THE IMPACT OF DIGITAL TRANSFORMATION ON DIGITAL EARTH

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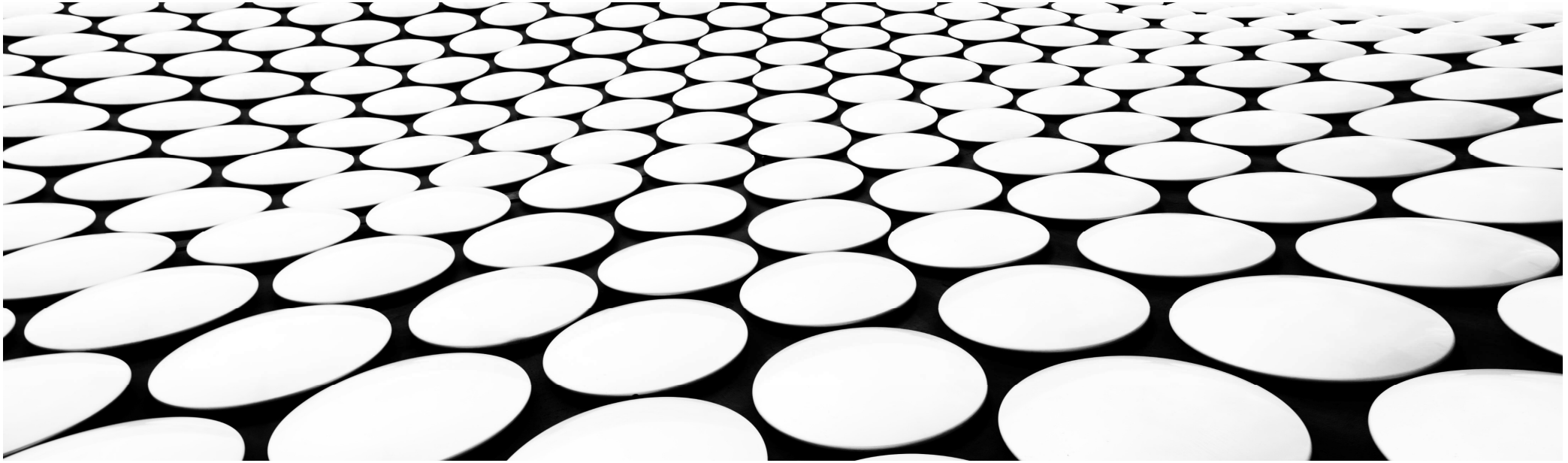
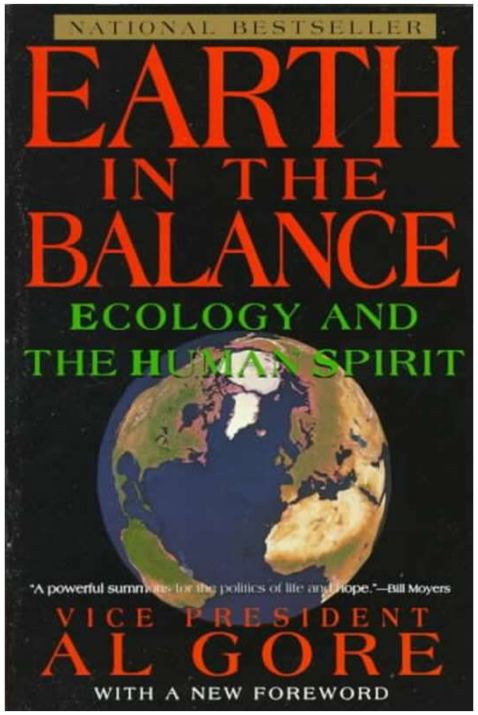


