Introduction: Our Ecological Niche: The Solar System!

SLIDE: COMPOSITE OF SOLAR SYSTEM

One of the primary objectives of this course on "Resources from Space" is to examine the concept of the Earth, Moon, and Mars, indeed, the entire solar system, as being part of one environmental system. For example:

One common energy source, the Sun, directly or indirectly provides for the energy needs of the solar system.

The debris not aggregated in the Sun 4.6 billion years ago interacted dramatically during the formation of the terrestrial planets, asteroids, and comets.

Evidence from the Moon and Mars strongly suggests that the terrestrial planets followed parallel paths of evolution as planets for as much as the first billion years in the history of the solar system, including the environment in which earliest life forms developed.

Asteroidal and cometary impacts on the Earth and other terrestrial planets have continued to influence their histories, including, at least on Earth, the course of speciation.

Human visits to the Moon, automated probes to and around the planets, and growing human needs on Earth have begun a modern form of environmental interaction.

Integrated, environmental monitoring by a wide variety of spacecraft has begun to bind this solar environmental niche together more and more tightly.

The time has come, then, to consider the Earth, Moon, and Mars as One Environmental System and this course, among many other objectives, will attempt to do that.

Much is known about the origin and nature of the Solar System and the relationships of the Earth, Moon, Mars, and other bodies of that System came to be and relate to each other (Lectures # 5, 6, 7, and 37)

The Earth and the Moon have been tied dynamically to each other as a two planet system for most if not all of their 4.6 billion year individual histories (Lectures #10 and 11).

SLIDE: CLEMENTINE VIEW OF EARTH AND MOON

Early in their history, the Moon appears to have been captured by the Earth from a near-Earth Orbit or derived from the debris produced by a Mars-sized asteroid impact on the Earth.

The Moon appears to have recorded and preserved much of the early history of this two planet system, as well as the early history of Mars and other terrestrial planets.

CLEMENTINE WEB PAGE
http://nssdc.gsfc.nasa.gov/planetary/clementine.html

PROSPECTOR WEB PAGE
http://nssdc.gsfc.nasa.gov/planetary/lunarprosp.html

This planetary symbiosis may have had profound influence on the development of life on Earth, as the two planet system may be significantly more stable dynamically, and therefore thermally, that the Earth would be by itself.

Mars appears to have been far more Earth-like in its early history than it is at present, although Mars has only 3/8 Earth’s gravity and is possible less dynamically stable without a large moon (Lectures #15 and 16).

The record of the early geological and possibly biological evolution of Mars will provide great insights into the early evolution of the Earth beyond what the Moon has already told us.

VIKING WEB PAGE
http://pds.jpl.nasa.gov/planets/welcome/viking.htm

PATHFINDER-SOJOURNER WEB PAGE
http://www.gsfc.nasa.gov/hqpao/pathfinder.html

MARS GLOBAL SURVEYOR: http://marsweb.jpl.nasa.gov/

Impacts on Mars have caused the ejection of Martian rock from the planet, some of which subsequently has entered the Earth's atmosphere.

MARS METEORITE ALH 84001 WEB PAGE
http://cass.jsc.nasa.gov/lpi/meteorites/mars_meteorite.html

The existence of abundant water-ice on Mars provides the basis for permanent human settlement.

Asteroidal and cometary material has impacted the Earth, Moon, and Mars, at times profoundly influencing geological and biological events and creating an even larger, intrarelated environmental system (Lectures #18 and 25).

With respect to future symbiosis between the Earth, Moon, and Mars, material presented in this course will establish the following:

1. Future energy, environmental, and human needs on Earth will require alternatives to the use of fossil hydrocarbons as fuel (Lectures #2, 3, 4, and 40).

Uncertainty about the net environmental effect of burning fossil hydrocarbons in the attempt to satisfy the needs and desires of future billions on Earth, if nothing else, makes it prudent to seek alternatives.

Global climate change is inevitable: natural and possibly anthropogenic warming in the near centuries, cooling in the far centuries (Christensen, 1997).

ANNAPOLIS CENTER WEB PAGE/CLIMATE CHANGE WORKSHOP: http://www.ttemi.com/annapoliscenter

Solar energy from space, including from the surface of the Moon, is one non-terrestrial energy option (Lectures #35 and 36).

Another is lunar ^3He as a fusion fuel. The energy equivalent dollar value of ^3He, as compared to coal, and the low capital cost potential of inertial electrostatic confinement (IEC) technologies, strongly suggest that lunar ^3He could support commercially competitive electrical power economy on Earth (Lectures #27, 28, 34, and 42).

