OCCUPATIO IN CAELO: THE ROMAN PROPRIETARY TAXONOMY AS A SOLUTION TO THE "TRAGEDY OF THE COMMONS" IN THE SPACE *ECONOMY*.

From *Insula in Mari Nata* to *Asteroid Mining*: Manifesto for a Cosmic Property Right

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Abstract

While the evolution of aerospace technology makes the mining of asteroids imminent, the international regulatory framework, based on the *Outer Space Treaty* (1967), is in an interpretative paralysis, stuck between the principle of non-state appropriation and the need to incentivize private investment. The present study proposes to overcome the impasse by recovering the refined proprietary taxonomy of Roman Law. Through the dogmatic distinction between *res communis omnium* (empty space) and *res nullius* (celestial resources), and by applying the institution of the *occupatio* as a mode of acquisition by original title, it is shown that Roman *prudentia* offers the only model compatible with economic efficiency. The analysis, supported by Demsetz's theory of Property Rights and Hardin's critique of the "Tragedy of the Commons", outlines a legal regime that legitimizes private extraction without violating the prohibition of public sovereignty, transforming the current regulatory vacuum into a rational market order.

As aerospace technology renders asteroid mining imminent, the international regulatory framework, anchored in the Outer Space Treaty (1967), faces interpretive paralysis, caught between the principle of state non-appropriation and the need to incentivize private investment. This paper proposes overcoming this impasse by recovering the refined proprietary taxonomy of Roman Law. Through the dogmatic distinction between *res communis omnium* (void space) and *res nullius* (celestial resources), and applying the institute of *occupatio* as a mode of original acquisition, Roman *prudentia* is shown to offer the only model compatible with economic efficiency. Supported by Demsetz's Property Rights theory and Hardin's critique of the "Tragedy of the Commons," the analysis outlines a legal regime that legitimizes private extraction without violating the ban on public sovereignty, transforming the current legal vacuum into a rational market order.

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1.1. The economic horizon: towards the *ex-orbit extractive industry*

Humanity today finds itself on the threshold of a historical discontinuity comparable to the discovery of the Americas. If the twentieth century was the era of space exploration driven by geopolitical and military imperatives, the twenty-first century marks the advent of the *commercial Space Economy*. The border is no longer symbolic, but mining. Recent

spectroscopic measurements have confirmed that the main asteroid belt (located between Mars and Jupiter) and the Near-Earth Minor Bodies (NEAs) contain immense reserves of platinum group metals (ru, rh, pd, os, ir, pt), nickel, iron and rare earths, as well as precious volatile elements such as water and hydrogen, essential for in situ propulsion [1]. Conservative estimates, such as those developed by NASA in relation to the *Psyche mission* (directed towards the asteroid 16 Psyche), estimate the economic potential of individual celestial bodies in figures in the order of quadrillion dollars (1015), a nominal value that exceeds the aggregate global GDP [2]. In this context, private players such as *Planetary Resources*, *Deep Space Industries* (now acquired) and new players backed by venture capital, are developing exploration and capture technologies that will make *asteroid mining* technically feasible within the next decade. We are no longer in the realm of science fiction speculation, but in a phase of industrial *pre-deployment*.

1.2. The *Vacuum Iuris* and the paralysis of International Law

This technological acceleration corresponds, however, to a dangerous legal stagnation. The current regulatory architecture, hinged on the **1967 Outer Space Treaty (OST),** appears today as a vestige of the Cold War, inadequate to manage the dynamics of private capital. Article II of the OST enshrines the cardinal principle of "non-appropriation":

"Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." [3]

This rule, designed to prevent the USA and the USSR from turning the Moon into a missile base or a territorial colony, has generated a fundamental legal aporia: does the prohibition of "national sovereignty" necessarily imply the prohibition of "private property"? The internationalist doctrine is split:

1. Restrictive Interpretation (Common Heritage School): Based on the spirit of the failed *Moon Agreement* of 1979 (never ratified by the space powers), some jurists argue that space is the "common heritage of humanity", precluding any form of exclusive commercial exploitation [4].

