RES LUNA

RESOURCE SYSTEMS AND GOVERNANCE APPROACHES

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INTRODUCTION

Res Luna started as a legal working group to discuss and offer support to the international debate on space resource governance. However, it evolved beyond legal thinking to consider the wider range of possible innovative solutions for sustainable development and governance of space resources, with a particular focus on the Moon. The group drew on governance literature that sought to look at our extraterrestrial companion as more than a monolithic object, but instead saw the Moon as a diversity of resources coexisting in a larger system, each of which might warrant different management practices. Together, the group worked to identify distinct lunar resource systems and their potential role in upcoming lunar activities. As a result, over 20 resource systems were identified, a selection of which were characterized in detail, both physically and in the social context of their use.

Unsurprisingly, when breaking down lunar resources into distinct resource systems, it is clear that many exhibit quite different physical characteristics and are expected to involve different types of demand and usage patterns (social-ecological features). Based on the breakdown of lunar resource systems, Res Luna then set out to identify and analyze terrestrial resource systems with similar social-ecological features and contexts (analogs). The group developed a structured characterization of different governance arrangements to make them comparable.

It is clear that the variety of resource governance systems that exist, including social and environmental characteristics, is almost as diverse as the number of resource systems themselves. However, on the very highest level, their development proceeds from similar logic. Their foundational elements consist of allocating a set of more or less restricted property and decision-making rights to natural or legal individuals (privatization), groups of peoples (commoning), federal agencies (nationalization), or the international community (global commons).

While the exact decision-making processes, allocation arrangements, and limitations on the rights vary significantly, there are some recurring patterns or grammars that show up in establishing management regimes. These include:

- Coordination via a specialized (delegated) body
- Self-directed access with norms regarding limitations and scarcity management
- Standardization of resource units (eg. slot system)
- First come first served, with or without obligations
- The use of incentives (e.g. international legitimacy, due regard, access to liability regime, priority rights) to motivate desired behaviour.
- The use of fees, either to counterbalance tendencies towards overuse or to fund shared infrastructure that facilitates use .
- Subdivision of time or resource units; eg. limiting access by specific times/areas/frequencies.
- Creation of resource-specific market dynamics; eg. tradable credit system (distribution, fairness - eg access/benefits/externalities)

PUTTING IT ALL TOGETHER - PRAGMATIC GOVERNANCE OPTIONS

In the table below, we outline a selection of options for pragmatic approaches to governance that could emerge for each resource system, with the specific goal of highlighting alternatives to a top-down, one-size-fits-all approach. The options listed are not proposals, rather, they simply aim to highlight that there are multiple ways that each resource system could potentially be governed.

Resource System

Radio Quiet (Frequency Management)

General Governance Approaches

Stakeholder group that approves and coordinates uses - or a council that approves and a separate group of operators that coordinate use.

Delegation of specific frequency bands to expert stakeholder groups; remaining frequencies managed by ITU.

Decision to dedicate the radio quiet zone to a single international radio observatory, to be operated and managed as a unified international project.

Top down conservationist approach - eg. a treaty establishing radio quiet protection within specific frequencies and a process for exemption in special circumstances.

Stakeholder Groups

Astronomers, satellite operators, with special attention on communication providers .

A local/bespoke dimension of stakeholdership (as opposed to generic stakeholder groups) may also emerge based on the need for local frequency coordination.

Polycentric Aspects

Governance of radio frequencies overlaps with governance of landing sites, prospecting, and orbital slots/frequencies.

Potential Conflicts

Interference between far side mission operations, including surface and orbital assets, and ongoing astronomical observations.

Contention for “quiet” spectrum between different radio observatories operated by different stakeholder groups.

Lack of “ears” in a given frequency band may undermine transparency and confidence building.

Resource System

Landing Sites

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
First come first served basis (FCFS), no registration or coordination, with unenforced norms around transparency. FCFS or an application process, incentivized by recognition (eg. notification, non-interference, non-salvage, liability regime, priority rights) via the UN or an independent Inter Governmental Organization (IGO). Registration and transparency with a central agency made mandatory. The agency responsible for the registry facilitates connections between actors who may influence each others' behaviour spatially or temporally, so they can coordinate between themselves. High value landing sites, for example, around the peaks of eternal light, are identified by the international community and managed by an application process to a designated IGO or council of the UN; the remainder are FCFS.	Commercial companies and governments planning future missions. Conservation groups who seek protection. Scientists who want to land close to areas of interest or protect important scientific records.	Landing site selection and utilization has implications for radio frequency usage, dust mitigation, and sites of local significance.	Race to occupy high value or high prestige landing sites. Limited information leading to a concentration of interest for specific areas (eg. Shackleton crater), causing coordination problems such as divergent mission needs, large structure shadowing, frequency interference or dust interference. Lack of norms regarding occupation of landing sites and/or end of life disposal limiting others' uses, becoming effective appropriation as well as making it difficult to conduct subsequent missions nearby (navigation hazards, disturbed surface, etc.).

