Lunar Commitment Interdependency Map

How volatile interpretation propagates into site, access, support, disturbance, ISRU dependency, and infrastructure lock-in

Purpose

This document maps how lunar exploration decisions can become mutually reinforcing before the underlying evidence has become decision-adequate.

The poster shows the visual sequence from signal to commitment. The irreversibility map shows the pathway from early indication to lock-in. This interdependency map makes the coupling explicit. It identifies how one dependency creates the conditions for the next, and how a lunar site can move from exploratory interest into infrastructure commitment before the governing uncertainty has been resolved.

The Central Question Is:

When do evidence, access, support systems, disturbance, and resource assumptions begin reinforcing one another strongly enough that future refusal becomes non-credible?

This is not a mission architecture. It is not a site-selection model. It is a dependency map for commitment governance.

1. Core Chain

Volatile interpretation → site preference → access repetition → power/support geometry → disturbance → corridor formation → excavation planning → ISRU dependency → infrastructure lock-in

This chain describes how a volatile signal can gradually become an infrastructure commitment.

At the beginning of the chain, evidence remains exploratory. A hydrogen indication, thermal stability signal, radar/reflectance response, illumination advantage, or terrain/access condition may justify additional investigation. But as that signal begins shaping site preference, access patterns, support placement, disturbance, and resource-processing assumptions, the system begins to inherit the interpretation as structure.

The danger is not that one step alone is irreversible. The danger is that each step makes the next easier, more logical, and more difficult to refuse.

2. Interdependency Logic

2.1. Volatile Interpretation → Site Preference

A volatile indication becomes operationally consequential when it begins to privilege one site over comparable alternatives.

This may happen through:

- repeated use of the site in diagrams,
- mission-planning focus,
- partner coordination,
- payload targeting,
- power/access analysis,
- or language that treats the site as the working reference location.

At this stage, the site may still be exploratory. But once the interpretation begins organizing planning, the site has started to accumulate precedent.

Governance risk: a promising volatile signal is treated as an infrastructure anchor before volatile form, accessibility, continuity, concentration, or mechanical context are decision-adequate.

Screening question: Does the site remain one candidate among alternatives, or has it become the default future?

2.2. Site Preference → Access Repetition

Once a site becomes preferred, access logic begins to repeat. Landing approaches, traverse paths, mobility assumptions, communications geometry, and staging concepts start forming around that location. A route that begins as an exploratory path can become the practical access pathway for future work.

Repeated access is important because movement is not neutral. Movement creates familiarity, operational convenience, data asymmetry, and planning inertia.

Governance risk: a repeated route becomes a corridor before corridor commitment has been evaluated.

Screening question: Is the access pattern still reversible, or has movement begun to define the future operating geometry?

2.3. Access Repetition → Power / Support Geometry

Repeated access creates pressure for support.

Power, communications, navigation, thermal survival, local staging, and logistics become easier to justify along the repeated geometry. These support systems may be temporary at first, but even temporary support can privilege one site, one corridor, or one operating geometry.

Support systems are not neutral. They alter the relative cost of future choices.

Governance risk: support architecture makes one site easier to continue using than to abandon.

Screening question: Is support being placed to preserve bounded exploration, or is it beginning to define the architecture?

2.4. Power / Support Geometry → Disturbance

Once support exists, more intrusive forms of verification become feasible.

Drilling, trenching, sampling, heating, excavation, repeated traffic, and landing-related disturbance may become operationally easier. This can be valuable for knowledge acquisition, but it also alters the system being evaluated.

Disturbance is both epistemic and structural. It can produce knowledge while changing the evidence baseline, volatile conditions, thermal state, regolith context, or future trafficability.

Governance risk: verification becomes the first step of commitment.

Screening question: Does the disturbance reduce decision-dominant uncertainty faster than it creates irreversibility?

2.5. Disturbance → Corridor Formation

Disturbance often concentrates future operations.

A drilled location, disturbed patch, prepared path, repeated traverse, or tested area becomes more familiar and operationally convenient. The project may return there because it has data, access, equipment, or surface modification already present.

This can transform a one-time verification action into a durable operating pattern.

Governance risk: disturbance creates a reference site or route that future missions inherit.

Screening question: After disturbance, can the mission still re-site, re-rank, or abandon the location without treating prior work as a constraint?

