EOSC Study

Expanding EOSC: Engagement of the wider public sector and private sectors in EOSC

INDUSTRY COMMONS

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Executive Summary

The Expanding EOSC Study aims to deliver practical, actionable advice and models for technology transfer and engagement with existing and potential scientific research user groups outside of academia, with the objective to scale the impact of EOSC and further incentivise and reward its community of researchers and research institutions.

The study aimed at identifying 10 use cases resulting from cross-domain, data-driven applications created in pan-European collaborations by research communities, citizen scientists, public sector organisations and industry, as well as new and emerging case studies from grass roots innovation communities, industry demonstrators and European projects. Following stakeholder feedback, additional valuable use cases from a variety of domains and areas of application have been included.

This has resulted in a total of 23 use cases, including:

- UC01 SME business use case with Copernicus data;
- UC02 cross-domain data for medical prosthetic implants;
- UC03 pan-EU open media applications (EBU);
- UC04 Covid-19 (as per SRIA);
- UC05 Apollo in Real Time (NASA);
- UC06 Galaxy Cruise citizen science project (National Astronomical Observatory of Japan);
- UC07 Citizen scientist collectives (Visnjan Observatory);
- UC08 PaNOSC;
- UC09 OntoCommons cross-domain interoperability;
- UC10 green computing at the ICE Datacentre (RISE BDVA i- space);
- UC11 human rights data and privacy systems (Cambridge University);
- UC12 neural network intellectual property challenges;
- UC13 accessible musical instruments data (Drake Music charity);
- UC14 sonification of data in education (NTNU);
- UC15 cross-domain data for sustainable products (Axel Johnson);
- UC16 social media sourced climate data by hacker/maker communities;
- UC17 project on nutritional data by UN;
- UC18 data for monitoring of Transitional Targets (ClimateView)
- UC19 self-driving vehicles data challenges (Volvo);
- UC20 EU Oceans Mission (Vinnova)
- UC21 neurofeedback clinical patient data
- UC22 SME application for gravitational waves research (Wavefier)
- UC23 registration of IP for academic research (bloXberg)

Use cases have been analysed to derive an initial set of models and solutions for EOSC community engagement and long-term sustainability. These were presented to stakeholders in interviews with a diverse range of wider EOSC stakeholders and key experts.

46 interviews have been completed with stakeholders from across sectors and have been transcribed in full. They include:

- 8 experts in Open Innovation working with governmental institutions
- 6 high level industry professionals
- 7 experts from academia, part of the broader research community

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- 5 national and international research organisations supporting research and citizen science
- 7 members from the innovation community and innovative SMEs
- 13 EOSC stakeholders

Consultations with stakeholders have resulted in an expanded suite of potential frameworks, approaches and solutions to stakeholder engagement and sustainability models. Analysis of the feedback has been performed according to categories of models and solutions, including marketplace considerations, sustainability, value creation and potential risks.

Key findings include:

- Industry feedback indicates that EOSC should act as the validating organisation for industrial FAIR data as well as for data by research communities.
- The addition of JUST (Judicious, Unbiased, Safe and Transparent) which highlights accountability by a responsible researcher, has been equally well-received by all interviewed stakeholders;
- Broader academic research community have requested that the EOSC front end be a live, audiovisual platform for remote collaboration, inclusive of access to research data and value-added services (which can be added at a premium).
- An additional important stakeholder group has been identified in professionals working with large valuable datasets (e.g. clinicians) who wish to be part of the EOSC marketplace.
- The strategy for EOSC expansion based on Knowledge Circles has been universally supported by all interviewed stakeholders.

Recommendations include:

- As the 'Web of FAIR Data', the expertise of FAIR-ification should be a standard for all European Marketplaces including GAIA-X, Industry Commons and the new planned EIC marketplace, thereby supporting EOSC's key role and future sustainability.
- The funding vehicles of the INFRAEOSC-03 and INFRAEOSC-07 initiatives should be used to initiate, implement, or prototype as appropriate, a series of recommended actions (see further details in the individual analyses and the summary under INFRAEOSC-03 and INFRAEOSC-07 as testbeds for expansion).
- Synergies with parallel initiatives such as GAIA-X, EuroHPC, bloXberg, Industry Commons and the upcoming EIC marketplace ought to be exploited, to save on duplication and speed up deployment.

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Objectives

The intention of this study has been centred on the premise that expansion of EOSC beyond 2024 must enable further excellence by the European research community. The affordances created through the expansion of EOSC must:

- stimulate novel research methodologies and support research excellence;
- enhance existing research practices through greater access to data based on FAIR data principles;
- encourage the development of novel Open Science research exchanges that allow interdisciplinary and international collaborations, and open up new categories and fields of knowledge;
- establish a mechanism for a technology transfer that is grounded in the research communities' ethos and principles;
- enable a marketplace for exchange of knowledge and datasets, established upon FAIR data implementation guided by the research communities' values.

The study aims to achieve the following objectives:

- in close collaboration with the Sustainability WG, identify, select and outline **relevant use cases** which can illuminate the feedback from EOSC stakeholders provided during the EOSC Consultation Day[1];
- identify a series of **potential models for long-term stakeholder engagement** and financial sustainability value systems for the wider EOSC community;
- validate **potential financial sustainability solutions** with wider EOSC stakeholder groups of users and experts;
- evaluate the **potential impact** and value of the proposed solutions for the wider EOSC stakeholder communities;
- create a **set of guidelines and recommendations** for future EOSC financial sustainability development activities.

The results of the study provide the foundations for the definition and programming of reward systems (ontological and programmatic), financial sustainability and business models, for FAIR data services beyond MVE.

[1] https://www.eosc-hub.eu/eosc-hub-week-2020/agenda [Accessed 30.05.2020]

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Evolved methodology

The proposed methodology has been evolved during the course of the Study in line with the findings and stakeholder recommendations. Several stakeholder types were added to a considerably increased number of use cases. Anticipated models and solutions were amplified with further categories. Means for analysis were added following examples proposed by stakeholders.

Task 1: Use Cases

Proposed objectives

The study aimed at identifying 10 use cases resulting from cross-domain, data-driven applications created in pan-European collaborations by research communities, citizen scientists, public sector organisations and industry, as well as new and emerging use cases from grass roots innovation communities, industry demonstrators and European projects, in close collaboration with the Sustainability WG.

The methodology included:

a) The innovation community members of MTF Labs which largely consists of postgraduate students, postdoctoral researchers, independent developers and citizen scientists, who are experimenting with cross-domain data-driven applications. These stakeholders mostly belong to a younger demographic and regularly experiment in sandboxes, utilising knowledge of emerging markets, and therefore have the ability to provide valuable insights of novel cross-domain uses of data.

b) A second type of use case was drawn from industrial research consortia engaged with cross-domain industry demonstrators.

c) The study has also drawn on use cases from European projects focusing on digital innovation across domains.

Updated methodology following findings

Following community feedback, use case types were increased to include further groups of stakeholders:

d) Clinicians collecting big data daily as part of their practice, processing data with algorithms, and applying metrics for analysis;

e) Commercial AI-assisted recommendation engine experts requiring research and public data from multiple domains;

f) Industrial designers of autonomous IoT applications who require data from multiple research domains;

g) Broader research community processing sensitive (e.g. human rights related) data;

h) Global organisations (e.g. the UN) who require access to EU national data on e.g. nutrition;

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i) Educational institutions teaching students data sonification and visualisation.

Use cases were selected based on satisfying one or more of the following principles (below with example results):

- The use case carries fundamental values and ethos of the EOSC research community
  - ⇨ e.g. the Cambridge University *Whisper* system
- It acts as an enabler for inclusion and diversity in research.
  - ⇨ e.g. the *Whisper* system enhances research with minorities participation
- It supports a user reward mechanism which stimulates quality research
  - ⇨ e.g. *FAIRification* mechanism
- It incentivises responsible citizen science contributions to the accumulation of valuable datasets for AI training and machine learning.
  - ⇨ e.g. responsible researcher accountability with the *JUST* system
- It suggests a mechanism for a technology transfer that is grounded in the research communities' ethos and principles.
  - ⇨ e.g. SME use cases UC01, UC08; data for education and accessibility UC11, UC12 and UC14
- It bases any future EOSC market exchange for industry on an index derived from the values of the research community and not from outside market forces.
  - ⇨ e.g. the FAIRification / JUST model (see JUST research annotation by data creator/user: Judicious, Unbiased, Safe, Transparent) has been very well received as in the *FAIRification* of industrial and commercial data in the use case of Volvo and Axel Johnson

Task 2: Models and Solutions

The selected use cases were matched with value models for knowledge exchange and potential solutions for sustainable value chains were created, ensuring wherever possible that:

- the technological components of the proposed solutions build upon the components of the EOSC Core;
- the value solutions implement the principles of FAIR data;
- IPR and legal metadata models work with the EOSC-Core framework;
- novel value added applications for data can be enabled;
- incentives are compatible with the EOSC-Core open metrics framework
- user dashboards are compatible with the EOSC-Core user portal

Models and solutions were presented to stakeholders for evaluation, including (below with example results):

- potential innovative research incentivisation models that respond to the new digitally-mediated Open Research context, using indicators that measure Open Science behaviours as well as indicators that assess and demonstrate the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour;
  - ⇨ e.g. FAIRification applied throughout industry and commercial data
- enabling cross-domain research and business models for both industrial use and grass roots experimentation with data from multiple domains, to attract wider private and public stakeholders to the EOSC platform;

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- ⇨ e.g. multiple profit-based models – see Table 3: Models and Solutions - sustainability strategies
- models which encourage further development of value adding services for data, creation of novel data sets, new categories and fields of knowledge, with contributions including citizen scientists, independent developers, startups and ICT SMEs.
  - ⇨ e.g. multiple value models – see Table 2: Models and Solutions - types of stakeholders

Task 3: Community Feedback

Community feedback gathering was performed with the following categories in mind, and evolved according to a growing set of recommendations from the stakeholder community:

- **Questions and challenges** raised by EOSC stakeholders during the Consultation Day and further amplified upon analysis of use cases.
  - ⇨ Initial interviews used EOSC stakeholder feedback as a starting point for the discussion. Later interviews used broader stakeholder feedback, as appropriate. Renewed consultations with EOSC stakeholders in later interviews were almost entirely based on the broader stakeholder feedback.
- **Risks and threats** to EOSC sustainability as well as challenges to the research communities' ethos and principles that may arise from engagement with the wider public sector and private sectors.
  - ⇨ Broader stakeholder interviews required extensive briefings before addressing any risks and threats. Later EOSC stakeholder interviews benefitted from additional solutions in respect of risks and threats.
- **Incentives and rewards** including the possible introduction of a FAIR ratings system and rewards mechanism.
  - ⇨ From the start the incentives were increased to interrogate both FAIR and JUST principles. Later the breakthrough finding that this is an attractive incentive for industry to engage with EOSC (resulting from industry feedback) was fed back to EOSC stakeholders.
- **Impacts and values** including related costs and funding channels, the creation of value and public impact through technology transfer between the research communities, public sector and private sectors.
  - ⇨ From the beginning, consultations with stakeholders brought an expanded suite of potential frameworks, approaches and solutions to stakeholder engagement and sustainability models, which were progressively fed back into the interviews to verify them with other interviewees according to their domain expertise.

Task 4: Evaluation and Assessment

Analysis of the feedback has been performed according to categories of models and solutions, including marketplace considerations, sustainability, value creation and potential risks. As planned, the interviews have been transcribed, coded and analysed and the outcomes presented to the Sustainability WG. Proposed solutions have been further refined in close collaboration with the Sustainability WG. A set of recommendations has been created for EOSC financial sustainability implementation and expansion of EOSC with engagement of the wider public and private sectors.

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Stakeholder feedback and resulting recommendations have been analysed using a SWOT and Media Tetrad analysis of the proposed solutions. The tetradic approach applies the term 'media' broadly to include technologies, artefacts, interfaces, legislation, and scientific theories. The method explores and reveals four key effects of the new medium: Retrieval, Obsolescence, Enhancement (or Amplification), and Reversal[2] (see Figure 1: The Media Tetrad approach).