Resource System

Dust Mitigation

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
Standards established by spacecraft operators to protect their spacecraft (service providers alliance) Local coordination between potentially interfering operators in the spirit of “good neighbours”. Local flexibility and agency to adapt measures. Mutual monitoring. International standards for dust mitigation, managed and enforced by national supervisory/authorization functions. A centralized body to conduct dust monitoring and apply sanctions for behaviour that exceeds internationally agreed upon standards.	Depending on the scale, potentially global impact (all missions/operators). Exploration and scientific missions with delicate instrumentation (detectors, mechanical joints, solar panels, etc.). A local/bespoke dimension of stakeholdership (as opposed to generic stakeholder groups) may also emerge based on the potential for local dust impacts/interference.	Effective dust management overlaps with governance of landing sites, prospecting, resource extraction of any kind, and heritage protection sites.	Short lived missions lacking incentive for long term dust mitigation norms and development of best practices. Poor incentives to invest in dust mitigation infrastructure such as landing pads due to over head of associated coordination requirements (proximity operations, disposal, etc.) Lack of standards leading to a broken window syndrome/tragedy of the commons. Lack of monitoring and sanctions leading to unclear liability.

Resource System

Water Ice Prospecting

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
Free prospecting without norms or support for knowledge sharing. No place-based rights for priority. No protected area/nothing off limits. Information sharing in exchange for certain rights and recognitions (priority, notification, liability regime): a coordinated and transparent but separate system for surface regolith and water ice in volatiles. FCFS system with general information-sharing on a high level and organized by an agency that keeps record and redistributes identified sites under consideration of priority rights. An international campaign undertaken as a joint effort between nation states to fund development of ground truth prospecting data, and make it available to future operators as a public resource.	Both scientific and commercial operators with interest in lunar water-ice for selenological and industrial uses. National governments for prestige.	Governance of (ice) prospecting overlaps with governance of landing sites/site occupancy.	Co-option of limited resources for a single company or country; exclusion of access to certain resources or areas. Scarcity of knowledge and/or lack of clarity on priority rights leading to data hoarding, higher than necessary barriers to entry, impact scientific discovery or ongoing operations. Concentration of activity around sites of interest leading to follow-up coordination challenges.

Resource System

PSRs/Water Ice Extraction

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
State facilitated self-governance through pre-mission registration and "match-making" between future missions with potential conflicts/interference. An international agreement that prohibits alienation (commercial transaction) of water ice, but allows for commercial contracts to extract it (eg. governments or private operators who need ISRU to support infrastructure development or operations), with the effect of centralizing control of extraction into government hands. Bespoke coordination between governments for individual extraction facilities. Internationally funded public-private partnership that uses commercial services to provide a public utility, obligated to serve all actors	Commercial operators with interest in water ice and other volatiles, scientists with similar interests and an interest for rare and extreme environments, space agencies.	Governance of PSRs overlaps with governance of dust mitigation, prospecting, and contamination and pollution	Same as prospecting, and Long duration excavation and/or processing having significant externalities such as site co-option and interference with scientific activities, Lack of clarity about priority rights leading to squatting.

Resource System

PSRs/Water Ice Extraction

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
An international agency/organization with authority over the coordination of PSRs and other high value water-ice deposits. State stewardship over national operators ensures adherence with agreed-upon practices and a liability scheme. License allocation mechanisms aim for equitable access and distribution. The agency's responsibility could range from exploration to prospecting to extraction and even occupation of sites, all centrally coordinated by the agency and informed by stakeholder representatives. Allocation of extraction rights through tradable "credits" to spread between stakeholders/nation states which can allocate them domestically or trade them with other states over time. A quota system limiting the total number of simultaneous operations to stimulate/concentrate demand.	Commercial operators with interest in water ice and other volatiles, scientists with similar interests and an interest for rare and extreme environments, space agencies.	Governance of PSRs overlaps with governance of dust mitigation, prospecting, and contamination and pollution	Same as prospecting, and Long duration excavation and/or processing may have significant externalities such as site co-option, interference with scientific activities, Lack of clarity about priority rights may lead to squatting.