2. Extensive Interpretation (Commercial School): The United States, with the **Commercial Space Launch**

Competitiveness Act (CSLCA) of 2015, followed by Luxembourg (2017) and the United Arab Emirates, has legislated unilaterally, granting its citizens the right to own, transport, and sell abiotic resources mined in space [5].

We are therefore faced with a regulatory conflict: on the one hand an international treaty that freezes property claims, on the other national laws that incentivize them, risking violating supranational law. This uncertainty generates an unacceptable legal *risk* for institutional investors, paralyzing the flow of capital necessary for the development of the sector.

1.2. The Research Methodology: The Return to *Roman* Prudentia

To get out of this hermeneutical *cul-de-sac*, the present study proposes a radical paradigm shift. Instead of attempting to amend modern treatises that are now crystallized, the intention is to recover the dogmatic "toolbox" of Roman Law. Why Rome? Because Roman jurists found themselves dealing with problems structurally identical to those of today: how to regulate the appropriation of resources in spaces that belong to no one (the sea, the air, the emerged islands) without unleashing wars between powers or blocking economic initiative?

The methodology adopted in this work is twofold:

- **Dogmatics:** We will analyze the sources of the Digest and the Institutions (in particular Gaius and Marcian) to reconstruct the taxonomy of the *res* (*communes*, *nullius*, *publicae*) and the methods of acquisition by original title (*occupatio*, *accessio*, *specificatio*).
- **Law & Economics:** We will test the efficiency of these Roman categories through the lens of the economic analysis of law, using the theorems of **Garrett Hardin** (*Tragedy of the Commons*) [6] and **Harold Demsetz** (*Toward a Theory of Property Rights*) [7].

The aim is to demonstrate that the Roman system of the *occupatio* offers the only theoretical model capable of reconciling the prohibition of state sovereignty (the *imperium* over the universe) with the need for the right of private property (the *dominium* over resources), thus providing a solid and universal legal basis for the nascent multi-planetary civilization.

II. Roman Dogmatics: A Taxonomy for the Universe

To build a solid extraterrestrial property regime, it is first necessary to clear the field of terminological misunderstandings. Modern spatial law suffers from a certain ontological coarseness, tending to treat "space" as an indistinct *unicum*. Roman *iurisprudentia*, on the contrary, based its effectiveness on the ability to dissect phenomenal reality into discrete legal categories. The *summa divisio* that we propose to apply here to the cosmic environment is that between the fluid "container" and the solid "content".

2.1. The Ether as *Res Communis Omnium*: the negation of the *Imperium*

The first step is to define the legal status of the cosmic vacuum, orbits and trajectories. To this end, we are helped by the famous classification of Marcian, transposed in the Justinian Digest:

"Et quidem naturali iure omnium communia sunt illa: aer et aqua profluens et mare et per hoc litora maris." (D. 1.8.2.1) [8]

According to natural law (*ius naturale*), the air, the running water and the sea are common to all. The *rationale* of this attribution is not political, but physical: these goods are, by their nature, irrepressible and inexhaustible (or at least so they appeared to the ancients). They cannot be the object of *dominium* (private property) because they cannot be circumscribed; they cannot be the object of *imperium* (exclusive sovereignty) because their use by one subject does not prevent their simultaneous use by others (*non-rivalrous goods*). Celsus, with his usual incisiveness, reinforces the concept by affirming that the use of the sea is common to all men like air: *"Maris communem usum omnibus hominibus ut aeris"* (D. 43.8.3.1).

Translating these categories into the extra-atmospheric scenario, it is evident that they are perfectly overlapping with Art. II of the Outer Space Treaty. Empty space is the new *Mare Magnum*. It is a **Res Communis Omnium**. It follows that:

1. **Freedom of Navigation:** Just as Roman ships could sail the Mediterranean without asking permission from a sovereign (except for ports), so spacecraft have the right of harmless transit in orbits.

2. **Prohibition of Sovereignty:** No state can claim a sector of space as a "national territory". The *imperium*stops where the atmosphere (or the continental shelf, in the case of the sea) ends.

This dogmatic qualification validates, and indeed reinforces, the prohibition of appropriation of *space* understood as a medium. However, as we shall see, this does not imply the prohibition of appropriation *in space*.

