Teacher Guide
# Table of Contents

I. Introduction  
   A. The Air Force Collaboratory  
   B. The Air Force Collaboratory used to enhance the learning process  
   C. The Air Force Collaboratory connection to STEM and to the Next Generation Science Standards – Science and Engineering Process  

II. Getting Started  
   A. Activity to Promote Innovation  
   B. Classroom Implementation  
   C. Creating an account  
   D. Using the site  

III. Collaboration  
   A. Facilitating collaboration in the classroom  
   B. Facilitating collaboration digitally  
   C. Top Tips for collaboration  

IV. Engineering and Design Process  
   A. Identify the Problem  
   B. Identify the Criteria and the Constraints  
   C. Brainstorm Possible Solutions  
   D. Generate Ideas  
   E. Explore Possibilities  
   F. Select an Approach  
   G. Build a Model or Prototype  
   H. Refine the Design  

V. The Air Force Collaboratory Projects  
   A. Search and Rescue 2.0  
      1. Teacher Background  
      2. Project Introduction  
      3. Project Resources  
   B. Mind of a Quadrotor  
      1. Teacher Background  
      2. Project Introduction  
      3. Project Resources  
   C. The Launch of GPS IIF  
      1. Teacher Background  
      2. Project Introduction  
      3. Project Resources  

VI. Conclusion  
   A. FAQ
I. Introduction

The Air Force Collaboratory

The United States Air Force is initiating a new learning platform. As a result, Science, Technology, Engineering, and Mathematics (STEM) inclined high-school age youths will collaborate with the Air Force through an online-centered experience. This cooperative learning community, “The Air Force Collaboratory” will work together with the Air Force to solve real-world challenges.

For the first time, the Air Force is opening up three real-world, unclassified projects for open collaboration on The Air Force Collaboratory. Challenges will fall within three categories: search and rescue in collapsed structures, quadrotors using autonomous navigation and GPS satellite deployment in space. This is not a science fair or contest; this is an online educational platform that pairs students, teachers, and other innovators with the Air Force’s brightest minds to use science, technology, engineering and mathematics to make a significant impact on the world. While interacting with USAF subject matter experts, users will build upon solutions to these challenges.

The motivation for the users of this site will be to make an authentic impact in the world, challenge their mind, and demonstrate their expertise. The Air Force Collaboratory is a place where great innovations can happen.

The Air Force Collaboratory used to enhance the learning process

Innovation is not the product of routine word problems or the use of available technology to simplify a task. Innovation is the spark of imagination that comes from critically thinking about new applications for current technology and practices. The cognitive domain of Bloom’s Taxonomy of Learning involves knowledge and the development of intellectual skills (Bloom). The Air Force Collaboratory will enhance the later. It will provide a platform for the top two levels of Bloom’s Taxonomy of Learning. Synthesis is demonstrated by building an environment for creating a new meaning or structure to solve a real problem. Evaluation is demonstrated by opening communication among students, teachers and Air Force specialists to discuss and expand on each other’s ideas. The materials teachers often have access to are problems that have already been solved. Students often learn content and apply it but have difficulty synthesizing to new situations. The Air Force Collaboratory has an authentic set of problems that students and teachers can use to develop these two top levels of learning.

The Air Force Collaboratory connection to STEM and to the Next Generation Science Standards – Science and Engineering Process

The goal of STEM (Science, Technology, Engineering, and Mathematics) education is to improve the nation’s competitiveness in technology development. STEM addresses the concern that the subjects are often taught in isolation, instead of as an integrated curriculum. (Hallinen, 7) Participation in The Air Force Collaboratory will require the use of STEM knowledge. Students and teachers will need to look at problems and apply cross-curricular knowledge to find solutions. The solutions to these challenges will require one to think from a new perspective. This will mean combining concepts that may not traditionally go together to explore the possibilities of providing a solution. In order to solve these problems students will use the Next Generation Science Standards (NGSS) Science and Engineering Practices.
The students will have to analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (Next Generation Science Standard HS-ETS1-1)

The students will work with other collaborators including students, teachers, and Air Force personnel to design a solution to a complex real-world problem. The categories of The Air Force Collaboratory are arranged into projects, which the students will post “collaborations” to with the goal of solving the problems. (Next Generation Science Standard HS-ETS1-2)