2.6. Corridor Formation → Excavation Planning

Once corridors and support geometry form, excavation planning becomes more plausible and more constrained.

Excavation zones are likely to be chosen near accessible, powered, supportable locations. This can make sense operationally, but it can also cause excavation planning to inherit earlier access and support assumptions.

At this point, excavation is no longer only a scientific or technical act. It becomes a spatial commitment.

Governance risk: excavation geometry is determined by prior access/support convenience rather than decision-grade resource evidence.

Screening question: Is excavation planning based on verified resource accessibility, or on the path made convenient by prior commitments?

2.7. Excavation Planning → ISRU Dependency

ISRU dependency begins when the mission architecture, logistics plan, surface infrastructure, or industrial thesis assumes that local resources will be available and operationally usable.

This is a major threshold.

A volatile signal may justify prospecting. It may justify bounded verification. It may not justify replacing delivered logistics, sizing systems around extraction, or organizing future missions around local resource availability.

Governance risk: the system starts depending on a resource before the resource has earned that role.

Screening question: Does the architecture still function if the volatile interpretation resolves unfavorably?

2.8. ISRU Dependency → Infrastructure Lock-In

Infrastructure lock-in occurs when site, corridor, power geometry, disturbance history, excavation assumptions, and resource dependency reinforce one another.

At this stage, reversal requires more than updated evidence. It requires redesign, political retreat, capital loss, operational disruption, or institutional embarrassment.

This is where the project crosses from exploration into inherited commitment.

Governance risk: the architecture becomes committed to a resource interpretation that remains unresolved.

Screening question: Can the system still refuse the resource-dependent pathway, or has continuation become easier than abandonment?

3. Interdependency Table

Dependency	What it depends on	What it causes
Volatile interpretation	Hydrogen indications, thermal stability, radar/reflectance, illumination/shadow context, terrain constraints	Candidate resource logic, prospect ranking, early site attractiveness
Site preference	Volatile signal, illumination advantage, terrain/access feasibility, mission interest	Partner focus, mission planning, repeated diagrams, reference-site language
Access repetition	Preferred site, landing logic, traverse feasibility, mobility assumptions	Route familiarity, corridor formation, access bias, operational convenience
Power/support placement	Selected site geometry, repeated access, survival needs, communications/navigation requirements	Site privilege, local dependency, support-system lock-in
Disturbance	Verification need, access feasibility, support availability, payload or excavation plan	Altered evidence baseline, local precedent, measurement contamination, continuation pressure
Corridor formation	Repeated traverse, support-linked mobility, route conditioning, traffic concentration	Reachable-zone narrowing, logistics structure, reduced re-siting credibility
Excavation planning	Resource interpretation, corridor access, support geometry, disturbance results	Excavation dependency, material handling assumptions, local infrastructure concentration
ISRU dependency	Assumed volatile accessibility, continuity, concentration, extractability, processing feasibility	Architecture lock-in, logistics substitution, capital/industrial dependency
Infrastructure lock-in	Site preference, corridor, support placement, disturbance, ISRU dependency, institutional narrative	Reversal requires redesign, refusal becomes non-credible,

	future missions inherit the pathway

4. Dependency Classes

4.1. Evidence Dependencies

Evidence dependencies occur when a later decision relies on an interpretation that remains unresolved.

Examples:

- treating hydrogen indication as extractable volatile availability,
- treating radar response as architecture-grade resource evidence,
- treating illumination advantage as proof of site admissibility,
- treating local measurement as site-scale confidence.

Governance concern: evidence adequate for exploration is allowed to govern commitment.

4.2. Spatial Dependencies

Spatial dependencies occur when one site, route, landing zone, or corridor becomes operationally privileged.

Examples:

- repeated traverse paths,
- preferred landing approach,
- corridor rehearsal,
- power/support geometry organized around one site,
- fallback sites becoming less credible.

Governance concern: alternatives remain theoretically possible but operationally disfavored.

4.3. Support Dependencies

Support dependencies occur when power, communications, navigation, logistics, or survival systems begin shaping future operations.

Examples:

- fixed power node,
- relay or navigation support,
- local staging,
- thermal support,
- resource-handling support.

Governance concern: infrastructure meant to enable exploration begins deciding the site.

4.4. Disturbance Dependencies

Disturbance dependencies occur when the act of learning changes the system or creates pressure to continue.