Resource System

Extraction of Abundant Resources (e.g. Fe, Ti, Si)

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
FCFS governance due to abundance. National supervision for compliance with international law. Standards established for specific kinds of scientific or technical data sharing for all missions, enforced as norms through mutual monitoring and accountability, but not formally regulated. Licensing contingent on transparency of operations submitted to the UN or a delegated body, with incentives to share information and knowledge between operators for sustainable and safe practices. Licensing with limited-time extraction rights (priority rights) in exchange for good governance and behaviour. Coordination through an international prospecting and extraction agency that grants licenses to nation states and national operators under supervision	Commercial entities (mining, infrastructure development, suppliers of consumables), scientists and space agencies	Governance of abundant resource (i.e., Fe, Ti, Si) overlaps with governance of radio frequencies, dust mitigation, prospecting, and contamination and pollution	Abundance leads to lack of environmental stewardship or sustainability practices.

Resource System

Orbital Slots/Frequencies

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
Collective action of early adopters and stakeholder to create norms and institutions to sustainably populate the limited number of frozen orbits and coordinate i.e., comms and relay capabilities or pooled remote sensing. Slot system for smaller capacity orbits (low lunar orbits or frozen orbits) and registration system for high lunar orbits and lagrange points. This could be implemented through First-come first-served Tradable credits allocated initially to each State Tradable credits allocated to Lunar stakeholder governance of limited orbital slots. Criteria might include commitments to "good actor" standards - e.g. disposal, non-interference, joint monitoring, or case by case uses such as open relays, data sharing from onboard scientific instruments, etc.	Space agencies, prospectors, comms system operators and service providers, future transportation service operators.	Governance of orbital slots overlaps with frequency governance and the radio quiet zone.	Lack of norms around transparency of mission activities combined with lack of situational awareness leading to fear of surveillance and surprise. Lack of trust or collaboration leading to over-concentration of relay capabilities with increased chances of interference. Lack of disposal practices leading to risks for assets on the ground. Inaction regarding spectrum allocation for different activities leading to conflicting uses.

Resource System

Orbital Slots/Frequencies

General governance approaches	Stakeholder Groups	Polycentric Aspects	Potential conflicts
International agreement to reserve specific orbital positions for cislunar public services and utilities (eg. relay comms or public rather than private mission activities), international body to manage applications for provision of these services privately or by governments. ITU extends its scope to cover lunar frequency management. Centralized agency for slots and frequency allocation backed by nation states as key authorities, academia, and stakeholder representation.	Space agencies, prospectors, comms system operators and service providers, future transportation service operators.	Governance of orbital slots overlaps with frequency governance and the radio quiet zone.	Lack of norms around transparency of mission activities combined with lack of situational awareness leading to fear of surveillance and surprise. Lack of trust or collaboration leading to over-concentration of relay capabilities with increased chances of interference. Lack of disposal practices leading to risks for assets on the ground. Inaction regarding spectrum allocation for different activities leading to conflicting uses.

Design Considerations for all Governance Approaches

Transparency

All governance regimes face decisions about the degree of transparency and information sharing they incorporate. Registration of mission data with a repository for lunar activities that includes, eg. location and type of operations, could solve coordination and site selection conflicts, facilitate collaborations, and alleviate concerns about harmful interference.

Delegation

Considering the features of lunar resource systems (i.e. remoteness and lack of centralized monitoring capacity; size and interconnection of resource systems; system-specific knowledge; leadership qualities of operators; and importance/dependence on the resources for operators), many resource systems will be conducive to some degree of self-coordination amongst key stakeholders. Consideration will need to be given to the point at which management is delegated, which has implications for costs of management, the nature of monitoring and sanctions, adaptability, and accountability.

Coherence

Overlaps between and interconnectedness of governance regimes for different aspects of lunar activities need to be recognized and coordinated. Governance and policy-making in all respective regimes need to be considerate of that fact and designed in synergy with that diversity.

Design Considerations for all Governance Approaches

Collective Action

Access, exploration, and utilization of the Moon should be a collaborative endeavour benefitting all humankind. Therefore, the process by which governance and institutions are ultimately designed and selected, should be equally collaborative and inclusive of all stakeholder groups.

Agency

In the governance of any global commons the “who” has authority is always difficult. While our proposed governance systems rely heavily on granting agency to the stakeholders, the question of who grants and supervises this agency remains to be addressed. The UN can’t do everything and likely doesn’t move fast enough. New organizations, especially IGOs formally delegated to by the UN, come with a lot of cost, and overhead (formality, rigidity). Stakeholder groups may be ”closer” to the issues but often struggle with recognition, funding, consistency.