Students will also have the opportunity to reply to and evaluate the posted collaborations of other users based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (Next Generation Science Standard HS-ETS1-3)

References:


“There’s a classic obstacle to innovation called ‘functional fixedness,’ which is the tendency to fixate on the common use of an object or its parts. It hinders people from solving problems.” (McCaffrey, 215) Tony McCaffrey, a psychology PhD from the University of Massachusetts has developed a systematic way of overcoming that obstacle: the “generic parts technique” (GPT)

For each object in a problem, break it into parts and ask two questions:
1. Can it be broken down further?
2. Does the description of the part imply a use? (McCaffrey, 216)

Below are some sample problems to try with students using the GPT. If the materials are available, students can work with the manipulatives listed in the problem. However, they could also be given each as a discussion topic to work on in groups in order come up with possible solutions.

**Rings of Steel**

You are given two steel rings and told to make a figure-8 out of them that can be suspended from a peg on the wall. Your tools? A candle and a match.

Solution:
Remove the wick and tie the two rings together.

**The Nine Dots**

Come up with as many different solutions to the following problem as you can: Connect the dots by drawing four straight, continuous lines that pass through each of the nine dots, and never lifting the pencil from the paper.
Classroom implementation
Consider scheduling some time each week for students to work on The Air Force Collaboratory.

Creating an account
Creating an account can be done using two methods after clicking the CREATE link on the upper right of the site.

Facebook method
Click “LOG IN WITH FACEBOOK” and the site will copy all the profile information from Facebook into the profile

Email method
Use the form to create a profile. It is a wise idea to review the terms of service and then accept them by clicking the check box. Once that is completed a confirmation email will be sent to verify the account.
Using the site

Profile Screen

This is the first screen that is presented after log in. It can always be returned to by clicking on the profile name in the upper right hand corner next to the profile picture.

On this screen listed across the top are the three Air Force Collaboratory projects: Search and Rescue 2.0, Mind of a Quadrotor, and The Launch of GPS IIF. As each one is scrolled over a drop down appears showing a link to view the “collaborations” currently active. These will stay at the top of the screen as the screen is scrolled vertically.

Below The Air Force Collaboratory projects are the profile summary and the Popular Ideas Stream. In the profile summary each member has points, achievements, and rank listed as well as the number of ideas and comments that have been posted by the member. Most user actions within The Air Force Collaboratory are awarded points:

- “Complete your profile+10”,
- “Add an idea+1”,
- “Comment on a topic+1”,
- “Airmen Approval+10”,
- “Get your idea voted up+1”,
- “Get your idea voted down-1”.

Achievements are posting goals such as “Contribute one idea with a photo” or “Have 20 ideas voted up.” There are also Special Achievements. The Air Force Project Lead awards special achievements to users that demonstrate exemplary performance. Rank is based on the number of points accumulated.

Below the summaries are three tabs: Activity, Achievements and Ranking. Activity displays the “feed” of posts from the current user as well as posts marked as favorite by the user. This is the default tab displayed. The Achievements tab displays all the possible achievements and a percentage of completion for each. The Ranking tab displays a “Leader board” with the highest ranks appearing at the top.
The Air Force Collaboratory Project pages

Each project page follows a similar layout. The user should watch the brief presented when first landing on the project page. This will explain the project and give some background on the problem. The second thing the user should do is review the research. This can be accessed by clicking on either the research tab on the menu across the top or on the research button below the brief.

The research page for each project breaks the project down into sub-projects and lists “Related Collaborations” for users to review and post ideas on to further the project.

Once all the research is reviewed the user can choose to explore collaborations in a few ways. The user could continue to use the research page to explore a particular project. The user could scroll down to see the collaborations listed on the category page. The collaborations on the project page are the featured, newest, and most popular collaborations. The project page would be a good place to work from once all the current collaborations in the research page have been reviewed. The user could click the collaborations menu option across the top and be taken to a page listing all the collaborations for the project. There are several sorting options on this page to help navigate collaborations by date of post, number of comments on post, and curricular subject of post.

The timeline of the project is listed in several places but can be easily found on the main project page. The timeline demonstrates when the challenge the project is addressing will come to completion. The GPS project will have a hard completion date due to the fact that it will involve a satellite launch.

