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The SpaceOS

Establishing a Pioneering Space Economy That Embodies the Very Best of European Values: Democracy, Openness, Responsibility, and Solidarity

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Establish a Pioneering Space Economy That Embodies the Very Best of European Values: Democracy, Openness, Responsibility, and Solidarity

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Preface

The commercial exploration and utilization of Low Earth Orbit represent a transformative frontier for the European economy, holding immense potential for innovation, economic growth, and technological advancement. From advanced manufacturing and biotechnology to artificial intelligence and telecommunications, the benefits of engaging actively in space-based commercial ventures extend far beyond traditional space sectors, promising to reshape multiple industries fundamentally. Europe stands at a decisive juncture. As the Low Earth Orbit landscape evolves rapidly and competition intensifies globally, this is a critical moment for Europe to define its path clearly. Proactive measures are essential to prevent strategic dependencies on foreign technological giants, preserve European sovereignty, and secure a leadership role in global space governance and commercial activity.

The current absence of entrenched legacy structures in Low Earth Orbit provides Europe with a unique opportunity – a clean slate – to build from the outset a robust, decentralized, and data-sovereign institutional framework. Unlike today's internet, dominated by a handful of large corporations, the approach proposed in this paper emphasizes democracy, openness, responsibility, and solidarity. By consciously embedding these values into the foundational digital infrastructure for the Low Earth Orbit economy, Europe can foster broad participation, stimulate continuous innovation, and ensure fair and equitable access for all stakeholders.

This whitepaper serves not only as a technical blueprint but also as an invitation to dialogue and collaboration among policymakers, industry leaders, researchers, and innovators across Europe. We invite active engagement and partnership to shape the proposed frameworks and jointly build the nec-essary standards, institutions, and ecosystems.

Collective and timely action will enable Europe to leverage this unprecedented opportunity to establish itself as a global leader in the burgeoning commercial space economy. The moment is now – let us shape this future together.

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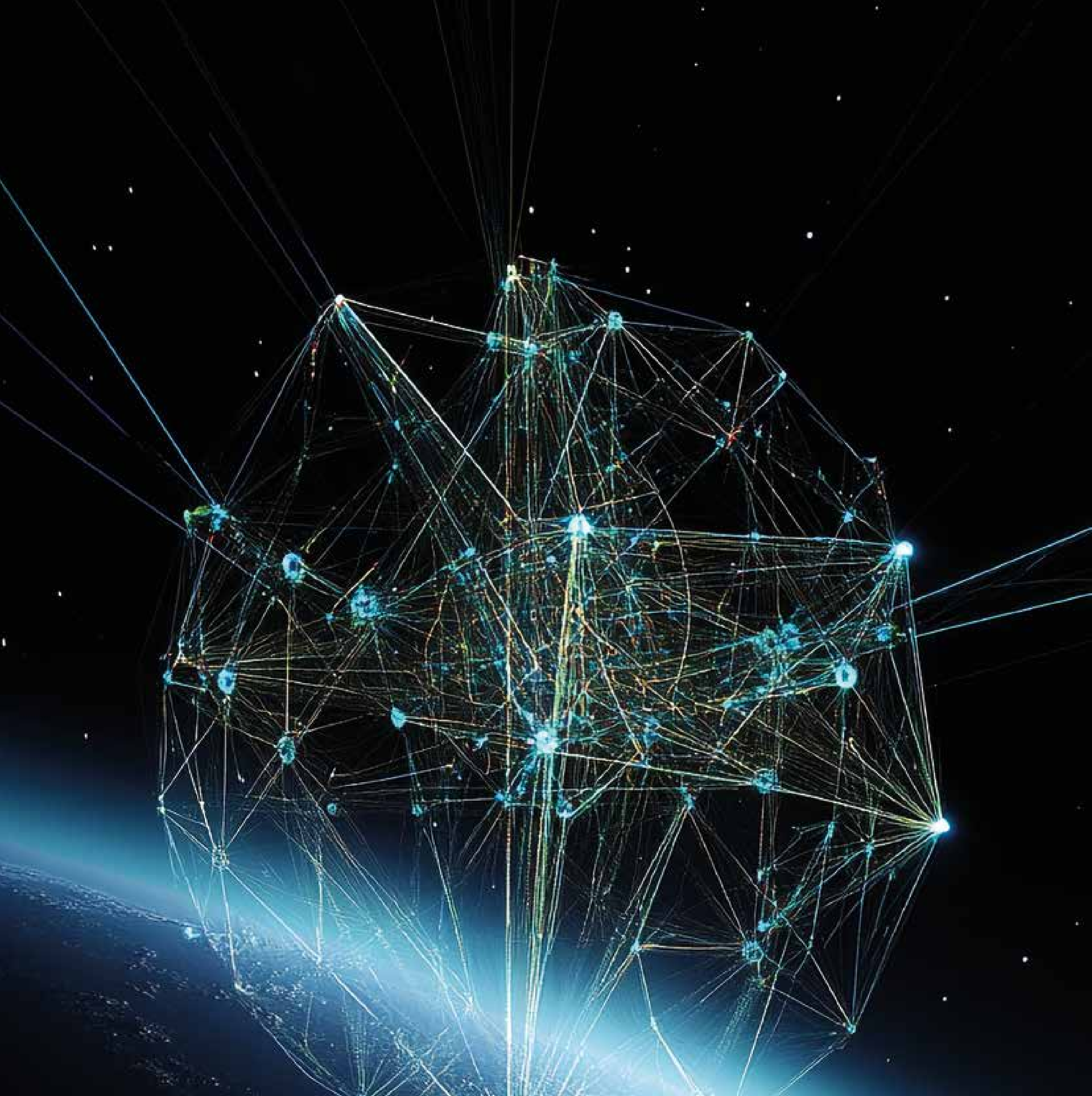


