# **Activity Three: Distance**

## **Educator Notes**

**Learning Objectives** 

### Students will

- Construct a scale model of the Earth–Moon and Earth–Mars systems depicting planetary size and distance from each other.
- Calculate the water needs of astronauts on a deep space mission.
- Calculate and graph water consumption rates and make determinations based on trends within a graph.

### **Challenge Overview**

Students begin by exploring the relative sizes of the Earth, Moon, and Mars and the distances between them to understand how much more of a challenge it is to send an astronaut crew to Mars than to the Moon. Students are given a scenario in which their Mars-bound spacecraft suffers a malfunction and the efficiency of its water recycling system is decreased. Students will research and investigate the water consumption rates of astronauts and determine if their current water supply is enough to sustain them on the remainder of their journey.

### **National STEM Standards**

**Suggested Pacing** 

60 to 90 minutes

Disciplinary Coro Idoas				
MS ESS1 3: Analyze and interpret data to determine scale properties of objects in the solar	evetam			
• M3-E33 1-3. Analyze and interpret data to determine scale properties of objects in the solar	System.			
Technolo	Technology (ISTE)			
Standards for Students	Standards for Students (continued)			
<ul> <li>Computational Thinker 5b: Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem solving and decision making.</li> </ul>	<ul> <li>Innovative Designer 4a: Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts, or solving authentic problems.</li> </ul>			
Mathemat	tics (CCSS)			
Mathematical Practices	Mathematical Practices (continued)			
<ul> <li>CCSS.MATH.CONTENT.8.F.B.4: Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x,y) values, including reading these from a table or from a graph latement the rate of change and initial value of a linear function is target of the</li> </ul>	<ul> <li>CCSS.MATH.CONTENT.6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.</li> <li>CCSS.MATH.CONTENT.6.NS.B.3: Fluently add, subtract, multiply, and divide multidigit</li> </ul>			
situation it models and in terms of its graph or table of values.	decimals using the standard algorithm for each operation.			
<ul> <li>CCSS.MATH.CONTENT.7.EE.B.4: Use variables to represent quantities in a real-world or mathematical problem and construct simple equations and inequalities to solve problems by</li> </ul>				
reasoning about the quantities.				

Science and Engineering (NGSS)

### **Activity Preparation**

### The educator should

- Read the introduction and background information, Educator Notes, and Student Handout to become familiar with the activity.
- Gather and prepare all necessary supplies on the materials list.
- Arrange students in teams of two to four and distribute supplies to each group.

### **Materials**

For each group:

- Printed Student Handout and Data Files
- 9-inch balloons, 3 (blue or green for Earth, white or yellow for the Moon, and red or orange for Mars)
- □ Metric rulers or measuring tape
- □ Several sheets of graph paper

- □ Calculator
- $\hfill\square$  Colored pencils

### 🛕 Safety

- Students should be aware of their surroundings and move carefully throughout the room when viewing other teams' work.
- Caution should be used when inflating balloons.

### Introduce the Challenge

- Display a balloon inflated to a diameter of 20.0 cm and tell students that it represents the size of the Earth. Ask student teams to
  inflate their "Earth" balloons to a size of 20.0 cm in diameter and tie them. Next, ask teams to inflate their Moon and Mars balloons
  (without tying them) to what they believe would be the proper scale size, based on their Earth balloons. Now have students look
  around the room and compare their Moon and Mars balloons to those of other students.
- Have each team use the data in Table 1 in the Student Handout to find the scale of their Earth balloon. Next, have them use that scale to complete Table 1 and inflate their Moon and Mars balloons to the proper diameter. Have students round to the nearest centimeter. (Answers are given here in bold).

•	In Table 1 and the calculations that follow, the real diameters of the celestial bodies are listed to the nearest whole number. All
	other numbers are rounded to the nearest tenth of a centimeter for consistency.