The Collaborations

Airmen ask the community to collaborate on solving a challenge in the collaborations. Users can submit ideas to the collaborations to help find a solution. Each collaboration page has a button for posting an idea, a description of the collaboration, and a listing of all the posts to that collaboration. The posts can be sorted by date and number of comments to the post.

The Posts

Each post will have a title, a narrative post and the option for pictures and video to be added. Pictures are added by upload from a computer. Video must be linked by URL from either YouTube or Vimeo. A user can either create a post or reply to a post that another user has created. Once the post is completed, the user should be sure to press post before leaving the page. The user can also vote on posts or a reply to a post. Clicking on the blue plus will “Vote up” the post and clicking on the red minus will “Vote down” the post. If a post has inappropriate content it can be flagged by any user for review by clicking on the flag next to the red minus button. Note this can be undone by clicking the flag again.
Other users

Each user may explore the profile of any other collaborator by clicking on the username. The user may see the Activity feed, the Achievements, and the Ranking of the other collaborators. The user can also reply to any post or reply made by any other collaborator.

Editing the Profile

The user profile may be customized. The user has control over the displayed first and last name, the profile picture (avatar) and the background picture of their profile page. For best quality, upload an image that is at least 256x256 for the avatar and 1140x338 for the background.

References:

III. Collaboration

Facilitating collaboration in the classroom

Groups can be set up in many different ways. Several suggested group modes are listed below.

The Chunking Strategy
Decompose the task into smaller parts. The group members research the assigned part. Students researching the same topic as members of other groups may meet together. This creates subject experts. The students then return to the group to teach the other members.

Think/Pair/Share
Each student in the group is given the same question to think about individually. The students then share with a partner their thoughts. The entire group then summarizes all thoughts.

Round Robin
Each student in the group is given a chance to speak on the subject in turn. This ensures all students in the group participate.

Group Debates
The students take positions that are opposite to their views and then argue that side of the issue.

Fish Bowl
The students arrange themselves into two concentric circles. The inside circle discusses the topic while the outside group observes.

(“The Basic Collaborative Learning Techniques”,1-4)

Facilitating collaboration digitally

Technology makes collaborative learning easier. Increased learning opportunities are the result of collaboration, whether done in person or via technology. Choose one or two collaboration services for your class as not to overwhelm students or the instructor with too many things to learn before they can start collaborating. Be sure to check school district policy before signing students up for services. Below is a list of collaboration tools.

1. Edmodo.com – is a course management system that looks a lot like a platform that many students use already. It allows for uploading files in a common storage library. As well as the ability to post and comment on posts. It is free and intuitive.

2. Google Docs – Google Docs provide real time document collaborations using shareable folders. Users can create text documents, spreadsheets, and presentations.

3. Dropbox – Dropbox is a virtual hard drive. Students can upload any files to an online folder and share that folder with anyone (even if the other person does not have an account).

4. Livebinders – Live Binders not only replaces the old 3-ring binder, but also opens up new opportunities for collaborating, organizing, and sharing that were never possible before.

5. Lino – Lino is a virtual collaborative bulletin board. Users can post sticky notes, pictures and media. It is free to sign up.
Top Tips for collaboration

1. Create goals for the group. This will keep the group on task and give the group a purpose.

2. Groups should be 4 to 5 students. A smaller group may not provide enough diversity and a larger group will create outlier students who do not get to participate.

3. Build a group dynamic. Help students deal with any interpersonal problems immediately. Assignments should encourage group members to explain concepts to each other.

4. Change up group members. In order to keep a positive flow of ideas, the group dynamic needs to change periodically. Adding a new member or switching out members will accomplish this task. Changing the entire group will lose the group dynamic that was already created and should be avoided.

5. Create group roles. This could be done by breaking the task down into parts and assigning each student a supervisory role. This could also be accomplished by giving students group jobs such as:
   - Task manager - Keep group members focused
   - Activity recorder - records what they do & what questions the group has
   - Life Line (can be doubled) - can leave the group to seek help
   - Evaluator - judge the effectiveness of the group and report only to the group

6. Create formative and summative assessments. This will allow the group to judge their effectiveness and provide a group goal.

