Today:

- Announcements
- 1 Minute Questions
- Next Time
- Guest Lecture
Announcements:

- Who is here for the first time?
- Attendance Sheet – should be up to date
- Pictures – If possible, after class today
- HW #01 Assigned Tuesday, HW #02 Assigned Today
- ITLL Access and Machine Shop Training
- Please put name on 1 Minute Reports
- Class does not use D2L
One Minute Report Questions:

“The function of education is to teach one to think intensively and to think critically. Intelligence plus character - that is the goal of true education.”

Martin Luther King, Jr.
Other Questions?
Next Time...

Spacecraft Overview – Part I

Plus HW #1 Due

Colorado Space Grant Consortium
Solar System
Exploration Missions

Jim Paradise
Lockheed Martin

Class #2

Colorado Space Grant Consortium
Exploring Space – August 2013

with Jim Paradise
Solar System Tour

Starting in the center…
Our Sun, the closest star to Earth!

At a mere 93 million miles distant, it takes light from the Sun only eight minutes to arrive on Earth.

The next closest are three members of Alpha Centauri and are just over 4 light years from Earth.
This is what our sun looks like from space

Image credit: NASA/JPL-Caltech
The Sun in extreme ultraviolet light
The material being observed here is ionized iron heated to over 1 million degrees.
SDO is a sun-pointing semi-autonomous spacecraft that will allow nearly continuous observations of the Sun with a continuous science data downlink rate of 130 Megabits per second (Mbps). The spacecraft is 4.5 meters high and over 2 meters on each side, weighing a total of 3100 kg (fuel included).

Interface Region Imaging Spectrograph (IRIS)  
Launched June 27, 2013
The material being observed here is ionized iron heated to over 1 million degrees.

IRIS resolution compared to SDO

SDO AIA 1600  IRIS Si IV
**Mercury**

- Distance From Sun: 36 Million Miles
- Average Temp: 332°F
  - Low: -270°F
  - High: +800°F
- Diameter: 3,000 miles
- Orbital Period: 88 days
- Rotation: 58 days
- Atmosphere: trace
- Moons: 0

Image credit: NASA/JPL-Caltech
MESSENGER
Mission to Mercury

August 3, 2004 - Launch
2006, 2007 - Mercury Flybys
March 2011 - Mercury Orbit

High Rez
Mercury - High Resolution Mapping in Progress
Venus

- Distance From Sun: 67 Million Miles
- Average Temp: 867°F
- Diameter: 7,500 miles
- Orbital Period: 225 days
- Rotation Period: 243 days
  - backwards
- Atmosphere: very dense at 92 times denser than Earth’s atmosphere
- Moons: 0

Image credit: NASA/JPL-Caltech
Under the clouds of Venus (Magellan images)

- Craters, volcanoes, mountain ranges, canyons, and more..
- 75% highlands / 25% lowlands, could not sustain an ocean.

Magellan Radar Mapping Mission
1990-1994

Image credit: NASA/JPL-Caltech
Venus in 3d
Earth

3rd Rock from the Sun

- Distance From Sun: 93 Million Miles
- Average Temp: 59°F
- Diameter: 8,000 miles

Image credit: NASA/JPL-Caltech
Earth and Moon (to scale)

Image credit: NASA/JPL-Caltech

From Galileo
Earth (as seen from our moon)
Mars

- Average Distance From Sun: 142 Million Miles
- Average Temp: -85°F
- Surface Temp: -220°F to +80°F
- Atmosphere: 1% of Earth
- Diameter: 4,200 miles
- Orbital Period: 1.9 years
- Rotation: 24.7 hours
- Moons: 2

Image credit: NASA/JPL-Caltech
Deimos – Mars smallest moon (8 miles diameter)

Image credit: NASA/JPL-Caltech
Phobos – Mars biggest moon (14 miles diameter)

Escape Velocity: 24 mph

March 3, 2010:

Previous flybys of Phobos have shown that it is not dense enough to be solid all the way through.

It must be 25-35% porous.

