Abstract

The NASA Office of Exploration case studies for FY 89 are reviewed with regard to study groundrules and constraints. Three study scenarios are presented: lunar evolution, Mars evolution, and Mars expedition with emphasis on the key mission objectives.
Specific Exploration Studies Goals and Objectives for FY 1989

Primary Goal

- Develop knowledge base for FY 91 "decision Year" Budget

Objectives

- Update and refine exploration cases
- Obtain a detailed understanding of prerequisite requirements
- Continue building exploration team capability
- Develop effective external interactions
- Conduct first relative cost estimate
Objective: Update and Refine Exploration Cases

Strategy for Case Study Additions and Modifications

• Do an in-depth penetration of technologies, systems, and operations capabilities required to conduct a "bare bones" trip to Mars.

• Investigate the potential for Mars evolution capability using scaled down vehicles and systems (relative to FY 88 studies) and constant annual investment (i.e., mass-to-LEO).

• Using the same constant annual investment strategy as in the Mars evolution case study, investigate the potential for a lunar evolution capability characterized by robust objectives for scientific achievement, technical research and development, operations support, and human acclimation.

Objective: Update and Refine Exploration Cases

Strategy for Case Studies Analysis

• Conduct systematic evaluations to ensure determination of cause and effect. Emphasize parametric analyses of capabilities and configurations, and conduct broad trade studies.

• Identify enabling technology areas and special exploration opportunities along with their associated systems alternatives.

• Conduct trade studies in technology and operations areas having potential for high yield relative to reduced mass-to-LEO, reduced dependency to a LEO node, improved systems performance and operation, and reduced cost.

• Evaluate the impact of using an artificial-g transfer vehicle and a conjunction trajectory on a mission to Mars/Phobos.

• Augment understanding of the effect of constant annual investment (using mass-to-LEO as the investment constraint) on lunar and Mars evolution strategy.
Objective: Update and Refine Exploration Cases

Strategy for Program Planning

- Formulate an advanced development plan and identify candidate case study technologies
- Conduct technical studies of international participation implications

Objective: Obtain a Detailed Understanding of Prerequisite Requirements

Areas

- Earth-to orbit transportation
- Life sciences
- Scientific precursors
- Space Station Freedom
- Technology

Strategy

- Seek to understand truly enabling vs. enhancing prerequisites
- Iterate plans with appropriate program offices
- Initiate (with Code E) science studies and user requirement and opportunity development
- Develop artificial gravity research facility feasibility and concepts
- Emphasize exploiting the systems and infrastructures that will be in place in the late 1990s for initiating exploration
Generic Groundrules and Constraints for Studies

- All case studies shall be evaluated to answer the question "why send humans?"

- All case studies shall be evaluated for the potential of maximizing science return

- All case studies shall be unconstrained by budget

- Relative, not absolute, cost estimates will be made for the FY 1989 case studies

- Evolutionary case studies shall be evaluated for the potential suitability of extraterrestrial resources

- All case studies shall be evaluated for the potential of international cooperation

FY89 Focused Case Studies

- Lunar Evolution
- Mars Evolution
- Mars Expedition
### Study Parameters Spread

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** To Be Studied

### Mars Expedition

- **Split Mission Concept**

- Outbound cargo consists of crew sortie vehicle for descent and ascent at Mars and supporting infrastructure

- Outbound piloted vehicle carries trans-Earth injection stage
MARS EXPEDITION CASE STUDY -- flight profile.
**Mars Evolution Case Study**

**Exploration Objectives**

- the emplacement of a permanent, self-sufficient base on Mars, and the establishment of early leadership in manned exploration of the Mars system

**Key Features**

- Annual limit on mass to low Earth orbit
- Advanced technology
- Establishment of an initial manned habitat on Mars
- Early emphasis on a martian moon gateway to produce water and cryogenic propellants
- Utilization of in situ resources
- Varied classes of missions using varied trajectories
- Block I reference
  - Initial flight uses opposition-class trajectory
  - all other flights use conjunction-class or opposition-class
- advanced chemical propulsion
- aerobraking at Mars and Earth
- reusable vehicles
- propellant production from indigenous resources
- Block II update
Mars Evolution

• BASE SITE LOCATION

• Simund Valley (Chryse Basin) in Hydraotes Complex
• 0 deg latitude, 33.5 deg west longitude
MARS EVOLUTION CASE STUDY

