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Sustainable Exploration

Lunar Surface Commitment Screens

Governance revies before exploration assets become infrastructure commitment.

Lunar ISRU decisions can harden before the resource is understood.

A hydrogen signal, PSR association, thermal context, radar response, reflectance signature, or resource model may begin shaping landing sites, excavation zones, mobility corridors, power placement, processing assumptions, logistics, and mission architecture before the subsurface state has been sufficiently constrained.

Sustainable Exploration provides bounded decision screens for lunar ISRU and surface infrastructure decisions where early exploration actions can become difficult to reverse. Each screen is tied to a real commitment threshold and resolves to a formal determination:

PROCEED — the next action is admissible within defined bounds.

DEFER — the project must preserve optionality while reducing decision-dominant uncertainty.

REFUSE — the proposed action creates exposure that the evidence does not justify.

We do not optimize mission architecture, select sites, design excavation systems, manage operations, or provide general advisory. We determine whether the next hard-to-reverse step should be allowed.

2. Lunar Surface Output Stack

Sustainable Exploration produces bounded decision outputs at different points in the lunar commitment pathway. Each output answers a different question as volatile evidence, site preference, access geometry, support systems, reconnaissance assets, disturbance, corridor formation, surface infrastructure, and ISRU assumptions begin to harden into commitment.

2.1. Commitment Exposure Review

Question: Where does lunar commitment begin?

Identifies where volatile evidence, site preference, reconnaissance activity, access repetition, support architecture, disturbance, corridor formation, excavation planning, surface infrastructure placement, communications anchoring, power dependency, or ISRU assumptions begin to become difficult to reverse.

This output is used when it is unclear whether an action remains exploration or has become commitment-bearing. It maps the threshold where evidence, access, support, recurrence, naming, placement, or architecture begins to create exposure.

In the lunar case, commitment exposure may begin before construction. It may begin when a candidate site becomes the assumed site, when a rover path becomes the default route, when a reconnaissance perimeter becomes an operating zone, when a reflector becomes a navigation anchor, when a communications node becomes an infrastructure center, or when a volatile signal becomes an architecture dependency.

Determines: Where the project is beginning to cross from exploration into commitment.

2.2. Minimum Evidence Determination

Question: What must be known before lunar commitment can be considered?

Defines the evidence required before site hardening, excavation, corridor formation, surface infrastructure placement, intrusive verification, power placement, communications anchoring, operating-zone formation, or ISRU dependency may proceed to admissibility review.

This output is used when lunar evidence supports continued exploration, but not yet commitment. It identifies the volatile, subsurface, terrain, illumination, thermal, disturbance, access, governance, or operational uncertainties that must be reduced before the next hard-to-reverse step can be considered.

Defines:

- the decision anchor
- the evidence currently being relied upon
- the uncertainty that remains decision-dominant
- the minimum additional evidence required
- what would change the determination
- actions that remain inadmissible until evidence improves
- bounded exploration actions that may remain acceptable

Determines: The minimum evidence required before a lunar surface commitment may proceed to admissibility review.

2.3. Instrument A — Pre-Commitment Admissibility Screen

Question: May this lunar surface or ISRU commitment be considered?

Determines whether the proposed lunar commitment is admissible to consider under the current evidence boundary.

2.3.1 Outputs:

ADMISSIBLE — the commitment may enter governed consideration within the defined boundary.

INADMISSIBLE — the commitment may not enter governed consideration under the current evidence and authority conditions.

In the lunar case, Instrument A may apply before primary site designation, fixed power placement, excavation planning, corridor establishment, intrusive verification, ISRU dependency, or surface infrastructure hardening.

Instrument A does not authorize execution, select a site, approve architecture, optimize mission design, or decide whether the mission should proceed.

2.4. Instrument B — Governance Posture Classification

Question: If the commitment is admissible to consider, which posture is defensible?

Classifies which governance posture remains defensible under current subsurface uncertainty, disturbance logic, access geometry, support dependency, authority conditions, and refusal credibility.

2.4.1 Outputs:

PROCEED-COMPATIBLE — proceeding within the stated boundary has not been eliminated by the governance constraints tested.

DEFERRAL-INDICATED — bounded learning remains governance-defensible, subject to stated controls and prohibited actions.

REFUSAL-REQUIRED — refusal is the only governance-valid posture under the stated evidence boundary and conditions.

