

Kids as Airborne Mission Scientists

Lesson overview: Developing the mission flight plan -- When and Where do I fly?

Lesson context: This lesson prompts students to select the best aircraft for their mission and create a flight plan given the mission characteristics. Based on their new understanding of NASA research aircraft, students will identify answers to their questions from previous lessons and use the answers to select the best aircraft for the airborne remote sensing mission. They will create a flight plan and then compare their flight plan to one that was used to fly the actual mission over Kailua Bay.

Key science concepts:

- Science technology and instruments: the characteristics of NASA research aircraft and remote sensing instruments
- Calculating the great circle flight path
- Latitude and longitude
- Weather: temperature, wind speed, wind direction, moisture in the air, dew and frost

Links to teacher background information:

- [ER-2 operating bases](http://www.dfrc.nasa.gov/airsci/er-2/er2bases.html) (http://www.dfrc.nasa.gov/airsci/er-2/er2bases.html)
- [ER-2 typical flight operations](http://www.dfrc.nasa.gov/airsci/er-2/fltops.html) (http://www.dfrc.nasa.gov/airsci/er-2/fltops.html)\
- [Atmospheric circulation research and flight paths](http://www-gte.larc.nasa.gov/pem/pemt_flt.htm) (http://www-gte.larc.nasa.gov/pem/pemt_flt.htm)
- [Pacific mapping research flight paths](http://www-gte.larc.nasa.gov/pem/pemb_flt.htm) (http://www-gte.larc.nasa.gov/pem/pemb_flt.htm)
- [Example flight plans](http://ghrc.msfc.nasa.gov/camex3/flight_plans/) (http://ghrc.msfc.nasa.gov/camex3/flight_plans/)
- [Great circle flight path display tool](http://gc.kls2.com/) (http://gc.kls2.com/)
- [AVIRIS](http://makalu.jpl.nasa.gov/html/overview.html) (http://makalu.jpl.nasa.gov/html/overview.html)

Problems addressed in this lesson:

- What is the best NASA research aircraft to fly the KaAMS airborne remote sensing mission?
- Create a flight plan for the Kailua mission.

Activity bursts:

- [Select aircraft based on characteristics of the remote sensing instruments](http://www.higp.hawaii.edu/kaams/lessonplans/develop/support.html#group1)
(http://www.higp.hawaii.edu/kaams/lessonplans/develop/support.html#group1)
- [Select aircraft based on mission planning factors](http://www.higp.hawaii.edu/kaams/lessonplans/develop/support.html#group2)
(http://www.higp.hawaii.edu/kaams/lessonplans/develop/support.html#group2)
- [Selecting aircraft based on flight planning parameters](http://www.higp.hawaii.edu/kaams/lessonplans/develop/support.html#group3)
(http://www.higp.hawaii.edu/kaams/lessonplans/develop/support.html#group3)
- Create a flight plan and compare it to the actual NASA flight plan

Links to other resources:

Lesson	<u>Teacher</u>	<u>Student</u>
	ER-2 http://www.dfrc.nasa.gov/airsci/er-2/er2perf.html	ER-2 http://www.dfrc.nasa.gov/airsci/er-2/er2perf.html
	DC 8 http://www.dfrc.nasa.gov/airsci/dc-8/dc8_his.html	DC 8 http://www.dfrc.nasa.gov/airsci/dc-8/dc8_his.html
	P-3B Orion http://www.wff.nasa.gov/~apb/p3.htm	P-3B Orion http://www.wff.nasa.gov/~apb/p3.htm
	King Air http://www.aero-charter-darta.com/english/k200.htm	King Air http://www.aero-charter-darta.com/english/k200.htm
	Pathfinder/ Centurion http://www.dfrc.nasa.gov/PAO/PAIS/HTML/FS-056-DFRC.html	Pathfinder/ Centurion http://www.dfrc.nasa.gov/PAO/PAIS/HTML/FS-056-DFRC.html
	SR-71 Blackbird http://www.dfrc.nasa.gov/PAO/PAIS/HTML/FS-030-DFRC.html	SR-71 Blackbird http://www.dfrc.nasa.gov/PAO/PAIS/HTML/FS-030-DFRC.html
Inform	Weather experiments (optional): <ul style="list-style-type: none"> • http://www.allstar.fiu.edu/aero/Experiment9.htm • http://www.allstar.fiu.edu/aero/Experiment10.htm • http://www.allstar.fiu.edu/aero/Experiment13.htm • http://www.allstar.fiu.edu/aero/Experiment15.htm • http://www.allstar.fiu.edu/aero/Experiment16.htm 	Weather experiments (optional): <ul style="list-style-type: none"> • http://www.allstar.fiu.edu/aero/Experiment9.htm • http://www.allstar.fiu.edu/aero/Experiment10.htm • http://www.allstar.fiu.edu/aero/Experiment13.htm • http://www.allstar.fiu.edu/aero/Experiment15.htm • http://www.allstar.fiu.edu/aero/Experiment16.htm

	<p>Weather map (optional) http://www.weather.com/maps/matype/currentweatherusnational/index_large.html</p>	<p>Weather map (optional) http://www.weather.com/maps/matype/currentweatherusnational/index_large.html</p>
	<p>Weather map (specific) http://www.weather.com/weather/local/USHI0032</p>	<p>Weather map (specific) http://www.weather.com/weather/local/USHI0032</p>
	<p>Interactive weather information (optional)</p> <ul style="list-style-type: none"> • http://iwin.nws.noaa.gov/iwin/hi/hi.html • http://iwin.nws.noaa.gov/iwin/iwdspg1.html • http://lumahai.soest.hawaii.edu/ • http://lumahai.soest.hawaii.edu/cgi-bin/satview.cgi?sat=g10&satregion=oah&channel=ni4&anim=no&size=stand 	<p>Interactive weather information (optional)</p> <ul style="list-style-type: none"> • http://iwin.nws.noaa.gov/iwin/hi/hi.html • http://iwin.nws.noaa.gov/iwin/iwdspg1.html • http://lumahai.soest.hawaii.edu/ • http://lumahai.soest.hawaii.edu/cgi-bin/satview.cgi?sat=g10&satregion=oah&channel=ni4&anim=no&size=stand
Try	<p>Flight path http://ghrc.msfc.nasa.gov/camex3/flight_plans/</p>	<p>The landing public site http://airnav.com/airports/state/</p>
	<p>Great circle flight path display http://gc.kls2.com</p>	<p>. Great circle flight path display http://gc.kls2.com</p>

Kids as Airborne Mission Scientists

Developing the mission flight plan -- When and Where do I fly?

