

Space Exploration Systems
Boeing CE&R Initial Concept
NASA ESMD & Fellow Contractors

September 13, 2004



Space Systems Development, Inc.





Boeing CE&R Initial Concept



- ◆ **Ground rules and assumptions**
- ◆ **Proposed objectives**
- ◆ **Activities to meet objectives**
- ◆ **Key features**
- ◆ **Initial Concept definition process**
- ◆ **Architecture summary**
- ◆ **Systems and elements**
- ◆ **Risks and technologies**
- ◆ **Key trades**

Ground Rules and Assumptions



- ◆ **Spiral definition for proposal (GR)**
 - **Spiral 1: CEV in LEO and robotic precursors**
 - **Spiral 2: Human and robotic lunar missions and robotic precursors**
 - **Spiral 3: Human and robotic Mars missions and robotic precursors**

- ◆ **Science and robotic probes continue through all spirals (GR)**

- ◆ **Permanent and continuous lunar occupancy (GR)**

- ◆ **Water ice confirmed and usable at lunar South Pole (A)**
 - **Concept designed to use when available**

- ◆ **Nuclear space/surface power source available (A)**
 - **Used but not required; other sources can be substituted**

GR = Ground rule; A = assumption



Specific VSE Objectives



- ◆ **Extend understanding of solar system (science)**
- ◆ **Nurture and inspire higher education (science and economic)**
- ◆ **Maintain technology leadership (economic and security)**
- ◆ **Enable private/commercial participation (economic)**
- ◆ **Enhance security through international cooperation (security)**
- ◆ **Establish defense for asteroid collision (security)**

VSE Activities to Meet Objectives



Science	Economic	Security
<p>Of the Moon (Everywhere)</p> <ul style="list-style-type: none"> • Lunar geology • Origins • Exploration <p>From the Moon</p> <ul style="list-style-type: none"> • Astronomy (RF to gamma-ray) (far side) • Earth orbit crossing object surveys • Continuous solar and planetary observations (circumferential) • Earth observation (earth facing) <p>On the Moon</p> <ul style="list-style-type: none"> • Resource utilization (mining and processing) (everywhere) • Low-g physiological effects • Radiation shielding effects • Mars Mission simulation <p>Space and Planetary Science Support</p> <ul style="list-style-type: none"> • Large observatory deployments • Planetary probe gateway • Space weather understanding and prediction 	<p>Earth-Based</p> <ul style="list-style-type: none"> • Commercial launch opportunities • Increasing high-skill, high-tech, high-paying job demand • Education driver to provide skills, inventions, and research needed • Research driver for improving space operations capabilities • He-3 fusion electricity generation • Entertainment <p>Space-Based</p> <ul style="list-style-type: none"> • Commercial transport opportunities • Propellant supply • Power generation and transmission • Tourism <p>Lunar-Based</p> <ul style="list-style-type: none"> • Propellant supply (South Pole driver) • Propellant production • Tourism • Power generation and distribution • He-3 mining 	<p>Domestic</p> <ul style="list-style-type: none"> • Infrastructure supports Earth observation missions (GEO transfer, LEO stages) • Exploration technologies can enhance terrestrial security • Energy independence via He-3 fusion • Space situational awareness <p>Global</p> <ul style="list-style-type: none"> • International cooperation for peaceful technology applications • Defense from asteroids and near-Earth objects • Species and knowledge survival <p>Economic</p> <ul style="list-style-type: none"> • Technology leadership through exploration leadership and full participation • Science and mathematics education leadership through skill demands and high-paying job opportunities