In the lunar case, Instrument B tests whether volatile evidence, access geometry, support architecture, disturbance, excavation planning, or ISRU dependency can support a defensible posture without over-authorizing the evidence.

These outputs are posture classifications. They are not mission recommendations, site selections, architecture approvals, execution instructions, legal opinions, investment conclusions, engineering validations, or operational clearances.

2.5. Instrument C — Commitment Integrity Determination

Question: Does the lunar commitment remain defensible as it hardens?

Evaluates whether an existing or emerging lunar commitment remains within its admissible basis as evidence changes, assumptions expire, dependencies accumulate, support systems harden, or refusal authority weakens.

2.5.1 Outputs:

MAINTAIN — the commitment remains within admissible bounds.

CONSTRAIN — the commitment may continue only under narrowed scope, added conditions, or explicit guardrails.

RE-EVALUATE — new evidence, changed assumptions, dependency growth, or authority degradation requires reassessment before further hardening.

TERMINATE — the commitment no longer satisfies its admissible basis and should not continue within the defined boundary.

In the lunar case, Instrument C may apply after site preference, access repetition, support placement, disturbance, corridor formation, excavation planning, or ISRU dependency has already begun to shape the architecture.

Instrument C does not manage execution, transfer authority, optimize outcomes, select sites, or assume mission responsibility. Responsibility remains with the Decision Authority.

3. Lunar Governance Review Menu

4. Moon Base Architecture Admissibility Screen

Use before: landers, rovers, drones, resource assumptions, power systems, communications assets, navigation infrastructure, or logistics plans are allowed to shape the Moon Base architecture.

This is the core lunar surface commitment screen. It evaluates whether an emerging Moon Base architecture should be allowed to depend on unresolved volatile, regolith, terrain, illumination, thermal, communications, access, operational, governance, or support-system assumptions.

Typical triggers include:

• selecting a primary lunar operating region
• allowing reconnaissance data to shape the surface architecture
• treating a candidate site as the center of gravity for future missions
• coordinating landers, rovers, drones, power systems, communications assets, and surface payloads around a premature architecture
• designing mission architecture around assumed volatile or resource availability
• placing power, thermal, communications, or navigation infrastructure around an unresolved site concept
• defining landing cadence around an assumed operating node
• allowing mobility corridors to shape future access geometry
• allowing science, ISRU, logistics, and habitation needs to converge on a single candidate location
• treating Phase One learning assets as de facto infrastructure precursors

Tests include:

• whether the architecture depends on unresolved site assumptions
• whether volatile, terrain, thermal, illumination, communications, or access uncertainty remains decision-dominant
• whether alternative plausible surface or subsurface states would materially alter the architecture
• whether early assets are beginning to define future operating zones
• whether the architecture preserves fallback sites and alternate pathways
• whether the proposed system remains modular, reversible, and evidence-responsive
• whether support infrastructure is forming before the evidence base can justify it
• whether the architecture is being shaped by convenience, schedule pressure, political signaling, procurement momentum, or partner dependency rather than decision adequacy
• whether the next step creates irreversible dependency between exploration, infrastructure, and precedent

Determines: Whether the emerging Moon Base architecture is admissible, should defer, should remain bounded as exploration-only, or should be refused as premature commitment.

Best for: space agencies, Moon Base architecture teams, Artemis partners, commercial lunar infrastructure companies, lander providers, rover teams, ISRU developers, science payload Resource Dependency Formation Screen

4.1. Lunar Site Commitment Screen

Use before: a candidate lunar site becomes the project anchor.

A promising lunar location can still be premature as a commitment. This screen evaluates whether a site has become decision-adequate enough to serve as the center of gravity for mission architecture, surface infrastructure, mobility planning, science operations, ISRU development, power placement, communications support, or future habitation.