Examples:

- drilling,
- trenching,
- excavation,
- sampling,
- landing plume effects,
- traffic compaction,
- thermal alteration.

Governance concern: verification alters the baseline and becomes commitment-bearing.

4.5. Resource Dependencies

Resource dependencies occur when future architecture assumes local resource availability.

Examples:

- logistics substitution based on local volatiles,
- excavation systems sized around assumed deposits,
- power architecture designed around processing,
- mission cadence dependent on local resource production,
- industrial or capital assumptions tied to ISRU availability.

Governance concern: the system depends on a resource before the resource has become decision-grade.

4.6. Institutional Dependencies

Institutional dependencies occur when public, partner, programmatic, or governance structures normalize the pathway.

Examples:

- a site described as primary,
- a corridor treated as the operational route,
- an architecture presented as resource-backed,
- partner expectations formed around one location,
- capital or industrial supply chains organized around the assumed resource.

Governance concern: refusal becomes reputationally, politically, or operationally non-credible.

5. Reinforcing Loops

Loop A — Signal to Site Bias

Volatile signal → site preference → targeted evidence → stronger site narrative → stronger site preference

This loop can be useful if it remains bounded. It becomes dangerous when targeted evidence is interpreted as confirmation rather than as continued uncertainty reduction.

Failure mode: confirmation bias becomes site commitment.

Loop B — Access to Corridor

Site preference → traverse planning → repeated access → route familiarity → corridor formation

This loop turns mobility into structure.

Failure mode: a route becomes infrastructure before it is recognized as a commitment.

Loop C — Support to Site Lock-In

Access repetition → power/support placement → easier continued operation → stronger site privilege → more support placement

This loop can create lock-in even before permanent infrastructure exists.

Failure mode: support systems begin to decide the site.

Loop D — Disturbance to Continuation Pressure

Verification need → disturbance → local data / local modification → planning around disturbed site → continued use

This loop makes the act of learning part of the commitment pathway.

Failure mode: the evidence baseline changes, but the project treats the disturbed site as increasingly authoritative.

Loop E — ISRU Dependency to Infrastructure Lock-In

Resource interpretation → excavation planning → processing assumptions → logistics substitution → mission dependency → infrastructure lock-in

This loop is the central ISRU risk.

Failure mode: resource promise becomes infrastructure permission.

6. Dominant Coupling

The dominant lunar coupling is:

volatile interpretation × access geometry × power/support architecture × disturbance

This coupling matters because each term reinforces the others.

A volatile signal makes a site attractive.

Access geometry makes the site operationally convenient.

Power and support architecture make repeated operations possible.

Disturbance produces local evidence while altering the site.

Together, these factors can make the site increasingly difficult to abandon.

This is the core pathway from signal to commitment.

7. Interdependency Failure Modes

7.1. Evidence-to-Architecture Inflation

A resource signal begins carrying more decision weight than it can justify.

Example: hydrogen indication is treated as sufficient for ISRU architecture.

Failure: evidence adequate for exploration becomes evidence used for infrastructure commitment.

7.2. Access Convenience Substitution

A site is favored because it is easier to reach, not because the resource evidence is decision-grade.

Example: an illuminated ridge or accessible traverse path becomes the practical site anchor.

Failure: access advantage substitutes for commitment admissibility.

7.3. Support-System Self-Justification

Support infrastructure is placed to enable exploration, then used as evidence that the site should continue.

Example: power, communications, or logistics assets become reasons to remain at the site.

Failure: infrastructure begins justifying itself.

7.4. Disturbance Laundering

Disturbance is described as verification, but it alters the site and increases pressure to continue.

Example: trenching or drilling creates local data while changing the evidence baseline and anchoring future work.

Failure: learning action becomes commitment-bearing action.

7.5. Corridor Normalization

Repeated movement becomes an assumed route.

Example: a traverse path becomes the default corridor for later mobility, power, or logistics.

Failure: movement choice becomes infrastructure pattern.

7.6. ISRU Dependency Creep

Resource use assumptions enter mission design incrementally.

Example: logistics, power, processing, or mass planning begins assuming local volatile availability.

Failure: the architecture depends on the resource before the resource has earned that role.

7.7. Programmatic Lock-In

A site, corridor, or resource zone becomes publicly or institutionally treated as primary.

