National Aeronautics and Space Administration

Exploring the Solar System

Outreach ToolKit Manual

Distributed for members of the *NASA Night Sky Network*

The Night Sky Network is supported by:

- **NASA's *Solar System Education Forum***
- **NASA's *Origins Forum***
- **The SETI Institute under NASA Grant NAG 2-6066 for the *Kepler Mission***
- **JPL's *PlanetQuest* public engagement program**
- **Suzaku Mission Education: http://suzaku-epo.gsfc.nasa.gov**
- **EPO: Sonoma State University http://epo.sonoma.edu/**

The Night Sky Network was founded by:

JPL's Navigator (*PlanetQuest***) public engagement program and the**

Astronomical Society of the Pacific http://www.astrosociety.org.

NASA Night Sky Network: http://nightsky.jpl.nasa.gov/

Contacts

The non-profit Astronomical Society of the Pacific (ASP), one of the nation's leading organizations devoted to astronomy and space science education, is managing the Night Sky Network in cooperation with NASA and JPL. Learn more about the ASP at http://www.astrosociety.org.

For support contact:

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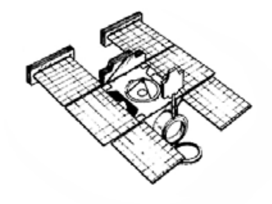
Introduction: Exploring the Solar System

Amateur astronomers often provide a child with his or her first look through a telescope. Some of our favorite telescope targets to share with the public are the planets of our Solar System. The view of Saturn through the eyepiece can be a life-altering experience.

This ToolKit is designed to provide tools to show the structure of our Solar System, including models for sizes and distances, to connect what is seen in the sky with where the planets are in relation to Earth.

The many NASA missions that explore our Solar System serve as an inspiration to children and adults. This ToolKit provides an introduction to the many ways we can explore, learn, and discover: fly-bys, orbiters, landers, probes, sample returns.



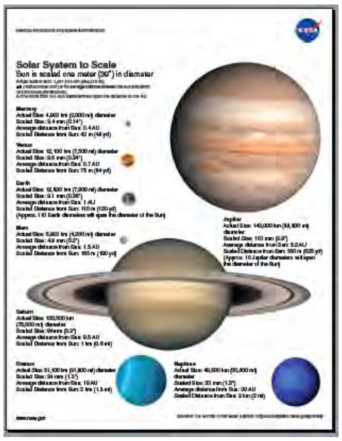
Have fun exploring the Solar System with your visitors!

For more resources:
http://education.jpl.nasa.gov/amateurastronomy/index.html

Summary of activities and resources:

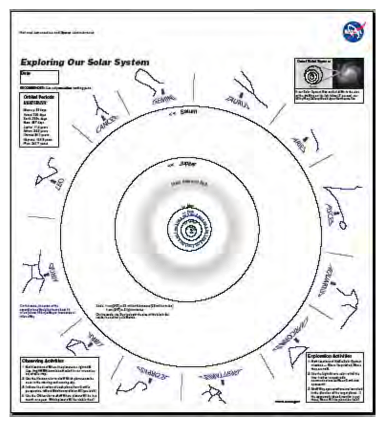
1. **Exploring Strange New Worlds:**
   A team exercise that provides insight into how NASA scientists explore our Solar System. Your visitors become teams of scientists living on a planet orbiting a distant star. They are on the threshold of exploring their own planetary system for the first time. Your club members get to create the planets!

2. **Solar System Models: Sizes and Distances**



   a) "Pocket Solar System": a simple activity to give you an easy way to demonstrate an overview of the approximate distances between the orbits of the planets, the Asteroid Belt, and the Kuiper Belt.

   b) "Worlds of the Solar System": Scale models of the planets, the asteroid Ceres, the Kuiper Belt object Pluto, and Earth's Moon. Scaled to a one-meter diameter Sun.



3. **Exploring Our Solar System:** A banner of our Solar System with accurately scaled orbits of the naked-eye planets helps dispel the common perceptions that the planets are all in a line, that they all move together, and that it is easy to quickly communicate with spacecraft exploring other planets. Includes handouts and star maps to connect the location of the planets with what we see in the sky.

4. **PowerPoint: Explorers' Guide to the Solar System:**

   A non-technical introduction to exploring the Solar System: Why we explore, how we explore, and how scientists piece together clues to better understand the worlds of our Solar System.

There are activities in this ToolKit appropriate for ages 7 to adult.

Thanks to the ToolKit Testers

NASA and the Astronomical Society of the Pacific (ASP) wish to thank the members of the astronomy clubs around the country who took the time and made the commitment to test these activities in a variety of settings and with a wide range of audiences. Their dedication and feedback helped to make this ToolKit appropriate and enjoyable for the members of the Night Sky Network.

Astronomy Club	State
Amateur Telescope Makers of Boston	MA
Antelope Valley Astronomy Club	CA
Astronomical Society of Northern New England	ME
City Lights Astronomical Society for Students	IL
Eastbay Astronomical Society	CA
Hawaiian Astronomical Society	HI
Latin School & Chicago Sidewalk Astronomy Club	IL
Mount Diablo Astronomical Society	CA
North Houston Astronomy Club	TX
Phoenix Astronomical Society	AZ
San Mateo County Astronomical Society	CA
Santa Barbara Astronomical Unit	CA
Warren Rupp Observatory	OH
Westminster Astronomical Society	MD

Ideas and Suggestions from the ToolKit Testers

Here are some comments from a few of the astronomy clubs who tested Exploring the Solar System ToolKit in answer to the following questions.

"If you had just 2 minutes to tell someone in your club about this ToolKit, what would you say?"

Hawaiian Astronomical Society
Exploring the Solar System Toolkit is one of the best toolkits for providing our members a clear understanding of the vastness of space; the comparative sizes of the planets compared to our sun; and the relationship between planets as they circle the sun and why we cannot see all the planets at any one time. Information on space exploration provides an insight into the problems NASA must consider to guide and communicate with space vehicles.

Latin School & Chicago Sidewalk Astronomy Club
This toolkit is great for giving people a feeling for the sizes & distances of the planets. The pocket solar system is a great activity for comparing the planet distances in our Solar System.

City Lights Astronomical Society for Students
This kit was fun and easy to do. It helped not only teach about the Solar System but gave new ideas for children so they understand. It was easy to explain to everyone attending the presentations and was a blast to do.

Astronomical Society of Northern New England
The scale model solar system bodies are fun to compare for size with the sun and each other. You can make this activity quite active for students as young as 3rd grade. These activities are definitely keepers!

North Houston Astronomy Club
The public wants to know more about the planets. These are always the highlight of any star party. Most people do not really understand how it all works together to show us the things we see in the night sky. This toolkit provides easy ways to show the public, without getting too technical, what the orbits look like, where the planets are now, and even a solar system to take home in your pocket.

“If you were to give advice to other clubs regarding this ToolKit, what would it be?”

Phoenix Astronomical Society
Let the kids explore – try not to tell them everything right off. The big vinyl poster is a big hit as are the planetary fact sheets.

Eastbay Astronomical Society
These activities are great for the period when you are waiting for it to get dark enough for observing, so that the public can better appreciate what they are observing.

City Lights Astronomical Society for Students
Take your time with the kids. The pocket solar system was a little tricky for the kids if you go fast. Give them time to do each fold. It was helpful to have them guess what planet came next. It makes it more fun for them.

Westminster Astronomical Society
Exploring Strange New Worlds was fun and hilarious. Be sure to try that one. You need to let your audience know that they have free range to imagine ANY type of planet.

Media & Resources

The “Media and Resources” bag includes:

- The ToolKit Manual on a CD
- The Training Video as a DVD
- Solar System Lithographs
- Materials for the activity, “Exploring Strange New Worlds.”

The “Training Video DVD” should be viewed as soon as you receive the ToolKit. This will provide an introduction to the activities and materials.

Explore the “Manual and Resources CD”. Insert it into your computer’s CD drive:

- For the **ToolKit Manual**, open the file: “SolSysManual.pdf”
- Open the file named “**HowFast.pdf**” that discusses “How Fast are you Moving When you are Sitting Still?”
- The **PowerPoint “Explorers’ Guide to the Solar System”** and its suggested script can be found in the “PowerPoint” folder. The script is “ExploreSolSysScript.doc” and as a PDF: “ExploreSolSysScript.pdf”. There are **three versions of the PowerPoint**:
  - Full Resolution: ExploreSolSysL.ppt
  - Medium Resolution: ExploreSolSysM.ppt
  - Low Resolution: ExplorSolSysS.ppt
- For **labels and logos** associated with this ToolKit, open the “LogosLabels” folder which includes the following.
  - The logo for the ToolKit as a jpeg file, “SolSysLogo.jpg”.
  - A PDF file “CDDVDlabels.pdf” to make labels for any additional DVDs and CDs that you choose to copy. Formatted for printing on Avery labels 5931 and 8692.
  - A PDF file for the ToolKit Box labels, “SolSysBoxLabel.pdf”. These are 3-1/3” x 4” labels. Formatted for Avery label 5524.

The handouts for the activities can be found in SolSysManual.pdf so you can personalize them with your club information and print out copies to make for your guests and other club members. The manual also includes sources where you can get more materials.

Feel free to make copies of the **Training DVD and Manual & Resources CD** for distribution to other club members or educators. Such materials must be provided free or at your cost.

Materials for Media & Resources

Copies of the **Training DVD and Manual & Resources CD** can be made at your local photo center or other media duplication service.

The Solar System Lithograph Set was provided by the NASA Solar System Exploration Education and Public Outreach Forum http://solarsystem.nasa.gov/education.

The lithographs are available for download and printing through Office Max http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Our_Solar_System_Lithograph_Set.html

Where could I use the resources included here?

MEDIA / RESOURCE	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)
			K-4	5-8	9-12		
PowerPoint: Explorers' Guide to the Solar System	√	√		√	√	√	√
Solar System Lithographs	√	√	√	√	√	√	√
Training DVD						√	
Manual & Resources CD						√	

Exploring Strange New Worlds

What's this activity about?

Big Question:

What are the ways NASA explores the Solar System?

Big Activity:

Your visitors become teams of scientists living on a planet orbiting a distant star. They are on the threshold of exploring their own planetary system for the first time. With planets you have created, teams explore the planets using the methods NASA scientists use to explore the Solar System.

Participants:

From the club: One to three members.

Visitors: This activity is appropriate for families, the general public, and school groups in grade 5 and up. Any number of visitors may participate. It is recommended that teams consist of 3 – 7 people.

Duration:

30 – 45 minutes.

Topics Covered:

What methods do scientists use to explore our Solar System?
Exploring by:

- Telescope
- Fly-by
- Orbiter
- Probe
- Lander / Rover
- Sample Return
- Human Exploration

What are examples of the different kinds of missions?
What decisions do scientists need to make when planning missions?

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Exploring Strange New Worlds		√	√	√		√	√	√		√

What do I need to do before I use this activity?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Make planets	*Optional*: Tweezers *Optional*: Copies of the "I Explored Strange New Worlds" certificate.	Make copies of the "Communication and Exploration" handout

Helpful Hints

You may want to use the PowerPoint, "Explorers' Guide to the Solar System" to introduce this activity. The PowerPoint and suggested script can be found on the Manual & Resources CD.

- Be sure to make your planets ahead of time. You might want to consider how durable your planet is and how many times it will survive "exploration."
- There are quite a number of ways you might run this activity. A basic set of rules and a list of variations are provided. You are likely to come up with others.
- This is particularly effective in a large field or park where you can have a number of planets spread out in different directions.
- If you are working with families, this can be quite a successful family activity. Assign each family as a team.
- If working with Scouts, assign each patrol or other group as a team.
- When doing this with young people, it is recommended that the children be at least 12 years old. Young people require a little more direction than families and older teens or adults.
- Use the "Communication and Exploration" handout to discuss how we have explored. Potential discussion questions:
    - How far have we sent humans?
    - Are there any worlds in our Solar System we haven't explored, except by telescope?

Background Information

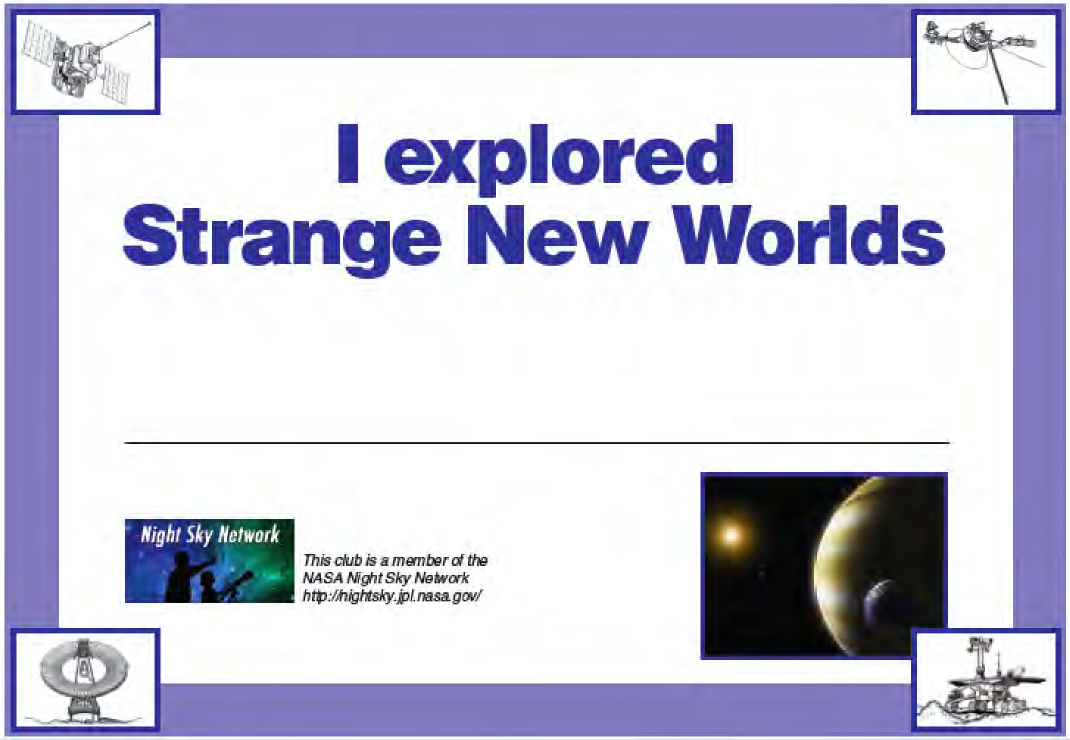
1. Ways we remotely explore the Solar System:

Method	Definition / Purpose	Examples of Missions / Facilities
Telescope	Either Earth or space-based telescopes Deep Space Network collects data from spacecraft exploring the Solar System	Keck Hubble Space Telescope Deep Space Network
Fly-by	Send a spacecraft to pass by one or more worlds of the Solar System for a brief survey and /or to gain speed through a gravity assist	Pioneers Voyagers New Horizons (Kuiper Belt)
Orbiter	Orbiting spacecraft that do detailed surveys of the world from space	Mars Reconnaissance Orbiter Lunar Reconnaissance Orbiter Cassini (Saturn) MESSENGER (Mercury) Dawn (Ceres and Vesta in the Asteroid Belt)
Probe	Impactor to blast material off the surface for analysis Instrument that floats down through the atmosphere to analyze composition	Deep Impact (Comet) Huygens Probe (delivered by Cassini to Saturn’s moon, Titan)
Lander / Rover	Spacecraft that land on and explore worlds from their surface	Mars Exploration Rovers
Sample Return	Collects material from a body and returns it to Earth for analysis	Genesis (Solar wind atoms) Stardust (Comet)

2. For information on the missions listed above: http://solarsystem.nasa.gov/missions
   Deep Space Network: http://deepspace.jpl.nasa.gov/dsn/
   Voyager and the Deep Space Network: http://science.nasa.gov/headlines/y2006/21sep_voyager.htm?list227097

3. For a history of the Robotic Exploration of space: http://solarsystem.nasa.gov/history/index.cfm. Select “History Timeline.”

4. Exploring Strange New Worlds is an adaptation of the classroom activity called Strange New Planet: http://solarsystem.nasa.gov/educ/docs/Strange_New_Planet.pdf
   Another game for exploring the topic of mission design and exploration can be found here: http://marsbound.asu.edu/



Detailed Activity Descriptions

1. Making your Strange New Worlds

Materials: Your choice. You may want to use the 6” dylite ball included in the ToolKit as a base. See below for suggestions.

Objective:

- Create a planet or set of planets to explore in the “Exploring Strange New Worlds” activity.

Making the Planet and Keeping it Hidden

For the activity, “Exploring Strange New Worlds,” you need to make a planet – or set of planets – ahead of time. Here is an opportunity for you and your fellow club members to get really creative.

If you are working regularly with a group, such as Scouts or a classroom, you can involve the group members in preparing planets to explore for the next time you meet.

Keep your completed planet(s) in a bag or covered with a towel to prevent your visitors from seeing them close up. Keeping the planets hidden until you start the activity is very important. You will be placing the planets quite some distance from your visitors so it will be difficult to discern detail from their home planet.

Displaying your Planets during the Activity

Remember to keep planets covered until the activity starts!
Here are a few options for displaying the planets:

- Set out chairs or small tables and place the planets on them.
- Insert a stick into each planet and:
  - pick a visitor to hold each one. This way, the visitors can rotate the planet.
  - OR push the other end of the stick into the ground (if the ground is soft enough)
  - OR push the other end into a lump of clay sitting on a table.

Suggestions for Constructing Planets

- **The planet should be** at least 5 inches in diameter and can be as large as 12" in diameter.
- **Include items of interest on the planet**: water, signs of life, sedimentary layers, signs of erosion. You might want to include a dinosaur, a building, or a coin.
- **Include an aroma:** Sprinkle with food flavoring such as mint, vanilla, or vinegar; imbed chunks of strong cheese; attach crushed bay leaves or other crushed, dried herb. Use sparing amounts of perfume or after-shave (some people have allergies to artificial scents).
- **Include areas where a sample** of the planet (either surface or atmosphere) could be pinched off – for sample return missions.

Ideas for the planet base:

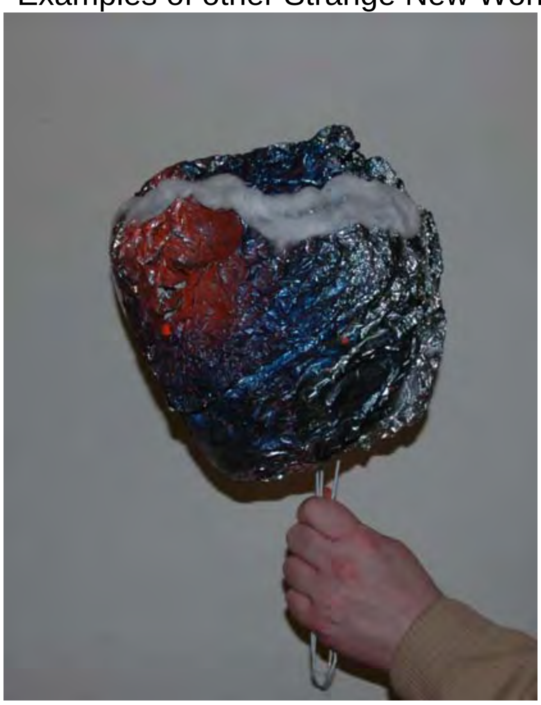
- Use the 6-inch dylite ball included in the ToolKit as a base for your planet
- Use an inflatable beach ball
- Use a roundish fruit, like cantaloupe, pumpkin, or large grapefruit.
- Use multi-colored clay or Play-Doh®
- Wadded-up newspaper core covered with crumpled and shaped aluminum foil (make mountains and plains), covered partially or fully with cotton batting.
- Mud ball planet: Freeze it
- If it is cold enough where you are, use a snowball as a base
- Use cotton batting or different colored felt and pull it apart to make a thick atmosphere – can wrap around a solid core or just leave it fluffy to make a gas giant. Carry in plastic bag and re-fluff when needed for use (see photos below).

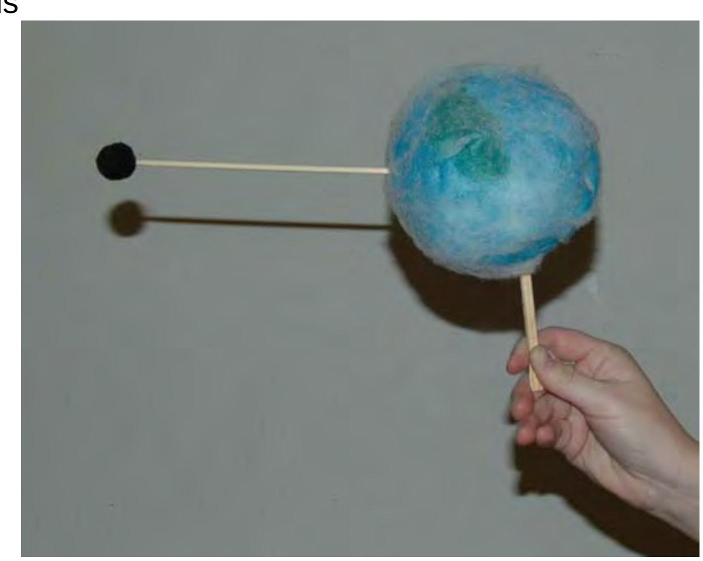
Other recipes:
http://www.quincypublicschools.com/schools/preschool/artrecipes_text.shtml

Ideas for decorating your planet:

- Use skewer sticks to attach “moons” to the planet.
- Make rings from Saturn’s rings (in the Activity “Solar System Models: Sizes & Distances”) printed on a transparency and laminated.
- Glue items to the surface: bark, moss, rocks, small plastic animals, sequins, marbles, seashells, anything small and interesting.
- Pull apart and attach cotton balls for clouds.
- Attach stickers and colored tape
- Attach or glue clay to it and imbed rubber bands (rivers), gravel, peppercorns, leaves.
- Paint it in a variety of colors.
- Spread glue on the surface and sprinkle on it sand, dirt, herbs, glitter, sawdust, or any other small grainy material.
- Carve canyons and river valleys.
- Drip colored candle wax on it – lakes or lava, depending on the color.
- Add an aroma (see above under “Suggested Rules”).

Examples of other Strange New Worlds





A wiffle ball covered with painted cotton batting. Includes a moon.

Constructed as wadded newspaper covered with aluminum foil and painted.
Pulled cotton balls for clouds.

2. Exploring Strange New Worlds

Leader's Role	Participants' Role (Anticipated)

Materials:
Pre-Made Planets (see previous section for suggestions on making planets)
Copies of "Communication and Exploration" handout with rules for the activity printed on the back.
The basic rules are available as a Word Document on the Manual & Resources CD so you can easily customize them. The file name is "StrNewWorldsRules.doc"
Optional: "I Explored Strange New Worlds" certificates, tweezers (for sample return missions).

Objective:

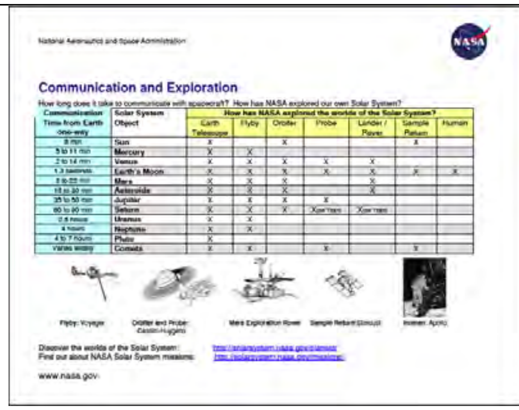
- This activity first introduces many of the ways to explore bodies in our Solar System.
- Then your visitors become scientists who use these techniques to explore some Strange New Worlds.

Set-Up:

To set this up, you'll want to place the planets (or the visitors holding the planets) at least 10 yards away from the rest of your audience so the audience cannot easily see detail on the planets. If you have more than one world, you can create a planetary system and place them at different distances.

If you have people holding the planets, rather than placing them on tables or chairs, for a little more reality, have each person slowly rotate their planet, say to a count of 20.

Depending on the size of the group and how much time you have, you can form teams or allow each visitor to explore the worlds on their own. In this case, teams are formed.

Leader's Role	Participants' Role (Anticipated)
To Do: Pass around the "Communication and Exploration" handout (shown at right) to your visitors and start by examining how we explore.  National Aeronautics and Space Administration **Communication and Exploration** How long does it take to communicate with spacecraft? How has NASA explored our own Solar System? *To Say:* Today you will become scientists exploring Strange New Worlds. (Point to the planets in the field) You will plan missions to explore these places. Take a look at this handout – what are some of the ways we can use spacecraft to explore our Solar System?	Fly-by! Orbiter!
To Do: Pick a visitor with a fuzzy hat or jacket and place the person about 10 feet from you and the audience. *To Say:* Let's quickly demonstrate each method. This will be your planetary scientist training session. Make yourself a viewer from your handout. *To Do:* Roll your handout into a tube. *To Say:* We'll use [visitor's name] and pretend she is a planet. First, we explore by viewing the planet from Earth through a telescope. Everyone view her. Then you send spacecraft to explore the planet.	Visitors roll up handouts. Visitors look through viewers.
To Do: Approach the planet visitor with your viewer and execute a fly-by. *To Say:* You can send **fly-by** missions, like the Voyager spacecraft– usually as part of a survey to fly by two or more planets to get a close, but quick look. *To Do:* With viewer to your eye, orbit the planet visitor. *To Say:* **Orbiters** like the Cassini mission at Saturn, get a more detailed, more thorough look at the planet – in some cases to determine where you might want to land your next mission.	

Communication Time from Earth one-way	Solar System Object	How has NASA explored the worlds of the Solar System? Earth Telescope	Flyby	Orbiter	Probe	Lander / Rover	Sample Return	Human
8 min	Sun	X		X			X	
5 to 11 min	Mercury	X	X					
2 to 14 min	Venus	X	X	X	X	X		
1.3 seconds	Earth's Moon	X	X	X	X	X	X	X
[illegible]	Mars	X	X	X		X		
[illegible]	Asteroids	X	X	X		X		
35 to 50 min	Jupiter	X	X	X	X			
[illegible]	Saturn	X	X	X	X[illegible]	X[illegible]		
2.5 hours	Uranus	X	X					
4 hours	Neptune	X	X					
4 to 7 hours	Pluto	X						
Varies widely	Comets	X	X		X		X	

Flyby: Voyager
Orbiter and Probe: Cassini-Huygens
Mars Exploration Rover
Sample Return Stardust
Human: Apollo

Discover the worlds of the Solar System: http://solarsystem.nasa.gov/planets/
Find out about NASA Solar System missions: http://solarsystem.nasa.gov/missions/

www.nasa.gov

Leader's Role	**Participants' Role (Anticipated)**
<u>*To Do:*</u> Use a finger and slowly descend to the top of the planet visitor's head or shoulder. <u>*To Say:*</u> **Probes**, like Huygens, which parachuted through the atmosphere of Saturn's moon, Titan, or Deep Impact which hit a comet, to analyze the material the object is made of. <u>*To Do:*</u> With the viewer to your eye, use your fingers to crawl over the planet visitor's head or shoulder. Keep your viewer focused on your fingers. <u>*To Say:*</u> **Landers and Rovers,** like those on Mars, explore a small area to collect and analyze surface material and get images from the surface. These can only explore a limited area of a planet so you must keep your landing site in your viewer at all times. This is the limit of your Rovers' range.	
And there are **sample returns**, like Stardust which collected material from a comet and returned it to Earth for analysis. <u>*To Do:*</u> Pull a piece of fuzz off a fuzzy sweater or hat and carry it back to the audience.	

Leader's Role	**Participants' Role (Anticipated)**
To Say: Now that you've been trained as planetary scientists, imagine we are scientists living on a planet orbiting a distant star. Like Earth's Sun, our parent star has other planets around it. But we haven't explored them yet. *To Do:* Open your handout and point to each method. *To Say:* Your job as scientists is to decide which of these methods you want to use to explore the planets in our system. You can have fly-bys, orbiters, probes, landers / rovers, and sample returns. You have a budget for three spacecraft missions, and your objective is to discover enough about these worlds to make a case for more missions. [or whatever objective you want to assign] Before we start the missions, use your telescopes and look out there from our home planet. Tell me what you notice about the planets. Can you tell how they are different?	Visitors view planets. Variety of comments regarding color, texture, moons
To Say: When you send spacecraft, what will you find on the planet? Water? Signs of life? Is it just gas or does it have a surface? We'll form two teams. *To Do:* Split the group into two or more teams. *To Say:* When you're done with your missions, your team will want to give reasons why more exploration should be done. Let's take a look at the rules on the back of your sheet.	

Leader's Role	**Participants' Role (Anticipated)**
<u>To Do:</u> Read the first rule, then choose different visitors to read each of the rest. <u>Basic Rules for the Activity:</u> (See *Variations and additional rules* on page 25) 1. Everyone on the team is a scientist, but one person at a time is assigned as a spacecraft. Scientists can take turns being the spacecraft. 2. Each team decides what type of missions to send and what they want their mission to accomplish. 3. Each team decides which planet or planets the spacecraft is to explore. More than one team can explore the same planet. 4. Your team's budget allows for three missions. 5. When the spacecraft's mission is done, you change to become a radio message that returns to Mission Control to tell the scientists what the spacecraft found. 6. The spacecraft must use its viewer during every mission as it approaches and as it examines the planet. 7. Only the spacecraft goes to the planet. The scientists remain at Mission Control.	
<u>To Say:</u> OK – time to plan your first mission. Choose who on your team will become the first spacecraft. You have 30 minutes to complete all your missions. Your time starts now. *<u>To Do:</u>* Continue with words of encouragement. When the time limit is reached, call a halt to the activity. *<u>To Say:</u>* Time's up! Now it's time for each team to report what was discovered and what future missions would you like to send. What further information would you want the next mission to get? *<u>To Say:</u>* Well, I think you all deserve funding for further exploration. Give yourselves a hand.	Teams plan and run their missions. Teams report. Visitors applaud.

Leader's Role	Participants' Role (Anticipated)
Presentation Tip: You can hand out small prizes or certificates "I explored a Strange New World" at the end. A template for a certificate is in the next section on pages 29 and 30. You may want to put your club information on the back. The template on page 30 allows you to enter your club name and up to three lines of information right on the front of the certificate, print it, then make copies. See instructions on the template. You can add variations to this activity, as suggested below. Depending on your audience and location, you may want to plan to keep the rules as simple as possible.	

<u>Variations and additional rules you may want to choose from:</u>

a. Assign a dollar value to each type of mission and give each team a dollar budget instead of a number-of-missions budget.
b. Add a rule that teams are allowed to collaborate. Teams could belong to different countries.
c. Place a time limit on completing their missions (e.g. “You have 20 years/months to complete your missions. But on our planet, a year/month is only 1 minute long.”)
d. Each planet could be given an in-transit time – the more distant planets take more time to reach, so you might use up your time budget before you’ve completed even one mission.
e. The spacecraft must walk at a certain rate, e.g. heel-to-toe to simulate the time to get to the planet. The radio message can travel much faster – the person can run back to Home Planet.
f. If a number of your visitors have cell phones with cameras, the spacecraft could be allowed to take pictures of the planets and either send or bring them back to the science team for review.
g. Have precedence rules, for example:
    - You can only send an orbiter after you’ve sent a fly-by to determine which of the planets warrants a more detailed mission.
    - You can only send a lander after you’ve send an orbiter to determine an appropriate landing site.
    - You can only send a sample return after you’ve run a mission to determine where to take the sample from.
h. For sample returns: Use tweezers
i. For probes: Allow visitors to use a skewer stick or pen to impact the surface of the planet.
j. If the science team decides to send a lander or rover, the craft can only explore within a defined range around its landing site.
k. Provide notepads to take notes and plan strategy.
l. Other objectives for the teams:
    - Find signs of life and win the Nobel Prize
    - Provide evidence that a planet has water on it (or not)
    - Give a report of what your planet is made of – how is the planet different from other worlds in this system?
    - Provide evidence that we might be able to live there (or not!).

Materials

<u>What materials from the ToolKit do I need?</u>

In the “Media & Resources” bag:

1. Copies of “Communication and Exploration” handout
2. Suggested rules for the activity (print these on the back of the handout)
3. Sticks to mount planets
4. A 6” ball to use as a base to make a planet (loose in the ToolKit box)

<u>What must I supply?</u>

- All other materials for the Strange New World(s) you want to build
- *Optional*: tweezers for sample return missions

<u>What do I need to prepare?</u>

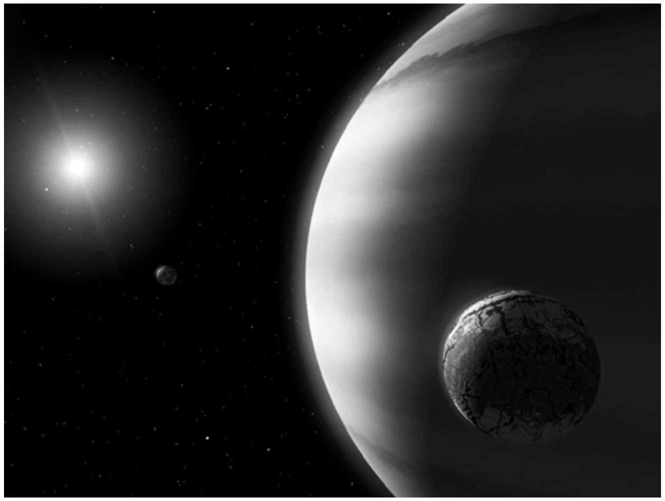
You and your club members can make a whole system of planets. For suggestions, look under “Detailed Activity Descriptions,” 1. Making your Strange New Worlds.

<u>Where do I get additional materials?</u>

1. Copies of “Communication and Exploration” handout: See next section for the master on page 28. This is also provided on the Manual & Resources CD as a Word Document, named “SolSysCommExploreHO.doc,” so you can update the chart as future missions explore more of the Solar System.
2. Suggested rules for the activity: The master is on page 27. This is also available as a Word Document on the Manual & Resources CD so you can easily customize it. The file name is “StrNewWorldsRules.doc.”
3. Sticks to mount planets: chopsticks are included in the ToolKit. Grocery or Asian stores.
4. Dylite (or polystyrene) ball: search the Internet for “dylite balls.” The ball provided with the ToolKit is 6 inches in diameter.

Exploring Strange New Worlds

1. Everyone on the team is a scientist, but one person at a time is assigned as a spacecraft. Scientists can take turns being the spacecraft.
2. Each team decides what type of missions to send and what they want their mission to accomplish.
3. Each team decides which planet or planets the spacecraft is to explore. More than one team can explore the same planet.
4. Your team's budget allows for three missions.
5. When the spacecraft's mission is done, you change to become a radio message that returns to Mission Control to tell the scientists what the spacecraft found.
6. The spacecraft must use its viewer during every mission as it approaches and as it examines the planet.
7. Only the spacecraft goes to the planet. The scientists remain at Mission Control.



Discover the worlds of the Solar System: http://solarsystem.nasa.gov/planets/

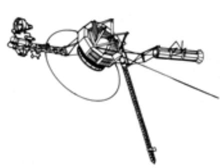
Find out about NASA Solar System missions: http://solarsystem.nasa.gov/missions/

www.nasa.gov

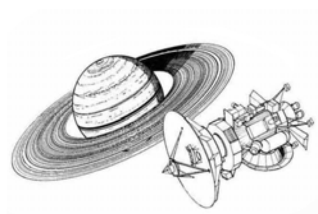
Communication and Exploration

How long does it take to communicate with spacecraft? How has NASA explored our own Solar System?