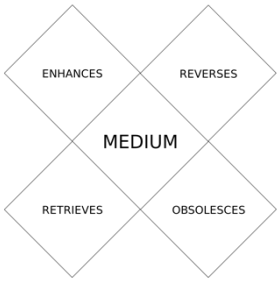

Figure 1: The Media Tetrad approach

The stakeholder categories and their interactions presented in Figure 2: The EOSC stakeholder categories according to the Minimum EOSC Competence Skillset have been updated and amplified according to use case scenarios, solutions and stakeholder feedback, to a *strategy for the expansion of EOSC Knowledge Circles* as shown in Figure 3: Expanding EOSC Knowledge Circles strategy building on the EOSC Competence Skillset.

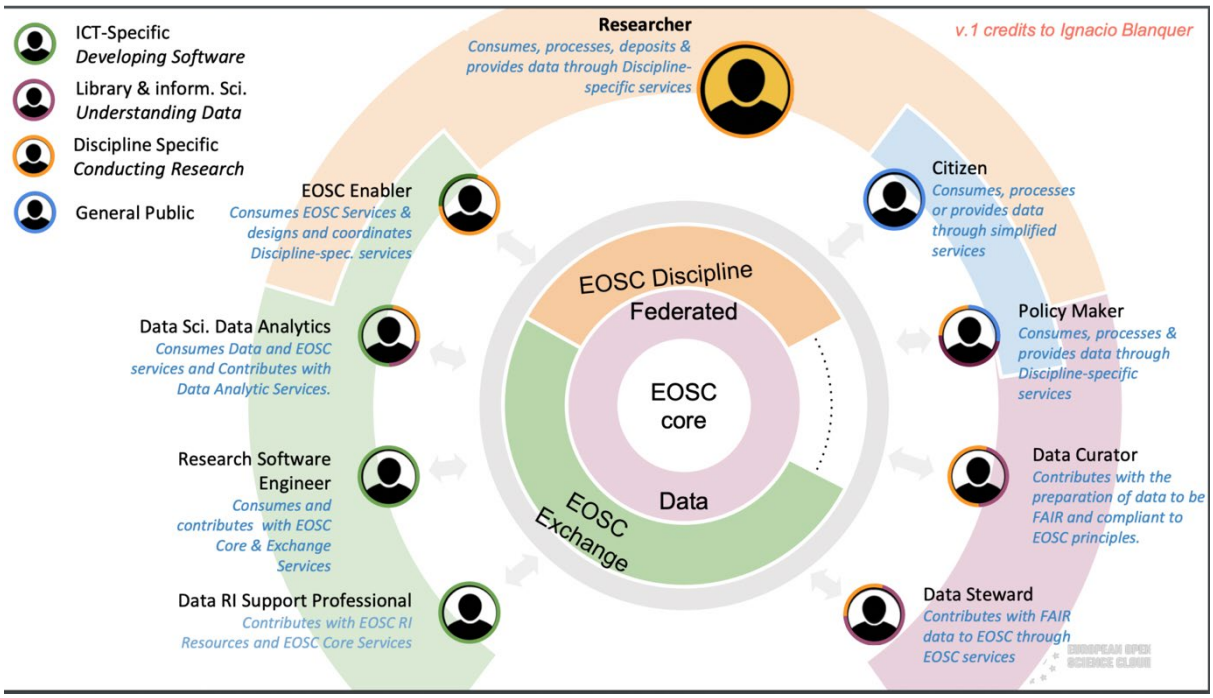

Figure 2: The EOSC stakeholder categories according to the Minimum EOSC Competence Skillset

[2] McLuhan M. & McLuhan E. *Laws of Media: The New Science (1988).*

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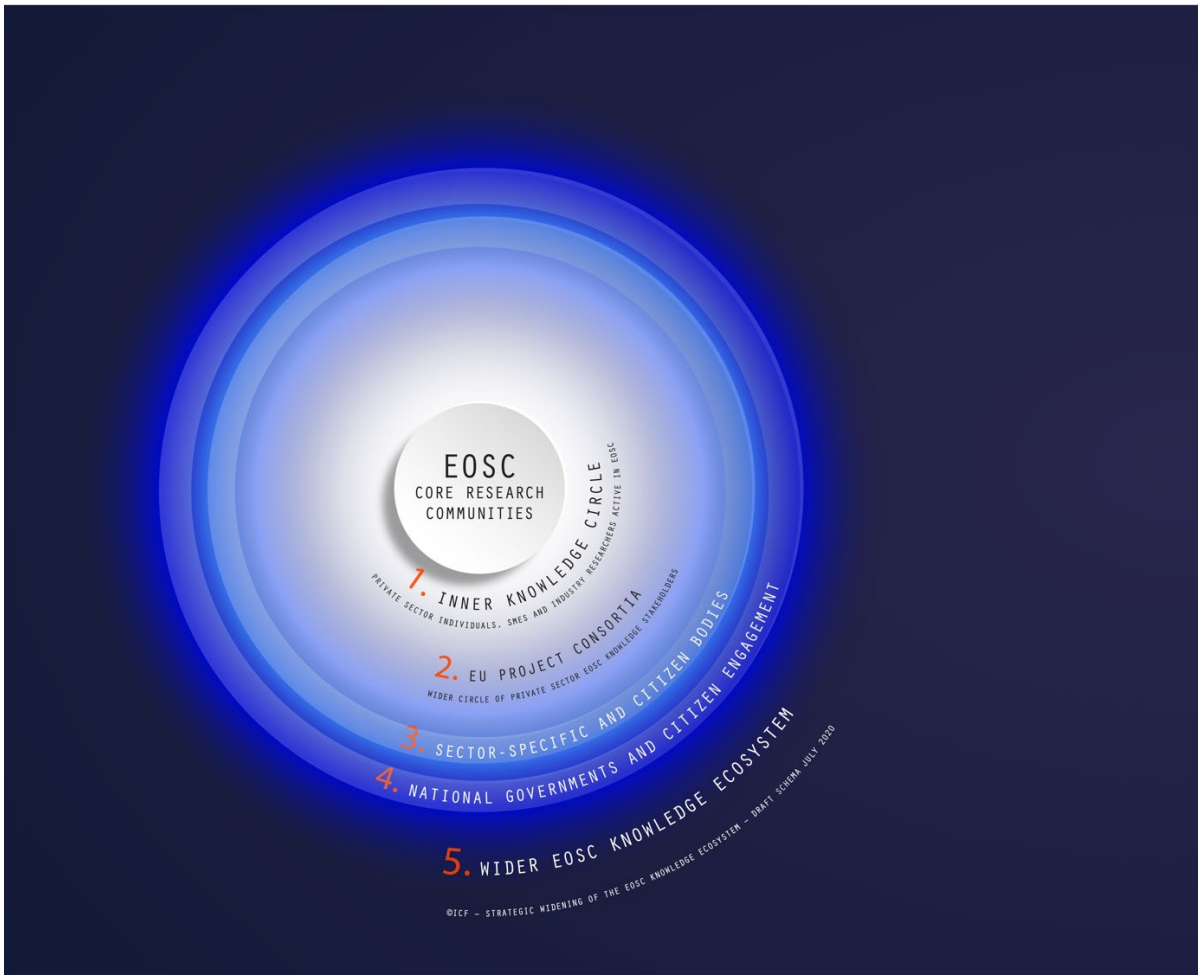

Figure 3: Expanding EOSC Knowledge Circles strategy building on the EOSC Competence Skillset

Models suggested by stakeholders

Additional models for analysis of sustainable EOSC use cases and applications were suggested by stakeholders during this study.

The matrix in Figure 4: Mapping models and solutions onto data challenges was created by evolving the methodology suggested by Gurvinder Ahluwhalia, ex CTO of IBM US and CEO of Digital Twin Labs (see his presentation which he has kindly authorised for use by EOSC, in Appendix 3: Additional proposed methodology). The model updates the Digital Twin Labs proposed category of Predictive to *Hypothetical*; the Data Model parameter to *Data Analysis*; and the Machine Model parameter to *Machine Learning,* following stakeholder discussions.

The simple matrix allows us to map the categories of research and innovation that require data onto the proposed parameters. For example, the Galaxy Cruise use case (UC06) starts with known questions (which type of Galaxy?) but unknown data (Galaxy types must be manually identified in each image). The next phase for this project is to accumulate sufficient known data to build an AI-assisted recognition system which can automatically generate the data descriptors, and this allows the use case to move to the product development category in the matrix.

The ultimate goal is to solve the challenge of *unknown questions* and *unknown data* and direct them towards pure research or industrial R&D, towards greater knowledge creation, and ultimately towards

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knowledge transfer for product development, as in the case of creative experimentation with big data from neural networks (UC12), and the associated IPR challenges.

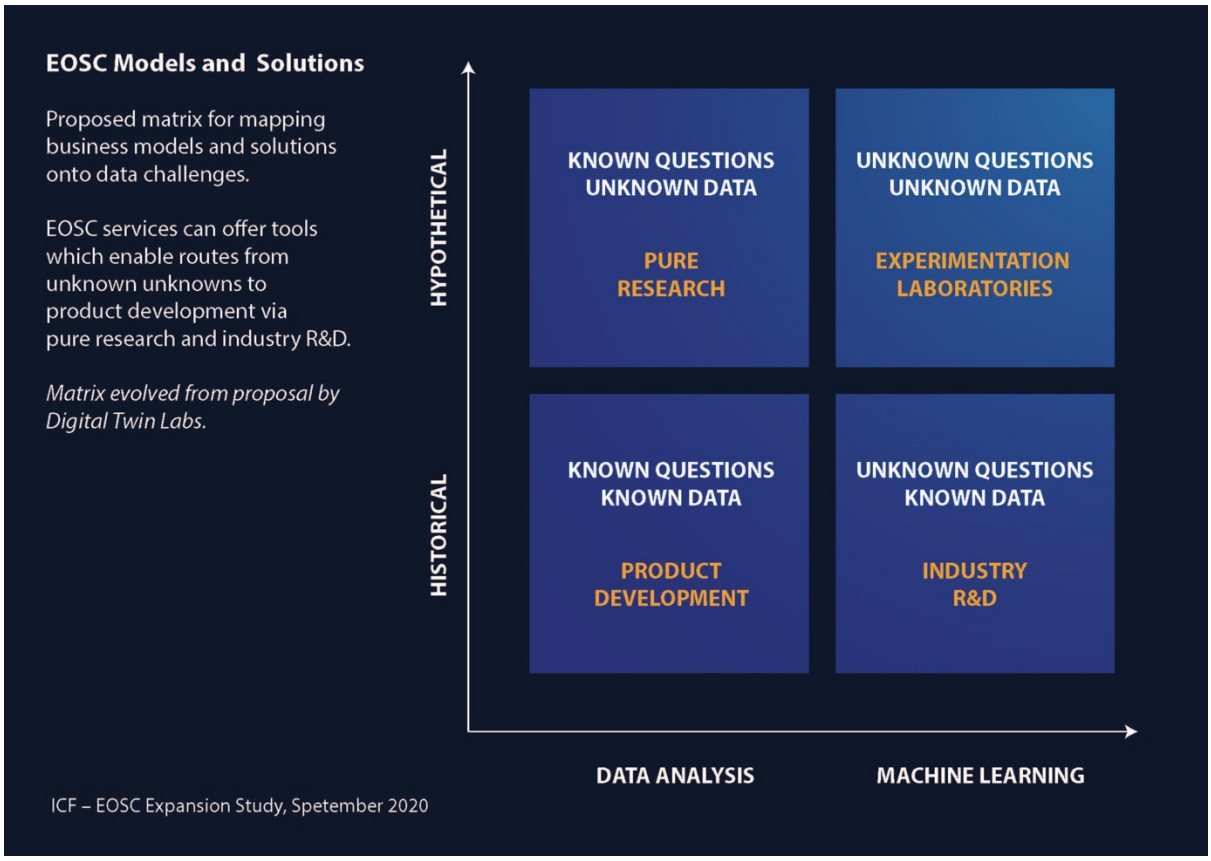

Figure 4: Mapping models and solutions onto data challenges

Another important model was identified as the Technology Readiness Levels (TRLs[3]), widely used throughout the Horizon Programme, particularly in Innovation Actions, Future and Emerging Technologies and SME instruments of the European Innovation Council, and in the activities of the European Institute of Innovation & Technology (EIT). This model is seen as providing further dimensions for analysis of readiness to the data-centric model above.