7. Included time for metacognition. It is important to let the group reflect on the process of group learning. Each member of the group could list one good thing about each member and one thing each member needs to work on in the group.

8. Let groups have fun. It is not always about being productive. Some of the most effective team conversations occur when stress levels go down.

9. Provide a model for shared leadership. Students should work together to maintain the voice of everyone in the group and accomplish the task. No one person should take control. All members of the group should take responsibility for initiating discussions, clarifying points, summarizing and challenging assumptions.

10. Groups need a model for dealing with conflict in the group. How to compromise and agree to disagree.

References:

IV. Engineering and Design Process

There are many different explanations of the engineering and design process. One example of this is the Engineering and Design process NASA published in 2008 as part of a design challenge on growing plants on the moon. This process is modeled with the following “collaboration” from The Air Force Collaboratory.

“Technology often gets inspiration from nature. Scientists studied spider webs to develop bulletproof vests. The latest color LED screens were inspired by a butterfly’s wings’ ability to reflect sunlight. The examples go on and on. What examples from nature can we apply to help save lives during search and rescue efforts? These examples can inspire new tools to develop or even new practices to apply while in the field.”

**Listing the problem**
Write the problem out as a specific question to research, such as “How can I design a rescue technology tool that will model something from nature?”

**Find all Criteria and Constraints**
Make a list of the requirements and the limiting factors of the problem. In this case that might be:

The technology tool needs to be modeled after something in nature
The technology tool needs to aid in the rescue of an individual trapped in a collapsed structure.

**Brainstorm Possible Solutions**
List all the possible things that might help the group solve this problem. All ideas are acceptable and there are no bad ideas at this point. In this case think about bats that navigate using sonar, bees that somehow know their way back to the hive, and fish that in the deepest part of the ocean find food in complete darkness. You may do this in the classroom or online with other collaborators.

**Focus on two solutions**
Pick two possible solutions from the brainstorming session to research and work into a more detailed plan. This could include sketches and diagrams as well as research material. This process can again be limited to the classroom but could also be done inside The Air Force Collaboratory. This site allows for the posting of video and photos, which will enable a complete “posting” of the solutions to The Air Force Collaboratory.

**Debate the solutions**
This is where the design team takes opposite sides and debates with each other in order to choose the best possible solution from the list. This debate should be backed up with the research and diagrams from the previous step. This debate can occur online with other collaborators or in the classroom.

**Select the solution that best solves the problem**
The team should write a statement listing their solution justified with diagrams and pictures. If the solution has not been posted yet, this is the point in the process where the idea needs be posted to The Air Force Collaboratory. The idea can then be responded to and worked on by other collaborators and Air Force specialists.
Rapid Prototyping
The Air Force will then work to create a prototype of the best solutions. The rapid prototyping will use the latest in 3D printing and the designs will be tested in the field.

Refine the Design
Once the design has been tested in the field it will be refined and modified. This new technology will then be used to save lives.

For more information on the engineering and design process visit http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html

References:
V. The Air Force Collaboratory Projects

Search and Rescue 2.0

Teacher Background

Search and Rescue has changed dramatically over the past 30 years. Searches no longer last for weeks. Usually they are over in 24 to 48 hours. (Goodman, 1) The average maximum survival time is about 6 days. (Macintyre, 1)

The beginning of the Federal Search and Rescue teams may be traced to congressional enactment of the Earthquake Hazards Reduction Act of 1977 to stimulate research and planning related to preparation for, and response to, the devastation of earthquakes. (Bea, 2) In 1979, Congress amended the 1977 statute to require FEMA to serve as lead agency. (Bea, 2) Under the direction of FEMA the Fairfax County Fire & Rescue and Metro-Dade County Fire Department began search-and-rescue (US&R) teams trained for rescue operations in collapsed buildings in the 1980s. The US&R teams worked on earthquakes in Mexico City, the Philippines and Armenia. In 1989 FEMA established the National Urban Search and Rescue (US&R) Response System as a framework for structuring local emergency services personnel into integrated disaster response task forces. (“What Urban Search & Rescue (US&R) Does”, 1)

Basic Earthquake Rescue Techniques & Tools

According to the BBC News, from an article based on information provided by International Rescue Corps, below are the 7 Basic Earthquake Rescue Techniques & Tools (“Earthquake Rescue: How Survivors Are Found.”, 1)

1. Work with the locals to find the best search locations.

2. Remove the rubble using heavy-lifting equipment if available, but often this is done by hand using tools such as pick axe, shoves, chainsaws, disc-cutters, diamond blades, and rebar cutters.