Typical triggers include:

• selecting a primary landing or operating site
• treating a ridge, crater rim, PSR-adjacent zone, resource region, or high-illumination area as the preferred site
• concentrating future missions around a named location
• aligning power, communications, mobility, and

resource assumptions around one candidate area
• using early site access to justify later infrastructure placement
• defining repeated lander, rover, or drone operations around a site
• narrowing fallback sites before uncertainty has resolved
• allowing site selection to shape procurement, partner roles, mission sequencing, or public communications

Tests include:

• volatile evidence sufficiency
• illumination and power assumptions
• thermal regime dependence
• PSR proximity and access constraints
• terrain, slope, bearing, and trafficability constraints
• landing access and plume interaction conditions
• traverse feasibility and route dependence
• communications geometry and line-of-sight constraints
• proximity to science, resource, logistics, power, and habitation objectives
• single-site dependency
• fallback-site preservation
• optionality half-life
• cost of reversal if the site fails
• whether unresolved site uncertainty remains decision-dominant

Determines: Whether the site should be allowed to become the mission or infrastructure anchor, should remain a candidate only, should require bounded verification, or should be refused as premature.

Best for: site selection teams, lunar architecture groups, science planning teams, ISRU planners, commercial lunar operators, agency review boards, infrastructure developers, and investors evaluating site-dependent lunar projects.

4.2. Surface Reconnaissance-to-Commitment Screen

Use before: scouting, mapping, prospecting, drone deployment, rover reconnaissance, or early surface imaging begins defining future operating zones.

This screen evaluates whether reconnaissance activity is still functioning as exploration, or whether it has begun to create commitment. Landers, rovers, drones, cameras, radar reflectors, mapping payloads, and surface sensors do not only collect information. They can also organize future access, establish preferred zones, define mobility patterns, create navigation anchors, and shape later infrastructure decisions.

Typical triggers include:

• deploying drones, hoppers, or rovers to characterize candidate Moon Base regions
• using rover scouting to identify future operating zones
• mapping terrain at high resolution for later infrastructure placement
• prospecting for water ice or other resources across candidate zones
• establishing a site perimeter or operational boundary
• placing reflectors, beacons, communications payloads, or navigation aids during reconnaissance
• using reconnaissance outputs to prioritize future landing sites
• turning preliminary mapped areas into default project geographies
• allowing early imagery or mapping to shape architecture before uncertainty is bounded

Tests include:

• whether reconnaissance assets are creating de facto operating zones
• whether mapping outputs are being treated as permission for later commitment
• whether reconnaissance has narrowed future options prematurely
• whether a perimeter, beacon, reflector, or communications node creates precedent
• whether surface characterization resolves or merely relocates uncertainty
• whether alternative plausible interpretations remain architecture-relevant
• whether reconnaissance-generated confidence exceeds evidence validity
• whether the activity can be reversed without altering the architecture
• whether the reconnaissance plan preserves access to alternate sites
• whether learning activity is being converted into commitment without a decision gate

Determines: Whether reconnaissance remains exploration-only, may support bounded follow-on action, requires additional evidence before use in architecture, or should be refused as premature commitment formation.

Best for: drone programs, rover reconnaissance teams, site characterization campaigns, surface mapping teams, science payload planners, navigation infrastructure teams, lander providers, and agencies managing phased lunar buildout.

4.3. Resource Dependency Formation Screen

Use before: a mission, architecture, business case, or surface system begins depending on local resources.

This screen evaluates whether ISRU dependence is forming before the resource has become decision-adequate. It does not ask whether water, oxygen, hydrogen, metals, regolith feedstock, or other resources may exist. It asks whether unresolved resource assumptions are being allowed to organize architecture.

Typical triggers include:

• designing mission mass around local resource availability
• assuming propellant production from lunar volatiles
• assuming consumables can be supplied from local resources
• sizing excavation, processing, or storage systems around expected resource conditions
• placing power or thermal infrastructure around a candidate resource zone
• defining landing cadence around an assumed resource node
• reducing non-ISRU fallback options
• treating resource access as a foundation for commercial viability
• allowing resource expectations to shape surface infrastructure

Tests include:

• mission mass dependence on local resources
• propellant or consumables assumptions
• excavation and processing dependency
• logistics cadence dependence
• infrastructure placement around assumed resource availability
• loss of non-ISRU fallback options
• dependence on volatile concentration, continuity, accessibility, or extractability
• dependence on regolith mechanics, excavation behavior, or thermal stability
• whether resource uncertainty remains decision-dominant
• whether fallback pathways remain credible if the resource assumption fails
• whether the architecture can survive without the assumed resource

Determines: Whether resource dependence should be allowed to enter the architecture, remain bounded, require additional verification, or be refused.

Best for: mission planners, ISRU developers, commercial lunar infrastructure teams, lander providers, investors, payload developers, agency review boards, and surface architecture groups evaluating resource-dependent systems.