We recommend an update to TRLs which expands this model even further and brings it in line with platform economy models. Market Adoption Readiness Levels (MARLs) were part of the original set of CONNECT Advisory Forum (CAF) recommendations for the Work Programme 2016/2017, and have been recommended for introduction into the WP 2018-2020 by CAF industry stakeholders as part of the CONNECT Innovation Recommendations, coordinated by one of the authors of this EOSC Expansion Study[4]. The CAF recommendations for the H2020 Work Programme 2018-2020 state:

The TRL model is driven by the degree of maturity requested from technology and is particularly suited to its original context, as developed by NASA in the 1980s. The NASA model typically deals with high-

[3] Available at https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

[4] Michela Magas coordinated the CAF Innovation Recommendations 2018-2020 which are referenced in this document (see reference in the text below).

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risk technologies, carries high development costs, is aimed at few end users, and yields important user data only after final deployment.

Applications which are quick and competitive economic drivers require development which considers adequate business models, user engagement, and societal aspects. This implies that new models are needed as guidelines particularly for EU Innovation Actions. One of the proposed models[5] is the "Market Adoption Readiness Levels" (MARLs). In addition to the technology readiness levels parameter, this model requires the assessment of three further value parameters: users (numbers of potential early adopters and values associated with feedback loops), data (potential quantity and value of data generated by the system and user interactions at each stage of the process) and the level of risk (assessment of benefits or adverse impacts of the technology on early adopters in various stages of the process). This MARLs model is strongly motivated by the disruptive nature of IoT, but is used more widely.

For example, creative applications are extremely low on risk, cheap to run, easy to understand and can get millions of early adopters, even as experimental proofs-of-concept (examples from the music industry include Spotify and SoundCloud). For a potential investor, a large number of early adopters, and the related substantial datasets, have often proven to be sufficient incentives for investment and acquisition in early stages of development (traditionally classified as TRL3 to TRL7). In the creative applications sector therefore, the market is extremely agile, with development of applications being cheap and typically low risk, and great potential of investment and acquisitions through clearly demonstrable social and economic benefits in early stages.[6]

In addition to the above quoted text, an increasing number of use cases related to data-driven applications (particularly in digital media and IoT) require continuous iterative loops between TRL8 back to TRL5 and onward again, in order to stay competitive in the applications market. We therefore recommend that as part of the work of INFRAEOSC actions and EOSC expansion, the CAF proposed model is further explored and refined.

Task 5: Reporting and Recommendations

During the course of this study we have had a continuous exchange with the EOSC Sustainability Working Group and have been reporting on every stage of the process. We kept informed of the parallel developments within EOSC including the progress of the EOSC Core Study, The EOSC Risk Assessment Study, the evolution of the Iron Lady document, the progress of the SRIA and the INFRAEOSC-03 – ensuring that we are fully informed in terms of importing knowledge from EOSC and feeding our findings into EOSC development activities.

[5] For a more in-depth discussion on innovation models in the digital era see the CAF paper on Innovation Recommendations, which can be accessed here: https://www.dropbox.com/s/2ok7m51zvq93y6u/5-CAF%20innovation%20recommendations%20%28with%20Annexes%29%20v1.0.pdf?dl=0

[6] The original document for distribution can be accessed here: https://www.dropbox.com/s/g9a0sfg5k4o1ovj/6-CAFs%20recommendation%20for%20H2020%20work%20program%202018-2020-v_final_for_distribution-clean.docx?dl=0

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Amplified Use Cases

The study proposed to examine 10 use cases that would provide a basis for an analysis of EOSC expansion to the public and private sectors. As part of the research, additional use cases that demonstrated important aspects of that expansion were suggested and added to the study. A total of 23 use cases have been included for analysis. In cases where the use cases contain commercially sensitive information we have not revealed confidential information (UC12, UC19, and UC20). However, these remain important cases for analysis.

UC01: Sentinel Hub: BlueDot Observatory

SMEs leveraging global monitoring of water bodies on a shoestring through API access. This use case highlights the commercial and societal potential for European Open Research Data, but also the challenges faced by EOSC to act as an intermediary and an enabler in this context.

UC02: 3D and Additive Technologies in the Biotech Field

Cross-disciplinary use of e-Infrastructures and distributed processing to enable collaboration of geographically dispersed specialist teams to quickly create bespoke medical prostheses and surgical implants. The use case demonstrates that European Research Data and e-Infrastructures are particularly useful when the tools themselves are collaborative, not just the people using them.

UC03: Open Media - EBU

Promotion of EU digital sovereignty and means of preserving and promoting cultural and historic value of European public media archives. The EBU use case describes a multiplier effect for news gathering and provision by providing instantaneous translation and targeted news aggregation and verification. The use case raises questions about the e-Infrastructure offering of data storage and processing at scale in competition with commercial providers for use in a public service media context.

UC04: COVID-19 (as per SRIA)

Pooling and analysis of data from the Humanities and Social Sciences in order to augment behavioural and attitudinal data to monitor citizen opinions and their effect on the occurrence and spread of the virus. This use case demonstrates the urgent need for research data to be made available in order to address critical contemporary issues, as well as the need to integrate with public sector organisations such as hospitals so that data can be shared and better insight and solutions can be quickly reached.

UC05: Apollo in Real Time: Citizen science public impact

Meticulously assembled and synchronised by Ben Feist, an amateur Apollo historian, the project website replays the Apollo missions in real time. It consists entirely of historical material, all timed to Ground Elapsed Time--the master mission clock. Footage of Mission Control, film shot by the astronauts, and television broadcasts transmitted from space and the surface of the Moon, have been painstakingly placed to the very moments they were shot during the mission, as has every photograph taken, and every word spoken. As a result of this project, Ben was employed by NASA[7]. A million people engaged with the website for 7 minutes or more[8]. The use case demonstrates the potential for

[7] https://www.airspacemag.com/daily-planet/relive-drama-apollo-13-real-time-it-happened-180974625/
[8] Source: MTFLabs interview with Ben Feist https://mtflabs.net/podcast068/

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public impact, engagement in scientific research and the potential reach and effect of allowing open access to data with an eye to communication and citizen-led science initiatives.

UC06: Galaxy Cruise: Citizen science volunteering

A small group of astronomy researchers working with thousands of citizen scientists to identify and classify high resolution images of galaxies. The use case demonstrates the simple incentive models that can be used to engage large communities of non-academic researchers in the service of scientific research as well as in the training of machine learning AI systems for large data sets.

UC07: Višnjan Observatory: Citizen science NGOs

As a member of the International Asteroid Warning Network (IAWN), Visnjan is amongst the top five observatories in the world in collecting more near-Earth object (NEO) measurements to determine if they are a threat to Earth. Without these so-called follow-up and confirmation measurements the majority of newly discovered asteroids that are daily discovered mainly from Hawaii, would get lost in a day or even in a matter of hours. Measurements are taken to ascertain if the discovered object is really there, calculate its trajectory and verify whether it is a potential threat. Višnjan is a member of Spaceguard Foundation, an association that supports the creation of a system to discover celestial bodies which could potentially be a threat to life on Earth. The use case demonstrates the impact and scientific gravitas of citizen science projects that exist outside academia and the potential for recognition and support through non-monetary incentivization mechanisms and acknowledgement.

UC08: INFRAEOSC: PaNOSC

Contribution to the realisation of a data commons for Neutron and Photon science, providing Open Data services and tools for data storage, analysis and simulation, for the many scientists from existing and future disciplines using data from photon and neutron sources. This use case demonstrates the potential for innovative SME bridging organisations to translate large amounts of specialist scientific data to meet the needs of industry research and product development, and the potential for new markets to emerge based on European research.

UC09: Industry OntoCommons: Siemens Complex Equipment

Describing and analysing the digital twin of products/industrial assets in manufacturing and energy industry across their lifecycle from design to service based on lT systems. This use case demonstrates the importance and centrality of FAIR data in industry and the potential for EOSC to act as a Web of FAIR data in a context within which Industry is developing ontological interoperability.

UC10: BDVA: ICE Datacenter i-Space

The ICE Datacenter Gold i-Space provides testing in a flexible full-scale datacenter - without large scale investment, with access to massive amounts of research data and with an on-call team of world-leading scientists who can contribute to an organisation’s innovation activities. The Green Computing use case, along with space data and other types of datasets, demonstrate the potential for Industry engagement with e-Infrastructures and a model for working with large research datasets for the private sector.

UC11: Human Rights Data: Cambridge Whisper

Collection and processing of highly sensitive and confidential data through interviews with refugees about their personal experiences of human rights abuses. This use case demonstrates the potential

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for unique tools that build upon the EOSC framework and portal, allowing for specific scenarios with software requirements that model best practice in the tools themselves.

UC12: Neural Networks: Dadabots

Intellectual property challenges in creative application and content creation building on neural network processing of large data sets including musical recordings. This case study underlines the importance of consulting with outside stakeholders to understand the transfer of research data to commercial applications and how that manifests in public use, particularly with respect to Intellectual Property and Copyright. It also underlines that use cases are very important for understanding specific aspects of data use within the European Context. For instance, this example grapples with Fair Use law in the US which does not apply in Europe.

UC13: Accessibility and the Arts: Drake Music

Creation of first Accessible Musical Instrument Collection (AMIC) to address the need to provide a focal point for the large community of Disabled musicians, instrument developers and researchers. This use case demonstrates a need for a cultural repository and toolkit for building accessible and usable research outputs for civil society. Many small breakthroughs in academic research are not given the technology transfer support they need and so projects that have a real world application may struggle to find their potential users, whose needs are addressed by that research.

UC14: Music Technology and Sonification

Higher education in Sonification practices to teach students to reveal or create meaning through the communication of data through sound. This use case demonstrates the potential for EOSC data to be the open platform on which critical education in data science, art and communication can be built.

UC15: AI-assisted Recommendation for Sustainable Products

Creation and training of an informed recommendation engine to help consumers make sustainable choices, built on a wide range of data sets from a multiplicity of disciplines. This use case demonstrates the industry's capabilities to address societal challenges as well as consumer needs, with the aid of publicly funded academic research and access to Open Data.

UC16: Training Data for Inclusive and Diverse Hacker and Maker Communities

Creative uses of data by hackers and makers to explore and communicate grand challenges such as climate change and levels of hope and fear reflected in social media. This use case demonstrates the creative and interpretive skill of the vast number of hackers and makers outside of academia for whom access to data and data services open up potential for new prototypes, new artistic expressions, new solutions to societal challenges and unanticipated ways of expressing and communicating through data.

UC17: UN and WHO Micronutrients Data

Analysis of the distribution and outcome of micronutrients for populations across different geographic and nutrition policy zones. This use case demonstrates the potential for public and private sector partnership to address grand challenges through access and contribution to Open Data and e-Infrastructure services.

UC18: Climate View: Transitional Targets

Creation and monitoring of transitional targets as a method of maximising impact of climate initiatives in cities around the world. This use case deploys 95 different indicators, calculations, validations and best practices to be tracked and shifted in order to reach the optimal path toward reaching local

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abatement goals. This use case underlines the potential for external organisations and initiatives to interact with open science in order to innovate new solutions to important issues.

