UP01

2ND GENERATION REUSABLE LAUNCH VEHICLE PROGRAM

LEVEL 1 REQUIREMENTS

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MSFC - Form 454 (Rev. October 1992)
DOCUMENT HISTORY LOG

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1. SCOPE/PURPOSE

1.1 SCOPE

The U.S. Space Launch Initiative (SLI), also known as the 2nd Generation Reusable Launch Vehicle (2nd Gen RLV) Program, is the central element of NASA’s Integrated Space Transportation Plan (ISTP), which is NASA’s long range strategy for safer, more reliable, and less expensive access to space. The ISTP consists of 3 major programs that include Shuttle safety upgrades, the 2nd Gen RLV Program and the 3rd Generation RLV (3rd Gen RLV) Technologies and In-Space Transportation System. The 2nd Gen RLV Program addresses 2nd Generation RLV risk reduction, NASA unique systems risk reduction, and enables alternate access to the International Space Station (ISS). Building on 20 years of success with America’s 1st Generation RLV— the Space Shuttle — the 2nd Gen RLV defines the plan of action to design and develop America’s next-generation RLV. The 2nd Gen RLV Program, is based on the philosophy that frequently launching NASA payloads on highly reliable, privately-owned-and-operated reusable launch vehicles will significantly reduce the cost of space access, allowing the Agency to focus resources on its core missions of scientific discovery and exploration.

In partnership with the Department of Defense (DoD), the U.S. aerospace industry, and academia, NASA will perform systems engineering, technology development and architecture definition trade studies to define at least two 2nd Generation RLV architecture designs that will best meet mission requirements. The NASA Research Announcement (NRA) 8–30 procurement for 2nd Generation RLV design-and-development activities took into account extensive NASA studies and contractor-provided input from NRA 8–27, which focused on detailed requirements evaluation, updated market projections, and risk-reduction priorities and plans. This systematic approach targets the research and development of high-priority advanced technologies — such as lightweight structures, long-life rocket engines, advanced crew systems, life support, robotics, flight control and avionics, and thermal protection systems — to be integrated into at least two vehicle architectures that will compete to go into full-scale development around mid-decade, with operations early next decade. The SLI, embodied in the 2nd Generation RLV Program, is NASA’s near-term plan to make access to space safer, more reliable, and less expensive for present and future customers. In this way, NASA’s mission requirements will be met more efficiently and U.S. leadership in space will continue in the new century.

1.2 PURPOSE

The Bush Administration’s “A Blueprint for New Beginnings,” released in February 2001, approved the SLI (2nd Gen RLV) as a continuing investment for Fiscal Year (FY) 2002, with great importance placed on promoting space launch opportunities for both Government and private sectors. Through the 2nd Gen RLV Program, NASA leads a team that includes DoD, U.S. aerospace industry, and academia to develop viable system architectures and technologies based on clearly defined system requirements. Therefore, the Level 1 requirements outlined in this document will serve as principal
inputs and form an integral part of the systems engineering and analysis activities and trade studies in accordance with the 2nd Gen RLV Program Plan. This document will be updated on an as-needed basis as the Program progresses.

### 1.3 DOCUMENT OVERVIEW

The way to safe, reliable, and affordable access to space has been blocked by technical and business challenges. NASA’s systems analysis and engineering expertise, combined with targeted investment areas, will help remove risk barriers for 2nd Gen RLV design and development. This document presents the Level 1 technical requirements for 2nd Gen RLV architectures and initiates the systems engineering and analysis process. As such, it is a guiding instrument for all activities in the 2nd Gen RLV Program. This document relates to the development of Level 1 2nd Gen RLV architecture requirements as illustrated in Figure 1.

![FIGURE 1. Document Flowdown Process](image)

### 1.4 DOCUMENT CONVENTIONS

The 2nd Gen RLV Level 1 architecture requirements are derived from an understanding of NASA, DoD, and commercial mission needs, and from deficiencies in the existing fleet of launch vehicles. Figure 2 illustrates how these two items factor into need statements that, in turn, drive Level 1 requirements.
FIGURE 2. 2nd Gen RLV architecture Level 1 requirements definition process

For clarity, the following definitions are offered:

a. Systems deficiencies include inadequate space transportation system safety and reliability, and excessive space transportation user costs.

b. Need statements identify system deficiencies in, and mission needs for, the current system capabilities. Need statements clearly define what NASA expects the new system to do.

c. Level 1 requirements state capabilities or characteristics the architecture must have to meet the needs.

To distinguish mission needs from mission requirements, as well as to facilitate reference and tracking, identifiers precede each statement, as applicable. Numerical identifiers are for organizational purposes and do not indicate prioritization. Therefore:

a. Mission need statements are preceded by an $N$ in brackets, for example:
   
   [N10] is the first need identifier.
   
