3. Ground Rules and Assumptions

At the beginning of the Exploration Systems Architecture Study (ESAS), a number of Ground Rules and Assumptions (GR&As) were established based on management guidance, internal and external constraints, design practices, and existing requirements. The purpose of this section is to summarize those GR&As below.

3.1 Safety and Mission Assurance (S&MA) GR&As

The S&MA GR&As are listed below.

- NASA Procedural Requirements (NPR) 8705.2, Human-Rating Requirements for Space Systems, will be used as a guideline for all architecture design activities. Required deviations from NPR 8705.2 will be noted in the applicable requirements documentation.
- Abort opportunities will be provided throughout all mission phases to the maximum extent possible.
- In the event of an abort from the lunar surface, return of crew to the Earth's surface will take no longer than 5 days—independent of orbital alignment.

3.2 Operations GR&As

The Operations GR&As are listed below.

- The Crew Exploration Vehicle (CEV) will deliver crew to and from the International Space Station (ISS) through ISS end-of-life in 2016.
- The CEV will deliver and return cargo to the ISS through ISS end-of-life in 2016.
- The architecture will separate crew and large cargo to the maximum extent practical.
- The architecture will support ISS up/down mass needs and other ISS requirements, as required, after Shuttle retirement.
- CEV operations will be performed at the Kennedy Space Center (KSC) through clearing of the launch pad structure.
- On-orbit flight operations and in-flight operations for crewed missions will be performed at the Johnson Space Center (JSC).
- Crew and cargo recovery operations from the crew and cargo launches will be managed by KSC with assistance from other NASA and non-NASA personnel and assets as required.
- Architectures will enable extensibility of lunar mission systems to human Mars exploration missions.
- The study will utilize the Mars Design Reference Mission (DRM) known as DRM 3.0, "Reference Mission Version 3.0 Addendum to the Human Exploration of Mars: The Reference Mission of the NASA Mars Exploration Study Team EX13-98-036, June 1998."
- The architecture will support lunar global access.
- The architecture will support a permanent human presence on the Moon.
- In-space Extra-Vehicular Activity (EVA) assembly will not be required.
- In-space EVA will only be performed as a contingency operation.
- Human-rated Evolved Expendable Launch Vehicle- (EELV-) derived Launch Vehicles (LVs) will require new dedicated launch pads.

3.3 Technical GR&As

The Technical GR&As are listed below.

- The CEV will be designed for up to a crew of six for ISS missions.
- The CEV will be designed for up to a crew of four for lunar missions.
- The CEV will be designed for up to a crew of six for Mars missions.
- The CEV to support the lunar and Mars exploration missions and the ISS missions will use a single Outer Mold Line (OML) for the entry vehicle.
- Architectures will be designed for the lunar and Mars exploration missions and modified as required to support ISS missions.
- No more than four launches will be used to accomplish a single human lunar mission. This does not include infrastructure launches or supporting logistics.
- The following inert weight contingencies will be used:
  - Zero percent (0%) for existing LV elements with no planned specification change and no anticipated modifications (e.g., Space Shuttle Main Engine (SSME), RS–68, RD–180);
  - Five percent (5%) on existing LV elements requiring minimal modifications (e.g., External Tank (ET), Orbiter aft structure, EELV boosters, upper stages, and shrouds);
  - Ten percent (10%) on new Expendable Launch Vehicle (ELV) elements with direct Shuttle or EELV heritage;
  - Fifteen percent (15%) on new ELV elements with no heritage; and
  - Twenty percent (20%) on new in-space elements with no heritage (e.g., CEV, Lunar Surface Access Module (LSAM)).
- Additional margins and factors of safety include the following:
  - Thirty percent (30%) margin for average power;
  - Two percent (2%) margin for reserves and residuals mass;
  - Two percent (2%) propellant tank ullage fractions for LV stages;
  - Fuel bias of nominal mixture ratio * 0.000246 * usable propellant weight;
  - A 2.0 factor of safety for crew cabins;
  - A 1.5 factor of safety on burst pressure for fluid pressure vessels;
  - A 1.4 ultimate factor of safety on all new or redesigned structures;
  - A 1.25 factor of safety on proof pressure for fluid pressure vessels;
  - Ten percent (10%) margin for rendezvous delta-Vs;
  - One percent (1%) ascent delta-V margin on LVs to account for dispersions;
  - Ten percent (10%) payload margin on all LV payload delivery predictions; and
  - Five percent (5%) additional payload margin on Cargo Launch Vehicle (CaLV) delivery predictions to account for Airborne Support Equipment (ASE).
- Technologies will be Technology Readiness Level-Six (TRL-6) or better by Preliminary Design Review (PDR).

3.4 Cost GR&As

The Cost GR&As are listed below.

- There will be only one CEV contractor after Calendar Year 2005 (CY05).
- There will be no 2008 CEV flight demonstration as originally planned.
- All Life Cycle Cost (LCC) estimates will include best-effort estimates of "full-cost" impacts (including corporate General and Administrative (G&A) at 5%, Center G&A, Center Civil Service salaries, travel, overhead, and Center service pool costs).
- Cost estimates will use 20 percent reserves for development.
- Cost estimates will use 10 percent reserves for operations.
- Cost estimates will use the April 2005 NASA New Start Inflation Index.

3.5 Schedule GR&As

The Schedule GR&As are listed below.

- There is a goal of 2011 for the first CEV human flight to ISS.
- There is a goal of performing the next human lunar landing by 2020—or as soon as practical.

3.6 Testing GR&As

The Testing GR&As are listed below.

- Ground Element Qualification
  - Elements will have ground qualification tests to demonstrate readiness for manned flight.
  - Multi-element integrated tests will be performed to demonstrate readiness for manned flight.
- Element Flight Qualification
  - Qualification of the CEV requires a minimum of one flight demonstrating full functionality prior to crewed flights.
  - Qualification of the LSAM requires a minimum of one flight demonstrating full functionality prior to lunar landing.
  - Qualification of any crewed LV requires three flight tests for human certification prior to crewed flight.
  - Qualification of any CaLV requires one flight test prior to flight of high-value cargo.
- Integrated System Qualification
  - Qualification of the Earth Departure Stage (EDS) for firing while mated to a crewed element requires a minimum of two flights to demonstrate full functionality prior to crewed flight.
  - Lunar mission rehearsal in-space with appropriate architecture elements and crew is required prior to attempting a lunar landing.

3.7 Foreign Assets GR&As

- Foreign assets utilized in LV configurations in this study will be assumed to be licensed and produced in the United States.