4.4. Volatile Evidence Sufficiency Screen

Use before: orbital, remote, indirect, or preliminary surface evidence is treated as sufficient for ISRU dependence.

This screen evaluates whether current evidence can support commitment to a volatile-dependent architecture. It is designed for the moment when hydrogen signatures, neutron suppression, radar response, thermal stability, ultraviolet reflectance, topography, shadow persistence, or preliminary surface observations begin to carry architectural weight.

Typical triggers include:

• treating a volatile signal as architecture-grade evidence
• using orbital data to justify site selection
• using hydrogen or neutron signatures to support ISRU planning
• assuming water ice form, depth, continuity, concentration, or accessibility
• treating thermal or shadow conditions as sufficient for volatile retention assumptions
• using radar, reflectance, or topography to infer extractable resources
• allowing volatile evidence to shape excavation, processing, or logistics systems
• proceeding toward intrusive verification based on non-unique evidence

Tests include:

• whether the signal uniquely constrains resource state
• volatile form ambiguity

- concentration ambiguity
- spatial continuity ambiguity
- accessibility and extractability uncertainty
- depth and layering uncertainty
- thermal stability and retention uncertainty
- mechanical behavior of host regolith
- contamination, disturbance, or preservation concerns
- whether alternative plausible subsurface states would change the architecture
- whether the evidence remains exploration-grade or has become commitment-grade

Determines: Whether the evidence is sufficient to support resource-dependent commitment, whether it remains exploration-grade only, or whether additional bounded verification is required.

Best for: resource investigators, remote sensing teams, ISRU planners, science payload teams, lunar prospecting groups, architecture teams, and investors assessing volatile-dependent lunar concepts.

4.5. Subsurface Access / Verification Screen

Use before: drilling, trenching, excavation, coring, heating, sampling, emplacement, or other intrusive verification activity.

This screen evaluates whether subsurface uncertainty has been reduced enough to justify physical intervention. It is designed for lunar settings where learning requires disturbance, but disturbance itself can alter the system, create precedent, or begin committing the architecture.

Typical triggers include:

- drilling into a candidate volatile-bearing region
- trenching or excavating to verify subsurface assumptions
- coring, heating, or sampling regolith to characterize volatile content
- disturbing a PSR-adjacent or thermally sensitive region
- using verification activity to justify later ISRU infrastructure
- placing support systems for excavation or subsurface access
- conducting intrusive investigation in a scientifically or operationally sensitive zone
- allowing verification hardware to become the first step in a processing architecture

Tests include:

- target ambiguity
- volatile distribution uncertainty
- volatile physical state uncertainty
- regolith mechanics and bearing uncertainty
- disturbance effects on volatile retention
- thermal alteration from verification
- contamination or plume effects
- scientific preservation concerns
- whether verification reduces uncertainty or prematurely commits the architecture
- whether less intrusive verification remains available
- whether the intervention creates precedent for future access
- whether disturbance consequences are reversible or containable

Determines: Whether subsurface access or intrusive verification is admissible under current evidence, should be bounded, should be deferred, or should be refused.

Best for: drilling teams, excavation teams, volatile investigators, ISRU developers, payload planners, science teams, mission review boards, and operators evaluating intrusive lunar surface activity.

4.6. Lunar Mobility / Corridor Commitment Screen

Use before: a traverse route, logistics pathway, access corridor, rover path, power corridor, or repeated mobility pattern becomes fixed.

Corridors often become commitments before they are recognized as infrastructure. This screen evaluates whether a proposed lunar route should harden before terrain, access, thermal, illumination, communications, operational, or resource uncertainty is resolved.

Typical triggers include:

- repeated rover traversal between landing sites and resource zones
- defining a preferred access route to a crater rim, PSR, ridge, or operating zone
- creating logistics paths between landers, habitats, power systems, and resource areas
- using terrain mapping to establish a default corridor
- placing navigation, communications, reflectors, or markers along a path
- designing power or cable corridors between

distributed assets
• accepting a traverse route as the basis for future operations
• allowing autonomous mobility systems to define future access geometry

Tests include:

• repeated traverse hardening
• terrain and slope constraints
• PSR access fragility
• landing-zone to resource-zone coupling
• power corridor dependence
• communications and navigation anchoring
• dust, traffic, plume, and regolith disturbance effects
• alternative route preservation
• emergency access and rescue feasibility
• reversal cost if the corridor fails
• whether the route creates single-path dependency
• whether the corridor is becoming infrastructure before it has been authorized as such

Determines: Whether a lunar route, traverse path, access corridor, or logistics pathway should be allowed to become the default pathway, remain exploratory, require additional validation, or be refused.