1

Vision

Defining the Rules of Orbit: A European Digital Infrastructure for the New Space Economy

Low-Earth Orbit is fast becoming a crucible of economic activity, technological ingenuity, and geopolitical weight. What began as a realm for government science missions is morphing into an arena where private industry, research institutions, and public agencies collaborate at orbital scale. For Europe, this shift is more than a market opportunity – it is a mandate to shape the rules of engagement in a way that reflects continental principles of democracy, openness, accountability, and solidarity.

A European space strategy, therefore, cannot rest on competitiveness alone. It must fuse economic ambition with legal certainty and ethical responsibility, turning Low Earth Orbit into a platform for growth that serves the public interest, protects sovereignty without isolationism, and encourages cross-border, cross-sector innovation.

Recognizing that vision is more than rockets, constellations and advanced hardware; it requires a digital backbone capable of linking satellites to factories, regulators to insurers, and investors to researchers. The SpaceOS platform is conceived as precisely that backbone: an interoperable, high-integrity infrastructure engineered to manage identities, data, and value flows across the orbital economy. Critically, this foundation does more than enable operations – it activates a self-reinforcing market: one in which trusted digital interactions create new business models, expand access to orbital services, and accelerate the maturity of the space economy as a whole.

Built from the ground up, the mindset behind SpaceOS draws on both the strengths and short-comings of the Internet era. By applying Web3 principles – such as blockchain-secured smart contracts, self-sovereign identity and privacy-preserving cryptography – it embeds democratic governance, transparency and user sovereignty directly into the core architecture, rather than adding them as an afterthought.

Above all, SpaceOS is value-driven yet outward-looking: European by design, global in reach, and open to all who are committed to a transparent, collaborative, and sustainably managed space economy. The time to act is now – not just to join the next frontier, but to define it.

2

Challenges

Challenges for Commercial Space Activities

Low Earth Orbit (LEO) is rapidly becoming the new frontier for European industrial progress. Unlike traditional terrestrial markets, Low Earth Orbit offers a unique environment – characterized by microgravity, unobstructed access to the vacuum of space, and broad vantage points for Earth observation and digital connectivity – that opens up entirely new possibilities for industry, science, and society.

Low Earth Orbit is thereby not just a territory above our planet – it is a new economic sphere with profound opportunities and challenges for Europe. To realize the full potential of a Low Earth Orbit economy for industry and society, several key barriers must be addressed:

Challenge 1: Fragmentation Between Non-Space and Space Companies

Europe boasts a wealth of industrial expertise, digital talent, and academic excellence. However, the emerging Low Earth Orbit economy suffers from a disconnect between traditional space actors and non-space industries that could benefit from – or contribute to – activities in orbit. Many potential industrial users remain unaware of microgravity opportunities or see entry into Low Earth Orbit as too complex or risky. Meanwhile, existing space projects often lack easy access to the capabilities, products, and insights available in Europe's robust terrestrial sectors. Yet, many of these industries remain oblivious to the strategic advantages that Low Earth Orbit can provide for future competitiveness and product innovation. However, due to the absence of robust collaboration frameworks and insufficient cross-sector visibility, these contributions are not consistently integrated into commercial Low Earth Orbit activities. This fragmentation slows innovation, limits knowledge transfer, and stifles the growth of a competitive European space economy.

Challenge 2: Lack of Trust Anchors

As Low Earth Orbit becomes more crowded and commercially relevant, the complex network of stakeholders from various industries, countries, and regulatory environments results in a lack of shared standards, harmonized regulations, and transparent governance mechanisms. This creates uncertainty for European companies – especially small and medium-sized enterprises – seeking to participate in orbital markets, as it results in high (financial) risks. Unclear rules for liability, intellectual property, and investment protection hinder cross-border collaboration and deter private investment. Without reliable, digital trust anchors and common procedures, disputes and inefficiencies are almost inevitable, making it harder for Europe's industries to scale and compete.

Challenge 3: High Cmplexity with Insufficient Transparency

Commercial ventures in Low Earth Orbit must contend with a complex web of stakeholders, supply chains, and operational risks – ranging from launch and hardware reliability to new forms of orbital service provision. A lack of real-time, verifiable project data – such as performance milestones, resource utilization, and risk management status – not only discourages investment but also hampers proactive governance and decision-making, especially for stake-holders unfamiliar with activities in Low Earth Orbit. For Europe to build a resilient and responsible space economy that actively integrates new Low Earth Orbit stakeholders, robust standards for transparency, open access to critical project data and independent verification mechanisms are crucial.

