National Space Grant Program
Mary Snow
10/24/2009

How to Talk Like an Astronaut
(or don't say uh-oh in space)

Lesson Objectives

- Develop and practice team communication skills.
- Interest students in space exploration.

This activity will familiarize students with the importance of both clear and precise verbal and written communication, **and** following directions in today's increasingly technical society.

Lesson Overview

This lesson is based on the Apollo 13 episode, described in books and the movie, where an engineering ground team creates the procedure for building an adapter for the carbon dioxide filter in the LEM by building a model on the ground. The procedure is read to the flight team in space who must construct an exact replica of the adapter, without seeing the original adapter built on the ground by the engineers.

Three readings on the Apollo missions and space flight operations are included in the **Lesson Information** section. After reading the **Lesson Information** section with the students, each group of 6 to 8 students is divided into 2 teams, an engineering ground and an astronaut flight team. The ground team builds an object and creates a build procedure describing how this object should be built by the flight team. The object should be constructed out of 5 to 10 parts. It should be given a name and purpose. The object is not required to be similar to the adapter built on Apollo 13. The build procedure is read to the flight team who must create a replica of the object without seeing the original object.

This lesson uses brief excerpts from three sources of information. As preparation for this lesson, if time permits, students, should become familiar with the following complete references:

1. **Apollo: The Race to the Moon** by Charles Murray & Catherine Bly Cox
2. **Lost Moon: The Perilous Voyage of Apollo 13** by Jim Lovell & Jeffrey Kluger
3. **Ellen Ochoa Presentation - 2/21/08** Johnson Space Center; National Management Foundation; http://nma.jsc.nasa.gov/Resources/

Standards

- New Mexico Science Content Standard Strand III Science and Society (K-12)
- New Mexico Language Arts Standard Strand I Reading and Listening for Comprehension (K-8)
- New Mexico Language Arts Standard Strand II Writing and Speaking for Expression (K-8)
- New Mexico Language Arts Standard Strand III Communication (9-12)
- New Mexico Language Arts Standard Strand IV Writing (9-12)

Class Time Required
The optimal class time is two one hour class periods, one to read and discuss the material included in the **Lesson Information** section, and one to do the activity described in the **Procedure** section.

Materials:

1. Lesson information handout. Print the **Lesson Information** section.
2. Optional - audio recording: **Wide Awake on the Sea of Tranquility.** This is an 8 minute recording of the Apollo 11 moon landing available from the NASA web site. (The recording can be downloaded to a computer or audio player) NASA - moon landing
3. Optional - books from library on space exploration including:
    - **Apollo: The Race to the Moon** by Charles Murray & Catherine By Cox
    - **Lost Moon: The Perilous Voyage of Apollo 13** by Jim Lovell & Jeffrey Kluger
4. Two boxes of miscellaneous identical parts for each group. Different groups may have different boxes of parts, but the two teams in each group must have identical sets of parts. Math manipulative kits plus scotch tape and rubber bands make a good set of parts, also building kits such as LEGOs, or miscellaneous items you collect in the classroom will work.
5. Two cardboard screens for each group. Each team in a group should not be able to see the object being built by the other team.
6. One Build Procedure form for each group. This will be filled in by the ground team. Print the Build Procedure which is on the last page.

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Lesson Information

Part 1 - "*Don't Say Uh-oh in Space*"
Ellen Ochoa Presentation - 2/21/08
In one of the first pieces of advice that I received from veteran astronauts as I was training for my first flight, I was told that "there's only two ways to mess up as an astronaut – (1) failing to follow the procedures exactly as written, and (2) following the procedures exactly as written". That advice was either extremely unhelpful, very profound, or possibly both.

It's true that we have written procedures for everything we do in flight (at least for a shuttle flight), but it's a mistake to believe that just being able to expertly execute the procedures makes a person a good astronaut. Certainly the procedures are extremely important. Particularly for launch and landing, it is imperative that the operators and systems experts determine pre-flight how to handle malfunctions. All kinds of factors are considered when there is the luxury of time, so that during flight, if problems occur, a well-trained crew can quickly execute steps that could save their mission, their vehicle and perhaps their lives. However, no procedure can cover the crew for all situations, and sometimes, given the combination of failures that a mission can bring, or more frequently that instructors deviously insert during a simulation, astronauts need to make a real-time decision to do something different than the pre-flight written procedure. It takes a thorough understanding of the situation, the systems and the assumptions that go into each step of the procedures to decide when they are appropriate and when they're not.