Best for: rover teams, LTV planners, autonomous mobility developers, site planners, logistics teams, surface infrastructure groups, power system planners, and mission architects.

4.7. Surface Infrastructure Placement Screen

Use before: landing pads, berms, power systems, communications assets, navigation infrastructure, depots, processing units, excavation support systems, or other fixed assets are placed.

This screen evaluates whether fixed surface infrastructure should be placed before site, resource, terrain, thermal, access, and operational uncertainties are sufficiently bounded. It is designed for the moment when temporary support activity begins to create permanent or semi-permanent surface architecture.

Typical triggers include:

• placing landing pads or blast berms
• installing solar arrays, nuclear systems, batteries, or power distribution systems
• placing communications, navigation, timing, or observation infrastructure
• establishing depots, storage nodes, or logistics hubs
• placing processing systems near assumed resource zones
• installing excavation support infrastructure
• anchoring future landings around a prepared surface zone
• creating fixed support systems for recurring operations
• treating infrastructure placement as reversible when it may not be

Tests include:

• fixed asset placement
• landing pad or berm commitment
• power infrastructure dependence
• processing-zone assumptions
• excavation support placement
• communications and navigation anchoring
• blast, dust, ejecta, and plume coupling
• terrain and bearing uncertainty
• thermal and illumination dependence
• site-precedent effects
• whether placement creates architecture dependence
• whether infrastructure can be relocated without redesigning the system
• whether the asset converts a candidate site into a committed operating zone

Determines: Whether surface infrastructure placement is admissible, should remain temporary or modular, requires additional evidence, or should be refused.

Best for: infrastructure developers, landing system providers, power system teams, communications providers, navigation system planners, excavation teams, ISRU developers, and lunar base architecture groups.

4.8. Power / Communications / Navigation Anchoring Screen

Use before: power nodes, communications relays, navigation aids, timing systems, retroreflectors, beacons, orbital relay assumptions, or surface network assets are allowed to anchor future operations.

Power, communications, navigation, and timing systems are not neutral support systems. Once placed, they define where operations can occur, where future landings become easier, where mobility concentrates, and where infrastructure begins to organize. This screen evaluates whether support-network placement is justified before it becomes a hidden architecture decision.

Typical triggers include:

- placing surface communications assets
- deploying retroreflectors, beacons, or navigation aids
- using drones, landers, or rovers as persistent network nodes
- establishing orbital relay assumptions for a surface region
- placing power generation or storage infrastructure
- linking future missions to an existing power or communications geometry
- defining operating zones based on line-of-sight or network availability
- allowing network convenience to override site uncertainty
- treating a support asset as temporary when it may create future dependency

Tests include:

- whether the asset creates a preferred operating zone
- whether the network placement constrains future landing, traverse, or infrastructure options
- whether communications, navigation, or power geometry is driving site selection
- whether the support asset establishes precedent
- whether the asset can be removed, relocated, or bypassed
- whether alternative network architectures remain available
- whether the placement creates lock-in around incomplete evidence
- whether future missions become dependent on the initial node
- whether the asset changes the political, operational, or governance status of the area

Determines: Whether power, communications, navigation, or timing infrastructure may be placed as support, must remain bounded, requires additional architecture review, or should be refused as premature anchoring.

Best for: communications providers, lunar network operators, surface infrastructure teams, navigation system planners, mission architects, agencies, commercial operators, and investors evaluating enabling infrastructure.

4.9. Landing Zone / Plume-Surface Interaction Commitment Screen

Use before: a landing zone, standoff distance, pad concept, plume mitigation system, or repeated landing geometry becomes operationally fixed.

Landing zones are often treated as logistics decisions, but they can become architectural anchors. This screen evaluates whether landing access, plume-surface interaction, ejecta effects, asset standoff requirements, and repeat landing cadence are sufficiently understood before future surface systems organize around a landing zone.