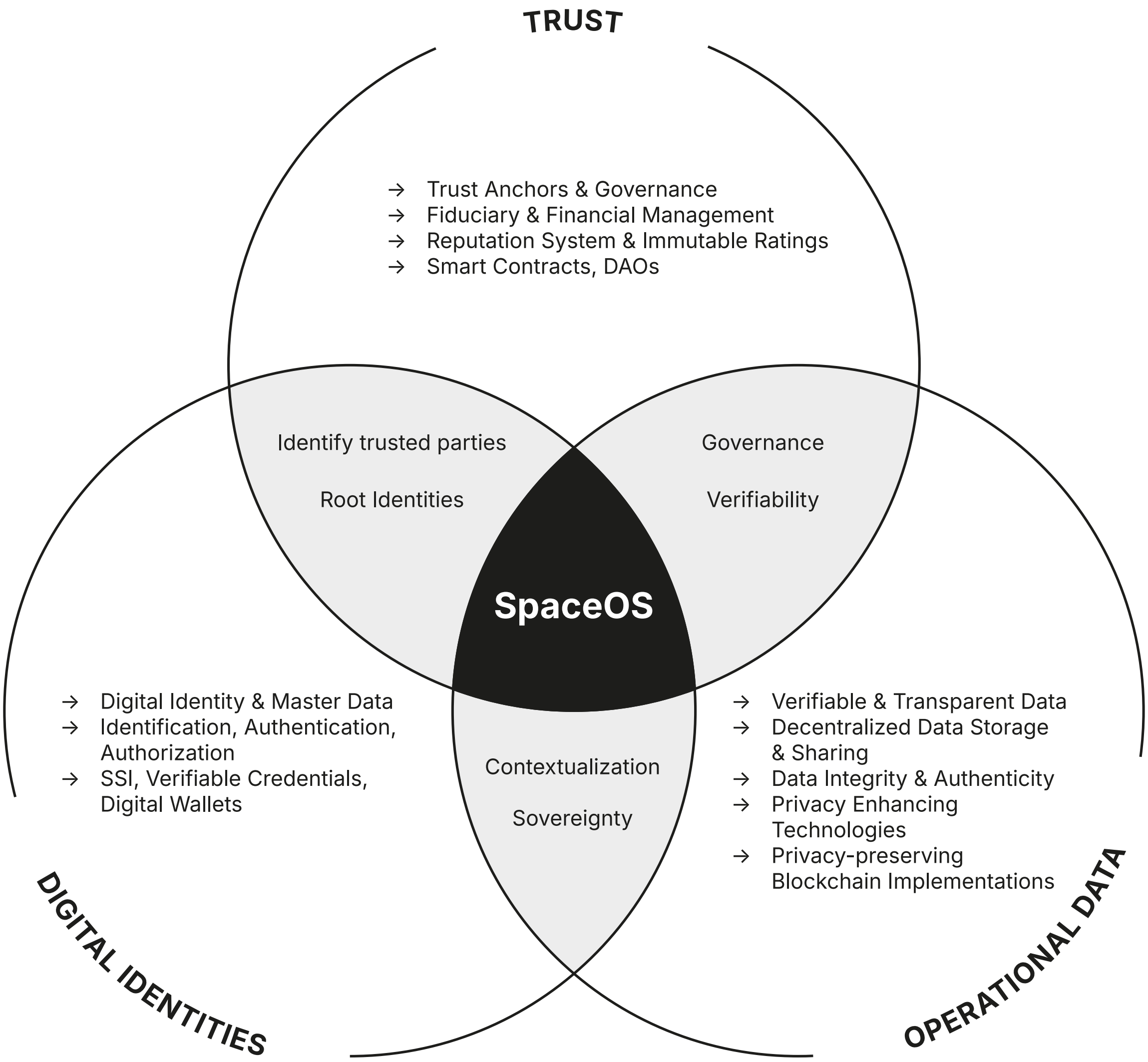
3

The Layers

Three Layers for Establishing an Innovation-Driven Ecosystem

Dependence on non-European technologies, platforms, or regulatory regimes in Low Earth Orbit could undermine Europe's economic resilience and strategic autonomy. To ensure a prosperous and secure future, Europe must set its own rules, safeguard digital sovereignty, and ensure that economic activity in space is guided by European values – democracy, openness, sustainability, and inclusion – rather than external interests. Establishing a thriving innovation-driven ecosystem for commercial projects in Low Earth Orbit, we see the following layers essential:

- Digital Identity Layer
- Trust Layer
- Operational Data Layer



Digital Identity Layer

The digital identity layer establishes a unified digital environment that enables companies – from aerospace leaders to healthcare and materials innovators – to discover, connect, and co-develop orbital solutions. This standardized layer guarantees the verification and trustworthiness of every participant, asset, and data point, thereby dismantling barriers between space and terrestrial industries. Well-defined and reliable identities for both companies and individuals are crucial for reducing fragmentation, ensuring accountability, and enhancing collaboration within Europe's burgeoning commercial Low Earth Orbit ecosystem. Without dependable identification, doubts about the legitimacy and capabilities of partners escalate, impeding both trust and cooperation.

Identity for companies and individuals, mostly including master data, refers to identification, authentication and authorization of an entity or individual within the ecosystem. This master data includes core attributes such as legal identity, organizational details, credentials, contact information, and relevant certifications or qualifications.