Table 1

Body	Diameter, km	Balloon model diameter, cm
Earth	12,756	20.0
Moon	3,476	5.5
Mars	6,792	10.6

		IVI	ais		0,7	52		10.0		
-	C 1.11			 	e (1		(40 750) 1	 	e	

- To find the scale of the Earth balloon, divide the diameter of the Earth in kilometers (12,756) by the diameter of the balloon model in centimeters (20.0).
- 12,756/20.0 = 637.8 (which rounds up to 638 for simplicity). To find the diameters for the other two balloon models, divide the actual diameter by the scale of the Earth model that was just calculated.
- Now that each team has properly inflated Earth, Moon, and Mars balloons, have students model how far away they think the Moon should be from Earth. Have them look around the room to compare their Earth-to-Moon distances with those of other students.
- Using the same scale calculated before (638 km in the real world = 1 cm in the scale world), have students complete the first line of Table 2 to find the proper scale distance between their Earth and Moon balloons.

Bodies	Approximate distance, km	Balloon model distance, cm
Earth to Moon	384,000	601.9 (6.019 m)
Earth to Mars	78,300,000	123,000 (1.23 km)

Table 2

To find the distance between each of the models, divide the actual approximate distance by the scale of the balloon models.

- Next, have students model the scale distance by holding their Earth and Moon balloons about 6 m apart. Explain to them that
  this distance represents the distance from the Earth to the Moon. This is the distance astronauts had to travel during the Apollo
  missions of the late 1960s and early 1970s and will have to travel again for the Artemis missions to the Moon. The trip takes
  about 3 days each way, or about the same time it takes to drive from the east coast to the west coast of the United States.
- Next, students will model how far away they think Mars should be from Earth. Have them look around the room to compare their Earth-to-Mars distances with those of others.

- Have students complete the second line of Table 2 to find the scale distance between their Earth and Mars balloons. Ask students if they can model it within the room. Can they model it in the hallway? Could they even model it on campus? Explain to students that for their models to be at the proper scale, they would have to be 1.23 km apart, or just over 3/4 of a mile. This demonstration shows just how much farther Mars is from the Moon. Instead of a 3-day journey, like the trip from Earth to the Moon, a journey from Earth to Mars will take at least 6 months.
- Explain to students that during a journey to Mars, the spacecraft coasts through space. It cannot stop, turn around, or meet up with another vessel to resupply. All the resources needed for the entire trip to Mars must be brought with the crew. They cannot be resupplied until they reach pre-positioned supplies either in orbit around Mars or on the Martian surface. One of the largest and heaviest resources that the astronauts will need is water. Clean drinking water is not something that can be found or acquired in space. It must be brought along on the journey. To save space and weight, only a limited supply of water can be brought along, and it must be continuously recycled back into the water supply. In the remainder of this activity, students will be given a scenario in which the water supply of their Mars-bound spacecraft is put at risk. It will be up to them to identify the extent of the risk and develop a solution.

### **Facilitate the Challenge**

### **?** Meet the Problem

- Ask students if they have ever unexpectedly run out of something important. (Examples: money, gas, their favorite cereal, etc.) What caused them to run out? (Examples: They did not plan properly, they used it at a faster rate than anticipated, they had to use a lot unexpectedly, etc.)
- Explain that even though NASA meticulously plans for all its missions, including emergency scenarios, there are still times when an unexpected situation arises. When astronauts are millions of kilometers from Earth, messages traveling at the speed of light can still take several minutes to reach them. During these times, the crew must take the initiative to troubleshoot the problem.
- Give students the following scenario:

Your team represents the four-member crew of HEM2 (Human Exploration of Mars 2), the second of NASA's manned missions to Mars. You are currently coasting on your 6-month (26-week) journey to the Red Planet. While the crew of HEM1 were the first to land on Mars, they were a smaller crew of three who only stayed on the surface for a few months. You are excited to be part of the first long-term mission, exploring the surface and performing scientific experiments for 18 months. Everything you need has been prepositioned. There is a logistical supply craft in orbit, containing spare parts, fuel, and supplies for your trip home, as well as a fully stocked outpost on the Martian surface, with everything you will need for your extended stay.