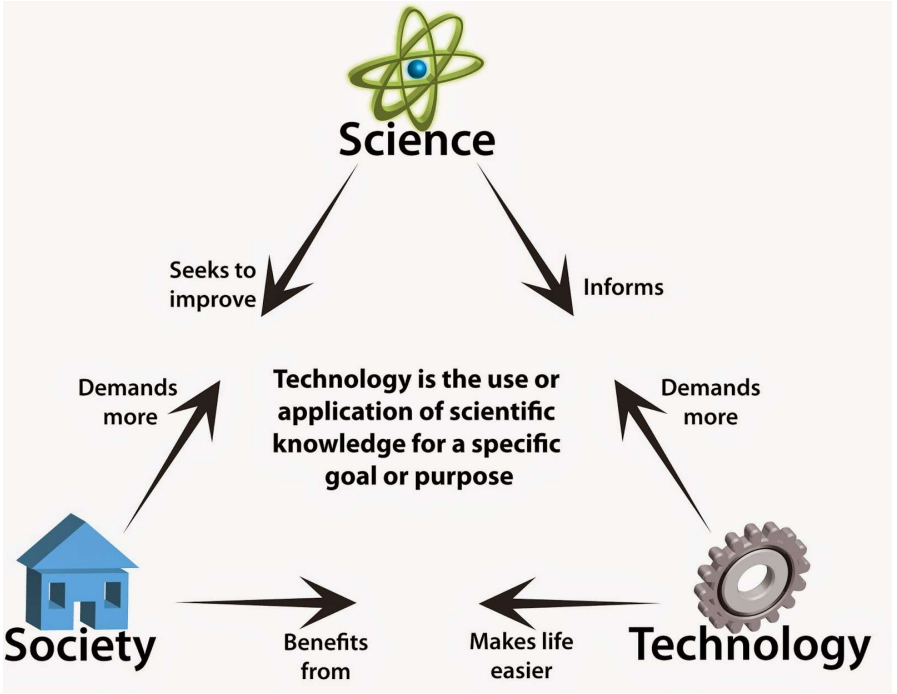
THE 1ST ISDE INTERNATIONAL LECTURES, 18 NOVEMBER 2022

THE PRINCIPLES OF DIGITAL EARTH (EARTH IN BALANCE, 1992)

People should be informed about the dangers of pollution, global warming and other planetary issues.

The key to the success of a detailed proposal to aid in saving nature is public awareness . If the public becomes aware of what is truly going on in the environment maybe people will change for the better and try to make the world better and cleaner place for future generations.





WHY IS DIGITAL TRANSFORMATION SO IMPORTANT FOR DE?

Digital transformation refers to the profound changes taking place in the economy and society because of the uptake and integration of digital technologies in every aspect of human life.