The identity layer will enhance and utilize both existing and forthcoming European identity infrastructures, including the eIDAS framework. This positions Europe at the forefront of digital identity solutions. By integrating these identification mechanisms from the start, the layer promotes compatibility and trust. Furthermore, it will introduce new standardized data assets designed specifically for the commercial space industry. Even machines can be provided with digital identities, laying the groundwork for reliable and direct communication between stakeholder and machines and even a machine-to-machine economy. This initiative will facilitate the development of comprehensive, robust, and digitally verifiable identities for commercial space companies and their stakeholders.

Trust Layer

Establishing trust is essential for fostering collaboration and investment within the commercial Low Earth Orbit ecosystem. Clearly defined and recognized trust structures significantly reduce uncertainties related to financial, operational, and contractual risks, thereby attracting investors, stakeholders, and partners. This foundation is particularly crucial for newcomers to Low Earth Orbit, encouraging their commitment to activities in this domain.

Trust is the confidence that stakeholders place in the integrity, reliability, and predictability of other parties, structures, and processes within the ecosystem. It ensures that interactions and transactions occur as expected, based on transparent, verifiable, and consistent rules and behaviors, thus facilitating effective collaboration and reducing uncertainty.

The Digital Identity Layer provides a robust foundation for the verifiable digital identification of organizations and individuals, ensuring the authenticity of their master data. Building upon this, the Trust Layer replaces the traditional need for trust in collaborations with a comprehensive infrastructure, frameworks, and mechanisms that are adaptable to various scenarios in the Low Earth Orbit economy. This layer fosters certainty for all stakeholders by facilitating processes such as assigning roles to identities, assessing risks, managing funds responsibly, and mediating disputes. These processes are crucial for a variety of Low Earth Orbit economy activities, including launching startups and funding large-scale projects. Furthermore, the governance of entire organizations can be managed through this layer in a transparent manner, enhancing confidence and transparency in stakeholder interactions. Thereby this layer aims to significantly reducing uncertainties and promotes effective and reliable cooperation.

Operational Data Layer

Documentation, transparency, and verifiability of operational data are essential for ensuring certainty in process execution, particularly when direct monitoring is not feasible, as in Low Earth Orbit. Verifiable operational data not only confirms the integrity of processes but also enhances efficient risk management and builds trust among stakeholders in the commercial Low Earth Orbit ecosystem. This reliability in assessing performance, resource allocation, and project progress significantly reduces perceived risks and investor hesitancy by providing con-crete assurances to partners and stakeholders.

Operational data refers to dynamic data on everything from fine-grained (primary) data of individuals or machines to pre-assessed information about the project, including project mile-stones, financial transactions, resource usage, contractual compliance and operational results.

The Operational Data Layer establishes the necessary infrastructure for capturing verifiable operational data and securely transferring it between stakeholders. Verifiability ensures the ability to confirm the authenticity (i.e., the creator) and integrity (i.e., the absence of tampering) of all records. The Digital Identity Layer provides the foundation for creating authenticity by enabling the identification of data creators, whether stakeholders or machines, thus adding context to the data. The Trust Layer implements governance frameworks, fiduciary oversight, and dispute resolution mechanisms essential for independently and objectively validating and auditing transaction data. It mediates the creation of standards for the Operational Data Layer to ensure interoperability and provides enhanced data governance mechanisms managing data access, thus upholding data sovereignty for all stakeholders.

The cumulative knowledge about each transaction's value and content creates an entirely new asset: a live, trustworthy map of commercial and technological activity in Low Earth Orbit. This level of market intelligence and operational transparency is unique in the orbital context and could also inspire models for terrestrial processes. It empowers stakeholders, investors, and regulators with real-time, evidence-based insight – serving as a catalyst for participation, innova-tion, and responsible growth.

4

Towards Implementing

Towards Implementing

Currently, no comparable (European) SpaceOS Platform exists. Against this backdrop, establishing a robust digital backbone to facilitate a thriving Low Earth Orbit economy becomes essential. At the same time, the absence of legacy information systems offers a unique opportunity to fundamentally rethink and design this digital infrastructure, creating a decentralized alternative distinctly different from existing centralized structures, such as those that dominate today's Internet.

Blockchain and distributed ledger technology have their roots in Bitcoin, introduced in 2008 as the first peer-to-peer electronic cash system. Bitcoin successfully removed the need for trusted intermediaries by solving the Byzantine Generals Problem, effectively preventing the double-spending issue inherent in digital transactions. Building upon this innovation, Ethereum emerged, significantly extending blockchain capabilities by introducing smart contracts. Smart contracts enabled users to build blockchain-based applications. Ethereum's programmable envi-ronment laid the foundation for Decentralized Finance and spurred the rapid growth of the broader distributed ledger technology ecosystem. Ultimately, these developments pave the way for the vision of Web3, an evolution of the Internet characterized by decentralization and genuine user ownership of digital assets and data. Unlike Web2, where a handful of powerful tech companies dominate the internet landscape, Web3 emphasizes democratization, enabling users not only to own their data and digital goods but to actively participate in governance and infrastructure.

The principles underpinning Web3 align closely with the mission of establishing a European platform dedicated to fostering an innovation-driven economy for commercial space projects. Ditributed Ledger Technology infrastructures allow for the participation of individuals and organizations likewise in developing novel innovations while leveraging cross-sectoral collaboration. By embracing these decentralized technologies, Europe can establish a digital backbone for enabling new services and business models – unique to Low Earth Orbit. With the platform, previously unimaginable services – like in-orbit manufacturing certification, M2M transaction engines for satellite constellations, orbital microgrids, or on-demand science-as-a-service – become possible.