2.2. The Asteroid as *an Insula in the Sea*: the Qualification of Resources

If space is sea, what is the asteroid? The mistake of modern jurists who support the thesis of the "Common Heritage" is to consider the celestial bodies as an integral part of the spatial fabric. But for a Roman jurist, this confusion is inadmissible. An asteroid is a solid, finite, delimited body susceptible to physical control. It floats in the *res communis*, but *it is not res communis*.

The most pertinent legal figure is that of the **island born in the sea** (*insula in mari nata*). Gaius addresses the problem of the ownership of a new land that emerges in international (common) waters:

"Insula quae in mari nata est (quod raro accidit), occupantis fit: nullius enim esse creditur." (D. 41.1.7.3) [9]

The island born in the sea becomes the property of the first occupant, since it is believed to belong to no one. This is the keystone of our theoretical framework. The asteroid:

1. It is immersed in a *res communis* (space/sea).
2. It is distinct from it by physical nature (solid vs. void).
3. It is, in its natural state, a **Res Nullius** (nobody's thing).

It is not *res publica* (of the State), nor *res divini iuris* (sacred), nor *res communis* (of all). It is simply an object waiting for a subject. This ontological qualification defuses Art. II of the OST: appropriating an asteroid (or its resources) is not "national appropriation of space", but "private occupation of a *res nullius* located in space". The distinction is subtle, but legally decisive.

2.3. The Acquisitive Dynamic: *Occupatio* as Original Title

Once the object has been identified, we must analyze the way of purchase. In Roman law, the "natural" way of acquiring the property of the *res nullius* is the **Occupatio**. As specified in the Institutions of Justinian (J. 2.1.12), everything that belongs to no one is granted by natural reason to the first occupant ("*quod enim nullius est, id ratione naturali occupanti conceditur").*

In order for the *occupatio* to be perfected and generate the *dominium*, two constituent elements are necessary, which in the spatial context take on a specific technological connotation:

1. **The Corpus (Objective Element):** The taking of material possession. Discovery (*inventio*) by telescope is not enough. Just as it was not enough to see the island to possess it, it is not enough to map the asteroid. A physical act of apprehension is necessary: the landing of a probe (*lander*), anchoring, the beginning of excavation operations. The *corpus transforms* the theoretical claim into effective control.
2. **The Animus (Subjective Element):** The will to keep the thing as one's own (*animus rem sibi habendi*). This element distinguishes occupation from mere scientific exploration. The declaration of commercial intent, combined with the investment of capital, unequivocally manifests the *animus* of the owner.

In summary, Roman dogmatics provides us with a perfect tripartite structure for the *Space Economy*:

- **Space:** *res communis* (inappropriate).
- **The Asteroid:** *Res Nullius* (Appropriable).
- **The title:** *Occupatio* (Effective Investment Award).

This conceptual architecture does not violate international law, but complements it, filling the void left by the OST with categories of proven millennial rationality.

III. The Mechanics of Appropriation: *Occupatio* and Possession at a Distance

Having defined the nature of *res nullius* of asteroid resources, it is necessary to analyze the acquisitive dynamics. The classic objection raised by the internationalist doctrine lies in the impossibility for the human being to exercise continuous physical possession over celestial bodies distant astronomical units from the Earth. However, Roman law, in its mature development, had already gone beyond the primitive conception of possession as mere physical contact, elaborating sophisticated theories on **possessio animo et corpore** mediated by third parties or instruments.

3.1. *Corpus* and *Animus* in the Robotic Age: The Probe as *an Instrumentum*

Roman possession is based on the coexistence of *animus* (intention of lordship) and *corpus* (material availability). In the context of *asteroid mining*, the human agent is not *on-site*. How is the *corpus constituted*?

