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Infrared Investigations: Re-Redirecting the Signal of a TV Remote Control

*Note: This lesson is designed for at least two 45-minute class periods or one 90-minute block. This lesson can also be tailored to either a middle school physical science class or a high school physics class.

Summary

This lesson explores infrared light and products. Students learn how engineers have to test products to make sure they work properly. Student teams are given a challenge of testing the limitations of infrared in a standard television remote control by devising a way to point infrared around a corner or between two rooms.

The first half of the lesson is the Research portion during which students gather information about infrared technology. The second half of the lesson is the Engineering portion during which students devise a plan to operate a television from an infrared remote control that is around a corner or in another room.

Objective

Students will demonstrate their understanding of infrared technology by writing an accurate description of it and answering a series of questions to 90% accuracy. Students will demonstrate their teamwork and problem-solving skills by successfully completing the engineering challenge.

Materials/Prep

- NASA flight suit (to be worn by instructor)
- Instructor reference materials:
 - Engineering Tomorrow: Today's Technology Experts Envision the Next Century (ISBN: 0780353625)
 - Engineering Science (ISBN: 0750652594)
 - Visual Science and Engineering (ISBN: 0824791851)
 - Instructor's edition of textbook
- Student worksheets (pages 5-10)
- Student resource sheets (pages 11-15)
- 2 or more televisions
- Enough television remotes (that work for at least one of the TVs) for all lab groups
- For each group: black paper, white paper, aluminum foil sheets (smooth), several small mirrors, flashlight, plastic wrap, plastic bag, clear plastic, other materials for testing beam, clear cup, water, food coloring, milk or other liquids.

NGS Standards

- Grades 6-8
 - MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
 - MS-PS2-1: Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.
 - MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- Grades 9-12
 - HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
 - HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
 - HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
 - HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
 - HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Steps (with differentiation and time requirements)

- Previous night’s homework: Read Reference Sheets (see pages 11-15) or corresponding text book pages and answer the following questions in your science journal:
 1. *Are wavelengths of infrared light longer or shorter than visible light?*
 2. *Name three technological uses of infrared light and provide one example of each.*
 3. *Define spectroscopy and use it in a complete sentence.*
 4. *Summarize the article on remote control in three complete sentences.*

Teacher

- Greet students at the door.
- Collect last night’s homework and take attendance.

Students

- File in (hopefully quietly) and get out their supplies.
- Instructions on board read: It’s another beautiful day of science! 1. Place your homework and lab book on your desk. 2. Get out your journal and a pen/pencil and answer the question below. You have **6 minutes**.
- Intro journal entry: *Explain how cell phones send signal. If you’re not sure, be creative! As always, use*

| | |
|--|---|
| | <i>complete sentences.</i> |
| <ul style="list-style-type: none"> Ask three students to share their journal entries (3 minutes). | <ul style="list-style-type: none"> Listen/share |
| <ul style="list-style-type: none"> Be sure that one of the televisions is in the front of the room. Ask for three student volunteers to come up to the front and have two of them bring their cell phones. Ask one student with phone to kneel down and call the other student with phone, making sure the third student stands in between them. Ask students to observe what happens. Thank students and ask one to return to his/her seats. Then have one student try to turn on a television while aiming the remote control through the second student. Then on board: "Explain in your journals what happened and why you think [the student] <i>could</i> make a cell phone call but <i>couldn't</i> turn on the television." Then ask, "Do you think there might be not just one but multiple types of electromagnetic radiation? If so, what might that other signal be?" (Remind them of EM spectrum scale, put up on board) (5 minutes). | <ul style="list-style-type: none"> Listen/participate |
| <ul style="list-style-type: none"> Explain to students that they are going to test the limitations of infrared technology in a remote control using a variety of materials, including plastic wrap, paper, foil, mirror, and other materials. In their lab notebooks, have them predict how the infrared beam will be affected by attempting to reflect the beam off of an object and back to the television. Then explain to them that they will test each object and evaluate their results (on lab sheets provided—these sheets will then be glued into their lab notebooks). (3 minutes) | <ul style="list-style-type: none"> Listen Write |
| <ul style="list-style-type: none"> Have students separate into lab groups of 2-3 (chosen previously or use popsicle sticks). Have one person from each group come up to collect a set of | <ul style="list-style-type: none"> Gather lab materials |