This has led planetary scientists to believe it is a dust covered ‘rubble pile’ circling Mars, or is hollow, or has caverns.
Mars, as seen from Phobos

Image credit: NASA/JPL-Caltech
Mars Odyssey
Launched: April 7, 2001
MOI: October 24, 2001
Controlled from Denver, CO

Major Instruments:
• Thermal Emission Imaging System (THEMIS)
• Gamma Ray Spectrometer (GRS)
• Mars Radiation Environment Experiment (MARIE)

Image credit: NASA/JPL-Caltech
Melas - The Grand Canyon of Mars

credit: NASA/JPL-Caltech
Olympus Mons

Largest Volcano in our Solar System: 100,000 feet tall

Image credit: NASA/JPL-Caltech
The very dark, nearly circular features range in diameter from 328 to 820 feet.

Image credit: NASA/JPL-Caltech
Mars Reconnaissance Orbiter (MRO)

Launched: August 12, 2005  
Arrived: March 10, 2006  
Controlled from Denver, CO

Major Instruments:

• Context Camera (CTX)  
• Mars Color Imager (MARCI)  
• High Resolution Imaging Science Experiment (HiRISE)  
• Compact Reconnaissance Imaging Spectrometer for Mars (CRISM)  
• Shallow Radar (SHARAD) (can see up to 1 km into ground)
Cave Entrance on Mars
Sand Dunes / Ripples
Trees?
Sediments
Swirl patterns
Lava coils
Face on Mars

Orbiter.

Sojourner
Mars 1997

Sojourner

Launched: Dec 4, 1996
Landed: July 4, 1998
Lasted: 92 days

Size
- Small
- Length: 20 inches
- Height: 10 inches

Image credit: NASA/JPL-Caltech
MARS PATHFINDER LANDING SITE

JULY 4, 1997
Sojourner on Mars

Image credit: NASA/JPL-Caltech
Mars 2003 Mars Exploration Rovers (MER)

**Spirit:**
- Launched: June 10, 2003
- Landed: January 4, 2004 at Gusev Crater
- Got stuck at Troy 8/5/2009
- Traveled 4.8 miles total
- Last communication: 3/22/2010

**Opportunity:**
- Launched: July 7, 2003
- Landed: January 24, 2004 at Meridian Planum
- Still rolling after more than 9.5 years
- Traveled 14.3 miles so far
- Next Destination: Solander Point

Landing sites on opposite sides of Mars. The mission was planned to last for 90 days each. The rovers were designed to travel up to 350 feet each Martian day, or sol (approximately 24 hours, 37 minutes).

Size: Golf Cart Size / 400 pounds

Image credit: NASA/JPL-Caltech

[video]
Mars 1/25/2004
Opportunity on Mars

Image credit: NASA/JPL-Caltech
Opportunity checking out it’s chute…
Opportunity finds a Meteorite

Image credit: NASA/JPL-Caltech
Opportunity finds Blueberries (Hematite Concretions)

In Southern Utah

On Mars

Image credit: NASA/JPL-Caltech
dunes
Sand Dunes
Opportunity finds Earth

You are here

Image credit: NASA/JPL-Caltech
A rocky outcrop
Opportunity approaches Victoria Crater

MRO View

Opportunity View (in distance)
Opportunity at Victoria Crater (MRO) from 200 miles up

Image credit: NASA/JPL-Caltech

“Cape Verde”

“Duck Bay”

Rover tracks

Opportunity

Camera mast shadow
Spirit’s Landing Area on Mars

Image credit: NASA/JPL-Caltech
Spirit at Comanche Cliffs

Image credit: NASA/JPL-Caltech
Spirit stuck in white dry powder at Troy (final resting place)
Curiosity Rover (Launched: Nov 26, 2011)
Curiosity compared to previous rovers:

- 7 feet tall — 9 feet wide
- 8 foot long arm
- Weighs 2000 lbs
- Can roll over 30” tall rocks
Landed in Gale Crater in August 5, 2012
Mount Sharp in the crater
Curiosity Parachute by MRO (8/5/2012)
Mount Sharp in the distance
Sedimentary Layers at Yellow Knife Bay
Pebbles – Remnants of an ancient streambed on Mars

Curiosity is now on a one year journey to the base of Mount Sharp, about 5 miles away
Mars' loss of its protective magnetic field may have triggered the loss of its atmosphere.