Things have gone smoothly on your mission so far. You have just completed the ninth week of your 26-week journey, and spirits within your spacecraft have been high. Suddenly, there is an alarm. Your water purification system is detecting a major malfunction. After several minutes of troubleshooting, you determine that hydraulic fluid has leaked into your water recycling system and you perform an emergency shutdown to prevent further damage. After repairing the hydraulic line, you restart the water recycling system and assess the damage. Here is what you determine:

### Share With Students



The water purification system currently on use aboard the International Space Station uses a three-step process. First, a filter removes particles and debris. Second, the water is passed through the multifiltration beds that remove organic and inorganic impurities. Finally, the catalytic oxidation reactor kills bacteria and viruses. The recycling of water aboard the space station saves over 18,000 kg of water each year!

#### Learn more:

www.nasa.gov/feature/new-brineprocessor-increases-waterrecycling-on-international-spacestation



NASA's Marshall Space Flight Center in Huntsville, Alabama, is home to the development of the Environmental Control and Life Support System (ECLSS). This is the system aboard the International Space Station that provides clean air and water for astronauts using the oxygen generation system and the water recovery system. The same technology used in the water recovery system has been adapted to help people around the world have access to clean drinking water by providing water bottle filling stations in remote areas.

#### Learn more:

www.nasa.gov/mission\_pages/st ation/research/news/b4h-3rd/itadvanced-nasa-water-purification



- The 20-liter (20-L) tank that feeds the water recycling system has been contaminated with hydraulic fluid, and that water cannot be recovered.
- Due to the emergency shutdown of the water recycling system, the system's memory was erased. You no longer have a
  record of how much water was originally supplied on the ship or how much clean water remains available. You do, however,
  have other sources of information about the water recycling system that you have accumulated from various sources. These
  are detailed in the included Data File.
- The water recycling system is currently operating at an efficiency of 86 percent, well below the designed efficiency of 90 percent.
- The sudden drop in hydraulic pressure caused the communications array to become misaligned. It will take several hours to realign the array, send a message to Earth, and receive a reply.

Since it will be several hours before you receive instructions from NASA, it is up to you to begin working the problem. Do you have enough water to make it to Mars orbit, where you have additional supplies and repair parts waiting? If not, make a specific plan that will ensure your crew will make it to Mars safely.

### Explore Knowns and Unknowns

- Ask students if they understand the purpose of the remainder of the activity. Do they understand what they are trying to accomplish?
- Have students make a list of everything they need to know in order to determine if they have enough water to make it to Mars. Give them time to come up with as much of the list as possible on their own. The list should include the following:
  - How much water did they start with at the beginning of week 1?
  - How much water do they have left at the end of week 9?
  - At what rate are they consuming that water?
  - Will that water run out before the end of their journey (end of week 26)?
  - If the water will run out, what can they do to extend their supply safely?
- Have students make a list of everything that they already know. Give them time to come up with as much of the list as possible on their own. The list should include the following:
  - They are 9 weeks into a 26-week journey.
  - They have already lost 20 L of their water supply.
  - Their damaged water recycling system is currently operating at 86 percent efficiency.

