumman, and Raytheon
- be part of the only research university in the world to have designed and built space instruments launched to every planet in the solar system
- Accelerate your future with a degree from one of the top-ranked programs in the nation! Science and engineering students from all disciplines are invited to apply.

OPPORTUNITIES FOR RESEARCH IN:

Unmanned Aircraft Systems
Earth and Space Sciences
Sensor Technologies
Astrodynamics
Aerodynamics
Fluid Physics
Space Physics
Mission Design
Remote Sensing
Spacecraft Design
Materials & Structures
Vehicle Systems & Control
Bioastronautics and Life Systems

FOCUS AREAS:

The MS and PhD programs in Aerospace Engineering Sciences are organized into four focus areas.

- **Bioastronautics**
- **Astrodynamics and Satellite Navigation Systems**
- **Aerospace Engineering Systems**
- **Remote Sensing**

Graduate students are admitted into a specific focus area which provides research advising, and financial support. Each focus establishes its own admission and program requirements and recommendations for course work within and outside the department.