Mars Atmosphere and Volatile Evolution Mission (MAVEN) will explore Mars' upper atmosphere, ionosphere and how it interacts with the Sun. The spacecraft will determine why Mars lost the denser surface atmosphere that once allowed it to support the presence of liquid water on its surface.
Jan 19, 2009 - PASADENA, Calif. – A possible source of Methane Plumes is microbial life deep beneath the surface of Mars.

Are the methane concentrations observed evidence that life is currently present on the Red Planet? We do not yet know. But the regions where plumes of methane were detected on Mars now beckon to us, calling us to resolve their mystery. The next time we send out a spacecraft to the Red Planet to search for life, we will know exactly where to look.

Image credit: NASA/JPL-Caltech
InSight
... into the early evolution of terrestrial planets.

- Launch: March, 2016
- Landing: Sept 20, 2016
- Surface Operations
  1 Martian year (720 days)
- Seismic Experiment for Interior Structure
- Heat Flow and Physical Properties HP³
Curiosity 2.0  
Launch Date: 2020
Asteroid Belt (gold colored specs)

- Distance From Sun: 260 Million Miles to center
- Over 166,000 asteroids
- Largest: Ceres 1/3 of all mass 600 miles in diameter

Image credit: NASA/JPL-Caltech
Asteroid: Gaspra

1st ever close-up photo of an asteroid

Gaspra (12x7 miles)

Image credit: NASA/JPL-Caltech
Ida (35 miles long)

Image credit: NASA/JPL-Caltech
A "dwarf planet" is a celestial body that
a) is in orbit around the Sun,
b) has sufficient mass for its self-gravity to overcome rigid body forces (nearly round),
c) has not cleared the neighborhood around its orbit, and
d) is not a satellite.

Image credit: NASA/JPL-Caltech
Launched: 9/27/07
Mars Flyby: 2/17/2009
Orbit Vesta: 7/15/2011
Depart Vesta: 9/4/2012
Orbit Ceres: Spring 2015

Journey to the beginning of the Solar System with the Dawn mission. Travel with the Dawn spacecraft as it explores Vesta and Ceres: *Current Mission Status*

Image credit: NASA/JPL-Caltech
Asteroid: Vesta Close-up Images
Asteroid: Vesta – 330 miles in diameter
This photo taken Sept 5, 2012 as Dawn left Vesta’s orbit

Image credit: NASA/JPL-Caltech
OSIRIS-Rex (mission to asteroid 101955 Bennu)  
Origins Spectral Interpretation Resource Identification Security Regolith Explorer

First US Asteroid Sample and Return Mission

Launch: 2016  
Asteroid Orbit/Sample: 2019  
Earth Return: 2023

101955 Bennu diameter: 1,900 ft
Jupiter

- Distance From Sun: 483 Million Miles
- Average Temp: -166°F
- Diameter: 88,000 miles
- Orbital Period: 12 years
- Moons: 67

Image credit: NASA/JPL-Caltech
Galileo

Launch: 1989
Orbit Jupiter: 1995
Mission End: 2003

First two years focused on Jupiter.

Extended mission (6 years) focused on Jupiter’s moons, with emphasis on Europa, Callisto, Ganymede, and Io.

Image credit: NASA/JPL-Caltech
4 of Jupiter’s 61 moons

- Io (with active volcanoes)
- Europa
- Ganymede
- Callisto

3 with Liquid Oceans?