Related subject area: science, geography, math

Overall problem: Which activities (if any) should be restricted around the coral reefs of Kailua Bay to insure their lasting protection?

Relationship of problem in this lesson to overall problem: In the previous lesson students developed and categorized a list of questions that need to be answered to select the best aircraft for their mission. Students will now find the answers to their questions and use the answers to 1) select the best aircraft for the mission and 2) create a flight plan given the mission parameters. Students begin by identifying the characteristics of the available NASA research aircraft. Then, they participate in a series of activities to gather information that will help them select the optimal NASA aircraft and prepare to create a flight plan. Students are split into three groups and assigned to investigate one of three mission planning parameters: 1) selecting aircraft based on remote sensing instrument parameters, 2) selecting aircraft based on mission planning factors, and 3) selecting aircraft based on flight planning parameters. Each group will decide which aircraft are best based on what they have learned, share their findings, and together as a class identify the optimal aircraft for the mission given all of the identified information. Students then use their new knowledge of mission planning parameters to create a flight plan. Finally, the students will compare their flight plan to the actual NASA mission.

Estimated time required: 8 to 9 class periods

Student outcomes/objectives:

- The students will choose the best aircraft for the remote sensing mission by analyzing aircraft characteristics, remote sensing instrument characteristics, mission planning factors, and flight planning.
 - The students will identify the characteristics of available NASA research aircraft.
 - The students will identify the characteristics of the remote sensing instrument.
 - The students will describe factors to be considered when planning an airborne remote sensing mission.
 - The students will describe factors to be considered when developing a flight plan.
- The students will create a flight plan for their mission.

- The students will compare their flight plan to the actual NASA mission flight plan.

Prerequisite skills or knowledge:

- Ability to work in teams.
- Basic internet skills.
- Basic reading and writing skills.
- Basic understanding of problem solving.
- Basic presentation preparation skills.

Teacher preparation:

- Print Student Journal / Activity sheets for these activities.
- Print [Actual flight path \(1\)](#)
- [Print Actual flight path \(2\)](#)
http://seawifs.gsfc.nasa.gov/cgihrs/aviris.pl?FN=f000412t01p03_r08
- Bookmark appropriate websites for students.

Student reflection and assessment: [Student reflection activities](#) | [Assessment](#)

Education standards supported by this lesson:

[National Science Education Standards](#) | [Project 2061 Benchmarks](#)

[National Standards for School Mathematics](#) | [National Technology Standards](#) | [National Geography Standards](#)

Cross-curricular connections to National Education Standards for this lesson:

[math](#) | [technology](#) | [geography](#)

Teacher activities	Student activities
<p>FRAME the lesson.</p> <p>Ask what is the overall problem that we have been investigating?</p> <p>Ask what types of questions do we need to answer to identify which aircraft is best for this mission?</p> <p>State NASA has five research aircraft that we can choose from to conduct this mission. But before we choose the best one for our mission you need to find information about the characteristics of each aircraft.</p> <p>Prompt students to identify the characteristics of the available NASA research aircraft. Students should create or complete a table that shows important characteristics of each aircraft. See Activity sheet: Aircraft characteristics (DMFP-1)</p> <p>Teacher note: There is no one correct table format for gathering data for this activity. The table should be developed based on the questions that students think are most important about the aircraft. If they are unable to narrow their choices with the information they gather, then they may need to go back and add additional information to their table. This exploration and decision making process is important in developing understanding of scientific process. The Activity sheet: Aircraft characteristics (DMFP-1) we provide for the teacher, and in the student journal, contains the minimum amount of information categories required to select the appropriate aircraft for a mission. Based on your students needs for support in this type of activity, you may choose to use the given table or not to give the table to the students, rather have them create their own.</p> <p>Provide students with NASA research</p>	<p>Sample student responses:</p> <ul style="list-style-type: none"> • What activities should be restricted around coral reefs? <p>Student activity:</p> <ul style="list-style-type: none"> • Students refer to the list of questions they created in the previous lesson (if that lesson was not conducted, use this time to have students brainstorm a list of questions and rationalize why they are important to the selecting aircraft for a mission - See "Airborne remote sensing mission: What do we need to know?" lesson plan. <p>Student activity:</p> <ul style="list-style-type: none"> • Students work in groups to search given aircraft web sites and record information in answer to their questions. They will use the data they collect in their table for comparison and decision making throughout the remainder of the unit. • Students build a table using Activity sheet: Aircraft characteristics (DMFP-1) and begin

<p>aircraft websites or lithographs and prompt them to identify and record important aircraft characteristics in their table.</p> <ul style="list-style-type: none"> • SR-71 facts • ER-2 facts mission information • DC-8 facts mission information • King-Air facts • Pathfinder facts mission information <p>Ask students to select the best aircraft for this mission based on what they now know.</p> <ul style="list-style-type: none"> • If they think they can, record their choice and ask for rationale. Note: At this point they have not answered all of their questions and not have a complete rationale for their choice. They may know enough from the lessons to date, so inform them that we need to continue to answer their questions to see if their choice and rationale hold up to the remaining mission parameters. <p>Ask what else do we need to consider about the mission to select the best aircraft?</p> <p>Discuss the next steps. Students will be investigating important content for selecting suitable aircraft for their mission.</p>	<p>to enter data based on their review of the different aircraft websites.</p> <p>Note: You may want to assign groups of students to investigate one of the aircraft and enter the information for their assigned aircraft on their table. Then, bring the class together to share each groups' findings on their specific aircraft and have the class generate a table with all of the data for each aircraft.</p> <p>Sample student responses:</p> <ul style="list-style-type: none"> • All of the aircraft are possible at this point, unless the students understand that the SR-71 is not used for these types of missions, rather is primarily used on aerodynamics research. <p>Sample student responses:</p> <ul style="list-style-type: none"> • Characteristics of the remote sensing instrument (AVIRIS) • Outside factors such as weather <p>Factors that affect flight planning</p>
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Teacher activities	Student activities
<p>INFORM students that they will be assigned to one of three groups and participate in an activity to help find their answers. Together, their answers should help</p>	

the class select the best aircraft and prepare to develop a flight plan for the mission.