Typical triggers include:

- selecting a recurring lander approach or touchdown zone
- placing surface assets relative to expected plume or ejecta effects
- establishing standoff distances between landers, rovers, habitats, and infrastructure
- designing landing cadence around a candidate operating zone
- preparing landing pads, berms, or surface stabilization systems
- placing rovers or LTVs near future crewed landing zones
- using early landing success to justify repeat access
- allowing landing geometry to constrain infrastructure layout

Tests include:

- plume-surface interaction uncertainty
- ejecta, dust, and blast coupling
- asset standoff requirements
- landing-zone terrain and bearing conditions
- repeated landing effects on surrounding infrastructure
- impact on mobility corridors and access paths
- landing pad or berm necessity
- fallback landing-zone preservation
- proximity to science, resource, and habitation zones
- whether landing access creates irreversible site dependence

• whether landing cadence hardens the architecture prematurely

Determines: Whether a landing zone or landing-support architecture is admissible, should remain provisional, requires additional verification, or should be refused as premature infrastructure formation.

Best for: lander providers, surface infrastructure teams, mission planners, rover/LTV teams, safety review boards, commercial lunar operators, and agencies planning repeated lunar surface access.

4.10. Lunar Science Preservation / Disturbance Screen

Use before: exploration, verification, mobility, landing, excavation, construction, or infrastructure activity may disturb scientifically significant lunar environments.

This screen evaluates whether a proposed action risks degrading the scientific value of the environment before the relevant knowledge has been captured or protected. It is designed for settings where operational learning, resource prospecting, or infrastructure development may alter the very conditions being studied.

Typical triggers include:

• operating near PSRs or volatile-sensitive regions
• entering or disturbing scientifically significant terrain
• driving across areas with high preservation value
• landing near regions of interest where plume or ejecta effects may matter
• trenching, drilling, heating, or excavating before preservation needs are defined
• placing infrastructure in areas with high scientific uncertainty
• introducing contamination, traffic, thermal alteration, or mechanical disturbance
• using science regions as future infrastructure zones

Tests include:

• scientific uniqueness of the site
• disturbance sensitivity
• volatile preservation concerns
• contamination risk
• traffic, dust, plume, and ejecta effects
• thermal alteration risk
• whether the action reduces future scientific interpretability
• whether lower-disturbance alternatives exist
• whether the scientific value has been adequately documented before intervention
• whether operational precedent could normalize future disturbance

Determines: Whether the proposed activity is admissible, requires preservation constraints, should be deferred, or should be refused to protect scientific integrity.

Best for: science teams, payload planners, ISRU teams, surface mobility operators, agencies, preservation advocates, mission review boards, and lunar infrastructure developers.

4.11. Precedent Formation / Operating Zone Screen

Use before: a surface activity, asset placement, perimeter, safety zone, recurring traverse, or named operating area begins establishing precedent for future activity.

This screen evaluates whether a technical action is also becoming a governance action. Lunar surface operations can create precedent through presence, recurrence, naming, support infrastructure, navigation aids, safety claims, operational boundaries, or partner coordination. This screen determines whether precedent formation is justified, bounded, and reversible.

Typical triggers include:

• defining an operating perimeter
• using drones, rovers, reflectors, or beacons to mark an area
• establishing a safety zone or deconfliction region
• repeatedly operating within a preferred surface zone
• placing infrastructure that signals long-term presence
• naming a site as a base, node, corridor, or resource zone
• coordinating partner activity around a preferred geography
• treating technical access as governance legitimacy
• allowing early presence to shape future rights, expectations, or norms

Tests include:

• whether the action creates de facto operating control

• whether technical placement implies priority, exclusion, or future entitlement
• whether reciprocal expectations under international practice are implicated
• whether other actors' future options may be constrained
• whether the operating zone is temporary, bounded, and reviewable
• whether the precedent is proportional to the evidence
• whether infrastructure, communications, navigation, or mobility assets reinforce the claim
• whether the activity can be unwound without creating conflict, confusion, or reliance
• whether governance meaning has been acknowledged before action

Determines: Whether a proposed activity may proceed without unacceptable precedent formation, should be bounded by explicit limitations, requires governance review, or should be refused.

Best for: agencies, international partners, commercial lunar operators, mission architects, legal and policy teams, surface infrastructure planners, safety-zone reviewers, and investors exposed to lunar governance risk.