Implementing the Digital Identity Layer

To effectively tackle the fragmentation between the European non-space and space sectors within the burgeoning Low Earth Orbit economy, the establishment of a robust identity infrastructure is essential. This layer should facilitate comprehensive identification, authentication, and authorization capabilities, enabling seamless collaboration among the various stakeholders, industries, and sectors engaged in commercial Low Earth Orbit activities. Additionally, machine-readable master data can lower onboarding costs and streamline collaborative processes, which is especially valuable given the complexity and scale of commercial space initiatives.

In light of the rise of new space tech giants in the Low Earth Orbit sector, such as SpaceX and Blue Origin, the digital identity layer must prevent centralized control, ensuring that no single entity wields quasi-monopolistic control over critical identity resources. This is imperative to avoid repeating past issues seen on the Internet, where federated identity management and single sign-on services provided by major technology firms like Alphabet, Amazon, and Meta have amassed significant market power. Therefore, the promotion of data sovereignty is crucial, enabling identity holders within the Low Earth Orbit economy to retain complete control over their identity data. This allows them to share specific attributes, such as production capabilities or financial status, securely and on their terms.

Upholding data sovereignty elevates trust by assuring participants that their data remains secure and under their stewardship. This assurance reduces entry barriers, inviting a broader spectrum of stakeholders – including smaller, innovative companies – to engage actively. Increased participation diversifies the ecosystem, mitigates monopolistic dominance, and stimulates a competitive milieu that is favorable for ongoing innovation and sustainable expansion.

Rather than initiating a complete bootstrap process, the proposed identity layer should leverage existing European identity infrastructures, such as the eIDAS[1] 2024 framework (EU 2024/1183), and trusted master data sources from other established sectors, such as the manufacturing or energy. Leveraging these existing resources will help accelerate adoption, ensure compatibility, and build on Europe's already strong foundations in digital identity management.

[1] https://eur-lex.europa.eu/eli/reg/2024/1183/oj/eng

Technology: Self-Sovereign Identity based matchmaking

The self-sovereign identity[2] paradigm, originally inspired by Web3 but also fully compatible with existing Web2 environments, closely aligns the aim to provide a scalable digital identity layer, which focuses on the sovereignty of its users, and is, therefore, ideally suited for the commercial Low Earth Orbit economy. Self-sovereign identity enables individuals and organizations to retain full sovereignty over their identity data, providing universally recognizable, secure, and verifiable digital identities that can bridge the gap between space and non-space sectors.

Self-sovereign identity utilizes verifiable credentials, essentially digital certificates issued by trusted entities. These credentials confirm identity attributes or qualifications securely, using asymmetric encryption, public key infrastructure, and digital signatures. They significantly enhance verifiability, authenticity, and integrity, and they directly address stakeholder fragmentation in commercial Low Earth Orbit activities.

Digital wallets are a cornerstone of self-sovereign identity, enabling stakeholders to securely store, manage, and selectively disclose their identity data. This capability supports efficient onboarding, authentication, and facilitates cross-sector collaboration. Moreover, digital wallets enable the secure management of cryptographic keys, which is crucial for signing transactions and establishing trust within blockchain ecosystems that are likely to play a vital role in the gov-ernance and transactional transparency of Low Earth Orbit projects.

While self-sovereign identity effectively addresses critical issues around identity management, it alone does not resolve the fragmentation among stakeholders between space and non-space sectors. A complementary marketplace or matchmaking platform could significantly bolster stakeholder connectivity, capability discovery, and collaboration within the Low Earth Orbit economy. Such a platform should feature structured directories for profiling stakeholder capabilities, alongside automated matchmaking and collaboration tools, as well as secure communication channels, enhancing verifiability and trust within the expanding ecosystem.

Leveraging semantic web concepts, like JSON-LD, could enable structured capability mapping and facilitate automated stakeholder discovery. Additionally, decentralized data storage and distributed ledger technologies offer added transparency and traceability to the digital identity layer, strengthening trust and collaboration among all stakeholders. Integrating artificial intelligencedriven matchmaking engines would allow for dynamic analysis of stakeholder profiles, enhancing the accuracy, efficiency, and responsiveness of matches. To further drive engage-ment, the platform could facilitate tokenized procurement or task listings – for example, "Low Earth Orbit Contracts" – where verified entities post and bid on mission-relevant tasks. The implementation of smart contract-based fulfillment, paired with milestone-based payments managed by fiduciaries, could lower the entry barriers for non-space entities and enable more agile procurement processes.

The combination of these technologies into an open, API-driven architecture, seamlessly integrated with self-sovereign identity, would create a flexible, secure, and interoperable platform. This integration would effectively reduce fragmentation and promote stakeholder engagement, business diversity, and innovation-driven growth within the Low Earth Orbit economy. The live, trusted transaction and performance data also creates the foundation for Low Earth Orbitspecific insurance, credit scoring, and financing models – derisking investment and broadening participation, especially for small and medium-sized enterprises.