Break students into small groups and assign each group to the title of one of the following activities to select the optimal aircraft for their group's mission.

- Group 1: [Selecting aircraft based on remote sensing instrument parameters](#) (To develop an understanding of AVIRIS and prompt students to think about the relationship between aircraft and remote sensing instrument.) See [Activity sheet: Selecting aircraft based on remote sensing instrument parameters \(DMFP-2\) and accompanying table \(DMFP-2A\)](#)
- Group 2: [Selecting aircraft based on mission planning factors](#) (To develop an understanding of factors, such as weather, that affect mission planning and prompt students to think about why identifying such factors is critical to the aeronautics.) See [Activity sheet: Selecting aircraft based on mission planning factors \(DMFP-3\) and accompanying table \(DMFP-3A\)](#)
- Group 3: [Selecting aircraft based on flight planning parameters](#) (To develop an understanding of factors that affect flight planning and prompt students to think about their flight plan.) See [Activity sheet: Selecting aircraft based on flight planning parameters and accompanying table \(DMFP-4A\)](#)

Circulate around to the groups and ask the

Student activity:

- Group 1: Complete [Activity sheet: Selecting aircraft based on remote sensing instrument parameters \(DMFP-2\) and accompanying table \(DMFP-2A\)](#) while exploring the characteristics of the [AVIRIS](#) and select the optimal aircraft based on information provided.
- Group 2: Complete [Activity sheet: Selecting aircraft based on remote sensing instrument parameters \(DMFP-2\) and accompanying table \(DMFP-2A\)](#) while exploring factors that affect mission planning such as preparation and weather and select the optimal aircraft based on the information provided.
- Group 3: Complete [Activity sheet: Selecting aircraft based on flight planning parameters and accompanying table \(DMFP-4A\)](#) while exploring the following websites: [Map of NASA Dryden](#), [Hawaii airports](#), [Airport information](#), and [Airport data \(runaway, map, and etc.\)](#), and select the optimal aircraft based on the information provided.

following questions:

- Which aircraft are appropriate for your mission?
- Why do you think that your chosen aircraft are appropriate for your group's mission?
- Why do you think that other aircraft are not appropriate for your group's mission?

Optional activities: Include an in-depth series of activities and explorations on meteorology and weather related to flight. Some engaging activities include:

- **Weather experiments:**
 - [Experiment 9](#) (Temperature)
 - [Experiment 10](#) (Wind speed)
 - [Experiment 13](#) (Wind direction)
 - [Experiment 15](#) (Moisture in the air)
 - [Experiment 16](#) (Dew and frost)

Weather exploration websites:

- [Weather map1](http://www.weather.com/maps/maptype/currentweatherusnational/index_large.html)
http://www.weather.com/maps/maptype/currentweatherusnational/index_large.html
- [Weather map 2 \(specific\)](http://www.weather.com/weather/local/USHI0032)
(<http://www.weather.com/weather/local/USHI0032>)
- [Interactive Weather Information](http://iwin.nws.noaa.gov/iwin/hi/hi.html)
<http://iwin.nws.noaa.gov/iwin/hi/hi.html>
- [Interactive Weather Information](#)

<p>http://lumahai.soest.hawaii.edu/cgi-bin/satview.cgi?sat=g10&satregion=oah&channel=ni4&anim=no&size=stand (<i>Teacher Note: only be concerned about areas which have a green, yellow, or red color: these colors are a good indication of rain</i>)</p>	
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Teacher activities	Student activities
<p>EXPLORE each groups' answers to their questions and as a class select the best aircraft or determine which information is still missing to select the best aircraft. Provide rationale for the optimal aircraft selection based on analysis all of the collected data.</p> <p>Prompt each group, one at a time, to present their selected aircraft and their rationale as to why their choice of aircraft is/are best given their specific information.</p> <ul style="list-style-type: none"> • Three groups present their selected aircraft to the class. <p>Discuss each groups' selection and determine the best aircraft for the groups' given mission parameters.</p> <ul style="list-style-type: none"> • Each group provides feedback about other groups' selection (s). • Be sure to point out the given parameters for each group and how the introduction of additional parameters from different perspectives helps to make the ultimate selection possible. • During these presentations the students construct an overall table 	<p>Sample student responses:</p> <ul style="list-style-type: none"> • Group 1: ER-2, DC-8, King Air (based on information about the remote sensing instruments) • Group 2: ER-2, DC-8, Pathfinder (based on information about mission planning factors, i.e. maximum cruise duration and weather requirements) • Group 3: SR-71, ER-2, Pathfinder (based on information about important questions to be considered while planning flight mission) <p>Note: Students may have already removed the SR-71 from the list of viable choices based on fact that the research purpose of the SR-71 is not remote sensing missions. However, students may find references to historical uses of the SR-71 for aerial reconnaissance - taking pictures.</p> <p>Sample student responses:</p> <ul style="list-style-type: none"> • ER-2 - purpose, altitude, crew,

<p>with all key information necessary to select the best aircraft.</p> <p>Note: Students may record notes on the provided worksheets that they did not complete during the group work or perhaps the class should create a combined table on the chalk board or poster paper.</p> <p>Ask which aircraft is best aircraft for this mission? Why?</p> <p>Ask how does this choice compare to your initial selection after identifying the characteristics of each of the aircraft?</p> <p>Discuss next step---- develop flight plan for the mission.</p>	<p>airport runways lengths available, flight distance and time, AVIRIS requirements.</p> <p>Students reflect back on their original choice and how their original selection was supported with the new information and needed to change based on what they learned</p>