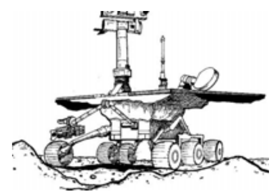
Communication Time from Earth one-way	Solar System Object	How has NASA explored the worlds of the Solar System?						
		Earth Telescope	Flyby	Orbiter	Probe	Lander / Rover	Sample Return	Human
8 min	**Sun**	X		X			X	
5 to 11 min	**Mercury**	X	X					
2 to 14 min	**Venus**	X	X	X	X	X		
1.3 seconds	**Earth's Moon**	X	X	X	X	X	X	X
3 to 22 min	**Mars**	X	X	X		X		
15 to 30 min	**Asteroids**	X	X	X		X		
35 to 50 min	**Jupiter**	X	X	X	X			
60 to 90 min	**Saturn**	X	X	X	X(on Titan)	X(on Titan)		
2.5 hours	**Uranus**	X	X					
4 hours	**Neptune**	X	X					
4 to 7 hours	**Pluto**	X						
Varies widely	**Comets**	X	X		X		X	



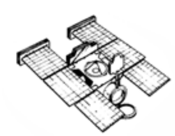
Flyby: Voyager



Orbiter and Probe: Cassini-Huygens



Mars Exploration Rover

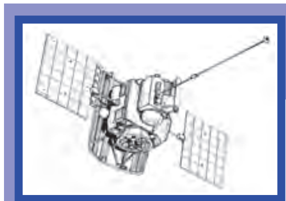


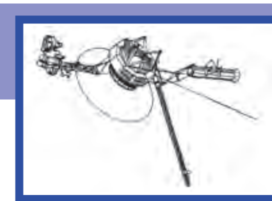
Sample Return: Stardust

Human: Apollo

Discover the worlds of the Solar System: http://solarsystem.nasa.gov/planets/
Find out about NASA Solar System missions: http://solarsystem.nasa.gov/missions/

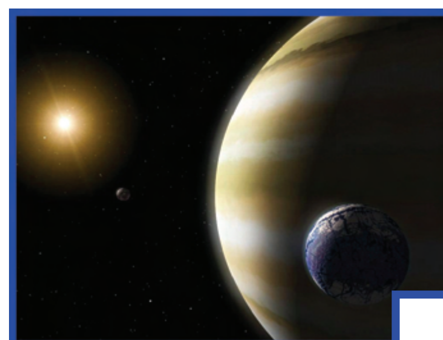
National Aeronautics and Space Administration

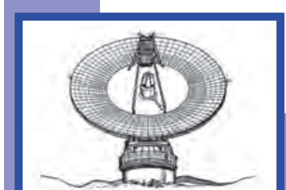


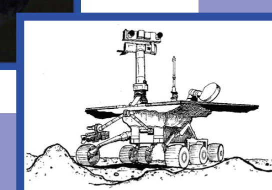


I explored Strange New Worlds

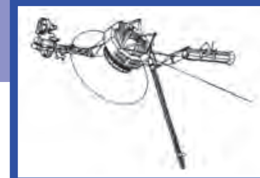
This club is a member of the
NASA Night Sky Network
http://nightsky.jpl.nasa.gov/







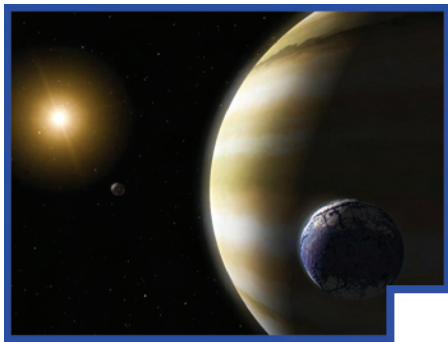
National Aeronautics and Space Administration

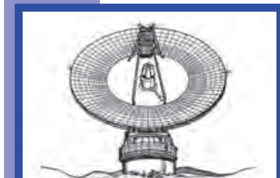


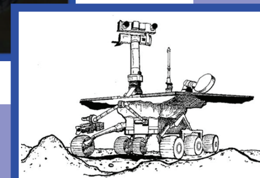
I explored Strange New Worlds

Click here and enter Club Name and up to 3 lines of information; Print and make copies.

This club is a member of the NASA Night Sky Network http://nightsky.jpl.nasa.gov/

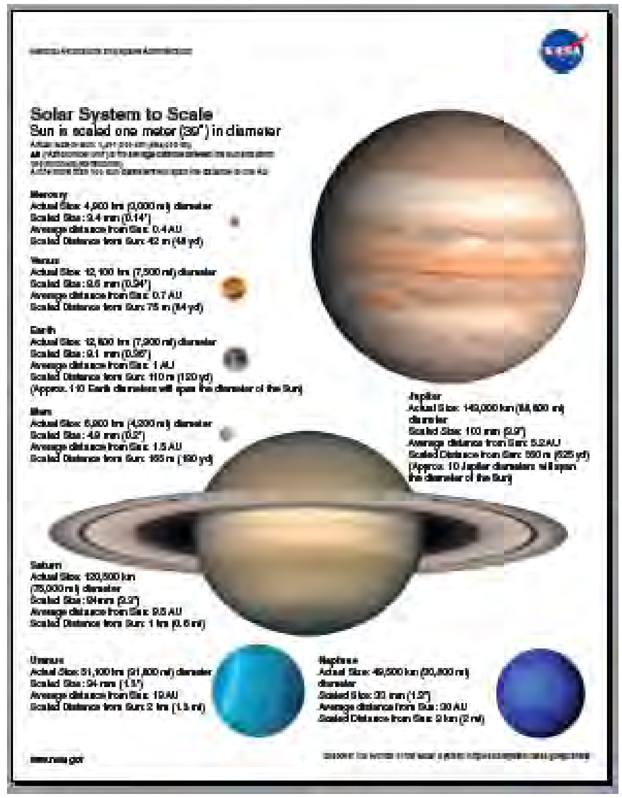






Solar System Models: Sizes & Distances

What's this activity about?



Big Question:

How big are the planets and what is the distance between them?
What are the main realms of the Solar System?

Big Activities:

"Pocket Solar System": Using a strip of paper, construct a quick scale model of the distances between the orbits of the planets, the Asteroid Belt, and Pluto as part of the Kuiper Belt.
"Worlds of the Solar System": Use a set of scaled balls and beads to show the relative sizes of the planets, the Moon, Ceres, and Pluto to each other and to the Sun. Handout included.

Participants:

From the club: A minimum of one person.

Visitors: Most activities are appropriate for families, the general public, and school groups in grade 2 and up. Any number of visitors may participate.

Duration:

A few minutes, up to a half hour, depending on the number of topics covered.

Topics Covered:

Scaled distances of orbits in the Solar System
Scaled sizes of the worlds of the Solar System
The realms of the Solar System:

- The Sun at the center
- The four rocky inner planets
- The four gas giant planets
- The Asteroid Belt that divides the rocky planets from the gas giants
- The Kuiper Belt of small icy bodies that surrounds it all.

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. Pocket Solar System	√	√	√	√	√	√	√	√	√	√
2. Scaled Worlds of the Solar System	√	√	√	√	√	√	√	√		√
3. "Solar System to Scale" Handout	√	√	√	√		√	√	√	√	

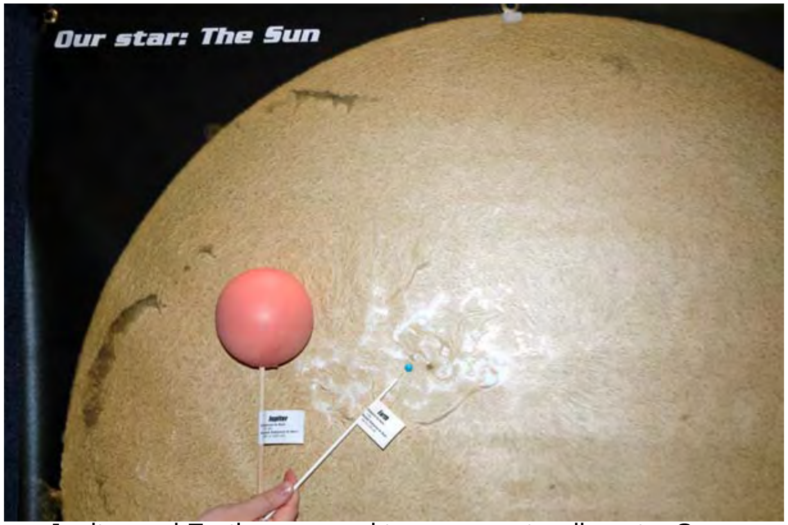
What do I need to do before I use this activity?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Assemble the models of the worlds of the Solar System. White glue, paper towel.	Extra pencils *Optional:* Local Map to show locations of planet orbits on the scale of a one meter Sun	Make needed copies of handouts

Helpful Hints

Discussion of Models and their Usefulness

These materials include models to demonstrate a variety of concepts. Models are useful, but their utility is always limited in some ways. It is often helpful to discuss the strengths and limitations of models with your visitors. For example, the four-inch ball in the ToolKit represents the size of Jupiter scaled to a one meter diameter Sun. What are some of its strengths as a model? How is it useful? Where does this NOT represent reality? What can't it be used for? These are questions you may want to include in your discussions with your visitors as they explore the Solar System with these materials.



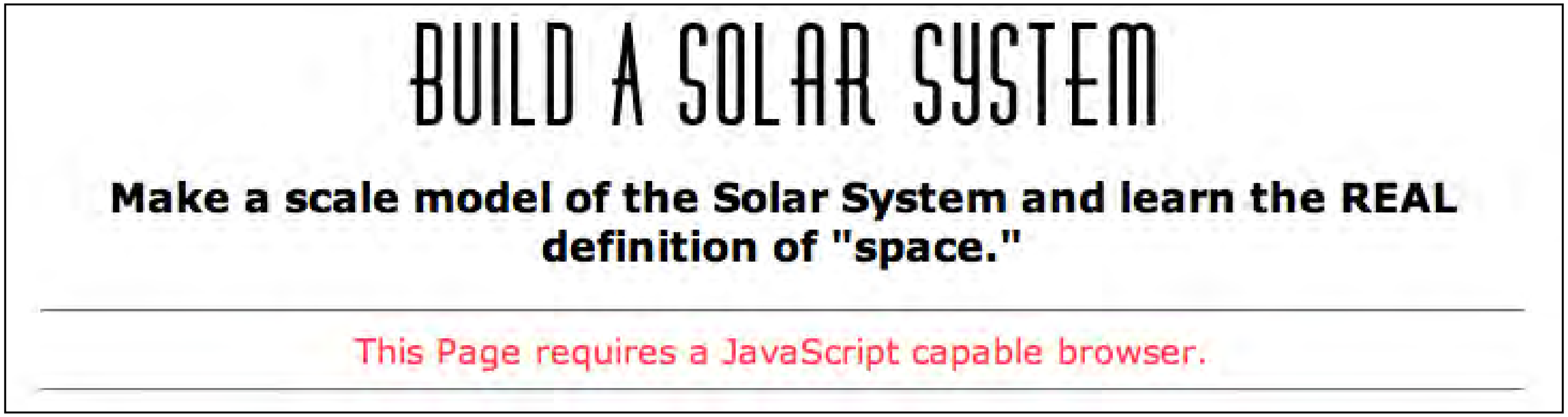
Jupiter and Earth compared to a one-meter diameter Sun.

Common Misconceptions:

- Planets are perceived to be much larger than they really are.
- The distances to the planets are perceived to be much smaller than they really are.
- The orbits of the planets are perceived to be evenly spaced between the Sun and Pluto.

Website:

A useful web site for **calculating scale models of the Solar System** is available from the Exploratorium: http://www.exploratorium.edu/ronh/solar_system/



Background Information

Website:
For additional information on the worlds of the Solar System, use NASA's Solar System Exploration website: http://solarsystem.nasa.gov/planets/index.cfm. On the chart below, the diameter of the planets is rounded to the nearest 100 km.

Scaled Worlds of the Solar System object sizes and distances (for beads and balls)

Solar System Body	**Diameter Sun = 1,391,000 km**	**Scaled Size where Sun = 1 meter (39")**	**AU distance (avg)** 1 AU = Earth to Sun Distance or 150 million km	Scaled Distance (approx) where Sun = 1 meter diameter	MAKE YOUR OWN SCALE: 1 AU = _____ METERS **Multiply by number of meters (or yards) in one AU.** **Example:** 1 AU = 4 meters For Mercury: 0.4 AU x 4 meters = 1.6 meters For Jupiter: 5 AU x 4 meters = 20 meters
Mercury	4,900 km	3.4mm(0.14")	0.4 AU	42 m / 48 yd	0.4 x ____ meters= _____ meters
Venus	12,100 km	8.6mm(0.34")	0.7 AU	75 m / 84 yd	0.7 x ____ meters= _____ meters
Earth Moon	12,800 km 3,500 km	9.1mm(0.36") 2.5mm(0.1")	1 AU	110 m / 120 yd (28 cm from Earth)	1 x ____ meters= _____ meters
Mars	6,800 km	4.8mm(0.2")	1.5 AU	165 m / 180 yd	1.5 x ____ meters= _____ meters
Asteroid Belt (Ceres)	960 km	0.8mm(0.03")	3 AU (approx) (3.2-1.8 A.U.) Ceres avg: 2.6 AU	285 m / 310 yd (asteroids are ~1 m apart)	3 x ____ meters= _____ meters
Jupiter	143,000 km	100mm(3.9")	5.2 AU	560 m / 625 yd	5 x ____ meters= _____ meters
Saturn	120,500 km	84mm(3.3")	9.5 AU	1 km / 0.6 mi	10 x ____ meters= _____ meters
Uranus	51,100 km	34mm(1.3")	19 AU	2 km / 1.3 mi	20 x ____ meters= _____ meters
Neptune	49,500 km	33mm(1.3")	30 AU	3 km / 2 mi	30 x ____ meters= _____ meters
Pluto (within Kuiper Belt)	2,400 km	1.6mm(0.06")	40 AU (average)	4 km / 2.6 mi	40 x ____ meters= _____ meters
Nearest Star: Alpha Centauri			290,000 AU	29,000 km (18,000 mi)	290 x ____ meters = ____ km

Pocket Solar System and Bode's "Law"

The progression followed for the positions of the orbits for the planets of our Solar System, as illustrated by the Pocket Solar System activity, is really just an interesting coincidence.

Bode's Law, also known as the Titius-Bode Law, was developed in the 1700's before the discovery of Uranus, Neptune, Pluto, or the Asteroid Belt. This "Law" is a mathematical way to describe the approximate spacing of the planets from the Sun. It is not a scientific law and does not work for all the planets of the Solar System, Neptune being a notable exception. It also does not appear to work for planetary configurations around other stars.

For more information on this "Law," try one of these websites:
http://en.wikipedia.org/wiki/Titius-Bode_law
http://milan.milanovic.org/math/english/titius/titius.html

Detailed Activity Descriptions

1. Pocket Solar System

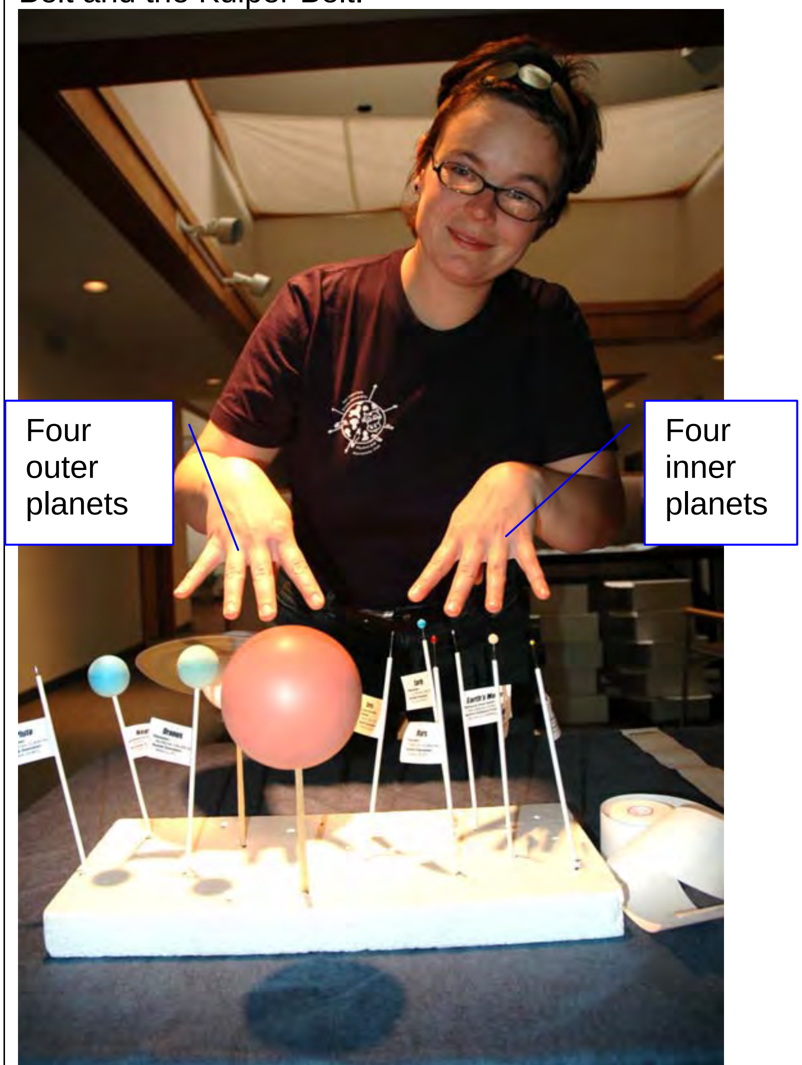
The order of the worlds of the Solar System going out from the Sun and their average distances are:

Object	Avg Distance in kilometers	Avg Distance in miles	Avg Distance in AU①
Mercury	58 million	36 million	0.4
Venus	108 million	67 million	0.7
Earth	150 million	93 million	1
Mars	228 million	142 million	1.5
Ceres ② (representing the Asteroid Belt)	414 million	257 million	2.6
Jupiter	778 million	484 million	5.2
Saturn	1,427 million	887 million	9.5
Uranus	2,870 million	1,784 million	19
Neptune	4,498 million	2,795 million	30
Pluto ② (representing the Kuiper Belt)	5,906 million	3,670 million	40 (range is 30 – 50 AUs)

①AU stands for "astronomical unit"and is defined as the average distance between the Sun and the Earth (about 93 million miles or 150 million kilometers).

②The International Astronomical Union (IAU), the organization in charge of naming celestial objects, classified these objects as "dwarf planets" in 2006.

Leader's Role	Participants' Role (Anticipated)
Materials: Roll(s) of register tape; Pencils *Optional*: Litho showing all the planets; "Solar System to scale" handout, set of 3-D planet models *Optional (you supply)*: Scissors	
Objective: Building scale models of the Solar System is a challenge because of the vast distances and huge size differences involved. This is a simple little model to give you an overview of the *distances* between the orbits of the planets and other objects in our Solar System. • Provide a quick, easy-to-make and remember scale of the approx distances of the planet's orbits and orbital distance of other realms (asteroids, Kuiper Belt) from the Sun. • Introduce basic "realms" of the Solar System: the Sun at the center, the four inner terrestrial planets separated from the four outer gas giants by the asteroid belt, and all of it surrounded by Kuiper Belt. • Can be referred to and used in other activities.	

Leader's Role	**Participants' Role (Anticipated)**
To say: Let's make a Solar System you can keep in your pocket! *To do:* First, establish with your audience the order of the planets. This provides a baseline to work from. List them on a sheet of paper, use the "Solar System to Scale" handout, the lithographs, or the 3-D models of the planets. Be sure to include the Asteroid Belt and the Kuiper Belt.  Pointing to the four inner rocky planets and the four outer gas giant planets.	 Yeah!

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td><u>To say:</u>
Pull off a strip of register tape about the length of the height of your body – that’s about fingertip to fingertip.

We’re going to make a model that shows the average distances of various orbits from the Sun.

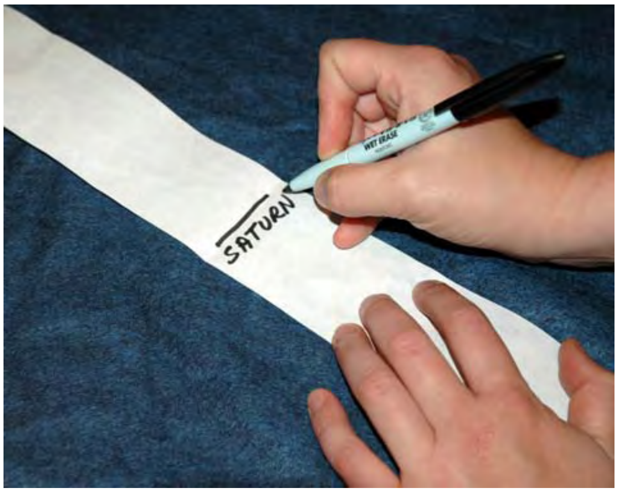
Fold over (or cut) the ends so they are straight. Label one end “Sun“ and the other end “Pluto/Kuiper Belt.” That will be our baseline – the average distance between the Sun and Pluto’s orbit.

Next, fold the tape in half, crease it, open it up again and place a mark at the half-way point. Let’s look at the list of planets in the Solar System. Which planet’s orbit do you suppose is half-way between the Sun and the average distance of Pluto’s orbit?

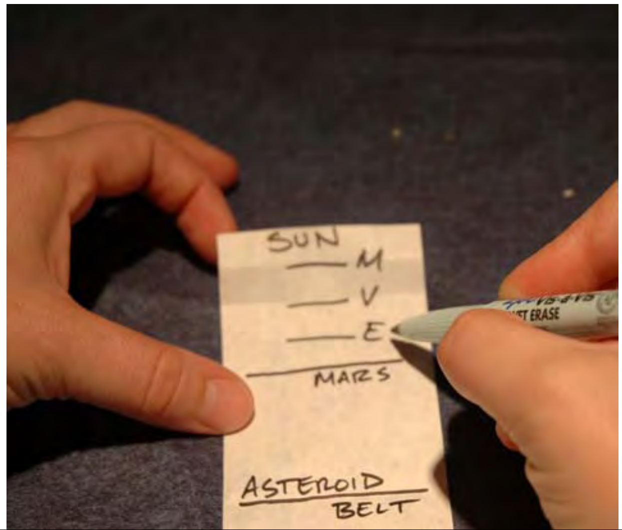
Let me give you a hint.</td><td>Follows directions.

Jupiter!
Saturn!</td></tr>
<tr><td colspan="2">Presentation Tip:
You’ll need to be careful about using this hint. It depends on your audience. Some people may be offended. It is quite popular with children, however.
Alternatively, just have them guess from the list of planets.
“Uranus” is often incorrectly pronounced as “yur-AY-nus.”
Correct pronunciation is “YUR-uh-nus.”
For more information: http://www.nineplanets.org/uranus.html</td></tr>
<tr><td><u>To do:</u>
Turn around so your back is to the audience. Hold the Pluto end of the tape at your head so the tape falls down your back to the floor.
<u>To say:</u>
If you hold the Pluto end at your head and the Sun at your feet, what body part is halfway between?
Right.
Bet you’ll never again forget which planet is halfway between the Sun and the average distance of Pluto.</td><td>

Uranus!</td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
To say: Draw a line on the fold and write "Uranus." Re-fold the tape in half, then in half again so you have quarters. Then unfold it. Now you have the tape divided into quarters with the Sun at one end, Pluto's orbit on the other, and Uranus' orbit in the middle. Label the fold closer to Pluto as "Neptune" and the fold closer to the Sun as – OK everyone guess. Saturn – draw a line and write Saturn on that orbit.  Here's an easy way to remember the order of the orbits of these three planets. There's a Sun at the center of the Solar System. *To do:* Point to the Sun end of the tape. *To Say:* And there's a "SUN" in the outer planets: (S)aturn (U)ranus (N)eptune S-U-N!	Jupiter? Mars?

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td colspan="2">Presentation Tip:
Encourage your visitors to draw a line along the fold marking the orbit and write the name of the planet along that line.   This will help keep the writing small enough so the names are less likely to overlap orbits for other planets, especially for the inner planets.

An alternative, to speed things up when visitors may not know how to spell all the names of the planets, is to just have them write the initial letter of the planet on each orbit line.

</td></tr>
<tr><td><u>To Say:</u>

You've mapped out 3/4 of the Solar System and you still don't have all the gas giants. Which gas giant is missing?</td><td>Jupiter!</td></tr>
<tr><td>So we have to fit everything else in that last quarter between the Sun and Saturn! Let's keep going.</td><td></td></tr>
<tr><td>Place the Sun end of the tape at Saturn's orbit and crease the tape at the fold. What's the next planet in?
Label that fold.</td><td>Jupiter.</td></tr>
<tr><td>Fold the Sun out to meet Jupiter's orbit. This is a little tricky. What structure is inside Jupiter's orbit?</td><td>Asteroids?</td></tr>
<tr><td>Right, the Asteroid Belt. Label that.</td><td></td></tr>
<tr><td>How many more planets do we need to mark?</td><td>Four!</td></tr>
<tr><td>At this point, things start getting a little crowded and folding is tough to get precise distances. Fold the Sun to the Asteroid Belt mark and crease it. Next planet in?</td><td>Mars!</td></tr>
<tr><td>Right – Mars. Label that.</td><td></td></tr>
</table>

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>How many more planet orbits do we need to place?

Yes, three.

Fold the Sun up to meet the orbit of Mars.
Leave it folded and fold that section in half again.
(See the “Schematic of the Pocket Solar System” on the next page)

Unfold the tape and you should have three creases. Mark Earth on the crease nearest Mars, then Venus, then Mercury closest to the Sun.

Stretch out your model and take a good look at what you’ve made. What surprises did you have?

Now, just roll it up and put it in your pocket – the Pocket Solar System.</td><td>Three – Earth. Venus, and Mercury.

Variety of comments.</td></tr>
<tr><td colspan="2">Misconception Tip:
Many people are unaware of how empty the outer Solar System is (there is a reason they call it space!) and how close, relatively speaking, the orbits of the inner Solar System are.</td></tr>
</table>

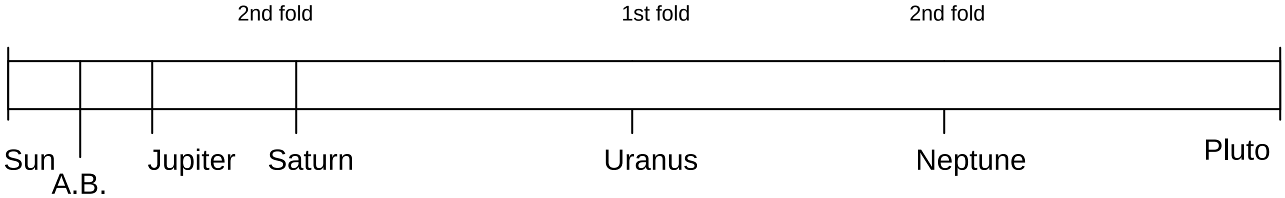
Here are some questions to consider while discussing your Pocket Solar System:

1. If your model is 1.5 meter long (about 5 feet), where would the nearest star be? (1.5m = 40 AUs, Proxima Centauri is 4.3 light years from the Sun, and 1 light year = 63,250 AUs)
2. How big would the Sun and planets be if your model were one and a half meters long?

Answers:

1. The nearest star would be about 10 kilometers or about 6 miles away.
2. The Sun would be smaller than a grain of sand – about the size of the period at the end of this sentence. You couldn’t see any of the planets without a strong magnifying glass on this scale!

Schematic of the Pocket Solar System:

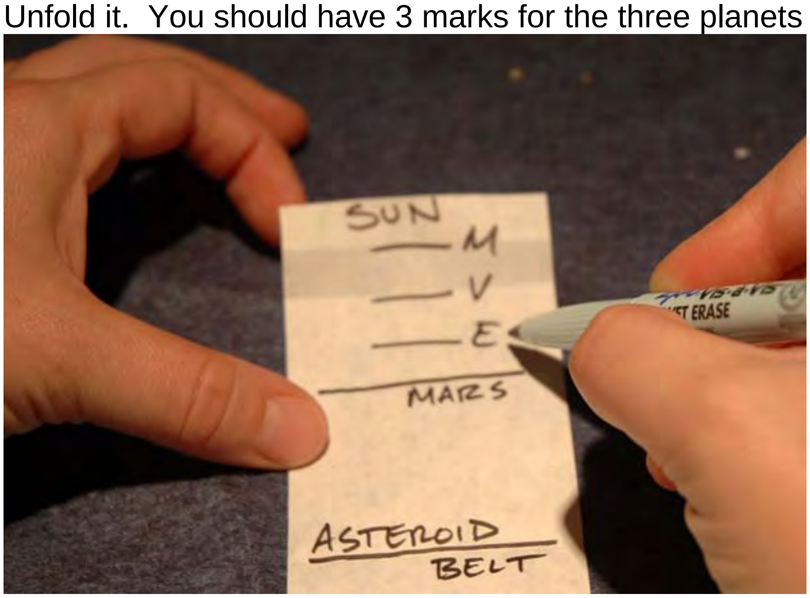


Fold Sun to Asteroid Belt, (“A.B.”) mark “Mars” on fold.

Fold Sun to Mars and leave it folded.

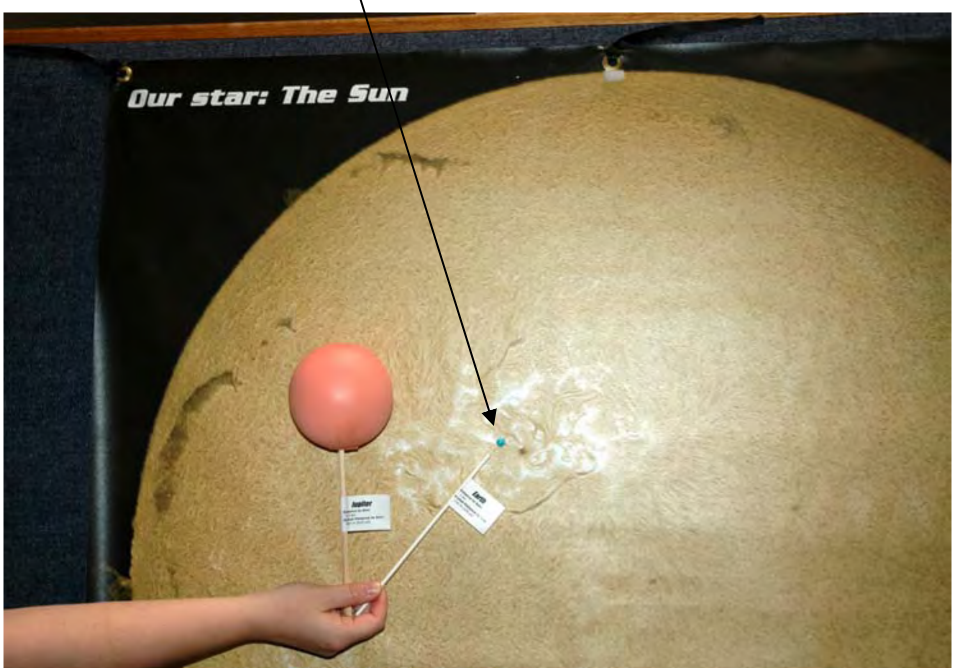
Then fold that section in half again.

Unfold it. You should have 3 marks for the three planets closest to the Sun.



2. *Worlds of the Solar System: Comparing Sizes & Distances*

Leader's Role	**Participants' Role (Anticipated)**
Materials: Assembled Worlds of the Solar System scale model "Our star: The Sun" banner (on opposite side of "Exploring Our Solar System" Banner) "Solar System to Scale" handouts Solar Viewer *Optional (you supply)*: Local Map marked with a few distances of planet orbits on the scale of the scale model: It can be helpful to make a small Pocket Solar System on the same scale as the map (2-1/2 miles or 4 km on the map = the length of the Pocket Solar System). See table under "Background Information"	
Objective: • Comparing scaled sizes of the planets and other objects in the Solar System to each other and to the of Sun. • Introduce scaled distances with scaled sizes and why it is difficult to make a scale model with both.	
Presentation Tip: Many people have the idea that the planets are not very different in size.	

Leader's Role	**Participants' Role (Anticipated)**
To Do: Hold up the 4" Jupiter ball. *To Say:* How big do you think the Sun would be if this was the size of Jupiter, the largest planet? Show me with your hands.	Visitors hold hands out.
To Do: Put up the Sun banner or have two visitors hold it up. Pass out the planets to your visitors and have them hold the planets next to the Sun and the planets to each other to get a sense of the size relationships. *To Say:* Compare the sizes of the planets to the Sun – and to each other. What do you notice? Any surprises?	Variety of comments.
How does the size of Earth compare to a sunspot?  Notice that if we made the Sun much smaller than one meter, Ceres, the largest asteroid, would be too small to see!	Wow – it would fit inside!

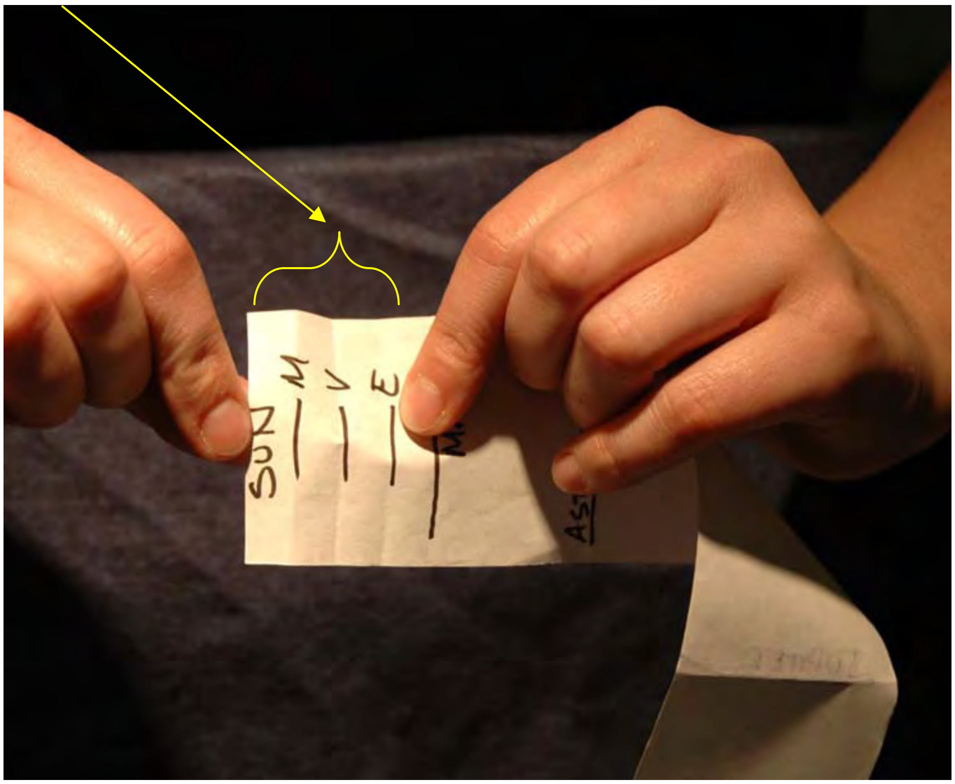
Leader's Role	**Participants' Role (Anticipated)**
<u>To Do:</u> Refer to the visitor who has Earth. *<u>To Say:</u>* Show me how far away you think the Earth should be on this scale. Hold out your hand at arm's length and close one eye. How many fingers does it take to cover the Sun on the banner?	Visitor holding Earth moves the planet a few feet away. My whole hand.
<u>To Say:</u> From here on Earth, the real Sun looks a lot smaller than that in our sky. Don't look directly at the Sun. *<u>To Do:</u>* Hand the visitor a solar Viewer. *<u>To Say:</u>* Here's a viewer to allow you to safely observe the Sun. Close one eye and hold this at arm's length toward the Sun. With your other hand, use your fingers to measure the size of the Sun. Which is the smallest finger you can use to cover it?	It's smaller than my pinkie finger!
<u>To Say:</u> Right! You need to move Earth far enough away so that *<u>this</u>* Sun (indicating the banner) looks smaller than the tip of your pinkie finger. Let me give you another hint. There are about 100 Sun diameters between Earth and the Sun. So we'd need to fit 100 one-meter Suns between you and this Sun. A meter is a little more than one yard. What can you think of that is 100 yards long? Yes – we'll have to move you at least 100 yards away from this Sun. When you get to the right distance, you should be able to cover the Sun on the banner with your pinkie.	A football field? Visitor holding Earth starts walking away.
<u>To Do:</u> Send Venus out about 2/3 of the distance the Earth is and Mercury about 1/3 the distance. Ask the people holding Venus and Mercury how many fingers it takes to cover the Sun from where they are. Then bring everyone back.	Venus and Mercury walk to their positions and measure the size of the Sun on the banner.

Leader's Role	**Participants' Role (Anticipated)**
To Do: If you have a local map marked with distances, show where the planets on this scale would be. If you made a Pocket Solar System on the scale of the map, have your visitors hold the map with the Pocket Solar System against it. *To Say:* Earth's distance from the one meter Sun is about the length of a football field. We only went out to the distance of Earth's orbit. Pluto's average orbit is two and a half miles away on this same scale. Who wants to take Pluto and walk there? This illustrates why it is difficult to make a scale model of the Solar System scaled to both size AND distance!	 Laughs.

3. Worlds of the Solar System: Relationships

Leader's Role	**Participants' Role (Anticipated)**
Materials: *Handouts:* Solar System to Scale 1 meter Sun on banner Vinyl strip of Jupiters Pocket Solar System	
Objective: • Help visitors remember a few sizes of the planets.	
<u>*To Do:*</u> Pass out "Solar System to Scale" handouts. Hold up strip of Jupiters, showing the Jupiter with the Earths across it. <u>*To Say:*</u> Note that it takes roughly 10 Earths to span the diameter of Jupiter. <u>*To Do*</u>: Attach the strip of Jupiters to the top of the Sun banner (using the Velcro). Or have a visitor hold the strip.  <u>*To Say:*</u> And how many Jupiters to span the diameter of the Sun? Let's count them.	Visitors count. "10 Jupiters."
Presentation Tip: There are closer to 11 Earths to span Jupiter, but 10 Earths and 10 Jupiters is easier to remember!	

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td><u>To Say:</u>
Yes, 10. So, it takes about 100 Earths to span the diameter of the Sun (10 Earths x 10 Jupiters).

And the distance between the Sun and Earth? About 100 Sun diameters.</td><td></td></tr>
<tr><td><u>To Do</u>:
Show a Pocket Solar System
<u>To Say:</u>
So, if we look at the Pocket Solar System, the distance from Sun to Earth is 100 Sun diameters.


How big would the Sun be on the scale of the Pocket Solar System?</td><td>Just a little dot!</td></tr>
</table>

4. Worlds of the Solar System: Building a Scale Model

Leader's Role

Materials:
Scale model of the Worlds of the Solar System
1 meter Sun on banner

Objective:
Involve visitors in pacing off the distance to planet orbits.