| | |
|--|--|
| <p>materials.</p> <ul style="list-style-type: none"> • *Be sure that pages 5-10 are included in each set of materials because these pages provide instructions for them to follow, data tables for students to fill out, and questions for them to answer. | |
| <ul style="list-style-type: none"> • Tell students that they are going to gather information about how infrared light responds to various materials (Part I, 23 minutes) and then later they will complete and conquer an Engineering Challenge (Part II, 23 minutes). Demonstrate how to test one of the materials; for example, bounce the TV remote signal off of one of the materials and at the TV). Throughout class, tell students how much time they have left and be sure that each group has time to use each television and answer the follow-up questions. At the beginning of Part II, discuss SOFIA experience, review EM spectrum, and discuss infrared (show slides, photos, flight plan (page 19), answer questions, 15 minutes). | <ul style="list-style-type: none"> • Listen • Complete lab, Parts I and II |
| <ul style="list-style-type: none"> • With 5 minutes remaining in class, have students clean up their lab tables and write in their lab books about their findings and try to explain why the infrared signal reacted in different ways to different materials. The next day in class, as lab groups, ask students to share their arguments and findings with each other (pairing lab groups one at a time and do think/pair/share between them) and then have a “speaker” from each paired group summarize their findings to the class. Prepare a lecture/PowerPoint/Prezi about infrared radiation specifically and electromagnetic radiation more generally to share with students to help explain their findings. | <ul style="list-style-type: none"> • Clean up lab tables and answer follow-up question. <p>Total time for <u>each</u> part: 45 minutes + 15 minutes in between to discuss SOFIA</p> |

Assessment

- Provided in Evaluation questions of Research and Engineering Challenge sections (please see pages 8 and 10).

Homework

- Have students complete their lab follow-up questions if they haven't already done so.
- Ask them to complete one or both of the worksheets found on pages 16-18.

Acknowledgements

- Infrared Investigations, Developed by IEEE as part of TryEngineering, www.tryengineering.org

Internet Resources

- TryEngineering (www.tryengineering.org)
- NASA Infrared (<http://imagers.gsfc.nasa.gov/ems/infrared.html>)
- Our Infrared World Photo Gallery
(http://coolcosmos.ipac.caltech.edu/image_galleries/our_ir_world_gallery.html)
- Herschel & His Discovery of Infrared
(http://coolcosmos.ipac.caltech.edu/cosmic_classroom/classroom_activities/herschel_bio.html)
- ITEA Standards for Technological Literacy(www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)



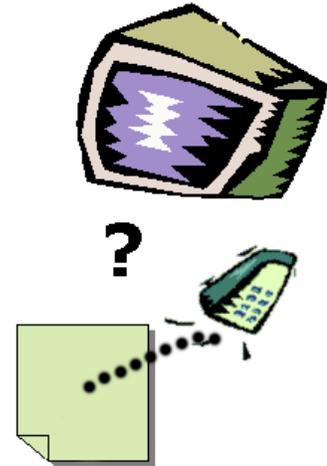
Infrared Investigations

Student Worksheet: Engineering Research

You are a team of engineers who have been given the challenge of testing infrared technology to understand its limitations and devise a plan to operate a television from around a corner or in another room.

◆ Research and Prediction Phase

1. Review the various Student Reference Sheets to learn about infrared and its applications.
2. Working as a team of "engineers," discuss and make predictions about how different materials will impact the infrared. What would happen if you tried to bounce the infrared off of paper, foil or other materials to see if it still controls the television?



| Material | White Paper | Black Paper | Flat Foil | Crumpled Foil | Plastic Wrap | Your hand | CD |
|------------|----------------|---------------|------------------------|-----------------------|--------------|-----------|-------|
| Prediction | | | | | | | |
| Material | Glass of Water | Glass of Milk | Glass of Colored Water | Black Electrical Tape | Other | Other | Other |
| Prediction | | | | | | | |

Infrared Investigations



Student Worksheet: Engineering Research (continued)

◆ Testing Phase

1. Test your teams' predictions about interference or extension of infrared by bouncing the infrared off of paper, foil or other materials to see if it still controls the television. Also test the effect of using a flashlight at a 90 degree angle and parallel with the beam to the television. Note your results below:

| Material | White Paper | Black Paper | Flat Foil | Crumpled Foil | Plastic Wrap | Your hand | CD |
|----------|----------------|---------------|------------------------|-----------------------|--------------|-----------|-------|
| Results | | | | | | | |
| Material | Glass of Water | Glass of Milk | Glass of Colored Water | Black Electrical Tape | Other | Other | Other |
| Results | | | | | | | |

Notes:

Infrared Investigations



Student Worksheet: Evaluation

◆ Use this worksheet to evaluate your team's results:

1. What result surprised your team the most? Why?

2. Based on your research, if your engineering team was considering using infrared to control an underwater system, would you agree to incorporate infrared? Why? Why not?

What about in space? Why? Why not?