3. Workers use excavators and hydraulic jacks to shift rubble.

4. Rescue Dogs are used to find life signs that human rescuers cannot detect.

5. Look in locations that provide the most likely location of survival.

6. Checking weak buildings is done as these types of structures give people a good chance of escape because of their light materials and low height.

7. Using special sound equipment to listen and carbon dioxide detectors, searchers can determine the locations that have the best chance of survival.
Modern Search and Rescue Technology

Scientists have developed sensors that can detect traces of breath and sweat. “The sensor technology was shown to accurately detect human-generated carbon dioxide and ammonia in air that wafted through gaps in the rubble during testing, something that previously only dogs could do.” (Phillips) This technology may not replace rescue dogs as the sensors need to be placed by someone and the conditions may not make that feasible, but it will add another tool searchers can use.

Radar is used to sense life signs through brick walls and concrete ruins. Currently, the most widely used radar life detection device is DKL Life Detector, launched by American STV Security System Company in 2005. DKL Life Detector uses the UWB radar technique in the field of safety and rescue and has been proved to perform successfully in the Wenchuan earthquake search and rescue. (Hu Ye, 664)

Optical life detections refer to the system that extends an optic sensor through a hole in the ruins. It is mainly a light source, micro microphone, and video sensor connected by wires inside a pole of variable length to a monitor. (Hu Ye, 665) This will allow rescuers to see survivors and access structural supports to rescue them.

Acoustic life detection systems consist of acoustic sensors, data acquisitions systems, and a computer processing system. This system searches for weak vibrations signals created by survivors when they move, tap or call out. The system then analyzes the signal to determine the location of the survivor. This system is vulnerable to interference of all kinds of noise in the surrounding environment. (Hu Ye, 664)

Infrared life detection systems developed on the concept that the characteristics of infrared radiation of a survivor are different from that of the surrounding environment. This system can separate images of a living being and the environment. Rescuers can use this system to find the exact location of the trapped individual. The Snake Eyes Life Detector and Visual Life Detectors of Germany KuMate have infrared sensors in a flexible cable that collect the information of rescue environments. That information is converted into video images, which help rescuers inspect quickly to determine whether there is a survivor or not. (Hu Ye, 664)

Project Introduction

Project Goal
- The goal of this project is to develop new technologies through rapid prototyping to save lives trapped in collapsed structures.

Essential Question
- What are detectable human life signs?
- How could the life in a collapsed structure be detected?
- Once life is detected how is that survivor retrieved?

Conversation Starters
- Have you ever been stuck somewhere you could not get out of?
- What are some ways you could determine if someone is in a room if you can’t see in?
**Introductory Activity**

Divide the class into two groups: searchers and survivors.

**Step 1:** Move the desks and tables out of the way so there is plenty of room. The survivors are to choose one thing they think might lead a searcher towards their location. They are to sit on the floor in locations around the room and perform that activity.

**Step 2:** The searchers should crawl on hands and knees blind folded (or with their eyes closed) to search for survivors. The purpose of the students on hands and knees is to protect from accidental falls and to simulate the kinds of conditions rescuers have to work in. Do this for 5 min.

**Step 3:** Switch the two groups and continue for 5 more min.

**Step 4:** Pull the students back together as a class and have a 5 min group discussion on the experience. Ask them what were the most effective survivor activities? What senses were the searchers using to find the survivors? How could those senses be extended to sense through wall and rubble?