To Do:
A useful web site for **calculating scale models of the Solar System** is available from the Exploratorium:
http://www.exploratorium.edu/ronh/solar_system/

Use the scaled Worlds of the Solar System as props as you pace out the distances to the orbits of planets.
To make your model more realistic, use the actual locations of the planets around the Sun, which can be found here:
http://www.fourmilab.ch/cgi-bin/uncgi/Solar
Just print out the map and send people off in the appropriate directions.

An easy way to estimate distances is to remember the **Pocket Solar System** and these relationships:
The distance from the Sun to Earth is roughly 100 Sun diameters (1 AU). "AU" stands for "astronomical unit" and is defined as the average distance between the Sun and the Earth.
Saturn is about 10 times the distance from the Sun to Earth (approx 10 AU).
From the **Pocket Solar System**, you remember that Saturn's orbit is 1/4 of the distance between the Sun and the average distance of Pluto.

Kids in Maryland walk the scaled distance from the Sun to Earth. (Courtesy of W. Bird)

Materials

<u>What materials from the ToolKit do I need?</u>

In the activity bag (or in the box):

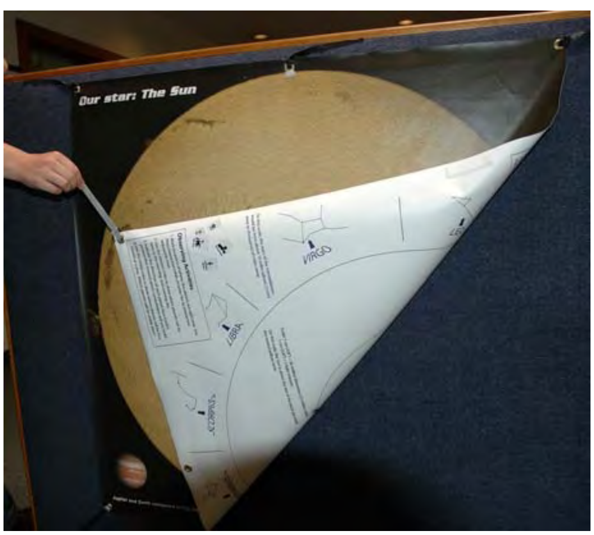
1. 1 – sheet of polystyrene (8” x18”x1.5”)
2. 1 – 4” Dylite ball – Jupiter
3. 2 half balls: 3-1/4” Dylite ball – Saturn
4. Saturn’s Rings
5. 2 – 1-3/8” Dylite balls – Uranus and Neptune
6. Rolls of register tape
7. Handouts with scaled sizes of planets “Solar System to Scale”
8. 3 – Jupiter balloons (large)
9. 2 – Uranus balloons (teal)
10. 2 – Neptune balloons (blue)
11. 1 – Sheet of Labels for all planets: includes actual & scaled diameters for 1 meter Sun, & actual and scaled distances
12. 2 – Solar Viewers
13. 1 – Vinyl strip with ten Jupiter images

Assembled into a small bag:

14. 1 - Sheet of sandpaper
15. Golf pencils

Assembled into a padded bag labeled “Solar System Assembly Pack”:

16. Straight pins
17. Silver 2.4mm beads for Moon
18. Blue 9mm bead - Earth
19. White 8.5mm bead - Venus
20. Yellow-headed pins 3.5mm - Mercury
21. Red 5mm bead – Mars
22. Silver bead-end pins 2mm – Pluto
23. Copper 0.8mm balls for Ceres (the largest asteroid)
24. White sticks
25. Super glue

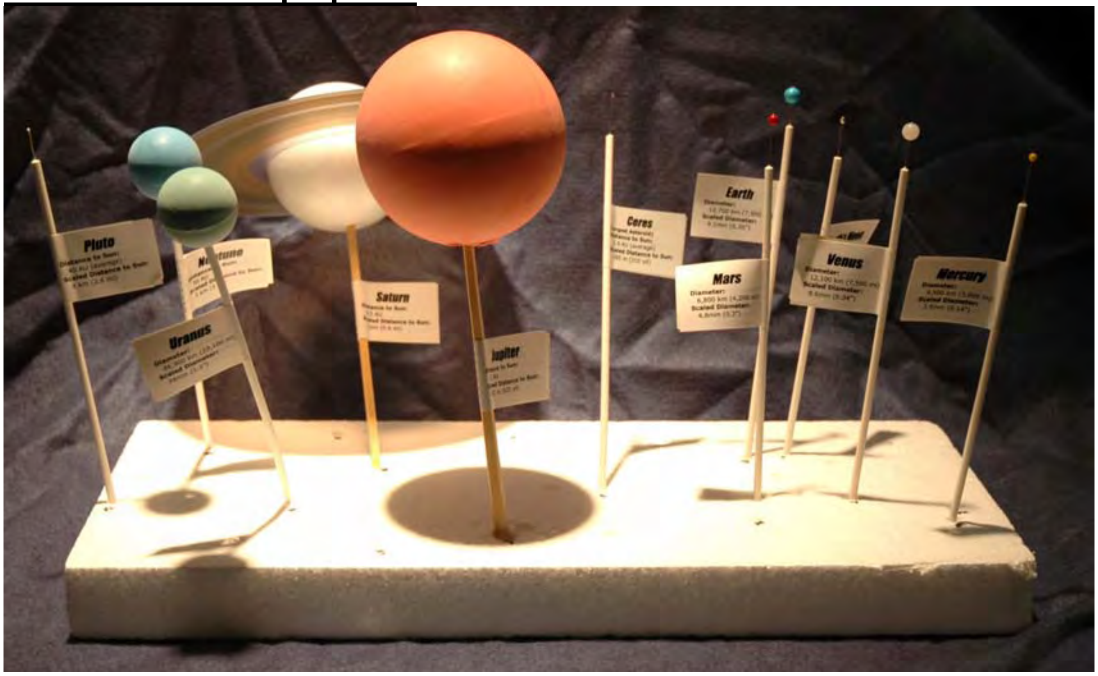


The Banner that includes the Sun image on one side and the diagram of the Solar System on the other side was shipped in a separate tube.

<u>What must I supply?</u>

- White glue

What do I need to prepare?



Assemble Worlds of the Solar System as follows:

Gas giants:

You can sand the Dylite balls smooth to get rid of ridges and surface features.

Jupiter:

Use the 4” Dylite ball.
If you want to give it some color, blow up one of the large balloons, no larger than about 8” to 10” or you may weaken it. Then let the air out.

Leaving about 3/4” of the neck, cut off the rest of the neck of the balloon. Stretch the balloon over the ball. You may need someone to help with this. See the training video for a suggested method. More than one balloon has been included in case of damage.

Use the super glue to glue the hole closed and hold it with a rubber band until it dries (see photo at left). It will dry in less than a minute.

Insert one of the chopsticks.

Alternatively, if you've aligned the hole in the balloon with the hole in the ball, you can place the end of the chopstick about 1/4" into the hole (Photo A), catch the open end of the balloon around the chopstick (Photo B), twist it, then push it into the hole (Photo C).


Photo A


Photo B


Photo C

Uranus (teal ballon) and Neptune (blue balloon): 1-3/8" Dylite balls

Blow up each balloon slightly (to about 4" to 6"). Let the air out. Cut the neck off each balloon, leaving a short tail, and stretch each over one of the balls. Use the super glue to glue the hole closed and hold it with a rubber band until it dries. It will dry in less than a minute.

Insert one of the sticks.

If you've aligned the hole in the balloon with the hole in the ball, you can catch the open end of the balloon around the stick, twist it, then push it into the hole.

Saturn:

Use the 2 half balls and the 8" rings printed on the square sheet of vinyl. Cut around the outside of the rings. Glue each half of Saturn on either side of the rings, in the middle. White glue works best for this. Allow to dry.

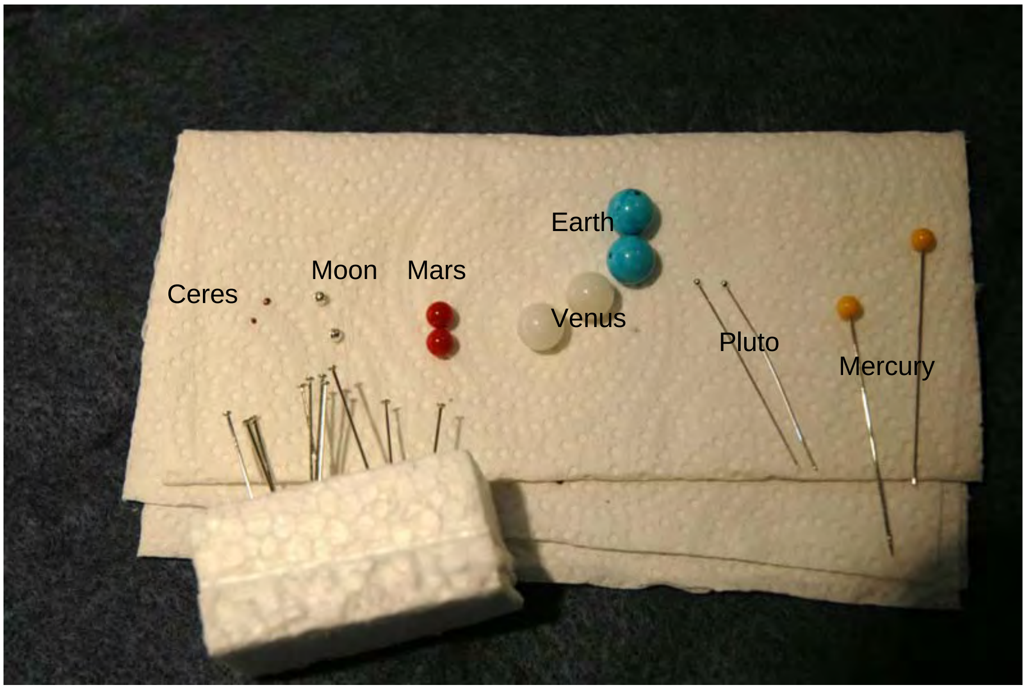
Insert one of the chopsticks.

If you want to get creative, you can purchase acrylic paints from a craft store and paint the balls. Here is an example:

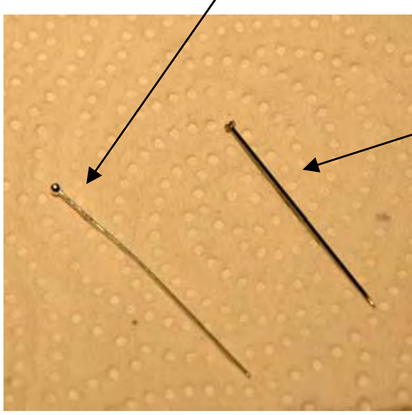
Smaller Worlds:

In the **Solar System Assembly pack**, there are at least two of each bead for each of the smaller bodies and the label on the bag tells you which bead is which.

Mercury: Yellow-top pin, 3.5mm **Venus:** White, 8.5mm
Pluto: Silver-top pin, 2mm **Earth:** Blue, 9mm
Earth's Moon: Silver bead, 2.4mm **Mars:** Red, 5mm
Ceres (largest asteroid): Smallest Bead, 0.8mm



Pluto (silver-topped pin) and Mercury (yellow-topped pin) are pre-made.
Don't mix up Pluto (round-headed silver pin) with the flat-headed pins.

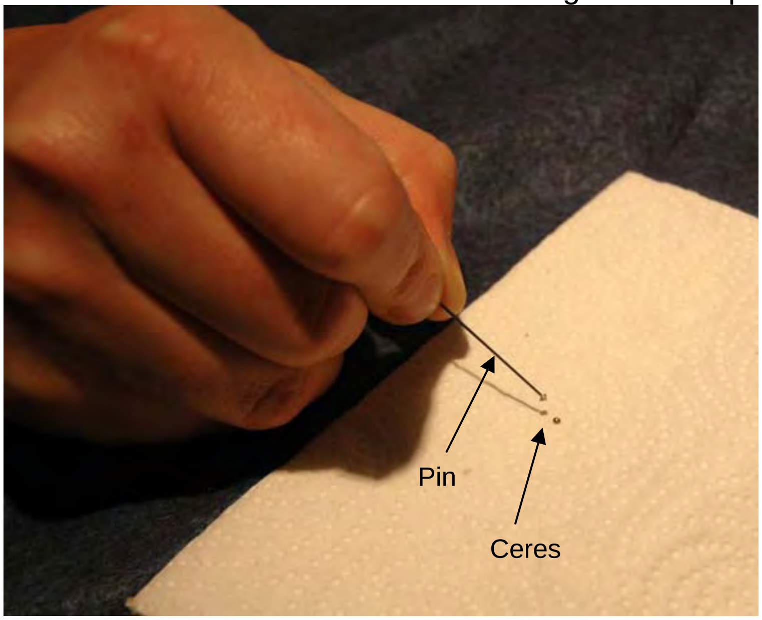


You can line up the rest of the beads in size order on a paper towel.
The smallest is Ceres, Earth's Moon, Mars, Venus, and Earth.

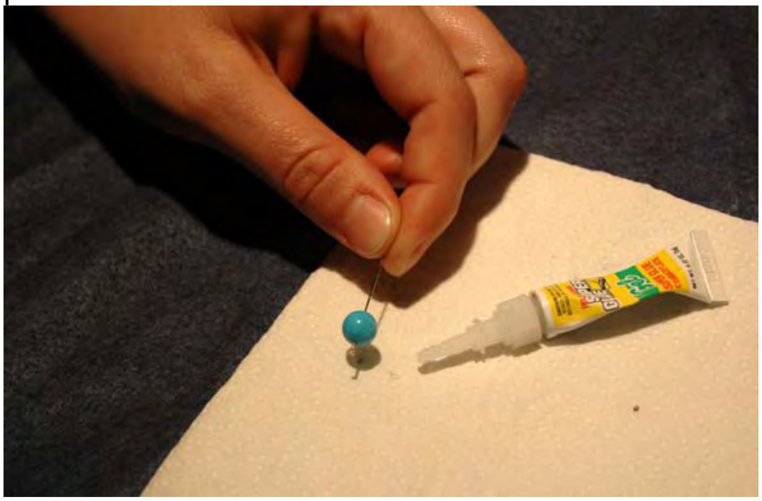
Use the Super Glue and the flat-headed pins for assembling these.

You might want to use the sandpaper to rough up the pins before gluing the beads on them for improved adhesion. Be sure to wipe off any residue before gluing.

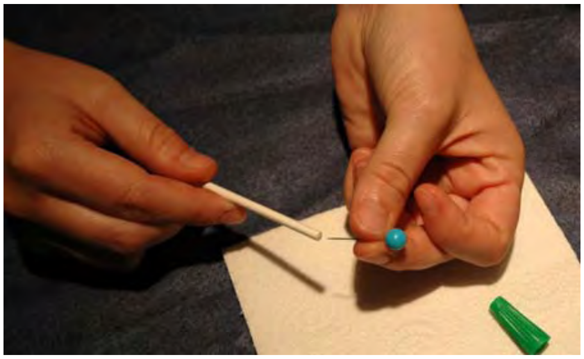
Ceres is too small to have a hole. Just glue it on top of one of the pins.



For the rest, insert the pins into the holes in the beads and glue the beads to the pins.



Tweezers can be useful.



Attach Sticks:

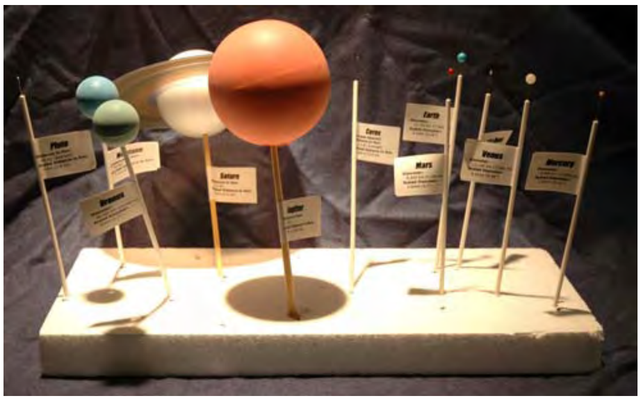
For each of the smaller worlds, place a little glue on the pointed end of the pin and insert about 1/4" to 1/2" (10mm to 15mm) into the end of one of the white sticks.

Attach Labels:

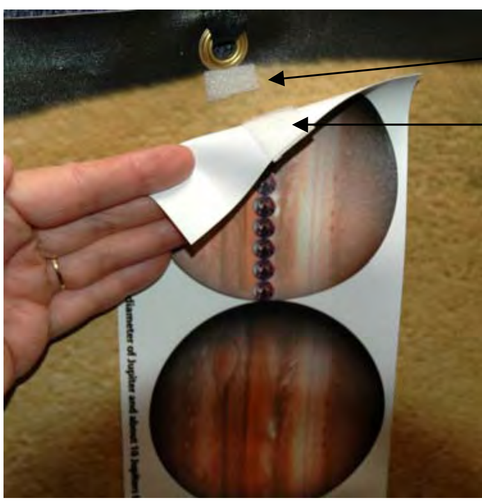
Lining up the center line of each label with the stick, fold each label in half around the stick of the appropriate world. See photo at right.

Display the Model:

Insert the sticks into the block of polystyrene foam.



Sun Banner and Strip of Jupiters:



Place a 1/2-inch (1 cm) length of Velcro loop at the top of the Sun image on the banner.

Place a 1/2-inch (1 cm) length of Velcro hook on one end of the strip of Jupiters.

You can attach the Jupiter strip to the Sun on the banner to demonstrate the size of the Sun compared to Jupiter and Earth.

<u>Where do I get additional materials?</u>

1. Sheet of polystyrene: Styrofoam from a craft store will work as well.
2. Dylite (or polystyrene) balls: search the Internet for “Dylite balls”:
   a) 4” ball – Jupiter
   b) 3-1/4” half-balls – Saturn (You can also get by with 3” half-balls) OR buy 3-1/4” whole balls and cut them in half
   c) 1-3/8” balls – Uranus and Neptune

3. Saturn’s rings: print template (see “Saturn’s Rings” on page 61) on a transparency sheet and either laminate it a couple of times or glue a 3 or 4 blank transparency sheets to it. This is to stiffen the rings.
4. Sandpaper: hardware store
5. Pencils: office supply store (avoid using pens – they may not write in cold weather)
6. Rolls of register tape: office supply store
7. Handout with scaled sizes of planets “Solar System to Scale”: print from templates on pages 59 and 60. These are in color and black & white versions.
8. Balloons:
   a) Jupiter: Blush 16” balloon
   b) Uranus: Sea Green Pearl Pastel 5” balloon
   c) Neptune: Light Blue Pearl Pastel 5” balloon
9. Sheet of Labels for all planets: print from template on page 62. (formatted for Avery 5162 1-1/3” x 4”)
10. Solar Viewer: search the Internet for “solar viewer”
11. Strip of Jupiters: print your own from the PDF file “SolSysJupiterStrip.pdf” found on the Manual & Resources CD.

“Solar System Assembly Pack”:

12. Straight pins: sewing store
13. Silver-topped pins for Pluto: sewing store: 1-1/2-inch Ball Head Pin .020 Dia.
14. Yellow-topped pin: this is a standard “quilting pin” and can be obtained at a sewing store.
15. Beads can be obtained from craft stores or online at any number of bead suppliers. Search the Internet for the “Search for” description:
    a) Silver 2.4mm beads for Moon: Search for “Silver Plate 2.4mm round beads”
    b) Blue 9mm bead – Earth: Search for “9mm blue round beads”
    c) White 8mm bead – Venus: Search for “White 8mm round beads”
    d) Red 5mm bead- Mars: Search for “Coral Red 5mm round beads”
    e) Copper 0.8mm balls for Ceres: Search for “Glass spheres 0.8mm Brown”
16. White Sticks: These are sucker sticks you can get from a baking or crafts store. You can also use wooden skewer sticks.
17. Super glue: craft store

Banner: “Our star: The Sun” and “Exploring Our Solar System”: The PDFs for this banner are on the Manual & Resources CD. The file names are “SolSysDiagram.pdf” and “SolSysDiagramSun.pdf”. You may have a full-size banner made from these files at a copy store or other printing company.

Solar System to Scale

Sun is scaled one meter (39") in diameter

Actual Size of Sun: 1,391,000 km (864,000 mi)
AU ("Astronomical Unit") is the average distance between the Sun and Earth: 150 million km (93 million mi)
A little more than 100 Sun diameters will span the distance of one AU

Mercury

Actual Size: 4,900 km (3,000 mi) diameter
Scaled Size: 3.4 mm (0.14")
Average distance from Sun: 0.4 AU
Scaled Distance from Sun: 42 m (48 yd)

Venus

Actual Size: 12,100 km (7,500 mi) diameter
Scaled Size: 8.6 mm (0.34")
Average distance from Sun: 0.7 AU
Scaled Distance from Sun: 75 m (84 yd)

Earth

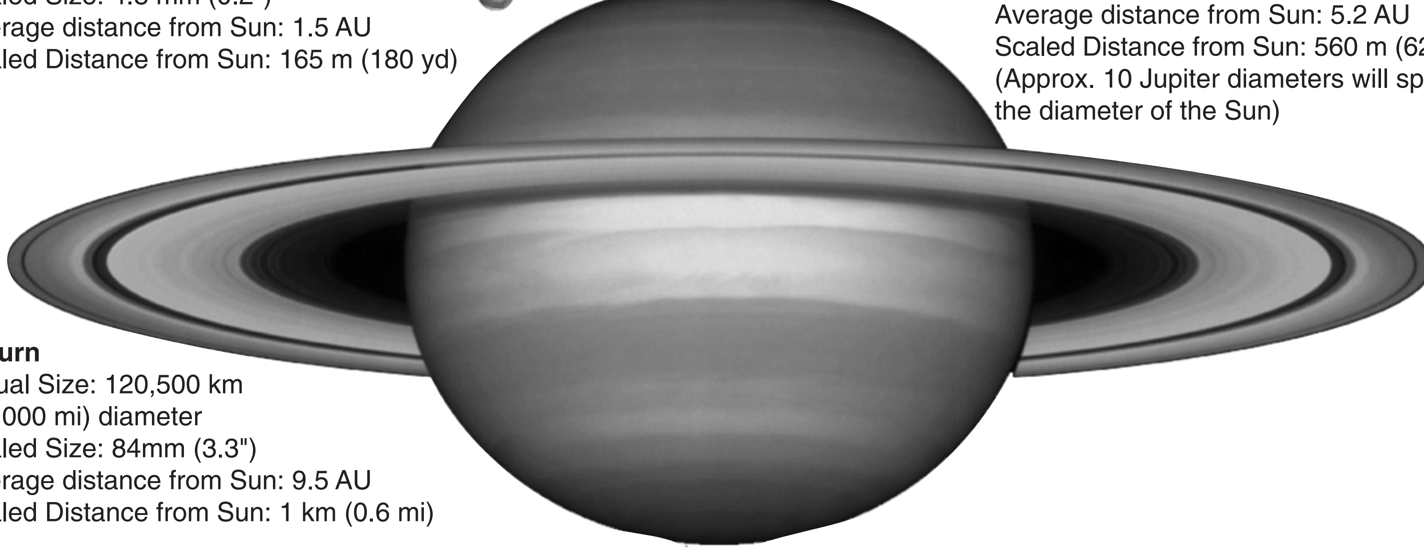
Actual Size: 12,800 km (7,900 mi) diameter
Scaled Size: 9.1 mm (0.36")
Average distance from Sun: 1 AU
Scaled Distance from Sun: 110 m (120 yd)
(Approx. 110 Earth diameters will span the diameter of the Sun)

Jupiter

Actual Size: 143,000 km (88,800 mi) diameter
Scaled Size: 100 mm (3.9")
Average distance from Sun: 5.2 AU
Scaled Distance from Sun: 560 m (625 yd)
(Approx. 10 Jupiter diameters will span the diameter of the Sun)

Mars

Actual Size: 6,800 km (4,200 mi) diameter
Scaled Size: 4.8 mm (0.2")
Average distance from Sun: 1.5 AU
Scaled Distance from Sun: 165 m (180 yd)

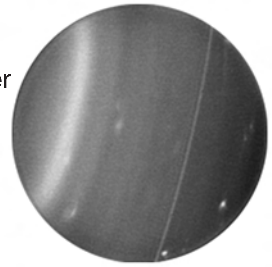


Saturn

Actual Size: 120,500 km (75,000 mi) diameter
Scaled Size: 84mm (3.3")
Average distance from Sun: 9.5 AU
Scaled Distance from Sun: 1 km (0.6 mi)

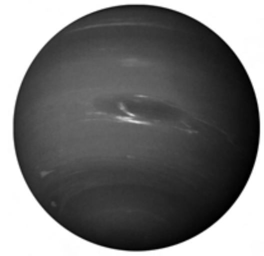
Uranus

Actual Size: 51,100 km (31,800 mi) diameter
Scaled Size: 34 mm (1.3")
Average distance from Sun: 19 AU
Scaled Distance from Sun: 2 km (1.3 mi)



Neptune

Actual Size: 49,500 km (30,800 mi) diameter
Scaled Size: 33 mm (1.3")
Average distance from Sun: 30 AU
Scaled Distance from Sun: 3 km (2 mi)



Solar System to Scale

Sun is scaled one meter (39") in diameter

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AU ("Astronomical Unit") is the average distance between the Sun and Earth: 150 million km (93 million mi)
A little more than 100 Sun diameters will span the distance of one AU

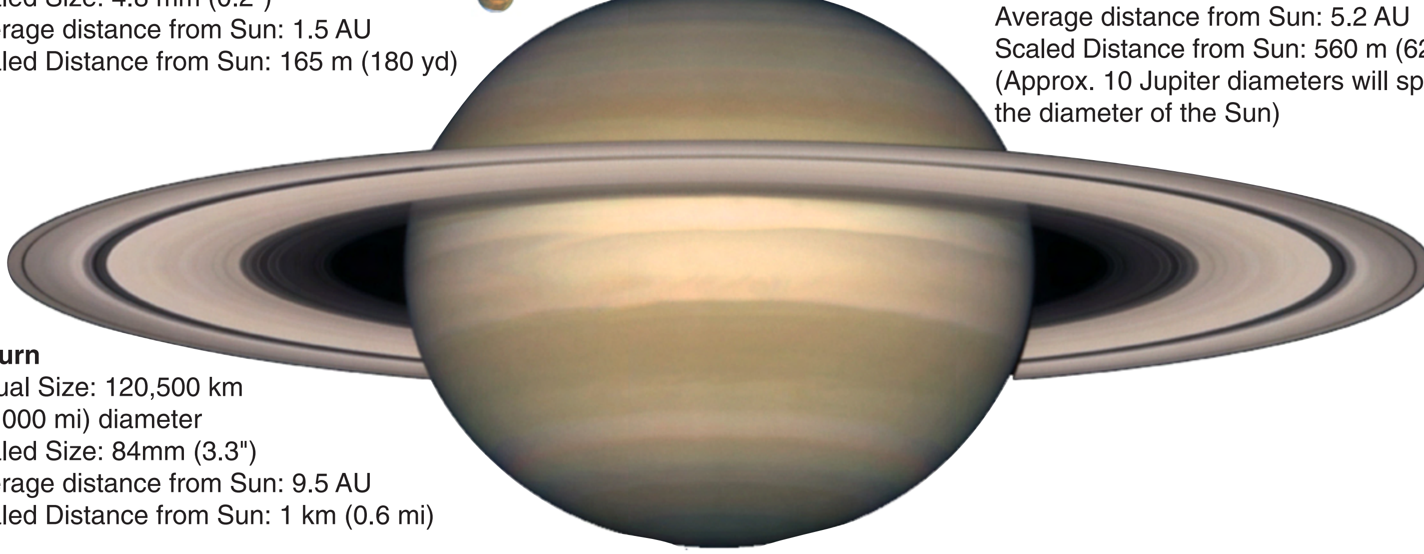
Mercury
Actual Size: 4,900 km (3,000 mi) diameter
Scaled Size: 3.4 mm (0.14")
Average distance from Sun: 0.4 AU
Scaled Distance from Sun: 42 m (48 yd)

Venus
Actual Size: 12,100 km (7,500 mi) diameter
Scaled Size: 8.6 mm (0.34")
Average distance from Sun: 0.7 AU
Scaled Distance from Sun: 75 m (84 yd)

Earth
Actual Size: 12,800 km (7,900 mi) diameter
Scaled Size: 9.1 mm (0.36")
Average distance from Sun: 1 AU
Scaled Distance from Sun: 110 m (120 yd)
(Approx. 110 Earth diameters will span the diameter of the Sun)

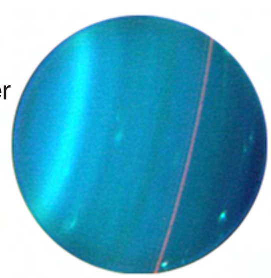
Jupiter
Actual Size: 143,000 km (88,800 mi) diameter
Scaled Size: 100 mm (3.9")
Average distance from Sun: 5.2 AU
Scaled Distance from Sun: 560 m (625 yd)
(Approx. 10 Jupiter diameters will span the diameter of the Sun)

Mars
Actual Size: 6,800 km (4,200 mi) diameter
Scaled Size: 4.8 mm (0.2")
Average distance from Sun: 1.5 AU
Scaled Distance from Sun: 165 m (180 yd)

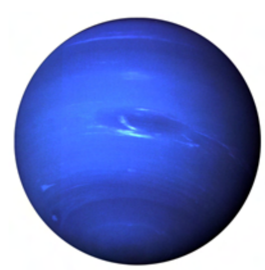


Saturn
Actual Size: 120,500 km (75,000 mi) diameter
Scaled Size: 84mm (3.3")
Average distance from Sun: 9.5 AU
Scaled Distance from Sun: 1 km (0.6 mi)

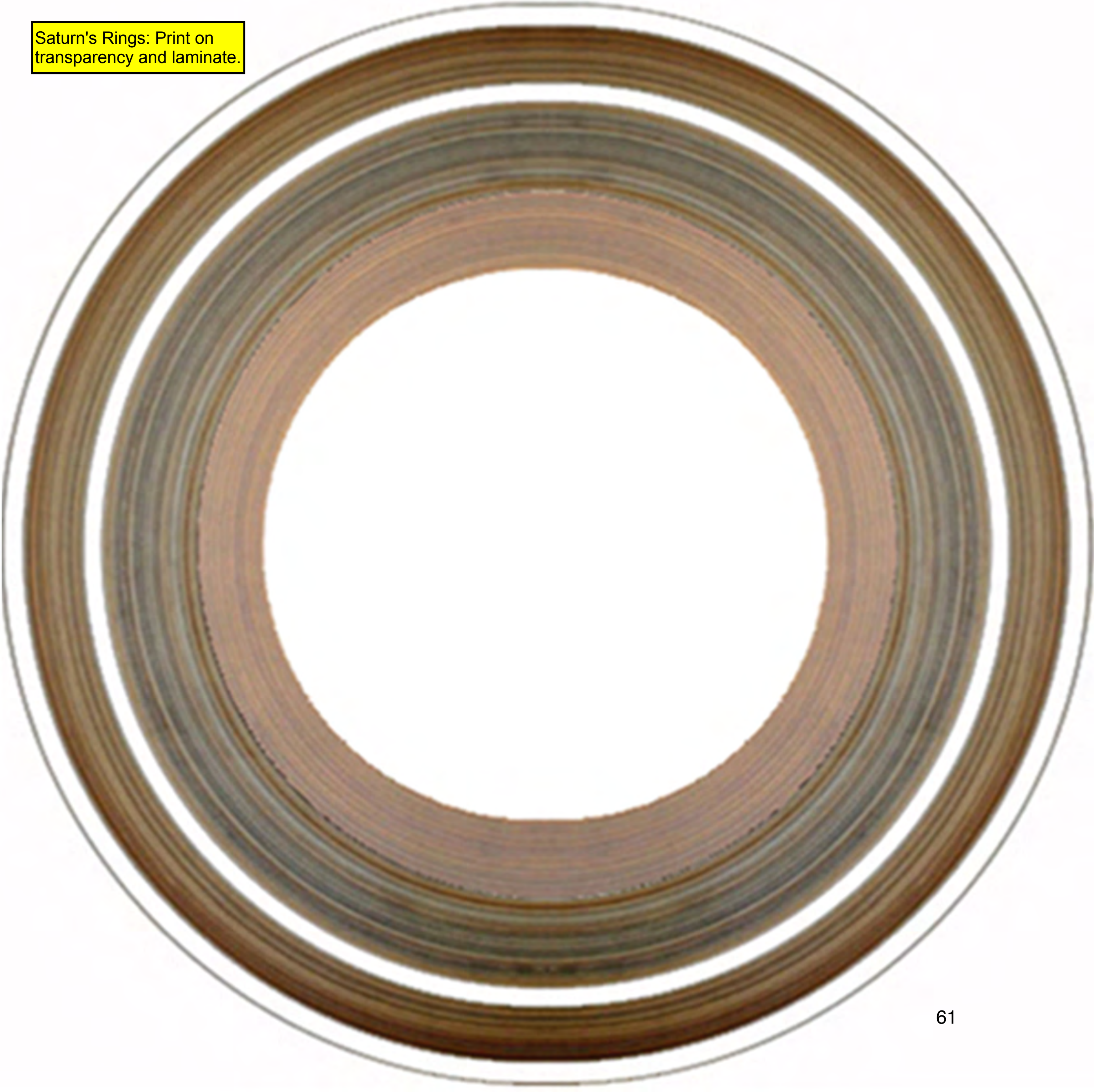
Uranus
Actual Size: 51,100 km (31,800 mi) diameter
Scaled Size: 34 mm (1.3")
Average distance from Sun: 19 AU
Scaled Distance from Sun: 2 km (1.3 mi)



Neptune
Actual Size: 49,500 km (30,800 mi) diameter
Scaled Size: 33 mm (1.3")
Average distance from Sun: 30 AU
Scaled Distance from Sun: 3 km (2 mi)



Saturn's Rings: Print on transparency and laminate.



Solar System Model Labels: Formatted for Avery Label 5162: 1-1/3" x 4"; 14 labels to a page

Mercury
Diameter:
4,900 km (3,000 mi)
Scaled Diameter:
3.4mm (0.14")

Mercury
Distance to Sun:
0.4 AU
Scaled Distance to Sun:
42 m (48 yd)

Venus
Diameter:
12,100 km (7,500 mi)
Scaled Diameter:
8.6mm (0.34")

Venus
Distance to Sun:
0.7 AU
Scaled Distance to Sun:
75 m (84 yd)

Earth
Diameter:
12,800 km (7,900 mi)
Scaled Diameter:
9.1mm (0.36")

Earth
Distance to Sun:
1 AU
Scaled Distance to Sun:
110 m (120 yd)

Mars
Diameter:
6,800 km (4,200 mi)
Scaled Diameter:
4.8mm (0.2")

Mars
Distance to Sun:
1.5 AU
Scaled Distance to Sun:
165 m (180 yd)

Earth's Moon
Diameter:
3,500 km (2,200 mi)
Scaled Diameter:
2.5mm (0.1")

Earth's Moon
Distance from Earth:
385,000 km (240,000 mi)
Scaled Distance from Earth:
28 cm (11 inches)

Ceres
(Largest Asteroid)
Diameter:
960 km (600 mi)
Scaled Diameter:
0.8mm (0.03")

Ceres
(Largest Asteroid)
Distance to Sun:
2.6 AU (average)
Scaled Distance to Sun:
285 m (310 yd)

Jupiter
Diameter:
143,000 km (88,800 mi)
Scaled Diameter:
100mm (3.9")

Jupiter
Distance to Sun:
5.2 AU
Scaled Distance to Sun:
560 m (625 yd)

Saturn
Diameter:
120,500 km (75,000 mi)
Scaled Diameter:
84mm (3.3")

Saturn
Distance to Sun:
9.5 AU
Scaled Distance to Sun:
1 km (0.6 mi)

Uranus
Diameter:
51,100 km (31,800 mi)
Scaled Diameter:
34mm (1.3")

Uranus
Distance to Sun:
19 AU
Scaled Distance to Sun:
2 km (1.3 mi)

Neptune
Diameter:
49,500 km (30,800 mi)
Scaled Diameter:
33mm (1.3")

Neptune
Distance to Sun:
30 AU
Scaled Distance to Sun:
3 km (2 mi)

Pluto
Diameter:
2,400 km (1,500 mi)
Scaled Diameter:
1.6mm (0.06")

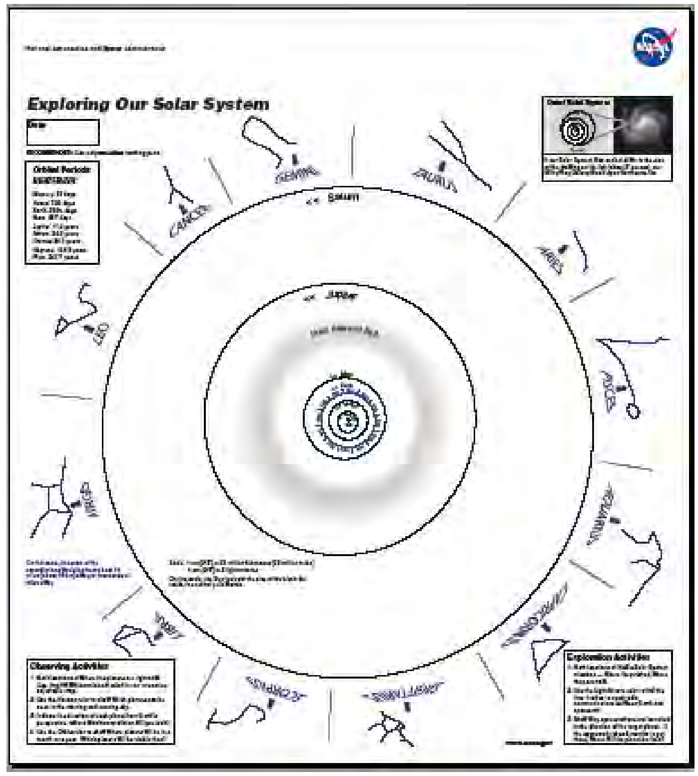
Pluto
Distance to Sun:
40 AU (average)
Scaled Distance to Sun:
4 km (2.6 mi)

Sun
Diameter: 1,391,000 km (864,000 mi)
Scaled Diameter: 1 meter (39")
(Approx 110 Earth diameters)

(A little more than 100 Sun Diameters to span distance between Sun and Earth)

Exploring Our Solar System

What's this activity about?