Now imagine yourself experiencing a launch for the first time. You're lying on your back, being shaken by the vibration from the solid rocket boosters, 3 g's of acceleration through your chest so that it feels like a gorilla is sitting on you, and let's say you're in the middeck of the shuttle with no windows, no gauges, no way to tell what's happening except by what you hear and feel, and what you hear is an unexpected sound and a voice from the flight deck saying "Uh-oh". Did somebody just drop their checklist or is catastrophe imminent? Thus, another communication rule in the astronaut office: unless everyone knows what you're referring to, don't say "Uh-oh". Or, to put it in a broader text, in any communication, there is the potential for misunderstanding, but many times it is preventable by realizing that others aren't viewing the situation from the same vantage point that you are, and don't have the same knowledge or information that you do. By providing context for your comments, and ensuring that your audience has the essential information to interpret them, you can prevent confusion, misinterpretation and the occasional heart attack.

Discussion Questions Part 1 - Don't Say Uh-oh in Space
- Can you think of some examples of procedures the astronauts might use?
- What are some examples of procedures you follow in your classroom?
- Can you think of a situation you might be in where you shouldn't say uh-ho?
- What might you say instead of uh-oh?

Part 2 - "*Houston, we've had a problem.*"

Apollo: The Race to the Moon by Charles Murray & Catherine Bly Cox Chapter 27

When Apollo 13 lifted off on April 11, 1970, manned space flight was one day shy of the ninth anniversary of Gagarin's flight. In the intervening years, the actual flights had been unexpectedly safe. Thirty-seven times, men had sat atop rockets and been blasted off into space; thirty-six times, they had returned safely. .... Of the thirty-six crews that had return safely the Americans had launched twenty-two - six in Mercury, ten in Gemini, six in Apollo.

So perhaps it was time for something to go wrong. Or perhaps the superstitious were right, and NASA was asking for it. Flight number 13? Launched at the thirteenth minute of the thirteenth hour of the hour of the day, Houston time? (People who set launch times aren't thinking about superstitions, NASA officials said later.) What else could one expect two days into the flight, when April 13 arrived, but that something awful would happen?

But while Apollo 13 was objectively a failed mission, it was something else altogether to the people who were involved in it. For Glynn Lunney thinking back to the long development of operation that had begun with such halting steps in 1959, "Apollo 13 was the crowning achievement" - not just for the Control Center people, but for the people flying and all the people on the ground. It was crowning because it was ultimate - no crisis that manned space flight faced in the future could be much worse, Lunney thought, and still survivable -- "We were as close as you get to the edge and are still able to pull back."

Discussion Questions Part 2 - Houston We've Had a Problem

- Have you seen the movie **Apollo 13**? What did you think of it?
- What happened to the astronauts in Apollo 13? Did they make it back home safely?
- Why was the Apollo 13 Mission considered a "crowning achievement"?
- What was it like in the command module at liftoff?

  Note: You might let the students experience this by having a few (3 or more) students lie on the floor on their backs as close to each other as possible. Have them move their feet up and down, banging their heels on the floor, to simulate the noise and vibration of liftoff. Then have them put their hands on their chests and push as hard as they can to simulate the g's that astronauts feel. Finally, have one of them say “uh-oh”.

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Part 3 - *"I hope the guys who thought this up knew what they were doing"*
Lost Moon: The Perilous Voyage of Apollo 13 by Jim Lovell & Jeffrey Kluger

Ever since Monday night, when Apollo 13 first began to bang and vent and spin, the men at the Space Center, and specifically the engineers in Crew Systems, had been fretting about the lithium hydroxide question. The problem of trying to fit the command module's square air-scrubbing cartridges into the LEM's round receptacles was a low-tech issue on a flight beset by so many high-tech malfunctions, but it was a pressing issue nonetheless. With three men living and respiring in Aquarius, the first of the lunar module's cartridges should become saturated with carbon dioxide by the 85-hour mark in the mission, requiring the second and last one to be snapped into place. Well before the ship reached home, that cartridge would be full as well, and the astronauts would quickly choke to death on their own waste gases. ...

Now in the early hours of Wednesday morning, the Building 30 elevator bumped to a stop at the third floor. Smylie stepped out, carrying his strange unwieldy invention with him. Walking down the white, windowless hall, he came at last to a pair of heavy metal doors on his left marked "Mission Operations Control Room." He opened one of the doors, and stepped inside, and scanned the room uneasily. With each passing minute, he knew, the three astronauts in the distant ship were coming closer to choking on their own carbon dioxide. ...

The fact that Smylie's box could be easily assembled in the lab was no guarantee it could be just as easily assembled in space, and the time for getting started on the job was growing short. ... [Up in the LEM] Fred Haise folded up his roast beef packet, left it to float near the back of the cockpit, and drifted over to the carbon dioxide gauge, what he saw brought him up short. "O.K.," Haise said evenly, "I'm reading 13 on the gauge." He squinted at the needle a second time. "Yeah, 13." [When it rose about 7, the crew was normally instructed to change their lithium hydroxide canisters.]