Impact of Digital Transformation on DE

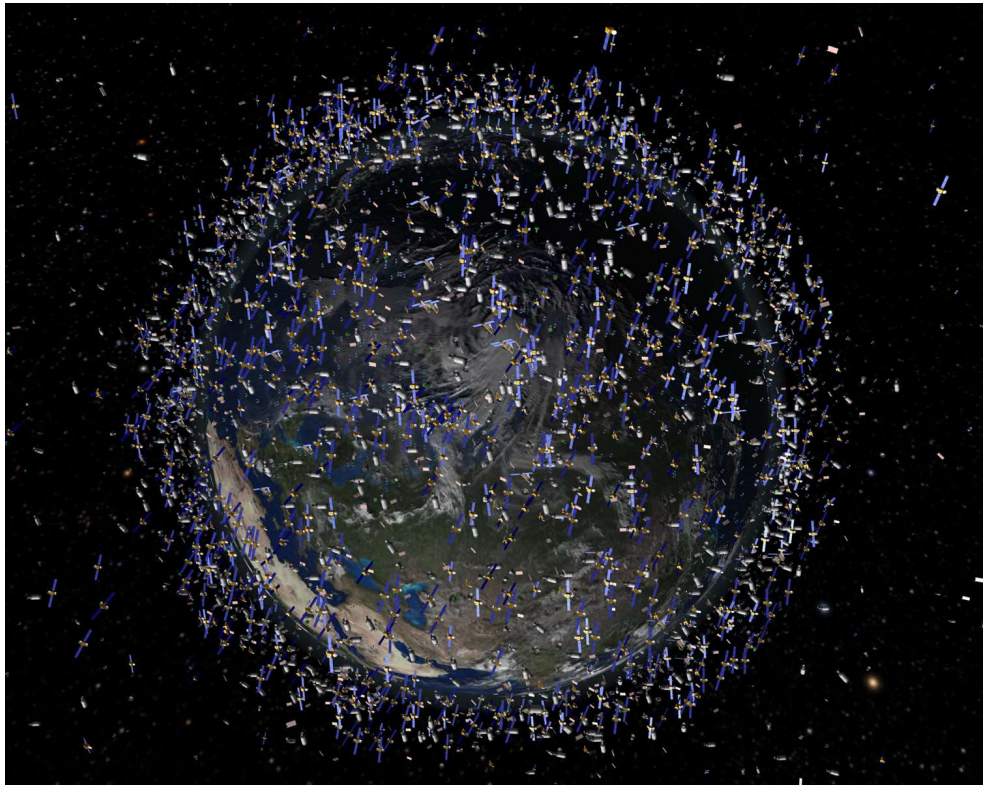
- More Data available (Satellites data, Personal Data, IoT ..)
- Ubiquitous and faster data access (optical fiber, 5G,..)
- Cheap digital devices (Smartphones , cameras, drones.)
- Increasing capacities in data processing and analytics (HPC, AI..)
- Progresses in Human computer interaction (VR, Voice,..)
- Machine to Machine interoperability (API)
- ...

We articulate the impact according to three key enablers:

1. Digital channels (including connected devices)
2. Digital analytics
3. Digital business model(s)

1. DIGITAL CHANNELS (INCLUDING CONNECTED DEVICES) 1/2

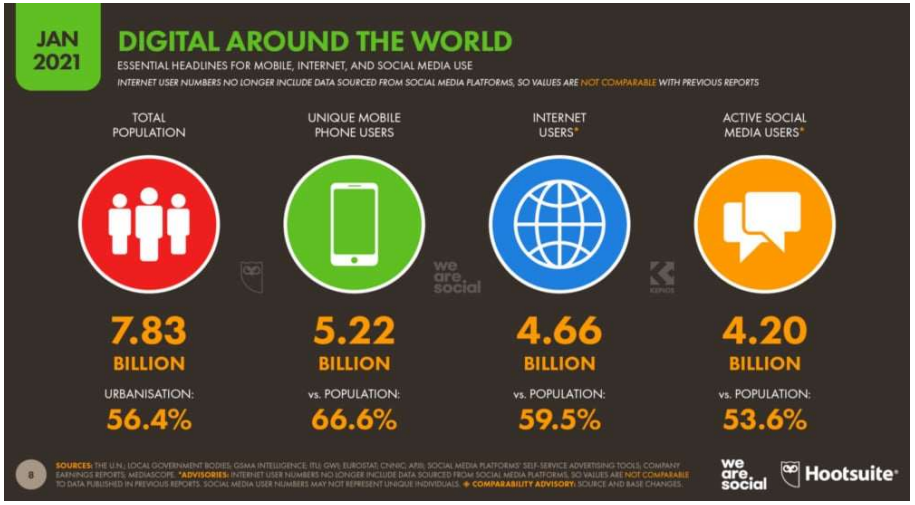
- Evolution of digital (communication and information) networks
  - 5G networks *(multi Gigabit per second data speed)*
  - Ultra-high-speed broadband Internet *(minimum 100 Mbs download speed)*
  - Global Navigation Satellite System (GNSS)
  - Personal and vehicle navigation systems
  - Long time-series and nano satellite systems



Source: ESA

1. DIGITAL CHANNELS (INCLUDING CONNECTED DEVICES) 2/2

- Evolution of digital (data/information) devices
  - Mobile devices (smartphones) (*7.26 billions by 2022*)
  - The Internet-of-Things (IoT) *(more IoT devices than humans)*
  - Surveillance cameras (*one billion by 2021*)
  - Drones *(US$ 55.8 billion market size by 2026)*