Big Questions:

What planets can we see in the night sky? Why can't we see all the planets?
Where has NASA explored in the Solar System?
Where are the spacecraft now?

Big Activities:

Using a banner with accurately scaled orbits of all the naked eye planets, explain a variety of concepts regarding the planets we see (and don't see) in the sky, what missions are exploring the Solar System, and how long it takes to communicate with spacecraft.

Use star maps to connect the positions of the planets on the banner to where the planets can be observed in the sky.

Participants:

From the club: A minimum of one person.

Visitors: Most activities are appropriate for families, the general public, and school groups in grade 5 and up. Up to 10 visitors at a time may comfortably participate in the banner activities. Any number of visitors can participate using the star maps.

Duration:

A few minutes, up to a half hour, depending on the number of topics covered.

Topics Covered:

Where are the planets right now in relation to Earth?
Which planets can be seen in the morning and evening sky?
Where do I look in the sky to find the planets?
Where will the planets be in a month or a year? Which planets will be visible then?
Where are NASA's Solar System missions right now?
How long does it take to send messages between Earth and the spacecraft?

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. **Banner: "Exploring Our Solar System"**	√	√	√	√		√	√	√	√	√
2. **Banner Handout for visitors**	√	√	√	√		√	√	√	√	√
3. **"Where are the Planets" Star Maps**	√	√						√		

What do I need to do before I use this activity?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Cut out stickers for banner. Attach Velcro straps to banner. *Optional*: Cleaner	Fence, Table, or Vehicle to display banner Printout of current locations of planets: http://www.fourmilab.ch/cgi-bin/Solar Printout of current locations of NASA missions: http://space.jpl.nasa.gov/ *Optional*: Yardstick or other straight-edge	Make needed copies of handouts *Optional*: Copy your club information on the back of the handouts

Helpful Hints

Common misconceptions addressed by these resources:

- Planets are in a line.
- We can see all the planets anytime during the night.
- Planets don't move in their orbits.
- Planets all move together as they orbit the Sun.
- We have sent people to Mars.
- Communication with spacecraft is instantaneous.

<u>Care of the Banner, Rulers, and Stickers</u>

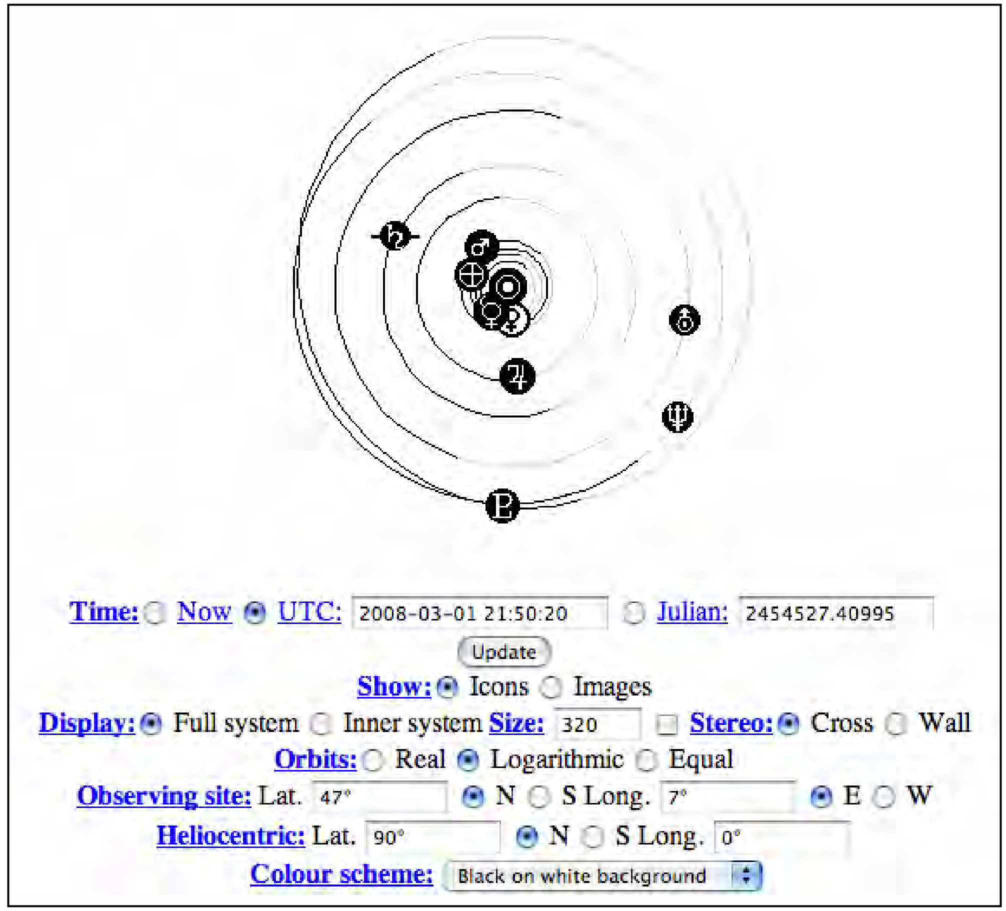
1. "Exploring Our Solar System" Banner
    a. Cleaning: Wash with a sponge and mild detergent. Rinse thoroughly.
    b. If marks remain, the banner can be cleaned with products like 409 or other spray cleaners, but be sure to rinse it thoroughly afterwards. The cleaner can degrade the vinyl if not rinsed off.
    c. Mark on the banner ONLY with wet-erase (also called "transparency") markers. The marks can be wiped off with a damp sponge or cloth. You can use dry-erase markers, but you'll need a cleaner (see "b." above) to remove the marks.
    d. If you are using the banner in a cold or damp area, the marks you make with a wet-erase marker may not dry, causing smearing. Under these conditions, use the included stickers or a dry-erase marker (discussed above in "c.").
    e. Keeping the banner clean will help keep the stickers sticky (see "3." Below).
2. Orbits, Light Minutes, and Horizon Rulers
    a. Clean with a damp sponge and mild soap.
3. Planet and Mission Stickers
    a. Try to keep the banner and stickers clean.
    b. Handling, grease, and dirt can cause the stickers to lose their stickiness.
    c. Wash stickers gently with a sponge and mild soap or detergent, rinse thoroughly, and allow to air dry. Much of the stickiness will be restored.

Websites: Locations of Planets and Spacecraft

For locations of planets on any desired day:

Solar System Live (shown at right):
http://www.fourmilab.ch/cgi-bin/Solar

- Use the "Time" field to change the day or time.
- You can make the map larger (up to about 900) or smaller by changing the "Size" field.
- Change the background to white by using the "Colour Scheme" field.
- Press the "Update" button.
- Then just print the page or right-click on the map and save it as an image.

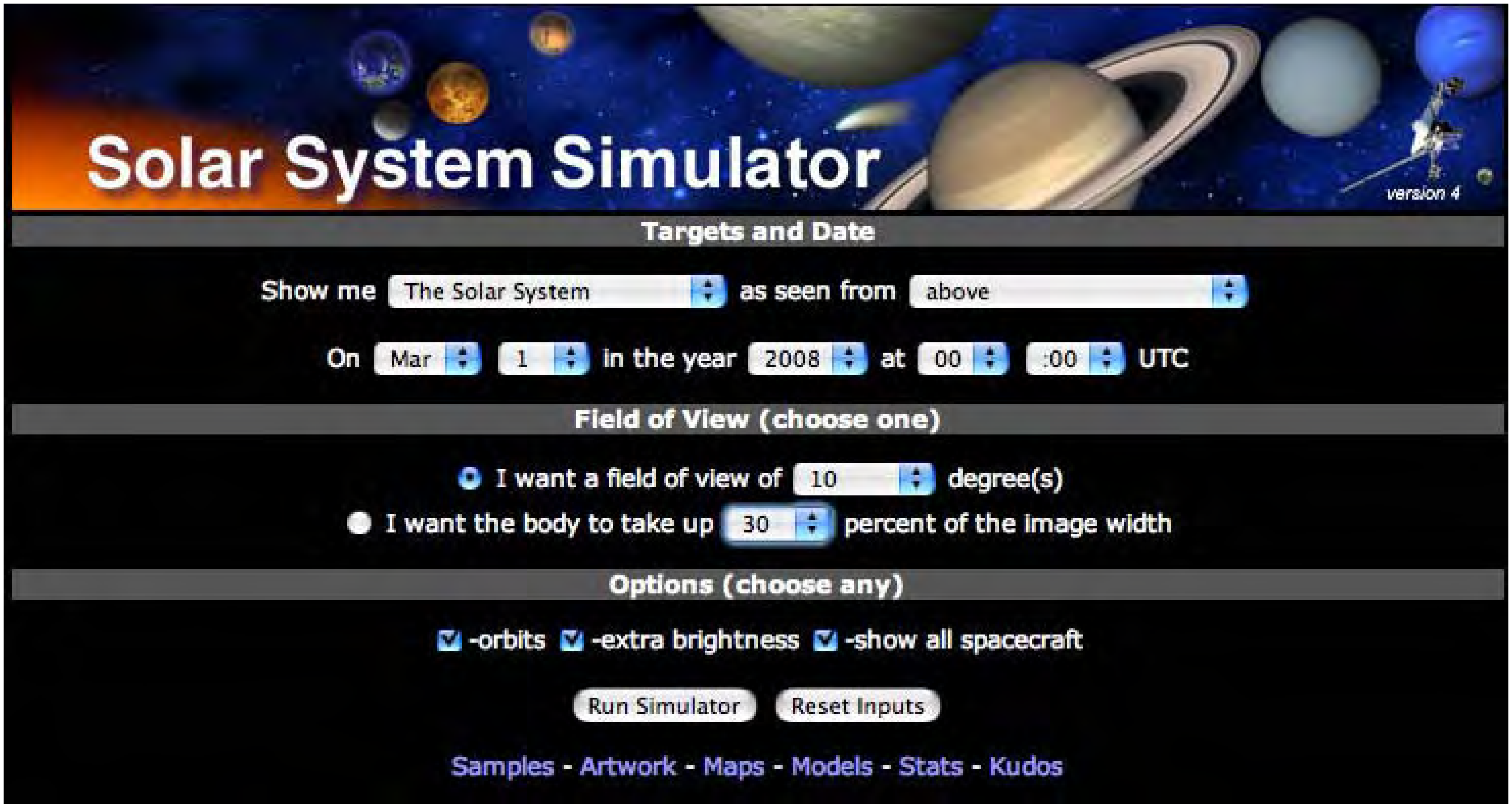


Heavens-Above: http://www.heavens-above.com/
You need to register and record your location. Once you are into the website, in the left-hand column under "Astronomy," choose "Solar System Chart." Scrolling down brings you to the controls to change the date and time and the size of the display.

For locations of spacecraft that are en route, use NASA's Solar System Simulator (shown below): http://space.jpl.nasa.gov/.

Set the settings as shown below, substituting the correct date. For a closer look at the inner Solar System, choose a field of view of 2 degrees.

Then press “Run Simulator.” The resulting display may not be oriented the same way as the banner. Print it out and line it up on the banner with the position of Earth and one other planet to get it oriented correctly.



More websites for spacecraft: Where are they now?

Voyagers and Pioneers:
http://heavens-above.com/solar-escape.asp?/

Stardust:
http://stardust.jpl.nasa.gov/mission/scnow.html
(North is on the right- rotate image 1/4 turn to the left to orient the same way as the poster)

New Horizons:
http://pluto.jhuapl.edu/mission/whereis_nh.php
(North is to the left). Rotate 1/4 turn to the right

Projecting the Banner with an Overhead Projector

If you have a large group and want to project the banner onto a screen, you can print the banner handout onto a transparency and use an overhead projector. Use the wet-erase, transparency marker to mark it with planet and mission locations. Use a pencil or short ruler as your Horizon Ruler. When printing transparencies, remember to set it to print in reverse so you can display it on the overhead projector with the printed side down.

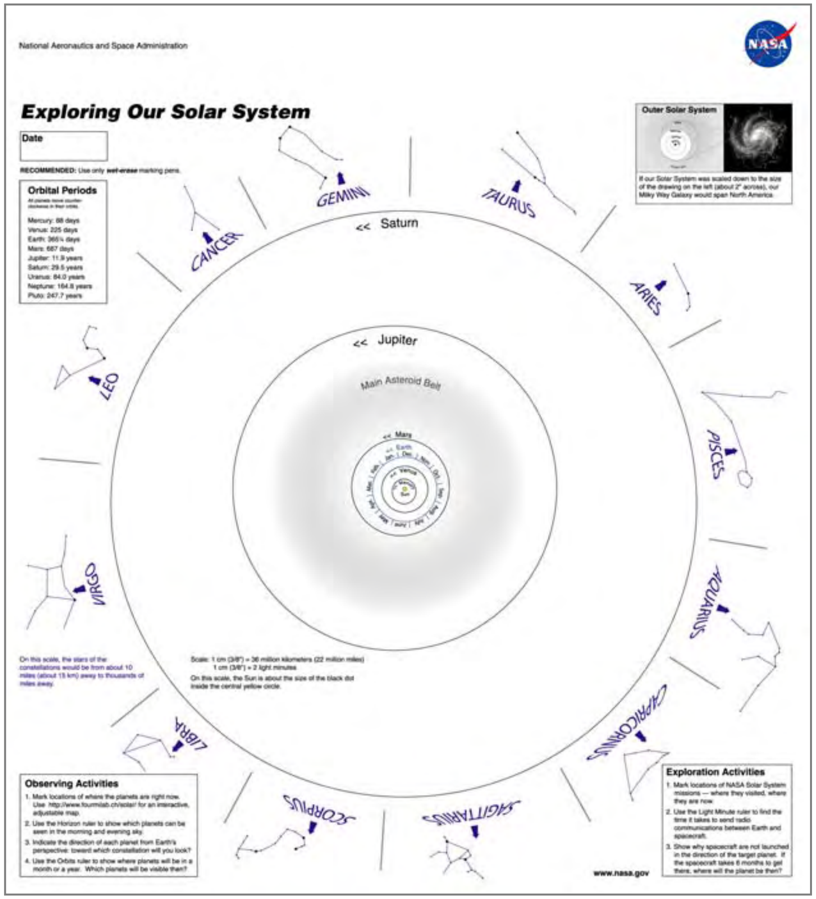
You can also print the PDF of the banner itself onto a transparency, making sure “Fit to Page” is set when printing.
On the smaller scale, 1mm = 1 light minute (approximately).

Background Information

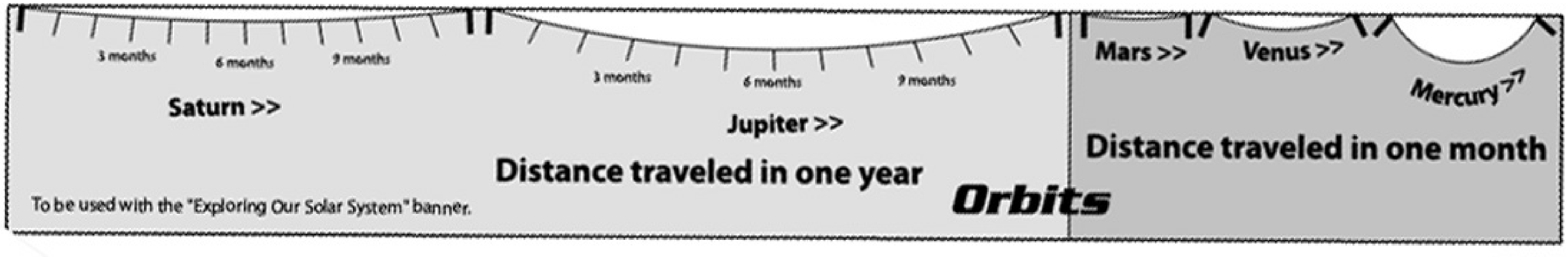
“Exploring Our Solar System” Banner and Rulers: Overview

The “Exploring Our Solar System” banner is made of vinyl and is about 47” x 42”. An image of the Sun with a diameter of one meter is on the reverse side.

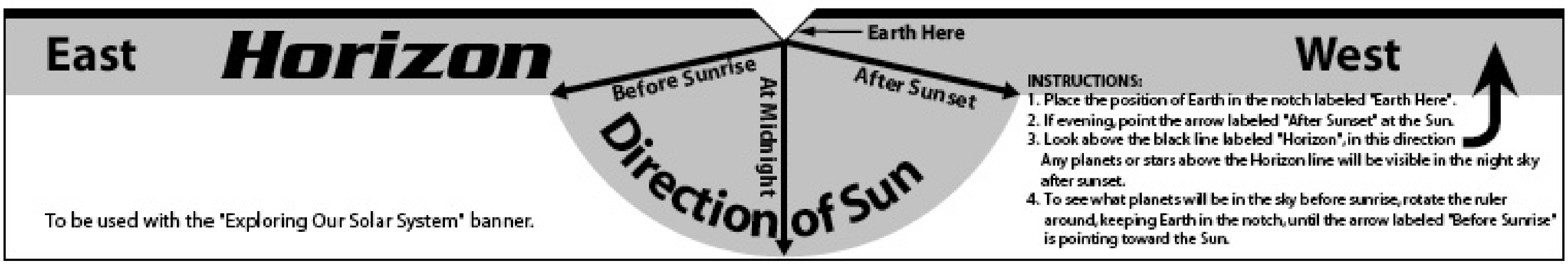
- The banner has accurate, scaled orbits of the planets of the Solar System.
- The Sun is in the center. The black dot in the center of the yellow circle is the size of the Sun on the scale of the banner.
- The scale is: 1cm = 36 million kilometers or 22 million miles or 2 light minutes
- The main part shows the naked-eye planets: Mercury through Saturn.
- The upper right includes the orbits of Uranus, Neptune, and Pluto, with Saturn to give a sense of the scale.
- The banner helps illustrate that the orbits of the planets are not perfectly circular.
- Orbital Periods are shown in a box in the upper left.
- See below for a discussion of the constellations shown on the banner (under “Constellations of the Zodiac”).



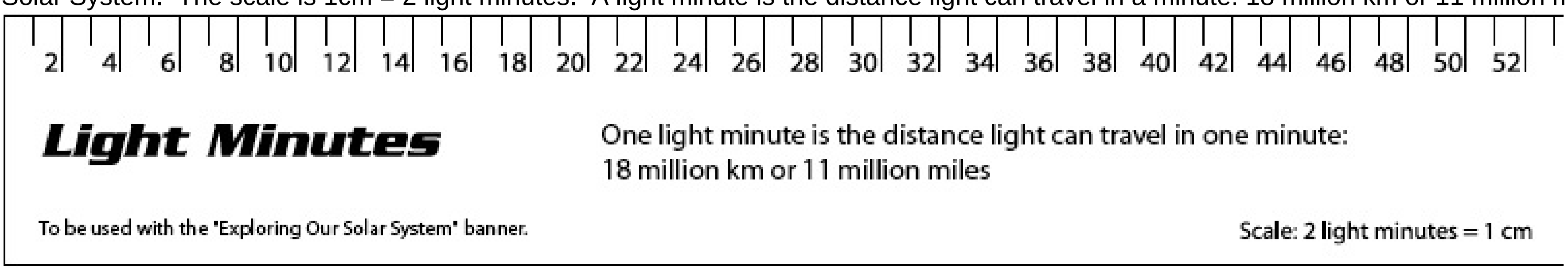
The **Orbits ruler** shows how far each planet moves in a month or a year. This is based on its orbital period, or the time it takes to make one orbit around the Sun (shown in the Orbital Periods box on the banner). The ruler shows the distance traveled in a month for the inner planets (Mercury, Venus, and Mars) and the distance traveled in a year for Jupiter and Saturn, with tick marks for the months. Earth is not on the Orbits ruler since its positions are marked on the banner. The arrows on the banner and on the Orbits ruler are a reminder that the planets move in a counterclockwise direction.



The **Horizon ruler** is used with the banner to show what constellations of the ecliptic and which planets can be seen above your local horizon from just after sunset, throughout the night, to just before sunrise.   Instructions are written on the ruler.



The **Light Minutes ruler** is used to show light travel (therefore radio communication) time between Earth and NASA spacecraft exploring our Solar System. The scale is 1cm = 2 light minutes. A light minute is the distance light can travel in a minute: 18 million km or 11 million miles.



Constellations of the Zodiac

The 12 constellations shown on the Exploring Our Solar System banner are the classical astronomical constellations of the Zodiac. It is acknowledged that Ophiuchus is the “13th constellation” along the ecliptic: the apparent path of the Sun across the sky. The boundaries of the constellations are the gray lines between each constellation on the banner. The banner combines the boundaries of Scorpius and Ophiuchus.

Brief background on a person’s “astrological sign”:

A person’s *astrological* sign or “Sun Sign” was traditionally the constellation that contained the Sun at the time the person was born. This is why the constellation with the same name as the person’s astrological sign is not visible at night on their birthday – the Sun is very roughly in the direction of that constellation.

However, due to the Earth’s precession, a 26,000-year wobble in the Earth’s axis, the Sun no longer occupies its traditional constellations for astrological signs. The “signs” have all been carried about one constellation to the west (clockwise on the banner).

In addition, the astrological signs each cover 30 degrees of sky (12 signs in 360 degrees). The modern boundaries of the *astronomical constellations* are of varying sizes. So the Sun appears to be in front of each constellation along the ecliptic for varying periods of time.

So do not confuse astrological signs with astronomical constellations.

Dr. James Kaler and Dr. Phil Plait provide more information:

http://www.astro.uiuc.edu/~kaler/celsph.html (See the chart of when the Sun crosses the boundary into each constellation of the Classical Astronomical Zodiac of 12 constellations).

http://www.badastronomy.com/bad/misc/zodiac.html

Missions Featured on the Mission Stickers that are used the Banner

Cassini-Huygens: http://saturn.jpl.nasa.gov/

Launched in 1997, Cassini-Huygens is an orbiter and probe. Cassini is the first spacecraft to orbit Saturn. The NASA orbiter is studying the features of Saturn's system of rings and moons. It also delivered the European Space Agency's Huygens Probe through the atmosphere to the surface of Saturn's moon Titan.

DSN (Deep Space Network): http://deepspace.jpl.nasa.gov/

DSN is an Earth-based worldwide network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for exploration of the Solar System. It collects data from spacecraft exploring the Solar System. The network also supports selected Earth-orbiting missions.

Dawn: http://dawn.jpl.nasa.gov/

Launched in 2007, Dawn's mission is to delve into the origins of our solar system through intense study of Ceres and Vesta, two minor planets that reside in the vast asteroid belt between Mars and Jupiter.

Deep Impact: http://deepimpact.jpl.nasa.gov/

On the evening of July 3, 2005, Deep Impact, a NASA Discovery mission, performed a complex experiment in space to probe beneath the surface of a comet and reveal the secrets of its interior. As its parent spacecraft released a smaller "impactor" spacecraft into the path of comet Tempel 1, the experiment became one of a cometary bullet chasing down a spacecraft bullet while a third spacecraft bullet sped along to watch. Results from this and other comet missions will lead to a better understanding of both the Solar System's formation and implications of comets colliding with Earth.

Lunar Reconnaissance Orbiter http://lunar.gsfc.nasa.gov/

Scheduled for launch in 2008, the LRO's mission is to search out sources of water ice that could be used for fuel, air, and growing plants when humans return to the Moon. It carries six different instruments to map the surface of the Moon in high detail.

Mars Reconnaissance Orbiter: http://mars.jpl.nasa.gov/missions/present/2005.html

Launched in 2005, the MRO's mission is to track changes in the water and dust in Mars' atmosphere, look for more evidence of ancient seas and hot springs and peer into past Martian climate changes by studying surface minerals and layering. The orbiter carries a camera capable of taking sharp images of surface features the size of a beach ball. At the conclusion of its science mission, Mars Reconnaissance Orbiter serves as a data relay station for future Mars missions.

Mars Exploration Rovers: http://marsrovers.jpl.nasa.gov/

Landing on the surface of Mars in 2004, the rovers are fully-equipped robot geologists. Both rovers are packed with sensors and cameras that have been revealing Mars in unprecedented detail from microscopic images of rocks to panoramic views of the rocky landscape.

MESSENGER: http://messenger.jhuapl.edu/

Launched in 2004, MESSENGER is a scientific investigation of the planet Mercury. Understanding Mercury, and the forces that have shaped it, is fundamental to understanding the terrestrial planets and their evolution.

New Horizons: http://pluto.jhuapl.edu/

Launched in 2006, New Horizons will help us understand worlds at the edge of our Solar System by making the first reconnaissance of Pluto in 2015. Then, as part of an extended mission, the spacecraft would head deeper into the Kuiper Belt to study one or more of the icy mini-worlds in that vast region beyond Neptune's orbit.

Stardust: http://stardust.jpl.nasa.gov

In early 2004, Stardust flew within 236 kilometers of Comet Wild 2 and captured thousands of particles in its aerogel collector, then returned these tiny particles to Earth in January 2006.

Voyagers: http://voyager.jpl.nasa.gov/

Launched in 1977, Voyager 1 and 2 explored all the giant planets of our outer solar system, Jupiter, Saturn, Uranus and Neptune; 48 of their moons; and the unique system of rings and magnetic fields those planets possess. The Voyager spacecraft will be the third and fourth spacecraft to fly beyond all the planets in our solar system. Pioneers 10 and 11 preceded Voyager but on February 17, 1998, Voyager 1 passed Pioneer 10 to become the most distant human-made object in space.

For more information on any of the worlds of the Solar System: http://solarsystem.nasa.gov/planets/

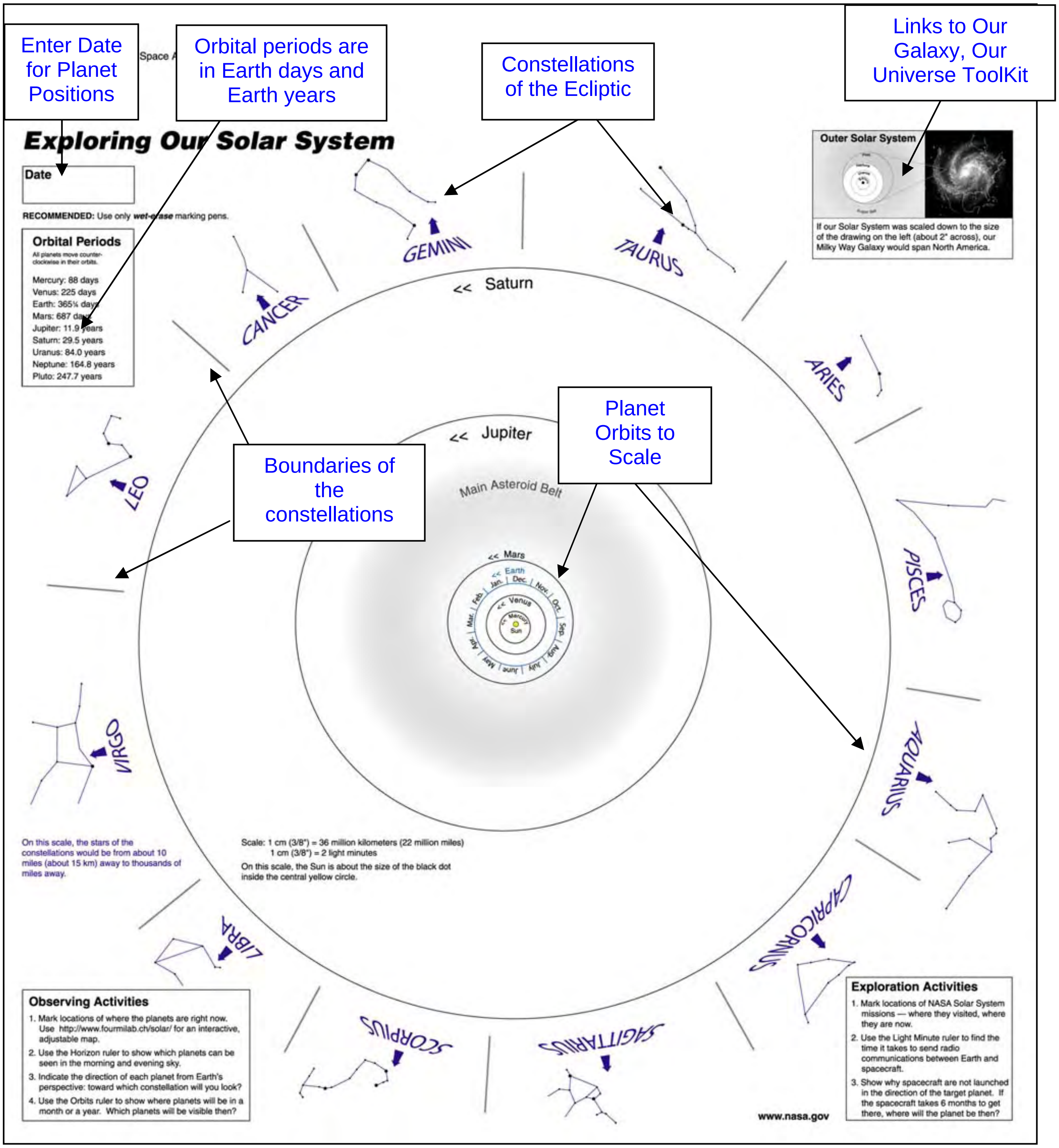
For information on NASA Solar System missions: http://solarsystem.nasa.gov/missions/

Animation of retrograde motion: http://mars.jpl.nasa.gov/allabout/nightsky/nightsky04-2003animation.html

Overview of Solar System mission timeline: http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=1

Amateur Astronomy Observing Campaigns and opportunities: http://education.jpl.nasa.gov/amateurastronomy

<u>**Solar System Banner Diagram**</u>



Detailed Activity Descriptions

1. Banner: "Exploring Our Solar System"

Discussion of Banner

Materials: "Exploring Our Solar System" Banner, planet and Mission stickers, Orbits, Light Minutes, and Horizon rulers, printout of planet positions and NASA spacecraft positions for your selected date.
Current locations of planets: http://www.fourmilab.ch/cgi-bin/Solar
Current locations of NASA missions: http://space.jpl.nasa.gov/ (Instructions for using this site are under "Helpful Hints" on page 66 of this manual).
Optional: Wet-erase marker, damp sponge, copies of "Communication and Exploration" handout, copies of "Where are the Planets" star maps
Optional (you supply): Yardstick

Objectives:

- Dispel misconceptions regarding the arrangement of the planets in our Solar System and how they move
- Introduce NASA missions exploring the Solar System and the concept that the speed of communication with spacecraft is limited to the speed of light

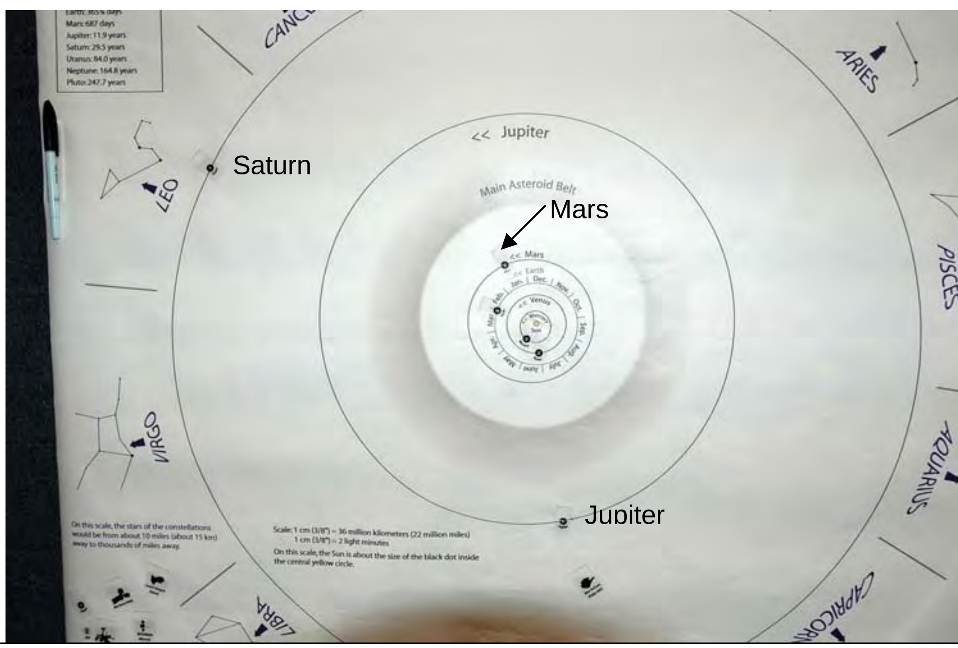
The "Exploring Our Solar System" Banner has accurate, scaled orbits of the planets of the Solar System. The main part shows the naked-eye planets. The upper right includes the orbits of Uranus, Neptune, and Pluto, with Saturn to give a sense of the scale. The banner helps illustrate that the orbits of the planets are not perfectly circular.

Summary of Activities to do with the Banner (most are also listed on the Banner):

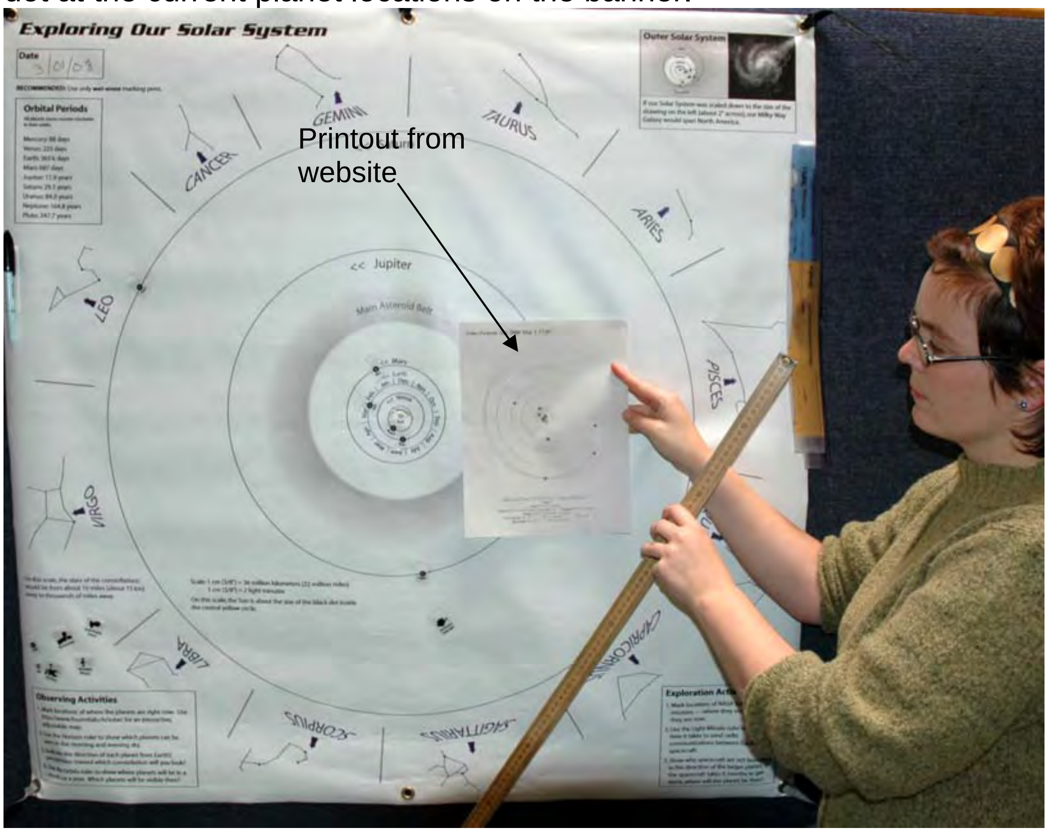
1. **Observing Activities**
   a) Mark locations of where the planets are right now.
   b) Indicate the direction of the planet from Earth's perspective: toward which constellation will you look?
   c) Use the Horizon ruler to show which planets can be seen in the morning and evening sky.
   d) Use the Orbits ruler to show where planets will be in a month or a year. Which planets will be visible in the evening then?
   e) Use a five-foot Pocket Solar System to show the orbits of Uranus and Neptune.
   f) Link the Solar System to its place in our Milky Way Galaxy.
2. **Exploration Activities**
   a) Mark the locations of NASA Solar System missions.
   b) Use the Light Minutes ruler to find the time it takes to send radio communications between Earth and spacecraft.
   c) Use the Orbits ruler to show why spacecraft are not launched in the direction of the target planet. If the spacecraft takes 6 months to get there, where will the planet be then?
   d) As you view planets in the telescope, discuss the missions that have visited that planet and/or its moons.