"All right," Lousma said, "that's pretty much what we've got here, so we're going to want to get started putting together the little canister we've come up with."

For the next hour, the work aboard Apollo 13 had little more orderliness than a scavenger hunt, and little more technical elegance. [On the ground] with Kerwin reading from the list of supplies Smylie had provided him, and the controllers standing behind him and consulting similar lists, the crew were dispatched around the spacecraft to gather materials that had never been intended for the uses to which they were about to be put.

Swigert swam back up into Odyssey and collected a pair of scissors, two of the command module's oversized lithium hydroxide canisters, and a roll of gray duct tape that was supposed to be used for securing bags of refuse to the ship's bulkhead in the final days of the mission. Haise dug out his book of LEM procedures and turned to the heavy cardboard pages that carried instructions for lifting off from the moon -- pages he now had no use for at all -- and removed them from their rings. Lovell opened the storage cabinet at the back of the LEM and pulled out the plastic-wrapped thermal under garments he and Haise would have worn beneath their pressure suits while walking on the moon. No ordinary long johns, these one-piece suits had dozens of feet of slender tubing woven into their fabric, through which water would have circulated to keep the astronauts cool as they worked in the glare of the lunar day. Lovell cut open the plastic packaging, tossed the now useless union suits back into the cabinet, and kept the now priceless plastic with him.

When the materials had been gathered, Kerwin began reading up the assembly instructions Smylie had written. The work was, at best, slow going.

"Turn the canister so that you're looking at its vented end," Kerwin said.

"The vented end?" Swigert asked.

"The end with the strap. We'll call that the top, and the other end the bottom."

"How much tape do we want to use here?" Lovell asked.

Kerwin said, "About three feet."

"Three feet ... " Lovell contemplated out loud.

"Make it an arm's length."

"You want the tape to go on sticky end down?" Lovell asked.

"Yes, I forgot to say that," Kerwin said. "Sticky end down."

"I slip the bag along the canister so that it's oriented along the sides of the vent arch?" Swigert asked.

"Depends what you men by 'sides,'" Kerwin responded.

"Good point," Swigert said. "The open ends."

"Roger," Kerwin responded.

This back-and-forth went on for an hour, until finally the first canister was done. The crewmen, whose hoped-for technical accomplishment this week involved nothing less ambitious than a soft touchdown in the Fra Mauro foothills of the moon, stood back, folded their arms, and looked happily at the preposterous tape-and-paper object hanging from the pressure-suit hose.

"O.K," Swigert announced to the ground, more proudly then he intended, "our do-it-yourself lithium hydroxide canister is complete."

"Roger," Kerwin answered. "See if the air is flowing through it."

In the spacecraft, Swigert, Lovell, and Haise turned to their instrument panel. Slowly, all but imperceptibly at first, the needle on the carbon dioxide scale began to fall, first to 12, then to 11.5, then to 11 and below. The men on the ground in Mission Control turned to one another and smiled. The men in the cockpit of Aquarius did the same.

[Insert a picture here of the filtering device.]

Discussion Questions Part 3 - "I hope the guys who thought this up knew what they were doing"

- For the astronauts, what do you think was the hardest part of building the filter adapter? Why?
- What did the ground crew do to make sure the filter adapter would work?
- What procedures do the engineers on the ground use when they what to talk to the astronauts in space? Explain the role of the CapCom.

Procedure for each group of 8 to 10 students

Note: The CapCom handles all communication with command module. For students not familiar with the normal NASA Communications Protocol, do a quick dry run of steps 3 through 7 below. Use a 2 piece object and a 1 step Build Procedure.

1. Read the Lesson Information Section with the students.
2. Divide each group of 6 to 8 students into 2 teams a ground team (engineers) and a flight team (astronauts). Teams should be physically separated. Place cardboard partitions such that each team cannot see the other teams work area.
3. The ground team constructs an object out of 5 to 10 parts from the materials provided and creates a written procedure for building the object. Set a time limit of 10 to 15 minutes for this part.
4. While the ground team is working, the flight team selects one person to be the CapCom (flight communications on the ground) and another person to be the Flight Commander (astronaut in space who talks to CapCom). The flight team familiarizes themselves with the materials for constructing the object.
5. After the ground team completes the build procedure, the CapCom from the flight team moves over to sit with the ground team. The ground team gives the procedure to the CapCom who reads the procedure to the Flight Commander. The ground team can answer questions the CapCom asks. The Flight Commander and the flight team build the object. The Flight Commander can ask the CapCom questions.
6. The Flight Commander directs the flight team in the construction of the object. Only the CapCom can communicate with the Flight Commander. The ground team can talk to the CapCom. The flight team can talk to the Flight Commander. Set a time limit of 10 to 15 minutes for this part.
7. Once the procedure is completed, the two objects are compared and the teams are debriefed.