**Project Resources**

Search and Rescue Dogs –
http://ardainc.org/

Structural search and rescue –
http://www.mfri.org/cgi-bin/dom.cgi

Search and Rescue Training manual –
http://www.clarkfr.org/training/Training%20Manual/TM%20Articles/Article_1-03_SAR.pdf

Search and Rescue Techniques –
http://www.lafra.org/grapevine/section/articles/training/search-and-rescue-techniques-%E2%80%93-part-17

Search Techniques Used by Trained Teams in the Field –

FEMA earthquakes readiness –
http://www.ready.gov/earthquakes

Gallery of Earthquake Rescue robots –

Earthquakes Guidelines on preparing, responding and recovering Red Cross –
Mind of a Quadrotor

Teacher Background

A quadrotor is a multi-rotor copter with four arms, each of which have a motor and a propeller at their ends. Quadrotors are similar to helicopters in some ways, though their lift and thrust comes from four propellers, rather than just one. Also, helicopters have a “pitch” or tail rotor that helps stabilize the craft, whereas quadrotors do not. In a quadrotor, two of the propellers spin in one direction (clockwise) and the other two spin the opposite direction (counterclockwise) and this enables the machine to hover in a stable formation. (What Is a Quadcopter? Or a Quadrotor?, 1)

Etienne Oehmichen, Dr. George de Bothezat and Ivan Jerome completed early designs of quadrotors in the 1920s. (DiCesare, 1) Etienne Oehmichen experimented with rotorcraft designs in the 1920s. In 1923 he demonstrated a quadrotor craft that could carry four people. The U.S. military was not interested in the design but did note the importance of the innovation to aircraft technology. (Seddon, 4) The craft had a record distance of 1 km on a closed circuit course and won a 90,000-franc prize from Service Technique de L’Aeronautique. (Seddon, 4) The main issue with the early quadrotors was the ability to control the motors. It has only been recently with the development of modern control algorithms and microcomputer technology that quadrotors have become practical. Today one can find small RC quadrotors online to purchase for under $50.

The University of Pennsylvania has been working on autonomous quadrotors in their General Robotics, Automation, Sensing and Perception Lab (GRASP). The GRASP Lab uses a Vicon motion-capture system. There are infrared cameras placed throughout a test-flying area, which communicate with tiny sensors on the quadrotors, feeding into a computer-based navigation system. (Bradley, 1) This limits these autonomous quadrotors to controlled, sensor lined environments but the demonstrations are very impressive to watch.

After the 2011 earthquake in Japan, a team from the University of Pennsylvania and Tohoku University in Sendai took non-autonomous quadrotors into the disaster zone. This team was able to send in quadrotors equipped with cameras and lasers to map three floors and create three-dimensional maps. (Bradley, 1)

Project Introduction

Project Goal
- The goal of this project is to build a system that allows a quadrotor to navigate its surroundings with minimal human interaction

Essential Questions
- What makes the quadrotor such a versatile craft?
- What senses are needed for the quadrotor to “feel” its way around?
- Why is it important for the quadrotor to perform with minimal human interaction in a search and rescue situation?

Conversation Starters
- Have you ever flown a quadrotor RC craft?
- How would you navigate a dark room and avoid obstacles?
- What could the potential misuses of quadrotors be?
Introductory Activity

To perform this activity the instructor will need a small bicycle wheel and a spinning desk chair.

**Step 1:** Have a volunteer (or the instructor can demonstrate) sit in the desk chair, hold the bicycle wheel in front of them with the axis parallel with the ground and with their feet up on the legs of the chair.

**Step 2:** Spin the wheel slowly for the volunteer. Then instruct the volunteer to tilt the wheel to the left and then to the right. The chair should spin in either direction. Then try it again with the wheel spinning faster.

**Step 3:** Ask the students in the class to write down their observations as the volunteer does this activity.

**Step 4:** After the experiment ask the students to share their observations with a student next to them.

**Step 5:** Finally have the class share out what they have discovered.

Project Resources

GRASP Lab Quadrotors in action –
http://www.youtube.com/watch?v=YQIMGV5vtd4
http://www.youtube.com/watch?v=_sUeGC-8dyk
The Launch of GPS IIF

Teacher Background

Launching a satellite into space

GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km. Each satellite circles the Earth twice a day. (“Space Segment”, 1) The satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth, each containing, at a minimum, four “slots” occupied by baseline satellites. This 24-slot arrangement ensures there are at least four satellites in view from virtually any point on the planet. (“Space Segment”, 1)