3. Why do you think engineers need to test components they are considering to incorporate in a new product or system?

4. Can you think of any other applications for which your engineering team thinks infrared controllers might be useful?

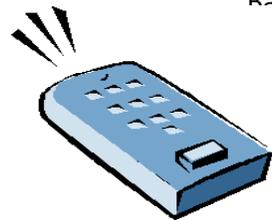
Infrared Investigations

Student Worksheet: Engineering Challenge

You are a team of engineers who have been given the challenge to devise a plan to operate a television from an infrared remote control is around a corner or in another room.

◆ Team Planning

1. Consider the results of your research and in the box below, devise plan that you think will solve the engineering challenge. Make sure make a list of all the materials you will require.



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Materials You Need:

Infrared Investigations



Student Worksheet: Engineering Challenge (continued)

◆ Testing Phase

1. Gather the equipment you predicted you would need, and test your teams' plan.

◆ Evaluate and Reflect

1. Did your plan work? If not, why not?

2. Did you find you needed to make changes to your plan in the testing phase? (either by changing the placement of items, or adding or removing materials?) If so, how did you need to change your plan to achieve your goal?

3. What systems that other team's developed did you think were particularly clever? Why?

4. Can you think of an application where a controller might need to be in a different room than the equipment it controls?

5. Meet as a team and consider what you'd like to see the next generation of remote controls be able to do. What engineering enhancements would be needed to make your ideas a reality?

Infrared Investigations

Student Resource : Infrared and its Applications

• What is Infrared?

Infrared (IR) radiation is electromagnetic radiation of a wavelength longer than that of visible light, but shorter than that of radio waves. The name means "below red" (from the Latin *infra*, "below"), red being the color of visible light of longest wavelength. Infrared radiation spans three orders of magnitude and has wavelengths between approximately 750 nm and 1 mm.

The infrared portion of the spectrum has a number of technological uses, including target acquisition and tracking by the military; remote temperature sensing; short-ranged wireless communication; spectroscopy, and weather forecasting. Telescopes equipped with infrared sensors are used in infrared astronomy to penetrate dusty regions of space, such as molecular clouds; detect low temperature objects such as planets orbiting distant stars, and to view highly red-shifted objects from the early history of the universe.

At the atomic level, infrared energy elicits vibrational modes in a molecule through a change in the dipole moment, making it a useful frequency range for study of these energy states. Infrared spectroscopy is the examination of absorption and transmission of photons in the infrared energy range, based on their frequency and intensity.

• Infrared Applications in Engineering

Engineers incorporate infrared technology into a variety of equipment and systems used in many industries. The following are just a few examples:

Night vision



Infrared is used in night-vision equipment when there is insufficient visible light to see an object. The radiation is detected and turned into an image on a screen, hotter objects showing up in different shades than

cooler objects, enabling the police and military to acquire warm targets, such as human beings and automobiles.

Spectroscopy

Infrared radiation spectroscopy is the study of the composition of (usually) organic compounds, finding out a compound's structure and composition based on the percentage transmittance of IR radiation through a sample.

Weather Satellites

Weather satellites equipped with scanning radiometers produce thermal or infrared images which can then enable a trained analyst to determine cloud heights and types, to calculate land and surface water temperatures, and to locate ocean surface features.

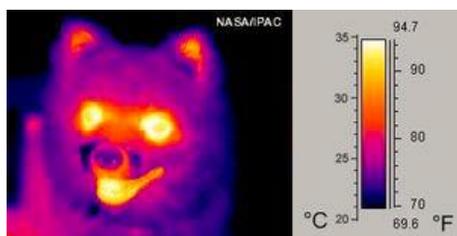


Space Applications

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is a 2.7-meter telescope on board a Boeing 747-SP. SOFIA takes infrared images of stars and planets.

Astronomers observe objects in the infrared portion of the electromagnetic spectrum using optical components, including mirrors, lenses and solid state digital detectors.

Heating Applications



Infrared radiation is used in infrared saunas to heat the occupants, and to remove ice from the wings of aircraft (de-icing). It is also gaining popularity as a method of heating asphalt pavements in place during

new construction or in repair of damaged asphalt. Infrared can be used in cooking and heating food as it heats only opaque, absorbent objects and not the air around them, if there are no particles in it.

Thermography Equipment

Infrared thermography is a non-contact, non-destructive test method that utilizes a thermal imager to detect, display and record thermal patterns and temperatures across the surface of an object. Thermography is widely used in law enforcement, firefighting, search and rescue, and medical and veterinary sciences.