Teacher activities	Student activities
<p>TRY using new knowledge about the aircraft and mission planning to develop a flight plan for the mission.</p> <p>Refer students to the Activity sheet: NASA Airborne science flight request form (DMFP-5) in their journal. Remind them that they completed one like this in a previous lesson "What are airborne mission scientists?"</p> <p>Ask What else do we need to develop to plan this flight? We know the following information:</p> <ul style="list-style-type: none"> • Type of aircraft and remote sensing instrument. • Purpose for the flight. • Location and time for data collection. • How does the pilot know where to fly? <p>Prompt students to think about the mission:</p> <ul style="list-style-type: none"> • Where are the takeoff and landing locations? • How far is it between these locations? • What are the capabilities of the aircraft? • What other conditions need to be accounted for in the mission plan? <p>Project examples of flight paths for other types of missions. This will give students an idea of how mission planners create different patterns to collect different types of data.</p> <p>Prompt student to think about:</p>	<p>Student activity:</p> <ul style="list-style-type: none"> • Review Activity sheet: NASA Airborne science flight request form (DMFP-5). <p>Sample student responses:</p> <ul style="list-style-type: none"> • Where will the mission start? • Where will the mission end? • What is the best flight path for the mission? • Develop map of flight. <ul style="list-style-type: none"> • NASA Dryden Flight Research Center at Edwards Air Force Base in southern California. • 2600 Miles (from NASA Dryden Flight Research Center at Edwards Air Force base to Kailua) • ER-2: maximum equipment weight=2600 lbs. • Weather <ul style="list-style-type: none"> • Flight path depends on various factors such as the mission, aircraft, takeoff and landing location, etc.

- Why are there different types of path ways to fly?

State these are complex flight plans and should give you an idea about specific plans the mission planner provides to a pilot who flies a mission. Our flight path will be much simpler, basically we will fly from NASA Dryden Flight Research Center at Edwards Air Force (home of the ER-2) to the mission target (Kailua) and eventually back to Dryden. Your job is to think about the important questions about the mission and develop a flight plan to go with the

[Activity sheet: NASA Airborne science flight request form \(DMFP-5\)](#)

Remind students to consider the information they gathered on their worksheet, e.g., aircraft characteristics, remote sensing instrument requirements, weather, etc.

Direct students to work in groups to complete the [Activity sheet: NASA Airborne science flight request form \(DMFP-5\)](#)

Ask students to work in groups to complete [Activity sheet: Flight planning table \(DMFP-6\)](#) and consider the elements of flight planning while they plan the flight over Kailua Bay.

Teacher Note:

- Explain that the map builder for [great circle flight path](http://gc.kls2.com/) (<http://gc.kls2.com/>) display does not recognize military airports and, thus, they have to use Honolulu Airport as a landing site (the closest civilian airport) for this exercise instead of Hickam airport.

Ask students to draw a flight path from NASA Dryden Flight Research Center at Edwards Air Force Base to Kailua.

Student activity:

- Students write answers to questions of flight planning table in the [Activity sheet: Flight planning table \(DMFP-6\)](#).
 - Students to identify what mission they have, why they need to request NASA research aircraft, what objectives they have, and what aircraft they will use.
 - Students gather the information about airports such as departure airport, destination airport, weather conditions, and the characteristics of Hickam airport.
 - Students find the airport code of NASA Dryden Flight Research Center at Edwards Air Force Base and Honolulu airport [by using the landing public sites.](#)
 - Students estimate a flight plan by writing

- Ask students to what is an overall flight path.
- Have students imagine their flight path by exploring [the map of North America](#) and [the map of islands of Hawaii](#).
- Ask students to draw a flight path from NASA Dryden Flight Research Center at Edwards Air Force Base to Honolulu Airport on the [Activity sheet: Map of airborne remote sensing mission flight path \(DMFP-7\)](#) based on the information collected from the [great circle flight path display](#) on the map of North America.
- Ask students draw a flight path from Honolulu Airport to Kailua on the [Activity sheet: Map of airborne remote sensing mission flight path \(DMFP-7\)](#) on the map of the islands of Hawaii.

Debrief activity by having students share their flight plans.

- Students present their flight plans to the class.
- Students provide feedback on each other's plans.
- Teacher should distribute [Actual flight path \(1\)](#)

[Print Actual flight path \(2\)](#)
http://seawifs.gsfc.nasa.gov/cgibrs/aviris.pl?FN=f000412t01p03_r08

Prompt students to discuss the differences and similarities between their flight plans

overall flight path and calculating the flight distance and flight time for collecting data.

- Students draw the flight path on the [Activity sheet: Map of airborne remote sensing mission flight path \(DMFP-7\)](#)
 - Students draw a flight path from NASA Dryden Flight Research Center at Edwards Air Force Base to Honolulu Airport the by using the [great circle flight path display](#) on the map of North America.
 - Students draw a flight path from Honolulu Airport to Kailua on the [Activity sheet: Map of airborne remote sensing mission flight path \(DMFP-7\)](#) on the map of Hawaii.

Student activity:

- Students write a description of their flight plan on [Activity sheet: My flight plan for the KaAMS mission \(DMFP-8\)](#).
- Students should review [Actual flight path \(1\) and Actual Flight Path 2](#) (http://seawifs.gsfc.nasa.gov/cgibrs/aviris.pl?FN=f000412t01p03_r08)

Students discuss the differences and similarities between their flight plans and the actual NASA mission: [\(1\)actual flight path from Dryden to Honolulu](#), [\(2\)actual flight path from Honolulu to Kailua Bay](#), and [\(3\)](#)

<p>and the actual NASA mission: <u>(1)actual flight path from Dryden to Honolulu,</u> <u>(2)actual flight path from Honolulu to Kailua Bay,</u> and <u>(3) narratives of actual flight plan.</u></p> <ul style="list-style-type: none"> • What are the differences between your plans and the actual NASA mission plan? • Why? <p>Prompt students to complete the reflection page in their journals. See Activity sheet: Reflection page(DMFP-9)</p> <p>Summarize lesson and introduce next steps: collecting and analyzing the data!</p> <p>Teacher resources:</p> <ul style="list-style-type: none"> • ER-2 Typical Flight Operations • ER-2 operating bases • 	<p><u>narratives of actual flight plan.</u></p>