Image credit: NASA/JPL-Caltech
Volcanic Eruption on IO

Image credit: NASA/JPL-Caltech

Callisto
Europa
Ice – 3 miles thick with liquid salt water ocean beneath

Image credit: NASA/JPL-Caltech
Europa

- Ice – 3 miles thick with

- Liquid salt water ocean beneath (40 – 100 miles deep)
Liquid lakes in the ice
JUNO - Launched August 5, 2011
Polar Orbit of Jupiter

Arrives at Jupiter: July 4, 2016

Image credit: NASA/JPL-Caltech

Solar Powered
Saturn

- Distance From Sun: 888 Million Miles
- Average Temp: -220°F
- Diameter: 75,000 miles
- Orbital Period: 29 years
- Moons: 62

Image credit: NASA/JPL-Caltech  Cassini
Cassini and Huygens

Mission to Saturn and its largest moon Titan.

Launch: 10/15/1997

Orbit Saturn: 7/1/2004

Huygens Release: 12/2004

Landed on Titan: 1/12/2005

Image credit: NASA/JPL-Caltech
Rings in true color

Image credit: NASA/JPL-Caltech

Earth from Saturn
snaps a photo of Earth
Wait...
Cassini Images of Saturn rings

Moon in ring gap

Image credit: NASA/JPL-Caltech
Cassini Images of Saturn Moons

Hyperion

Enceladus

Evidence of trace atmosphere and liquid ocean under ice.

Dione

Evidence of liquid ocean under ice.

Image credit: NASA/JPL-Caltech
Water Plumes from Enceladus south pole?

Image credit: NASA/JPL-Caltech Spectroscopy
Spectroscopy – Dissecting starlight to identify components

Wavelength

Absorption lines

Hydrogen

Sodium

Calcium

H

Na

Ca

CREDIT: Haven Gigue
Salt Water Vapor confirmed!

Background Star used: Zeta Orionis (Alnitak)
Images of Saturn’s moon Titan

Dense atmosphere

Continents/Oceans visible?

Hubble Image

Cassini Image

Image credit: NASA/JPL-Caltech
Huygens’ Descent

Entry

Pilot-chute deployment

Front-shield separation

Main-parachute jettison
Stabiliser-parachute deployment

Surface impact

Peak deceleration
Heat-flux peak

Back-cover release
Main-parachute deployment

Instrument configuration for descent

Stabiliser-parachute inflated

Surface mission phase duration >3 min

Actual Descent:
2.5 Hours

Actual Surface Mission: 90 Min

Image credit: NASA/JPL-Caltech
Lake Shore?

Image credit: NASA/JPL-Caltech
Liquid flow erosion on Titan

Image credit: NASA/JPL-Caltech
Huygens Probe image from the Surface of Titan
Liquid Hydrocarbon Lakes on Titan

Image credit: NASA/JPL-Caltech
Uranus

- Distance From Sun: 1.8 Billion Miles
- Average Temp: -319°F
- Diameter: 32,000 miles
- Orbital Period: 84 years
- Moons: 27

Image credit: NASA/JPL-Caltech
Neptune

- Distance From Sun: 2.8 Billion Miles
- Average Temp: -328°F
- Diameter: 31,000 miles
- Orbital Period: 165 years
- Moons: 13-14 (7/2013)

Image credit: NASA/JPL-Caltech
Pluto (1978)

- Distance From Sun: 3.7 Billion Miles
- Average Temp: -400°F
- Pluto diameter: 1,500 miles, Charon diameter: 750 miles
- Orbital Period: 248 years
- Moons: 1 (known in 1978)
  - Charon found in 1978

Image credit: NASA/JPL-Caltech
Pluto (7/1/2013)

Introducing: **Styx and Kerberos**

Pluto Moons: Now at 5
- Charon found in 1978
- Nix and Hydra found in 2005
- Kerberos found in 2011
- Styx found in 2012

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Pluto System

*Hubble Space Telescope • WFC3/UVIS*

Nasa, esa, and m. showalter (seti institute)
New Horizons  (Pluto - Kuiper Belt Mission)

Launched:  Jan 17, 2006
Pluto Flyby:  July 14, 2015

Image credit: NASA/JPL-Caltech
Kuiper Belt
TNOs (also known as Kuiper Belt Objects (KBOs))

How do we find planets?