Implementing the Trust Layer

Creating certainty for Europe's commercial Low Earth Orbit economy mainly focuses on three components: first, building a trust infrastructure that enables verifiable identities – ranging from individual service-provider profiles to immutable root identities; second, instituting genuinely democratized governance for all matters that require collective alignment, such as standardization, regulation, rules for data sharing and use, and every cross-layer decision affecting both the identity layer and operational data flows; and third, deploying technical infrastructure that removes the need for traditional intermediaries wherever possible and, where it cannot, articulating clear mechanisms and safeguards for those intermediaries.

The trust infrastructure begins with a decentralized, tamper-proof registry that records every public identity in the ecosystem. Service providers can verifiably publish their capabilities, allowing prospective partners to discover and assess them with confidence. Because each entry is cryptographically anchored to an underlying root identity, stakeholders can establish provenance and accountability from the very first interaction. A Web3-based reputation mechanism complements these identities by capturing bilateral feedback after each engagement, preserving transparency without exposing the market to central control or lockin.

Democratized governance adds a second layer of assurance. Rather than vesting decision-making power in any single entity, the system distributes authority across multiple sectors and stakeholder groups. True democratization through direct voting rights and sector-specific endorsement policies allow participants to set and update standards, define data-access rules, and adapt regulatory compliance requirements as the market evolves. Crucially, this governance layer also adjudicates all relevant decisions that cascade into the identity infrastructure and operational data layer, ensuring that changes to credentials, data-sharing protocols, or custodial processes are both transparent and collectively endorsed. By tying policy control to broad stakeholder participation, the model mitigates concentration risk while accelerating consensus on emerging technical and legal norms.

Finally, reducing reliance on trusted intermediaries demands an infrastructure that can automate or verifiably supervise the roles they once played. Smart contracts compliance verification, milestone-based escrow, and immutable audit trails handle routine onboarding, funding flows, and compliance checks, sharply lowering counterparty and liquidity risk. Where human fiduciar-ies remain indispensable – such as mediating complex disputes or safeguarding multi-party project assets – the framework prescribes transparent mandates, strict separation of duties, and cryptographic proof of every action they take. By embedding both self-executing code and tightly defined human oversight into the same architecture, the system balances efficiency with the safeguard of last-resort recourse.

Technology: Public Blockchain and Smart Contracts

A mature, security-hardened public blockchain supplies the technical backbone for all three components of the trust layer. The chains immutable ledger becomes the shared source of truth for identity, governance, and operational execution, while smart contracts convert every rule the community agrees on into tamper-proof code.

The identity pillar begins with a “root-identity registry” that records decentralized identifiers under the control of the most trusted actors – space agencies, national authorities, or tier-one primes. Each root identity can spawn lightweight on-chain profiles for individual service providers. Those profiles publish capability statements, compliance documents, and data endpoints in a standard machine-readable format, so any participant can verify provenance with a single query. After each completed cooperation, all participating parties issue cryptographically signed ratings that are permanently attached to the other partners’ profile. Because reputations are fixed to identities rather than accounts that can be discarded, good behaviour compounds over time and bad actors cannot simply »walk away«.

The second pillar – democratized, cross-layer governance – is handled through a hierarchy of decentralized autonomous organizations (DAOs). At the top sits the SpaceOS DAO that steers the evolution of shared protocol libraries, approves upgrades to the identity registry. Because calls that modify identities, data-sharing rules, or operational contracts must carry a DAO signature, every change in the identity or data layer is automatically traceable to an explicit, on-chain vote. Below it, any constellation, mission, or infrastructure venture can launch its own Mission DAO. Each Mission DAO has configurable working groups with earmarked budgets, clear voting thresholds for commercial or technical decisions, and a rotating set of multisignature custodians who execute whatever the membership approves.

The third pillar replaces traditional intermediaries with narrowly scoped smart-contract modules and, where humans remain indispensable, wraps them in strict guardrails. A milestone-escrow contract, for example, releases funds only when an authorized oracle submits proof – such trustworthy telemetry – that a deliverable has been met. If a dispute arises, an arbitration contract summons a randomly selected pool of preselected jurors whose verdict triggers the appropriate fund transfer or reversal. The ownership of physical or intellectual assets can be parked in an onchain vault that requires approval from the relevant Mission DAO before anything moves. An audit-trail module records a hash-chained log of all critical interactions so in-surers, auditors, or future investors can chronologically reproduce the complete operational history.

By weaving these elements together – verifiable on-chain identities, multi-layer participatory governance, and smart-contract infrastructure that executes or supervises what intermediaries once handled – the architecture delivers the transparency, accountability, and execution power that Europe’s commercial Low Earth Orbit economy needs, without reinstating the gatekeepers it set out to avoid.

Implementing the Operational Data Layer

Implementing the operational data layer centers on turning every commercial Low Earth Orbit activity into a stream of transparent, verifiable, and sovereign information. Its first task is reliable data creation: only entities anchored in the trust-and-identity layer – whether a ground station, a satellite subsystem, or a mission controller – may sign payloads, telemetry, or financial events. Tamper-proof hardware such as trusted-execution environments or hardware secure elements safeguards private keys and cryptographic operations, so each datum carries an indelible cryptographic link to its origin.

Verifiability alone is not enough; data must remain contextual and sovereign. Digital signatures, immutable timestamps, and on-chain metadata allow anyone to trace a value back to the precise device, operator, and contractual milestone that produced it ensuring ultimate proofs of existence, while self-governed usage policies define who may read, reshare, or migrate that data. Because these policies execute in a decentralized environment rather than through a central broker, smaller providers keep control of their assets and avoid lock-in without choking off beneficial exchange.