2. Banner: Observing Activities

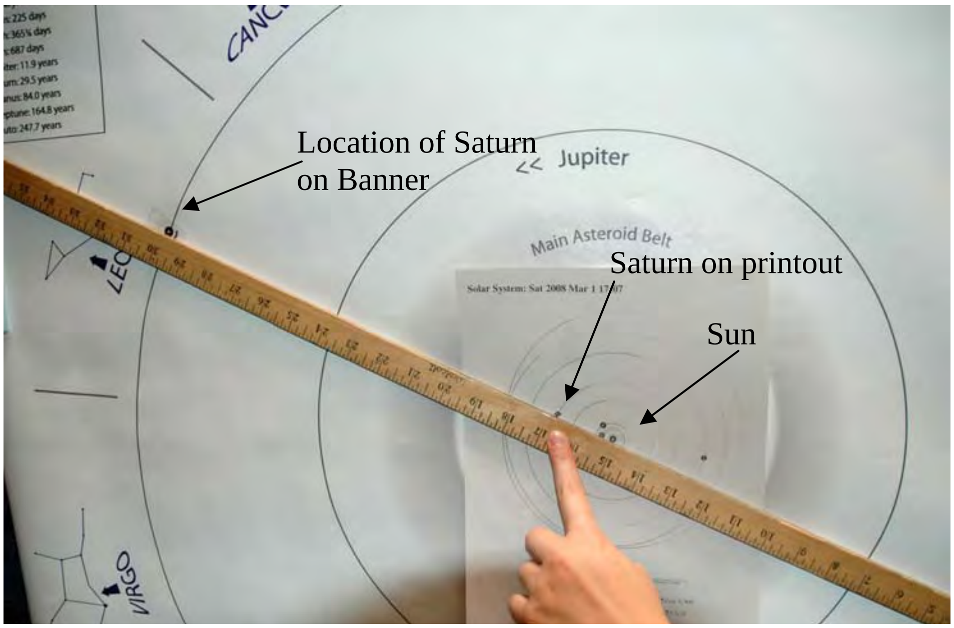
<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td colspan="2">Materials:
Banner, planet and mission stickers, copies of "Where are the Planets" star maps, wet-erase marking pen, sponge.
Orbits Ruler
Horizon Ruler
Light Minutes Ruler
Printout of current locations of the planets: http://www.fourmilab.ch/cgi-bin/Solar
Optional: A five-foot Pocket Solar System</td></tr>
<tr><td colspan="2">Objectives:
Provide visitors with an understanding that the planets are not all in a line, that they don't all move together, and that it is not easy to get from one planet to another.
Help visitors understand why they see only a few planets at a time in the night sky.
Provide an understanding that NASA has a variety of missions exploring the Solar System using a variety of methods: includes where the missions are in relation to Earth and how we communicate with them.</td></tr>
<tr><td colspan="2">LOCATIONS OF THE PLANETS</td></tr>
<tr><td><u>To Do:</u>
NOTE: In the examples here, we are using a date of March 1, 2008. You will be using the date of your presentation to set the locations of the planets.

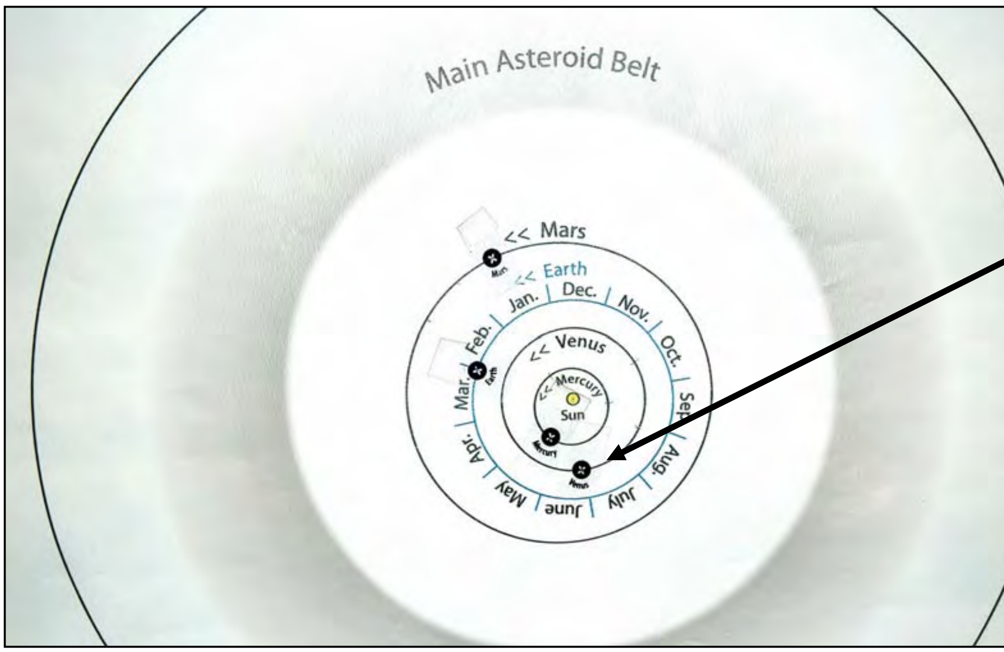
Mark the locations of where the planets are right now and indicate the direction of the planet from Earth's perspective: toward which constellation will you look?

</td><td>** If you are working with an organized group, such as a classroom or Scouts, it is recommended that you let your visitors locate the planets on the banner themselves. Doing is the best way to learn and understand!</td></tr>
</table>

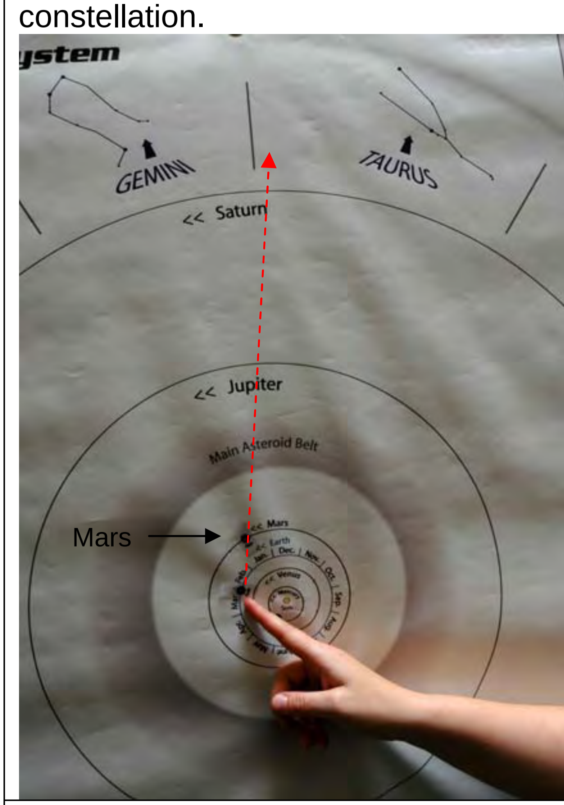
<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>
Using a printout from one of the websites to get the correct planet locations, use the planet stickers or the wet-erase marking pen to place a dot at the current planet locations on the banner.

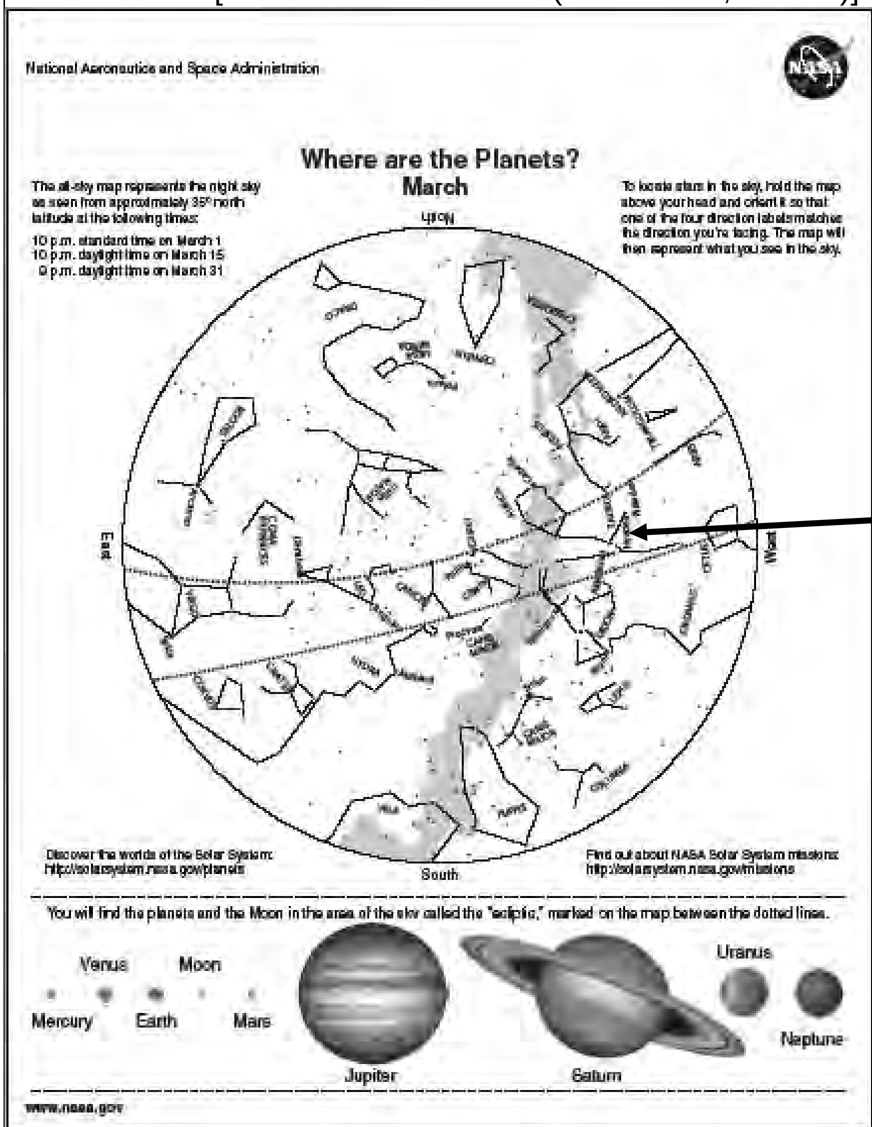


When using the stickers, place the center of the “X” over the location of the planet. On the websites, the center of the icon for the planet is the correct location for the planet.
</td><td></td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
An easy way to correctly locate Jupiter and Saturn is to line up the Sun on the printout with the Sun on the banner and get a straight-edge to line up the Sun and the planet on the printout. Place the planet's sticker on the planet's orbit where the straight-edge intersects the orbit.  	

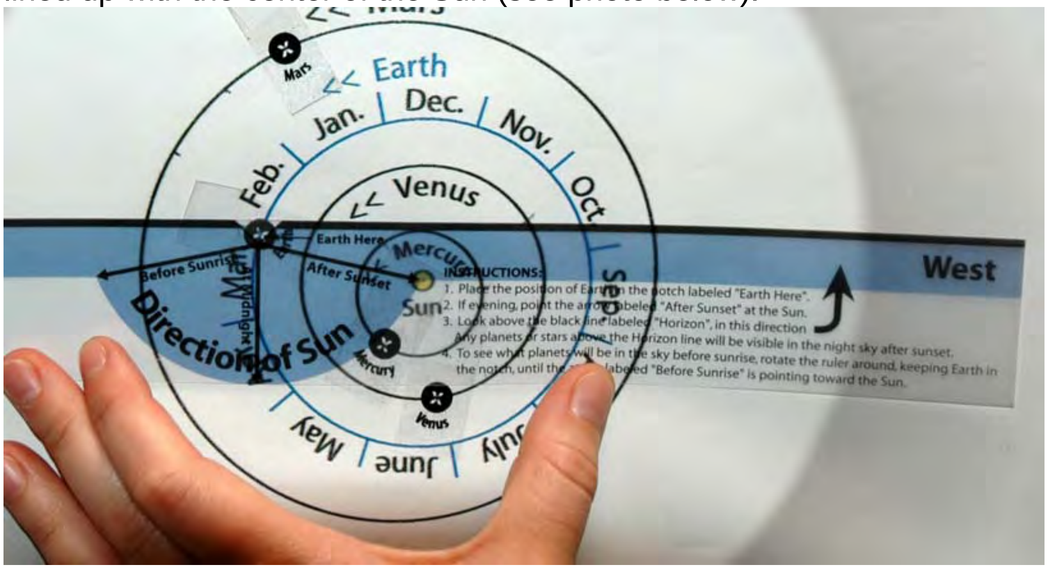
Leader's Role	**Participants' Role (Anticipated)**
<u>To Do:</u> Just showing your visitors the banner with the planets placed helps to dispel the perception many people have that the planets are in a line.	
<u>To Say:</u> Here are the orbits of the planets in our Solar System, from Mercury through Saturn. These are the planets we can see with just our eyes.	I didn't know we could see any planets without a telescope!
These stickers show where the planets are right now in their orbits. Who can find Venus?  	Here it is!
Do you think we'll see it tonight in the sky?	Hope so.

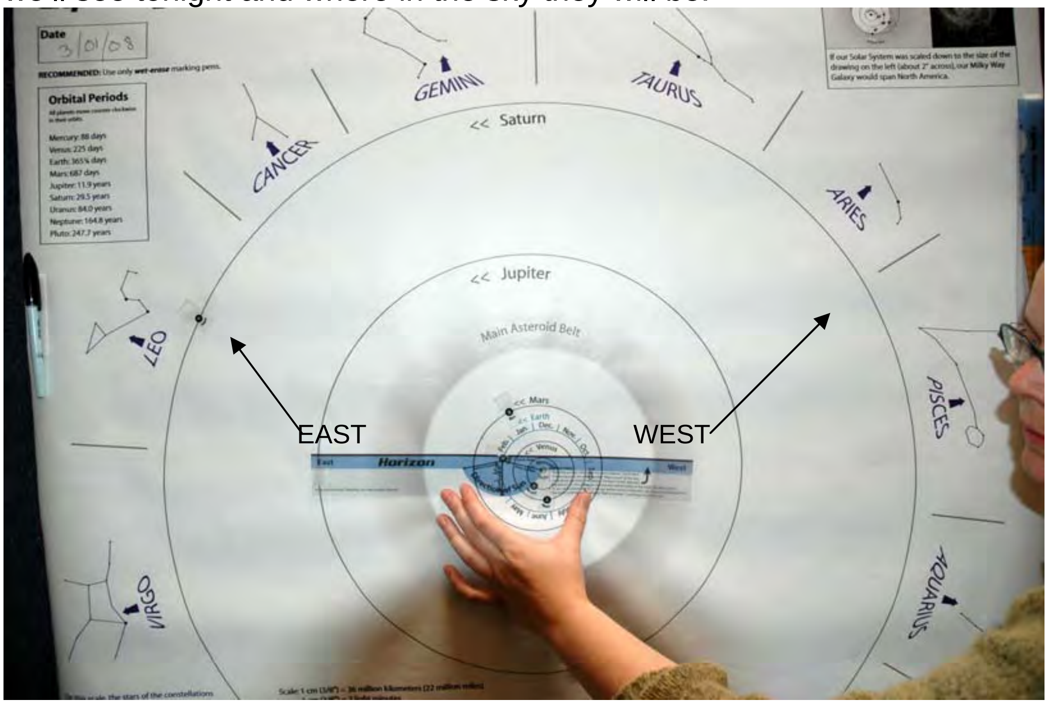
Leader's Role	**Participants' Role (Anticipated)**
<u>To Do:</u> Point to the constellations around the edge of the poster. *<u>To Say:</u>* These are the constellations of the ecliptic. The ecliptic is the apparent path the Sun and planets take across the sky, among the constellations. What do you notice about the names of these constellations? Right, the planets and the Moon are always seen in the area of the sky where these constellations are. That's why these constellations were special to ancient people. Now this is important, the stars of these constellations are not in our Solar System, but if our Solar System was scaled down to the size of this diagram, these stars would be many miles away. The constellations are on the banner to show that we'll see the planets in the direction of certain constellations.	Signs of the Zodiac. Astrology signs.
<u>To Do:</u> Pick a planet visible in the evening sky. Trace with your finger a straight line on the banner from Earth to the planet, then beyond to the constellation.  *<u>To Say:</u>* For example, from Earth, Mars looks like it is in this direction, toward Taurus on this date. (See photo at left – the finger is pointing to Earth. The red arrow draws a line-of-sight from Earth to Mars to the constellation Mars is in front of on March 1, 2008). So Mars will appear to be in Taurus.	
<u>To Do:</u> Pass out "Where are the Planets" star maps for the current month.	Takes map.

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>To Say:
Who can find [name the constellation (in this case, Taurus)] on this star map?


We’ll see [the planet (in this case, Mars)] in the direction of that constellation tonight.</td><td>Here it is!

Cool.</td></tr>
</table>

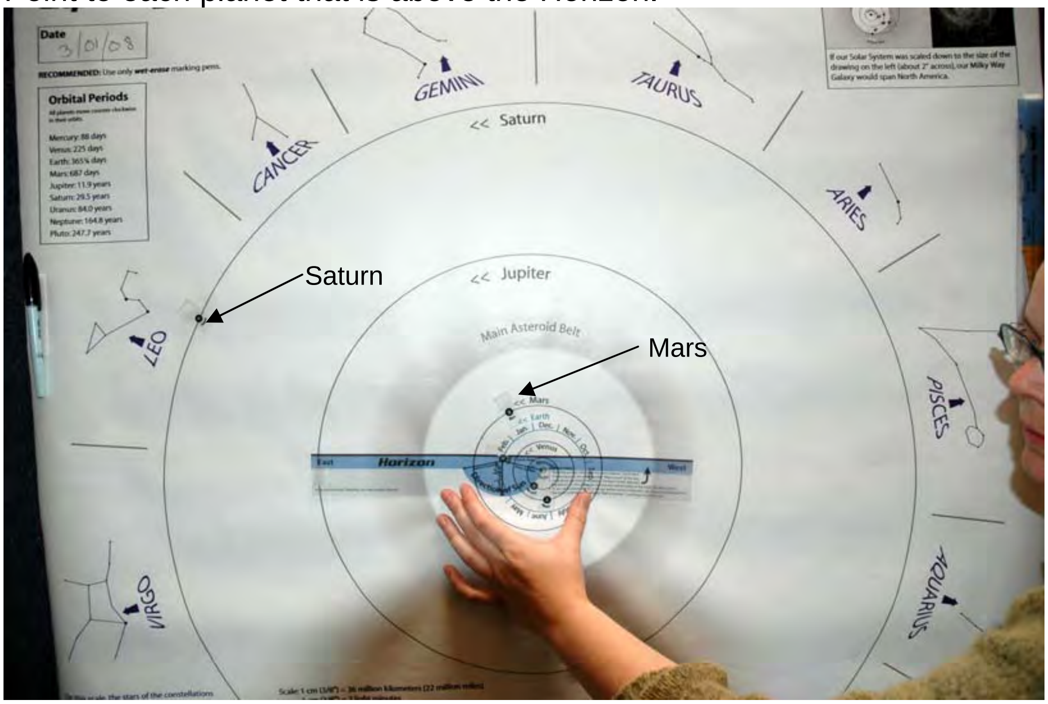
Leader's Role	**Participants' Role (Anticipated)**
HORIZON	
<u>To Do:</u> **Show the Horizon Ruler** and place Earth's position on the banner in the notch. Rotate the "Direction of Sun" so that the "After Sunset" arrow is lined up with the center of the Sun (see photo below).  The banner in this photo is set for March 1, 2008. ***<u>IMPORTANT:</u>*** This example shows a date of **March 1, 2008.** You will be using the date of your presentation to set the locations of the planets.	

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td>
<u>To Say:</u>
This ruler is used to show where our Horizon is from our perspective here on Earth. We’ll use this to figure out which planets and constellations we’ll see tonight and where in the sky they will be.


The banner in this photo is set for March 1, 2008.

<u>To Say:</u>
When you look to the west, as it starts getting dark, which constellations will we see toward the west?
<u>To Do:</u>
Point to the constellations near the western horizon (above the “West” end of the Ruler).
<u>To Say:</u>
And in the east?
<u>To Do:</u>
Point to the constellations near the eastern horizon (above the “East” end of the Ruler).
</td><td>
Calls out names of constellations (in this case, Aries and Pisces).

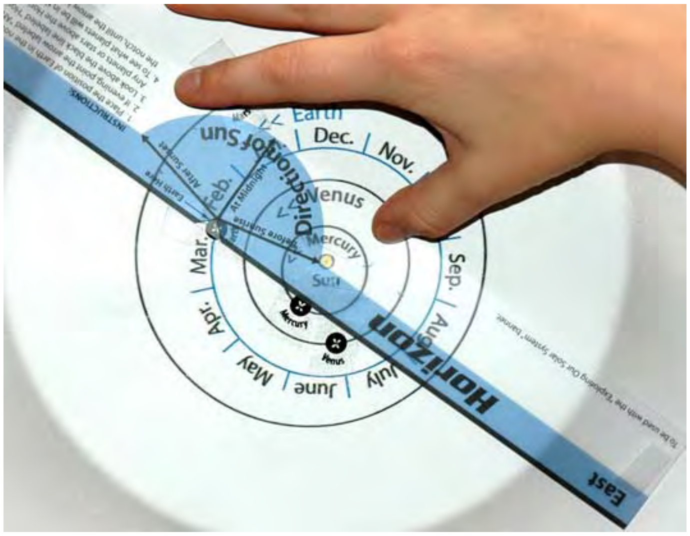
Calls out names of constellations (in this case, Leo).
</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
<u>To Say:</u> Which planets will we see in the sky this evening? *<u>To Do:</u>* Point to each planet that is above the Horizon.  The banner in this photo is set for March 1, 2008.	Calls out names of planets (in this case, Mars and Saturn).
<u>To Say:</u> [This planet (in this case, Saturn)] is in the direction of which constellation?	Calls out name of constellation (in this case, Leo).

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td>

To Do:

Rotate the Horizon Ruler until the "Before Sunrise" arrow is lined up with the center of the Sun.



The banner in this photo is set for March 1, 2008. **Note that in the morning, Mercury and Venus are visible. Both are just above the eastern horizon.**

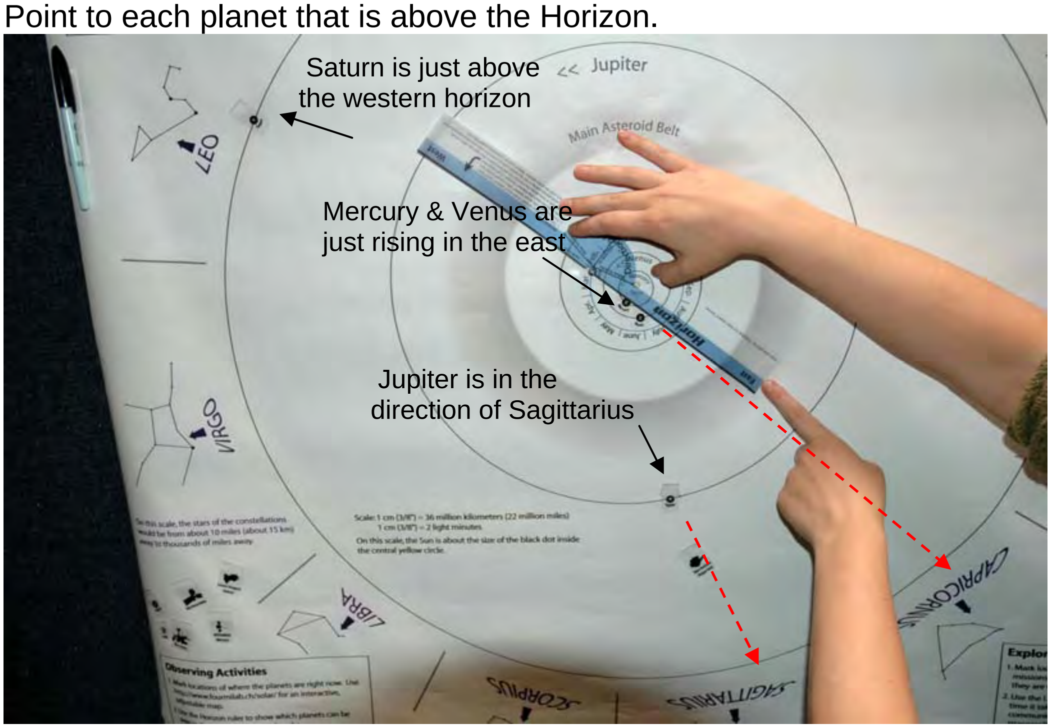
<PHOTO>

To Say:

If you get up before sunrise, which planets will you see in the morning sky?

To Do:

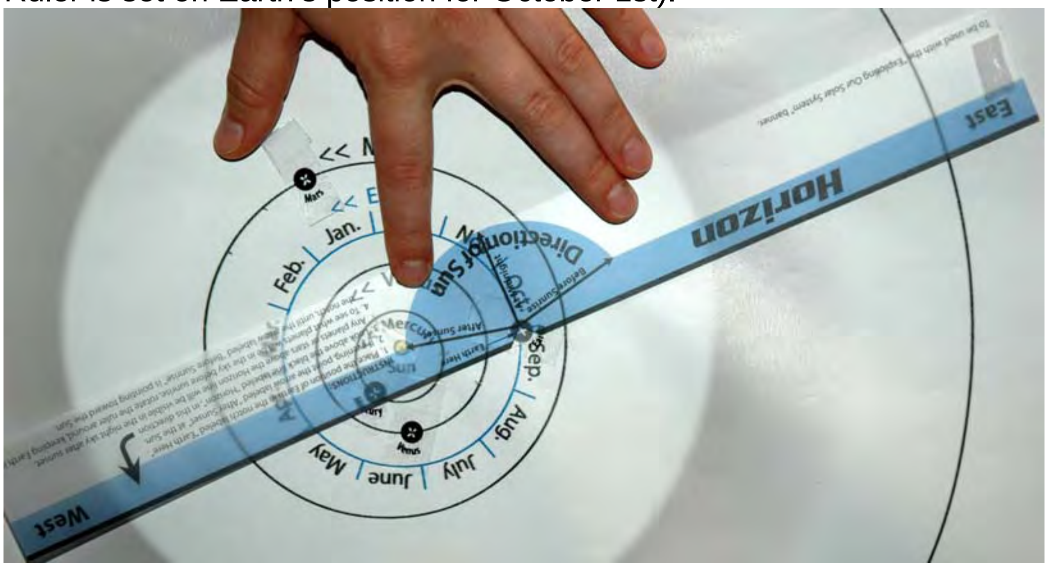
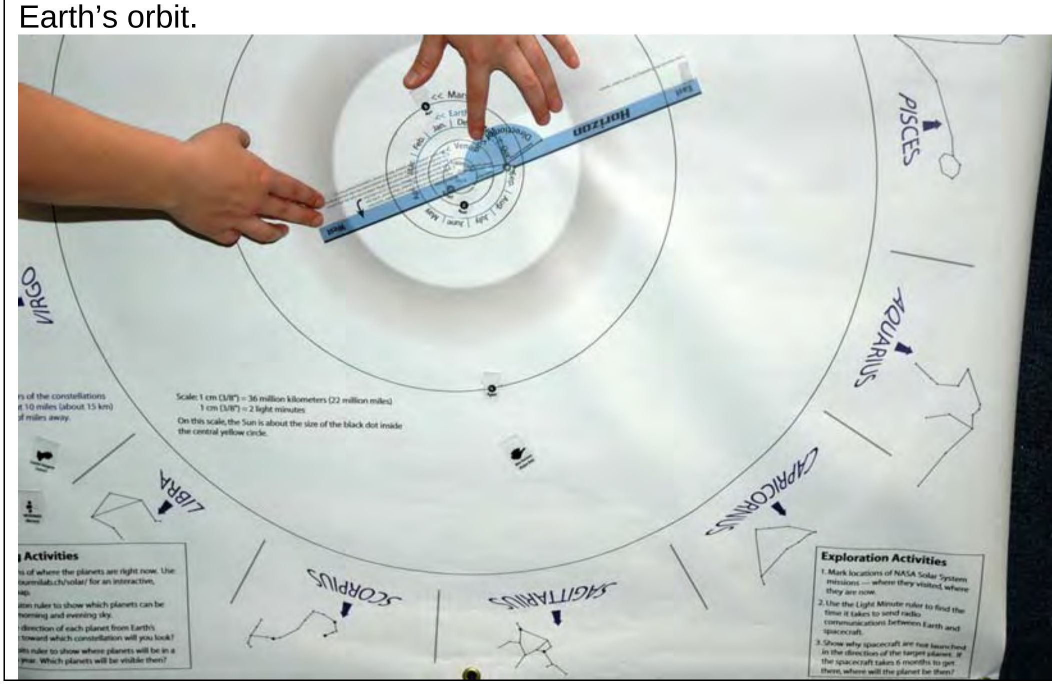
Point to each planet that is above the Horizon.

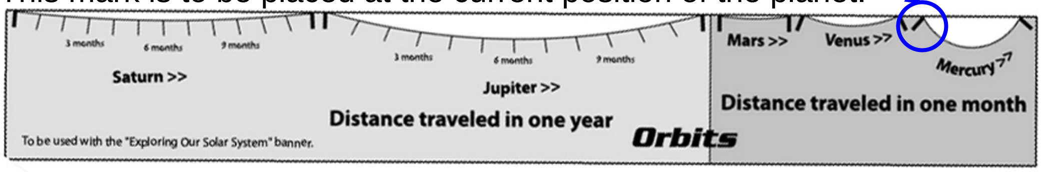
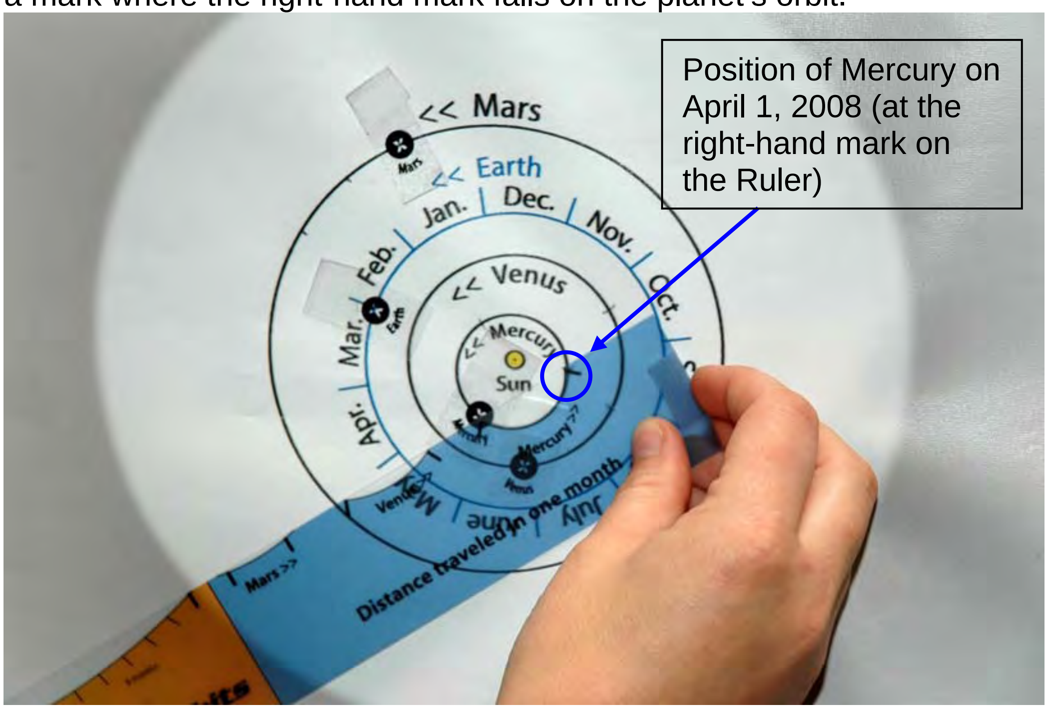


</td><td>

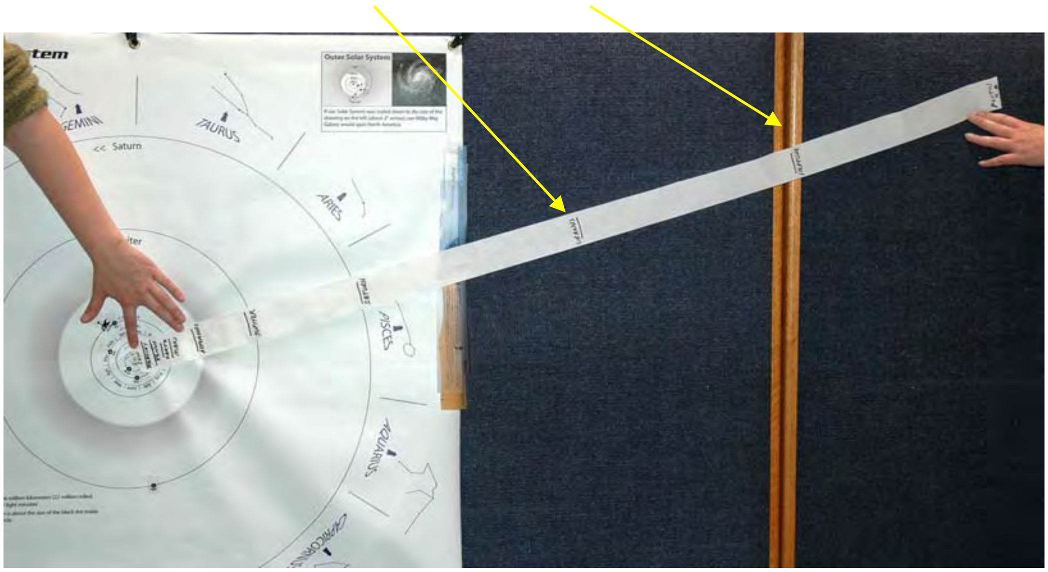
Calls out names of planets

</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
<u>To Say:</u> How many know that we see different constellations in the evening at different times of year? Let's see why. *<u>To Do:</u>* Line up the Horizon Ruler at different places on Earth's orbit, with the "After Sunset" arrow pointing to the Sun (see photo below – the Horizon Ruler is set on Earth's position for October 1st). 	Hands raise.
<u>To Say:</u> As Earth orbits the Sun, the constellations we see change every month. *<u>To Do:</u>* Point to the constellations visible in the evening at each location around Earth's orbit. 	In October, after sunset, Libra is in the west and Pisces is in the east.

Leader’s Role	Participants’ Role (Anticipated)
ORBITS	
<u>To Do:</u> **Show the Orbits Ruler.** Left mark of Mercury’s orbit is here This mark is to be placed at the current position of the planet.  *<u>To Say:</u>* Where will the planets be next month? This ruler is used to help us find out. *<u>To Do:</u>* Pick a planet and place the left mark of the planet’s orbit at the current position of the planet on the banner. Line up the curve of the orbit on the Ruler with the orbit line on the banner. Move the planet’s sticker or place a mark where the right-hand mark falls on the planet’s orbit.  The banner shown in the photo above is set for March 1, 2008. The Orbits Ruler is set to be ready to mark the position of Mercury on April 1, 2008.	

Leader's Role	**Participants' Role (Anticipated)**
To Say: That's where the planet will be in a month. Who wants to mark where [another planet] will be?	Visitor uses Orbits ruler to mark location of another planet.
What about Earth – where will it be? *To Do:* Mark (or have your visitors mark) the rest of the planets. *To Say:* The distance the planet moves in a month is related to the length of its year – how long it takes to orbit the Sun. *To Do:* Point to the "Orbital Periods" box on the banner. *To Say:* (There are a number of discussion topics, such as:) Which planet moves the farthest in a month? Will we see any of these planets in the evening in a month? (Use the Horizon Ruler to check) Where will this planet be next year at this same time? Will we see the same planets in the evening sky? In the direction of which constellations will we see each of the planets? **More Topics:** Venus as morning and evening "star." Mercury is always very close to the horizon.	Visitor points to the place on Earth's orbit.

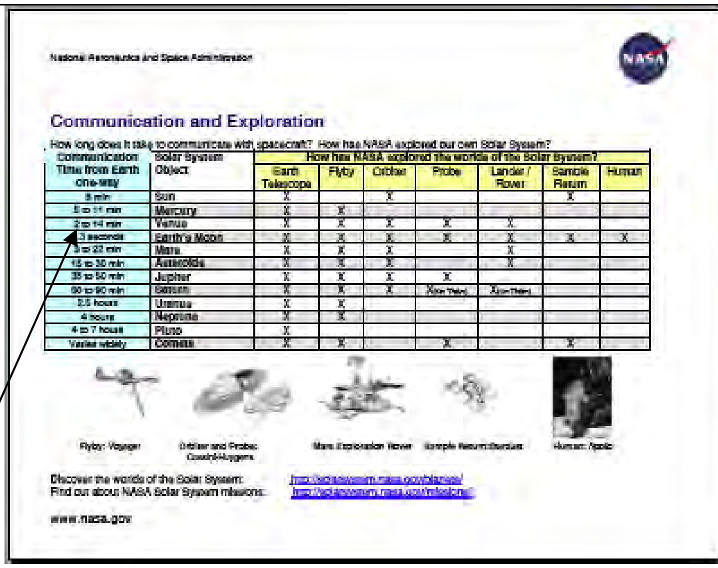
Leader’s Role	Participants’ Role (Anticipated)
LOCATIONS OF ORBITS OF URANUS AND NEPTUNE	
To Do: If you made a five-foot Pocket Solar System, hand the Sun end to a visitor and have them hold it against the banner at the Sun’s position. *To Say:* Let’s see how far away the orbits of Uranus and Neptune will be from the Sun. *To Do:* Stretch out the Pocket Solar System, lining up Jupiter’s and Saturn’s orbit. Point out where Uranus and Neptune’s orbits would be.  *To Say:* Remember that the stars on the banner just represent the direction of the stars. On this scale, the stars are about ten miles to thousands of miles away. Are there are stars between the orbits of Saturn and Uranus? How many stars are in the Solar System? And what do we call it?	Visitor holds Sun end. No! ONE! The Sun!
To Do: Point to the diagram that includes the orbits of Neptune, Uranus, and Pluto in the upper right of the banner. *To Say:* This is on an even smaller scale than the diagram. If our Solar System was shrunk even farther down to be this size, the Galaxy we live in – the Milky Way would span North America.	
Presentation Tip: If you have the Our Galaxy, Our Universe ToolKit, you can use the presentations in that ToolKit to discuss the Galaxy in relation to the Solar System.	