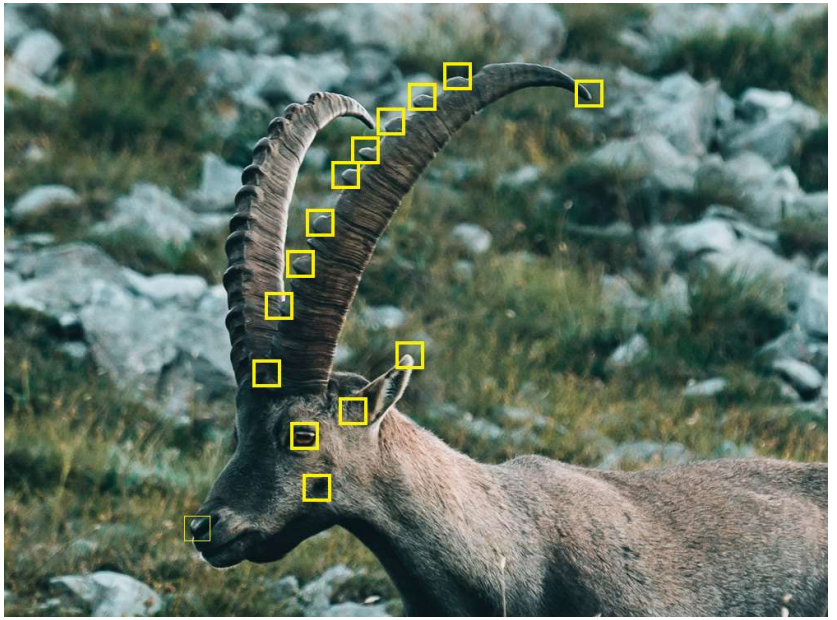


Image: Chris Zwettler, Source: Pexels.com

An individual ibex could be identified by AI using landmarks

EVOLUTION OF DIGITAL ANALYTICS

- High-performance and cloud (computing) infrastructures
- The new spring of (data-driven) AI *(language translation, image recognition, voice recognition, ..)*
- Data cubes and the Analysis ready data (ARD) platforms *(time series analysis, big earth data analytics)*
- IoT 2.0 and the edge computing paradigm *(IoT devices as edge computers with sensors and actuators attached to them)*.
- The human-enriched digital content *(citizens as sensors, digital video, digital phot and digital audio).*
- Visualization, Extended Reality, and Immersive Technologies

https://www.youtube.com/watch?v=oIhRKIDUAnA

EVOLUTION OF DIGITAL BUSINESS MODELS

- Private sector role *(Small Satellite Launch Services Market' estimates that over 11,000 small satellites will be launched by 2030)*
  - Data Providers, New Technologies and Novel Services
- Citizen science, crowdsourcing and personal data *(general data protection regulation GDPR)*
- Cybersecurity, trustworthiness and fighting against fakes *(code of practice on disinformation, fake generation)*
- Ethics of AI systems *(UNESCO principles)*
- System-of-systems digital governance *(public value, inclusiveness, digital sovereignty)*

Historical images available in Google Earth with respective dates of acquisition. The image taken into 2010 is not consistent with the others.

DE PERSPECTIVES AND WAY FORWARD

- Innovation perspectives
  - 6G revolution and the (global) satellite internet constellations *(internet everywhere)*
  - An innovative engineering paradigm for DE
  - The Digital Twins (r)evolution
  - Game technologies
  - Toward a Metaverse
- Integration perspectives
  - From SDI to the digital ecosystem paradigm
  - Digital governance
  - AI ethics
- Inclusivity perspectives
  - Citizen engagement and gamification
  - Industry engagement
  - Education and capacity building
  - Young generation and digital divide
  - Digital Earth as art

FROM SDI TO THE DIGITAL ECOSYSTEM PARADIGM

- Digital data infrastructures (SDI) were designed and developed to apply the **interoperability paradigm based on search and discover services** (find, download and use the data locally)
- In the new cyber-physical world Interoperability is pushed from the **level of sharing observed data to sharing of the information and knowledge generated by data analytics platforms.**

WHAT IS AN ECOSYSTEM?