Communications Devices

IR data transmission is also employed in short-range communication among computer peripherals and personal digital assistants. Remote controls and IrDA devices use infrared light-emitting diodes (LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The remote works by using a low frequency light beam, so low that the human eye cannot see it. The beam is modulated, i.e. switched on and off, to encode the data. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances.



Engineering Advances in Remote Control

Many Methods of Remote Control

The first remote intended to control a television was developed by Zenith Radio Corporation in the early 1950s. The "remote" was unofficially called "Lazy Bones" and was actually connected to the television set by a long wire. To improve the cumbersome setup, a wireless remote control called "Flashmatic" was developed in 1955 which worked by shining a beam of light onto a photoelectric cell. Unfortunately, the cells did not distinguish between light from the remote and light from other sources and the Flashmatic also required that the remote control be pointed very accurately at the receiver.

In 1956 the "Zenith Space Command" was developed. It was mechanical and used ultrasound to change the channel and volume. When the user pushed a button on the remote control it clicked and struck a bar. This explains why some people used to call remote controls the "clicker." Each bar emitted a different frequency and circuits in the television detected this noise.

The invention of the transistor made possible cheaper electronic remotes that contained a piezoelectric crystal that was fed by an oscillating electric current at a frequency near or above the upper threshold of human hearing, though still audible to dogs. The receiver contained a microphone attached to a circuit that was tuned to the same frequency. Some problems with this method were that the receiver could be triggered accidentally by naturally occurring noises, and some people, especially young women, could hear the piercing ultrasonic signals. There was even a noted incident in which a toy xylophone changed the channels on these types of TVs since some of the overtones from the xylophone matched the remote's ultrasonic frequency.

In the late 1970s, most commercial remote controls had a limited number of functions, sometimes only four: next station, previous station, increase, or decrease volume. At the time BBC engineers began talks with one or two television manufacturers which led to early prototypes in around 1977-78 that could control a much larger number of functions. ITT was one of the companies involved, and later gave its name to the ITT protocol of infrared communication.

By the early 2000s, the number of consumer electronic devices in most homes greatly

increased. According to the Consumer Electronics Association, an average American home has four remotes. To operate a home theater as many as five or six remotes may be required, including one for cable or satellite receiver, VCR or digital video recorder, DVD player, TV and audio amplifier.

Name _____

Waves & Electromagnetic Spectrum Worksheet**Directions:** Use the word bank to answer the following questions. **Each word will be used only once.**

| | | | |
|---------------|--------------|-----------------|----------|
| Crest | Frequency | Mechanical | Infrared |
| Trough | Transverse | Radio | Gamma |
| Wavelength | Longitudinal | Ultraviolet | X-Rays |
| Visible Light | Amplitude | Electromagnetic | |

- _____ waves are used to penetrate solids and are used in doctor's offices and as airports.
- _____ is the distance between one point of a wave to the same point in the next wave.
- _____ is the number of waves per unit of time.
- _____ waves occur when the motion of the medium is parallel to the direction of the wave.
- _____ waves have a color spectrum known as ROYGBIV.
- _____ waves disturb matter.
- The _____ is the top of a wave.
- The _____ is the bottom of a wave.
- _____ is the maximum distance that matter is displaced from the resting position.
- _____ waves are produced by stars and galaxies.
- _____ waves occur when the motion of the medium is at right angles (perpendicular) to the direction of the wave.
- _____ waves are often used in heat lamps.

13. _____ waves are utilized by insects to locate nectar.

14. _____ waves are transverse waves that disturb electromagnetic fields.

15. _____ waves have the shortest wavelength and the highest frequency.

Name _____

Period _____

Electromagnetic Spectrum Worksheet #1

1. In each of the following pairs, circle the form of radiation with the LONGER WAVELENGTH:

- a. red light **or** blue light b. microwaves **or** radiowaves
c. infrared radiation **or** red light d. gamma rays **or** UV radiation

2. In each of the following pairs, circle the form of radiation with the GREATER FREQUENCY:

- a. yellow light **or** green light b. x-rays **or** gamma rays
c. UV radiation **or** violet light d. AM radio waves **or** FM radio waves