Decentralized sharing protocols expose certified data streams – orbital production outputs, resource-consumption logs, milestone attestations – through standard APIs. Investors, insurers, and credit-rating engines can subscribe to them in real time, turning once-opaque project information into a monetizable asset class and transforming space ventures from speculative R&D into bankable commercial undertakings.

The result is a resilient, European-led data system, built on open standards and self-sovereign identity. Project milestones, cash flows, and compliance events become instantly auditable, giving stakeholders and regulators continuous visibility, catalyzing innovation, and shielding the Low Earth Orbit economy from single-point failures or external capture.

Technology: Data Ecosystem

A secure, self-sovereign data ecosystem completes the architecture by turning every Low Earth Orbit data flow into a verifiable, privacy-preserving asset. Each datum – whether instrument telemetry, a parts-traceability update, or a payment confirmation – is signed by the key of its originator, be that a certified operator, an autonomous subsystem, or a metering device sealed in tamper-proof hardware. The signature links the record to its public identity in the trust layer, ensuring verifiability and thus certainty.

From there, data travel through peer-to-peer channels or into purpose-built data spaces where usage policies are enforced by the same on-chain governance that guards the identity layer. Public blockchains supply indisputable existence proofs – hash-stamping each payload – while privacy-respecting roll-ups or side-chains anchor the evidence without disclosing sensitive content. When deeper confidentiality is required, zero-knowledge proofs attest to facts (for example, that a satellite remained within its power budget) without revealing sensitive underlying raw data, and homomorphic encryption lets analytics run on ciphertext so proprietary models stay hidden.

Distributed storage networks such as IPFS back the system with resilient, vendor-neutral persistence: fragments are replicated across many nodes, keeping mission-critical data online even if a ground station, cloud provider, or national link fails. A particularly relevant blueprint is the Gaia-X Hub for Aerospace, which has already specified connectors, semantic vocabularies, and policy-enforcement services for the entire life-cycle of space and air vehicles – from CAD files and test data to in-orbit telemetry and maintenance logs. Because Gaia-X is built around the same principles of self-sovereign identity and decentralized policy control, its reference imple-mentations can be plugged directly into the SpaceOS stack: the Gaia-X Data-Space Connector becomes the off-chain interface that pushes hashed payloads to the blockchain; its catalogue and consent services mesh with on-chain permission smart contracts; and its certification processes give regulators an auditable path to verify compliance without demanding raw data. Leveraging this existing work short-cuts standardization effort, ensures alignment with European sovereignty goals, and lets smaller suppliers join the network by adopting tooling they may already know.

By combining cryptographic signing, decentralized storage, policy-aware Data Spaces, advanced privacy techniques, and proven Gaia-X blueprints, the data-ecosystem layer transforms operational information from a liability into a tradable asset class. Investors obtain tamper-proof audit trails, small and medium-sized enterprises gain equal-footing access to high-value data streams, and Europe secures a resilient, scalable foundation for commercial growth in Low Earth Orbit.

5

Turning Vision into Orbit

Building a Commercial Space Station through SpaceOS

The emergence of Low Earth Orbit as a domain of commercial activity presents a historic opportunity for Europe to take the lead in shaping a space economy based on democratic values, openness, responsibility and solidarity. The development, construction and operational of a commercial space station as the foundation for European collaboration in Low Earth Orbit requires not only technological excellence, but also a trustworthy framework for cooperation, transparency and verifiable economic interaction across borders and industries. On this example we want to demonstrate SpaceOS' potential as an operating system for commercial Low Earth Orbit activities.

The pathway enabled by SpaceOS follows a clear and structured process: investors, companies and institutions join the ecosystem through the *digital identity layer*; projects are tendered through the *trust layer*; suppliers and partners are matched and contracted based on verified capabilities on the intersection of the *digital identity* and *trust layer*; manufacturing and services are built and assembled with full traceability trough the *operational data layer*; assets are deployed and operated in orbit with live digital twins to ensure operational integrity through the intersection of the *digital identity, trust and operational data layer*; and over time, participants grow their reputations, access new funding mechanisms, and expand into emerging orbital markets based on the intersection of the *digital identity and trust layer*. This process not only supports the operational of a single station – it lays the foundation for a sustainable, self-reinforcing European space economy.

Through the integrated capabilities of SpaceOS and its distinct layers the construction, management and operational of a commercial space station becomes verifiable, transparent, and scalable:

Partner Onboarding

A consortium of European industry and research players agrees on a project to develop a modular commercial space station in Low Earth Orbit. Using SpaceOS, each stakeholder on the project consortium first establishes a digital identity. They onboard via SpaceOS' digital identity layer, each verifiably presenting credentials such as ISO certifications, environmental impact assessments, and financial soundness ratings.

Planning

After finalizing the planning of the commercial space station, all partners agree on a common governance for the project and setup a DAO on SpaceOS' trust layer, strongly connected to their digital identities. Within that they initiate a digital twin of the planned station, and decide on all relevant aspects, like environmental compliance and project funding. These decisions are implemented through smart contracts and determine the further course of the project

Smart Market Matching and Tendering

The consortium publishes modular work packages as tokenized requests-for-quote, represented by smart contracts that specify technical requirements, milestones, and payment terms. Examples include precision manufacturing of titanium structures, development of autonomous docking robots, and assembly of life support systems. The SpaceOS matchmaking engine ranks potential suppliers based on verified technical capabilities, historical performance, environmental compliance, and insurability stored on the digital identity layer. Topranked suppliers automatically receive smart contract proposals with milestone-based payment terms secured by decentralized escrow agreements.

