Space, the final frontier
How Do Explorers Travel?

- Ship
- Space shuttle
- Lunar rover
- Horseback
- Canoe
- Foot
- Covered wagon
- Saturn V
- Ares and Orion
Wheels in the past, wheels in the future

©John Chiarello
What Challenges Facing Explorers Are the Same?

Basic needs:
- Food
- Water
- Air
- Shelter

Transportation:
How do we get there?

The unknown:
What will be there when we get there?
What will it be like?

I am going to miss my friends
Exploration Timeline

- **2008 – 2014**: Transportation System to Low Earth Orbit
- **2015 – 2020**: 4-6 crew to lunar surface for extended-duration stay
- **2020 – TBD**: Long duration human lunar exploration
- **2025+**: Human exploration to Mars vicinity
- **2030+**: Human exploration of Mars surface

**Timeline events:**
- **2008 – 2014**: Transportation System to Low Earth Orbit
- **2015 – 2020**: 4-6 crew to lunar surface for extended-duration stay
- **2020 – TBD**: Long duration human lunar exploration
- **2025+**: Human exploration of Mars surface
- **2030+**: Human exploration to Mars vicinity
NASAs Exploration Roadmap

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Lunar Lander Development
Lunar Heavy Launch Development
Earth Departure Stage Development
Surface Systems Development

Orion Production and Operations

1st Human Orion Flight

Commercial Crew/Cargo for ISS
Space Shuttle Ops

Initial Orion Capability

Lunar Robotic Missions

Science Robotic Missions

Lunar Outpost Buildup

Early Design Activity
The Moon – the First Step to Mars and Beyond….

- Gaining significant experience in operating away from Earth’s environment
  - Space will no longer be a destination visited briefly and tentatively
  - “Living off the land”
  - Human support systems

- Developing technologies needed for opening the space frontier
  - Crew and cargo launch vehicles (125 metric ton class)
  - Earth ascent/entry system – Crew Exploration Vehicle

- Conduct fundamental science
  - Astronomy, physics, astrobiology, historical geology, exobiology

Next Step in Fulfilling Our Destiny As Explorers
High Priority Lunar Exploration Sites

- Aristarchus Plateau
- Rima Bode
- Mare Tranquillitatis
- Mare Smythii
- Oceanus Procellarum
- South Pole-Aitken Basin Floor
- South Pole
- North Pole
- Central Farside Highlands
- Orientale Basin Floor

Luna
Surveyor
Apollo
Moon Maps

Clementine Map of the South Polar Region of the Moon

Clementine Topographic Map of the Moon
Components of Program Constellation

- Earth Departure Stage
- Orion - Crew Exploration Vehicle
- Heavy Lift Launch Vehicle
- Crew Launch Vehicle
- Lunar Lander

Exploration Vehicle
Challenging physically, emotionally, and socially

Frontier was the great unknown!

In order to survive, one needed food, water, and shelter

Had to bring everything they might need with them

Without first explorers, discovery would have been impossible

Explorers in history were important to the expansion of the human race
Frontier Life On The Moon

- Challenging physically, emotionally and socially
- The lunar frontier is the great unknown!
- In order to survive, space explorers will need food, water, shelter, and air
- Our lunar explorers will need to bring everything they’ll need with them
- The explorers will set up habitat missions, science missions, & commercial ventures
- Future generations will use the knowledge gained from these initial mission to journey through out the galaxy
History of Space Life Science

Mercury Project

Gemini Project
Apollo Space Life Science

- Cardiovascular evaluations
- Vestibular assessment
- Light flash investigations
- Radiation shielding and effects
- Clinical biochemistry
- Effects of cosmic rays
- Endocrinology, electrolyte and fluid volume assessment
- Exercise response
- Hematology and immunology studies
- Metabolism and heat dispersion during EVA
- Microbial responses
- Nutritional studies
- Skeletal response
Skylab Space Life Science

- Muscular De-conditioning and its Prevention
- Radiological Protection and Medical Dosimetry
- Microbiology Studies
- Immunity In-vitro
- Pulmonary Function and Evaluation
- Bone Mineral Measurement
- The Effects of Prolonged Exposure to Weightlessness on Postural Equilibrium
- Bio-Assay of Body Fluids
- Special Hematological Effects
- Sleep Monitoring
- Human Vestibular Function
Stressors

Bone

Psychosocial

Central nervous system

Cardiovascular

Nutrition

Muscle

Sensory perception

Sleep
Stressors

- Gravity effects on the Body - Adaptation (bone and muscle loss, alterations to the immune system, changes in cardiac function)
- Isolation effects on interpersonal behavior, changes in the immune system
- Radiation effects on human systems (immune, eyes), effects on food and medications, effects on instruments
- Light/Dark cycle impacts on circadian rhythm, change in sleep habits overall performance
Space & the Human Body

- Atrophy of muscles
- Loss of bone mass
- Changes in blood volume and cardiovascular system
- Issues with food and nutrition
- Changes in the immune system
- Changes in balance, hand-eye coordination
- Exposure to radiation
Human Factors-Behavior and Performance

- Isolation from family
- Sleep & workload
- Social interaction
- Psychological well-being
- Privacy and personal space
- Recreational activities
Environmental Factors Effecting Humans in Space

- Clean water
- Nutritious food
- Breathable air
- Acceptable noise and vibration limits
- Exposure to radiation
Medicine and Human Health in Space

- Medical support
- Health assessments
- Exercise
- Personal hygiene
- Stability of pharmaceuticals
As I stand out here in the wonders of the unknown at Hadley, I sort of realize there's a fundamental truth to our nature, Man must explore . . . and this is exploration at its greatest.

~Dave Scott, Commander Apollo 15, upon becoming the 7th man to walk on the Moon, 31 July 1971.