

A Time-Sensitive Opportunity to Expand Crew Survival and Recovery Options

How can capabilities delivered through uncrewed Moon Base missions provide options for extended crew survival after an initially survivable failure, while advancing permanence and commercial returns?

PURPOSE: This discussion brief does not prescribe solutions or replicate NASA's mission-risk analysis. It seeks NASA and industry feedback to identify: 1) which NASA and industry teams own or are advancing the cross-provider ConOps, trade studies and partnerships needed to evaluate feasible ways to extend crew survival and preserve recovery options; 2) which initially survivable risk scenarios could benefit most from crew-survival extension and recovery capabilities; and 3) which planned or pre-positioned assets, and feasible additions to them, could provide useful backup capabilities across plausible single-site and multi-site architectures. NASA and its partners are addressing the OIG-identified risks and may already be evaluating these capabilities. The brief asks where cross-provider, program-level collaboration could reinforce that work while strengthening ongoing operations, Moon Base permanence and commercial returns. Examples are illustrative prompts for expert review. ^[12]

What Is Time-Sensitive and Why?

NASA and its HLS providers are mitigating vehicle-level hazards, developing crew-survival features and planning substantial ground, orbital and uncrewed lunar testing before the first crewed landing. ^[1, 5]

NASA's Office of Inspector General (OIG) identified a specific gap: crew-survival analyses often mature too late to drive risk reduction and do not account for extended crew survival to allow time to resolve the underlying threat. NASA concurred with updating the analyses and decision packages. It updated the HLS Crew Survival Analysis Report in September 2025 and developed two decision packages for HLS Control Board consideration in 2026. ^[1]

NASA is also accelerating robotic landings, cargo, mobility, power, communications, habitation and technology demonstrations through its phased Moon Base effort. These investments create an opportunity to add resilience rapidly and economically through capabilities that also improve ongoing operations, advance Moon Base permanence and strengthen commercial returns. ^[2, 3]

Apollo 13 demonstrated how alternate hardware, ground expertise and rapid cross-team adaptation can develop a recovery path under severe time pressure. Its team had only 87 hours to diagnose, improvise and execute backup plans after the explosion. Roughly 18 months remain before the planned 2028 crewed landing, but the opportunity to influence systems and assets already being designed, funded or manifested may close much sooner. ^[2, 4, 5]

Why Extended Survival Matters

Even with the planned testing, the uncrewed HLS lunar demonstrations will not include key crew systems or carry representative crewed-vehicle mass. Full-mass injection, insertion, landing, ascent and return, along with end-to-end propellant aggregation, will therefore remain untested before the first crewed landing. Artemis is also implementing these systems through a new firm-fixed-price commercial model after more than 50 years of workforce turnover since Apollo-era lunar operations. As missions move toward permanence, longer surface exposure increases risk that initially survivable anomalies evolve into prolonged emergencies. ^[1, 5]

A prolonged, globally witnessed emergency without viable preplanned recovery capabilities could have profound human, public-support and funding consequences, particularly if it ended in crew loss. ^[6, 7]

Working Hypothesis

For some initially survivable emergencies, adding selected resilience capabilities to planned missions may expand crew survival and recovery options sooner and at lower incremental cost while increasing the value these capabilities add to ongoing Moon Base operations. Where does this premise hold, where is it unsupported, and where may this work already be underway?

Three Questions for NASA and Industry

1) STABILIZE & SUSTAIN

How can planned surface assets help stabilize and sustain a crew after an emergency while also increasing ongoing mission value?

2) REPAIR & REPLENISH

How can planned missions preserve timely delivery of repair equipment, spares and consumables while expanding or accelerating their primary and commercial objectives?

3) PRESERVE RECOVERY PATHS

How can demonstration HLS vehicles, subsequent assets and prepositioned surface or orbital capabilities preserve alternate shelter, crew-transfer and recovery options while retaining productive value?

SCOPE: Some immediately catastrophic events would allow no response. The primary scenario considered is an initially survivable HLS anomaly that leaves critical systems degrading or unavailable. A capability need not complete the entire rescue chain to matter: detecting & safing, sustaining & communicating, or enabling movement, repair or transfer can each preserve time and options. ^[13, 14]

1) Stabilize & Sustain Near the Landing Site

NASA's Moon Base effort is developing capabilities with dual-use potential: power and storage, communications and navigation, remotely supervised mobility and logistics, robotic systems, site preparation, construction, habitation and shelter and ISRU.