3. Banner: Exploration Activities

Leader's Role	**Participants' Role (Anticipated)**
Materials: Banner, stickers, copies of "Communication and Exploration" handout, wet-erase marking pen, sponge. Light Minutes Ruler Orbits Ruler **For locations of spacecraft** that are en route use NASA's Solar System Simulator: http://space.jpl.nasa.gov/. See "Helpful Hints" for settings.	
Objective: • Provide a clearer understanding of where NASA missions are - connect to viewing planets in the sky • Introduce communication lag time • Provide understanding why we can't send a spacecraft toward where the planet is right now.	
NASA MISSIONS EXPLORING THE SOLAR SYSTEM	
_To Do:_ For the planets visible that evening, place a few of the NASA Mission stickers next to the planets the spacecraft are studying, near, or will be studying. Examples: Saturn: Cassini-Huygens Mars: Mars Exploration Rover  Place the DSN (Deep Space Network) stickers around Earth. These radio telescopes are on Earth and facilitate communications with spacecraft.	

Leader's Role	Participants' Role (Anticipated)
To Say: For some of the planets we'll be viewing in the telescopes tonight, NASA has spacecraft exploring them. Who has heard we have rovers exploring the surface of Mars? Who knows what mission is exploring Saturn right now? We won't see the spacecraft in the telescopes, but you can imagine them at the planet. [Pick a couple of missions to talk about – See "Background Information"]	 Hands up. Cassini
ACTIVITY: WALK LIKE A RADIO WAVE	
To Say: How do we communicate with these missions? Can we call them up or control them with a joystick? We are going to pretend to transform each of you into energy. You will become a radio wave sending communications between Earth and spacecraft in the Solar System. Radio energy is a kind of light energy, just with long wavelengths instead of short wavelengths. Radio energy travels at the same speed as visible light. How far does light travel in a second – anyone? Look at your foot. The length of your foot will represent 186,000 miles. So how far can you travel from heel to toe? And if we pretend you're traveling at the speed of light, how long will it take you to go 186,000 miles or one foot length? Let's spread out and try walking like a radio wave for 10 seconds, heel-to-toe and counting the seconds. (clap for each second as you demonstrate radio-wave-walking. Go to 10 seconds) Stop. How far did we travel in 10 seconds with your foot length representing 186,000 miles? That's 10 light seconds.	 No! 186,000 miles (300,000 km) 186,000 miles 1 second. 1,860,000 miles.

Leader's Role	Participants' Role (Anticipated)
To Do: Hand out "Communication and Exploration" sheet. *To Say:* Here's a chart that shows how long light takes to travel from Earth to various places in the Solar System. Look at the column on the left called "Communication Time from Earth – one-way."	


National Aeronautics and Space Administration

Communication and Exploration

How long does it take to communicate with spacecraft? How has NASA explored our own Solar System?

Communication Time from Earth one-way	Solar System Object	How has NASA explored the worlds of the Solar System? Earth Telescope	Flyby	Orbiter	Probe	Lander / Rover	Sample Return	Human
8 min	Sun	X		X			X	
5 to 11 min	Mercury	X	X					
2 to 14 min	Venus	X	X	X	X	X		
1.3 seconds	Earth's Moon	X	X	X	X	X	X	X
3 to 22 min	Mars	X	X	X		X		
15 to 30 min	Asteroids	X	X	X		X		
35 to 50 min	Jupiter	X	X	X	X			
60 to 90 min	Saturn	X	X	X	X (on Titan)	X (on Titan)		
2.5 hours	Uranus	X	X					
4 hours	Neptune	X	X					
4 to 7 hours	Pluto	X						
Varies widely	Comets	X	X		X		X	

Discover the worlds of the Solar System: http://solarsystem.nasa.gov/planets/
Find out about NASA Solar System missions: http://solarsystem.nasa.gov/missions/

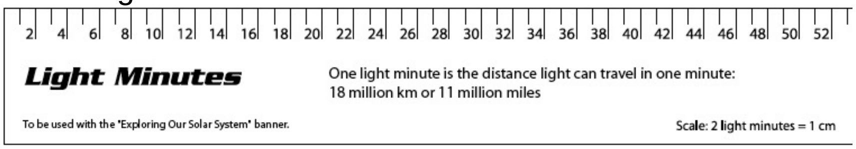
www.nasa.gov

Leader's Role	Participants' Role (Anticipated)
How long does the chart say it takes radio waves to get from Earth to Moon?	1.3 seconds.
How many foot-lengths is that?	One plus a little bit.
So is the Moon farther than 186,000 miles or closer?	Farther!
When Earth and Mars are closest, how long will it take to send a communication?	3 minutes.
Yes, that's 180 seconds. So is it farther than 186,000 miles away?	A lot farther!
I'll let you use your calculators to figure out how far.	
So if the distance light travels in one second is called a light second, what do we call the distance light can travel in a minute?	A light minute.
And the distance light can travel in a year?	A light year!

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td>LIGHT MINUTES RULER: COMMUNICATIONS</td><td></td></tr>
<tr><td>

To Do:

Show Light Minutes Ruler.



To Say:

All the distances to the planets in the Solar System can be measured in light minutes.

We can use this to measure on the banner how long it takes to communicate with spacecraft at other planets.

This is marked in light minutes. One light minute is the distance light can travel in a …?

</td><td>

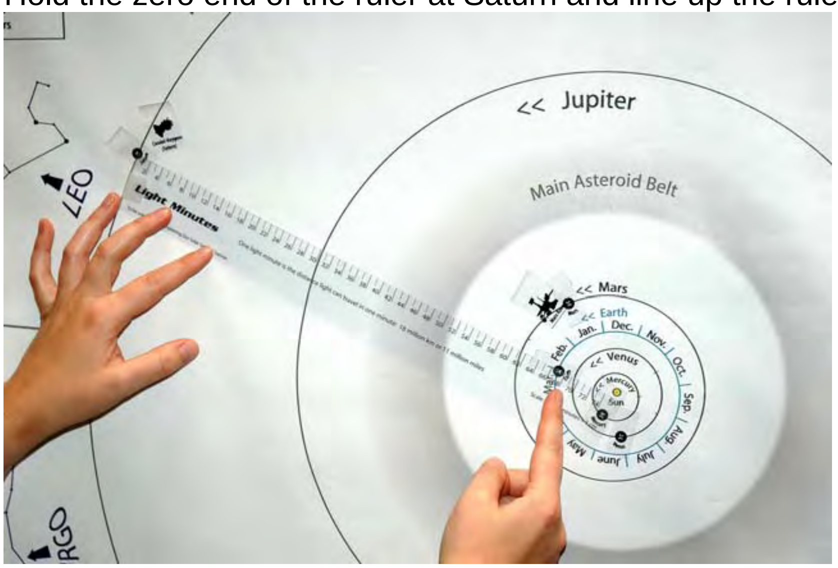
Minute!

</td></tr>
<tr><td>

Let's measure how long it takes for a photo of Saturn radioed by Cassini to reach Earth.

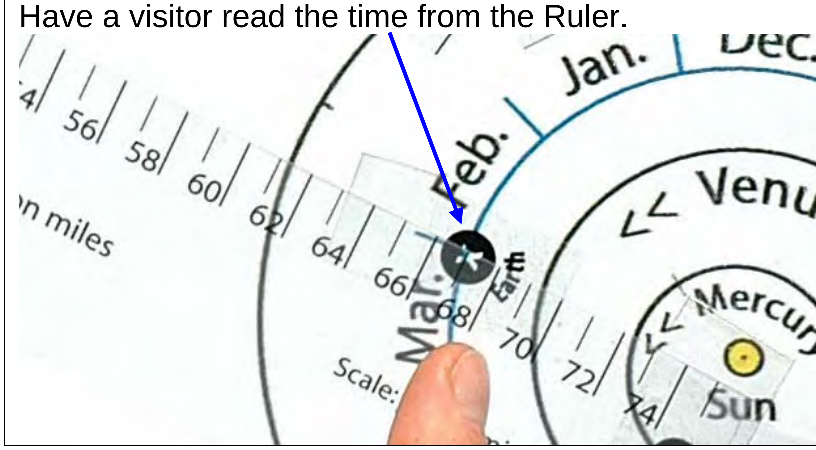
To Do:

Hold the zero end of the ruler at Saturn and line up the ruler with Earth.



</td><td></td></tr>
<tr><td>

Have a visitor read the time from the Ruler.



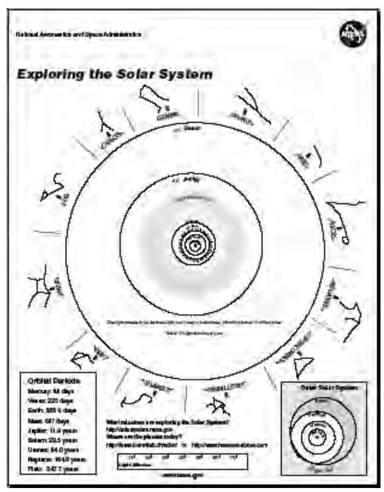
</td><td>

67 minutes (or whatever it is in your own example).

</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
To Say: What time is it right now? What time will it be when that radio message Cassini is sending right now reaches Earth?	Visitor looks at watch & gives time. Time+67 minutes.
To Say: Remember that spacecraft traveling to the planets take a lot longer to get there than radio communications do. How long did the handout say it takes to send a message to the Moon? Can we travel to the Moon that fast? That's right. It can take a few days to get there. But the other planets, it can take a few months or years to get there. Many people think that the best time to send a spacecraft is when the planet is closest to Earth. *To Do:* Place the Mars sticker on the orbit of Mars across from where Earth is. Pick up the Orbits Ruler. *To Say:* If we aim the spacecraft in that direction and if it takes six or seven months, say, to travel from Earth to Mars, where would Mars be six months later? *To Do:* Use the Orbits Ruler to mark the location of Mars in six months. *To Say:* Would the spacecraft reach Mars? Right, we need to aim the spacecraft where the planet WILL be, like where a quarterback has to throw a football to reach his receiver. Ready to see the planets in the telescopes?	 1.3 seconds. No. No! Yeah!

4. Handout: Exploring Our Solar System

Leader's Role	**Participants' Role (Anticipated)**
Materials: Handout for banner: Exploring the Solar System *Optional*: Pencils. *Optional*: You may want to copy your club information on the back of the handout.	
Objective: • Provide visitors with a handout that reinforces some of the messages of the banner • Provide visitors with websites to get more information about NASA missions exploring the Solar System and about the planets.	
<u>*To Do:*</u> After your presentation, pass around copies of the banner handout. *Optional*: Pass out pencils. <u>*To Say:*</u> Here is a copy of the banner with some websites to find out more about NASA missions exploring the Solar System. Let's mark the locations of the planets on your handouts. 	Takes handouts. Visitors mark the locations of planets from the locations shown on the banner.

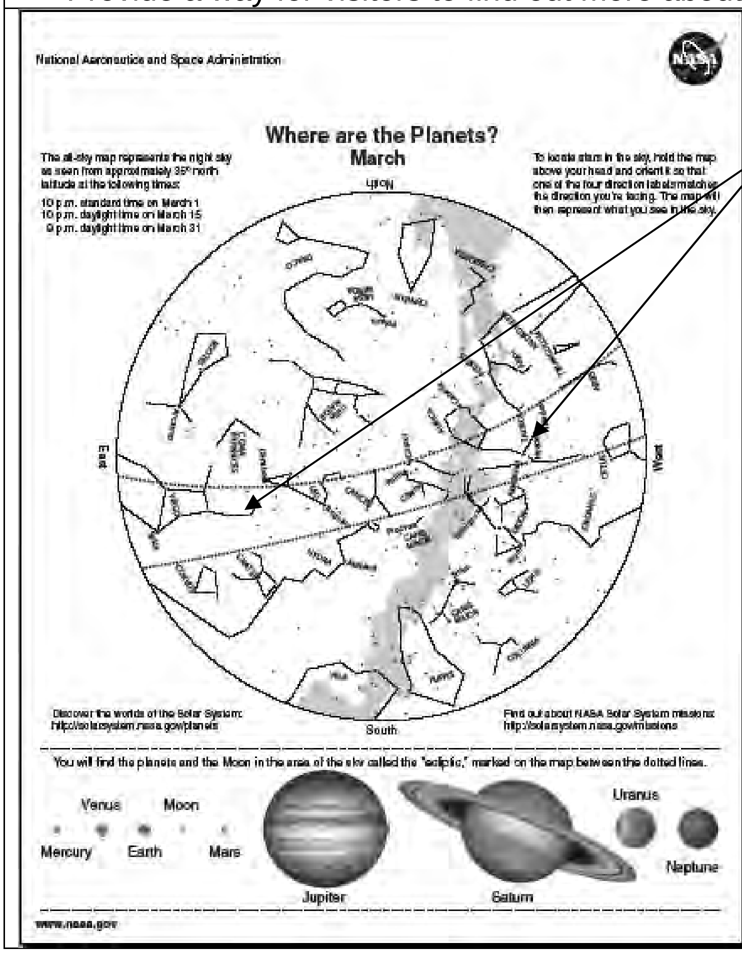
5. Star Maps: Where are the Planets?

Leader's Role	**Participants' Role (Anticipated)**

Materials:
Copies of current month's star map: Where are the Planets?
Optional: You may want to copy your club information on the back of the map.

Objective:

- Provide visitors with a handout to plot the positions of the planets they saw in the evening sky.
- Provide visitors with scaled sizes of the planets.
- Provide a way for visitors to find out more about the planets and NASA missions.



More information on the star maps:
This star map has 20-degree wide area centered on the ecliptic. The planets and Earth's Moon will be found in this region of the sky.

Presentation Tip:
Most people think the Moon and planets might be found anywhere in the sky. This map helps reinforce the message of the banner that the planets will be found in the direction of the constellations of the ecliptic in the plane of our Solar System.

Be sure to help your visitors orient the map correctly. If facing north, the side of the map marked "North" should be down, toward the northern horizon. The same is true for each direction.

Leader’s Role	**Participants’ Role (Anticipated)**
To Do: Pass around copies of the star maps. *To Say:* These star maps just show the constellations in the sky and don’t include the positions of the planets. You get to mark on the map where you saw the planets. Pictures of the planets, scaled to the correct sizes, are shown at the bottom of the map. See the dotted area on the map? This is the region of the sky where you look to find planets and Earth’s Moon. If you see a bright object that looks like a star and it’s not moving (moving “stars” could be airplanes or satellites), it might be a planet. Look at your star map and see if the star-like object shows up as one of the stars on the map. If it doesn’t, you are probably seeing a planet. Ask one of the telescope operators to show it to you. You might be able to tell which planet it is by seeing it in the telescope.	Takes maps. Yes. Looks up at the sky, looking for planets.
To Do: You may want to provide a quick training on how to use a star map. *To Say:* Road maps are read with the map oriented down, where the roads are. A star map is oriented up, where the stars are. Let’s all face north. Rotate your star map so the side of the map marked “North” is down toward the northern horizon. All the constellations in that quarter of the map will be visible in front of you. Now let’s turn toward the east. Rotate the map so the side of the map marked “East” is down toward the eastern horizon. All the constellations in that quarter of the map will be visible in front of you.	Visitors follow directions.
To Say: Now look straight up. What part of the map will show the stars over your head? Right! Now, who can find [name a constellation]?	The center of the map? Visitors use star map.

Materials

<u>What materials from the ToolKit do I need?</u>

In the activity bag:

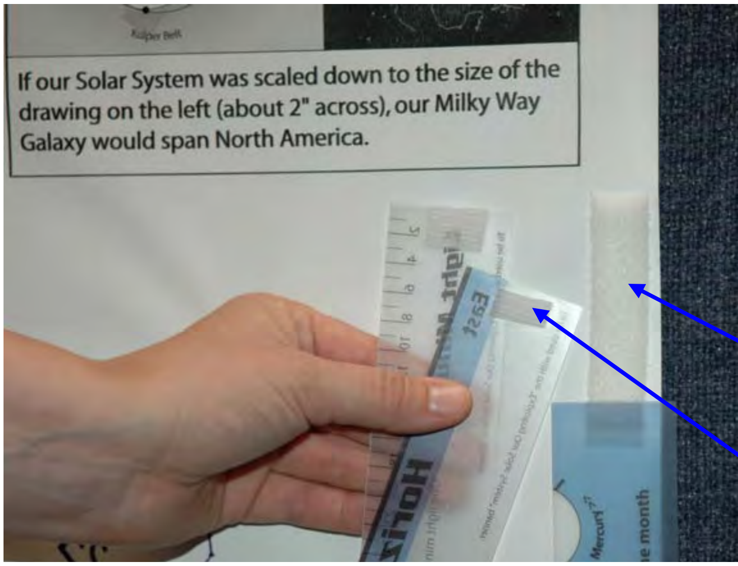
1. Banner: “Exploring Our Solar System”
2. Planets & Missions sticker sheet
3. 1 wet-erase marking pen
4. Sponge
5. Orbits Ruler
6. Light-Minutes ruler
7. Horizon Ruler
8. Velcro straps
9. A strip of Velcro
10. Copies of Banner Handout
11. Copies of “Where are the Planets?” star maps (one for each month: March through July)
12. 1 copy “Communication and Exploration” handout
13. Printout of planet positions for March 1, 2008

<u>What must I supply?</u>

- Scissors to cut out the Planet and Mission stickers.

What do I need to prepare?

Rulers



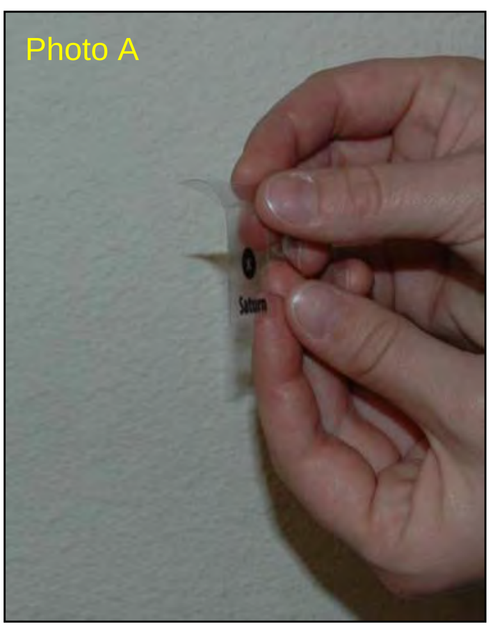
The Orbits, Light Minutes, and Horizon rulers are used with the Solar System banner.

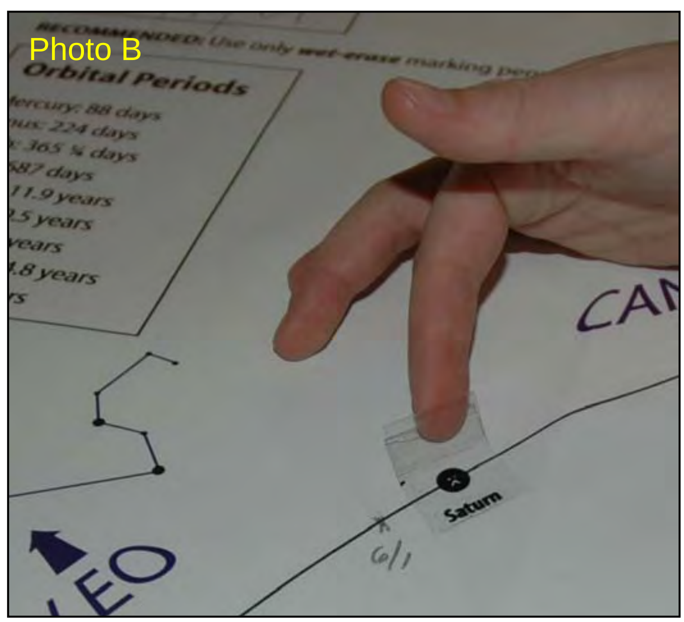
If you want to attach the rulers to the banner, cut a 2" to 3" strip of Velcro loop material and attach it to the banner. Then cut small pieces of Velcro hook material and place them at one end of each ruler. Attach the rulers to the banner.

Planet and Mission Stickers

These are used with the Solar System banner. They are used to mark the current location of each planet and NASA missions on the banner. They are on clear low-stick vinyl.

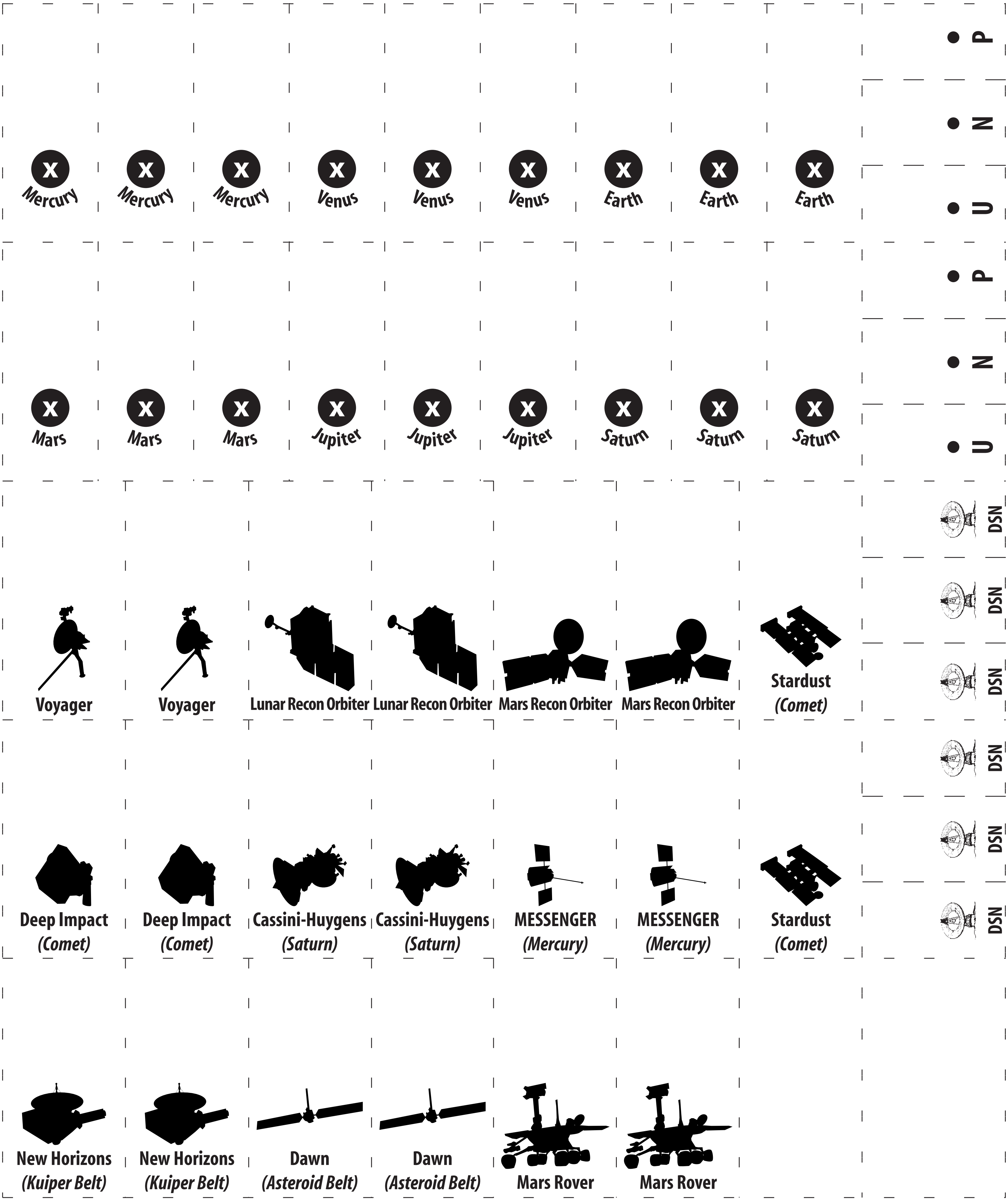
Cut out the stickers, cutting just inside the dotted lines. Peel off the backing, then fold the top part of each sticker in half so you have a tab (See Photo A below). You will use the tab as a "handle" to place the sticker on the banner (see Photo B) and then easily pull it off. See "Helpful Hints" for cleaning the stickers on page 65.



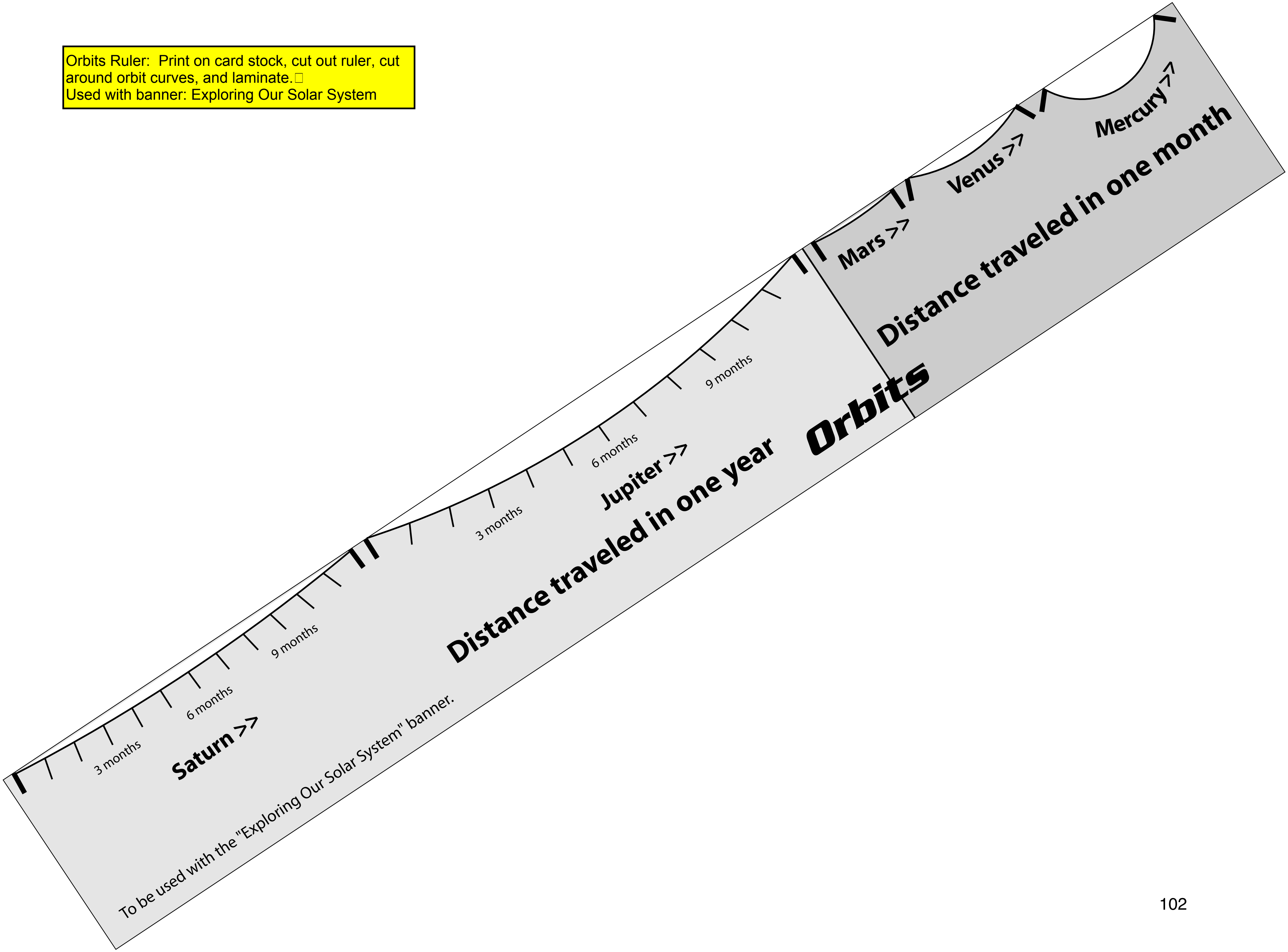


Where do I get additional materials?

1. Banner: “Exploring Our Solar System”: The PDFs for this banner are on the Manual & Resources CD. The file names are “SolSysDiagram.pdf” and “SolSysDiagramSun.pdf” (for the reverse side). You may have a full-size banner made from these files at a copy store or other printing company.
2. Planets & Missions sticker sheet: Instead of the stickers, you can use the wet-erase marking pens. See “Helpful Hints” for how to clean the stickers.
3. Wet-erase marking pen: office supply store.
4. Sponge: grocery or variety store.
5. Orbits, Light Minutes, and Horizon rulers: The PDFs for the rulers are on pages 102 and 103. Print onto card stock. For durability, laminate them after you cut them out.
6. Velcro straps: office supply
7. Copies of Banner Handout: the master for this is on page 104.
8. Copies of “Where are the Planets?” star maps: the masters for these start on page 105.
9. Copies of “Communication and Exploration” handout: The master is on page 28. This is also provided on the Manual & Resources CD as a Word Document, named “SolSysCommExploreHO.doc,” so you can update the chart as future missions explore more of the Solar System.
10. Printout of planet positions for March 1, 2008: the master for this is on page 117. Make you own from http://www.fourmilab.ch/cgi-bin/Solar

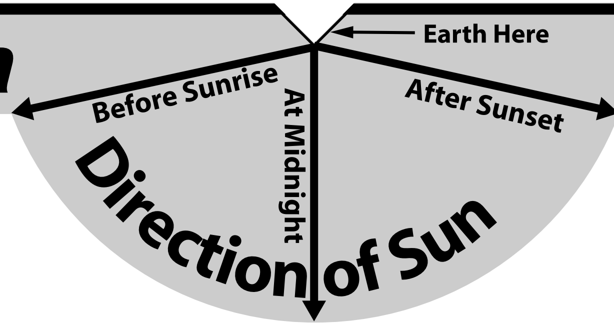

X Mercury
X Mercury
X Mercury
X Venus
X Venus
X Venus
X Earth
X Earth
X Earth
X Mars
X Mars
X Mars
X Jupiter
X Jupiter
X Jupiter
X Saturn
X Saturn
X Saturn
P
N
U
P
N
U
Voyager
Voyager
Lunar Recon Orbiter
Lunar Recon Orbiter
Mars Recon Orbiter
Mars Recon Orbiter
Stardust (Comet)
Deep Impact (Comet)
Deep Impact (Comet)
Cassini-Huygens (Saturn)
Cassini-Huygens (Saturn)
MESSENGER (Mercury)
MESSENGER (Mercury)
Stardust (Comet)
New Horizons (Kuiper Belt)
New Horizons (Kuiper Belt)
Dawn (Asteroid Belt)
Dawn (Asteroid Belt)
Mars Rover
Mars Rover
DSN
DSN
DSN
DSN
DSN
DSN

Orbits Ruler: Print on card stock, cut out ruler, cut around orbit curves, and laminate.
Used with banner: Exploring Our Solar System



Horizon Ruler and Light Minutes Ruler: Print on card stock, cut out and laminate.
Used with banner: Exploring Our Solar System

East **Horizon** **West**



INSTRUCTIONS:

1. Place the position of Earth in the notch labeled "Earth Here".
2. If evening, point the arrow labeled "After Sunset" at the Sun.
3. Look above the black line labeled "Horizon", in this direction
   Any planets or stars above the Horizon line will be visible in the night sky after sunset.
4. To see what planets will be in the sky before sunrise, rotate the ruler around, keeping Earth in the notch, until the arrow labeled "Before Sunrise" is pointing toward the Sun.

To be used with the "Exploring Our Solar System" banner.

2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52

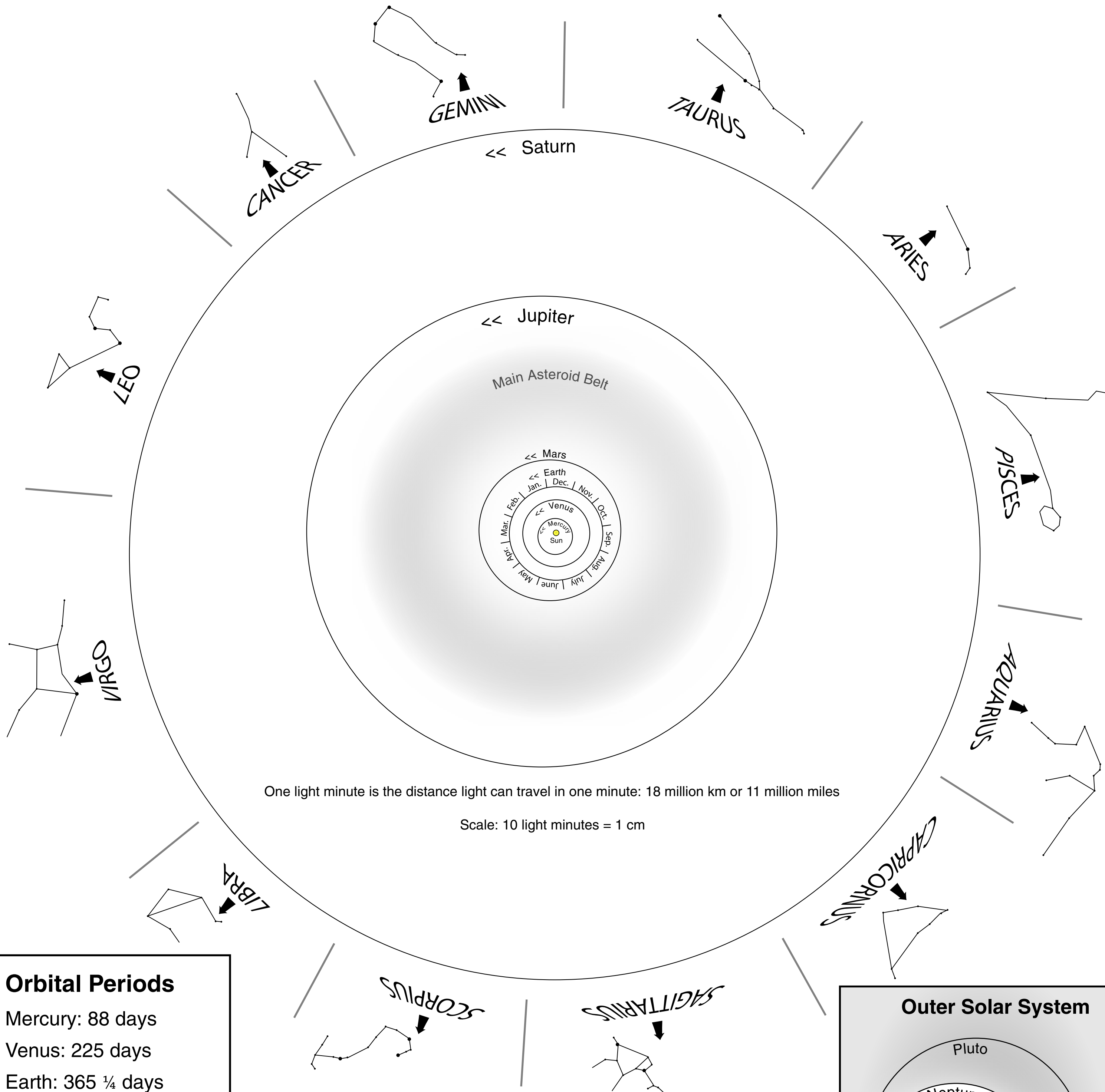
Light Minutes

One light minute is the distance light can travel in one minute:
18 million km or 11 million miles

To be used with the "Exploring Our Solar System" banner.