There would be a large net positive environmental effect on the Earth-Moon system as a consequence of the use of lunar ^3He in terrestrial fusion electric power plants (Lecture #40).

The geologically temporary disturbance of the lunar surface would be more than balanced by the permanent reduction in the chemical and possible thermal alteration of the Earth's environment by the continued use of fossil hydrocarbons.

Reduction of pollution on Earth:

- carbon, sulfur, nitrogen based effluents
- ash and scrubber waste
- high level radioactive waste production
- low level radioactive effluents
- thermal alteration

Elimination of potential fission plant meltdowns

Elimination of potential radiation releases during fission and tritium fusion plant failures

Reduction of fuel and waste transport risks

Elimination of existing inventories of spent fission fuel rods by transmutation using IEC technologies.

Fossil hydrocarbons also would be preserved for use as valuable natural chemicals for the benefit of future generations.

(Increase in noise and effluents from lunar transport rockets - water and nitrous oxides)

Effects on the Moon

Elimination of small craters less than about 10m in diameter (little or no change in albedo)

Temporary release of small amounts of solar wind volatiles into the lunar atmosphere

Permanent or long duration human settlements

Excess equipment and solid waste storage areas

3. Strong philosophical, as well as scientific and political, arguments exist that support the establishment of human settlements on the Moon and Mars (Lectures #1, 23, 24, 41 and 42).

Such settlements, at a minimum, reduce the risk to the human species of being confined to one planet, a planet at some risk to a variety of terrestrial and extraterrestrial hazards.

At a maximum, lunar and Martian settlements accelerate the technological evolution of the human species as a galactic inhabitant.

4. By-products from the production of lunar ^{3}He, directly or indirectly, include the materials necessary to sustain indefinitely settlements on the Moon and Mars (Lectures #12, 13, 17, 19, 23, and 24).

Lunar volatiles (water, hydrogen, oxygen) and lunar access and settlement technologies will support the beginning of the exploration and settlement of Mars.

Although Mars could ultimately be self-sufficient by using its own resources, the shipment of lunar resources to Mars may be economical in the early decades of Mars settlement.

5. The technological resources necessary to access lunar ^{3}He also provide capabilities to satisfy many other societal demands, including the capability to deflect any major asteroid or comet that may be on a collision course with Earth (Lecture #8, 25, 30, 31, and 32).

Asteroid and comet identification and trajectory tracking is already within the state-of-the-art of existing technology and computational systems.

6. Business, legal, international and financial considerations strongly suggest that a variety of private and/or private/governmental options exist to support the continued movement of the human species into the solar system (Lectures #9, 33, 34, 38, 39, and 42).

These conclusions support future consideration of the Earth, Moon, and Mars as one environmental system, indeed, as one ecological system.

In this planetary environmental system, the Moon, with its resources of ^{3}He and the by-products of ^{3}He production, forms the bridge between the preservation and advancement of human civilization on Earth and its expansion elsewhere in the Solar System.

"A place is not a place until people have lived in it, and died in it." –Wallace Stegner**,** *The American West as Living Space*, 1987

We must create a permanent "sense of place" in the Solar System before heading to the Stars.

SLIDE: APOLLO 17 FULL EARTH

References:

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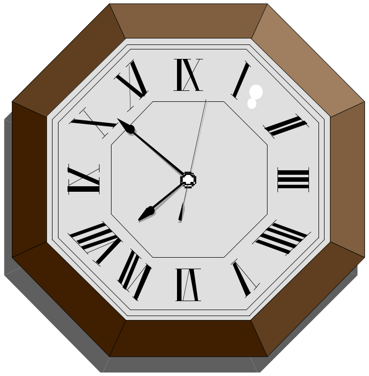
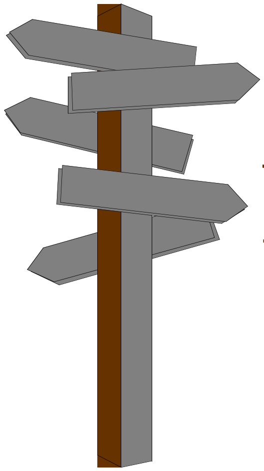
EARTH, MOON, and MARS