Finding KBOs

Largest known trans-Neptunian objects (TNOs)

- Dysnomia
- Eris
- Pluto (Charon)
- Makemake
- Haumea
- Sedna
- Orcus
- Quaoar
- Varuna

Image credit: NASA/JPL-Caltech
Oort Cloud  
(home of comets)

• Extends out more than 1 light year from the sun

Image credit: NASA/JPL-Caltech
Short Period Comets
(Dirty Snow Balls from the Kuiper Belt)

Temple 1

Wild 2

Image credit: NASA/JPL-Caltech
Coming November 28, 2013

2012 S1 (ISON)

“brightest comet ever”  “as bright as full moon”  “even visible during the day”
What if the planets were side by side?
Milky Way Galaxy – As seen from Colorado

Slow animation
You are Here!
NASA’s Planetary Transit Champion – Kepler Space Telescope

Prime Mission ended 8/19/2013

Images credit: NASA/JPL-Caltech
Current Counts

Candidate Planets: 3,346
Suns with planets: 2,036
Confirmed Exoplanets: 879
Total Exoplanets: 4,225
Habitable Zone (where liquid water could exist)

Found So Far:
27 Exoplanets In Habitable Zone

Images credit: NASA/JPL-Caltech
GJ-504b, a “cherry blossom” planet orbiting a hot young sun
• 57 light years from Earth
Is Kepler-62f (July 28, 2013) another Earth?
is about
1,200 light-years from Earth
Just 40% larger than Earth
In the Habitable Zone
orbits its host star every 267 days
Kepler Mission Discovers Worlds Orbiting Two Stars

Kepler-16b – (9/15/2011)
Kepler-34b and Kepler-35b (1/11/2012)
Kepler-38b (Aug 20, 2012)
Kepler 47b and 47c (Aug 28, 2012)

2,165 known binary stars

Tatooine from Star Wars:)

Images credit: NASA/JPL-Caltech.
PH1 — a Neptune-size planet in a 4 star system (2012)

- 2 stars in center orbiting each other every 20 days

- Exoplanet PH1 orbits binary stars every 138 days

- 2 more stars orbiting binary stars at 1,000 au

CREDIT: Haven Giguere/Yale
Current Planet Types
• Rocky and Terrestrial (like Mars and Earth)
• Gas Giants (like Jupiter and Saturn)
• Ice Giants (Like Uranus and Neptune)

GJ1214b
• 2.7 x Earth’s diameter
• Orbits red-dwarf star every 38 hours
• Surface Temp is 450 degrees F
• Density is 2 g/cm³
  • Earth density is 5.5 g/cm³
• Data is consistent with dense water vapor atmosphere
Exoplanet 55 Cancri e twice Earth’s Size – and made largely of diamond.

Oct 12, 2012 – Wired UK
Spectroscopy – to analyze Exoplanet atmospheres during transit

Starlight filters through the planet's sodium-rich atmosphere.

Light Curve of a Star During Planetary Transit

Images credit: NASA/JPL-Caltech
Summary: What We Have Found So Far...

4,225 Exoplanets
In small circle area

Milky Way Planet Estimate
Stars: 200 - 700 Billion
Planets: At least 500 Billion
Goldilocks Zone: >60 Billion
Galaxy Count: >125 Billion

Habitable Zone Planets Estimate: 8,520,000,000,000,000,000,000,000

Images credit: NASA/JPL-Caltech

Why Human Exploration?
HUBBLE Space Telescope

1st of 4 Great Observatories
Launched 24 April 1990

Images credit: NASA/JPL-Caltech
Spiral Galaxy M81
Two Galaxies Colliding

Images credit: NASA/JPL-Caltech
So........How good is Hubble?
After servicing……How good is Hubble?