In ongoing service, these capabilities can add resilience, reduce operating costs, raise utilization, accelerate science and resource development, and increase customer value. In a contingency, selected capabilities could extend crew survival and preserve options.^[9]

Illustrative Dual-Use Possibilities to Evaluate

POWER, THERMAL & COMMUNICATIONS

How can expanded power, thermal support and communications capacity accelerate mobility, payload functions and ISRU during ongoing operations while retaining the ability to connect quickly enough to mitigate a degraded or unavailable HLS subsystem?

MOBILITY & LOGISTICS

How can mobility and logistics that routinely move cargo be extended to also deliver compatible consumables, replacement units, tools and adapters within validated response times?

SHELTER & CONSTRUCTION

How can excavation, construction and shelter be accelerated to protect equipment and expand production during ongoing operations while potentially sheltering contingency assets or crew in an emergency?

ROBOTIC SERVICING

Could mobile robotic servicing inspect, connect, maintain and reposition assets during ongoing operations while developing the ability to stabilize, rig, upright or externally power a disabled vehicle?

Recover Learning and Residual Value from Off-Nominal Missions

Athena and Odysseus are candidate test cases for learning and possibly even partial value recovery. Athena landed on its side inside a crater, yet returned 250 megabytes of data and completed some instrument checkouts. Odysseus leaned into the lunar surface and still supported seven days of science and technology operations.^[8, 9]

ILLUSTRATIVE TEST CASE

How could robotic servicing gain knowledge or recover residual value from Athena, Odysseus or future off-nominal missions while prepositioning mobile manipulation, power and communications useful for ongoing operations and later resilience? Illustrative tests could include inspection, stabilization, anchoring and rigging, winch uprighting, external-power connection, payload access and data recovery.

2) Repair & Replenish Through Planned Missions

To become an emergency resource, an asset must be more than nearby. Its available capacity, decision authority, readiness and operating workflow must also be planned before an emergency. NASA and providers could also examine how selected additions for resilience can expand or accelerate each asset's primary mission.

Questions to Resolve in Advance

CAPACITY & RESPONSE

What payload margin, useful life, delivery time, surface range and readiness time would be required for emergency redirection?

INTERFACES

Which power, data, mechanical, consumable, robotic and crew-transfer interfaces are compatible or can be bridged with adapters?

STATE, AUTHORITY & WORKFLOWS

What asset-state information, decision rights and exercised workflows are required to redirect capacity without undermining the primary customer or mission?

BUSINESS MODEL

Which commercial and contracting model best balances incremental cost, ownership, intellectual property, productive use, priority access, liability and readiness?

One model worth evaluating is for NASA to fund the justified resilience delta (engineering, mass, integration, verification, preservation and readiness) and procure defined interfaces, demonstrations or emergency access. Providers could retain ownership, background intellectual property and productive use, gaining revenue and customers while increasing asset utilization and maturity. NASA could thereby avoid dedicated standby assets with no ongoing return.

3) Preserve HLS Value and Alternate Recovery Paths

Surface endurance can create time, but survival is not the same as return. If the primary HLS cannot ascend, additional habitation, crew-transfer and transportation capabilities may still be required. The near-term question is whether assets already planned for demonstration, delivery or disposition can retain useful roles without assuming that any one asset completes the rescue chain.

Questions to Evaluate

SURFACE RESIDUAL VALUE

Across the uncrewed lunar demonstration and subsequent HLS missions, what surface residual value (habitation, power, communications, spares, donor access, training, data or commercial service) could justify preserving selected vehicles?

ORBITAL READINESS

Could one suitably capable HLS or other crew-transfer asset be preserved or refueled in NASA's eventual standard Artemis rendezvous orbit while selected HLS assets remain on the surface? What productive role could offset preservation and readiness costs?

STAGED RESOURCES

Could selected spares, consumables, adapters or transfer hardware be prepositioned on the surface or in an appropriate staging location?