Student reflection activities:

Prompt students to think about the following:

- Why do you need to consider aircraft characteristics, remote sensing instruments, outside factors, and the flight planning parameters when planning a mission?
 - What was their original thought on the best aircraft for the mission given only the aircraft characteristics and how did it change after considering other factors and mission parameters?
 - What role does questioning play in scientific inquiry?
 - Why does understanding the principles of flight help you develop a mission plan?
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Assessment:

- Check the information collected by the students on their worksheets for accuracy.
 - Check students rationale for selecting aircraft given the information they gathered.
 - Review flight plans for accuracy.
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Ideas for math lesson connections:

- Given the flight duration and distance to be traveled, fuel efficiency of aircraft, and fuel cost, students estimate the fuel costs for the mission.
- Students create a scale map of the flight path, using units appropriate for NASA missions. Students can also practice metric to British and British to metric system conversions.
- Students examine flight path from Dryden Flight Research Center in California to Hickam AFB in Honolulu, Hawaii and identify the relationship between arc length and radius around a circle. This could be a convenient time to introduce different angle measures.

Related National Education Math Standards:

- [number and operations](#)
 - [geometry](#)
 - [measurement](#)
 - [representation](#)
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Ideas for geography lesson connections:

- Students study the weather conditions for each location, Southern California and Hawaii for different times of the year and use this information to determine when the best time of year is for conducting this mission based upon mission requirements.
- Students develop relief maps of the target location and plot the coral reefs on their map/model using latitude and longitude measures.

Related National Education Geography Standards:

- [Places and Regions](#) (#4)
 - [The World in Spatial Terms](#) (#1)
 - [The Uses of Geography](#) (#18)
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Ideas for technology lesson connections:

- Students use the Internet to locate information regarding the development of various methods for navigation including inventors and inventions. Emphasis could be placed on air navigation to reduce the scope.
- Students use email to contact air traffic controllers and/or aircraft navigators to learn about the systems and methods employed to make sure aircraft safely reach their destinations.

Related National Education Science Technology Standard:

- [The Designed World](#) (#17) Information and Communication
- [Technology and society](#) (#7) The influence of technology on history
- [The Designed World](#) (#18) Transportation technologies

Activity sheet: Aircraft characteristics (DMFP-1) - answer key

The **blue bolded** text represents the information that students identify from the given websites

	SR-71	ER-2	DC-8	King-Air	Pathfinder
Purpose	high altitude / high speed research	flying laboratory, environmental research	flying laboratory, environmental research	environmental research, people transport	environmental research
Maximum equipment weight	2,000 lbs.	2600 lbs.	30,000 lbs.	4400 lbs.	100 lbs.
Maximum equipment power	some available	high capacity 28 volts DC	high capacity AC/DC 125 KW 400 Hz & 60 Hz	some available AC/DC 60 amps DC	2 kW
Altitude	85,000 ft	65,000 - 70,000 ft	41,000 ft	35,000 ft usually 26,000 ft.	80,200+ ft
Maximum cruise speed	2,200 mph	470 mph	570 mph	300 mph	21 mph
Maximum cruise range	2,000 miles	3,000 miles	4,500 miles	2,000 miles	14-15 hours (315 miles)
Crew	1-2	1	4 to 50	2 to 4	0
Weather requirements	clear, stable	takeoff in up to 15 knot cross winds	takeoff in up to 35 knot cross winds	anything but icy weather	maximum 12 mph wind at take off, limited or no clouds
Needed Runway Length	.	500 to 1500 ft.	6,000 ft	1900 ft.	200 ft.
Expense	very high	moderate	moderate	low	low

- Can you select the best aircraft for KaAMS mission based on what you know?
- Which aircraft is the best aircraft? Why?

Group activity reference sites

Groups	Student Activities
<p>Group 1- Selecting aircraft based on remote sensing instrument parameters</p>	<p>Students are encouraged to think through the process of selecting the most appropriate research aircraft given specific remote sensing instrument parameters. Students will use an Activity sheet: Selecting aircraft based on remote sensing instrument parameters (DMFP-2) and accompanying table (DMFP-2A) to compare important features of AVIRIS with those of NASA research aircraft.</p> <ul style="list-style-type: none"> • AVIRIS
<p>Group 2- Selecting aircraft based on mission planning factors</p>	<p>Students are encouraged to explore various factors that affect flight and propose which aircraft would be best suitable for the overall mission. Students will use an Activity sheet: Selecting aircraft based on mission planning factors (DMFP-3) and accompanying table (DMFP-3A) to investigate the factors that may affect mission planning.</p>
<p>Group 3- Selecting aircraft based on flight planning parameters</p>	<p>Students are encouraged to identify the appropriate airports, available airport runway length, flight distance, and time to help them identify flight planning parameters that are important in mission planning. Students will use an Activity sheet: Selecting aircraft based on flight planning parameters and accompanying table (DMFP-4A) to help them select the best aircraft based on flight planning parameters.</p> <ul style="list-style-type: none"> • Map of NASA Dryden • Hawaii airports • Airport information •

Activity Sheet: Selecting aircraft based on remote sensing instrument parameters (DMFP-2) - answer key

There are many different kinds of remote sensing instruments. They come in a wide variety of sizes and weights based on their purpose and the methods they use for data communication and storage. Some remote sensing instruments work best at certain altitudes or below certain speeds. Others may be limited to the certain weather conditions. All of these factors must be considered when choosing the most appropriate aircraft for the mission.

- The remote sensing instrument for this mission is the [AVIRIS](#). Characteristics of the AVIRIS include:
 - Weight: 720+ pounds
 - Power requirements: 28 volts DC, 400 Hz
 - Best altitudes for data collection: 35,000 to 65,000 feet
 - Best speed for collecting data: 450 mph

Consider the following questions as you consider the optimal aircraft for flying a mission using the AVIRIS:

- How much power does the remote sensing instrument need to operate? Is it available on the aircraft?
- At what altitude can the aircraft fly? What is the optimal altitude for operating AVIRIS?
- How fast does the aircraft fly? What is the optimal speed for collecting data using the AVIRIS?