No Earth-based telescopes can see anything in the red square, so…
let’s have Hubble look there

Images credit: NASA/JPL-Caltech
Hubble's Deep Core Sample of the Universe

<table>
<thead>
<tr>
<th>Year</th>
<th>Image Name</th>
<th>Total Exposure</th>
<th>Oldest Galaxy Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Hubble Deep Field</td>
<td>11.3 days</td>
<td>12.9 B years</td>
</tr>
<tr>
<td>2009</td>
<td>Hubble Ultra Deep Field</td>
<td>Added Infrared</td>
<td>13.0 B years</td>
</tr>
<tr>
<td>2012</td>
<td>Hubble eXtreme Deep Field</td>
<td>22 days</td>
<td>13.2 B years</td>
</tr>
<tr>
<td>2018</td>
<td>James Webb Space Telescope</td>
<td>&lt;4 days</td>
<td>13.5 B years</td>
</tr>
</tbody>
</table>
James Webb – 2018 (will be parked at L2)
Voyager 1 and 2

Our most distant spacecraft

- Launched in 1977
- 36 Years Old
- Traveling at 38,200 mph
- Distance from Sun
  - V1: >11 billion miles
  - V2: >9 billion miles

Image credit: NASA/JPL-Caltech
Both spacecraft are currently passing through the Heliosheath. Voyager 1 is expected to cross Heliopause and enter interstellar space soon.
Voyager 1 will leave our solar system in the next year or so, and… reach another star system in approximately 4,000 years.

What if intelligent life there finds the spacecraft?

What would you want them to know about us and Earth?

A committee, chair by Dr. Carl Sagan, selected material representative of Earth and recorded the data onto a 12 inch gold-plated phonograph record.

Each record is encased in a protective aluminum jacket, together with a cartridge and a needle. Instructions, in symbolic language, explain the origin of the spacecraft and indicate how the record is to be played.
The Gold Record

What’s on the record?

• Scenes from Earth
  • 115 images

• Music from Earth
  • 27 songs

• Sounds from Earth
  • 21 collections

• Greetings From Earth
  • in 55 languages

• Printed Messages
  • President Carter
  • UN Sec Gen Waldheim
Scenes from Earth

Image credit: NASA/JPL-Caltech
<table>
<thead>
<tr>
<th>Composer/Location, Artist/Performer, Time Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bach, Brandenburg Concerto No. 2 in F. First Movement, Munich Bach Orchestra, Karl Richter, conductor. 4:40</td>
</tr>
<tr>
<td>3. Senegal, percussion, recorded by Charles Duvelle. 2:08</td>
</tr>
<tr>
<td>4. Zaire, Pygmy girls' initiation song, recorded by Colin Turnbull. 0:56</td>
</tr>
<tr>
<td>5. Australia, Aborigine songs, &quot;Morning Star&quot; and &quot;Devil Bird,&quot; recorded by Sandra LeBrun Holmes. 1:26</td>
</tr>
<tr>
<td>6. Mexico, &quot;El Cascabel,&quot; performed by Lorenzo Barcelata and the Mariachi México. 3:14</td>
</tr>
<tr>
<td>7. &quot;Johnny B. Goode,&quot; written and performed by Chuck Berry. 2:38</td>
</tr>
<tr>
<td>8. New Guinea, men's house song, recorded by Robert MacLennan. 1:20</td>
</tr>
<tr>
<td>9. Japan, shakuhachi, &quot;Tsuru No Sugomori&quot; (&quot;Crane's Nest,&quot;&quot;) performed by Goro Yamaguchi. 4:51</td>
</tr>
<tr>
<td>10. Bach, &quot;Gavotte en Rondeaux&quot; from the Partita No. 3 in E major for Violin, performed by Arthur Grumiaux. 2:55</td>
</tr>
<tr>
<td>13. Peru, panpipes and drum, collected by Casa de la Cultura, Lima. 0:52</td>
</tr>
<tr>
<td>14. &quot;Melancholy Blues,&quot; performed by Louis Armstrong and his Hot Seven. 3:05</td>
</tr>
<tr>
<td>15. Azerbaijan S.S.R., baqpipes, recorded by Radio Moscow. 2:30</td>
</tr>
<tr>
<td>16. Stravinsky, Rite of Spring, Sacrificial Dance, Columbia Symphony Orchestra, Igor Stravinsky, conductor. 4:35</td>
</tr>
<tr>
<td>18. Beethoven, Fifth Symphony, First Movement, the Philharmonia Orchestra, Otto Klemperer, conductor. 7:20</td>
</tr>
<tr>
<td>20. Navajo Indians, Night Chant, recorded by Willard Rhodes. 0:57</td>
</tr>
<tr>
<td>22. Solomon Islands, panpipes, collected by the Solomon Islands Broadcasting Service. 1:12</td>
</tr>
<tr>
<td>23. Peru, wedding song, recorded by John Cohen. 0:38</td>
</tr>
<tr>
<td>24. China, ch'un, &quot;Flowing Streams,&quot; performed by Kuan P'ing-hu. 7:37</td>
</tr>
<tr>
<td>25. India, raga, &quot;Jaat Kahan Ho,&quot; sung by Surshri Kesar Bai Kerkar. 3:30</td>
</tr>
<tr>
<td>26. &quot;Dark Was the Night,&quot; written and performed by Blind Willie Johnson. 3:15</td>
</tr>
<tr>
<td>27. Beethoven, String Quartet No. 13 in B flat, Opus 130, Cavatina, performed by Budapest String Quartet. 6:37</td>
</tr>
</tbody>
</table>