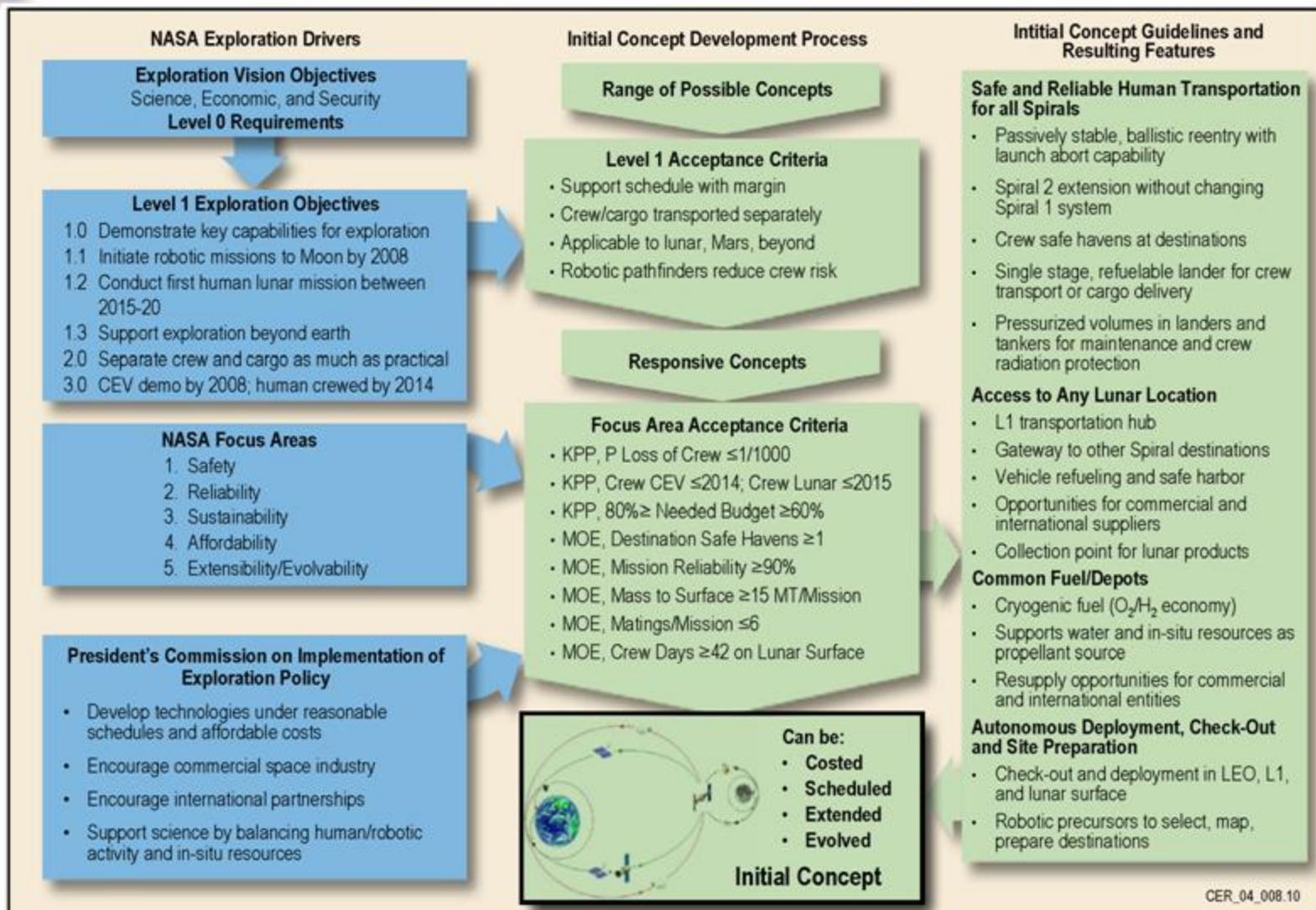


Initial Concept Desired Features



- ◆ **Passively stable ballistic reentry**
- ◆ **Full mission abort capability**
- ◆ **Spiral 2 uses Spiral 1 CEV**
- ◆ **Crew safe havens at destinations**
- ◆ **Single stage refuelable crew and cargo lander/ascent vehicle**
- ◆ **Multiple pressure volumes for safety**
- ◆ **L1 transportation node**
- ◆ **Gateway to other destinations**
- ◆ **Cryogenic propellants (LOx/LH)**
- ◆ **Vehicle refueling and safe harbor**
- ◆ **Lunar propellant source anticipated**
- ◆ **Commercial and international supply**
- ◆ **Robotic precursors to map and prepare**
- ◆ **Autonomous LEO, L1, and lunar surface C/O and deploy**

Initial Concept Definition Process



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An Initial Concept for the Vision for Space Exploration

Initial Concept Features

- Passively Stable Ballistic Reentry Capsule
- Full Envelope Flight Abort Capability
- Spiral 2 Uses Spiral 1 CEV
- Crew Safe Havens at Destinations
- Single Stage Refuelable Crew and Cargo Lander
- Multiple Pressure Volumes for Safety
- L1 Transportation Hub
- Gateway to Other Destinations
- Cryogenic Propellants
- Vehicle Refueling and Safe Haven
- Lunar Propellant Source Anticipated
- Commercial and International Supply
- Robotic Precursors to Map and Prepare
- LEO, L1, and Lunar Surface C/O and Deploy

Spiral 1

Launch Vehicle Options



L1

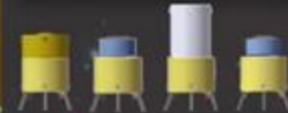
Spiral 2

L2

Equatorial Site



South Pole Site



Spiral 3

Mars Site



Our Initial Concept Systems and Elements

- Spiral 1
 - CEV: Crew Module/ Resource Module/ Flight Abort System
 - 20MT Launch Vehicle
- Spiral 2
 - Translunar Stage
 - Mission Module
 - Lunar Module
 - Tanker/Refueling Modules
 - Lunar Surface Ops Equipment
 - 20 to 80MT Launch Vehicle
 - Comm and Nav Satellites
- Spiral 3
 - Interplanetary Transfer Vehicle
 - Mars Descent/Ascent Vehicle
 - Mars surface Ops Equipment
 - Comm and Nav Satellites