An ecosystem is a community of living organisms interacting with each other and their non-living environment.

What makes up an ecosystem?

- All living things (plants, animals, and bacteria)
- Non living things (the sun, rocks, and soil)

https://eschool.iaspaper.net/what-is-ecosystem/

- A **Geospatial Ecosystem** comprises literally billions of 'actors' (citizens, companies, governments, civil society organisations, Internet of Things (IoT) devices, and increasingly also 'intelligent' machines) producing and consuming geospatial information, mediated through ever changing platforms, an increasingly diverse set of geo-analytical tools, and dynamic, constantly evolving networks. *(source UNGGIM)*

The digital ecosystem model seems to fit particularly well the constantly evolving nature and needs of the cyber-physical, where heterogeneous stakeholders can decide to cooperate from time to time and on a use case base.

DIGITAL GOVERNANCE

- **Digital governance** is a key factor to design, implement, and operate a successful infrastructure or platform. For example a geoscience digital ecosystems is enabled by at least three conditions under which actors in the eco-system operate:
  - **The regulatory condition** (laws, policies, standards, ..)
  - **The institutional/organizational condition in which the actors operate** (set of shared social and cultural values, ..)
  - **The current ICT capabilities condition** (the computational, network elements, communications protocols..)

- Collaborative and inclusive governance structures require a careful balancing of perspectives between stakeholders.

- Strengthening the role of citizens and creating more inclusive data governance structures is key to ensure
  - **Public value** (value of data redistributed amongst various stakeholders in society)
  - **Data sovereignty** (providing individuals and organisations the ability to exert authority over their data)
  - **Inclusivity** (ensuring the inclusion of marginalized or less powerful actors)

AI ETHICS

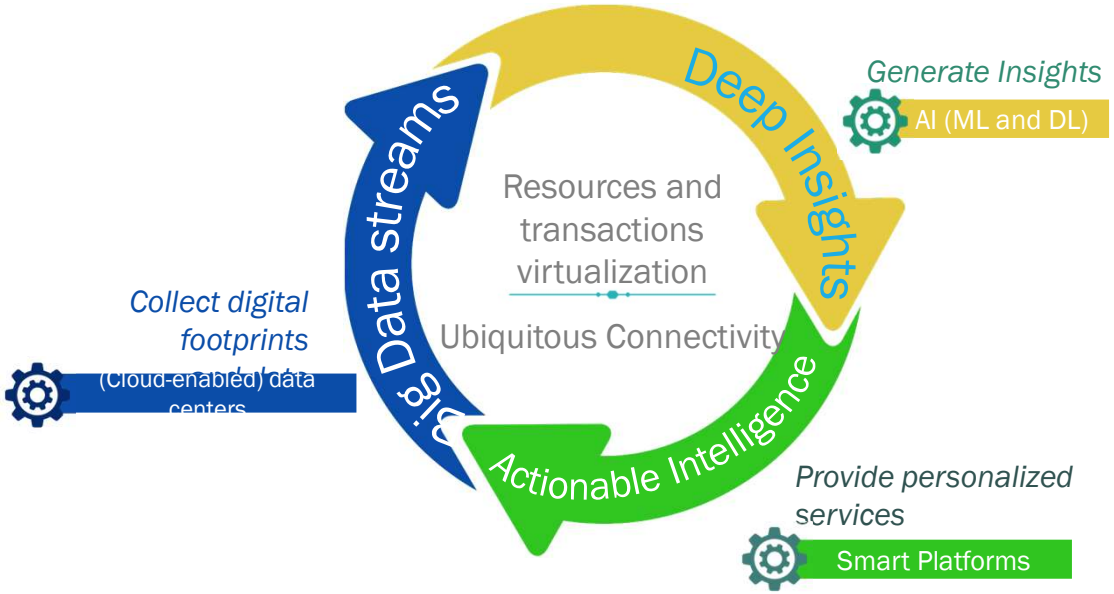
DOCUMENT TIMELINE

Source: Fjeld et al.(2020) principled artificial intelligence: mapping consensus in ethical and rights-based approaches to principles for AI. Berkman *Klein* Center research publication no 2020-1