- They have a Data File that contains additional information concerning the water usage and the recycling system.
- Have students use the information they already know and the information they gather from the Data File to answer their questions. Clues and encouragement may be given along the way, but allow them to figure out as much as possible on their own.
- There are two ways to determine how much water was originally aboard the HEM2 ship. Students can use either method
  depending on their ability level.
  - Easier method: Have students look at the HEM1 water usage graph in their Data File. The beginning of week 1 shows the total amount of water aboard at the beginning of the HEM1 mission, 290 L. This also includes a 50-L emergency supply. Subtract the 50 L; the amount left is the amount of water for needed for a three-person crew: 240 L, or 80 L per crew member. Since HEM2 has a four-person crew and will have the same 50-L emergency supply, the formula to find the original water supply for the HEM2 will be 4/3(290 L 50 L) + 50 L, or 370 L.
  - Advanced method: Have students look at the excerpt from the Consumable Supply Guide in their Data File. It states that the ship will be packed with the estimated water needed by the crew, based on the water allotted to each astronaut and the efficiency of the water recycling system, plus 50 L of water as an emergency supply. The daily water allotment, taken from the Personnel Manual excerpt in their Data File, states that each astronaut is given a daily allotment of 4.4 L of water. So, each crew member uses 30.8 L of water per week. With a crew of four astronauts aboard HEM2, the total weekly usage would be 123.2 L of water. We know that the average efficiency of the water recycling system is 90 percent, so there is a net loss of 12.3 L of water each week aboard the spaceship. For a 26-week mission, this is a total estimated use of 320 L for the mission. Adding in the 50-L emergency supply brings the total to 370 L.
- To find out how much water they have at the end of week 9, when the accident occurred, students will use the water they started with, 370 L, and subtract the total water consumed/lost. This should all be graphed on the HEM2 water usage graph that they will create. The estimated efficiency of the water recycling system is 90 percent, but by chance, a picture was taken of the water recycling system's display just a few days before the accident. This is shown in the Water System Photo in the students' Data File. The picture shows that the system had been operating at an average efficiency of 91 percent for the first 9 weeks of the mission, before the accident, meaning that only 9 percent of the water used each week was not recovered. So, the net water usage was 0.09 (123.2 L), or 11.1 L per week. This is the rate of water consumption for the first 9 weeks of the mission. This can be graphed week by week, or more advanced students can use the rate as the slope of the line for the first 9 weeks. After 9 weeks, 99.9 L of water should have been used up, giving 270.1 L remaining. Also remember, 20 L of water was permanently lost in the accident due to contamination. This gives us a total of 250.1 L of water remaining after 9 weeks. Student graphs should show a steady slope during the first 9 weeks of the mission, and then a vertical drop, equal to 20 L, at the end of the ninth week.
- After the accident, we know that the water recycling system is operating at an efficiency of only 86 percent. With the consumption rate of 123.2 L of water per week, we now have a new net usage rate of 0.14 (123.2 L) or 17.2 L of water per week. This will be the new consumption rate from the end of week 9 through the remainder of the 26-week journey.
- To determine if they have enough water to complete their journey to Mars, have students use their newly calculated consumption
  rate of 17.2 L of water per week to graph the water usage from the end of week 9 until the end of week 26. The point on the
  graph where the line crosses the x-axis will be the point where their crew runs out of water. Have them continue to plot the graph
  below the x-axis all the way to 26 weeks. The distance below the x-axis at 26 weeks will represent the amount of water the crew
  will be short in order to complete their journey.
- Have them create a similar graph using the information they have calculated for the HEM2 mission. Have students use this graph to determine when their water supply will run out.

### Generate Possible Solutions

- Have students answer the following questions:
  - At current consumption rates, does your crew have enough water to complete the journey to Mars? If not, when will you run out of water?
  - How many additional liters of water would you need to make it safely to Mars?
  - How could you possibly extend your current water supply? Allow students time to come up with their own answers. If they are having trouble, point them to the Personnel Manual excerpt in the Data Files. It breaks down the 4.4-L daily water

allotment for each astronaut into the amounts for drinking water, food rehydration, and personal hygiene. Ask students if any of those can be decreased and to what extent.

• Have students brainstorm several plans for how they are going to ration the water. Their plans should be well thought out and include calculations. Remind them that this will begin at week 9 and last until week 26.

## ??? Consider Consequences

- Have students choose their most viable plan and graph it on their HEM2 water usage graphs, beginning at week 9 and using a different color. Remind students that the changes they make must be reasonable and must keep the water supply above zero (the x-axis) all the way to week 26, when they arrive at Mars.
  - Observe students and provide help when needed. They may need guidance on how to use their new water rationing allotment with their calculations.

## 🐖 Present Findings

- Have each group present their graph to everyone. They should explain what steps they took to reduce crew members' daily water
  ration and the possible effects those changes would have on the crew. They should also walk through their calculations to
  illustrate how their new water consumption rates will ensure the water supply will last until the crew reaches Mars.
- After the presentations, ask the following discussion questions:
  - Compare your team's graph with those of other teams. Should all of your graphed lines be the same? Answer: No
  - Which one is different? Answer: The final line from week 9 through week 26
  - Why? Answer: Each team created their own new daily consumption rate based on how they cut back on the daily water allotment.
- Optional: Share students' results on social media using #NextGenSTEM. Be sure to include the module and activity name.