UC19: Volvo: Autonomous Vehicles

Electric vehicles are significantly more likely to cause low speed accidents involving pedestrians and cyclists. To avoid this, regulations have been developed that vehicles must emit sound at a certain volume in order to maintain a safe city for all (including hearing-impaired citizens). However 1.6 million 'healthy life' years are lost in European cities due to noise pollution, and especially traffic. This industrial research project draws on a wide range of scientific disciplines to investigate sonic communication, environmental acoustic properties and smart adaptation of frequencies and volume. The use case demonstrates the need for industry access to a wide range of knowledge and data from across a broad spectrum of knowledge domains, as well as a guide that will enable them to locate the kinds of research data that will be of use to them.

UC20: Ocean Data

Navigating complex data sets and studies across a wide range of disciplines in the EU Oceans Mission in order to initiate agile and adaptive prototyping projects that give both citizens and industry the tools and autonomy to engage with and respond to a richer understanding of seas and oceans. This use case demonstrates the potential for academic research to engage with citizen users in order to collaboratively address local challenges as well as those that affect industry and the environment.

UC21: Neurofeedback Patient Data

Clinicians collect and process large amounts of patient data from EEG Brainwave monitoring. There are significant challenges in storage and analysis of this data and enormous potential for anonymised data sharing that would reveal larger patterns and more nuanced understanding. This use case highlights the potential for EOSC to act as an intermediary Web of FAIR Data verification platform between non-academic professional researchers.

UC22: Wavefier

Industrial collaboration project that embedded an SME in a European funded academic research project about gravitational waves that not only unlocked value for the SME but also significantly contributed to the results, usability and impact of the research. This use case demonstrates the value of connecting academic research and data to external private organisations in collaboration with academic researchers, and that organisations outside of academia can contribute at a very high level to the research process itself, and not simply act as recipients and users of research results.

UC23: bloXberg

Independently initiated agile blockchain infrastructure from the Max Planck Institute for registering provenance and tracking Intellectual Property in the domain of academic research data. bloXberg provides certification of research data and a peer review system - with over 40 research institution members across 21 countries already utilising the platform. This use case demonstrates the potential for academic research to verify and correctly attribute the research findings on a tracked and timestamped basis, allowing for the creation of verificable incentive programmes for researchers within and outside of academia.

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Expected impacts

Table 1: Amplified Use Cases – expected impacts

#	Use Case	Economic Impact	Societal Impact	Knowledge Production
UC01	**SME business use case with Copernicus data**	Already high impact economically, outside of EOSC ecosystem	Potential for high societal impact in areas of resource management	High potential impact: creation of a knowledge layer on top of existing available open data
UC02	**Cross-domain data for medical prosthetic implants**	Cost reduction implications for public health / high potential economic impact for private medicine	Very high societal impact on patient health, wellbeing and mobility	Pedagogical impact and professional development
UC03	**Pan-EU open media applications (EBU);**	Added value applications built on top of European broadcasting services	High societal impact due to EU-wide access to trusted news in local languages	Develops an informed populace and contributes to trust in science
UC04	**Covid-19 (as per SRIA);**	Economic impact of public health and safety	Addressing the global pandemic with connected knowledge	Medical research as well as broader understanding of social aspects of public health issues
UC05	**Apollo in Real Time (NASA);**	Potentially significant for the citizen scientist concerned, ability to build commercial layers on top of infrastructure	Contributes to public understanding of scientific endeavour	Documentary feature and pedagogical material already created with further internal NASA research underway
UC06	**Galaxy Cruise citizen science project (National Astronomical Observatory of Japan);**	Considerable cost reduction and time saving in training AI systems	Citizen engagement in grand scientific challenges	Contribution to academic research from citizen scientists
UC07	**Citizen scientist collectives (Visnjan Observatory);**	Contributing to funded academic knowledge production and knowledge economy	Regular contribution to school and undergraduate education	Identification of previously unknown asteroids and planetary objects in space

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#	Use Case	Economic Impact	Societal Impact	Knowledge Production
UC08	**PaNOSC;**	Deployment of PaNOSC results for commercial use	Contribution to societal challenges through practical application of scientific discovery	Greater application of research knowledge to wider domains
UC09	**OntoCommons cross-domain interoperability;**	Creation of new markets and products through potential hybrid development with interoperable industries	Addressing global challenges through commercial innovation	Transfer of knowledge across industry domains
UC10	**Green computing at the ICE Datacentre (RISE BDVA i- space);**	Provision of commercial supercomputing and storage services	Development of green computing	Advancement of data science
UC11	**Human rights data and privacy systems (Cambridge University);**	Assisting in the integration of refugee communities as economic actors	Addresses human rights abuse and privacy issues in refugee social justice	Contributes to knowledge about refugee management and human rights abuses
UC12	**Neural network intellectual property challenges;**	Creation of new creative works	Evolution of Intellectual Property and authorship in a new technological paradigm	Contribution to knowledge of neural networks and AI; understanding of creative works and creativity
UC13	**Accessible musical instruments data (Drake Music charity);**	Entrepreneurial opportunity for customised Accessible Music Technologies	Access to creative expression and participation for those excluded by traditional musical instruments	Collection and archiving of disconnected research area
UC14	**Sonification of data in education (NTNU);**	Graduates trained for future occupations that extract value from data	Greater public understanding of the meaning of data sets that affect them	Communication of the value, content and meaning of data
UC15	**Cross-domain data for sustainable products (Axel Johnson);**	Customised AI recommendation for sustainable products in retail applications	Promotion of sustainability in consumer choices in circular economy	Inclusion and wider application of cross-domain research knowledge in knowledge transfer

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#	Use Case	Economic Impact	Societal Impact	Knowledge Production
UC16	**Social media sourced climate data by hacker/maker communities;**	Potential impact on economic behaviour in use of clean energy / circular economy products	Considerable raising of awareness of the effects of climate change	Contribution to public knowledge by adding a meaning layer to data sets
UC17	**Project on nutritional data by UN;**	Redistribution of economic power between food production and nutrition	Healthier population and better nutritional choice in developed world	Greater understanding of nutrition, nutritional choices and impact on health
UC18	**Data for monitoring of Transitional Targets (ClimateView)**	Focuses spend of public funds on achieving effective transitional targets	Clean cities and higher impact on climate progress toward the green deal	Considerable contribution to the understanding of effective climate action
UC19	**Self-driving vehicles data challenges (Volvo);**	Revolutionising the automotive industry with new and profitable product lines	Contribution to clean, connected, safe and societally friendly transportation	Building a cross-domain pool of knowledge for autonomous vehicle development
UC20	**EU Oceans Mission (Vinnova)**	Reducing negative economic impact of oceanic pollution on agriculture and fisheries	Inclusion of local citizens in action and knowledge creation around oceanic pollution	Shared knowledge creation between industry, citizens and public sector
UC21	**Neurofeedback clinical patient data**	Greater productivity for clinicians and development of new treatments	Improved wellbeing and mental health therapy methodologies	Exchange of knowledge between clinicians and research groups
UC22	**SME application for gravitational waves research (Wavefier)**	Increase in SME data-driven commercial applications	Removes barriers between academic research, commercial domain and wider society	SME contribution to research and knowledge creation
UC23	**Registration of IP for academic research (bloXberg)**	Potential to build value-adding commercial applications as a result of knowledge transfer from research	Considerable speeding up of the ability to address grand challenges through early availability of IP	Considerable speeding up of knowledge dissemination

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Evolved Models and Solutions

The models and solutions proposed were developed iteratively following continuous feedback and suggestions received throughout the interview process. In some interviews, stakeholders had very clear and well-articulated ideas of how EOSC could address their needs and create a sustainability model for their use case. In each instance, the newly discovered model was then incorporated into the subsequent interviews to gather further feedback and refine the suggestion.

The evolved Models and Solutions are summarised below and mapped in terms of stakeholder type and sustainability models in Table 2: Models and Solutions - types of stakeholders and Table 3: Models and Solutions - sustainability strategies.

Sustainable value chains

Several value models for knowledge exchange and solutions for sustainable value chains have been included:

- Expanding EOSC Knowledge Circles
- Public funding of EOSC Services through cascading voucher scheme to external organisations
- Modes of engagement of wider civil society
- EOSC as platform for the European Citizen Science Association
- Public Service Media' metaphor for EOSC (BBC for Open Science)

Expanding EOSC Knowledge Circles

Through European project consortia, existing networks and even within the EOSC Secretariat and Working Groups, representatives of Industry, SMEs, public institutions and other stakeholders outside of academia already have close connections with EOSC. This strategy proposes expansion through the knowledge circles shown in Figure 3: Expanding EOSC Knowledge Circles strategy building on the EOSC Competence Skillset. The network effect can be successfully achieved by giving each new circle the information, incentive and, above all, the updated technological framework that they require to act as ambassadors for EOSC in their domains.

Cascading voucher scheme to external organisations

Throughout the study, we received suggestions of voucher schemes for public funding that would provide external stakeholders with the purchasing power to incentivise competitive and high quality offerings as well as usable and user-friendly interfaces. The aim is to establish habitual practices and workflows within industry and SMEs, that incorporate the EOSC e-Infrastructures. However, difficulties with this idea have also been highlighted, primarily concerning cross-border transactions and varying levels of VAT. Tokenisation is suggested as a possible option, since it allows for non-monetary value to be exchanged without additional complexity. Tokens are analogous to currency within the confines of the system, though the terms ‘money’ and ‘currency’ are typically avoided as they suggest that the value tokens are freely convertible to legal tender, which is not the case and would re-introduce cross-border and VAT complexity. Tokens or virtual access credits have also been discussed in other documents, such as the EOSC Core Study. This model allows for value at the point of reimbursement to reflect local funding levels and regional cost differences.

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Modes of engagement of wider civil society

Several methods and incentives for connecting with wider civil society through communication outreach have been identified as well as compelling reasons for EOSC to adopt a leading role in this domain. Public trust in science and the proliferation of fake news and conspiracy theory have had an extreme impact on the global political ecosystem, and scientific research (and especially national scientific research funding) is not immune to the changing conditions that result from this atmosphere of mistrust. Modes of engagement have been Identified through associations or collectives actively engaging with EOSC services (UC07), volunteer researchers for large-scale data projects (UC06), and students and audiences who benefit from disseminated knowledge from EOSC (UC05, UC13, UC14).

EOSC as community engagement platform for the European Citizen Science Association

Engagement of citizen scientists provides a multiplier effect both for research teams who have a use case for outsourceable data verification to large groups requiring minimal rudimentary training, as well as for AI machine learning systems that can process big data sets but require a significant quantity of high quality models on which to base their analysis. Instead of each individual research project using its own communication skills and networks to seek out groups of citizen scientists, EOSC can provide a community portal that brings together potential citizen science projects together with the European Citizen Science Association (ECSA) and their EU project initiatives[9]. This would allow projects to connect with and recruit teams while also helping to communicate and engage the wider public with science.

Public Service Media' metaphor for EOSC

EOSC's overarching philosophy and mandate should be aligned with other 'public good' frameworks and entities - in particular with the ethos and guiding principles of national public media services. In this respect, EOSC would be comparable to a 'BBC for Open Science', focusing on addressing market failure, supporting the communication of scientific research, addressing inequality, ensuring the public benefit of scientific research, representing a diversity of viewpoints, ensuring that science was not subject either to political or commercial behest, and that in its dealings with broader public and private stakeholders that its primary duty of care is to the welfare and public benefit of European citizens and the UN Sustainable Development Goals.

Innovative research incentivisation models

The study has incorporated innovative research incentivisation models that respond to the new digitally-mediated Open Research context, using indicators that measure Open Science behaviours as well as indicators that assess and demonstrate the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour:

- Public funding of FAIR data: Findable, Accessible, Interoperable, Reusable
- JUST data creator/user: Judicious, Unbiased, Safe, Transparent
- FAIR / JUST data evaluation in EOSC as a basis for non-academic knowledge exchange

FAIR data: Findable, Accessible, Interoperable, Reusable

FAIR data is the central pillar for EOSC's role in European Research. FAIR scores also have the potential to provide non-monetary incentives for researchers by allowing data sets to act as analogous to peer-reviewed article publications and citations, and be used for promotion of research results and inclusion in researchers' CVs. Despite much discussion about the details of what FAIR means in

[9] See the list of ECSA's current projects on https://ecsa.citizen-science.net/projects/

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practice, stakeholder feedback suggests that FAIR should be evolved *through use*, and refined according to an increased pool of diverse use cases.