- Ethics of AI systems
  - great heterogeneity in the **values** and **principles** they endorse but in general they focus on promoting: transparency, justice, non-maleficence, responsibility, accountability and privacy, safety, and trust
  - in near future, likely more **regulations** and **standards** enforcing such principles
  - Despite the proliferation of AI ethics guidelines, there is a considerable lack of **implementing guidelines.**
  - The trade-offs between and nuanced understanding of these principles will vary between local contexts. This leads to another key challenge that DE data is global by nature whereas the **framing and balancing of ethical priorities differs between local contexts**

DATAFICATION

- **Datafication** is a new paradigm for processing and extracting knowledge from the large volume of available data



- The adoption of datafication model requires cultural, organizational, and industrial changes, including:
  - Move from the Web-as-a-Network (WaaN) to the **Web-as-a-virtual Platform (**WaaP) philosophy
  - Operate in a cyber-physical world **interacting (mainly) at the level of digital platforms**
  - Adopt the **digital ecosystems philosophy** and its principles (i.e., flexibility, evolvability, viability, autonomy)
  - Introduce **innovative styles of governance**
  - **Build trust** (i.e., address challenges dealing with ethics, cybersecurity, privacy, transparency, etc.).

THE DIGITAL TWINS (R)EVOLUTION

A **digital twin** is the virtual representation of a physical object or system across its life-cycle. It uses real-time data and other sources to enable learning, reasoning, and dynamically recalibrating for improved decision making.

- To fully embrace the Digital Twins of the Earth (r)evolution, DE should address important scientific and modelling challenges, including:
  - to model the different granularity levels of DTs and their possible composability
  - to unify the (existing) data and scientific model standards
  - to effectively share data and scientific models
  - to introduce innovative web-based services (notably, behaviour-based)
  - to introduce specific standards for DT reference frameworks, clearly distinguishing between «digital model», «digital shadow», and «digital twin»
  - to implement effective multi-cloud platform interoperability
  - to establish fora for sharing views and knowledge on the DTs of the Earth.