3. In each of the following pairs, circle the form of radiation with the LOWER ENERGY:

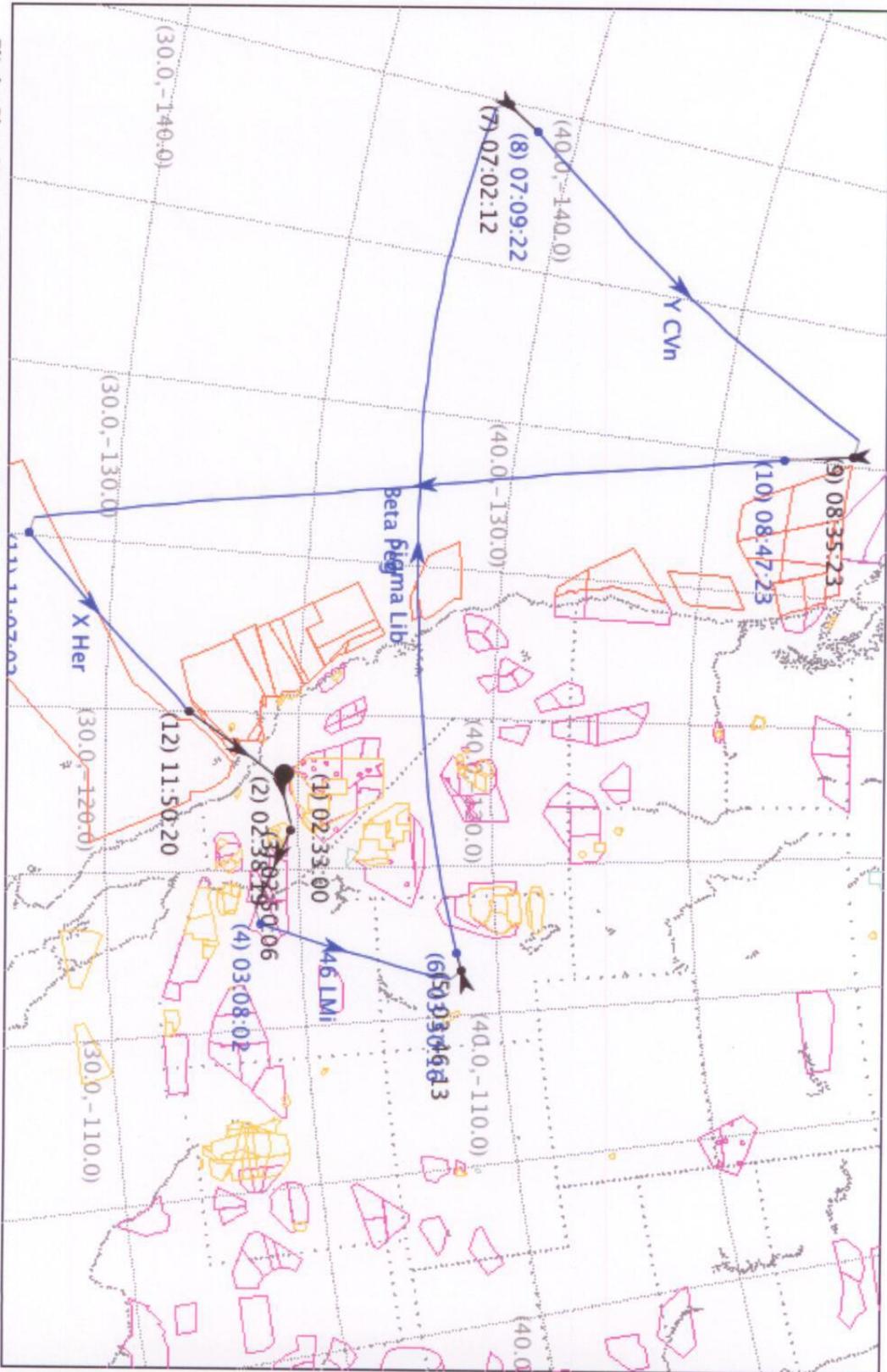
- a. red light **or** blue light b. microwaves **or** radiowaves
c. infrared radiation **or** red light d. gamma rays **or** UV radiation
e. yellow light **or** green light f. x-rays **or** gamma rays
g. UV radiation **or** violet light h. AM radio waves **or** FM radio waves

4. Springfield's "Classic Rock" radio station broadcasts at a frequency of 102.1 MHz. What is the length of the radio wave **in meters**?

5. A beam of light has a wavelength of 506 nanometers. What is the frequency of the light? What color is the light?

6. Blue light has a frequency of 6.98×10^{14} Hertz. Calculate the wavelength of blue light **in nanometers**.

My SOFIA Flight Plan! (Flight 109, June 25, 2013)



Flight Plan Name: File: 201305_FO_05_WX12.fp
Flight ID: 2013/06/19
Est. Takeoff Time: 2013-jun-19 02:33 UTC
Est. Landing Time: 2013-jun-19 12:20 UTC
Flight Duration: 09:47
Weather Forecast : 1200 Tue Jun 18 2013 - 0000 Fri Jun 21 2013 UTC
Saved: 2013-jun-18 16:05 UTC User: kbower