The answer lies in the theory of the **minister** (intermediary of possession). The Romans acquired possession through sons (*filii familias*) and slaves (*serfs*). The slave, legally, was a *res*, an "instrument endowed with a voice" (*instrumentum vocale*). When the slave took possession of a piece of land in Asia on behalf of the *dominus* in Rome, possession was constituted in the hands of the master:

> *"Adquiritur nobis possessio per procuratorem, tutorem, curatorem: et ideo per nosmet ipsos et per eos quos in potestate habemus."*
>
> (Paul, D. 41.2.1.20) [12]

In the age of automation, the robotic probe or the mining drone take on the legal function of the *instrumentum*. The robot is the *agent* (devoid of its own will, just like the slave in the acquisitive moment) that exercises the *corpus on the asteroid*. The continuous telemetry connection (the radio signal) replaces the master's voice (*iussum*). Therefore:

1. The company on the ground holds the **Animus rem sibi habendi**.
2. The robot exercises the **Corpus in space**.
3. Possession is instantly constituted in the hands of the company by **instrumental ministry**.

In addition, the figure of the **Traditio Longa Manu comes to** the rescue: the possession of a thing (e.g. a fund or goods in a warehouse) could be transferred simply by pointing to it from the tower (*oculis et affectu*), as long as it was under visual control. The sensors and cameras of the probes ensure this constant "visual check". As long as telemetry is active, the asteroid is in the operator's *custody*, meeting the requirements of the strictest Roman possession [13].

3.2. *Separatio* and *Specificatio*: the moment of establishment of the right

Once possession is established, how do you turn it into ownership without violating the OST's prohibition of territorial appropriation? Here Roman dogmatics offers the most elegant solution: the distinction between the mother thing and the fruits.

At. Separation (*Separatio*) It is not necessary to claim ownership of the entire asteroid (which could be interpreted as "territorial sovereignty"). It is enough to claim ownership of the extracted resources. In Roman law, fruits (natural or industrial) become the object of autonomous property at the time of **separatio** (detachment from the mother thing).

> *"Fructus, pendentes pars fundi videntur..separated, intelleguntur esse facti eius, cuius est fundus."* (D. 6.1.44)

The operation of excavation (*mining*) is legally an act of *separation*. As long as the mineral is embedded in the rock, it is part of the celestial body (*pars fundi* - subject to the OST regime). When the drone detaches it and stores it in the tank, it becomes an autonomous mobile res, the exclusive property of the extractor. This elegantly circumvents Art. II OST: we do not appropriate the "territory" (the asteroid remains there), but only the "fruits".

B. The Specification (*Specificatio*) An even stronger argument is that of the **Specificatio**. If space activity transforms matter (e.g. extraction of regolith and its refining in water or propellant), a *new species* is created. According to the Proculian school (confirmed by Justinian in the Institutions, J. 2.1.25), if matter is transformed so that it cannot return to its primitive state, ownership belongs to the **specifier** (the one who did the work) [14]. The enormous technological and industrial investment necessary to process materials in zero gravity justifies the attribution of ownership to

original title per *specificatio*. The company owns the refined metal not because it owns the asteroid, but because it has created a new object through its own work (*opera*).

3.3. *Derelictio*: End-of-Life Management

The Roman model also closes the circle on the management of space *debris*. If the company ceases to exercise control or exhausts the mine, **Derelictio** (abandonment) can operate. The *res* returns to being *nullius* (or refusal), freeing the operator from proprietary liability, except for the modern obligations of *the Liability Convention* for damages to third parties (which, however, concern the damage, not the property) [15].

IV. Law *& Economics*: Allocative Efficiency and Incentive Structure

The validation of a legal model, in modern legal science, cannot be separated from the verification of its economic efficiency. If Roman Law provides us with the "form" (the *occupatio*), *Law & Economics* explains the "substance": why applying this institution is the only way to avoid the failure of the space market.

4.1. Avoiding the *Tragedy of the Commons*: The Critique of the "Common Heritage"

The main ideological obstacle to *asteroid mining* is the concept of *Common Heritage of Mankind* (CHM), introduced into international law by the *Moon Agreement* of 1979 (art. 11) [16]. This doctrine would like to impose a regime of collective ownership or forced redistribution of the benefits deriving from space resources, similar to that in force for the ocean floor (UNCLOS).

However, economic analysis shows that the CHM inevitably leads to the Tragedy of the Commons*, theorized by the biologist and economist* Garrett Hardin in 1968 [17]. The model is well known: if a pasture is open to all (without rights of exclusion), each shepherd will have the rational incentive to add an extra sheep, privatizing the income (the wool) and socializing the cost (the degradation of the grass). The end result is the destruction of the resource.