JUST research annotation by data creator/user: Judicious, Unbiased, Safe, Transparent

In addition to having the qualities of being Findable, Accessible, Interoperable and Reusable, we have suggested to stakeholders that researchers ought to annotate data sets by considering trustworthiness of the data sources, highlight any known bias, ensure that privacy of data has been preserved where sensitive issues are at stake or where stakeholders have recommended it, and that the researcher can account reliably on data provenance. We created a memorable acronym to make this researcher's responsibility easy to pair with FAIR. The acronym JUST, proposed to stand for Judicious, Unbiased, Safe and Transparent, is not meant to be understood literally, and quantitative values are not required to be attached to each term. Instead, it is a reminder to annotate the dataset as thoroughly and as responsibly as possible by the researcher, and to pass relevant and important information about data collection or derivative research to fellow researchers who will then use it as basis for further studies.

For example, while stakeholder feedback indicates that data itself cannot be 'unbiased', it is possible to mitigate against the effects of data bias through annotation and documentation that describe the conditions and context of the data collection and the ways in which that data has been applied. This approach has received overwhelming support by both broader and core EOSC stakeholders during our study. Suggestions followed that accountability and annotation ought to be standard not only for a "JUST researcher", but also data from regional councils and large research organisations. Ensuring widespread responsibility and accountability for how data is gathered and presented may be crucial in situations where individual responsibility is hidden in large organisations.

If it is considered that an evaluation or verification of JUST research and data use practices is desirable, then a minimum implementation level for JUST accreditation is simply that a data collector must provide documentation providing context and addressing issues of provenance, privacy, security and ethical considerations. Lacking specific and contestable criteria, it is sufficient as a starting point, that the documentation exist and for that consideration to have occurred. Likewise, for a data user to be assigned JUST accreditation, annotation should be provided that expands upon the original documentation and outlines the ways in which the data has been deployed, with respect to those same considerations. Documentation and annotation standards should be designed in such a way that they are, at minimum, machine-readable in addition to providing narrative context.

FAIR / JUST data evaluation in EOSC as a basis for non-academic knowledge exchange

Feedback from the stakeholders interviewed suggest that EOSC's USP as the "Web of FAIR data" extends beyond the FAIRification of scientific research data. There are significant use cases in which data would be shared between external public and private sector organisations (especially in the use case of actively researching clinicians) that is currently not being shared because the data is not trusted. By providing FAIR verification (or 'FAIRification') as a service, and by ensuring JUST annotation is implemented by participating researchers, EOSC becomes a central hub in an exchange between external stakeholders that might otherwise not make use of the EOSC e-Infrastructures. As the Web of FAIR data, several industry stakeholders have suggested that EOSC services that allow for 'FAIRification' of industrial data sets would be welcome as a trustworthy standard that underpins industrial data exchanges.

In addition to FAIR Data, FAIR principles should be applied across the board to support knowledge exchange between domains, industries, organisations and individuals through the support and flourishing of Open Education. EOSC's Web of FAIR Data can be extended to a Web of FAIR knowledge

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that allows for easily accessible, findable and shareable online curricula and short courses. In addition, to support the professional and lifelong learning that results from these Open Learning resources, Open Standards are to be encouraged, in a context enabled by Open Policy which takes ideas from the grass roots and introduces them at the highest levels. Calls for public submissions on policy issues are not in themselves "open" but activities that include key stakeholders and early adopters in new areas (eg: AI applications) should have their knowledge ported into the development of policy that directly impacts upon them and the effect of which they will see clearly before others.

Cross-domain research and business models

EOSC is in the position to enable cross-domain research and business models for both industrial use and grass roots experimentation with data from multiple domains, to attract wider private and public stakeholders to the EOSC platform:

- Dynamic multimodal tools for online collaboration
- Cross-domain applications harmonising ontologies/interoperability standards
- Cross-domain services alignment ensuring FAIR and cross-domain e-infra reach
- Exchange of datasets and algorithms for data processing in collaboration between outside professional practitioners and academic research centres

Dynamic multimodal tools for online collaboration

At present researchers wishing to collaborate on projects that use data sets are forced to use a variety of tools to collaborate – from Zoom to Slack, Google Docs, Discord, Github and other (primarily US) tools for communication and collaboration. This is especially true of young researchers who often feel restricted by the cautious IT infrastructure of their institutions and so adopt unauthorised but necessary and agile methods to accomplish their goals. A recommendation to build an EOSC front end that not only enables, but prioritises multimedia synchronous communication and data sharing and processing tools on top of the EOSC framework and portal has been seen by stakeholders as a great incentive for engaging regularly with the EOSC platform, and also for stimulating further cross-disciplinary and international research. This approach can also become the primary front-end mechanism for accessing e-infrastructure services as shown in 'Creation and provision of value-added toolkit of EOSC services and applications built on top of online collaboration tool'.

Cross-domain applications harmonising ontologies/interoperability standards

By collaborating with the OntoCommons CSA which launches in November 2020, EOSC has the potential to facilitate industrial demonstrators that combine data across multiple knowledge domains with FAIR data certification, while benefitting from data interoperability and standardisation resulting from the development of the cross-domain ontology translation framework for the Industry Commons. This combination of FAIR and semantic cross-domain interoperability, opens the possibility for hybrid innovation based upon diverse data sets from multiple domains of both research and industry.

Cross-domain services alignment ensuring FAIR and cross-domain e-infra reach

While there are use cases that would benefit from a combination of multiple EOSC e-Infrastructure services, there is currently no mechanism to bundle recurring use cases which require the same workflow from multiple services. Through joint agreements between complementary e-Infrastructure services, external users who would otherwise have to search for individual services, are incentivised to use more than one EOSC service at a time. Bundling could be responsive to patterns of usage and facilitate 'upselling' that would contribute to EOSC sustainability.

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Exchange of datasets and algorithms for data processing between outside professional practitioners and academic research centres

A category of external stakeholders broadly overlooked by the discrete categories of Industry, SME and Citizen Scientist is that of professional researchers and clinicians. Those who have emerged from the academic sector and now operate a professional practice collecting and applying big data in their practice, do so without the analytical support infrastructure of a research institution. By providing a bridge between external professional practitioners and academic research using FAIRification of data as condition of participation, professionals can benefit from better data processing algorithms, while European researchers can make a significant contribution to e.g. patients of specialist clinicians to and society at large.

Value adding services

The following models encourage further development of value adding services for data, creation of novel data sets, new categories and fields of knowledge, with contributions including citizen scientists, independent developers, startups and ICT SMEs:

- Extracting value from Data: e.g. modelling, processing, comparative applications, simulating, visualisation, sonification etc.
- Directory / matchmaking with data librarians / curators: research domain experts who can provide guidance for commercial organisations
- Creation and provision of value-added toolkit of EOSC services and applications built on top of online collaboration tool
- Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure (eg: AirBnB for compute services)

Extracting value from Data: e.g. modelling, processing, comparative applications, simulating, visualisation, sonification etc.

The platform model of engaging SMEs, developers and researchers in building applications and extracting additional value from data has been proven in countless App Stores. For EOSC, receiving 10-20% of any revenue generated by the application developers in a busy applications marketplace would guarantee long term sustainability. However stakeholders have been careful to point out that this model requires a thriving marketplace, and in order to build a critical mass of apps developers, the platform would have to go through a phase of trial and error. Questions have been raised about the motivations for joining such a platform by SMEs who are already successfully capitalising from publicly available data. Challenges of market platform scaling have been discussed in the EOSC Core Study.

Directory/matchmaking with data librarians/curators: research domain experts who can provide guidance for commercial organisations

Several industry stakeholders have provided industrial use cases which require access to scientific research from across a wide range of domains, and particularly those related to the creation of AI recommender systems and autonomous systems (e.g. Axel Johnson and Volvo). Individual domain jargon and specific terminology used in metadata generates barriers for data findability across domains. Stakeholders have expressed the need to access curatorial assistance and data expertise from different domains. This suggestion aligns with the “Data Stewardship” concept mentioned in the EOSC Core Study. However, where the role of the Data Steward is to focus on the technical quality and care of the data along with best technology practice for data management, the Data Librarian/curator role focuses more on the human interface between users of data and the data sets themselves, assisting with locating, guiding, suggesting and connecting potentially relevant data on behalf of the

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user. The growing need for this category of specialist may become a regular skill in research institutions or evolve from independent consulting.

Creation and provision of value-added toolkit of EOSC services and applications built on top of online collaboration tool

This model combines the front end collaboration platform (as described in Dynamic multimodal tools for online collaboration), with value adding applications and access to e-infrastructures directly from within the platform. Dedicated applications for management of sensitive data (e.g. UC15) or services which cater for specific needs of a research domain, can make the EOSC dynamic collaborative front end the "go-to" platform for research with data for researchers with different needs.

Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure

In addition to collaboration platform tools and applications that provide extra functionality, third parties such as innovative European SMEs can be invited to optimise administrative efficiencies and maximise downtime for e-infrastructure services. For instance, an SME can manage an 'AirBnB for Compute services' with smart allocation of national computing resources to researchers who might otherwise have been priced out of the market. Profit made from exploitation of compute facilities downtime can be used towards EOSC sustainability.

Types of stakeholders

Table 2: Models and Solutions - types of stakeholders

	Use Case	Stakeholder category	Technology transfer path	Data volume
1) Value models for knowledge exchange and solutions for sustainable value chains				
Expanding EOSC Knowledge Circles (See Figure 3)	UC08 - PaNOSC value-added SME application for industry use	EOSC insiders with good contacts with broader communities	EOSC research data transferred to industry	large
	UC01 - Copernicus data on subscription to governments via the Sentinel Hub by Sinergise SME	bridging EOSC and SMEs; SMEs to governments, industry or citizen science communities	EOSC data transferred to governments, industry or citizen science communities	small to large
	UC09 - OntoCommons CSA cross-domain Siemens use case	EU consortia mixing EOSC with SMEs and industry	EOSC research data to industry	small to large

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	Use Case	Stakeholder category	Technology transfer path	Data volume
	UC04 - Covid-19 data; UC10 - Ri.se ICE Datacentre green computing; UC17 - UN Nutrition data; UC20 - Oceans data	connecting to national governments and global research initiatives	EOSC research data to governments and civil society	large
Public funding of EOSC Services through cascading voucher scheme to external organisations	UC11 human rights data Cambridge University Whisper system; UC12 neural networks IP; UC18 - Transitional targets for cities data; UC1; UC13; UC14; UC15; UC16; UC19; UC21	Private sector beneficiaries receive tokens to spend on EOSC services that are of direct value to them	EOSC data and services to private sector in a 'pull' modality rather than 'push'	small to large
Modes of engagement of wider civil society	UC07 - Citizen scientists NGO-run Visnjan Observatory	associations or collectives actively engaging with EOSC services	citizen science collectives to EOSC research communities	small to large
	UC06 - Galaxy Cruise Japan; UC16 - sonification of crowdsourced climate data from social media	volunteer researchers for large-scale data projects	citizen scientists to EOSC research communities	small to large
	UC05 - Apollo In Real Time NASA; UC13 - Accessible musical instruments data Drake Music and Arts Council England; UC14 - education programs in data sonification NTNU	students and audiences who benefit from disseminated knowledge from EOSC	EOSC knowledge transfer to broader education	small to large
EOSC as Community Engagement Platform for the European Citizen Science Association	UC05 - Apollo In Real Time NASA; UC06 - Galaxy Cruise; UC07 Istria Observatory	Academic researcher units in collaboration with citizen scientists	research to citizen scientists / citizen scientists to research	from small select data to large volume data pro-cessing