**Activity sheet: Aircraft selection table based on remote sensing instrument
(DMFP-2A) - answer key**

			SR-71	ER-2	DC-8	King-Air	Pathfinder
Remote sensing instrument	Equipment weight	720 lbs.					
	Necessary equipment power	28 volts DC, 400 HZ					
	Aircraft altitude	30,000 to 65,000 ft.					
	Aircraft speed	300-470 mph					
	Select the best aircraft		.	X	X	X	.
	Why or why not?		too fast, lacks equipment power	altitude, payload, speed	altitude, payload, speed	altitude, payload	too much payload

**Activity Sheet: Selecting aircraft based on mission planning factors
(DMFP-3) - answer key**

Suppose that you are preparing to take a vacation. Generally you think about where you are going, when you will leave and arrive, and what you will do while away. You might also think about other possibilities that might affect your journey such as car trouble, weather, and money. Like planning a vacation, mission planners think about factors that might affect a mission. What factors do you think need to be considered when developing a mission plan?

- When to fly, flight distance and duration, target locations, weather, number of flight passes (duration), time of day for data collection, people involved in flight operations, ground crew
- Weather and cloud cover, day or night

Here is information provided by a mission planner that needs to be considered for this mission.

Mission planning factors

Maximum cruise range	3000 miles
How often will data need to be collected?	1 time
What time of day will data need to be collected	daylight
What are the weather requirements for the mission?	clear skies, less than 15% clouds

Select the optimal aircraft while thinking about the following questions:

- What is/are the best aircraft considering the range of the flight?
- What is/are the best aircraft considering time of day for data collection?
- What is/are the best aircraft considering the required weather conditions?

**Activity sheet: Aircraft selection table based on mission planning factors
(DMFP-3A) - answer key**

		SR-71	ER-2	DC-8	King-Air	Pathfinder
How far do I need to be able to fly the aircraft to collect data?	over 2600 miles					
How many passes are needed for data collection?	1 time					
When do I need to sense data?	day					
Weather requirements	clear skies					
Select the best aircraft		.	X	X	.	X
Why and why not?		too fast to collect data, flight time	flight time	flight time	flight time	flight time

Activity sheet: Selecting aircraft based on the important questions for flight planning (DMFP-4) - answer key

When a mission planner develops a flight plan, many different parameters are defined that help select the aircraft and plan the mission. The following questions are commonly researched: What aircraft is available to fly the mission? What is the necessary runway length for the available aircraft? Where will the aircraft need to fly, how long will it fly? What airports are near the target site? Do we have access to those airports? Do the available airports have the necessary equipment to support the aircraft?

1. For this mission, consider the available airports between the aircrafts' home base and the target remote sensing location. Where are the airports that can be used to support this mission? [Edwards AFB - home of the NASA Dryden research aircraft- and airport in Hawaii is Honolulu](#)
2. Where is NASA Dryden located? [NASA Dryden is on Edwards Air Force Base in Southern California](#)
3. Where is the remote sensing target location? [Coral reefs at Kailua Bay on the island of Oahu.](#)
4. How far is it from the home base to the target? [Approximately 2600 miles between Dryden and Kailua Bay](#)

Here is additional information provided by mission planning:

- One pilot is available who is prepared to fly the mission, no other pilots are available, ground and support crews are available to support any type of aircraft at all airports.
- Data needs to be gathered from an altitude of 65,000 ft.
- Airport runway lengths are between 5,600 and 12,000 ft.

Consider the following questions while selecting the optimal aircraft for this mission.

- What aircraft is best given the availability of crew?
- Which aircraft is best given the altitude requirement?
- Which aircraft is best given the runway length of the available airports?

Activity sheet: Aircraft properties table for mission possibilities for flight plan (DMFP-4A) - answer key

			SR-71	ER-2	DC-8	King-Air	Pathfinder
Flight plan	Airport runway	5,600 - 12,000 ft.					
	Crew available	1					
	Altitude of image	65,000 ft					
	Select the best aircraft		X	X	.	.	.X
	Why and why not?	.	altitude, crew	altitude, crew	altitude, not enough crew	altitude, not enough crew	altitude, runway

Activity: Creating a flight plan

Activity sheet: Flight planning table (DMFP-6)

Name:

Material/information required:

- Map on takeoff, mission target, and landing sites
- Type of aircraft for the mission
- Ruler and unit conversion information
- Sample flight plan form

Key activity	Questions for flight plan	Answers for flight plan	Why is it important?
Identify mission	What is your mission?	To find and evaluate the state of coral reefs	I need to identify the problem in order to find solutions for KaAMS mission.
	What aircraft have you chosen?	ER-2	I must choose appropriate aircraft for investigating the mission.
	Where is the mission site?	Kailua Bay on the island of Oahu	I must identify where the aircraft will fly for the mission.
Gather airport information	What is the departure airport?	NASA Dryden Flight Research Center at Edwards Air Force Base in southern California	Because we will use NASA aircraft, departure airport should be a NASA airport base and near Hawaii.
	When will the aircraft take off?	Early morning, 8:00 a.m. western standard time	Because we need to collect data about coral reefs during daytime, the aircraft must takeoff early morning.
	What will be the cruise speed of ER-2 aircraft?	470 mph	Since it will take a long time to fly over Kailua Bay, we need to check the cruise speed of ER-2 to estimate the total flight time
	What weather is required for take off?	Light winds, less than 15 % cloud coverage	We need to check the conditions of airport to take off safely.