ONE ENVIRONMENTAL SYSTEM



PAST SYMBIOSIS - 1

- EARTH AND MOON:
  - TIED DYNAMICALLY THROUGH HISTORY
  - INFLUENCE ON DEVELOPMENT OF LIFE?
    - TWO PLANETS MORE STABLE THAN ONE
    - THUS, EARTH MORE STABLE THERMALLY THAN OTHERWISE
- MOON
  - PRESERVES NON-AQUEOUS HISTORY OF TERRESTRIAL PLANETS
- MARS
  - PRESERVES EARLY AQUEOUS HISTORY



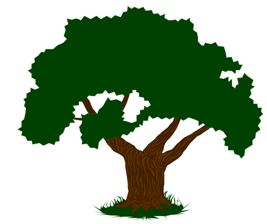
PRESENT SYMBIOSIS - 2

- SAME ENERGY SOURCE - SUN
- ASTEROID/COMET IMPACT
- INTERACTION AND EXCHANGE
- HUMAN STUDY AND MONITORING

FUTURE SYMBIOSIS - 3

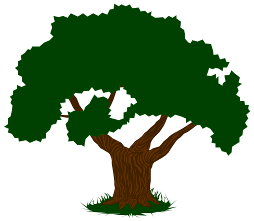
- HUMAN NEEDS ON EARTH
  - ENERGY
  - ENVIRONMENT
  - CONSUMABLES
- ALTERNATIVES TO HYDROCARBONS
  - UNCERTAINTY LONG TERM
- NEEP 533 EXPLORES IMPLICATIONS OF SPACE RESOURCES

ENERGY/ENVIRONMENT-1



- GLOBAL ENERGY USE BY 2050
  - 8+ TIMES USE TODAY
    - DOUBLE POPULATION (X2)
    - SATISFY ASPIRATIONS (X4)
    - RESPONSE TO CLIMATE CHANGE (X?)
      - WARMING
      - COOLING
      - WARMING THAT LEADS TO COOLING

ENERGY/ENVIRONMENT-2



- FOSSIL FUEL USE CONSEQUENCES
  - CLIMATE CHANGE ?????
  - HEALTH CONSEQUENCES?????
  - IMPORT RESTRICTION ?????
  - PROHIBITIVE COST?????
  - LOSS OF SOVEREIGNTY?????
  - LOSS OF HYDROCARBONS
    - FOOD, FERTILIZER, PLASTICS

ENERGY ALTERNATIVES

- CONSERVATION
- SOLAR
  - ELECTRIC, THERMAL, WIND, BIOMASS, HYDRO, HYDROGEN, SPACE SOLAR
- FISSION (ADVANCED)
  - LIGHT WATER, BREEDER, HIGH-T GAS
- FUSION
  - D/T, D/D, D/^{3}HE, ^{3}HE/^{3}HE, p/^{11}B

^{3}HE ALTERNATIVE -1

- LUNAR RESERVES EXTENSIVE
- HIGH POTENTIAL VALUE
  - COMMERCIALLY ATTRACTIVE
- NET POSITIVE ENVIRONMENTAL EFFECT
- SAVE EARTH'S RESOURCES
- BRIDGE TO MARS

^{3}HE ALTERNATIVE - 2

- ^{3}HE FROM THE MOON
  - LEADS TO MARS AT LOWEST COST
    - TECHNOLOGY DEVELOPMENT
    - FUSION ROCKET SYSTEMS
    - LUNAR CONSUMABLES
- SETTLEMENT OF MOON AND MARS
  - REDUCED RISK TO HUMAN SPECIES
  - TECHNOLOGICAL EVOLUTION OF HUMANS INTO A GALACTIC SPECIES

^{3}HE ALTERNATIVE -3

- LUNAR BY-PRODUCTS
  - HYDROGEN, OXYGEN, AND WATER
    - SUSTAIN MOON SETTLEMENTS
    - HELP START MARS SETTLEMENT

- TECHNOLOGY BY-PRODUCTS
  - ASTEROID/COMET DEFLECTION

EARTH, MOON, and MARS

ONE ENVIRONMENTAL SYSTEM

- LUNAR ^{3}HE AND BY-PRODUCTS
  - – BRIDGE COMPETING NEEDS
    - PRESERVATION AND ADVANCEMENT OF HUMAN CIVILIZATION ON EARTH
    - EXPANSION INTO THE SOLAR SYSTEM

WALLACE STEGNER

- "…a place is not a place
  - until people have been born in it,
  - have grown up in it,
  - lived in it,
  - known it and
  - died in it."
    - » Where the Bluebird Sings to the Lemonade Springs, 1992, p. 201