Procedure Quick Reference Guide

Ground Team - Engineers	**Flight Team - Astronauts**
Separate the 2 teams and put the cardboard screens in place. Each teams work area should be shielded from the other team.	
Build object and write build procedure. (10 – 15 minutes).	Select CapCom and Flight Commander. Examine parts you will be using to build object.
CapCom moves to sit with Ground Team.	
Engineers can hear Flight Commander, but can only talk quietly to CapCom.	Astronauts can hear CapCom, but can only talk quietly to Flight Commander.
CapCom reads procedure to build object to the flight team a step at a time, confirming each step as it is completed.	Astronauts build object following steps as read by CapCom. (10 – 15 minutes)
When CapCom receives questions from Flight Commander, engineers may provide information to the CapCom who will tell the flight team.	Astronauts may quietly ask Flight commander to ask CapCom questions about object as they are building it. Flight Commander then asks CapCom the questions.
Engineers answer questions through CapCom	Astronauts complete their version of the object.
Teams compare objects and debrief	

Assessment - Debrief Discussion

- How many times did an engineer or astronaut say "Uh-oh"?
- Are the two objects equivalent?
- Was the procedure correct as written? Did the procedure include a name and purpose?
- If updates to the procedure were required were they noted on the procedure?
- Were both the flight and ground teams able to follow the communication restrictions?
- If you did this activity again in the same role what would you change?

Extensions and Enrichment

- Put ground and flight teams in separate rooms and communicate via walkie talkie or speaker phone. Increase the time, and number of pieces used to construct the object.
- After the first activity, switch all members of the two teams to their opposite roles.
- Have the students turn the team activity into a skit.
- Watch the NASA TV Channel broadcasts from the International Space Station.
- Follow space exploration activities on http://www.nasa.gov
- Read the book **Lost Moon: The Perilous Voyage of Apollo 13** by Jim Lovell & Jeffrey Kluger; 1994
- Read the book **Too Far From Home: A Story of Life and Death in Space** by Chris Jones; 2007
    - **From Publishers Weekly:** When the space shuttle *Columbia* broke up during its re-entry into Earth's atmosphere in February 2003, two American astronauts were still aboard the International Space Station, along with a Russian flight engineer. With further NASA flights suspended for months, perhaps years, questions began to emerge not only about how to bring the three men back, but how to provide them with enough supplies while they remained in space.
- Watch the NOVA video **Hubble's Amazing Rescue.**
    - **From the PBS Website:** In the spring of 2009, NASA sent a shuttle crew on a risky mission to service the Hubble Space Telescope for the last time. The astronaut servicing team must carry out the first ever in-space repairs of Hubble's defective instruments, a task that requires ingenious engineering fixes and the most intensive NASA spacewalk ever.

Additional References

- Books:
    - **Apollo 11 First Moon Landing** by Michael D. Cole (for K - 6)
    - **Apollo 13 Space Emergency** by Michael D. Cole (for K – 6)
    - **Rocket Boys – a True Story** by Homer Hickam (for K -8)
- Websites:
    - http://history.nasa.gov - allow students to explore this sight
    - NASA - moon landing **Wide Awake on the Sea of Tranquility**
    - Project Apollo **Project Apollo - NASSP** An Apollo add-on for the Orbiter space flight simulator
    - Apollo 11 Launch Checklist from the Project Apollo Website
- Movies
    - **Apollo 13 (1995)** - movie (rated PG)
    - **The Right Stuff (1983)** - movie (rated PG)

Vocabulary

- **CapCom -** Generally the only person who communicates directly with a manned space crew. During much of the U.S. manned space program, NASA felt it was important for all communication with the astronauts in space to pass through a single individual in the Mission Control Center. That role was designated the Capsule Communicator or **CAPCOM** and was filled by another astronaut, often one of the backup crew members. It is believed that an astronaut is most able to understand the situation in the spacecraft and pass information in the clearest and most efficient way.
- **Lithium hydroxide -** Lithium hydroxide is used in carbon dioxide scrubbers for purification of gases and air.
- **LEM** – The **Apollo Lunar Module** was the lander portion of the Apollo spacecraft built for the US Apollo program by Grumman to achieve the transit from lunar orbit to the surface and back. The module was also known as the **LM** from the manufacturer designation (often pronounced "lem," from NASA's early name for it, **Lunar Excursion Module**).

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Build **Procedure**

Object Name:

Purpose:

Parts List:

Steps to Build: