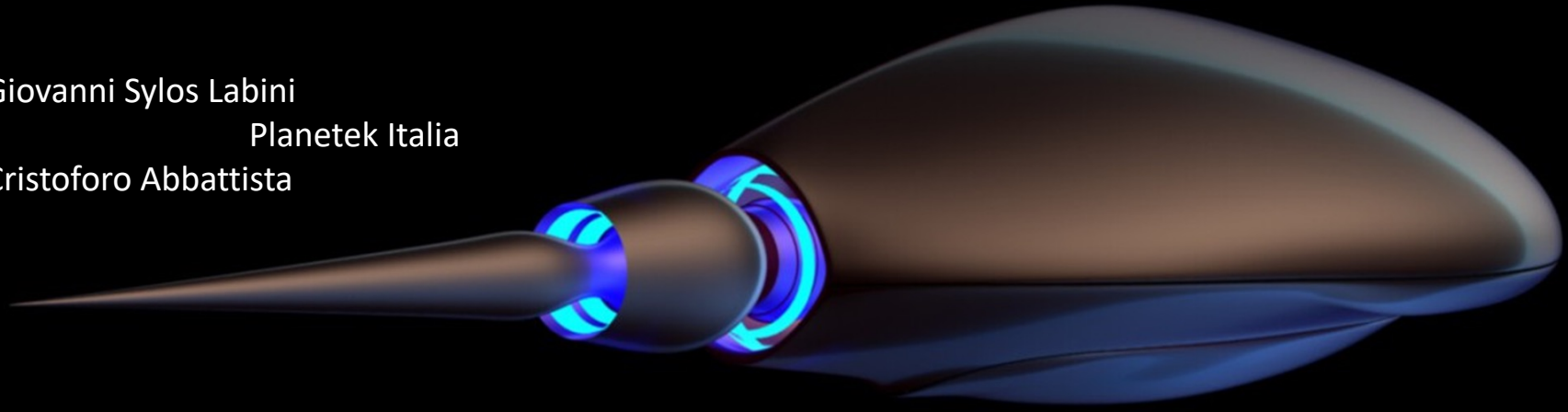
Do Satellites Dream of Electric Cars?

Giovanni Sylos Labini
Planetek Italia
Cristoforo Abbattista



Blockchain-enabled smart Contracts: Benefits for Multi-sided EO and IoT

ESA_Labs Annual Event - May 8, 2023
“Space Data Management Workshop”

Università degli Studi del Molise
Remo Pareschi
Stake Lab,
University of Molise

Sapienza Università di Roma
Claudio Di Ciccio e Paolo Bottoni
Sapienza University of Rome,
Department of Computer Science

and

BB LAB
info@bb-smile.net

A Machine to Machine Conversation

- Satellite: Alert: Landslide detected ahead. Traffic congestion observed. Suggest alternate route.
- Vehicle: Acknowledged. Please provide suggested alternate route.
- Satellite: Route updated in your navigation system. Toll charge of $X will be incurred as per your smart contract with the road network operator. Please confirm.
- Vehicle: Please wait while I verify the quality of the EO service provider and their cyber security protection.
- Satellite: Smart contract and wallet balance authenticated. Toll fee will be automatically deducted from your digital wallet.
- Vehicle: Thank you for the secure and transparent transaction.
- Satellite: You're welcome. Our blockchain-enabled satellite onboard computing system ensures secure and automated transactions between vehicles, road network operators, and other service providers.

The EO industry is in a Perfect Storm

The growing digital component of EO has a substantial impact on the downstream segment of the value chain:

- ❑The commoditization of data (Space Data included)
- ❑The lowering cost of HPC
- ❑The growing onboard processing capabilities
- ❑The shift from the human user to the machine user.
- ❑The Digital Transformation of Several Industries

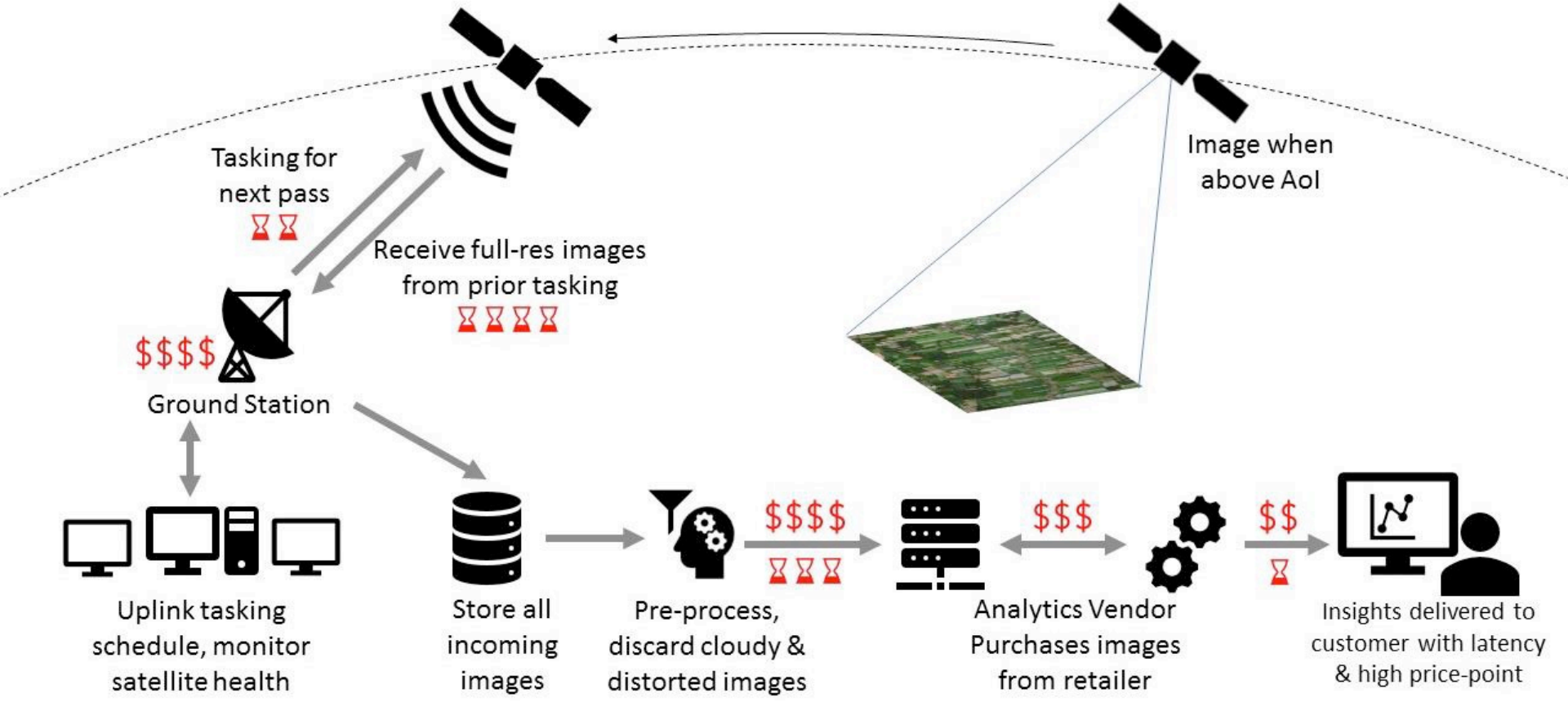
With the risk of the disruption of the EO Value Chain as we know it

The EU DS INDUSTRY & THE STORM

- Highly Fragmented
- Exposed to a largely subsidized competition
- Compressed between New Entrants and Large System Operators
- Still lagging in a transition to a scalable Info@as go2M model

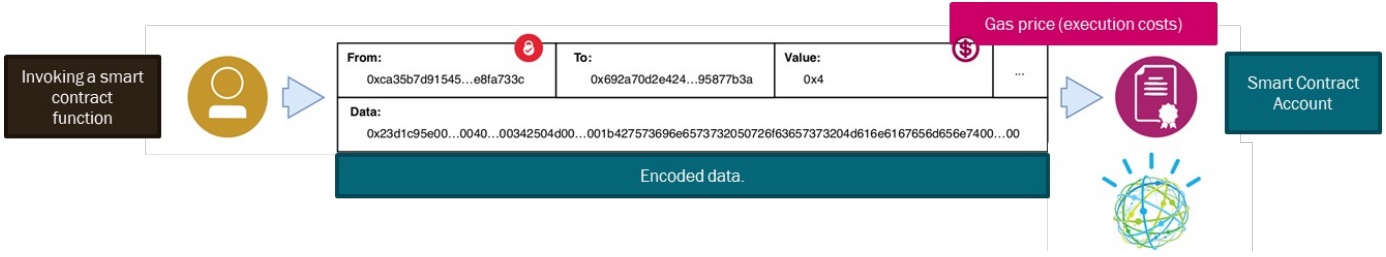
The Actual EO Value Chain

From Methods to Leverage Onboard Autonomy in Remote Sensing
Adithya Kothandhapani 2020



Smart contract

- A digital agreement or set of rules that govern a transaction (or a sequence thereof)
- Implemented as a program operating on chain
- Invoked by transactions
- In Solidity (Ethereum-based contract language):
  - A transaction can include data (the “payload”) and Ether.
  - If the target account contains code, that code is executed, and the payload is provided as input data.

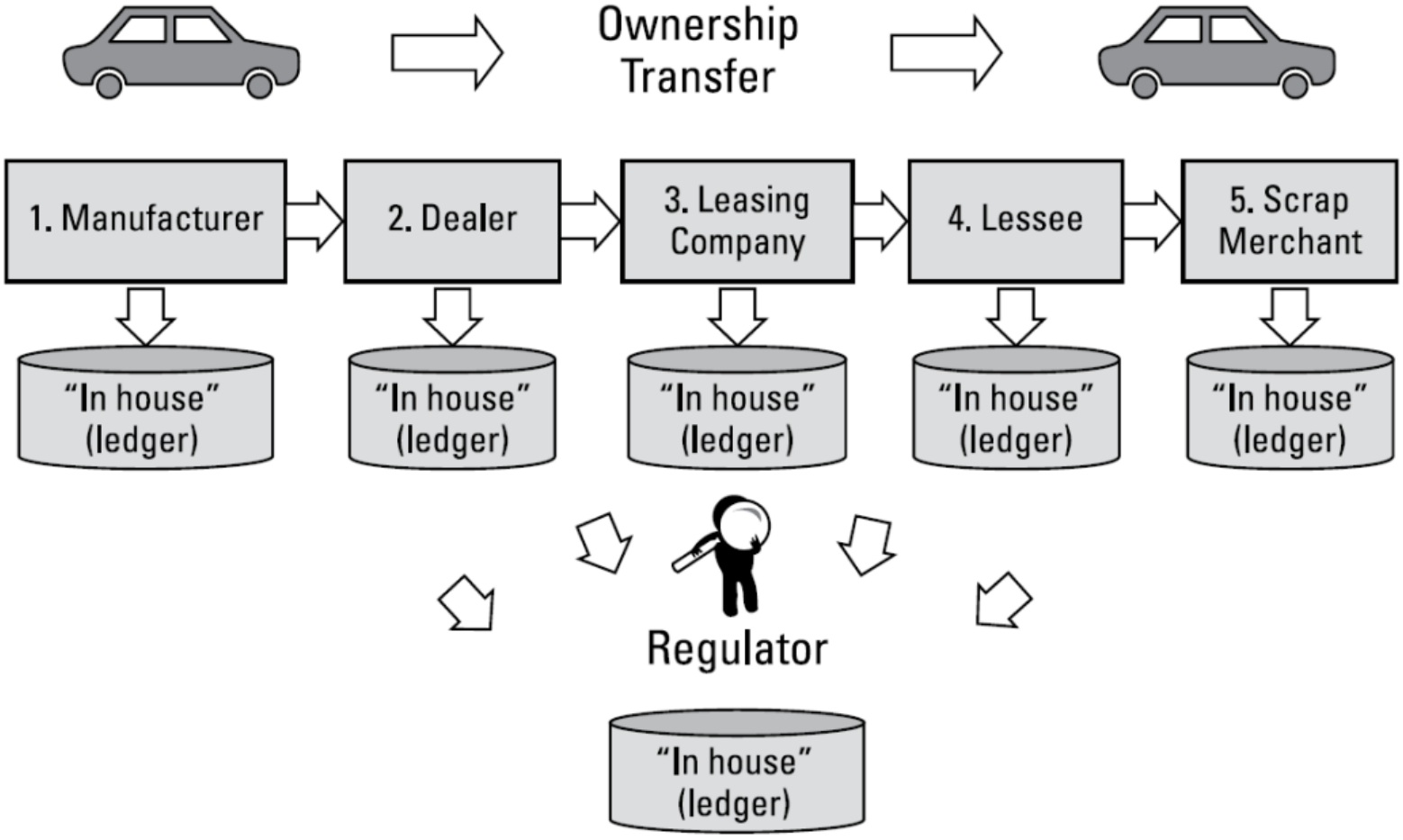


What is a blockchain

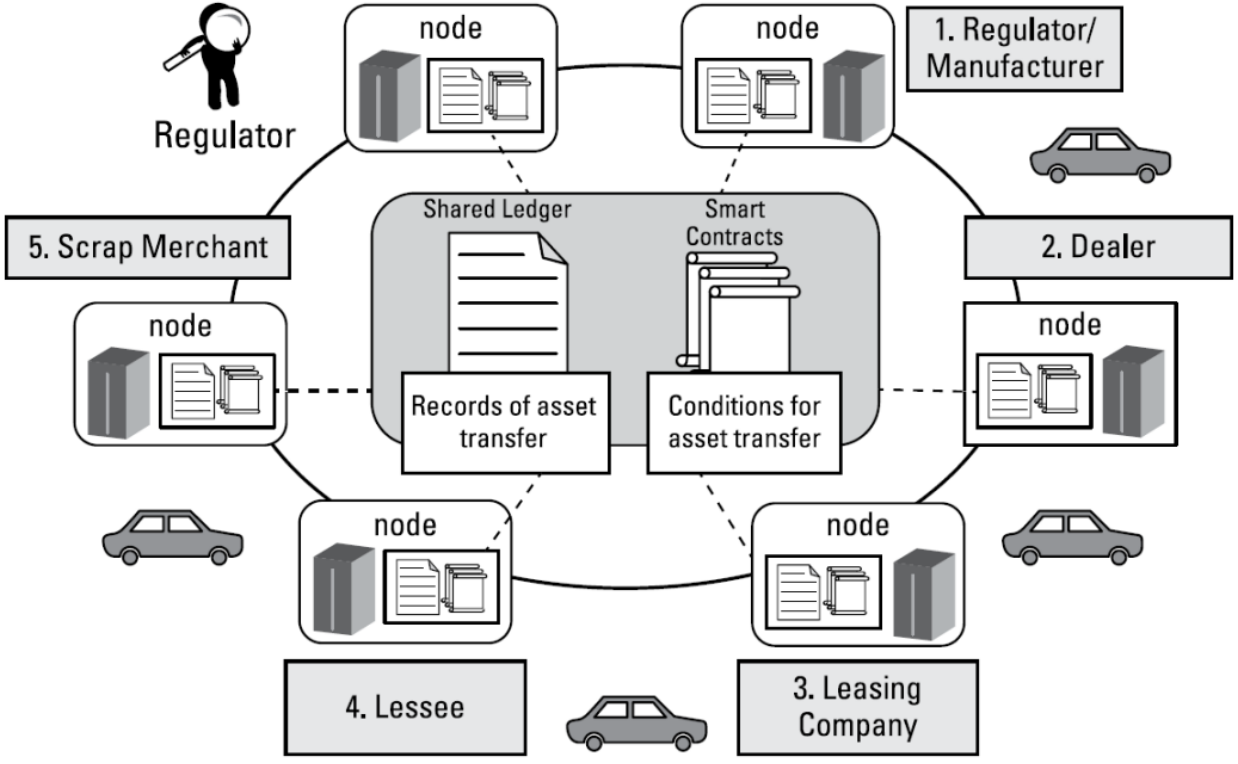
A blockchain is a shared, distributed, immutable ledger recording transactions in a (business) network:

- *Shared:* each participant has equal access to the information stored in the network
- *Distributed*: *information not stored in a central database replicated at each node*
- *Immutable*: information can not be erased or updated only added
- *Ledger*: where business information is stored
- *Transactions*: typically transfer of assets among participants
- *Network*: participants act as globally interconnected nodes

Car property: the traditional view



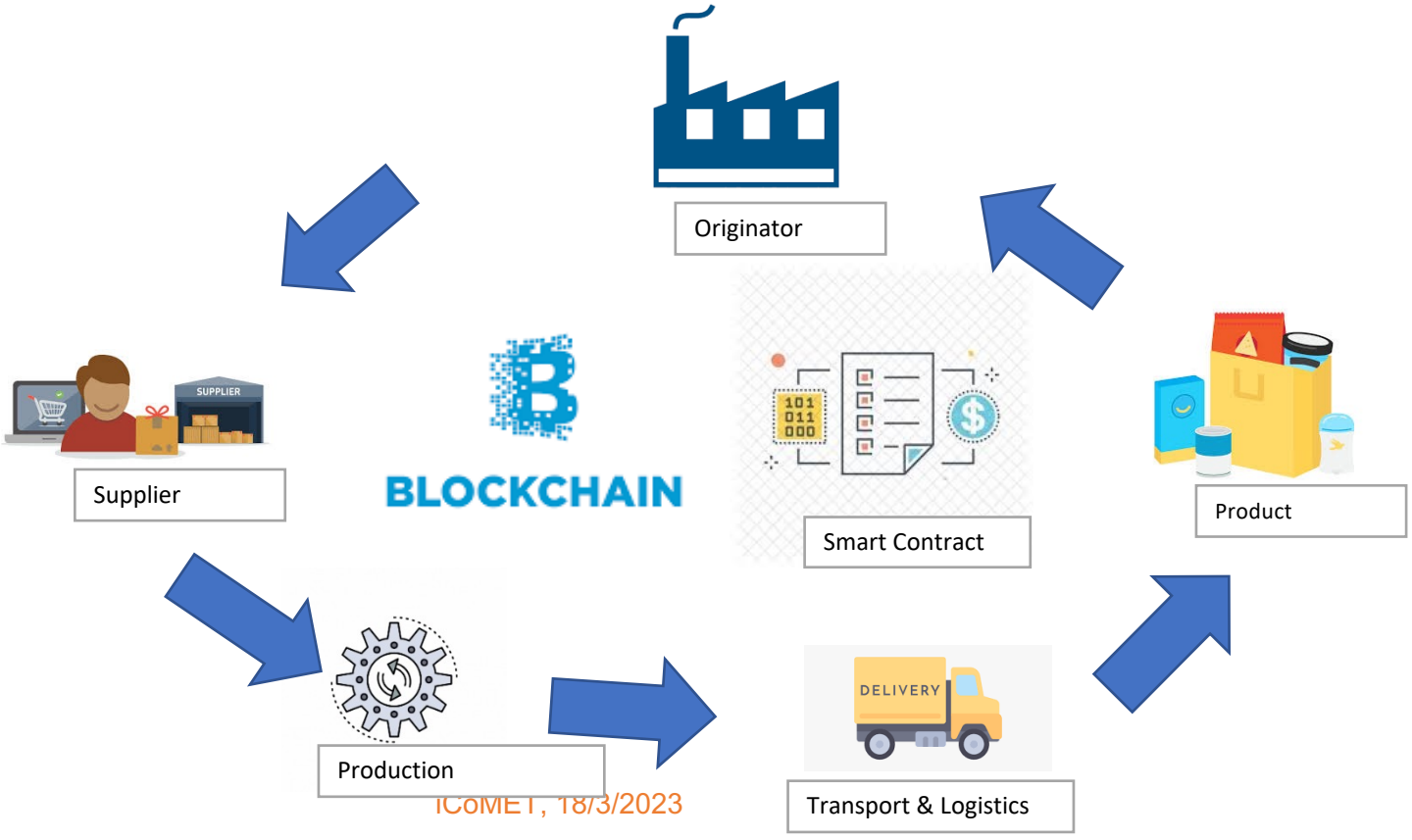
Car property with blockchain



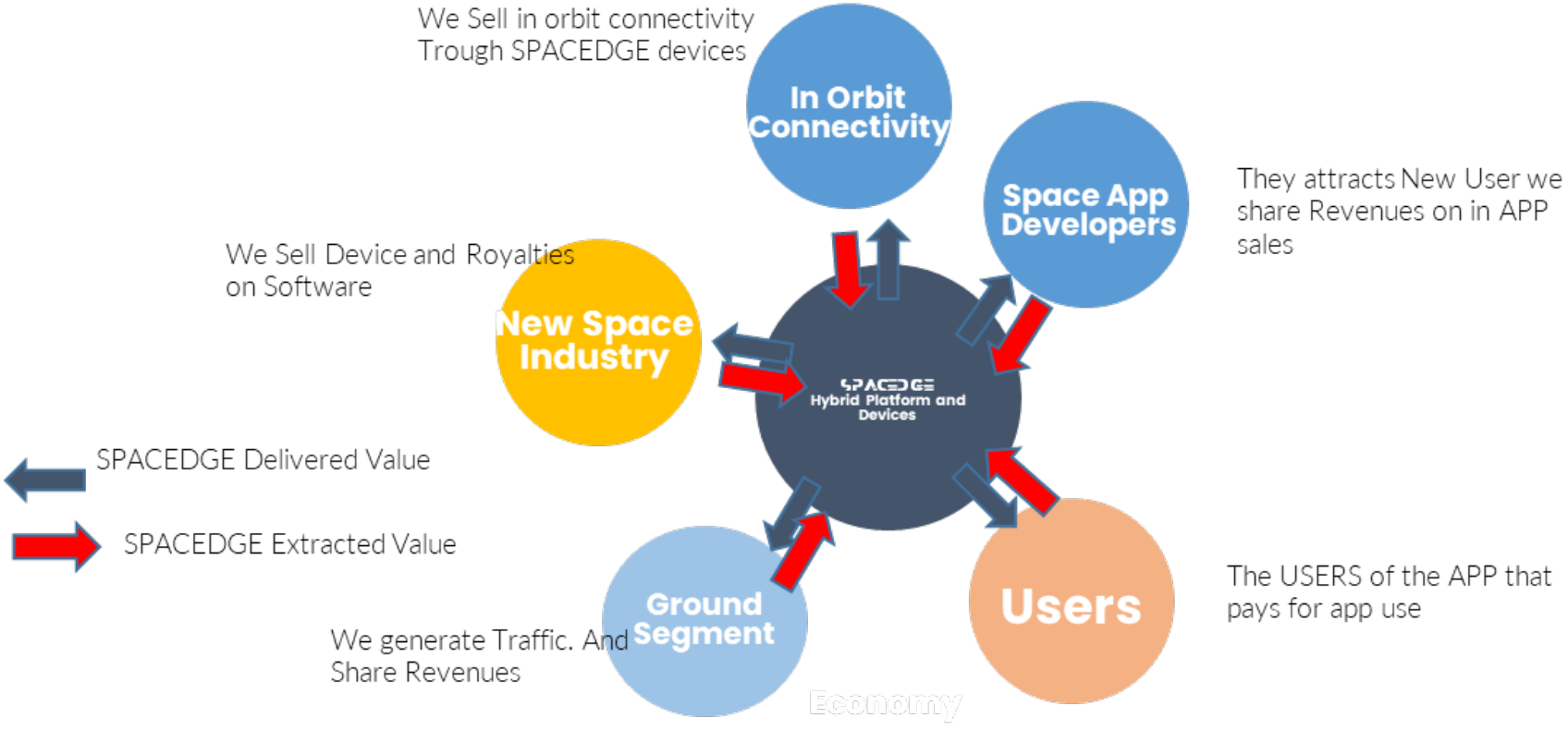
Traditional Supply chains

- Graph (typically rooted and layered) describing the integration of production, logistics and distribution functions towards marketing a specific product or line of products
- Participants obtain material from the underlying level, perform some transformation and forward the results to the upper level
- Participants have different bargaining power
- Top level often acting as a monopolist

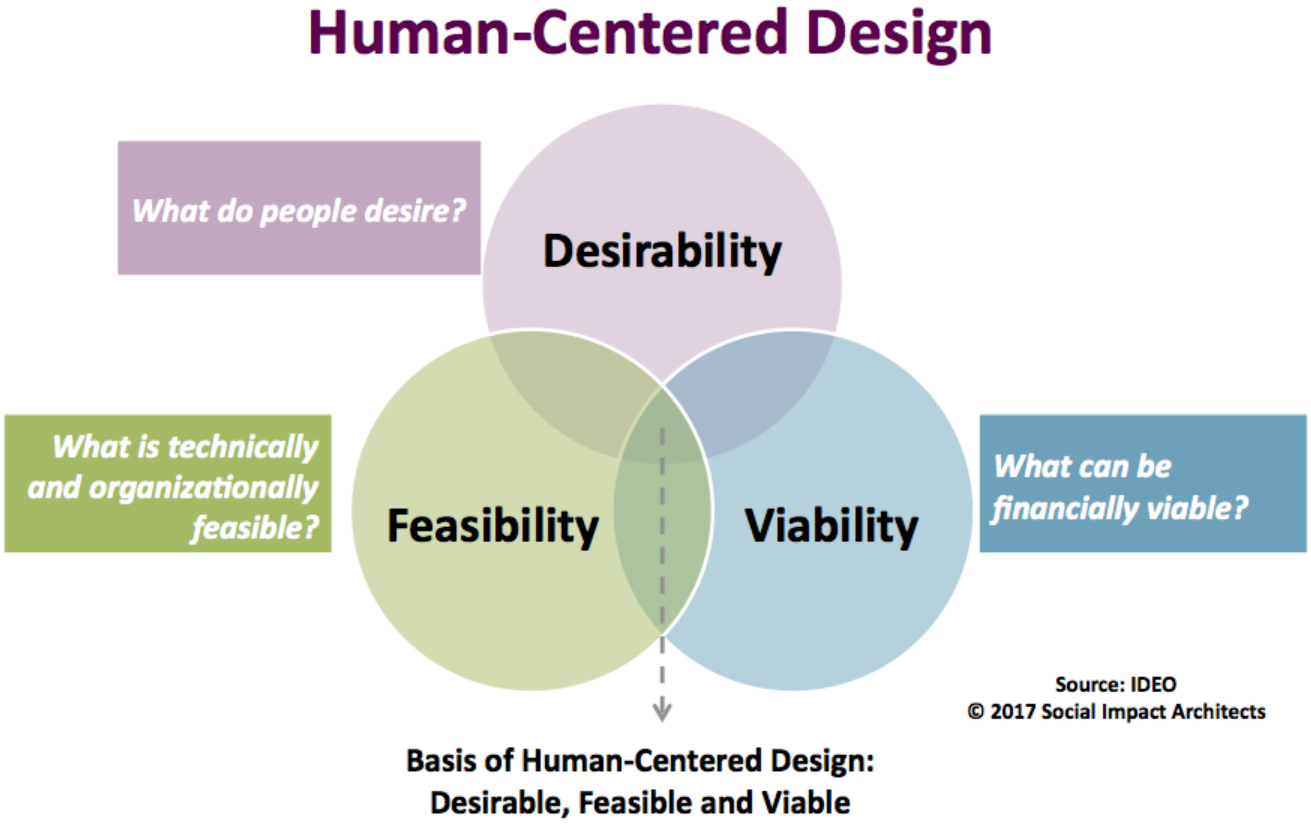
Supply chains as smart contracts



The actors of EO shared Economy

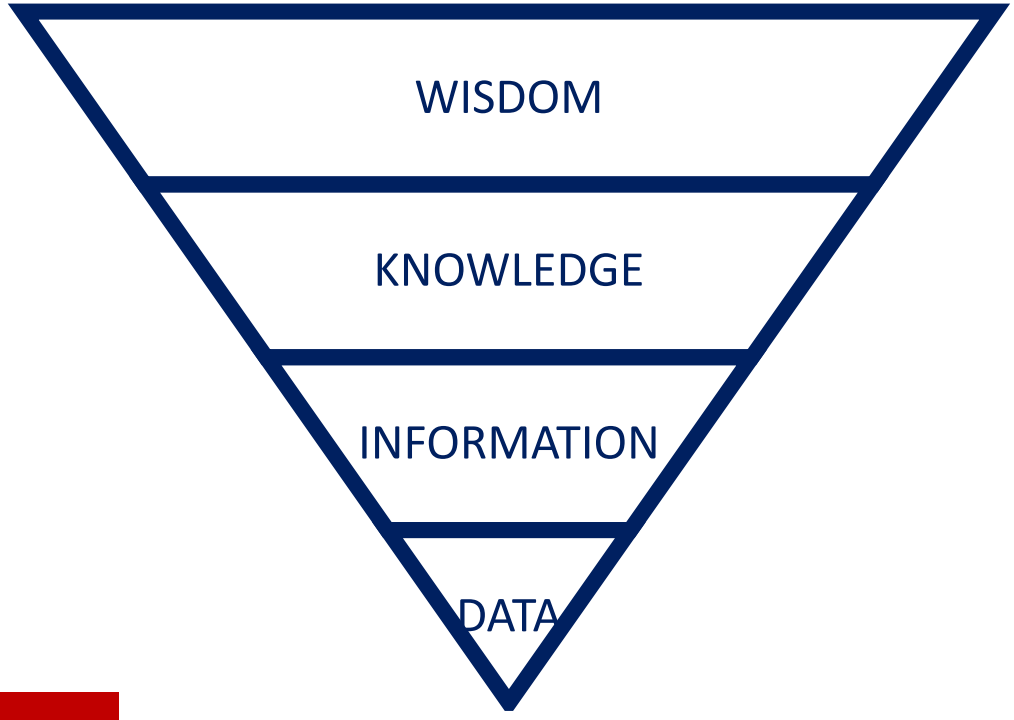


The user-centred Design



The Earth Intelligence Pyramid

- Data consists of facts.
- Information is an assembly of the data.
- Knowledge is the awareness of the information.



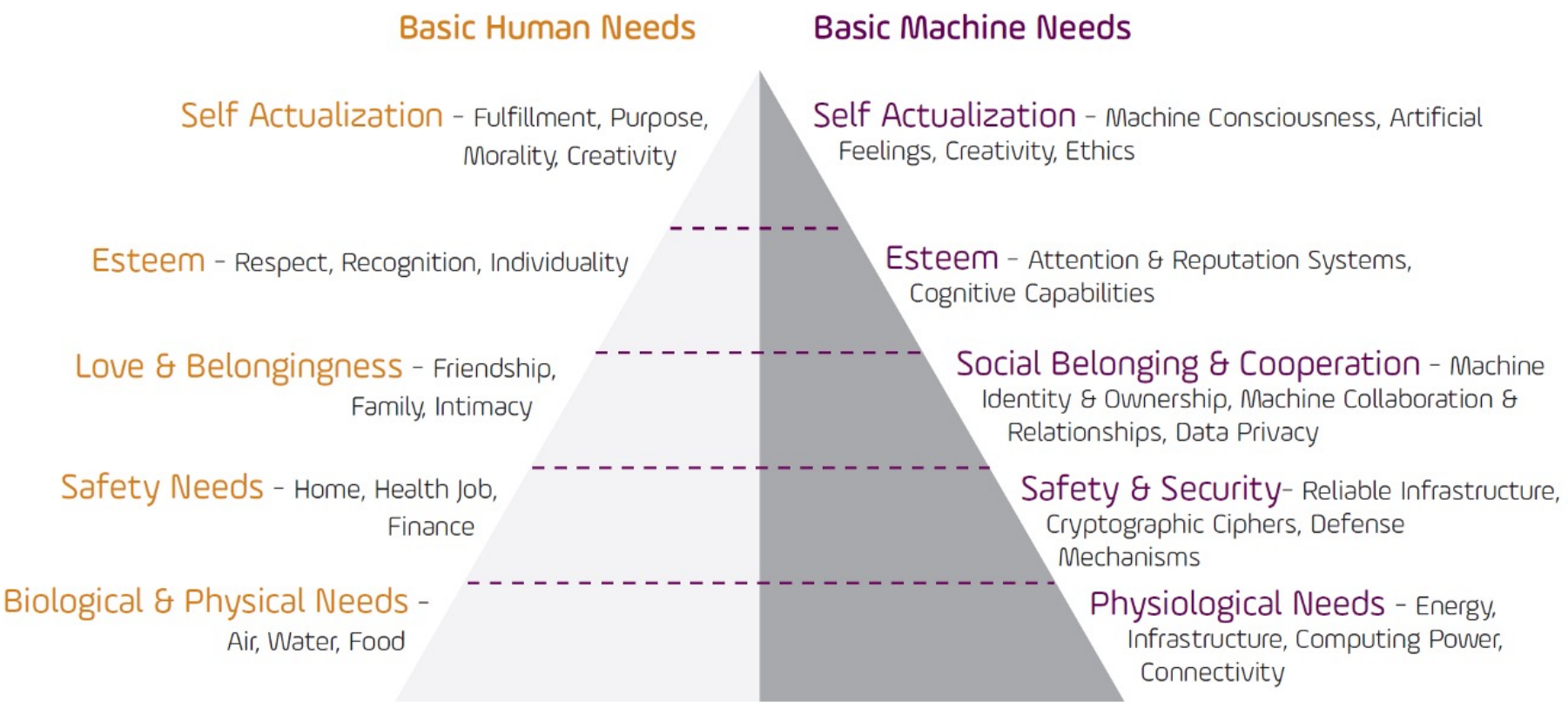
Wisdom is the accumulated knowledge to make appropriate decisions depending on the situation

“But what-if the User is a Machine?”

Human vs. Machine Needs

planetek italia

Maslow Pyramid of Humans Needs vs. innogy Pyramid of Machine Needs



XAI in the Consensus Network

Original EO Imagery

Imagery Producer Identity

Imagery could be produced by any device. Information about device identity, position, status, ownership, etc. is collected and organized to contribute to a signature.

Signature

Content Addressable Storage Engine

Signature

Identity Composer

Signature

ansaction Manager

Files are not identified by their names but by their signatures.

The resulting signature, which in fact contains many information about imagery and its source, is sent to the shared ledger for being stored permanently.

Investigated by CTEO (ESA ϕ-lab project)

EO-BBIE Off-chain components

Earth Observation Blockchain-based Information Ecosystem :

- ❑ Storage: handling satellite-generated data, EO analytics results, and user requests
- ❑ Business layer: processing and analyzing EO data off-chain for efficiency
- ❑ User Interface: interaction with EO data, analytics, and services via web/app interfaces or APIs

EO-BBIE On-chain components

Earth Observation Blockchain-Based Information Ecosystem

- **Private Blockchain:** a network of nodes managed by satellite operators, EO analytics providers, and end-users
- **Permissioned Blockchain:** access control for data privacy and security
- **Shared business logic:** smart contracts for data sharing, licensing, and payments
- **Identity Management System:** managing stakeholder identities and access rights
- **An explorer:** transparently browsing EO data transactions and usage
- **Link to an external public blockchain:** anchoring for data immutability and trust
- **IoT-oriented Distributed Ledger Technology (e.g. IOTA):** a scalable and feeless DLT component designed for automated machine-to-machine communication, enabling seamless data exchange and microtransactions between connected devices (e.g., satellites, sensors, and IoT devices) within the EO ecosystem. (**EO-specific component**)

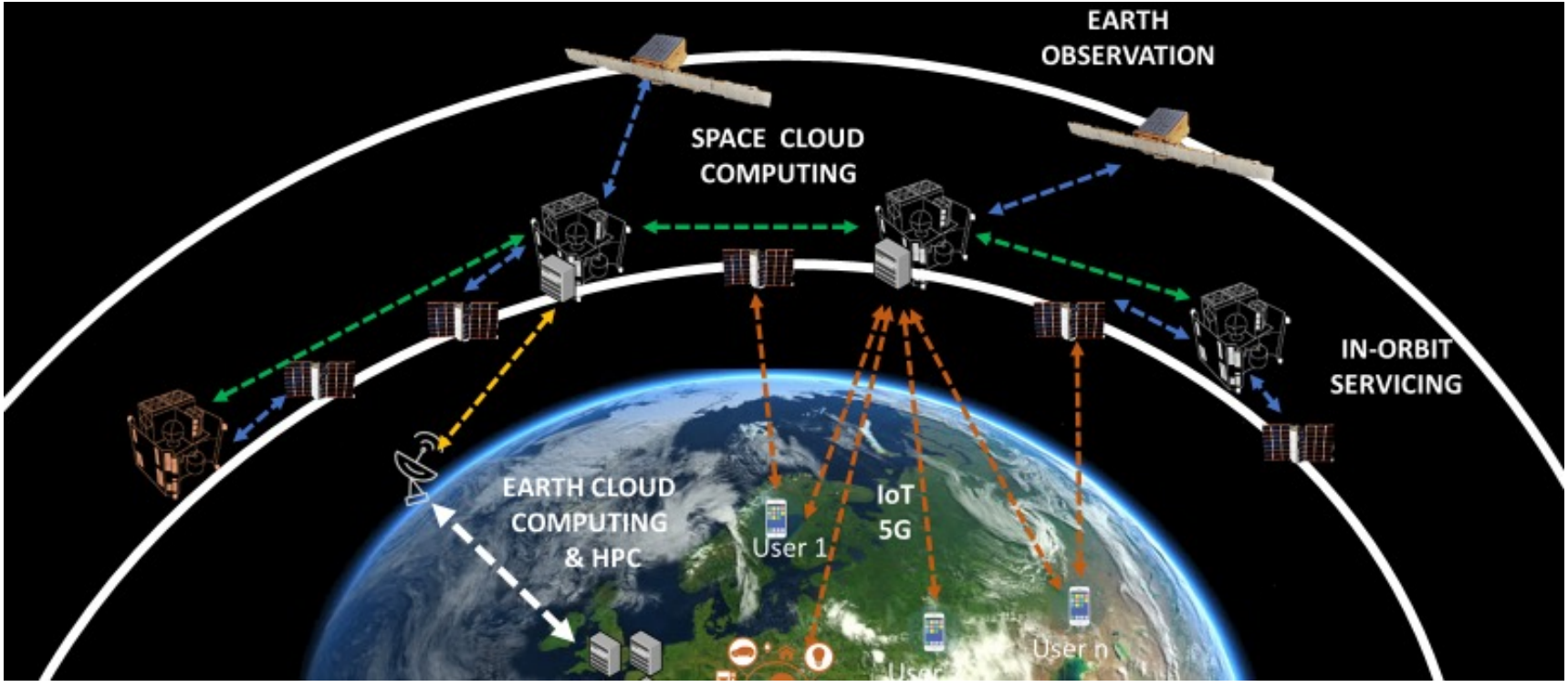
Benefits of EO-BBIE to the EO industry

- **Enhanced Collaboration and Interoperability**: The decentralized nature of blockchain technology can facilitate the integration of different EO data sources, analytics providers, and end-users, making it easier to share and access data across the industry, reducing fragmentation.
- **Increased Trust and Transparency**: Blockchain's immutable and transparent nature can improve trust among stakeholders, including satellite operators, EO analytics providers, and end-users, enabling more efficient and transparent data transactions and usage tracking.
- **Streamlined Data Licensing and Payments**: Smart contracts can automate data sharing, licensing, and payment processes, simplifying transactions and reducing the administrative burden for both data providers and users.
- **Better Access Control and Data Privacy**: Permissioned blockchains and Identity Management Systems can ensure that only authorized users can access specific data sets, enhancing data privacy and security while complying with data protection regulations.
- **Improved Resilience to Subsidized Competition:** By fostering a more collaborative and transparent ecosystem, the blockchain-based system can enable smaller EO players to better compete with subsidized entities, leveraging shared resources and data to improve their services and reduce costs.

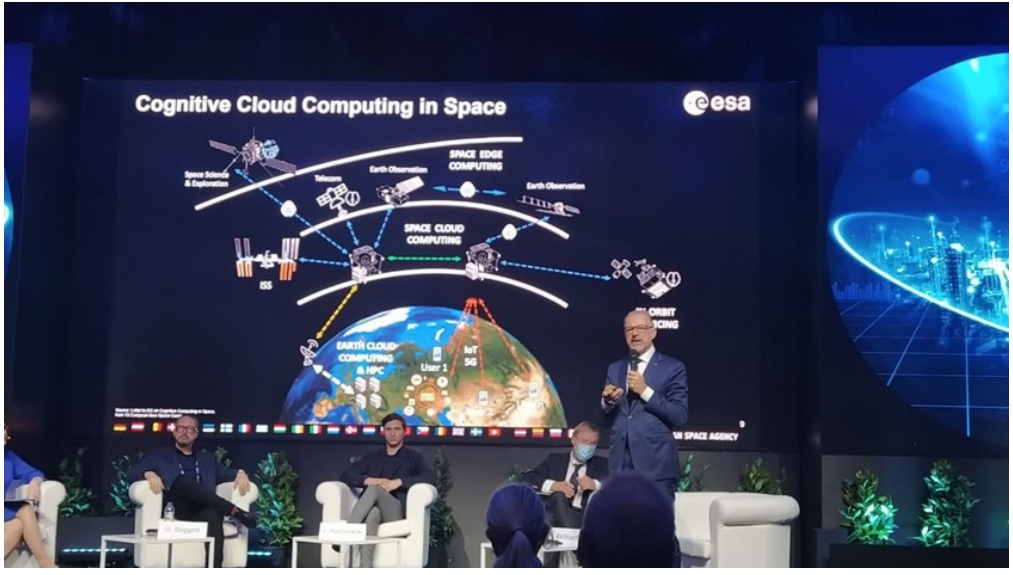
Benefits of EO-BBIE to the EO industry (continued)

- **Facilitated Transition to Info-as-a-Service (IaaS) Model:** The proposed EO blockchain ecosystem can ease the transition to a scalable IaaS model by simplifying data sharing, access, and payment processes, and enabling seamless interaction with EO data, analytics, and services through web/app interfaces or APIs.
- **Attracting New Entrants and Innovators:** By creating a more accessible and transparent EO data infrastructure, the blockchain-based ecosystem can attract new entrants and innovators to develop novel applications and services, fostering innovation in the industry.
- **Reducing Barriers between Large System Operators and New Entrants:** The decentralized and collaborative nature of the blockchain-based ecosystem can help bridge the gap between large system operators and new entrants, enabling more efficient collaboration and data exchange to benefit all stakeholders.

The enabling infrastructure



Overall, an Earth Observation Blockchain-based Information Ecosystem can significantly enhance the EO industry's efficiency, transparency, and competitiveness, fostering innovation and enabling the transition to a scalable IaaS model.



Reserve Slides

A Space ECOSYSTEM As-a-Service

AIX

on-board component loads the APP on the satellite(s) and manages all the HW resources

AI^{X} ground component defines a Space App-Store

aiko

planetek italia

D-ORBIT

Blockchain-based Information Ecosystems

The business Idea behind:

- **Integrating traditional components**: BBIE integrates traditional company information systems with shared consortium components, enabling seamless interaction and data exchange.
- **Decentralized trust**: BBIE leverages blockchain technology to create a self-managed, decentralized trust system, ensuring reliable transactions and interactions among consortium participants.
- **Dynamic entry**: The BBIE infrastructure allows for the dynamic entry of new subjects, fostering collaboration, innovation, and growth within the ecosystem.
- **Project-specific or sector-wide**: BBIE can be implemented for a single project or extended to an entire industrial sector, facilitating continuous service and global reach (e.g., Earth Observation Industry).
- **Enhanced collaboration**: BBIE fosters a collaborative ecosystem that streamlines communication, data sharing, and decision-making among diverse stakeholders.
- **Scalability and adaptability**: BBIE's flexible architecture can adapt to evolving business needs and industry trends, ensuring long-term sustainability and growth.

Blockchain-based Information Ecosystem

Off-chain components

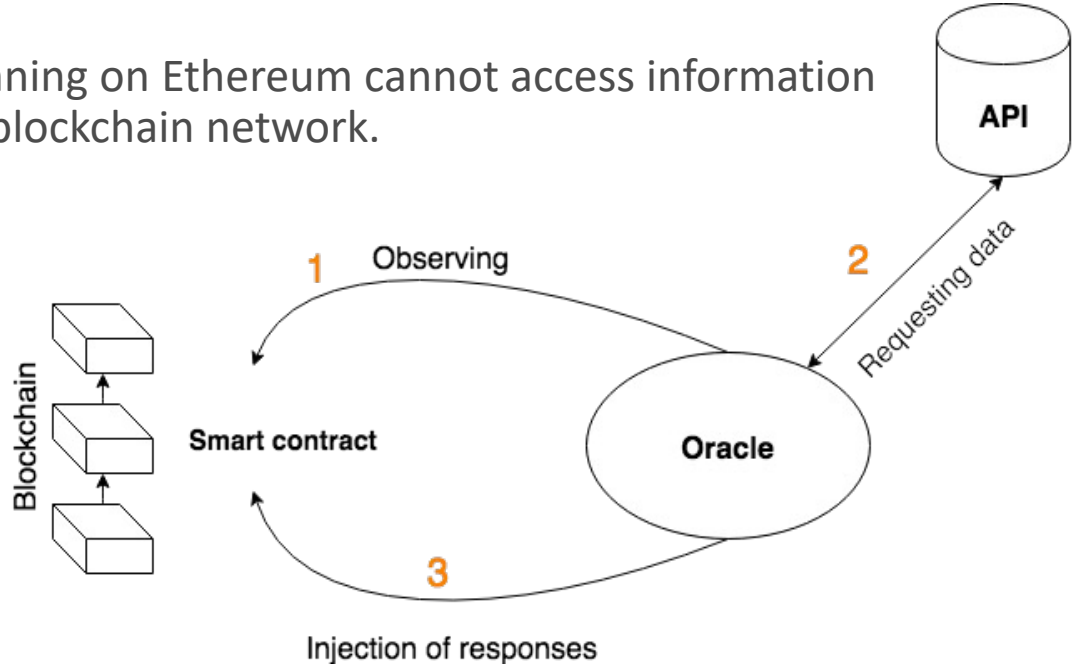
- Storage: handling large volumes of data from various sources
- Business layer: resource-intensive computations performed off-chain
- User Interface: interaction with the business layer via web/app interfaces or APIs

(Basic) On-chain components

- Private Blockchain: closed network of regular and validator nodes
- Permissioned Blockchain: accessed by anyone or authorized users only
- Shared business logic: managed through smart contracts
- Identity Management System: managing participant identities and access
- An explorer: browsing the blockchain state for transparency
- Link to an external public blockchain: anchoring for immutability

Oracles

- Represent a way to bring data from *off-chain* data sources into the blockchain for smart contracts to use and vice-versa.
  - Smart contracts running on Ethereum cannot access information stored outside the blockchain network.



BBIE generic architecture

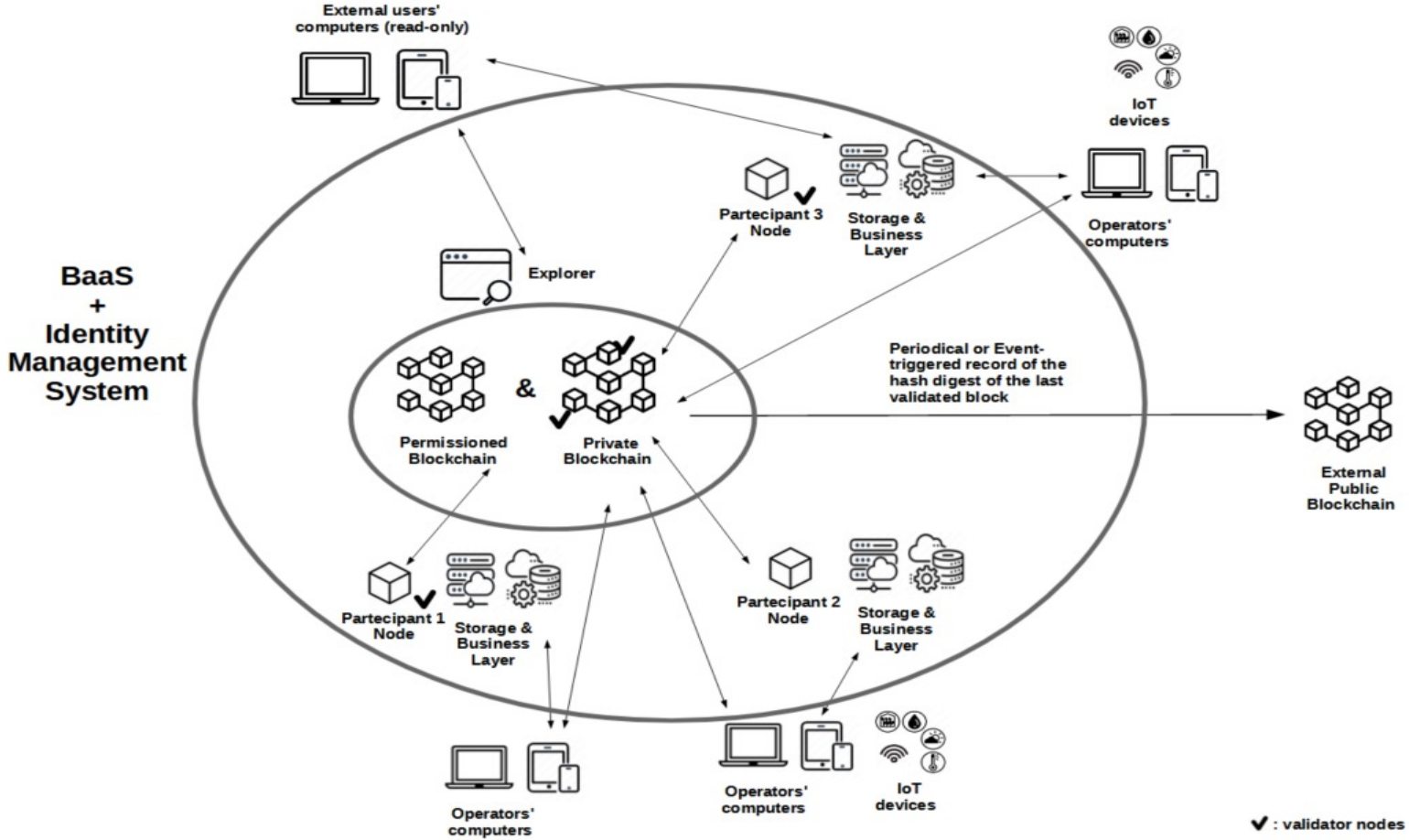
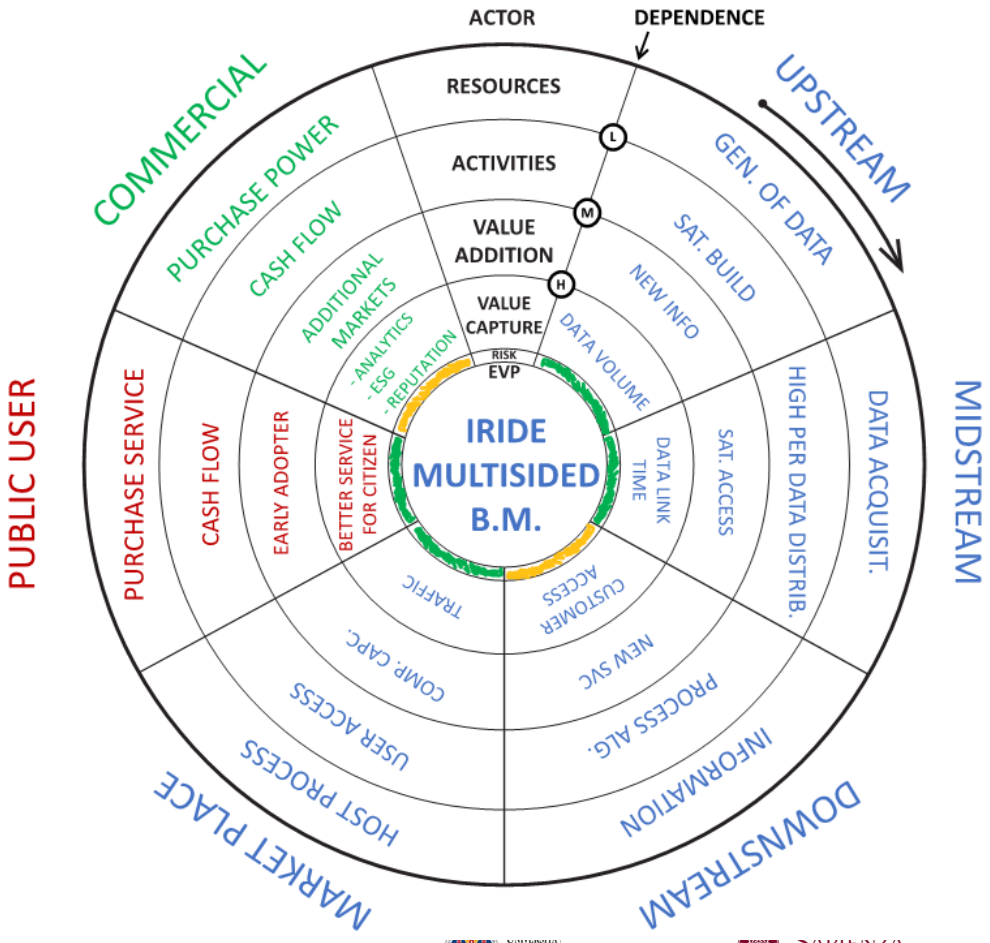


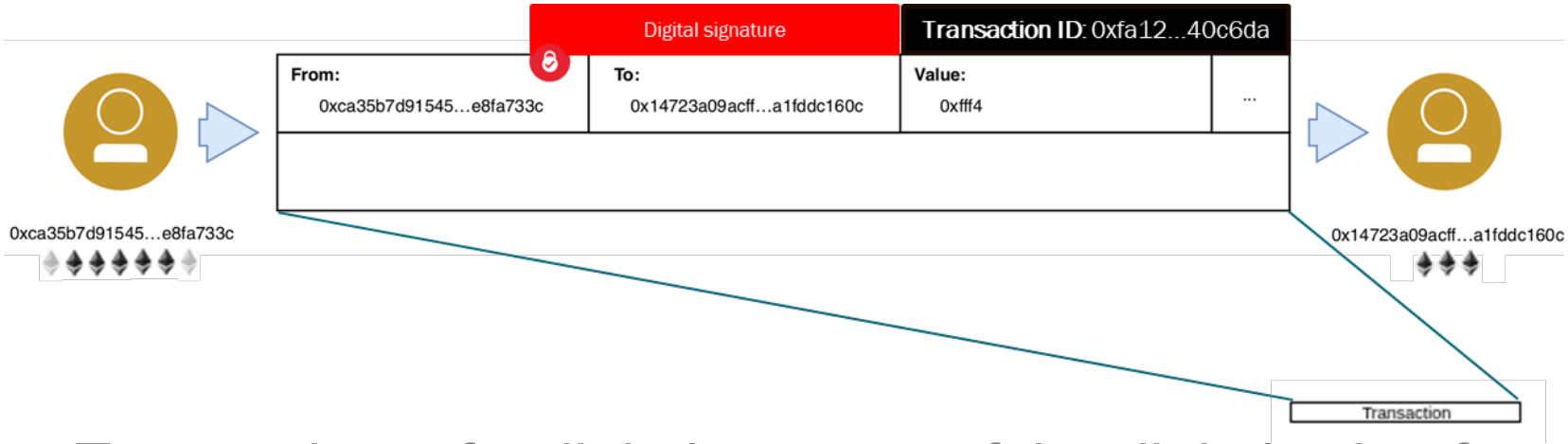
Figure: Salzano et al. (2023) Blockchain-based Information Ecosystems. In: Distributed Ledger Technology Workshop (DLT 2023). To appear.

The Multisided Constellation Model

Ecosystem Pie Model methodological guidelines, available at:
https://www.ecosystempie.com/guidelines.pdf



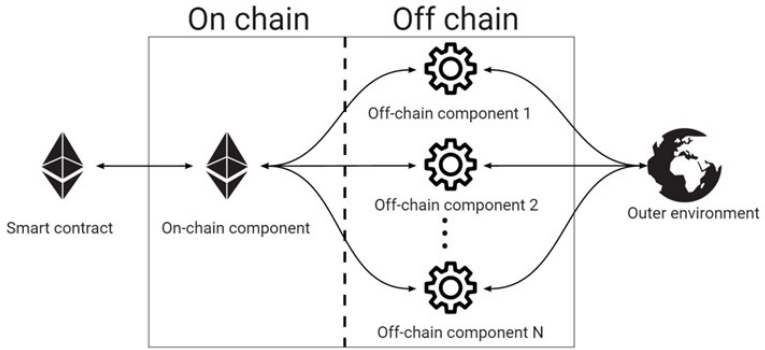
A transaction



- Transaction: of a digital asset or of the digital twin of a physical one. Timestamped.

planetek italia

Information exchange with the off-chain world through oracles



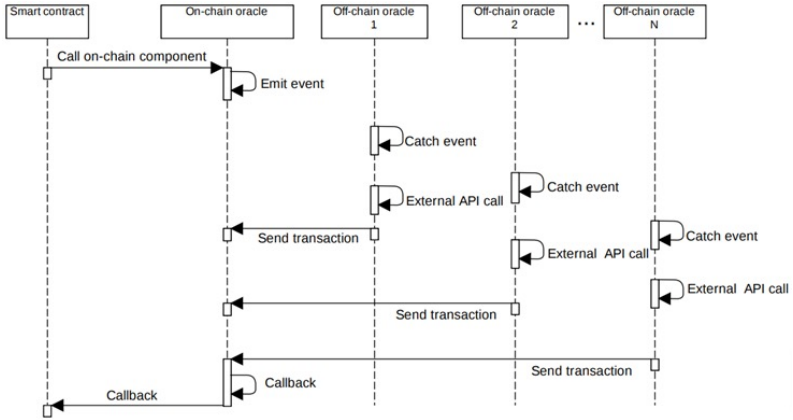


Figure: Basile et al. (2021) Enhancing Blockchain-Based Processes with Decentralized Oracles. In: BPM Blockchain and RPA Forum 2021, 102-118, Springer. DOI: 10.1007/978-3-030-85867-4_8.