GAME INDUSTRY

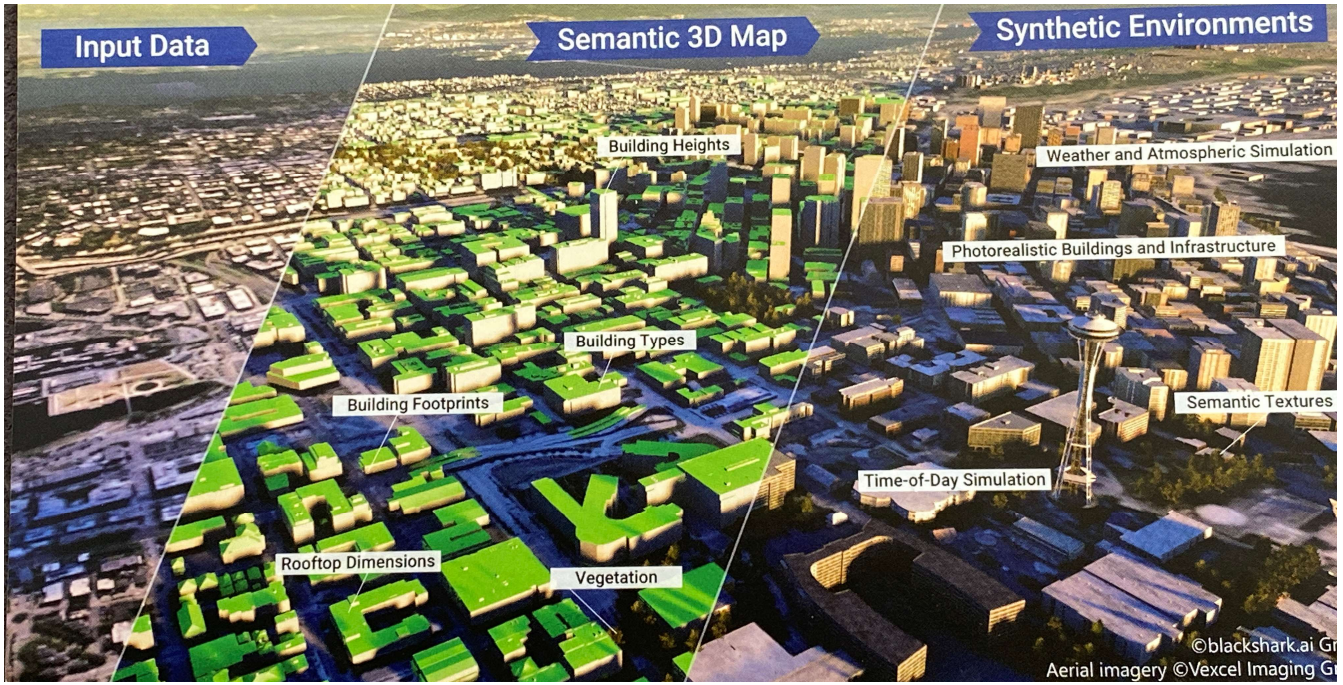
- The game industry is able to support a massive participatory process with millions of online users connected providing suitable tools and methodologies.
- The **game industry reaches 1 in 3 people on the planet** and has a platform with unprecedented influence.
- UNEP has been working with the gaming industry to explore how, through their massive reach, they can **inspire young people to learn and act in support of the environment** (i.e. kids change their behaviour toward climate change by playing specific games)

The Playing for the Planet Alliance was launched on 2019 during the UN Climate Action Summit. In joining the Alliance, members have made commitments ranging from integrating green activations in games, to reducing their emissions and supporting the global environmental agenda.

https://playing4theplanet.org

GAME INDUSTRY AND GAME TECHNOLOGIES

- The game industry develops technologies, infrastructure, and data streams that can be beneficial for DE
  - (e.g. to advance human-computer interfaces and develop virtual reality and immersive experiences)
- Blackshark's AI-driven technology enabled **Microsoft's Flight Simulator** to display the surface of the entire planet in 3D – with over 1.5 billion photorealistic buildings.



- The blackshark.ai geospatial platform extracts insights about the planet's infrastructure from current satellite and aerial imagery via machine learning at global scale. Missing attributes are enriched by AI to provide a photorealistic, geo-typical, or asset specific digital twin. Results can be used for visualization, simulation, mapping, mixed reality environments, and other enterprise solutions.