	Where is the landing site for this mission?	Honolulu Airport	It is recommended that we use an Air Force base for a landing site because it is easier to route the flights through the military and a NASA mission has close ties to the military. Hickam airport is the only Air Force base in the islands of Hawaii. Therefore it is considered to be the ideal destination airport for the mission. However the map builder for great circle flight path display does not recognize military airports and we will use Honolulu (the closest civilian airport) as a landing site for this exercise instead of Hickam airport.
Identifying the airport code	NASA Dryden Flight Research Center at Edwards Air Force Base	edw	X
	Honolulu Airport	hnl	X
Creating flight plan	Write your overall flight path	Dryden - Honolulu - the mission site (Kailua Bay) - Honolulu - Dryden	Since it will take a long time from NASA Dryden Flight Research Center at Edwards Air Force Base to Honolulu Airport, the ER-2 airplane will need to land and refuel at the Honolulu Airport before collecting the data and before returning to the home base at Dryden.
	Calculate the distance from takeoff to data collection pattern	About 2600 mile	X
	Calculate the flight time from Dryden to Honolulu airport	About 5.5 hours	2600 miles (Total distance) / 470 mph (ER-2 maximum cruise speed)
	Calculate the time for data collection	About 2 hours	We need to know the time for data collection to calculate total flight time as well as the time it will take to climb and descend to/from an altitude of 65,000 ft.

**Activity sheet: Map of airborne remote sensing mission flight path
(DMFP-7)**

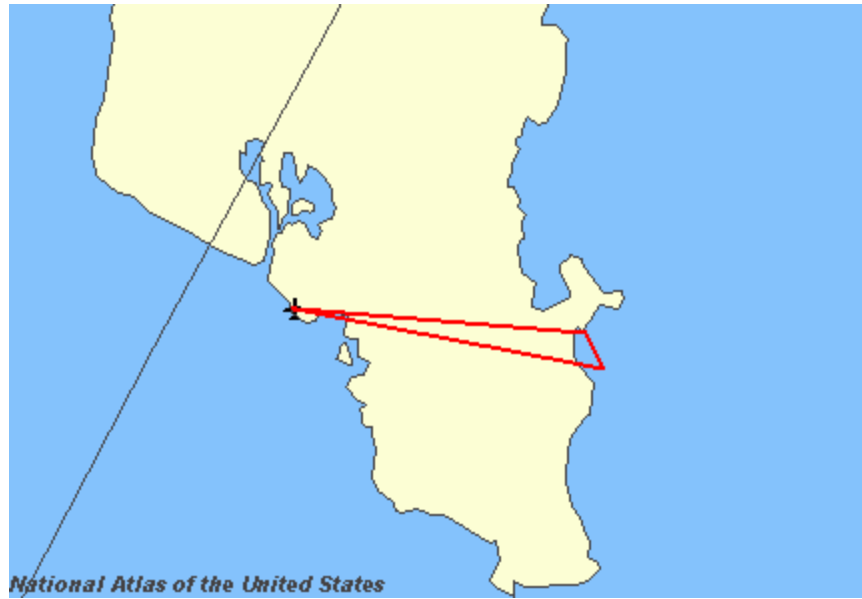
MAP-1

Draw the flight path from NASA Dryden Flight Research Center at Edwards Air Force Base to Honolulu Airport.



MAP-2

Draw the flight path to and from Honolulu Airport and Kailua Bay.



Latitude/Longitude for our mission:

Upper left
coordinate: 21° 25' 35" N

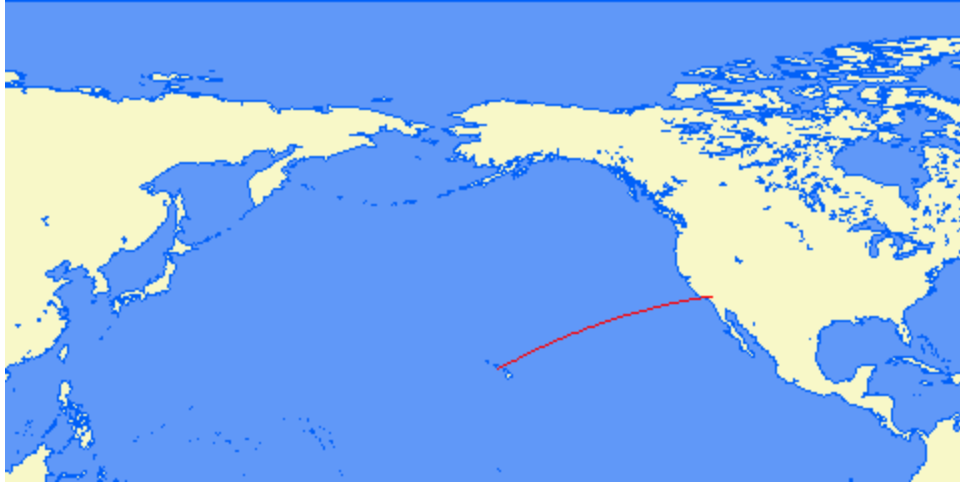
 157° 44' 5" W

Lower left
coordinate: 21° 24' 44" N

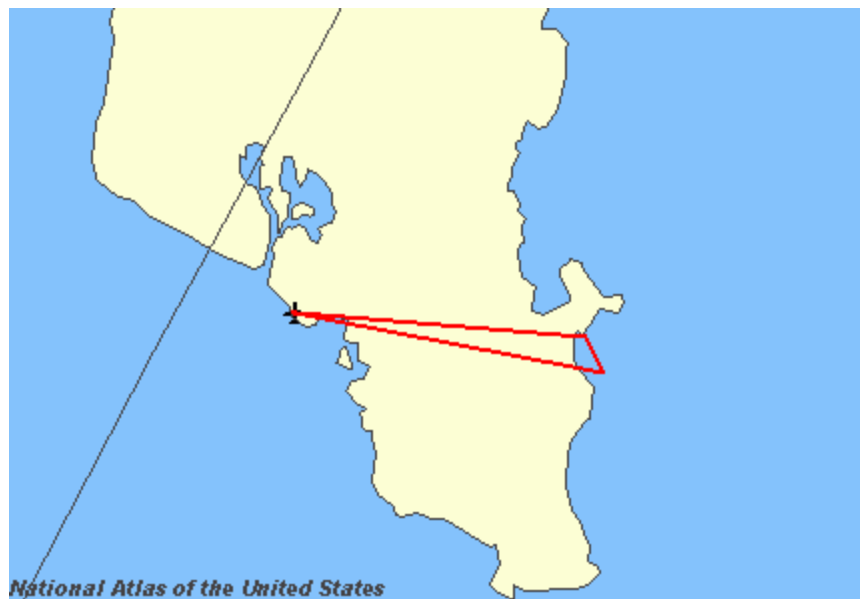
 151° 42' 36" W

Actual flight path

1) To and from Dryden and Honolulu



2) To and from Honolulu and Kailua Bay



Latitude/Longitude for our mission:

Upper left
coordinate: $21^{\circ} 25' 35''$ N

$157^{\circ} 44' 5''$ W

Lower left
coordinate: $21^{\circ} 24' 44''$ N

$151^{\circ} 42' 36''$ W

Activity sheet: My flight plan for the KaAMS mission (DMFP-8)

Based on the flight planning table, flight path maps, and all information about flight planning, briefly write an essay about your own flight plan for KaAMS mission.