### Extensions

- Have students graph their HEM2 water consumption electronically by creating a data table in a spreadsheet.
- Have students calculate the volume and mass of water needed for their journey if they did not have a water recycling system. Remember, 1 L of water is equal to 1 kg.
- Have students model the volume of water needed for the mission three dimensionally to show how much space it will take up.
- Have students repeat the activity, using a different number of astronauts or a different length journey.

### Reference

Earth, Moon, and Mars Balloons

www.nasa.gov/audience/foreducators/k-4/features/A\_Earth\_Moon\_Mars\_Balloons.html

# **Activity Three: Distance**

## **Student Handout**

In this activity, you will work as a group to create a scale model of the Earth, the Moon, and Mars to illustrate the difference in difficulty between a crewed mission to the Moon and a crewed mission to Mars. You will also determine the amount of water needed for a 6-month mission to Mars and how the water supply will be controlled during the trip.

### Introduction Activity

- Inflate your Earth balloon to a diameter of 20.0 cm and tie.
- Using your Earth balloon as a reference of scale, inflate your Moon and Mars balloons to the size that you believe they should be. Do not tie the Moon or Mars balloons at this time.
- Using the data in Table 1, calculate the ideal diameter for your Moon and Mars balloon models.
- In this section, round all of your balloon model diameters to the nearest tenth of a centimeter.

Tabla 1

Body	Diameter, km	Balloon model diameter, cm
Earth	12,756	20.0
Moon	3,476	
Mars	6792	

• To find out the scale of your Earth balloon, divide the actual diameter of the Earth in kilometers (12,756) by the diameter of the balloon model in centimeters (20.0). Round your answer to the nearest whole number.

12,756/20.0 = \_\_\_\_\_

- To find the diameters of the other two balloon models, divide the actual diameter by the scale of the models that you just calculated.
- Now inflate the Moon and Mars balloons to the size you calculated in Table 1.
- Model how far away you think the Moon should be from Earth by holding the Moon and Earth balloons apart. Look around the room to compare your Earth-to-Moon distances with those of others.
- Now use the same scale as calculated earlier (638 km in the real world = 1 cm in the scale world) and the information in Table 2 to find the actual distance your Moon balloon needs to be from your Earth balloon. Record this in the top line of Table 2.

Bodies	Approximate distance, km	Balloon model distance, cm
Earth to Moon	384,000	
Earth to Mars	78,300,000	

### Table 2

# 😇 Fun Fact

Do astronauts actually drink their own urine? Well, not really. The first step in turning urine back into drinking water is distillation. Urine is made up of mostly water, and in the distillation process, it is heated until the water boils away as steam. The steam is cooled and condensed back into water before going through the remaining steps of the recycling process. So, astronauts do not really drink their own urine; they just drink the water that used to be in their urine.

### Learn more:

www.nasa.gov/centers/marshall/n ews/releases/2020/nasa-marshallengineers-refine-hardware-applyinnovative-solutions-to-morereliably-recycle.html



Turn your passion for science into a career with NASA. Dr. Jill Williamson's early interest and aptitude in chemistry led to a NASA internship and an eventual career. She is currently the Lead Subsystem Engineer for the Urine Processor Assembly. Watch her interview to learn more about the career path that led her to NASA. Watch the whole series to learn about other NASA STEM Stars!

Learn more: youtu.be/dUb\_NT2JRAE

- To find the distance between each of your models, divide the actual approximate distance by the scale of the balloon models.
- Now that you have calculated the correct scale distance between the Earth and Moon, model the distance by holding your Earth
  and Moon balloons about 6 m apart. This distance represents the distance from the Earth to the Moon that astronauts traveled
  during the Apollo missions to the Moon during the late 60s and early 70s. They will have to travel that distance again for the
  Artemis missions to the Moon later in this decade. The trip takes about 3 days each way, or about the same time it takes to drive
  from the east coast to the west coast of the United States, stopping only to rest.
- Finally, model how far away you think Mars should be from Earth. Look around the room to compare your Earth-to-Mars distances with those of others.
- Complete the second line of Table 2 to find the actual distance apart that your Earth and Mars balloons would have to be in order to be at the proper scale. Can you model it in the room? Could you model it in a hallway? Could you even model it on a football field? Why or why not?