Example: partner materials, agency language, investor decks, or mission diagrams normalize one pathway.

Failure: refusal authority weakens before the evidence burden has been met.

8. Interdependency Screening Questions

Before a lunar commitment-bearing action proceeds, ask:

1. What dependency does this action create?
2. Which prior assumption does it inherit?
3. Which future options does it make less credible?
4. Does it preserve the ability to re-site, re-sequence, or refuse?
5. Does it make one site, corridor, or support geometry easier to continue than abandon?
6. Does it depend on volatile form, accessibility, continuity, or concentration being true?
7. Does it alter the evidence baseline needed to test the original assumption?
8. Would a negative evidence update still be actionable after this step?
9. Which actors begin to depend on this interpretation if the step proceeds?
10. Has exploration begun to become architecture?

The central test:

Can the project still refuse the pathway after this dependency is created?

If not, the action is commitment-bearing.

9. Dependency Severity Classes

Class 1 — Reversible / Learning-Preserving

The dependency supports learning but does not strongly constrain future options.

Examples:

- orbital prospect ranking,
- broad site comparison,
- non-hardening analysis,
- distributed sensing,
- short-duration reconnaissance.

Allowed when: evidence supports exploration interest and optionality remains open.

Class 2 — Bounded / Controlled

The dependency supports local verification but remains constrained by explicit scope, exit conditions, and refusal authority.

Examples:

- limited rover traverse,
- bounded local sensing,
- temporary instrumentation,
- strictly limited sampling plan.

Allowed when: the action is tied to a specific evidence question and does not privilege one pathway beyond the evidence burden.

Class 3 — Commitment-Proximate

The dependency begins shaping future geometry, access, support, or operational assumptions.

Examples:

- preferred landing logic,
- repeated traverse,
- temporary support that privileges one site,
- localized disturbance that becomes a planning anchor,
- excavation planning tied to a candidate resource zone.

Requires: pre-commitment screen.

Class 4 — Commitment-Bearing

The dependency materially reduces the ability to refuse, re-site, re-sequence, or preserve alternatives.

Examples:

- site hardening,
- fixed power placement,
- corridor establishment,
- drilling or excavation tied to future operations,
- resource-processing dependency,
- public primary-site designation.

Requires: formal admissibility determination.

Class 5 — Lock-In

The dependency makes reversal require redesign, institutional retreat, or abandonment of accumulated infrastructure, narrative, or capital exposure.

Examples:

- ISRU-dependent mission architecture,
- fixed logistics network,
- surface infrastructure tied to resource interpretation,
- shared corridor or support architecture,
- public/programmatic site commitment.

Requires: commitment integrity review and may require refusal or termination if the basis is not defensible.

10. Decision Outputs

Proceed

Proceed only if the dependency remains bounded, evidence is adequate to the burden of the action, and refusal authority remains credible.

Proceed does not mean unlimited escalation. It means the specific action is admissible within defined bounds.

Defer

Defer when the dependency would begin hardening the pathway before the dominant uncertainty has been reduced.

During Defer, only bounded evidence acquisition may continue.

Defer does not authorize quiet preparation for commitment.

Refuse

Refuse when the dependency would create irreversible or hard-to-reverse exposure that current evidence cannot justify.

Refuse applies when:

- the action depends on an unresolved volatile interpretation,
- future refusal would become non-credible,
- disturbance would change the evidence baseline without sufficient decision value,
- site/corridor/support architecture would become difficult to abandon,
- or ISRU dependency would enter the architecture before resource adequacy has been demonstrated.

11. Governance Rule

A lunar dependency becomes commitment-bearing when it reduces the practical ability to refuse, defer, re-site, or re-sequence later.

It is not enough to ask whether hardware can be moved or whether a plan can technically be changed. The relevant question is whether the mission, partners, architecture, and support systems can still treat refusal as legitimate after the dependency forms.

12. Canonical Interdependency Statement

In lunar systems, prospecting, access, power, disturbance, and logistics do not simply support exploration. They co-produce the surface commitment pathway.

A volatile signal becomes dangerous when it does not merely guide inquiry, but begins organizing site preference, access repetition, support geometry, disturbance, excavation planning, ISRU dependency, and infrastructure lock-in.

The governing rule is:

No dependency should harden faster than the evidence that justifies it.