Scale: 2 light minutes = 1 cm

Exploring the Solar System



One light minute is the distance light can travel in one minute: 18 million km or 11 million miles

Scale: 10 light minutes = 1 cm

Orbital Periods

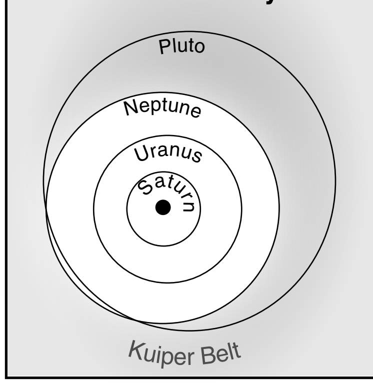
Mercury: 88 days
Venus: 225 days
Earth: 365 ¼ days
Mars: 687 days
Jupiter: 11.9 years
Saturn: 29.5 years
Uranus: 84.0 years
Neptune: 164.8 years
Pluto: 247.7 years

What missions are exploring the Solar System?
http://solarsystem.nasa.gov
Where are the planets today?
http://www.fourmilab.ch/solar/ or http://www.heavens-above.com

10	20	30	40	50	60	70

Light Minutes

Outer Solar System

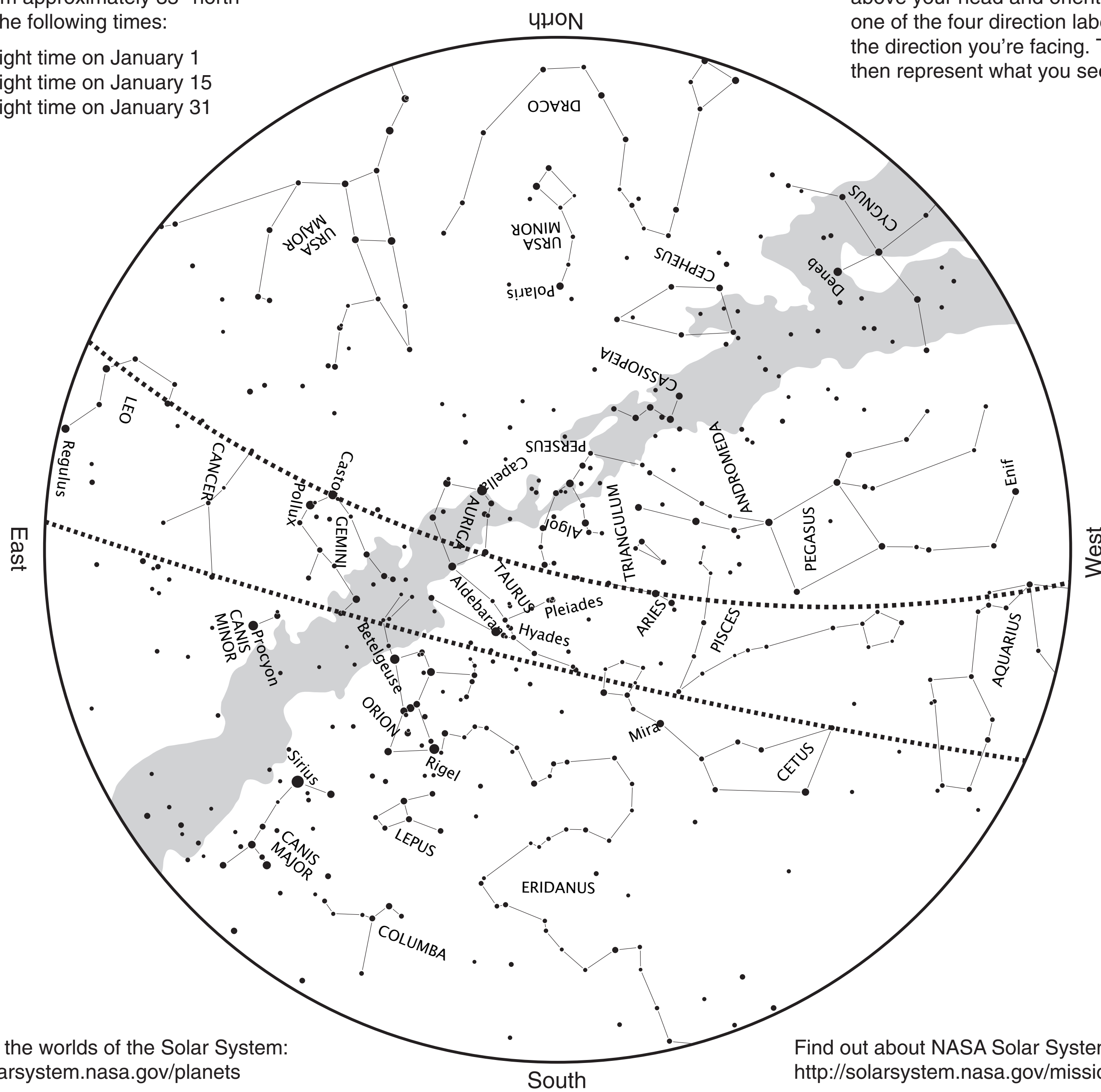


Where are the Planets?
January

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. daylight time on January 1
8 p.m. daylight time on January 15
7 p.m. daylight time on January 31

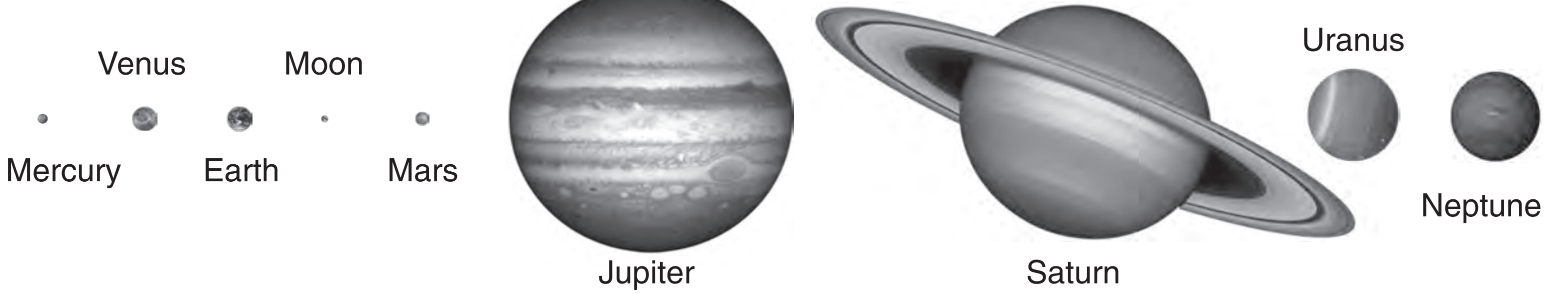
To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
http://solarsystem.nasa.gov/planets

Find out about NASA Solar System missions:
http://solarsystem.nasa.gov/missions

You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



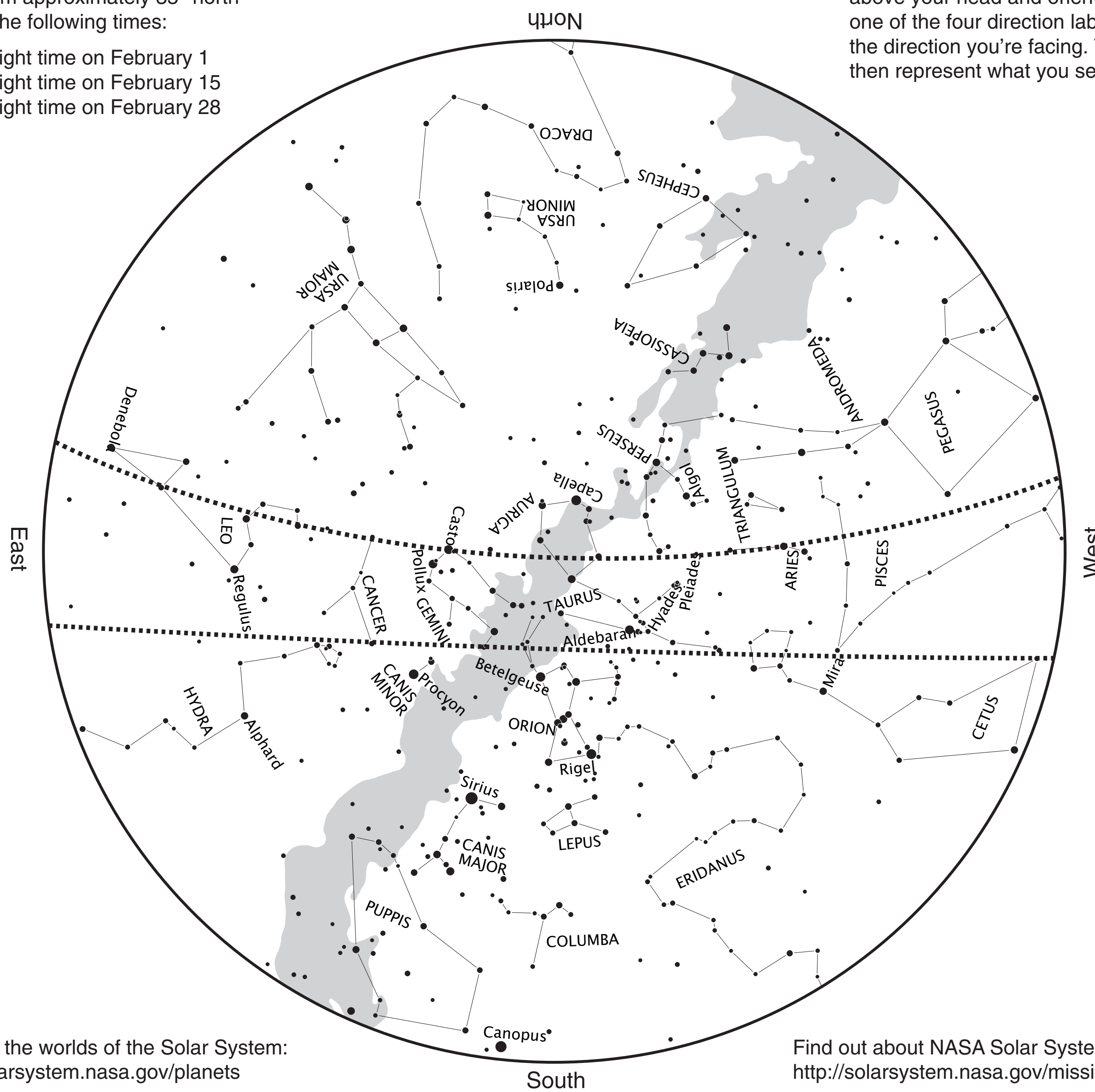
National Aeronautics and Space Administration

Where are the Planets?
February

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. daylight time on February 1
8 p.m. daylight time on February 15
7 p.m. daylight time on February 28

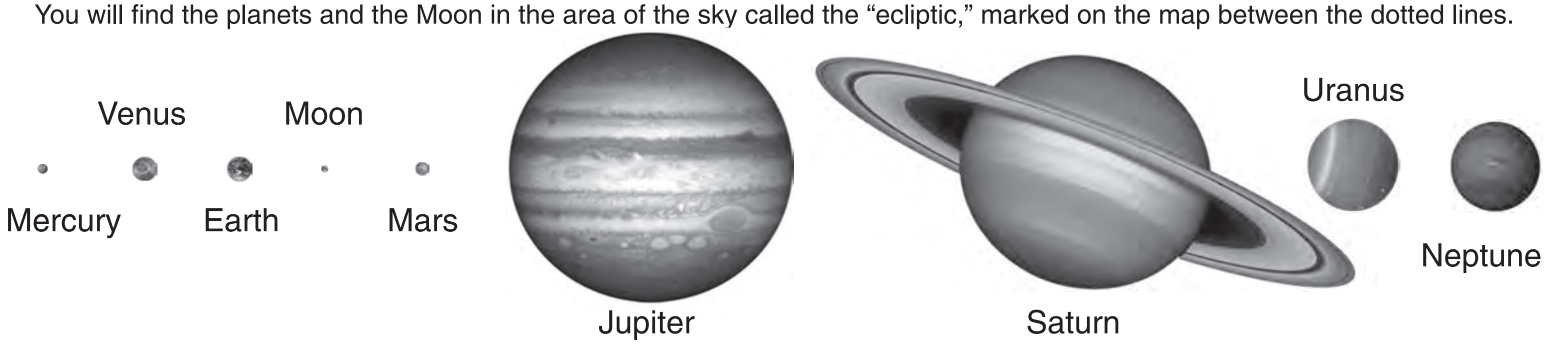
To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
http://solarsystem.nasa.gov/planets

Find out about NASA Solar System missions:
http://solarsystem.nasa.gov/missions

You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



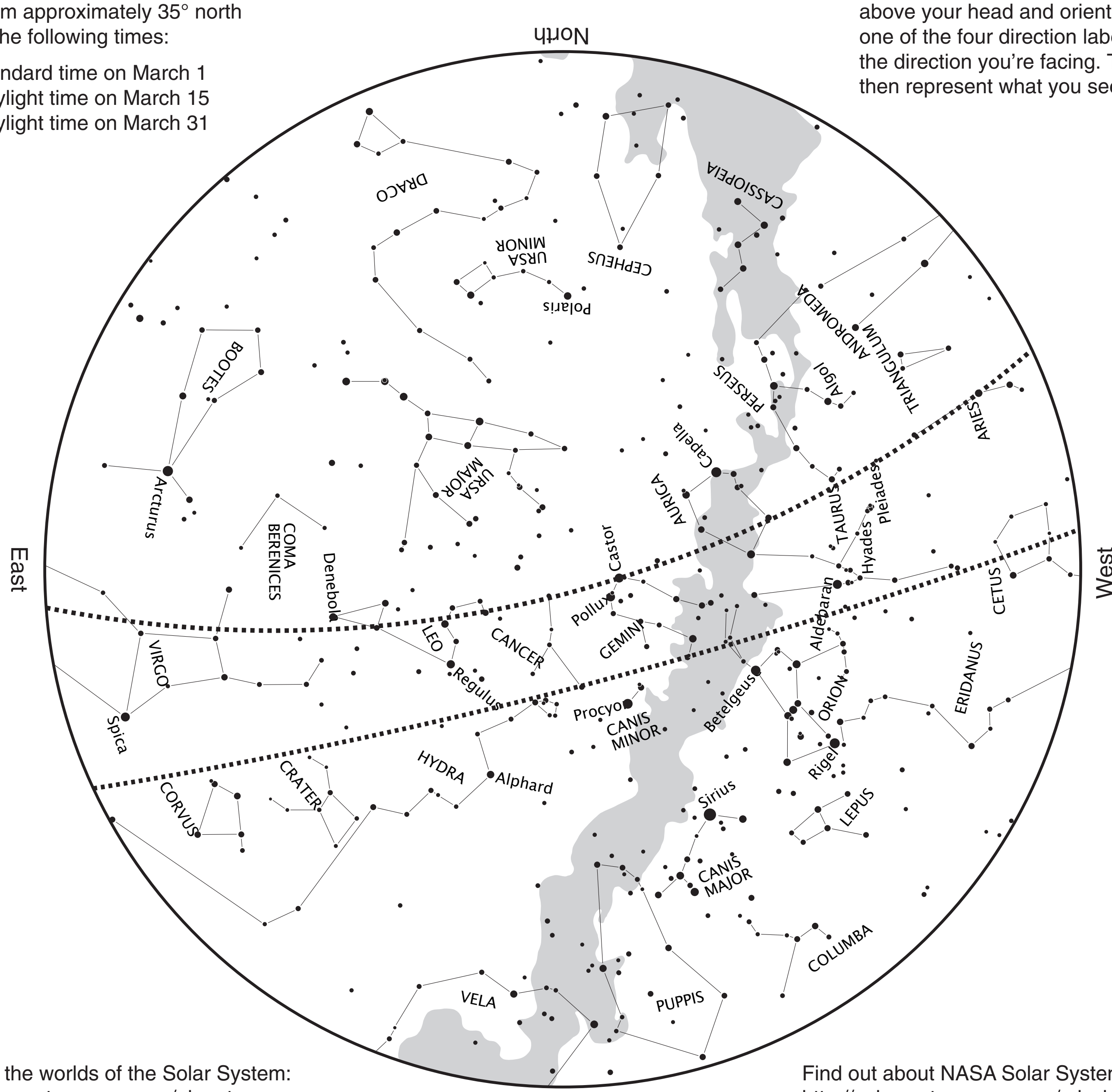
National Aeronautics and Space Administration

Where are the Planets?
March

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. standard time on March 1
10 p.m. daylight time on March 15
9 p.m. daylight time on March 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
http://solarsystem.nasa.gov/planets

Find out about NASA Solar System missions:
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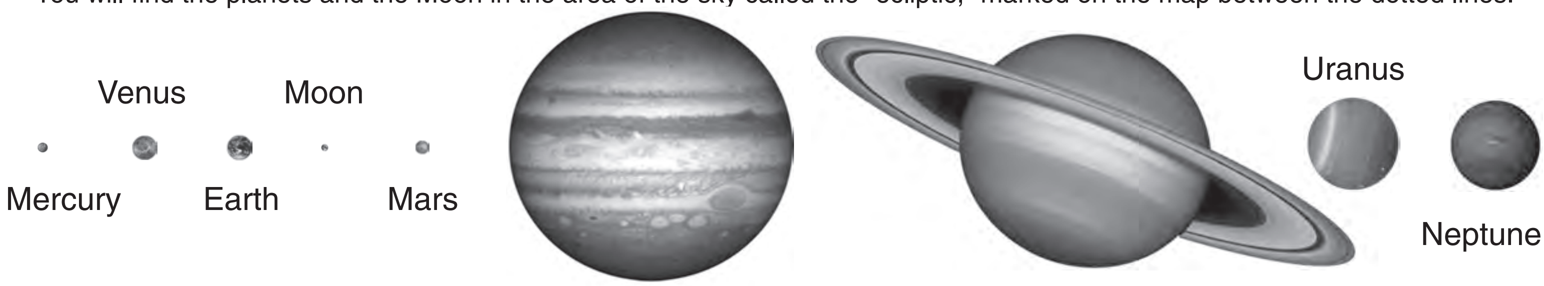
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.

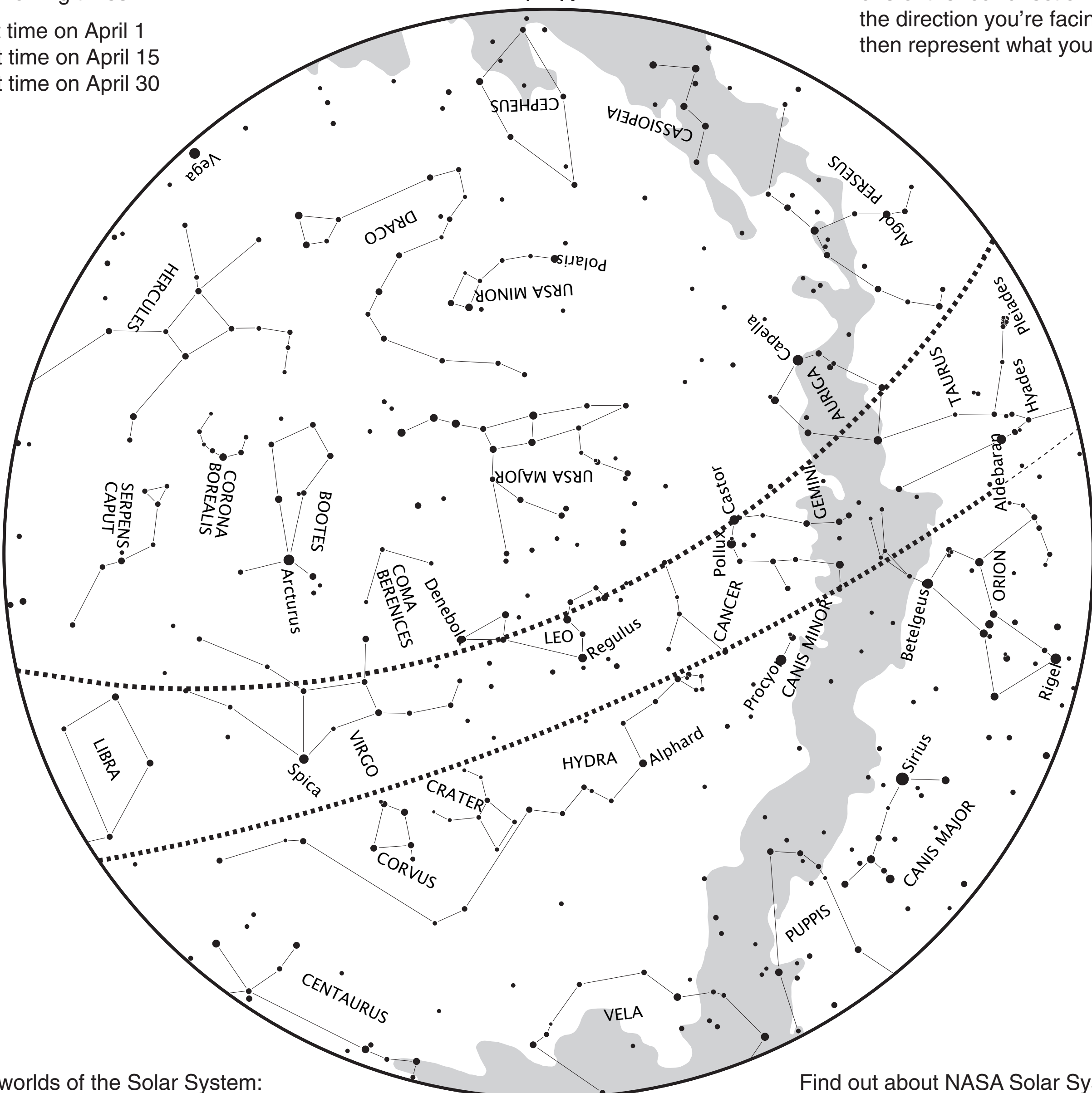


Where are the Planets?
April

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

11 p.m. daylight time on April 1
10 p.m. daylight time on April 15
9 p.m. daylight time on April 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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Find out about NASA Solar System missions:
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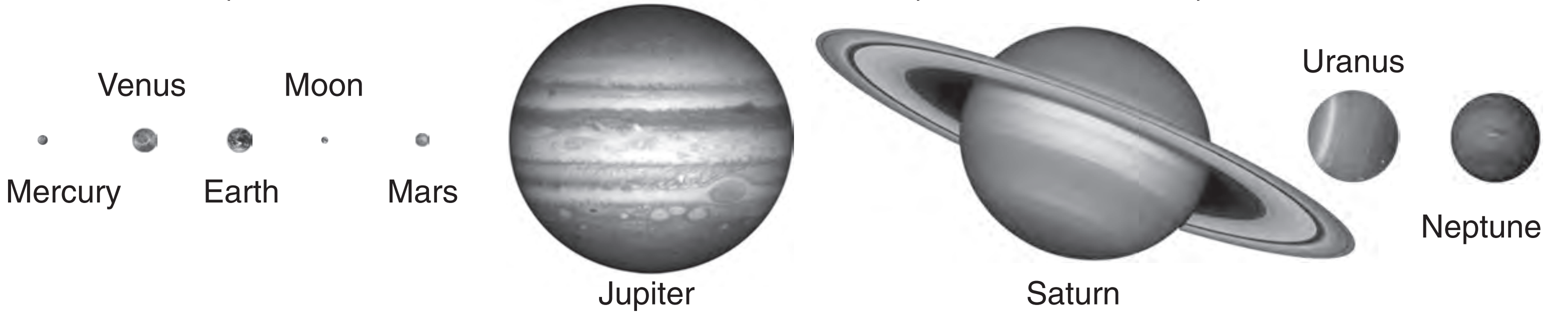
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



National Aeronautics and Space Administration

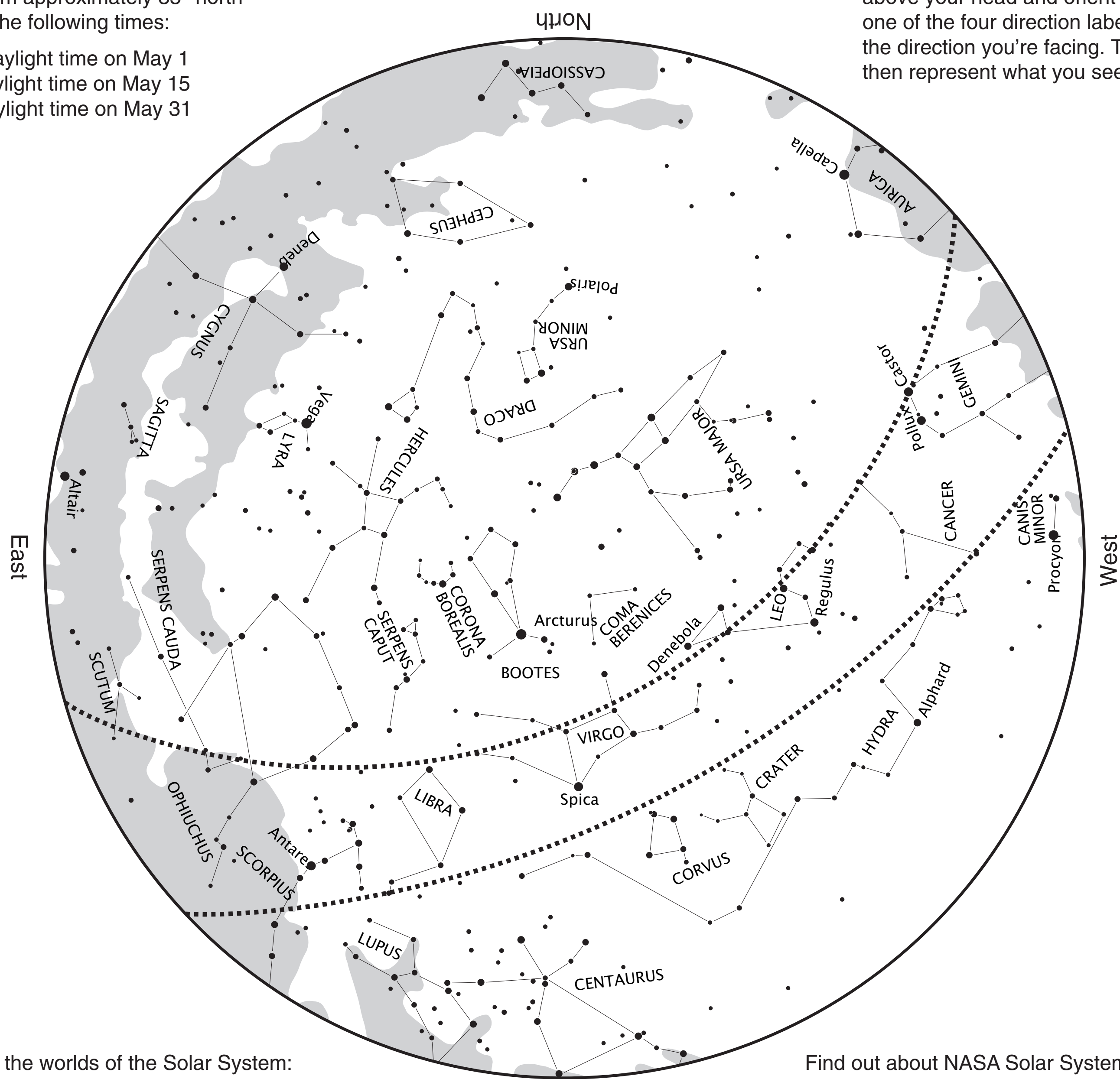
Where are the Planets?

May

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

Midnight daylight time on May 1
11 p.m. daylight time on May 15
10 p.m. daylight time on May 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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Find out about NASA Solar System missions:
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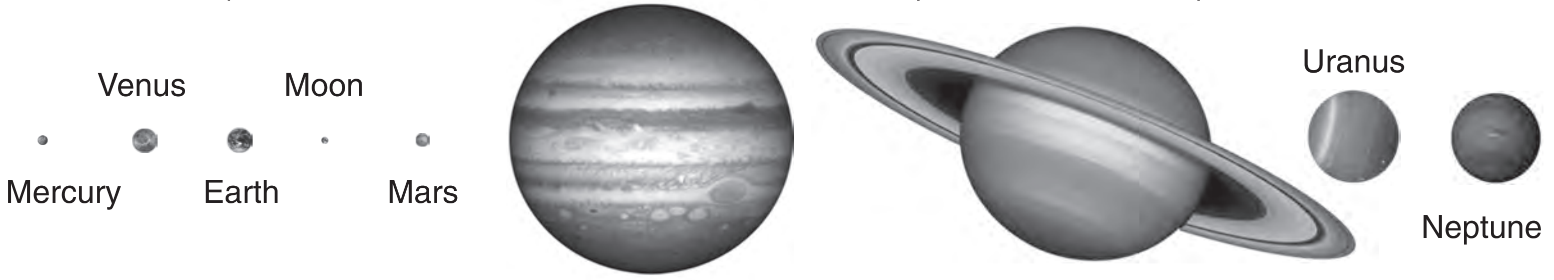
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



National Aeronautics and Space Administration

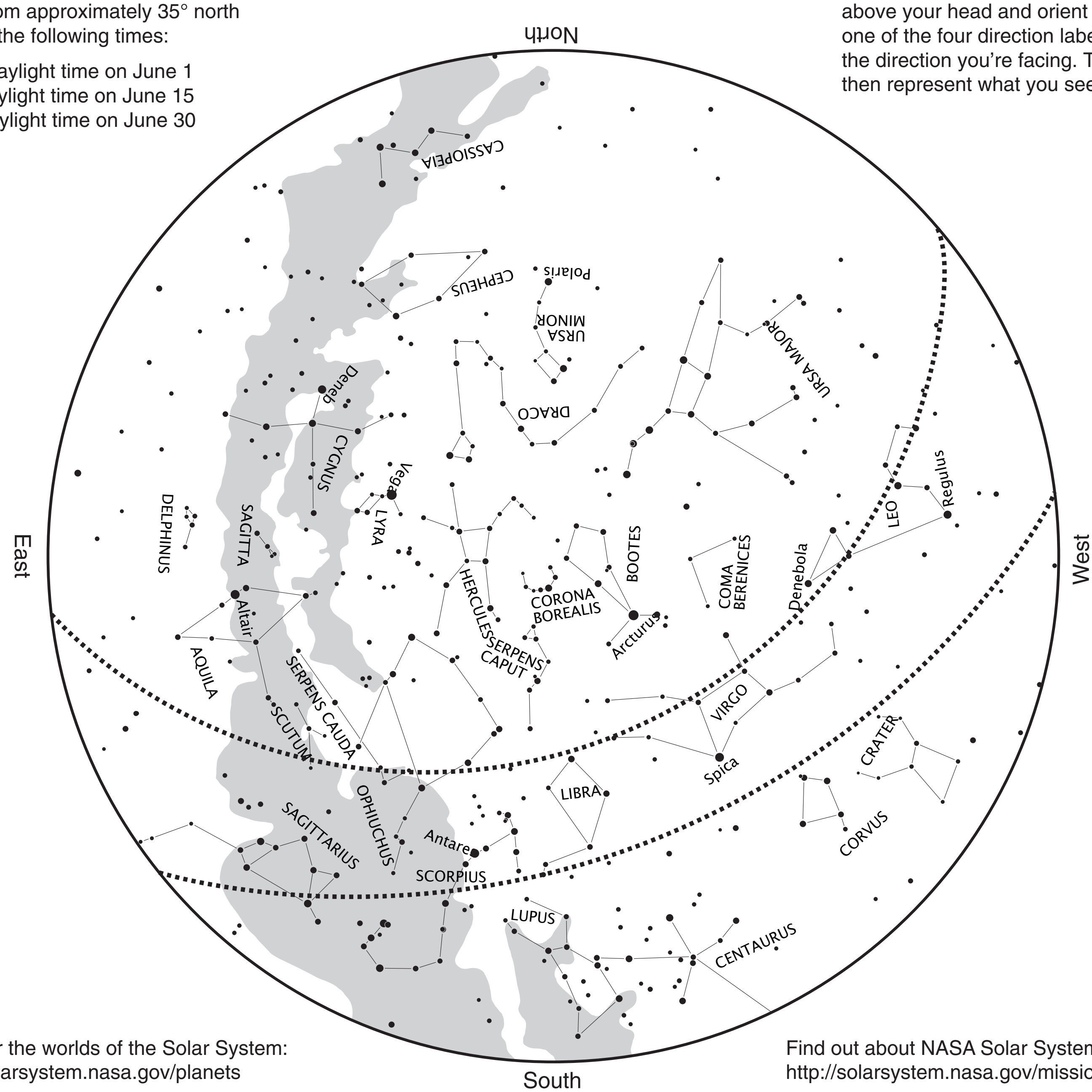
Where are the Planets?

June

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

Midnight daylight time on June 1
11 p.m. daylight time on June 15
10 p.m. daylight time on June 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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http://solarsystem.nasa.gov/planets

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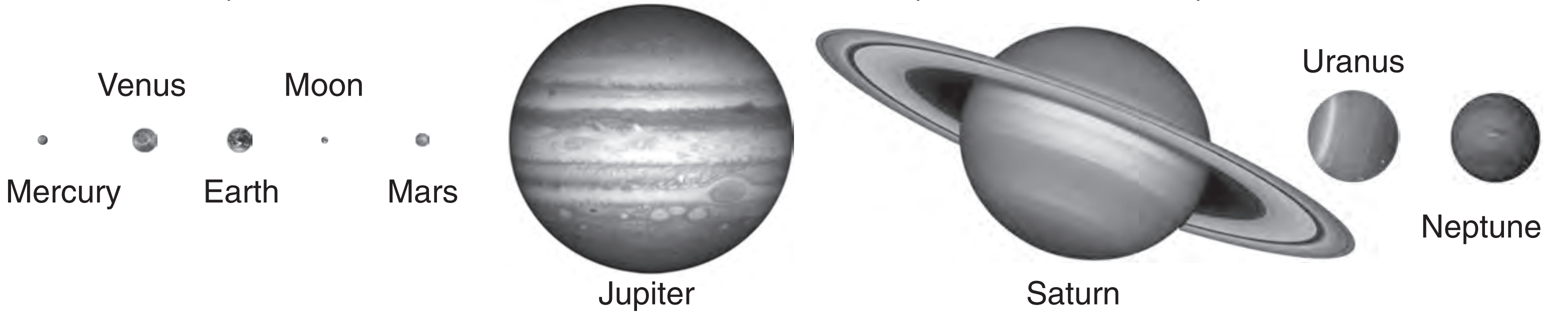
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



National Aeronautics and Space Administration

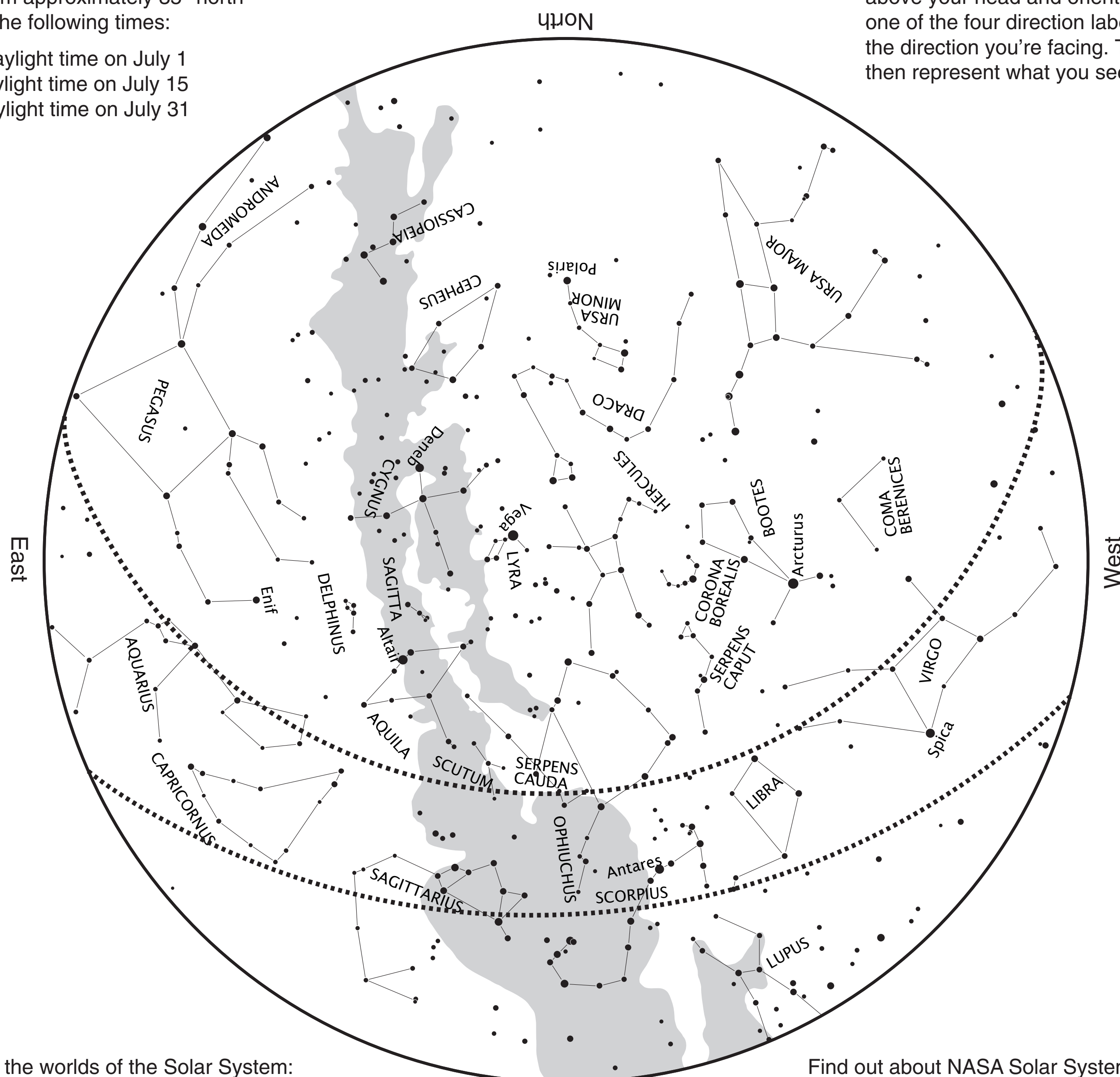
Where are the Planets?