Challenge

## **?** Meet the Problem

- Have you ever unexpectedly run out of something important? What caused it to run out?
- Even though NASA meticulously plans for all its missions, and even accounts for emergency scenarios, there are still times when an unexpected situation arises. When you are on a spacecraft, millions of kilometers from Earth, messages traveling at the speed of light can still take several minutes to reach you. During these times, it is up to the crew to take the initiative to troubleshoot the problem.
- Here is your team scenario for the remainder of this activity:

Your group represents the four-member crew of HEM2 (Human Exploration of Mars 2), the second of NASA's manned missions to Mars, currently coasting on your 6-month (26-week) journey to the Red Planet. While the crew of HEM1 were the first to land on Mars, they were a smaller crew of three who only stayed on the surface for a few months. You are excited to be part of the first long-term mission, exploring the surface and performing scientific experiments for 18 months. Everything you need has been pre-positioned. There is a logistical supply craft in orbit, containing spare parts, fuel, and supplies for your trip home, as well as a fully stocked outpost on the Martian surface with everything you will need for your extended stay.

Things have gone smoothly on your mission so far. You have just completed week 9 of your 26-week journey, and spirits within your spacecraft have been high. Suddenly, there is an alarm. Your water purification system is detecting a major malfunction. After several minutes of troubleshooting you have determined that hydraulic fluid has leaked into your water recycling system and you perform an emergency shutdown to prevent further damage. After repairing the hydraulic line, you restart the water recycling system and assess the damage. Here is what you determine:

- The 20-liter (20-L) tank that feeds the water recycling system has been contaminated with hydraulic fluid and that water cannot be recovered.
- Due to the emergency shutdown of the water recycling system, the system's memory has been erased. You no longer have
  a record of how much water was originally supplied on the ship or how much clean water remains available. You do, however,
  have other sources of information about the water recycling system that you have accumulated from various sources. These
  are detailed in the included Data File.
- After the accident, the water recycling system is currently operating at an efficiency of 86 percent, well below the designed efficiency of 90 percent.
- The sudden drop in hydraulic pressure caused the communications array to become misaligned. It will take several hours to realign the array, send a message to Earth, and receive a reply.

Since it will be several hours before receiving instructions from NASA, it is up to you to begin working the problem. Do you have enough water to make it to Mars orbit, where you have additional supplies and repair parts waiting? If not, make a specific plan that will ensure your crew will make it to Mars safely.

## Section Explore Knowns and Unknowns

- Does your team understand what they are attempting to accomplish for remainder of the activity?
- As a team, make a list of everything you need to know in order to determine if you will have enough water to make it to Mars.
- As a team, check off items from your list that you already know.
- Use the information that you already know and any additional information you can gather from the Data File to determine how
  much water you have left aboard your spacecraft and the rate at which it will be consumed. Use the HEM1 graph as an example
  to create a graph that shows your water consumption for HEM2.
  - Remember that you have a crew of four aboard HEM2, and HEM1 only had three crew members.
  - Also remember that your graph will change drastically at week 9. You will have a sudden loss of water due to contamination, and your rate of consumption will change due to the damaged water recycling system.
  - Continue to plot the graph to 26 weeks even if you fall below the x-axis.

### Generate Possible Solutions

- Answer the following questions:
  - At current consumption rates, does your crew have enough water to complete the journey to Mars?
  - When will you run out of water?
  - How many additional liters of water would you need to have to make it safely to Mars?
  - How could you possibly extend your current water supply?
- As a team, brainstorm a few plans for how you are going to ration the water.
  - Remember that this will begin at week 9 and last until week 26.
  - Make all the calculations to show that your plans will extend your water supply.