4.12. Human Surface Operations Readiness Screen

Use before: crewed surface activity, repeated EVA cadence, LTV use, pressurized rover operations, or human interaction with early surface infrastructure is allowed to depend on the emerging lunar architecture.

This screen evaluates whether the surface environment, support architecture, mobility systems, communications, rescue pathways, power availability, and operational assumptions are sufficient to support human activity without premature dependency on unresolved systems.

Typical triggers include:

• planning crewed surface operations around early infrastructure
• relying on LTVs, rovers, or pressurized mobility assets
• defining repeated EVA plans around a candidate site
• depending on communications, navigation, or power systems for human operations
• placing crew near unverified terrain, resource, or infrastructure zones
• using early robotic missions to justify human follow-on activity
• assuming rescue, fallback, or contingency access across uncertain terrain
• compressing operational cadence before support systems are mature

Tests include:

• EVA cadence dependence
• communications and navigation reliability
• mobility and rescue pathway adequacy
• terrain and slope uncertainty
• power and thermal support assumptions
• radiation and exposure conditions
• lander-to-rover and rover-to-site access
• fallback site and fallback mode preservation
• crew safety under incomplete infrastructure
• whether human operations are being used to validate architecture rather than operate within an already admissible architecture

Determines: Whether human surface operations are admissible under current architecture, require additional robotic validation, should remain bounded, or should be deferred.

Best for: Artemis surface operations teams, astronaut mobility planners, LTV developers, pressurized rover teams, EVA planners, safety boards, mission architects, and agency decision authorities.

4.13. Commercial Lunar Commitment Screen

Use before: a commercial business case, investment decision, partnership, procurement award, or infrastructure plan becomes dependent on unresolved lunar surface assumptions.

This screen evaluates whether commercial commitment is forming before the underlying lunar evidence, architecture, and operating conditions are decision-adequate. It is designed for investors, companies, agencies, and partners deciding whether a lunar surface business model is ready to support capital, procurement, or long-term strategic commitment.

Typical triggers include:

• investing in a resource-dependent lunar business case
• awarding contracts tied to an assumed site,

resource, mobility pathway, or infrastructure architecture
• committing to hardware before key lunar surface assumptions are bounded
• using NASA demand signals as substitutes for independent commitment adequacy
• relying on future ISRU, surface logistics, power, communications, or mobility markets
• assuming recurring lunar customers beyond government demand
• building commercial strategy around a candidate Moon Base geography
• allowing public momentum to substitute for evidence adequacy

Tests include:

• resource dependence in the business model
• site dependence in the commercial strategy
• reliance on future infrastructure not yet admissible
• exposure to schedule, procurement, and policy shifts
• fallback markets if lunar assumptions fail
• dependency on one agency, one site, one payload class, or one architecture
• whether capital commitment outruns evidence maturity
• whether the commercial plan survives deferral of ISRU, mobility, or infrastructure milestones
• whether the venture can remain viable if the architecture changes

Determines: Whether commercial lunar commitment is admissible, should remain option-bounded, requires staged exposure, or should be refused.

Best for: investors, lunar startups, aerospace primes, commercial infrastructure developers, agency procurement teams, insurers, strategic partners, and venture groups evaluating lunar surface exposure.

4.14. ISRU Architecture Admissibility Screen

Use before: volatile evidence is allowed to anchor mission architecture.

This is the core lunar ISRU screen. It evaluates whether a proposed architecture should be allowed to depend on unresolved volatile, regolith, terrain, thermal, access, or operational assumptions.

Typical triggers include:

• selecting a primary ISRU site
• treating a volatile indication as architecture-grade evidence
• fixing excavation or processing assumptions
• designing mission mass around local resource availability
• placing power or thermal infrastructure around a candidate resource zone
• defining landing cadence around an assumed resource node
• allowing resource dependency to shape surface architecture
• connecting resource assumptions to commercial, logistics, or habitation plans

Tests include:

• whether volatile evidence is decision-adequate
• whether resource uncertainty remains decision-dominant
• whether alternative plausible volatile states would change the architecture
• whether excavation, processing, or storage assumptions are premature
• whether power, thermal, landing, or traverse systems are being placed around unresolved resource assumptions
• whether non-ISRU fallback options remain credible
• whether the architecture is still viable if the resource assumption fails
• whether the proposed commitment preserves reversibility

Determines: Whether the next ISRU commitment is admissible, should defer, should remain bounded, or should be refused.