   [N20] is the second need identifier.

b. Mission requirement statements are preceded by an $M$ in brackets, for example:
   
   [M10] is the first mission requirement identifier.
   
   [M20] is the second mission requirement identifier.
c. Architecture requirement statements are preceded by an A in brackets, for example:

[A10] is the first architecture requirement identifier.

[A20] is the second architecture requirement identifier.

The requirements described in section 7.0 below are defined in terms of threshold values and objective values, defined as follows:

a. Threshold values are the minimum acceptable values that are necessary to satisfy the Level 1 requirement.

b. Objective values are the values desired by the 2nd Gen RLV Program.

2.0 APPLICABLE DOCUMENTS

This section includes listings of applicable, reference and relevant documents. (Note that some documents are to be specified (TBS).)

2.1 APPLICABLE DOCUMENTS

The following documents are applicable to 2nd Gen RLV architecture requirements:

JSC 28354 Human Rating Requirements
TBS 2nd Gen RLV Program Plan
TDSD8.1.1-04 ISS Integrated Traffic Model Report, Design Analysis Cycle 8; updated annually.
SSP 50235 Interface Definition Document for International Space Station Visiting Vehicles

2.2 REFERENCE DOCUMENTS

The following are reference documents:

2GRLV-DOC-010 NASA Design Reference Missions (DRMs) Document
The NASA Strategic Plan 2000, dated September 2000
The Aerospace Technology Enterprise Strategic Plan, dated April 2001
The Human Exploration and Development of Space Strategic Plan
2nd Generation Space Transportation Architecture Level 1 Requirements, dated August 1999
3.0 DEFINITIONS/ACRONYMS

3.1 DEFINITIONS

Architecture - the integrated set of elements of a candidate launch system including the Earth-to-orbit launch vehicles, on-orbit transfer vehicles and upper stages, mission planning, ground and flight operations, and ground-based and on-orbit-based support infrastructure

Alternate Access — enables the U.S. aerospace industry to develop unique technologies, system designs, and innovative procurement mechanisms for a system that includes both space launch and the capability to dock or berth with the Space Station; an incentive for both established and emerging launch companies to provide near-term, commercial launch services to ferry spares, logistics materials and other cargo; provides logistics backup for the Space Shuttle and Progress vehicles.

Crew — any personnel aboard an element of the 2nd Gen RLV architecture during ascent, while on orbit, and/or during descent and landing.

Design Reference Mission — provides a technical description of mission inputs for analysis, including orbits, cargo, duration, weight, size, etc.

Evolutionary Mission – missions that enable an evolutionary growth path to support the missions beyond primary and secondary missions that cannot be supported at IOC.

Launch Availability — the probability that the system is operable and ready to perform within a scheduled launch opportunity.

Launch Price – price charged by the launch operator for a mission; includes all recurring operations cost plus amortization of investment, depreciation, interest, profit, etc.

Level 1 Requirement — a capability or characteristic the system or architecture must have to meet clearly defined needs.

Loss of Crew — the loss of life of any crewmembers during any portion of the 2nd Gen RLV mission.

Loss of Mission — failure of a 2nd Gen RLV architecture element to perform to specifications, leading to mission failure.
Needs Statement — identifies perceived deficiencies in current system capabilities and clearly defines what performance NASA expects the 2nd Gen RLV system to deliver.

Objective Values — the values desired by the 2nd Gen RLV Program.

Primary Mission — a mission that the 2nd Gen RLV architecture must be able to perform by IOC.

Recurring Operational Cost — All costs incurred by the operator(s) to operate the 2nd Gen RLV architecture flight and ground systems, including the labor force and the infrastructure, from mission to mission. The recurring Cost is inclusive of the fixed costs and the flight rate variable operations costs.

Fixed Costs — Operations costs incurred by the operator(s), which exist as costs regardless of flight rate.

Variable Operations Costs — Operational costs incurred by the operator(s) as the incremental or additional costs needed to add flight rate capability. That is, the mean cost for one additional flight per year within a given architecture and its fixed infrastructure.

Responsiveness — The ability to provide timely space transportation services as specified by the customers. Typically, responsiveness is characterized by turnaround times, flight rate capability, surge rates or “launch-on-demand,” capacity & throughput capability, and customer flexibility. Architecture also is pre-planned to easily receive upgrades to the various systems that benefit the customer.

Secondary Mission — a non-primary mission that the 2nd Gen RLV architecture must be designed to accomplish, but is not required to be incorporated at IOC.