In space, the "tragedy" is not overexploitation (resources are immense), but **underinvestment**. A mining mission on an asteroid requires *Capex* (capital expenditures) in the range of $10-50 billion and extreme technological risks. If the asteroid were legally "everyone's" (or if profits were to be socialized), no private investor (the rational agent) would allocate capital, since he could not exclude *Free Riders* (competitors or non-investor states that claim a share). Uncertainty about the proprietary title acts as an implied 100% tax on innovation. The result is a sub-optimal Nash balance: zero investment, zero resources extracted, zero benefit to humanity.

4.2. The Demsetzian function of private property in space

To break the deadlock, we must resort to **Harold Demsez'**s theory of property rights [18]. In his seminal 1967 article, Demsetz explains that property rights are not metaphysical dogmas, but economic tools that emerge spontaneously when it is necessary **to internalize externalities**.

In the spatial context:

1. **The Positive Externality:** The company that develops the technology to extract platinum from an asteroid creates an immense benefit (reduction of the cost of raw materials on Earth, new propulsion technologies).
2. **Internalization:** In order for the company to invest, it must be able to capture this value. The Roman institution of the **Occupatio** (exclusive right based on taking possession) is the legal mechanism that allows this internalization.

Roman law, by guaranteeing that *"he who captures, keeps"* (*cuius est occupantis*), aligns private interest (profit) with social interest (availability of new resources). In Pareto terms, the transition from *res nullius* to private property is a Pareto improvement: the investor is better off (profit), and humanity is not worse off (the asteroid was useless before, now it injects resources into the market), on the contrary it benefits from the increase in aggregate supply.

4.3. Dynamic Efficiency vs. Statics

Proponents of the "Common Heritage" worry about **static efficiency** (how to divide the existing pie). But in space the "cake" does not yet exist; must be cooked. Roman law favors **dynamic efficiency** (incentive to create

new wealth). The regime of *occupatio* and *specificatio* rewards technological innovation. Only those who develop drones capable of *corpus* (physical grip) and *separatio* (extraction) get the right. This triggers a virtuous competition (race to the top) similar to that which drove geographical exploration or the gold rush in the nineteenth century. Economic history teaches that *Open Access* regimes (open access without ownership) lead to the dissipation of rent (*Rent Dissipation*), while clear ownership regimes lead to the maximization of value. The Roman taxonomy, by defining clear boundaries between *res communis* (navigation) and *res privata* (extraction), minimizes transaction costs and maximizes dynamic efficiency [19].

V. Conclusions. *Ad Astra Per Aspera Iuris*: Legal Humanism as an Infrastructure of the Cosmos

5.1. The Perenniality of the Method: Roman Law as a Technology of Civilization

At the end of this examination, which dared to juxtapose the dust of ancient codices with the stardust of *Near-Earth asteroids*, a truth emerges that transcends mere legal technique: Roman Law does not constitute an archaeological relic to be venerated in museums of history, but a living, pulsating intellectual technology of unsurpassed logical precision. The investigation has shown how the dogmatic categories elaborated by Gaius, Marcian and the Severan jurists were not linked to the contingency of an agrarian empire, but intercepted universal ontological structures of the relationship between Man and the Thing. The distinction between *res communis* and *res nullius*, between the sea that unites and the island that enriches, is revealed today as the only conceptual algorithm capable of ordering sidereal vastness without reducing it to a theater of conflicts. Recognizing this continuity is not passé; it is the acknowledgement that Western legal reason already possesses, in its millenary DNA, the antibodies against the regulatory chaos that threatens the new frontier [20].

5.2. *Imperium* and *Dominium*: Peace through Property

The great misunderstanding of spatial modernity, crystallized in the aporias of the UN treaties, lies in having confused political sovereignty with economic appropriation. Our proposal to recover the Roman taxonomy

serves to separate, with surgical clarity, the *Imperium* from *the Dominium* [21]. Where the *Imperium*—the pretense of hoisting flags and drawing state boundaries—must stop at the threshold of the atmosphere, ensuring that space remains a sanctuary of peace free from nationalism, the *Dominium*—the individual's ability to make resources his own through labor and ingenuity—must be able to flourish. This separation is not a legal artifice, but a profoundly human necessity: it allows the Universe to be preserved as a place of common transit, while unlocking that vital drive, that economic *conatus* that has always been the engine of human exploration. Without the certainty of "mine" and "yours" guaranteed by the *occupatio*, space would remain a sterile desert, a museum of unreachable stones, precluded to the progress of our species.