Best for: mission planners, lunar infrastructure teams, payload developers, resource investigators, commercial ISRU teams, space agencies, investors, and architecture groups approaching a consequential lunar surface decision.

4.15. Minimum Evidence for Lunar Surface Commitment

Use when: the next step is not yet ready, but the evidence burden must be defined.

This is the lighter SRR entry product. It determines what must be known before a lunar surface or ISRU-dependent action can proceed.

Defines:

• the lunar decision anchor
• the proposed hard-to-reverse next step
• the volatile, subsurface, site, terrain, access, disturbance, or support-system uncertainty that dominates the decision
• current evidence insufficiencies
• evidence required before commitment
• what would change the determination
• actions that remain inadmissible until evidence improves
• bounded exploration actions that may remain acceptable

Determines: The minimum evidence required before a lunar surface, infrastructure, or ISRU-dependent commitment may proceed.

Best for: early conversations, poster follow-ups, SRR contacts, commercial teams, science teams, investors, agencies, and architecture groups that need a bounded decision product before a full screen.

4.16. Lunar Commitment Integrity Review

Use after: a lunar surface, infrastructure, or ISRU commitment has already begun.

A lunar commitment that was initially admissible may lose integrity as evidence changes, assumptions expire, dependencies accumulate, surface infrastructure hardens, operating zones form, or refusal authority weakens. This review evaluates whether the commitment remains defensible.

Typical triggers include:

• site preference has already begun shaping the architecture
• access repetition has already begun forming a corridor
• support infrastructure has already been placed
• reconnaissance assets have begun defining an operating zone
• volatile evidence has begun shaping resource dependency
• excavation, drilling, trenching, or verification has begun
• power, communications, or navigation systems have become anchors
• commercial or institutional commitments have escalated
• new evidence undermines the original admissible basis

Outputs:

MAINTAIN — commitment remains within admissible bounds.

CONSTRAIN — continue only under narrowed scope or added conditions.

RE-EVALUATE — new evidence or changed structure requires reassessment.

TERMINATE — commitment no longer satisfies its admissible basis.

Best for: projects already advancing through site selection, resource dependency, surface infrastructure placement, intrusive verification, mobility corridor formation, power placement, communications anchoring, or lunar architecture hardening.

4.17. Typical Engagement Format

Each screen is bounded around a specific decision threshold.

Inputs may include:

• mission or project description
• candidate site, region, corridor, or operating zone
• available volatile and subsurface evidence
• terrain, illumination, thermal, access, and communications constraints
• surface mobility assumptions
• power and support-system assumptions
• landing-zone assumptions
• known uncertainties
• proposed next action
• decision timeline
• authority and termination conditions

Outputs include:

• formal determination
• decision rationale
• dominant uncertainty
• dominant irreversibility
• commitment triggers
• minimum evidence requirements
• allowed next actions
• prohibited actions
• deferral or refusal rationale where applicable
• conditions for reconsideration

5. When to Engage:

Engage Sustainable Exploration before a lunar surface, Moon Base, ISRU, or infrastructure project:

- selects a primary lunar site
- allows volatile evidence to shape architecture
- depends on an unresolved resource assumption
- authorizes drilling, trenching, excavation, heating, sampling, or intrusive verification
- fixes a traverse route, access corridor, logistics pathway, or power corridor
- places surface infrastructure
- deploys communications, navigation, timing, or observation assets that may become anchors
- establishes an operating zone, perimeter, or recurring surface pattern
- escalates capital, mission design, procurement, or institutional commitment
- converts exploration evidence into operational dependency
- moves from demonstration to infrastructure
- treats a successful exploratory action as permission for permanence

The best time is while the decision can still go more than one way.

After commitment hardens, the question changes from whether the step should proceed to how much exposure must be managed.

Core Principle

A lunar surface system should not become committed before it becomes admissible.

A signal is not an anchor.
A site is not a base.
A traverse is not a corridor.
A drone perimeter is not permission.
A reflector is not merely a payload.
A communications node is not neutral.
A power asset can define architecture.
A landing zone can become precedent.
A verification activity can become disturbance.
A resource assumption can become dependency.
A successful demonstration can become commitment.

These screens exist to determine when learning remains exploration, and when it has begun to harden into infrastructure.

6. Core Principle

A lunar resource system should not become committed before it becomes admissible.