2nd Gen RLV Architecture — the integrated set of Earth-to-orbit and on-orbit vehicles; mission planning; ground and flight operations; and ground-based and on-orbit support infrastructure required to meet all NASA, DoD, and commercial space transportation requirements.

2nd Gen RLV Systems — the individual elements of the space transportation architecture for Earth-to-orbit and on-orbit vehicles, and mission planning.

Threshold Values — the minimum acceptable values that are necessary to satisfy Level 1 requirements.

Total Flight Profile of a Mission — phases of a mission, including launch, ascent to orbit, on-orbit operations, descent, re-entry, and landing.

### 3.2 ACRONYMS

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<td>CRV</td>
<td>Crew Recovery Vehicle</td>
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<td>DoD</td>
<td>Department of Defense</td>
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<td>DRM</td>
<td>Design Reference Missions</td>
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<td>FY</td>
<td>Fiscal Year</td>
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<td>IOC</td>
<td>Initial Operating Capability</td>
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4.0 PROGRAM OBJECTIVES

The overall goal of the 2nd Gen RLV Program is to substantially reduce technical and business risks associated with developing safe and reliable RLVs, and providing affordable launch operations. NASA’s specific goals are:

a. To improve the safety — risk of crew loss — to less than 1-in-10,000 missions.

b. To decrease the cost by a factor of 10 — to approximately $1,000 per pound of payload launched to Low Earth Orbit (LEO).

2nd Gen RLV architectures will consist of commercially owned and operated launch vehicles combined with Government-unique hardware. The integrated architecture will be designed to meet NASA’s mission, while improving U.S. competitiveness in the space launch industry and enabling DoD missions to the greatest extent possible. Due to the broad range of NASA, commercial and DoD mission requirements, the program will be programmatically phased to meet these requirements. The 2nd Gen RLV program will reduce the technical and programmatic risks, thereby enabling at least two commercially competitive RLV architectures to go into full-scale development around the middle of this decade and could begin operations early next decade.

2nd Gen RLV Program investments will emphasize risk-reduction activities selected according to industry and NASA needs. The high priority risk reduction areas identified included technology development and demonstration, business and program planning, and systems engineering and analysis. The Program will implement decision processes that link specific investments to the highest priority risk areas and technologies that
support multiple commercial competitors. High-priority investment areas for the 2\textsuperscript{nd} Gen RLV Program are identified in the 2\textsuperscript{nd} Gen RLV program plan.

5.0 NEED STATEMENTS

The Space Transportation Council has identified the need to improve the capability of current space transportation systems. The needs identified below provide the basis for 2\textsuperscript{nd} Gen RLV architectures.

System deficiency driven need statements are:

[N10] Significantly improve the safety of transporting humans into low-Earth orbit (LEO).

[N20] Significantly reduce the cost of transporting humans and cargo into LEO.

Mission needs drive the following need statements:

[N30] Perform Government-defined primary, secondary and evolutionary missions, as specified in section 6.0 below.

[N40] Improve the probability of mission success.

[N50] Improve launch availability and responsiveness of transporting humans and payloads into space.

[N60] Enable and support a growth path to the future commercial development of space.

[N70] Enable and support a growth path to the future human and robotic exploration of space.

[N80] Coordinate NASA, DoD and commercial mission needs to maximize investment opportunities for the stakeholders.

[N90] Enable alternate U.S. access to the ISS.

6.0 MISSION DEFINITION

New space transportation architectures are required to accomplish a broad range of crewed and uncrewed missions, requiring a comprehensive set of functional capabilities. Design reference missions (DRMs) have been developed which outline the capability envelope required of the 2\textsuperscript{nd} Gen RLV. These missions are grouped into three categories: Primary, Secondary and Evolutionary as described below. These missions provide the basis for assessing an architecture’s ability to meet the program goals and objectives.

6.1 GOVERNMENT PRIMARY MISSIONS

Second Generation RLV baseline architectures must be capable of performing the primary set of missions at the time of Initial Operating Capability (IOC) and, as such, provide the benchmark for defining the basic performance capabilities of the
architecture. DRM descriptions are found in the (2GRLV-DOC-010) NASA DRM. International Space Station (ISS) logistics missions must be in accordance with the ISS Integrated Traffic Model Report, Design Analysis Cycle 8, TDSD8.1.1-04, and the Interface Definition Document for International Space Station Visiting Vehicles, SSP 50235, as applicable.

[M10] Support the ISS logistics for re-supply, maintenance or crew exchange.

[M20] Deliver payloads to various low-Earth orbits and other orbital destinations.

[M30] Deliver payloads to various low-Earth orbits for activation, checkout, deployment, and return to Earth, if required.

[M40] Reserved.