5.3. The *Occupatio* as a Creative Act: Towards a Multi-Planetary Civilization

In the final analysis, this study intends to ethically rehabilitate the institution of the *occupatio*. Too often denigrated as an instrument of colonial robbery, it appears to us, in its Roman essence, as the primordial and founding legal act of civilization. The *occupatio* is not subtraction, it is creation. Transforming an inert asteroid — brute and purposeless matter — into resources, energy, habitat, means extending the range of human action, bringing life where there was only silence. When the Roman jurist recognizes the property of the one who operates the *specificatio*, he is celebrating the dignity of human work that infuses value into matter. In an age in which humanity no longer looks to the stars only to dream, but to survive and prosper, the law has the moral duty to build roads, not walls. Roman *prudentia*offers us these paths. It teaches us that order is not the enemy of freedom, but its precondition. To adopt this model is to accept the highest challenge: to export into space not only our machines, but our greatest immaterial invention — Law — so that the expansion towards infinity is not a leap into the darkness of barbarism, but an orderly and rational ascent towards our cosmic destiny [23].

Footnotes

[1] J. S. Lewis, *Mining the Sky: Untold Riches from the Asteroids, Comets, and Planets*. Reading, MA: Addison-Wesley, 1996. See also M. Elvis, "Let's mine asteroids—for science and profit," *Nature*, vol. 485, p. 549, 2012, which highlights the critical need for rare metals for the terrestrial electronics industry.

[2] L. T. Elkins-Tanton et al., "The Psyche mission: Journey to a metal world," *Space Science Reviews*, vol. 216, no. 8, 2020. The economic value is calculated on the basis of the current market prices of raw metals, although the massive injection of these resources would inevitably cause a deflationary supply shock.

[3] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (Outer Space Treaty), Art. II, Jan. 27, 1967, 610 U.N.T.S. 205.

[4] S. Hobe, "Adequacy of the Current Legal and Regulatory Framework Relating to the Extraction and Appropriation of Natural Resources in Outer Space," *Annals of Air and Space Law*, vol. 32, 2007. The author discusses the legacy of the *Moon Agreement* and the concept of *res communis humanitatis* as an obstacle to privatization.

[5] *U.S. Commercial Space Launch Competitiveness Act*, Pub. L. No. 114-90, § 402, 129 Stat. 704 (2015). The law explicitly states: "A United States citizen engaged in commercial recovery of an asteroid resource or a space resource... shall be entitled to any asteroid resource or space resource obtained."

[6] G. Hardin, "The Tragedy of the Commons," *Science*, vol. 162, no. 3859, pp. 1243–1248, 1968.

[7] H. Demsetz, "Toward a Theory of Property Rights," *The American Economic Review*, vol. 57, no. 2, pp. 347–359, 1967. Demsetz theorizes that private property emerges to internalize externalities when the benefits of internalization outweigh the transaction costs associated with defining rights.

8] T. Mommsen and P. Krueger, *Corpus Iuris Civilis, Vol. I: Digesta*. Berlin: Weidmann, 1870. See also D. 43.8.3.1 (Celsus) on the public nature of the use of the sea, which anticipates the modern concept of "Global Commons".

[9] Gaius, *Digesta*, 41.1.7.3. On the relevance of occupation as an original mode of acquisition in the law of nations, see P. Birks, "The Roman Law of Property and Obligations," in *Oxford Principles of Roman Law*, Oxford Univ. Press, 2014, p. Birks emphasizes that the *occupatio* is the only logical mode of acquisition in the absence of a previous owner.