Build and Assembly Operations

Once a contract is awarded, manufacturing and testing proceed under the transparent oversight of the SpaceOS platform's operational data layer. Every stage of production is logged through verifiable data feeds emitted by IoT-equipped factory systems, while independent verification laboratories issue digitally signed quality certificates that, upon validation, automatically unlock the corresponding milestone payments. As modules are completed, they are serialized and entered into the digital identity layer finally representing their digital twins, preserving an unbroken chain of traceability from terrestrial fabrication to eventual orbital deployment. Finally, each certified component is incorporated into the launch manifest and tracked by SpaceOS-enabled orbital-logistics services, ensuring continuous end-to-end visibility from the factory floor to in-orbit assembly.

Orbital Deployment and Station Management

When station modules reach orbit and are joined together, each digital identity is immediately on the SpaceOS identity layer that continuously holding its maintenance history, operational usage, and current ownership up to date. Implemented governance rules on the trust layer autonomously schedule inspections, coordinate repairs, and renew insurance, ensuring upkeep is never left to chance. Meanwhile, the module's telemetry, environmental readings, and other performance metrics stream into a live digital twin of the entire station realized on the intersection of the digital identity and operational data layer, which authorized engineers, investors, and regulators can consult at any moment through the SpaceOS data governance interface. Every structural component and func-tional subsystem is tokenized, so ownership stakes can be bought, sold, or reassigned with a simple smart-contract transfer, delivering both operational transparency and fluid capital participation.

Financing, Insurance and Ecosystem Growth

Throughout the project's life cycle, SpaceOS also drives financing, insurance, and wider ecosystem growth. Anticipated cashflows – whether microgravity-research leases, hosted-payload fees, or satellite-service contracts – can be factored and monetized early on the platform's decentralized marketplace, providing liquidity long before the revenue is realized in orbit. Space insurers, meanwhile, price and underwrite risk using the station's realtime performance metrics and the immutable operational history processed on the operational data layer, lowering premiums for well-run assets. Every participating firm accumulates a portable, tamper-proof reputation profile as it delivers contracts, a credential that shortens duediligence cycles, boosts competitiveness, and ultimately raises its enterprise value when bidding in future orbital tenders and auctions.

6

Blueprint

Blueprint: From Frontier to Framework

Bridging Space and Earth

SpaceOS is not just about space. It is the interface between in-orbit operations and terrestrial markets. By connecting Low Earth Orbit activity to Earth-based stakeholders, it opens new opportunities both in orbit (upstream) and on Earth (downstream) – from microgravity-optimized pharmaceuticals and materials to realtime climate services and advanced industrial automation. This two-way bridge also unlocks access for non-space actors – manufacturers, researchers, logistics providers, and digital service companies – making the Low Earth Orbit economy more inclusive, innovative, and cross-sectoral. The SpaceOS platform sets the stage for a vibrant and dynamic European commercial ecosystem in Low Earth Orbit.

Governance with European Values at Its Core

Europe now has a strategic window to shape the norms, infrastructure, and governance of Low Earth Orbit before they are defined elsewhere. SpaceOS advances multistakeholder, inclusive governance – giving small and medium-sized enterprises, research institutions, and national actors a voice in platform development and rulesetting. Through decentralization and modularity, the platform eliminates single points of failure, enhances security, and promotes democratic participation – aligning with the principles of the Digital Markets Act and the European Data Strategy.

Strategic Value for Europe

In a world increasingly defined by geopolitical tech dependencies, Low Earth Orbit is no longer just a scientific frontier – it is economic infrastructure. SpaceOS supports Europe's autonomy in critical technologies, strengthens digital sovereignty, and enables leadership in the next phase of industrial expansion. This is Europe's chance not just to compete in the global space economy – but to set the standard. By embedding strong decentralization principles within each layer, the SpaceOS aligns directly with core European values: facilitating an open and competitive internal market, serving as an incubator for crosssector innovation, and enabling collaboration across national borders. This decentralized approach not only promotes democratic participation and market openness but also ensures resilience, robustness, and security by eliminating single points of vulnerability.

Infrastructural Resilience

Resilience is particularly crucial in the context of today's complex geopolitical landscape. Dependence on a few large, non-European technology corporations for critical infrastructure represents a significant strategic risk, compromising European sovereignty and limiting defensive capabilities. Decentralization inherent in the SpaceOS platform mitigates these vulnerabilities, enhancing Europe's capability to withstand both natural disasters and cybersecurity threats through its distributed and secure infrastructure.

Maintaining Competitiveness

Furthermore, European cooperation and proactive engagement in the development of commercial Low Earth Orbit initiatives are critical for maintaining competitiveness against global space powers such as the United States and China. A collaborative and united European approach is vital to prevent new strategic dependencies from emerging and to ensure Europe maintains sovereign capabilities in space. Now is the time for Europe not just to adapt to space as an economic frontier – but to shape it as a rules-based, inclusive, and sovereign domain.

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