Description of flight plan

The ER-2 aircraft is located at NASA Dryden Flight Research Center at Edwards Air Force Base in southern California. This is where the airplane will take off to begin the flight. Takeoff will be at 8:00 AM western standard time under clear skies with less than 15% cloud coverage, and less than 15 knot (17.3 mph) cross winds. The ER-2 will then fly to a cruise altitude of approximately 65,000 feet for about 5.5 hours on its way to Hawaii. The landing destination is Honolulu airport located on the island of Oahu. Hickam Air Force Base is located near the Honolulu airport. The aircraft will land at approximately 11:30 AM Hawaii time. After landing in Honolulu, the ER-2 will be refueled, and the pilot will rest before beginning the data collection. From Honolulu, the aircraft will fly for approximately one and a half hours to and from the coral reef site on the Island of Oahu for data collection. The remote sensing equipment will be turned on for data collection over the Kailua Bay, then turned off to return to Honolulu Airport. The total duration of the data collection leg of the flight will occupy approximately one and a half hours including the climb and decent to/from an altitude of 65,000 feet. Again refueling and rest for the pilot is needed before flying back to California. The final portion of the trip is returning the ER-2 to its home base at NASA Dryden. The aircraft will take off from Honolulu airport, fly for 5.5 hours, and land at Edwards Air Force Base in southern California.

Activity sheet: Airborne science flight request form (DMFP-5) - answer key



AIRBORNE SCIENCE FLIGHT REQUEST FORM



National Aeronautics and Space Administration

Investigation title: **Should activities be restricted around coral reefs?**

Reason for requesting use of NASA facilities: Use of AVIRIS sensors and the ER-2 aircraft are essential for collecting data about coral reefs at Kailua Bay.

Investigator(s): Kids as Airborne Mission Scientists participants

Background and primary science objectives:

To study the coral reefs at Kailua Bay.

Aircraft required: ER-2 DC-8 P-3B Orion
 (circle) King Air Pathfinder SR-71 Blackbird

Data requirements and aircraft sensor:

TYPE OF DATA BEING COLLECTED: Airborne images of Kailua Bay showing the coral reef features. The images will show characteristics that we may not be able to see with our eyes.

SENSORS (circle):

MODIS AVIRIS MAMS MACAWS Harvard Co2
Dual-Beam UV-Absorption Spectrometer Aerial Camera Systems

General flight window (month):

General site location (state or country):

A) *April 2000*

A) *Kailua Bay on the Island of Oahu, Hawaii*

B)

B)

C)

C)

D)

D)

This form must be completed and returned to NASA/DFRC by:

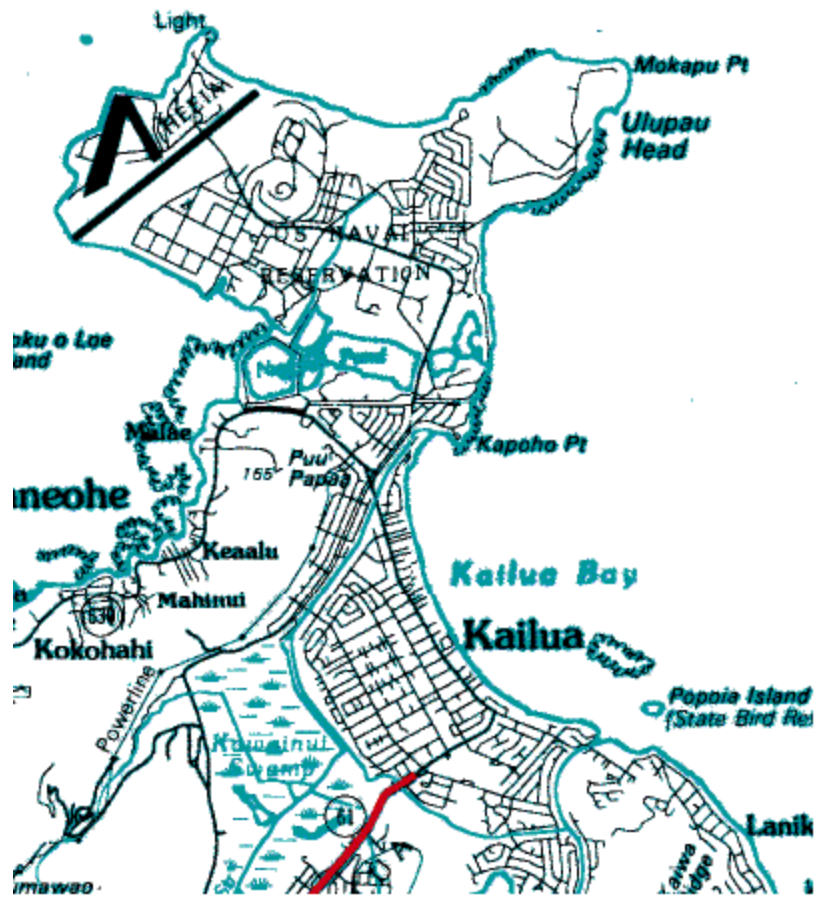
(Do not mark in this space/For office use only)

Mail completed forms to:

**Dryden Flight Research Center
National Aeronautics and Space Administration**

REFERENCE:

Map of Kailua Bay (courtesy of Mapquest.com)



Latitude/Longitude for our mission:

Upper left
coordinate: 21° 25' 35" N

157° 44' 5" W

Lower left
coordinate: 21° 24' 44" N

151° 42' 36" W

Map of Hawaii (courtesy of Mapquest.com)