July

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

Midnight daylight time on July 1
11 p.m. daylight time on July 15
10 p.m. daylight time on July 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
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Find out about NASA Solar System missions:
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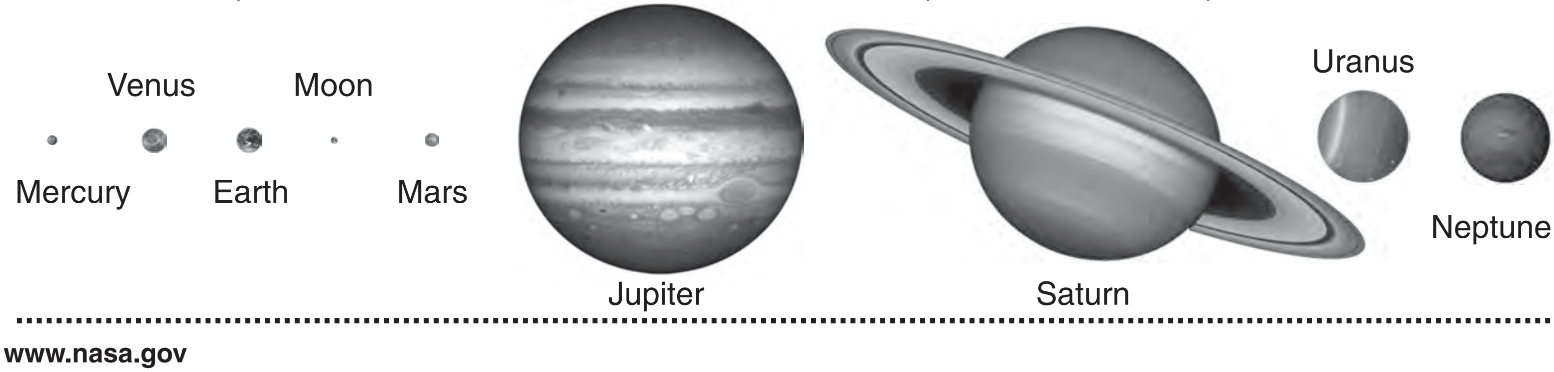
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.

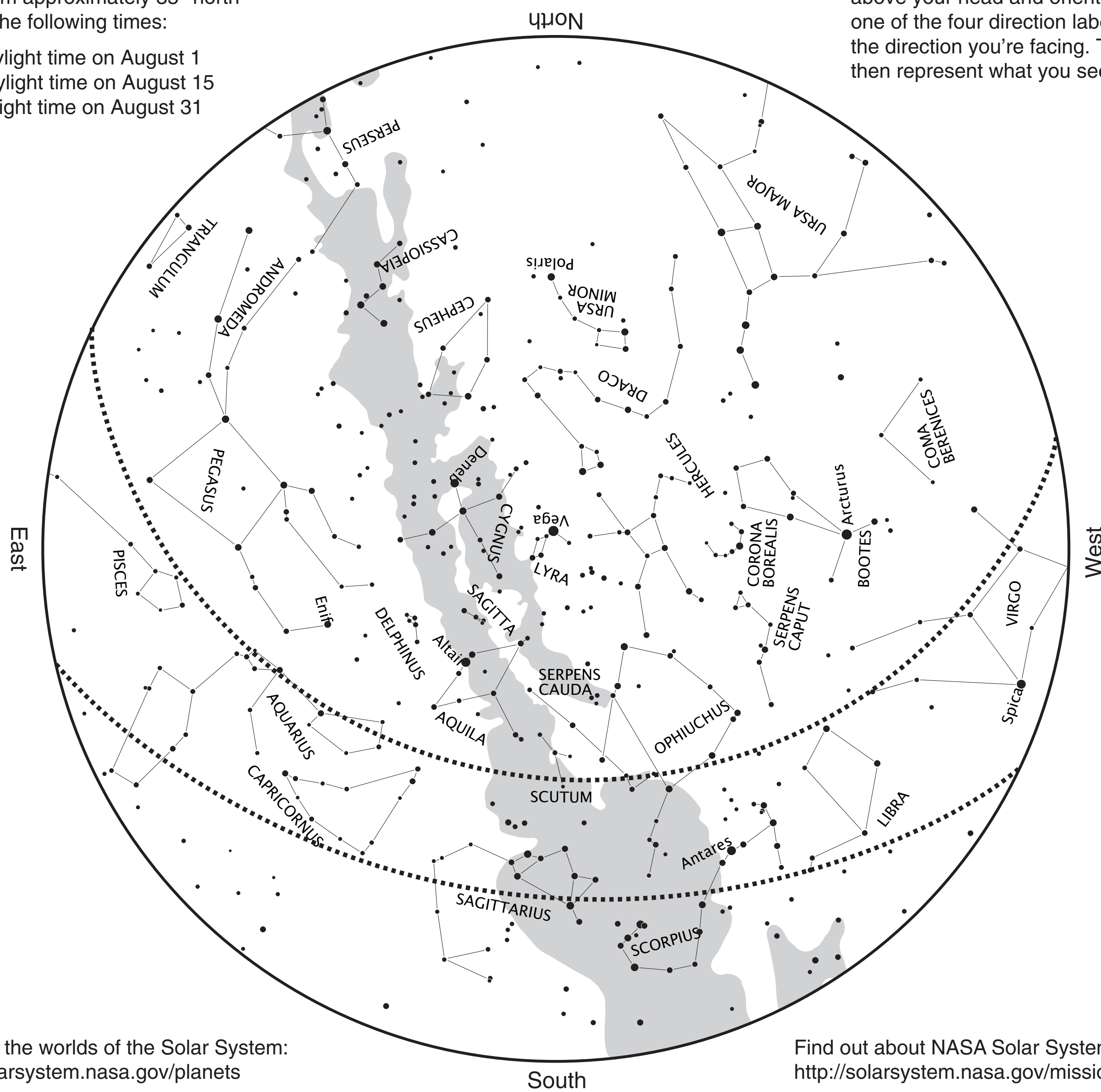


Where are the Planets?
August

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

11 p.m. daylight time on August 1
10 p.m. daylight time on August 15
9 p.m. daylight time on August 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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http://solarsystem.nasa.gov/planets

Find out about NASA Solar System missions:
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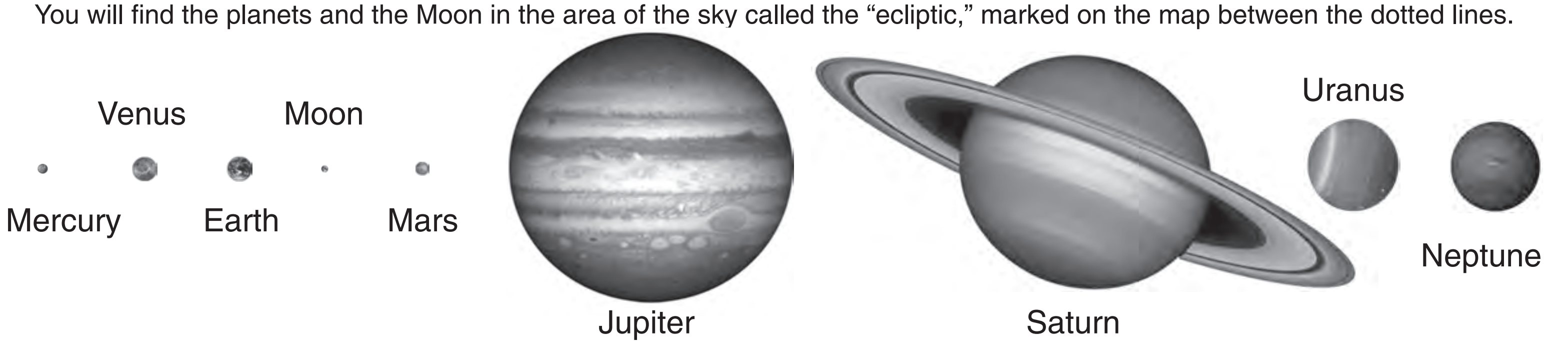
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



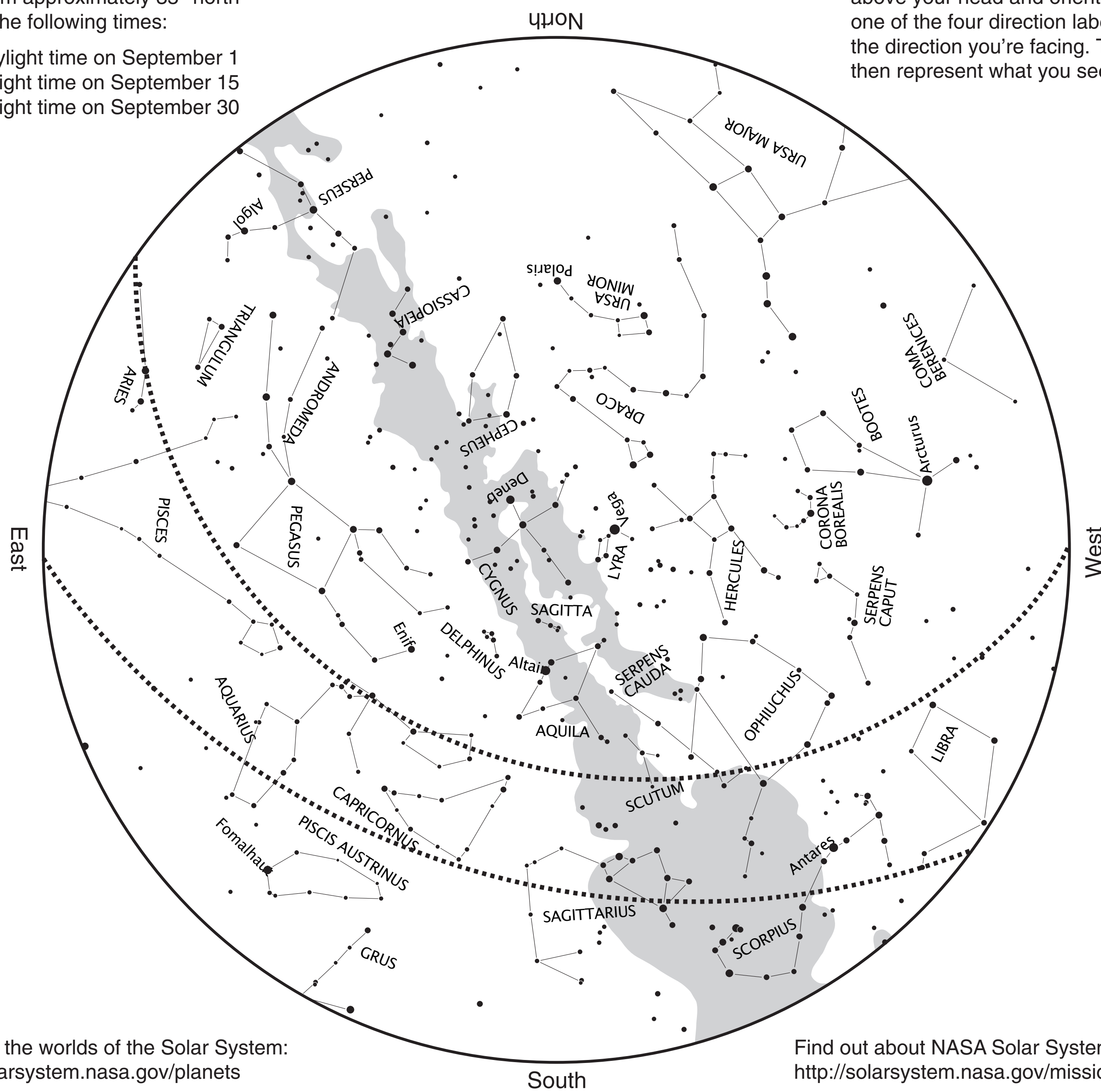
National Aeronautics and Space Administration

Where are the Planets?
September

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on September 1
9 p.m. daylight time on September 15
8 p.m. daylight time on September 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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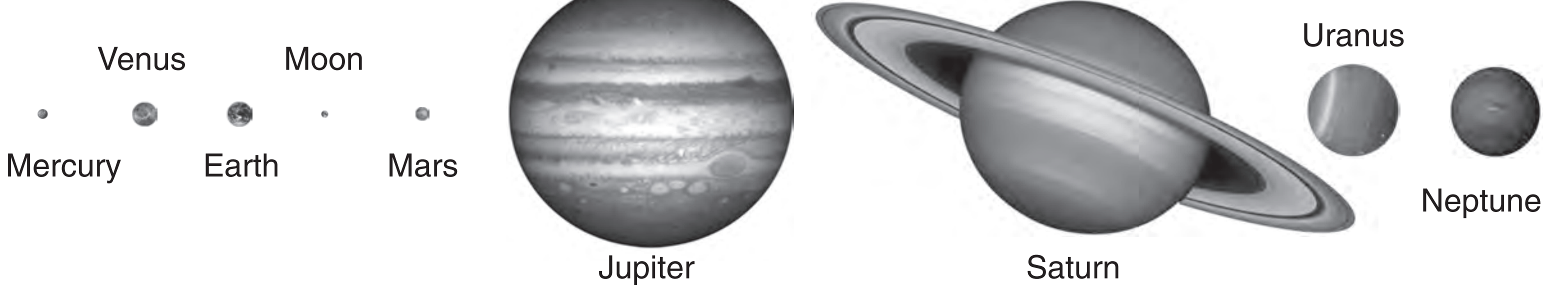
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



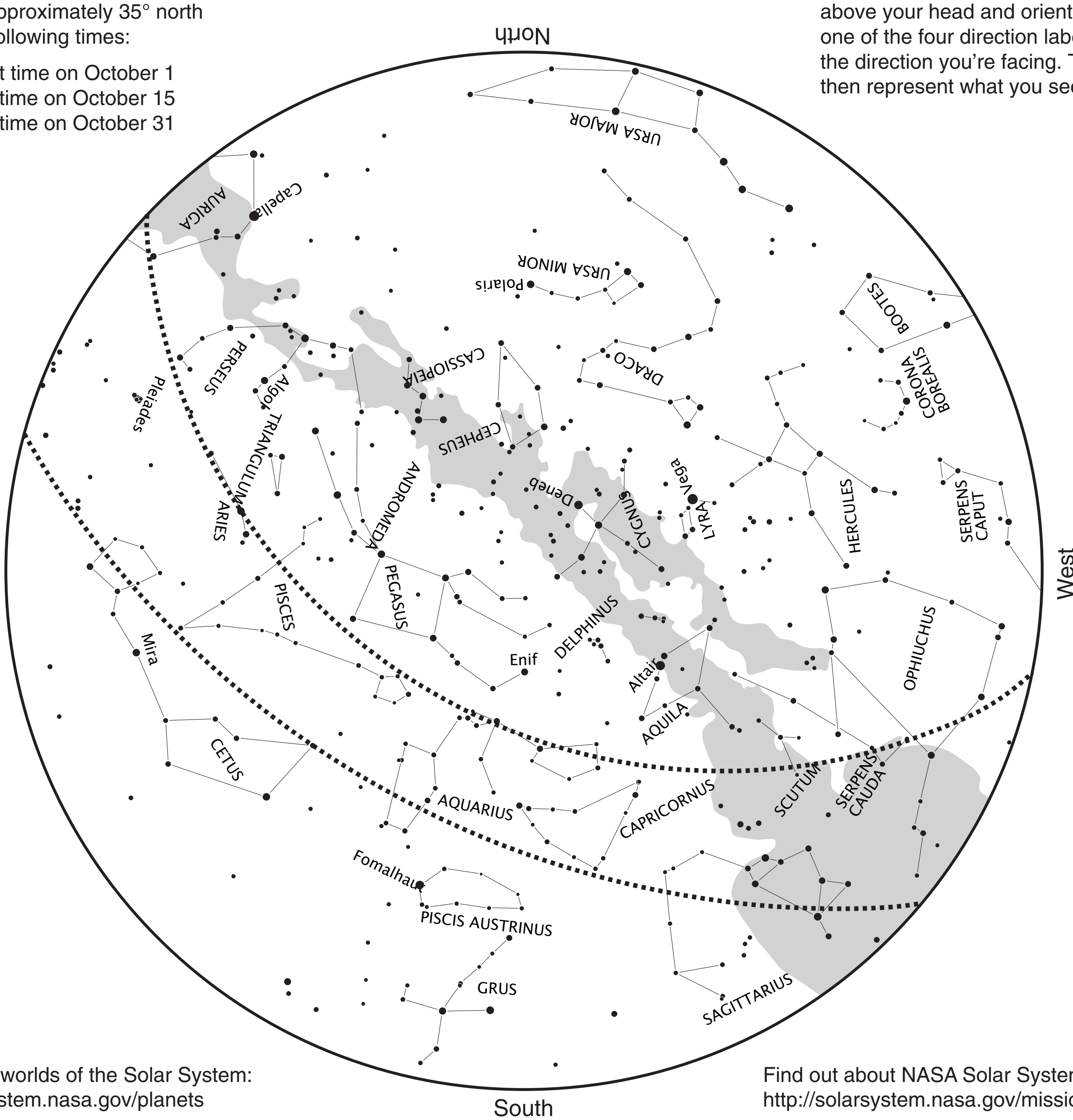
National Aeronautics and Space Administration

Where are the Planets?
October

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on October 1
9 p.m. daylight time on October 15
7 p.m. daylight time on October 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
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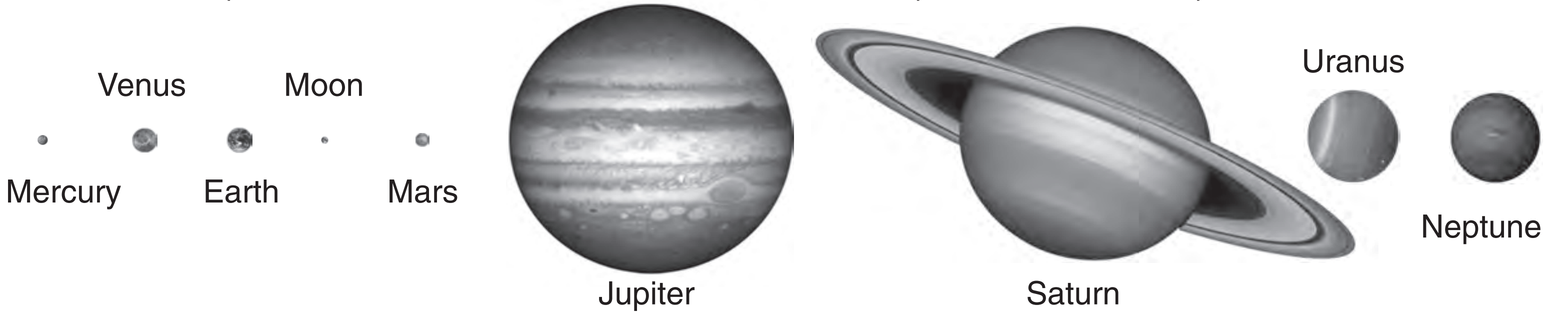
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



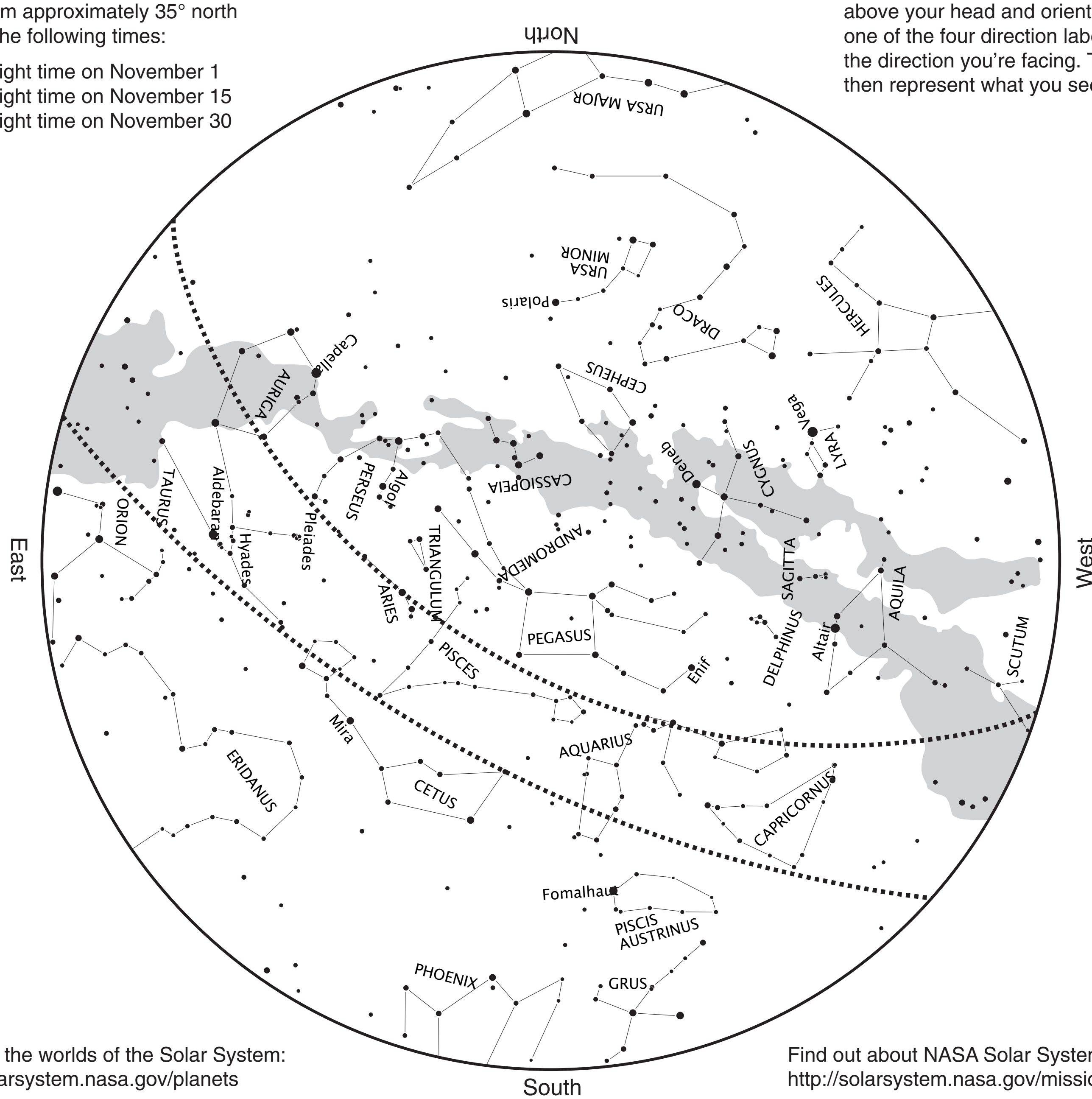
National Aeronautics and Space Administration

Where are the Planets?
November

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. daylight time on November 1
8 p.m. daylight time on November 15
7 p.m. daylight time on November 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
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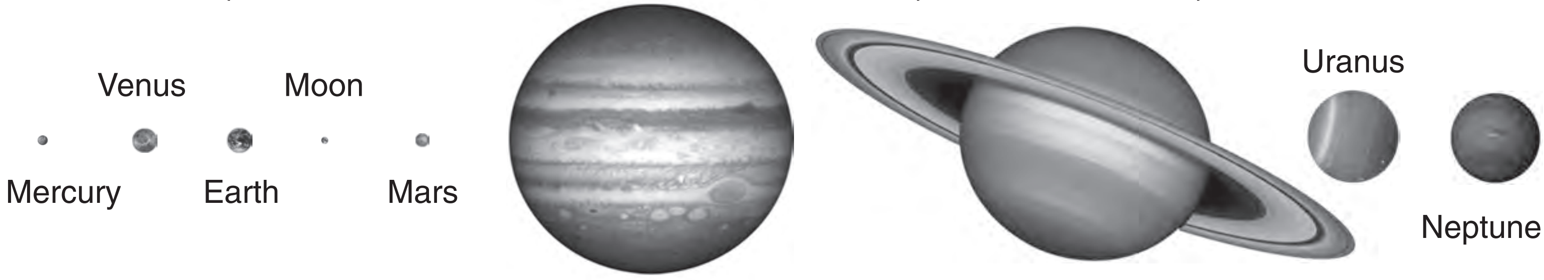
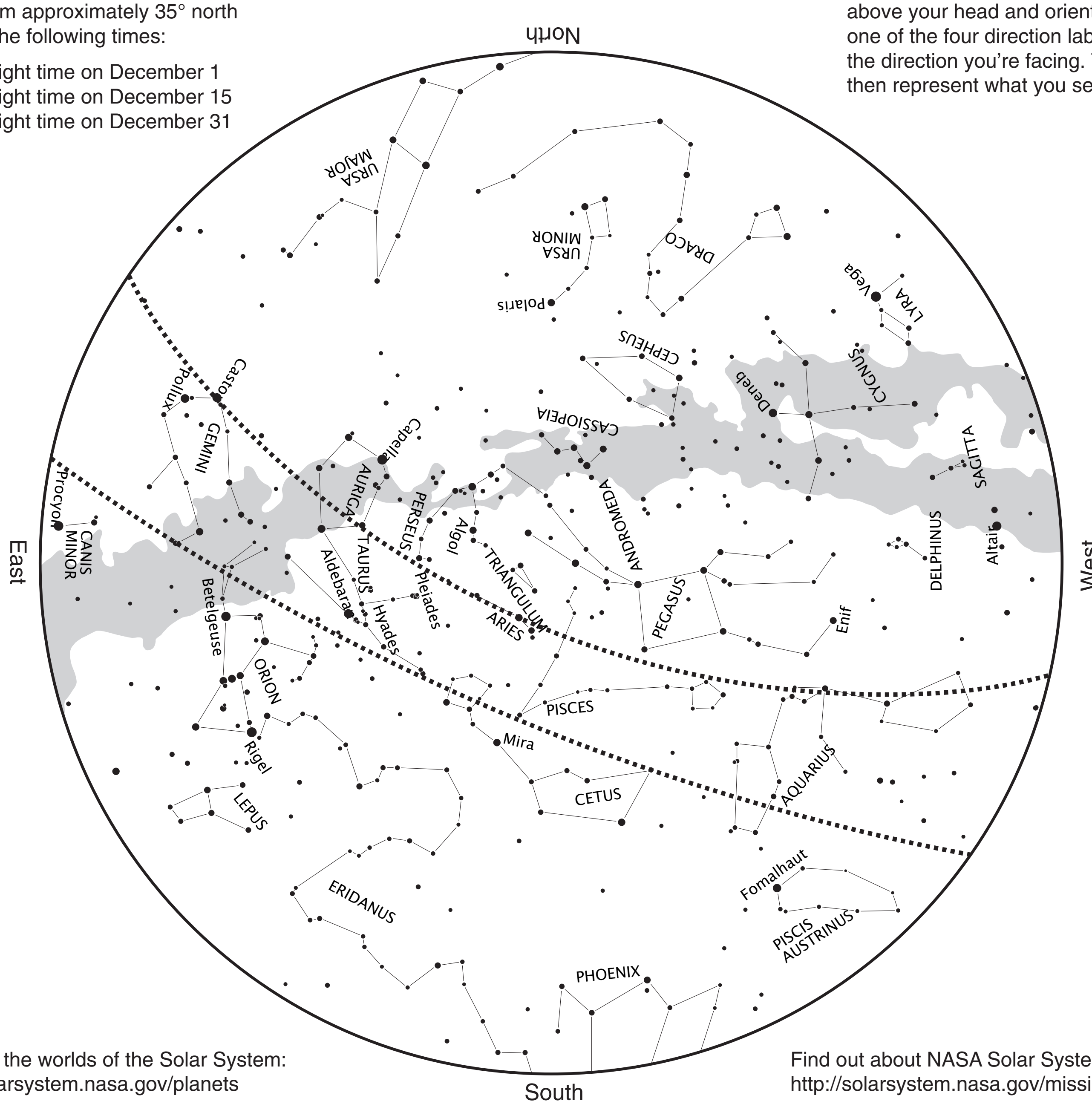


Where are the Planets?
December

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. daylight time on December 1
8 p.m. daylight time on December 15
7 p.m. daylight time on December 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Discover the worlds of the Solar System:
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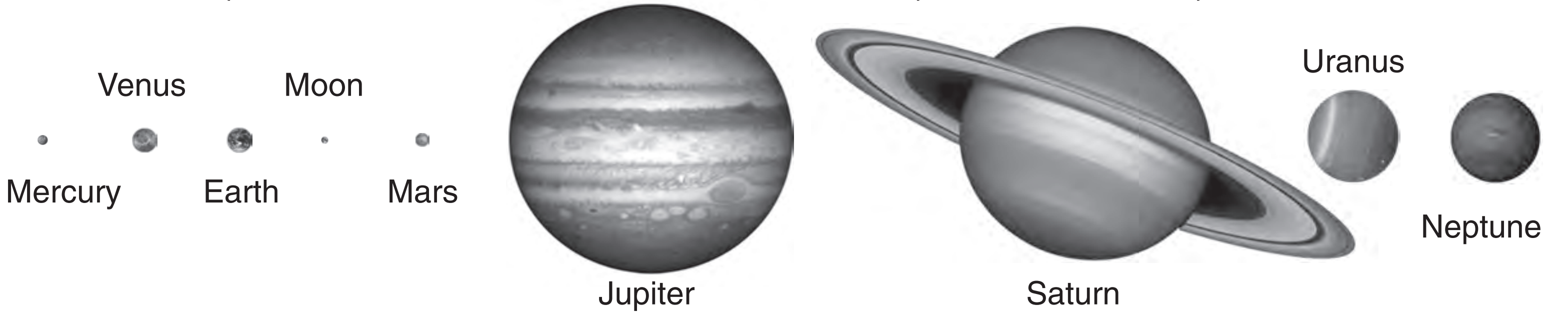
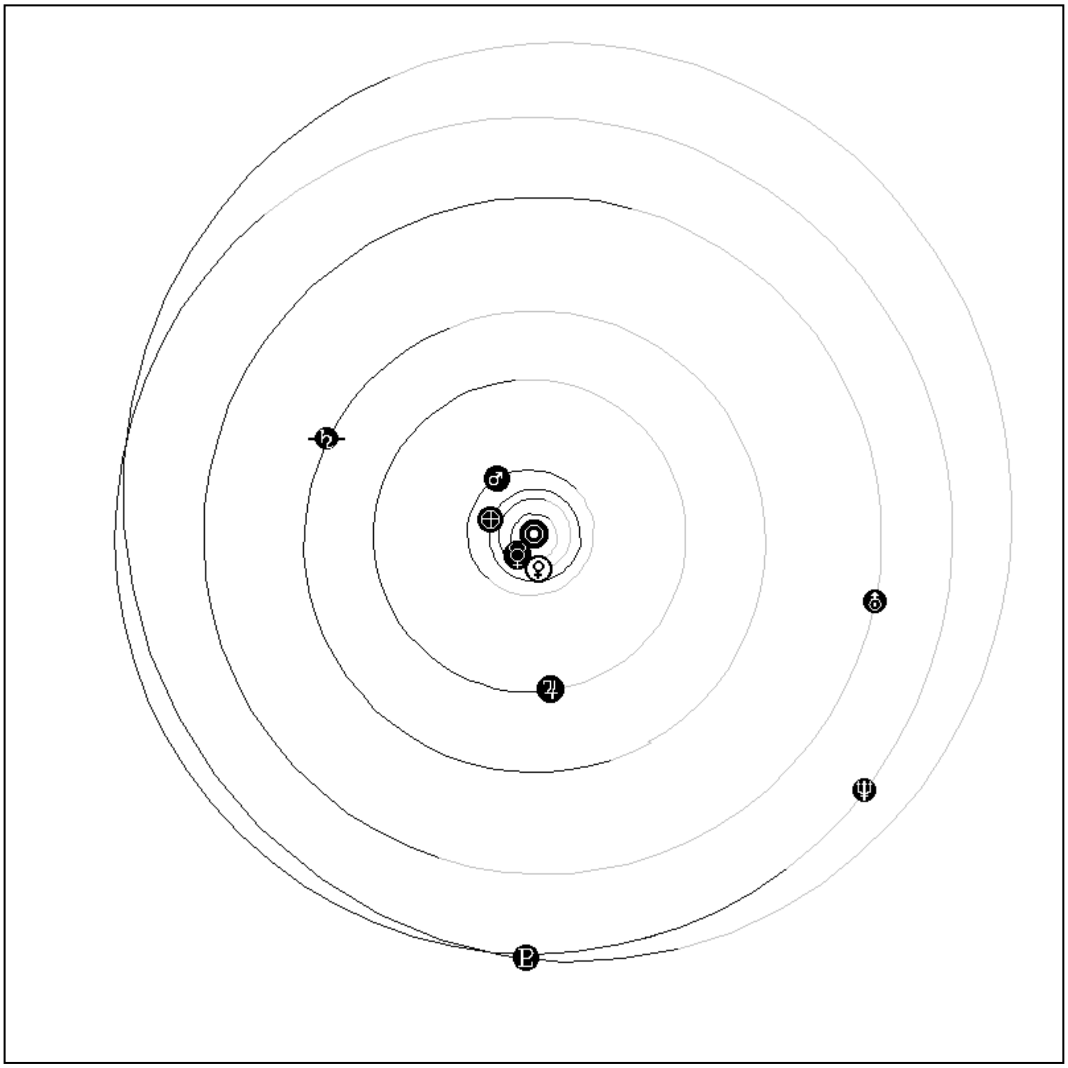
You will find the planets and the Moon in the area of the sky called the "ecliptic," marked on the map between the dotted lines.



Website Source: http://www.fourmilab.ch/cgi-bin/Solar

Solar System: Sat 2008 Mar 1 18:25



Planet Positions as of March 1, 2008

Use as an example for positioning the planet stickers on the banner “Exploring Our Solar System.”

Exploring the Solar System Outreach ToolKit

Media & Resources

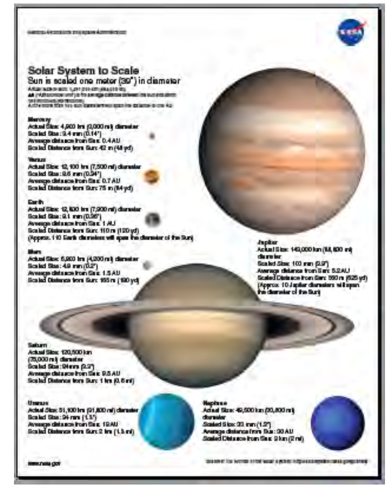
- GETTING STARTED -

1. **INSERT "MANUAL & RESOURCES CD" INTO YOUR COMPUTER. Click on SolSysManual.pdf to navigate through the ToolKit Manual. You need the free Adobe Acrobat Reader to view the manual: http://www.adobe.com/products/acrobat/readstep2.html.**
2. **For best results copy the entire CD onto your computer hard drive in any folder you choose.**
3. **VIEW THE TRAINING VIDEO as you review materials in the ToolKit – this is a DVD labeled "Training Video DVD."**
4. Questions? Contact nightskyinfo@astrosociety.org

WHERE COULD I USE THE RESOURCES INCLUDED HERE?

MEDIA / RESOURCE	Pre-Star Party – Indoors	Pre-Star Party –Outdoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)
				K-4	5-8	9-12		
Training DVD							√	
Manual & Resources CD							√	
Solar System Lithographs	√		√	√	√	√	√	√
ACTIVITY: **"Exploring Strange New Worlds"** provides insight into how NASA scientists explore our Solar System. You allow your visitors to become teams of scientists exploring their own planetary system for the first time. 	√	√	√		√	√	√	

Solar System Models: Sizes & Distances



Make scale models of the Solar System: sizes of the planets and distances between orbits.

See the ToolKit Manual and Training Video for assembly and suggested presentations.

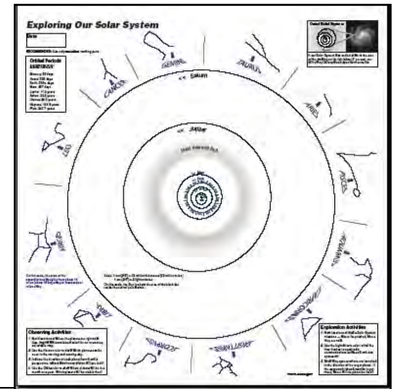
WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. Pocket Solar System	√	√	√	√	√	√	√	√	√	√
2. Scaled Worlds of the Solar System	√	√	√	√	√	√	√	√		√
3. "Solar System to Scale" Handout	√	√	√	√		√	√	√	√	

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Assemble the models of the worlds of the Solar System. White glue, paper towel.	Extra pencils	Make needed copies of handouts

Exploring Our Solar System



Using a banner with the scaled orbits of all the naked eye planets to explain a variety of concepts regarding the planets we see (and don't see) in the sky, what NASA missions are exploring the Solar System, and how long it takes to communicate with spacecraft. Use a star map to connect the positions of the planets on the banner to where the planets can be observed in the sky.

WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. Banner: "Exploring Our Solar System"	√	√	√	√		√	√	√	√	√
2. Banner Handout for visitors	√	√	√	√		√	√	√	√	√
3. "Where are the Planets" Star Maps	√	√						√		

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Cut out planet and NASA mission stickers for banner. Attach Velcro straps to banner. *Optional*: Vinyl Cleaner	Fence, Table, or Vehicle to display banner Printout of current locations of planets: http://www.fourmilab.ch/cgi-bin/Solar Printout of current locations of NASA missions: http://space.jpl.nasa.gov/ *Optional*: Yardstick or other straight-edge	Make needed copies of handouts

www.nasa.gov