Image credit: NASA/JPL-Caltech
Sounds From Earth

- Tame Dog
- Tractor, Riveter
- Chimpanzee
- Mud Pots
- Tractor, Bus, Auto

- Music of the Spheres
- Volcanoes, Earthquake, Thunder
- Wind, Rain, Surf
- Crickets, Frogs
- Birds, Hyena, Elephant
- Wild Dog
- Footsteps, Heartbeat, Laughter
- Fire, Speech
- The First Tools
- Herding Sheep, Blacksmith, Sawing
- Morse Code, Ships
- Horse and Cart
- Train
- F-111 Flyby, Saturn V Lift-off
- Kiss, Mother and Child
- Life Signs, Pulsar
Greetings From Earth

- Akkadian
- Amoy (Min dialect)
- Arabic
- Aramaic
- Armenian
- Bengali
- Burmese
- Cantonese
- Czech
- Dutch
- English
- French
- German
- Greek
- Gujarati
- Hebrew
- Hindi
- Hittite
- Hungarian
- Lla
- Indonesian
- Italian
- Japanese
- Kannada
- Kechua
- Korean
- Latin
- Luganda
- Mandarin
- Marathi
- Nepali
- Nguni
- Nyanja
- Oriya
- Persian
- Polish
- Portuguese
- Punjabi
- Rajasthani
- Romanian
- Russian
- Serbian
- Sinhalese
- Sotho
- Spanish
- Sumerian
- Swedish
- Thai
- Turkish
- Ukranian
- Vietnamese
- Welsh
- Wu
International Space Station (ISS)

This is the furthest we have gone in 40 years
...We should dream bigger...
Update on Manned Missions

Old: Space Shuttle
Status: Retired

New: Orion
Status: 500 days to first launch
LAS and Multi-Purpose Crew Vehicle

Image credit: NASA/JPL-Caltech
Launch Abort System (LAS)
Exploration Flight Test -1 (EFT-1) Sept 2014
Exploration Mission-1 (EM-1)
Unmanned Mission to L2 in 2017

Lagrange Points
Exploration Mission-2 (EM-2)
Manned Mission in 2021 to somewhere
Visit lassoed asteroid in lunar orbit?
Future Mission Candidates

Visit near-Earth asteroid

Visit Phobos or Deimos

Return to the Moon

Man on Mar (2033)
Earth Departure Stage

130t SLS
Heavy Lift Launch Vehicle

70t SLS
Crew Vehicle

ORION Multi-Purpose Crew Vehicle

Lunar Lander
Let's finish with...
...a trip to the Moon
Thank you...

Questions?