For crew return from Mars

Specific Objectives

- Extend Understanding of Solar System (Science)
- Nurture and Inspire Higher Education (Science & Economic)
- Maintain Technology Leadership (Economic & Security)
- Enable Private/Commercial Participation (Economic)
- Enhance Security Through International Cooperation (Security)
- Establish Defense for Asteroid Collision (Security)

Key Risks/Technologies

- Cryo Fluid Mgmt and Storage
- Mating Systems
- Auton Rendez and Prox Ops
- EVA Capability
- Radiation Shielding
- Lunar Surface Power
- Precision Lunar Landing
- Advanced Flight Abort System
- Cryo Propulsion System
- SoS Common Op Environ
- Autonomous Element Activity, C/O and Control
- Auton Surface Ops

Key Trades

- Alternative Launch Vehicles
- Lunar Module Configuration
- Transport Node Location
- Wet vs. Dry Launch
- Vehicle Interface Types
- Alternate In-space Propulsion
- Reusability
- Cargo Transport Approach
- Cargo Return Capability

Our Program Approach

- Washington D.C. Based Requirements Team
- SoSE and DoDAF Guidelines
- 4 Design Analysis Cycles Supporting Major Reviews
- Boeing-wide and Small Business Team
- International Cooperation

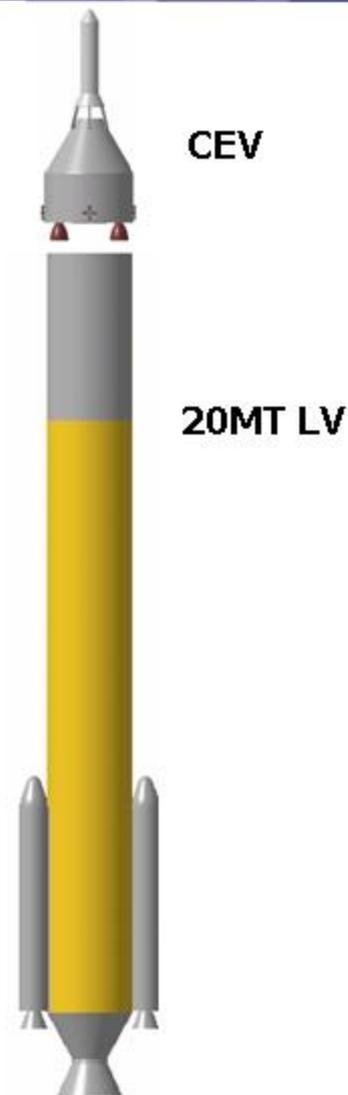
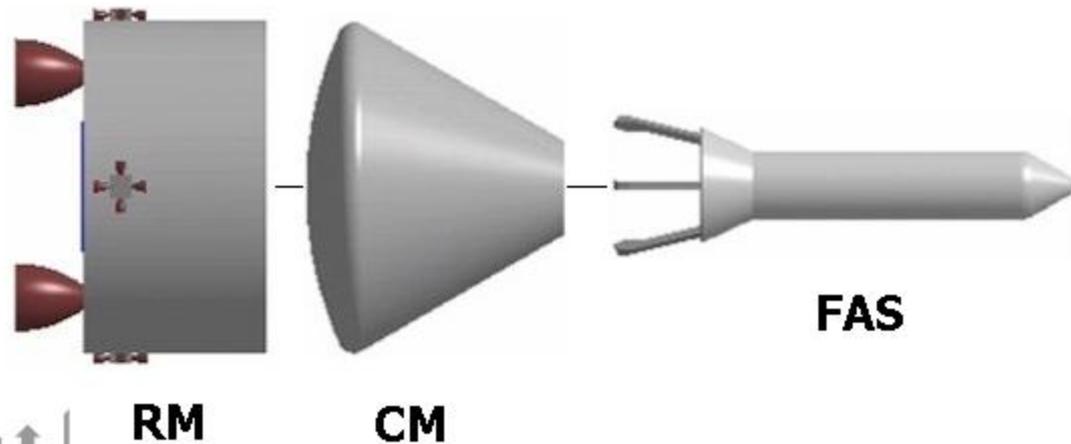
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Initial Concept Systems and Elements Spiral 1



- ◆ **Crew Exploration Vehicle:**
 - Crew Module (CM)
 - Resource Module (RM)
 - Flight Abort System (FAS)
- ◆ **20MT Launch Vehicle**
- ◆ **Precursor missions**