The launch of a satellite or space vehicle consists of a period of powered flight during which the vehicle is lifted above the Earth’s atmosphere and accelerated to orbital velocity by a rocket, or launch vehicle. Powered flight concludes at burnout of the rocket’s last stage at which time the vehicle begins its free flight. During free flight the space vehicle is assumed to be subjected only to the gravitational pull of the Earth. If the vehicle moves far from the Earth, its trajectory may be affected by the gravitational influence of the sun, moon, or another planet. (Braeunig, 1)

A space vehicle’s orbit may be determined from the position and the velocity of the vehicle at the beginning of its free flight. A vehicle’s position and velocity can be described by the variables r, v, and Y, where r is the vehicle’s distance from the center of the Earth, v is its velocity, and Y is the angle between the position and the velocity vectors, called the zenith angle. (Braeunig, 1)

Project Introduction

Project Goal
- The goal of this project is to target the precise coordinates within the GPS constellation to launch our newest GPS satellite.

Essential Question
- Why is it important for the new GPS satellite to be in the correct spot in the GPS constellation?
- What is needed to find the precise coordinates within the GPS constellation?
Conversation Starters
- Is there direction in space?
- Since the satellites in the GPS constellation are orbiting the earth every 12 hours, the coordinates are moving targets. Have you ever tried to hit a moving target?
- How is that different from a stationary target?

Introductory Activity
To perform this activity the instructor will need some plastic spoons and masking tape. The desks should be clear from the center of the class to make room for the activity. Arrange one desk for each team facing the center of the room.

Step 1: Have the students tape the spoon handle to the desk with the spoon facing towards the center of the room.

Step 2: Place targets in the room for the students to hit using the spoons as a catapult and small wads of paper as projectiles.

Step 3: Have students “fire” at one of the targets. They should then use the data of misses to align the desk to the target.

Step 4: Have the students “fire” on a new target. This time they should use the aiming information they learned previously and try to hit the new target in one shot. If they miss they should see how many adjustments it takes to hit the new target and compare that number to the previous target.

Step 5: When students have completed the task have them answer the following questions in their group and then report to the whole class. Ask: What was the most helpful piece of data from the first target attempt when trying the hit the second target? If your group tried this with several targets what process might arise to calculate target locations? Is it ever possible to hit the target right on or will there always need to be some type of adjustment?

Project Resources
GPS Example – http://www.pbs.org/wgbh/nova/shackletonexped/navigate/gps/
Spaceflight Now Tracking Station Worldwide launch schedule – http://spaceflightnow.com/tracking/
Launching a space craft – http://www.braeunig.us/space/orbmec.htm#launch
References


VI. Conclusion

FAQ

How do I return to the profile screen?
It can always be returned to by clicking on the profile name in the upper right hand corner next to the profile picture.

How are points awarded?
Points are awarded with everything done on The Air Force Collaboratory: “Complete your profile+10”, “Add an idea+1”, “Comment on a topic+1”, “Airmen Approval+10”, “Get your idea voted up+1”, “Get your idea voted down-1”.

What are achievements?
Achievements are posting goals such as “Contribute one idea with a photo” or “Have 20 ideas voted up.”

How do I get the special achievements?
Special achievements are awarded by the Air Force Project Lead to users demonstrating exemplary performance.

How is my rank calculated?
Rank is based on the number of points accumulated.

What is the first thing I should do on a category page?
View the brief and go through the research.

What is a collaboration?
Collaborations are where Airman ask the community to collaborate about how to solve a challenge.

What can I add to a post?
Each post has a title and a narrative post. Pictures are added by upload from a computer. Video must be linked by URL from either YouTube or Vimeo.

How can I communicate with other collaborators?
The user can vote on posts or reply to a post.

What can I change on my profile?
The user has control over the displayed first and last name, the profile picture (avatar) and the background picture of their profile page. For best quality, upload an image that is at least 256x256 for the avatar and 1140x338 for the background.

What is the goal of the Search and Rescue 2.0?
The goal of this project is to develop new technologies through rapid prototyping to save lives trapped in collapsed structures.

What is the goal of Mind of a Quadrotor?
Build a system that allows a quadrotor to navigate its surroundings with minimal human interaction.

What is the goal of The Launch of GPS IIF?
Target the precise coordinates within the GPS Constellation to launch our newest GPS satellite.