## **???** Consider Consequences

- Choose your most viable plan to extend your water supply. Using a different color, graph it onto your HEM2 water usage graph, beginning at week 9.
  - Remember that the changes you make must be reasonable and must keep the water supply above zero (the x-axis) all the way to week 26, when you arrive at Mars.
  - Make careful calculations to show how your new water rationing plan will change the overall water consumption rate.

## 🐖 Present Findings

- As a team, prepare to present your HEM2 graph to everyone.
  - Explain what steps you took to reduce the daily ration of water of your crew members and what the possible effects of those changes would be on your crew.
  - Walk through the calculations you made, showing that the new water consumption rate ensures that the water supply will last until your crew reaches Mars.
- After your presentation, you will be asked the following questions:
  - Compare your team's graph to those of other teams. Should all your graphed lines be the same as theirs?
  - Which one is different?
  - Why?

# Data File

After the loss of the water recycling system's memory, your crew rounded up as much information about the water recycling system as they could from various sources aboard your spacecraft. Here are five items you have put together that contain useful information:

- 1. HEM1 Mission Water Usage Graph: This graph was found in one of your training manuals and depicts the actual water consumption rates of the HEM1 expedition.
- 2. Personnel Guide Excerpt: This page from your crew personnel guide shows various rules and regulations for the mission, including how much water allotment each astronaut receives.
- 3. Consumable Supply Guide Excerpt: This page from the consumable supply guide shows regulations regarding how the amounts of various consumables are chosen for the mission.
- 4. Crew Member Photo: This casual photo of one of your crew members was taken just days before the malfunction. The display of the water recycling system can be seen in the photo, showing the system's overall average efficiency thus far on the mission.
- 5. Note Pad: Depicts a few important things your crew remembers jotted down from their training about the water recycling system and about the emergency as well as some important questions that will be helpful to answer.



# HEM1 Mission Water Usage Graph

## Personnel Guide Excerpt

0	conclusion of an exercise routine, it is the responsibility of the crew member to make all equipment ready for its next use:
0	<ul> <li>a) Use a moistened sanitizing wipe to clean all contact surfaces.</li> <li>b) Properly reset all resistance settings to their default mode.</li> <li>c) Stow equipment into its storage area.</li> <li>d) Make note of any damage to equipment or any equipment that is operating outside its designed parameters.</li> </ul>
0	Daily Water Allotments
- T	The daily water allotment for each crew member (4.4 L) has been set with
0	specific guidelines in mind. It is recommended that each crew member make
-	an effort to use their daily water allotment according to these
0	guidelines:
-	a) 2.5 L daily for drinking water and for use in preparing beverages
0	b) 0.4 L daily for the rehydration and preparation of food
0	c) 1.5 L daily for bathing, brushing of teeth, and other forms of
~	personal hygiene
0	Sharing and Trading Supplies
	Although the supplies that are packed for each expedition are, to some
0	degree, tailored to individual needs or each crew member, it is permitted,
	for the purposes of necessity and comradery, for crew members to
0	

## **Consumable Supply Guide Excerpt**

for each crewmember per week of the planned mission, plus an additional 10 packages for incidental and emergency use.

#### Potable Water

0

 $\circ$ 

0

0

0

0

0

0

The amount of potable water suppled for each mission is strictly set by the calculated needs of the crew. It is determined by the number of crew members assigned to the mission, the duration of the mission, and the projected efficiency of the water purification system.

- a) Each crew member is allotted 4.4 L of water for daily use.
- b) After calculating water supply needs of the crew and accounting for the water that cannot be recycled, an additional supply of 50 L will be placed aboard each mission for emergency use.

#### Food

Food storage packed for each mission takes into account the dietary needs of each crew member. Crew members may make personal choices from the provided menu options as well as make recommendations to

## **Crew Member Photo**



## Note Pad

- EXPECTED EFFICIENCY OF 90%
- 20 LITERS OF WATER LOST, NEW EFFICIENCY OF 86%
- HOW MUCH WATER DID WE START WITH?
- HOW MUCH WATER LEFT?