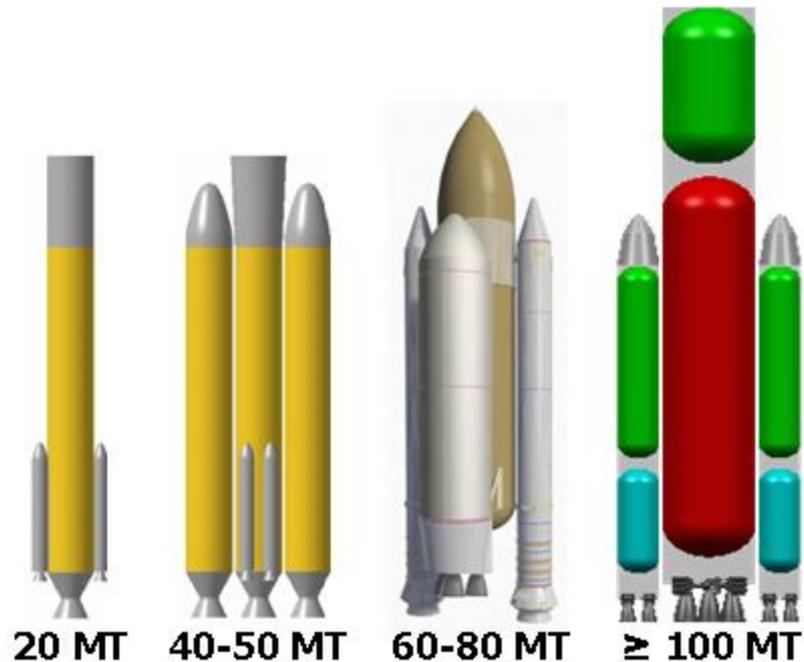
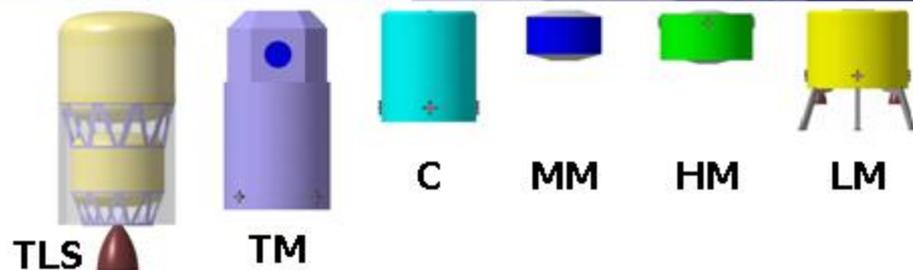


Initial Concept Systems and Elements

Spiral 2



- ◆ Translunar Stage (TLS)
- ◆ Mission Module (MM)
- ◆ Lunar Module (LM)
- ◆ Tanker/Refueling Modules (TM)
- ◆ Hab Module (HM)
- ◆ Lunar surface ops equipment
- ◆ Cargo carrier (C)
- ◆ 20 to 80MT Launch Vehicle (LV)
- ◆ Lunar Comm and Nav satellites
- ◆ Robotic precursor missions



Potential cargo launch vehicles

Initial Concept Systems and Elements

Spiral 3



- ◆ **Interplanetary Transfer Vehicle**
- ◆ **Mars Descent Vehicle**
- ◆ **Mars Ascent Vehicle**
- ◆ **Mars surface ops equipment**
- ◆ **Mars Comm and Nav satellites**
- ◆ **Mars precursor missions**



Key Risks and Technologies



- ◆ **Advanced flight abort system**
- ◆ **Autonomous rendezvous and proximity operations**
- ◆ **Mating systems (pressurized and unpressurized)**
- ◆ **System of Systems common operational environment (NCO)**
- ◆ **Autonomous element activation, C/O and control**
- ◆ **Cryogenic (LOx/LH) propulsion systems**
- ◆ **Cryogenic fluid management and storage**
- ◆ **Precision lunar landing**
- ◆ **Autonomous surface operations**
- ◆ **Radiation shielding**
- ◆ **EVA capability**
- ◆ **Lunar surface power**

- ◆ **Alternate launch vehicles (ELV, SDV, New, capability)**
- ◆ **Lunar module configuration (single stage, two stage)**
- ◆ **Transport node location (LEO, L1, LLO)**
- ◆ **Wet vs. dry launch**
- ◆ **Vehicle interface types**
- ◆ **Alternate in-space propulsion (cryo, storable, nuclear, electric)**
- ◆ **Reusability (none, limited, all in-space)**
- ◆ **Cargo transport approach (impulsive, low-thrust, cyclers)**
- ◆ **Cargo return capability (none, CEV capability, new element)**

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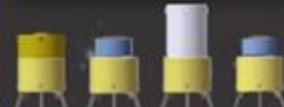
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