6.2 GOVERNMENT SECONDARY MISSIONS

The secondary missions describe capabilities that the baseline 2nd Gen RLV architecture must be designed to accomplish, but are not required to be incorporated at IOC. The candidate architectures may provide alternative methods of accomplishing the missions outlined in the DRM description. The alternative methods must be more efficient and/or enhance attainment of one or more of the program goals and objectives. A reference description of these missions is found in the (2GRLV-DOC-010) NASA DRM.

[M50] Support assembly and checkout of space platforms and modules.

[M60] Service and re-boost on-orbit spacecraft, platforms, and other orbital assets.

[M70] Retrieve on-orbit assets for repair and/or service, and return to Earth, if required.

[M80] De-orbit space debris or inactive spacecraft.

6.3 GOVERNMENT EVOLUTIONARY MISSIONS

Evolutionary missions generally are those that require architectures to have significant additional capabilities over and above those required for either primary or secondary missions. Additional lift capability, on-orbit impulse, reentry cross range capability, and/or the ability to remain on orbit for extended periods may be required to accomplish this set of missions. It is anticipated that the capability to perform evolutionary missions may not be needed until after 2nd Gen RLV IOC. The architectures provided to meet the primary and secondary missions must provide an identified growth path to meet the evolutionary missions. A reference description of these missions is found in the (2GRLV-DOC-010) NASA DRM.

[M90] Support crew rescue

[M100] Support polar orbit missions, both crewed and uncrewed.

[M110] Support human exploration vehicle element delivery missions to low earth orbit

[M120] Support human exploration crew delivery missions
7.0 GOVERNMENT LEVEL 1 REQUIREMENTS

Following is a listing of Level 1 requirements for Government missions:

[A10] Comply with all applicable NASA, DoD, and civil flight safety requirements as defined in [A11] through [A14] and in accordance with the Human Rating Requirements, JSC –28354, as applicable.


[A12] Achieve a probability of loss of crew (LOC) for the total flight profile of a mission.
   a. Threshold — must equal a probability of 1/10,000 (TBR) or less.
   b. Objective— should equal a probability of 1/10,000 or less.

[A13] Assure safety of personnel on the ground (transportation employees and customers).

[A14] Assure safety of high value assets.

[A20] Reserved.

[A30] Deliver payloads into a low earth circular orbit, as described in the NASA DRM document.
   a. Threshold — must provide a recurring operational cost of $1,000/pound or less.
   b. Objective — should provide a launch price of $1,000/pound or less.

[A40] Achieve a probability of loss of mission (LOM) throughout the design life of the 2nd Gen RLV architecture.
   a. Threshold — must provide a probability of 1/100 or less.
   b. Objective — should provide a probability of 1/200 or less.

[A50] Provide the capability of supporting the Government missions defined in section 6.0 above.
   a. Threshold — must provide the capability of performing all primary missions at IOC.
   b. Objective— should provide the capability of performing secondary missions at IOC.

[A60] Achieve a probability of launching a Government payload within its scheduled launch opportunity.
   a. Threshold — must exceed 90% (TBR) probability that a payload will be launched within its specified opportunity.
   b. Objective — should exceed 95% probability that a payload will be launched within its specified opportunity.

[A70] Provide a growth path to support the Government secondary missions that cannot be supported initially.

[A80] Provide an evolutionary growth path that will enable the future commercial development of space.

CHECK THE MASTER LIST - VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE
[A90] Provide a viable growth path to support the Government evolutionary mission to enable the future human and robotic exploration of space by FY 2017.

[A100] Provide an evolutionary growth path to support future DoD launch needs.

8.0 ALTERNATE ACCESS LEVEL 1 REQUIREMENTS

[AA10] The alternate access capability must comply with all applicable NASA and civil launch and orbital safety requirements.

[AA20] The alternate access capability must achieve a probability of LOM throughout the design life of the launch system architecture.
   a. Threshold — must provide a probability of 1/100 or less
   b. Objective — should provide a probability of 1/200 or less

[AA30] The alternate access capability must provide the capability of supporting the missions defined in section 6.0 [M10] of this document.

[AA40] The alternate access capability must achieve a probability of launching a payload within its scheduled launch opportunity.
   a. Threshold — must exceed 90% probability that a payload will be launched within its specified opportunity.
   b. Objective — should exceed 95% probability that a payload will be launched within its specified opportunity.

9.0 COMMERCIAL LEVEL 1 REQUIREMENTS

Commercial Level 1 requirements are not provided in this document due to proprietary and/or competition-sensitive concerns. However, architecture contractors will develop their unique proprietary commercial requirements. These requirements will be provided as an annex to the Systems Requirements document, and also will be proprietary.

10.0 RECORDS

None.