INTERFACES & EXERCISES

Which mechanical, environmental, software, command and crew-transfer interfaces could be tested robotically or during uncrewed demonstrations?

As NASA refines its post-Gateway orbital rendezvous and lander-disposition architecture, how can those decisions preserve additional productive, habitation, crew-transfer and recovery options? ^[10]

Where Cross-Industry Operating Experience May Add Value

NASA and its providers own the technical analyses and mission-risk decisions. My contribution could be to help identify cross-provider gaps and opportunities, structure the architecture and partnerships, and translate approved priorities into funded, executable capabilities. I am seeking the NASA or industry team where that experience can add the most value.

In prior Remote Process Management (RPM) deployments, sensing, anomaly triage, local response, exception escalation, streamlined resolution and operational learning reduced operator time by approximately 90 percent, expanded the production window threefold and increased maximum output by more than three times. A similar exception-driven operating model could reduce supervision burden, raise utilization and improve results across persistent lunar assets. Shared state, resource matching, local safing, decision authority and exercised workflows could also improve emergency readiness. RPM demonstrates transferable operating-model experience; it is not a proposed lunar rescue system.

A collaborative process could map work already underway, test options against selected risk scenarios, compare crew-survival, recovery and ongoing commercial value against incremental cost and readiness requirements, identify discrepancies and decision owners, and prioritize a small number of demonstrations. If a worthwhile demonstration emerges, an eligible industry team could consider a future NextSTEP-3 Appendix B topic call (or another open solicitation) as one possible maturation pathway. ^[11]

Specific feedback requested

EXISTING WORK & OWNERS

Which NASA or industry teams own or are advancing work across these three response horizons, and what work is already underway?

ASSUMPTIONS

Which assumptions or illustrative possibilities should be corrected, narrowed or set aside?

PRIORITY RISKS

Which initially survivable risk scenarios warrant the greatest additional attention?

TIMING & ECONOMICS

Which dual-use options could mature in time to influence Artemis IV or V while improving near-term provider economics?

IMPLEMENTATION

Which interfaces, partners, demonstrations, commercial arrangements and decision authorities would be required?

The most desired response is a correction, confirmation that this work is already underway, or guidance to the team that owns it. - I also welcome suggestions on where my experience could contribute. LinkedIn comments & private conversations are both helpful. This brief is offered in the spirit of NASA Tech Force's effort to open the agency's innovation aperture to relevant experience beyond traditional aerospace pathways. Crew & Moon Base resilience are important enough to warrant this small, proactive contribution and invite the experts already leading the work to correct, refine or redirect it.

Sources and Notes

Primary sources are from NASA or the NASA Office of Inspector General.

1. NASA Office of Inspector General, NASA's Management of the Human Landing System Contracts, IG-26-004, March 10, 2026.
2. NASA, Moon to Mars: NASA's Artemis Program - current mission sequence and early-2028 Artemis IV target.
3. NASA, Moon Base Development - phased robotic missions, infrastructure, mobility, habitation and logistics.
4. NASA, Apollo 13: Mission Details.
5. NASA, How NASA's Artemis III Lander Test Will Pave Way for Moon Landings, July 15, 2026.
6. NASA, 30 Years Ago: STS-26 Returns Shuttle to Flight.
7. NASA, 20 Years Ago: Remembering Columbia and Her Crew.
8. NASA, NASA Receives Some Data Before Intuitive Machines Ends Lunar Mission, March 7, 2025.
9. NASA, NASA Collects First Surface Science in Decades via Commercial Moon Mission, March 1, 2024.
10. NASA, NASA Unveils Initiatives to Achieve America's National Space Policy, March 24, 2026.
11. NASA, NextSTEP-3 B: Moon Base Demonstrations - infrastructure, mobility, autonomy and robotics, habitation, and Concepts of Operations.

Notes and limitations

12. Illustrative examples prompt expert review; they are not recommendations for mission approval, certification or asset disposition.
13. Distances, response times, payload margin, survivability, compatibility and feasibility require provider- and mission-specific analysis.
14. Trajectory-recovery architecture is outside this surface-focused brief and may warrant a separate orbital-resilience initiative.