Initial Science Outpost

- All-up, multi-key return class
- Artificial life
- 1 crew to Mars surface, in pressurized rovers
- Open-ended stay-time in 395 days
- AC in space station
- Underground city
- Radiation shield
- Manned solar power plant
- Base surface equipment landed
- Begin robotic-controlled operation of IPP plant
- Gateway operational

Long-range objective: Permanent, self-sufficient base
Key constraint: Constant, annual investment strategy

Human-Tended Phase

- All-up, conjunction class
- Artificial life
- 3 crew
- begins propellant for IPP, 2 IPP return
- AC in space station
- VIP freighters

Operational Phase

- Flight 9-11
- Profile for human flight to Martian moons

Flight 1 profile.

MARS EVOLUTION CASE STUDY -- Flight 1 profile.
Exploration Objectives

• Long range objective
  • establishment of a permanent facility on the lunar surface with a significant capability for self support

• Evolutionary objectives
  • provision of test bed and learning center for long duration planetary missions
  • cut the tie to Earth by development of the lunar resource potential including propellant production and exploitation of resources
  • development of a significant science research capability for astronomy, planetary science, life sciences, and other fields
  • development of a gateway both inward for lunar base expansion and outward to support expansion of human presence into the solar system
Lunar Evolution Case Study

Key Features

- Lunar base evolves through three phases: human-tended, experimental, and operational
- Annual limit on mass to low Earth orbit
- Use of advanced technology
- Emphasis on early development of a human-tended outpost
- Utilization of in situ resources
- Lunar facility has a variety of scientific, technological, and operational objectives
- Block I reference
  - advanced chemical propulsion
  - aerobraking
  - reusable vehicles
  - propellant production from indigenous resources
- Block II update
  - additional mass-to-LEO allocation, and/or
  - new technology

Lunar Evolution

• BASE SITE LOCATION
  - North of crater Moltke in southern region of Mare Tranquillitatis
  - 0 deg latitude, 24 deg east longitude

• FAR-SIDE ASTRONOMY SITE
  - 0 deg latitude, 141 deg longitude
LUNAR SITE DIAGRAM

FAR-SIDE

MARE ORIENTALE

MARE IMBRIUM

LUNAR EVOLUTION CASE STUDY

2004  2005  2006  2007

HUMAN-LED

BASECAMP AND EARLY SCIENCE OUTPOST
- CREWS OF 4 ROTATED WITH VARYING STAY TIMES
- OXYGEN PRODUCTION FACILITY DELIVERED
- SCIENCE EXPERIMENTS EMBEDDED
- PHASE CONCLUDES WHEN CAPABILITY TO SUPPORT CREW OF 4 FOR 6 MONTH TOUR OF DUTY HAS BEEN ACHIEVED

PERMANENT HABITATION
- ESTABLISH AND TEST SYSTEMS TO EXTEND BOTH CREW SIZE AND TOUR OF DUTY
- EXPAND TO 6 CREW
- 6 MONTH TO 1 YEAR TOUR OF DUTY
- LUNAR SURF/LUNAR ORBIT ROUND-TRIPS USING LUNAR PROPS
- LUNAR OBSERVATORY SET-UP UNDERTAKEN
- PHASE CONCLUDES WHEN CAPABILITY TO SUPPORT CREW OF 6 FOR 2 YEAR TOUR OF DUTY HAS BEEN ACHIEVED

LONG-RANGE OBJECTIVE: PERMANENT, SELF-SUFFICIENT BASE
- LEARNING CENTER FOR LONG-DURATION PLANETARY MISSIONS
- LUNAR RESOURCE UTILIZATION
- SIGNIFICANT SCIENCE RESEARCH CAPABILITY

KEY CONSTRAINT: CONSTANT, ANNUAL INVESTMENT STRATEGY

SELF-SUFFICIENCY WITH MINIMAL EARTH RE-SUPPLY
- UP TO 30 CREW
- UP TO 2 YEAR TOUR OF DUTY
- LUNAR HYDROGEN PRODUCTION FOR PROPELLANT USAGE INITIATED
- INITIATE MARS EVOLUTION PROGRAM
LUNAR EVOLUTION CASE STUDY -- science outpost/human-tended phases.

LUNAR EVOLUTION CASE STUDY -- science outpost/human-tended phases.
LUNAR EVOLUTION CASE STUDY -- experimental phase.

LUNAR EVOLUTION CASE STUDY -- operational phase.