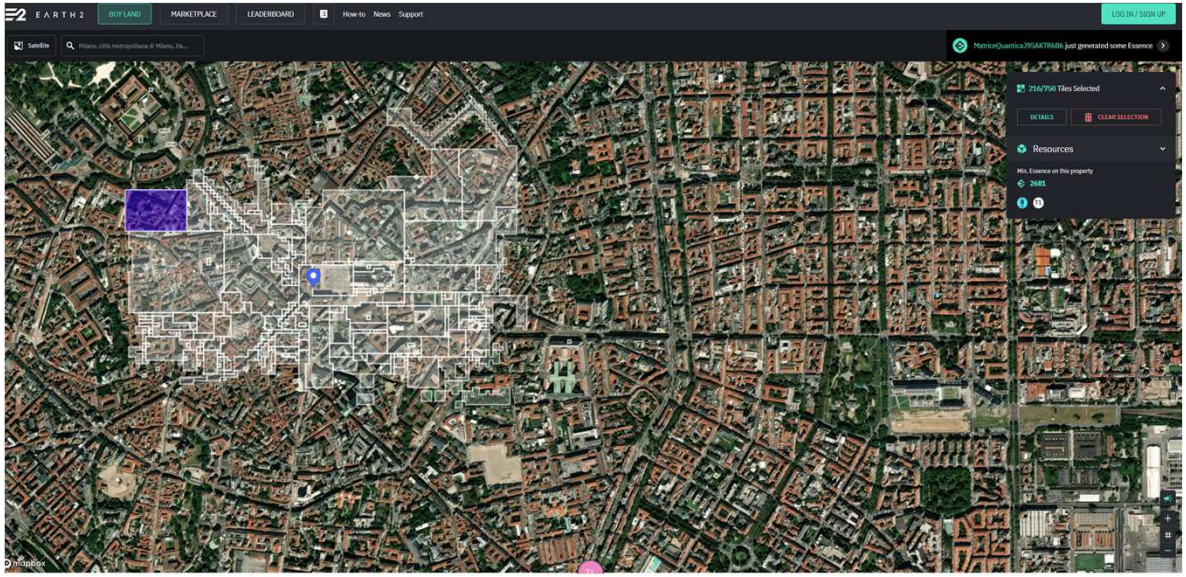
TOWARDS THE DE METAVERSE

- *The metaverse is an* ***interoperable and large-scale network of three-dimensional virtual worlds represented in real time****, which can be used synchronously and persistently by an unlimited number of people with an individual feeling of presence and with continuity of data* (Ball 2022).
- It motivates the **novel integration and deployment of diverse technologies for collaborative spatial computing**
  - interactive 3D graphics, extended reality, geospatial systems, end-user content tooling, digital twins, real-time collaboration, physical simulation, online economies, multi-user gaming, and more – at new levels of scale and immersiveness.
- The **Metaverse Standards Forum** was launched on 2022
  - to bring together leading organizations and companies for cooperation on interoperability standards needed for an open metaverse.
- DE can be seen as the **link between the real and the virtual Earth**, "*with the aim of becomes aware of what is truly going on in the environment and try to make the world better and cleaner place for future generations*". (Gore 1992). It seems so natural for DE to evolve toward a "metaverse" where people gather to socialize, discuss, and act.

TOWARDS THE DE METAVERSE AN EXAMPLE

- *Earth 2® is a futuristic concept for a second earth; a metaverse, between virtual and physical reality in which real-world geolocations on a sectioned map correspond to user generated digital virtual environments. These environments can be owned, bought, sold, and in the near future deeply customized.*

https://earth2.io/



- The 10 x 10 meter virtual land tiles cover the entire world. The tiles can be bought for different prices, varying from country to country. The price of the tiles fluctuate, for example because of their land class. The more people buy tiles in a certain area, the higher the price. .

CONCLUSIONS

- It is inevitable that the DE vision should adapt to the societal changes
  - because the DE paradigm and its general (and technology-neutral) framework is largely enabled by the Digital Transformation of society –while, at the same time, DE contribute to advance the society digitalization.
- But its main underlined principles should not change over time:
  - Ecosystem nature and openness (i.e. viability and evolvability)
    - Collaborative and multi-lateral approach –including governance
    - Knowledge generation and sharing to support society
    - Powerful collaboration and communication tool
    - Technologically neutral
  - Usability (i.e. user-centric, and transparency)
    - Participatory approach (DE for all);
    - Support education and capacity building;
  - Public good for the sustainable development of society (i.e. application driven)
    - Focus on ensuring sustainable development;
    - Data and processing fairness and ethics;
    - Trust and cybersecurity.

"Without a DE-For-All perspective for children and international organizations, the planet will not coalesce on issues of sustainable development. In the twenty plus years of DE vision, no agency outside of ISDE has taken on the challenge. The DE Vision represents the grandest vision outside limited commercial interest to provide a planetary good." Tim Foresman

THANK YOU FOR YOUR ATTENTION

www.digitalearth2023.org

Acknowledgment

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