[10] For a comparative analysis of the Roman concept of *res nullius* and modern *terra nullius* in international law, see R. Zimmermann, *The Law of Obligations: Roman Foundations of the Civilian Tradition*, Oxford: OUP,

1996. Zimmermann notes how modern doctrine has often confused territorial sovereignty with private property, a distinction that is very clear in Roman texts.

[11] On the insufficiency of mere sight (*oculis*) for the acquisition of possession and the necessity of physical (*bodily*) contact, see D. 41.2.3.1 (Paul). This principle is crucial to invalidate speculative claims based on remote astronomical observation alone.

[12] Paulus, *Digesta*, 41.2.1.20. Modern doctrine has extensively discussed the analogy between slave and intelligent agent; see U. Pagallo, *The Laws of Robots: Crimes, Contracts, and Torts*, Springer, 2013, which recovers the notion of *peculium* for robots, but here the analogy serves to found the purchase of possession.

[13] R. Savigny, *Das Recht des Besitzes* (The Right of Possession), 1803. Savigny's classical theory of possession requires the physical possibility of acting on the thing. Modern robotics extends human *possibilitas* beyond atmospheric boundaries, making spatial *possession* dogmatically permissible.

[14] Iustinianus, *Institutiones*, 2.1.25. *"Si ex aliena materia species aliqua facta sit... si ea species ad materiam reduci non possit, eum potius probandum est qui fecerit"*. The chemical or physical transformation of space minerals is irreversible, which assigns ownership to the producer/extractor.

[15] *Convention on International Liability for Damage Caused by Space Objects*, Mar. 29, 1972, 961 U.N.T.S. 187. It is crucial to note that the Roman law of property (*derelictio*) must here interface with the international law of civil liability: the abandonment of property does not exempt from liability for damage caused by the abandoned object (e.g. a decommissioned satellite hitting the ISS).

16] *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, Dec. 5, 1979, 1363 U.N.T.S. 3. It is significant to note that none of the major space powers (USA, Russia, China) has ratified this treaty, making it *de facto* ineffective as an international custom, precisely because of its anti-competitive clauses.

[17] G. Hardin, "The Tragedy of the Commons," *Science*, vol. 162, no. 3859, pp. 1243–1248, 1968. Although Hardin focused on overpopulation and Earth's natural resources, the logic is perfectly translatable to saturated orbits (debris) and disputed mineral resources.

[18] H. Demsetz, "Toward a Theory of Property Rights," *The American Economic Review*, vol. 57, no. 2, pp. 347–359, 1967. Demsetz empirically demonstrates (using the example of Native American furs) that private property emerges when the value of the resource exceeds the costs of monitoring and defending it. In space, technology is lowering monitoring costs, making the "Demsettian" moment ripe.

[19] R. A. Posner, *Economic Analysis of Law*, 9th ed., New York: Wolters Kluwer, 2014. Posner points out that *first possession* is the most

efficient rule for resources not yet owned, as it avoids the administrative costs of centralized allocation (space bureaucracy).

[20] A. Schiavone, *The Invention of Law in the West*, Harvard University Press, 2012. The author masterfully argues how Roman law has created a "technology of form" capable of isolating legal relationships from religious or political constraints, making them universally applicable. It is this formal abstraction that makes the *Digest* applicable to Mars as well.

[21] H. Grotius, *Mare Liberum*, 1609. The Grotian distinction is fundamental: the sea (space) cannot be occupied because it cannot be delimited, but what is found in it (fish/resources) is appropriate. Applying Grotius to space means saving freedom of navigation without sacrificing freedom of enterprise.

[22] J. Locke, *Two Treatises of Government*, 1689 (II, § 27). Locke's theory of property is based on labor: man has ownership of his own person and of the "labor of his hands." When he mixes his work with natural matter (the asteroid), he acquires its property. The Roman *occupatio*, read through Locke, becomes the affirmation of the dignity of *Homo Faber*.

[23] C. Schmitt, *The Nomos of the Earth in the International Law of the Jus Publicum Europaeum*, Telos Press, 2003 [1950]. Schmitt identifies the *Landnahme* (land taking) as the radical act that founds every order ("Nomos"). Expansion in space represents a new *Raumnahme* (taking of space): without a founding juridical act of appropriation and division, there can be no order, but only nihilistic chaos.