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	Use Case	Stakeholder category	Technology transfer path	Data volume
Public Service Media' metaphor for EOSC (BBC for Open Science)	UC05 - Apollo In Real Time NASA; UC06 Galaxy Cruise	EOSC e-infrastructures, researchers; industry and international citizen science initiatives	research to industry and civil society	large
2) Potential innovative research incentivisation models that respond to the new digitally-mediated Open Research context, using indicators that measure Open Science behaviours as well as indicators that assess and demonstrate the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour				
FAIR data: Findable, Accessible, Interoperable, Reusable	ALL: evaluation / ranking of each dataset according to ease of operation and quality of metadata/formats	ALL	All TTs	high
JUST data creator/user: Judicious, Unbiased, Safe, Transparent	ALL: societal/ethical awareness indicators for each data creator/user which incentivise trustworthiness, inclusion, privacy, and disclosed provenance	ALL	All TTs	high
EOSC in charge of FAIR / JUST data evaluation for non-academic knowledge exchange	UC21 neurofeedback professional clinical therapy data	private sector	industry/SME to industry/SME; research to industry/SME	small to large
3) Enabling cross-domain research and business models for both industrial use and grass roots experimentation with data from multiple domains, to attract wider private and public stakeholders to the EOSC platform				
Dynamic multimodal tools for online collaboration	UC14 - education programs in data sonification NTNU; UC21 - neurofeedback professional clinical therapy data	Academic researchers in collaboration with ALL	knowledge transfer of research to innovation, industry and civil society	very high bandwidth and CPU combined with high volumes of data

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	Use Case	Stakeholder category	Technology transfer path	Data volume
Cross-domain applications harmonising ontologies/interoperability standards	UC09 - OntoCommons CSA cross-domain Siemens use case; UC15 - cross-domain research data for sustainable products	OntoCommons industrial research stakeholders in collaboration with EOSC and RDA research stakeholders	value adding data applications connecting research and industry	large volumes of data
Cross-domain services alignment ensuring FAIR and cross-domain e-infra reach	UC02 - medical data, 3D modelling data and design services, and additive manufacturing for emergency prosthetic implants	EOSC e-infrastructures services and beneficiaries	research services to innovation, industry and civil society through e-infrastructure clusters	alignment of select datasets
Exchange of datasets and algorithms for data processing between outside professional practitioners and academic research centres	UC21 - neurofeedback professional clinical therapy data	Academic researcher units in collaboration with professional practitioners	professionals to research; research to professionals	large - raw data sets; medium - processed data sets extrapolated to create meaningful information; small - interpreted metrics
4) Models which encourage further development of value adding services for data, creation of novel data sets, new categories and fields of knowledge, with contributions including citizen scientists, independent developers, startups and ICT SMEs				
Extracting value from Data: e.g. modelling, processing, comparative applications, simulating, visualisation, sonification etc.	UC01 - Copernicus data on subscription to governments via the Sentinel Hub by Sinergise SME	existing value-adding SMEs using EOSC data	open data from research to SME; SME platform to governments, developers and industry	from small select data to large volume processing
	UC03 - pan-EU media applications EBU. UC22 - Wavefier SME collaborating with academic research	SMEs providing value adding applications	aggregated data from a variety of service providers to SME	from small select data to large volume processing

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	Use Case	Stakeholder category	Technology transfer path	Data volume
	UC08 - PaNOSC value-added SME application for industry use	needed SME involvement to enable service	research to SME; SME to industry	from small select data to large volume processing
Directory / matchmaking with data librarians / curators: research domain experts who can provide guidance for commercial organisations	UC15 - cross-domain research data for sustainable products; UC19 self-driving vehicle data Volvo; UC10 ICE Datacentre green computing	private sector stakeholders with expert research community	research to private sector	targeted information
Value-adding toolkit of EOSC services and applications integrated with the online collaboration tool	UC11 human rights data Cambridge University Whisper system; UC03 EBU instant translation	Private sector and academic units providing core tools	SME to research / research to research	small to large
Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure (eg: AirBnB for compute services)	UC12 - neural networks, UC03 Open Media	SMEs providing value adding applications	SME to research / SME to industry	large

Sustainability strategies

Table 3: Models and Solutions - sustainability strategies

	Economic model	Societal impact	Challenges	Timeline
1) Value models for knowledge exchange and solutions for sustainable value chains				
Expanding EOSC Knowledge Circles (Figure 3)	VALUE CHAIN MODEL: UC08 leading to applications of research in business; novel business models in EOSC marketplace	increased technology transfer from research to industry	opening up opportunities for SMEs to build applications for research	Short-term, can be incentivised through INFRAEOSC-3

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	Economic model	Societal impact	Challenges	Timeline
	VALUE CHAIN MODEL: UC01 good business evangelist candidates for EOSC, especially when combined with profit models in 3) and 4)	greater popularisation of science with industry and broader populations	opening up EOSC data marketplace for SMEs to build applications	Already deployed
	VALUE CHAIN MODEL: UC09 greater technology transfer opportunities from research to industry	increased scientific collaboration and cross-fertilisation of knowledge	clear IPR accountability / tracking model	Short to medium term, demonstrators planned 2020-2023
	VALUE CHAIN MODEL: UC04, UC17, UC20 increased science funding by national governments and bodies	greater government engagement and popularisation of science	engaging national governments	Medium term (requires standardisation and coordination of national data sets)
Public funding of EOSC Services through cascading voucher scheme to external organisations	VALUE CHAIN MODEL: establishment of work flows and practices that build a culture of use of EOSC services which are of value to external stakeholders	greater dissemination and deployment of EU research in industry and society. Streamlining and efficiencies for EU funding directly to e-Infrastructures through tokenisation	EU funding rules, individual country VAT	Short term (subject to identification of funding mechanism), can be tested through INFRAEOSC-03
Modes of engagement of wider civil society	VALUE CHAIN MODEL: UC07 greater alignment of institutions and bodies in the contribution to science; greater institutional investment overall	increase in problem solving and addressing grand challenges	funding inclusion of NGOs and independent science associations	Short term (subject to policy of inclusion)
	VALUE CHAIN MODEL: UC06 greater results with greater distribution of time and effort	greater volume and increased quality of scientific results	promotional reach; access to large numbers of people	Short term (subject to policy of inclusion)

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	Economic model	Societal impact	Challenges	Timeline
	VALUE CHAIN MODEL: UC05, UC13, UC14, greater dissemination and public understanding of science brings greater funding from national governments and bodies	educational impact on millions of people	funding of valuable initiatives	Long term (subject to front end readiness and public engagement strategy)
EOSC as Community Engagement Platform for the European Citizen Science Association	VALUE CHAIN MODEL: access to citizen scientist to engage in research projects eg: for AI training sample sets	multiplier effect for public engagement in science; build trust and understanding of science	community engagement, moderation and management	Medium term (can be implemented through a CSA or a call in INFRAEOSC-3)
Public Service Media' metaphor for EOSC (BBC for Open Science)	PROFIT MODEL: commercial syndication of core services and content to US and beyond	Focus on public communication of science within Europe; broader international reach of European scientific research, contribution to global knowledge with immediate benefits to European citizenry and content widely available to EU universities in contributing countries	establishment of syndication infrastructure and cross border partnerships	Long term strategy
2) Potential innovative research incentivisation models that respond to the new digitally-mediated Open Research context, using indicators that measure Open Science behaviours as well as indicators that assess and demonstrate the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour				
FAIR data: Findable, Accessible, Interoperable, Reusable	VALUE SYSTEM: a new economic value system for industry, based on values from the research community	greater data availability for solving grand societal challenges	the means of evaluation	Short term (FAIR should be refined through use)

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	Economic model	Societal impact	Challenges	Timeline
JUST data creator/user: Judicious, Unbiased, Safe, Transparent	VALUE SYSTEM: a new value system for commerce, based on societal, environmental and human values	impact on trust, inclusion, security and transparency in society	the means for evaluation e.g. based on documentation and annotation of data set and its application	Short term (JUST should be refined through use)
EOSC in charge of FAIR / JUST data evaluation for non-academic knowledge exchange	VALUE SYSTEM (CAN EVOLVE INTO PROFIT MODEL): verification and evaluation platform for assessing that data is FAIR and JUST as bases to commercial data market	increased business innovation, sector support (eg: anonymised medical data)	Assessment of the veracity of data and authority/trust worthiness of data providers and users	Medium term (subject to building a reputation in FAIRification; subject to sufficient resources)
3) Enabling cross-domain research and business models for both industrial use and grass roots experimentation with data from multiple domains, to attract wider private and public stakeholders to the EOSC platform				
Dynamic multimodal tools for online collaboration	PROFIT MODEL: subscription to collaborative tool with free access to data; potential to bolt on sophisticated on-demand services; EOSC marketplace	greater collaboration across stakeholder groups and domains	long term platform maintenance and governance	Medium term (can be implemented through a call in INFRAEOSC-3)
Cross-domain applications harmonising ontologies/interoperability standards	PROFIT MODEL: high volume of novel applications and business models; contribution to the platform at point of commercialisation; EOSC marketplace	considerable contribution to interoperability standards	EOSC marketplace maintenance and governance	Short to medium term, demonstrators planned 2020-2023
Cross-domain services alignment ensuring FAIR and cross-domain e-infra reach	PROFIT MODEL: services on demand by commercial organisations; EOSC marketplace	improved services; greater efficiency	funding a series of tests which join diverse e-infrastructures into a coherent offering	Short to medium term, use cases already exist
Exchange of datasets and algorithms for data processing between outside	PROFIT MODEL: research and data analysis / verification services on demand by professionals (e.g.	multiplier effect for e.g. professional clinical research by parallel data processing in	establishment of matchmaking and	Medium term (subject to basic data marketplace)

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	Economic model	Societal impact	Challenges	Timeline
professional practitioners and academic research centres	clinics); EOSC marketplace data and algorithm exchange	partnership with academic researchers; notable contribution of data to research	collaboration infrastructure	
4) Models which encourage further development of value adding services for data, creation of novel data sets, new categories and fields of knowledge, with contributions including citizen scientists, independent developers, startups and ICT SMEs				
Extracting value from Data: e.g. modelling, processing, comparative applications, simulating, visualisation, sonification etc.	PROFIT MODEL: UC01 payable or on subscription service; can be charged per volume of API use; EOSC marketplace	SME growth / economic impact; more solutions to societal challenges	why be part of EOSC marketplace when they can operate independently?	Already deployed
	PROFIT MODEL: UC03 classic app model where percentage can go to the platform; EOSC marketplace	greater knowledge access; commercial impact	apps require a thriving market to be sustainable	Medium to long term (can be tested through a call in INFRAEOSC-3)
	PROFIT MODEL: UC08 value adding payable or on subscription service; EOSC marketplace	increased business solutions and efficiencies	sufficient industry interest to make SaaS sustainable	Short-term, can be incentivised through INFRAEOSC-3
Directory / matchmaking with data librarians / curators: research domain experts who can provide guidance for commercial organisations	PROFIT MODEL: consultancy service matching industry with EOSC trusted experts to explain terminology and help access data sets	increased business solutions and efficiencies, faster knowledge transfer	creation of expert / researcher to industry matchmaking platform within EOSC	Long term (subject to development of skillsets; subject to established services)
Value-adding toolkit of EOSC services and applications integrated with the online collaboration tool	PROFIT MODEL: Additional incentivisation of subscription model by creating targeted functionality and usability	greater collaboration across stakeholder groups and domains	Core applications need to be broadly applicable	Lond term (subject to development of online collaborative front-end for researchers)

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	Economic model	Societal impact	Challenges	Timeline
Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure (eg: AirBnB for compute services)	PROFIT MODEL: maximisation of resource utilisation across e-infrastructures	increased effectiveness and efficiency within EOSC core e-infrastructure creating a multiplier effect for beneficial research	resistance to disruption of existing pricing and business models by 3rd parties	Medium to long term (can be tested through a call in INFRAEOSC-3)

Community Feedback

46 interviews have been completed with stakeholders from across sectors and have been transcribed in full. The semi-structured nature of the interviews has allowed to feed recommendations from early interviews into later consultations with EOSC stakeholders to solicit feedback on newly uncovered models and solutions (see details in the above Evolved methodology section). As planned, consultations with stakeholders have resulted in an expanded suite of potential frameworks, approaches and solutions to stakeholder engagement and sustainability models.

The broader EOSC stakeholders consulted include:

- 8 experts in Open Innovation working with governmental institutions
- 6 high level industry professionals
- 7 experts from academia, part of the broader research community
- 5 national and international research organisations supporting research and citizen science
- 7 members from the innovation community and innovative SMEs
- 13 EOSC stakeholders

For the full list of interviewed stakeholders, their affiliations, CVs and type, please see Appendix 2: List of broader EOSC community stakeholders interviewed.

Evaluation and Assessment

Analysis of the feedback has been performed according to categories of models and solutions, including marketplace considerations, sustainability, value creation and potential risks.

The interviews have been transcribed, coded and analysed and the outcomes presented to the Sustainability WG. Proposed solutions have been further refined in close collaboration with the Sustainability WG. A set of recommendations has been created for EOSC financial sustainability implementation and expansion of EOSC with engagement of the wider public and private sectors.

Stakeholder feedback and resulting recommendations have been analysed using a SWOT and Media Tetrad analysis of the proposed solutions. The tetradic approach applies the term ‘media’ broadly to include technologies, artefacts, interfaces, legislation, and scientific theories. The method explores and reveals four key effects of the new medium: Retrieval, Obsolescence, Enhancement (or Amplification), and Reversal[15] (see Figure 1: The Media Tetrad approach).

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SWOT Analysis

Table 4: Models and Solutions - SWOT Analysis

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
1) Value models for knowledge exchange and solutions for sustainable value chains				
Expanding EOSC Knowledge Circles (See Figure 3)	Evangelism and word of mouth organic expansion and uptake of EOSC	Relies on technology readiness to move to the next knowledge circle	Unexpected use cases and recommendations of potential users by word of mouth	Technology may not be ready to go to the next level of expansion, leaving potential users frustrated and disappointed.
Public funding of EOSC Services through cascading voucher scheme to external organisations	Incentivises competitive service by e-infrastructures and removes VAT burden for funding recipients and EOSC users	Requires technological infrastructure including DLT (such as Blockchain)	Creation of new services and potential to uncover unanticipated use cases. Builds EOSC workflow in external organisation habitual practice.	Potential gaming of the system eg: lock-in and exclusivity of data provision for token payment that removes portability; secondary market created for token exchange for cash.
Modes of engagement of wider civil society	Public communication of science and engagement with scientific knowledge.	Requires communication, engagement and marketing infrastructure, funding and staffing.	Addresses public mistrust in science, and encourages scientific curiosity leading to greater engagement in STEM education and employment.	Investment in public engagement and communication potentially diverts important resources from EOSC Core activities
EOSC as Community Engagement Platform for the European Citizen Science Association	Connects existing European Citizen Scientists and collates CS projects. Offers an entry point to interested and potential Citizen Scientists.	No particular reason for a pan-EU Citizen Science Association to be specifically using EOSC.	Greater civic engagement with scientific research. Greater pool of citizen science volunteers to assist with research.	Risk of bad faith actors and requirement for intensive moderation.

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	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Public Service Media' metaphor for EOSC (BBC for Open Science)	Provides a strong basis for governmental funding of EOSC for broader citizen outreach. Over-arching ethical code of practice with a mission to make EOSC data and services broadly available for the public good.	Places focus on communication and advocacy rather than data services to researchers.	Engagement and creation of citizen scientists, broader public understanding of science and scientific literacy, creation of an educated and informed population.	Dumbing down of necessarily complex scientific research for communication to broader population.
2) Potential innovative research incentivisation models that respond to the new digitally-mediated Open Research context, using indicators that measure Open Science behaviours as well as indicators that assess and demonstrate the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour				
FAIR data: Findable, Accessible, Interoperable, Reusable	New knowledge can be easily built upon existing diverse data sets, thereby accelerating European scientific research and technology	Lack of agreement over specific definitions of Findable, Accessible, Interoperable and Reusable	Creation of FAIR verification as citation equivalent and incentive for researchers. Opportunity to develop FAIR scoring and licensing for reuse outside academia	Potential exclusion or disincentivisation of data categories that are not easily made interoperable or reusable, despite their inrtrinsic value as a standalone dataset.
JUST data creator/user: Judicious, Unbiased, Safe, Transparent	Ethical foundation for the use and re-use of scientific data and an assurance for 3rd party observers or potential data users that the creators of users of the data have been certified as JUST. Creates additional incentive for non-academic researchers to engage.	Interpretation requires significant agreement and complex and potentially opaque verification process that awards JUST status. System for annotation and documentation (both human and machine-readable) requires development.	European Researchers to have a certification and quality mark of JUST practices in research which could lead to a preference of European researchers for external organisations to partner with.	Potential exclusion of data sets - even those validated as FAIR - because of a bottleneck in JUST verification in order to be included in EOSC Core services.

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	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
EOSC in charge of FAIR / JUST data evaluation for non-academic knowledge exchange	EOSC as the trusted Web of Fair Data and in charge of the implementation of data validation processes for both commercial and research data. Provides EOSC with a strong USP.	Reluctance to release data for open sharing among competitors, even under FAIR and JUST conditions without appropriate IP licensing considerations.	Basis for collaboration with other European initiatives such as GAIA-X. In addition, a strong incentivisation system for both academic and external EOSC users to be validated and 'FAIRified'.	Risk of insufficient capacity to process high volumes of data FAIRification.
3) Enabling cross-domain research and business models for both industrial use and grass roots experimentation with data from multiple domains, to attract wider private and public stakeholders to the EOSC platform				
Dynamic multimodal tools for online collaboration	Attractive USP and interface for young data researchers looking for agile collaborative environment for data projects.	Requires the creation of a robust and compelling offering that improves on the combination of existing commercial (and largely US) platforms. Needs to be adopted because it is better than alternatives rather than through data lock-in.	Fast creation and execution of transnational and interdisciplinary research projects that engage stakeholders from across all potential user groups. Can be developed in collaboration with GAIA-X.	Risk of being poorly developed and seen as yet another communication platform that adds stress and clutter to the researcher's workflow.
Cross-domain applications harmonising ontologies/ interoperability standards	Creates an EOSC marketplace for cross-domain products, applications and services that add value to external stakeholders	Requires proof of concept for applications and services before establishing a higher quality offering over time.	Unanticipated innovation that can be built upon the hybridisation of different data sets from different domains. Sustainability model through app-store economic model.	Openness of EOSC data means that it is possible to provide hybrid applications that are built on EOSC data but made available on other platforms.

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	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Cross-domain services alignment ensuring FAIR and cross-domain e-infra reach	Creates pre-packaged solutions that bundle EOSC e-Infrastructure provisions for recurring use cases. User-friendly.	Requires strong partnerships and joint service agreements.	Streamlining of regular workflows. Reduced duplication.	Changes in partner status; partnership imbalances.
Exchange of datasets and algorithms between outside professional practitioners and academic research centres	Addition of valuable data sets for research collected by professional specialist practitioners (eg: clinical psychologists) in exchange for improved processing algorithms.	Imbalance of power between researchers with a public mandate to create scientific knowledge and independent researchers with a commercial incentive to exploit that mandate.	New collaborative research made possible based on real-world clinical and other professional data.	Risk of release of personally or commercially sensitive data. Potential for exploitation by international corporate interests.
4) Models which encourage further development of value adding services for data, creation of novel data sets, new categories and fields of knowledge, with contributions including citizen scientists, independent developers, startups and ICT SMEs				
Extracting value from Data: e.g. modelling, processing, comparative applications, simulating, visualisation, sonification etc.	Establishes EOSC as the 'app store' for data driven applications. Sustainability profit model for subscription or percentage paid to platform.	Apps require a thriving market in order for that marketplace to be sustainable.	Increased business solutions, addressing industrial and societal needs. EOSC becomes critical resource for SMEs bridging knowledge to industry.	Opportunity for SMEs to utilise publicly available research data and provide value-added applications without EOSC involvement.
Directory / matchmaking with data librarians / curators: research domain experts who can provide guidance for commercial organisations	Consultancy service offering matching of industry with trusted domain experts to explain domain terminology and help access and suggest data sets	Requires building of expert skillsets for various domain data curators.	Potential to initiate and guide new external projects that utilise EOSC data and services that contribute to platform sustainability.	Commercial bias of outside consultancies offering EOSC data expertise

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	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Value-adding toolkit of EOSC services and applications integrated with the online collaboration tool	Provides incentivisation of subscription model and value-added services by creating targeted functionality and usability for specific research use cases.	Adds a layer of complexity to the design if the front end.	Channel all e-infrastructure services through front-end portal. Extra income from independent SME-developed value-adding tools.	Insufficiently integrated services; poor selection of additional services; researchers migrating to more agile or well-developed platforms.
Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure (eg: AirBnB for compute services)	Maximise resource use and billable work for EOSC e-Infrastructures through managed allocation of service provision	Requires collaboration by potentially competing services for a single pool of users. Needs a technical and user interface design infrastructure.	Lowers the barrier to potential EOSC external users who can contribute to EOSC sustaibability.	Disinterest from individual nationally funded compute services to engage with additional users.

Tetradic Analysis

Table 5: Models and Solutions -Tetradic Analysis

	ENHANCES	OBSOLESCES	RETRIEVES	REVERSES
1) Value models for knowledge exchange and solutions for sustainable value chains				
Expanding EOSC Knowledge Circles (fig. 3)	Expansion of EOSC core community utilising the network effect through close and existing connections	The need for external communication and marketing strategy 'starting from scratch'	Collegial and collaborative research practices	Commercialisation of EOSC, erosion of research community ethics
Public funding of EOSC Services through cascading voucher scheme to external organisations	Competitive offer of EOSC Core services to attract tokenised funding and establish working practices within external stakeholder groups that normalise EOSC use.	Problematic / complex funding structures and cross-border taxation issues	User-focused and accessible high quality e-infrastructure services that are attractive to young academic researchers as well as external stakeholders	Potential focus on gaming the system to attract or maximise tokens and funding rather than rigorous and high quality provision. Style over substance.

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	ENHANCES	OBSOLESCES	RETRIEVES	REVERSES
Modes of engagement of wider civil society	Widespread public communication of the practice and impact of scientific research.	Obscuritanism and inaccessibility of public funded research.	Public trust in science and broader scientific interest	Dumbing down or oversimplification of legitimately nuanced and necessarily complex research outputs.
EOSC as Community Engagement Platform for the European Citizen Science Association	Collaboration between general public and scientific research. Leverages the crowd for identification of data to jumpstart AI training of large data set analysis.	The resourcing restrictions placed on scientific research units. Scientific research no longer purely the domain of the professional scientist.	Hobbyist research and the lifelong learning application of knowledge gained within academia that can be used once leaving that domain. Public engagement and ownership of scientific research.	Exploitation of free and cheap research and processing labour. 'Mechanical Turk'
Public Service Media' metaphor for EOSC (BBC for Open Science)	The role of academia as educator, critic and conscience of society. The place of the public intellectual. Public service ethos embracing FAIR and JUST research practices rather than led by commercial imperatives.	Scientific research silos, impenetrable 'ivory tower' nature of complex research data and results, and locking of research results away from the public in closed access subscription-only peer-reviewed journals…	Public trust in science, broader scientific interest and communication as a core role of scientific practice.	Popularity and social media metrics as indicators of success of scientific research.

2) Potential innovative research incentivisation models that respond to the new digitally-mediated Open Research context, using indicators that measure Open Science behaviours as well as indicators that assess and demonstrate the quality, value and potential impact of the research outputs in a way that incentivises open science behaviour

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	ENHANCES	OBSOLESCES	RETRIEVES	REVERSES
FAIR data: Findable, Accessible, Interoperable, Reusable	Creates a multiplier effect for existing and new scientific research data and a potential impact for cross-disciplinary work. Provides an incentive mechanism for data researchers	Research silos, repetition and redundancy in data gathering	Unlocks the value in existing data sets that may have otherwise been unusable in new contexts and in relation to other categories of data from other disciplines.	Validation and 'FAIR-ification' of non-academic data sets from industry and other external research enabling industry stakeholders fo share and build on each other's data. EOSC provides the independent assessment of data quality.
JUST data creator/user: Judicious, Unbiased, Safe, Transparent	Researcher and data user accountablity. Promotes European values and ethics in data privacy, security, representation and openness.	Data sets with thoughtless bias or the potential to be misrepresented in a biased way. Privacy conerns.	Documentation and annotation of archival and legacy data sets that might otherwise have remained unused due to ethical concerns. JUST mitigates against uncritical data collection and re-use.	CV incentivisation value similar to weight of citations. A 'JUST' researcher is more highly valued within and beyond academia
FAIR / JUST data evaluation in EOSC as a basis for non-academic knowledge exchange	Reputation and trust basis for similar organisations to safely share data with EOSC as an intermediary.	Data hoarding and competitive rivalry in domains that would benefit from a shared resource and knowledge pool on which new discoveries could be made.	Guilds and professional collegiate associations where knowledge and best practice are shared.	Brinksmanship. Willingness to participate only if competitor shares first with more valuable data.
3) Enabling cross-domain research and business models for both industrial use and grass roots experimentation with data from multiple domains, to attract wider private and public stakeholders to the EOSC platform				
Dynamic multimodal tools for online collaboration	Potential for rapid, agile and cross-disciplinary collaboration with remote colleagues or external partners	Makeshift and ad hoc amalgamation of commercial services that each provide part of the solution	"Yet another tool or messaging system that I have to use".	"Yet another tool or messaging system that I have to use".

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	ENHANCES	OBSOLESCES	RETRIEVES	REVERSES
Cross-domain applications harmonising ontologies/interoperability standards	Interoperable nature of digital data enabling hybridity and new research-led innovations that build upon the affordances of shared format media and platform agnosticism	Silos between knowledge domains.	Interdisciplinary experimentation and 'tinkering' leading to unanticipated discoveries. The role of the generalist in both academic and public intellectual life.	Data matchmaking and horizontal scanning across knowledge domains as a valued specialism in industry and research.
Cross-domain services alignment ensuring FAIR and cross-domain e-infra reach	Speed and agility of EOSC delivery, providing packaged solutions that bundle multiple e-Infrastructures for recurring use cases.	High bar to entry and steep learning curve for newcomers wishing to discover and combine available e-Infrastructure services.	Full service delivery as if by a single procurement provider.	Paralysis of choice: too many menu options that bundle EOSC services in a wide array of configurations.
Exchange of datasets and algorithms for data processing between outside professional practitioners and academic research centres	Leverages the unique field research strengths of external clinicians and professional practitioners and the analytical expertise of research institutions.	The disconnect between professional practitioners and the academic domain from which they have graduated.	Research and discovery as a joint venture between academia and professional practice.	Outsourcing of data collection for academic research to the professional sector.
4) Models which encourage further development of value adding services for data, creation of novel data sets, new categories and fields of knowledge, with contributions including citizen scientists, independent developers, startups and ICT SMEs				
Extracting value from Data: e.g. modelling, processing, comparative applications, simulating, visualisation, sonification.	Engagement of rigorous practice from across disciplines and sectors to unlock value from existing and new data sets in creative ways, revealing new affordances and enabling rich meaning creation.	Artificial barriers between art and science as modes of human discovery, knowledge and communication. Black box of unexplained AI and big data.	Imagination as a key driver and creativity as translator of research within, between and outside knowledge domains.	Scientific data as leaping off point for artistic expression that may have purely aesthetic outcomes (eg: sonification of space data)

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	ENHANCES	OBSOLESCES	RETRIEVES	REVERSES
Directory / matchmaking with data librarians / curators: research domain experts who can provide guidance for commercial organisations	Links between academia and industry for whom new challenges require guided access to deep knowledge from across a broad range of research disciplines. Technology transfer.	Industry R&D as sole driver of product development.	Public libraries. EOSC as a curated repository of human knowledge from which new ideas can be brought to life in the public domain.	EOSC e-Infrastructures as gatekeepers of scientific research.
Creation and provision of value-added toolkit of EOSC services and applications built on top of online collaboration tool	Ability for researchers to create collaborative, interdisciplinary and international teams for research projects within the EOSC ecosystem.	Discrete, non-standard and disconnected tools from commercial (usually US) providers.	Co-working in research units and laboratories with the correct tools and resources at hand.	EOSC collaboration platform and toolkit provides the template and range of affordances for all scientific research, narrowing diversity of results.
Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure (eg: AirBnB for compute services)	Technology transfer. Expansion of EOSC to industry through the bridge of innovative and agile SMEs. Productivity and economic value unlocked by maximising resources.	Poor allocation of expensive resources. High barrier to entry and restrictions on industry applications that could use the results if first processed and interpreted.	Efficiency and value for money of European funded e-Infrastructure services.	Separate commercial layer on top of EOSC e-infrastructures driving down prices and reducing profitability (cf: Online delivery services for Restaurants)

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Recommendations

Recommendations from this report are tied to direct and indirect sustainability models for EOSC, as outlined in Table 3: Models and Solutions - sustainability strategies.

Web of FAIR data

A key recommendation emerging from this study is that for EOSC to have the greatest impact and reach to external stakeholders it must establish itself as the Web of FAIR data as its primary USP. Validation and interoperability of data in knowledge transfer and technology transfer are key to its centrality in the application (and collection) of research data from beyond the realms of academia. Note that this also works in the clinical example as well as industry-to-industry and in all cases where SMEs could build innovation on top of existing data. It also provides an incentive and an imperative to make as much European research data as possible – both new and historical – available in this ecosystem. The expertise of FAIR-ification should be a standard for all European Marketplaces including GAIA-X, Industry Commons and the new planned EIC marketplace, thereby supporting EOSC's key role and future sustainability (see Alignment with EU marketplace initiatives).

Ensuring accountability for RRI

All interviewed stakeholders have welcomed solutions for responsible research which address both restricted data, biased data (most data is biased), and capture the ethical parameters for data sets that perhaps haven't originally been ethically processed. Our recommendation of a JUST system to be paired with FAIR, emphasizes accountability of the researcher or the research organization uploading data. Referring to the researcher or data provider as JUST (Judicious, Unbiased, Safe and Transparent) is not intended as a metric, and not to be quantified or interpreted literally, but rather a checklist to ensure that annotation and documentation about data provenance is provided, that any privacy and security concerns are highlighted, that any bias inherent in the data is flagged up, and that data can be deemed reasonably trustworthy. Establishing an annotation and documentation practice will in time bring forth examples of best practice, and could potentially lead to a number of standards for data annotation and documentation, especially in respect of annotation aspects which are to be included in metadata which is linked to data sets.

Quality vs fit for purpose

Data-driven applications are frequently low on risk, cheap to run, easy to understand and can get millions of early adopters, even as experimental proofs-of-concept. Early iterations of data-driven solutions (TRL3-6) may be technically imperfect, however they are adopted quickly when it is clear that they deliver a value service to communities and close gaps in emerging markets, which makes them already fit for purpose. Early adopters, who include the innovator community stakeholders interviewed in this study, and particularly young (and young-at-heart) researchers, developers and startups whose curiosity drives them to test novel solutions, have proven to be regular contributors of solutions and improvements for early application releases. The ethos has evolved from the Open Source community, where coming up with solutions is a matter of personal pride and accomplishment, while it allows to build knowledge and keep up with emerging technologies. Aside from perfecting their problem-solving skills, early adopters also acquire a sense of ownership of the platform to which they have contributed, and have an ongoing vested interest to help it scale. For this reason, inviting early adopters to co-create the EOSC platform can place EOSC much closer to emerging platform practice, and can create a multiplier effect through engagement of contributors who have a vested interest in its success.

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Another factor to take into account is that the measure of quality is relative to the individual ambition or a pre-set objective. If the objective is to achieve a high standard of deployment, which caters for multiple functions and user groups simultaneously, it may be difficult to decouple one element which does not perform according to the expected standard when it is already tightly embedded in the architecture. Involving early adopters at earlier stages of development allows for simpler testing of individual elements of the structure. In our laboratories we have regularly observed that simpler components, which may not be worthy of a peer-review, prove to be very versatile, and can be readily coupled with other technological solutions that solve a set problem. We do not therefore recommend lowering the bar for research or for excellence in technological development, but instead to increase quality by reducing risk, securing adoption, and opening the architecture to a broader set of agile technological solutions.

A concrete action point in conjunction with the above recommendation is to evolve the concept of MARLs (Market Adoption Readiness Levels), as outlined in Models suggested by stakeholders. This could be an initiative by INFRAEOSC-03, and developed in conjunction with the proposed RDA WG (see A new RDA WG focusing on solutions for widening public-private cooperation).

Widening of EOSC Knowledge Circles

The strategy for EOSC expansion through the widening of EOSC knowledge circles as shown in Figure 3: Expanding EOSC Knowledge Circles strategy building on the EOSC Competence Skillset has been universally well received by all interviewed stakeholders. The widening can be successfully achieved by updating the technological framework to cater for the broader communities; by including each new circle of stakeholders early in the transition; and by inviting key members of those communities to collaborate with EOSC governance. Core services which cater for each expanding circle must be fit for purpose before that expansion is made, to the extent discussed in Quality vs fit for purpose. Empowering key members of those communities to act as ambassadors for EOSC in their domains is an effective strategy for EOSC governance. Participation by representative stakeholders in EOSC governance can lead to joint development and adoption of standards and good practices, which considerably alleviate risks of low adoption and facilitate transitions to broader communities.

It is worth noting that aside from the data expert SME and industrial research stakeholders who are already closely linked to the EOSC core, representatives from citizen science, innovation/developer communities and particularly clinicians or professional practitioners working with data, ought to be included in EOSC WGs and contribute to roadmaps and strategies for expansion to their communities.

EOSC funding tokens

Several stakeholders have suggested a voucher system to incentivise external users of e-Infrastructures and to ensure high quality provision of services. The principle is that vouchers can be allocated to SMEs or other external users across the EU to spend on EOSC e-Infrastructure services. The e-Infrastructures can then redeem the amount of vouchers they receive at face value for European funding. However, as a financial instrument, voucher schemes for purchase of services are subject to VAT accounting at the point of sale, as well as to cross-border currency conversions for countries which do not use SEPA. Additional complexity is presented by different rates of VAT in different territories. As a result, the risk is that the original public funding becomes diluted, and the e-Infrastructure receives less than the face value of the voucher.

Tokenisation provides a potential solution to the voucher problem while still giving the SME users the opportunity to invest in services that are of greatest value to them and for them to act as decision makers for which services should receive EC funding and in what proportion. As stated in the EOSC

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Core Study, virtual tokens can provide a fluid value stream, and give (a certain degree of) autonomy to the users to choose how to allocate resources.

Not to be confused with cryptocurrency, our recommendation is to adopt the model where EOSC funding tokens work in a manner analogous to frequent flyer miles (or 'airmiles'). They are not freely convertible, but they can be spent on e-Infrastructure services offered within the ecosystem, and those tokens can then be exchanged for public funding only by the participating e-Infrastructures. As a loyalty programme, SMEs are incentivised to retain their EOSC accounts, and continue using EOSC e-Infrastructure services after the EOSC funding tokens have been allocated. e-Infrastructures are incentivised to compete on pricing and on quality to give the best value for money to SME users.

The related software platform can be developed to provide a booking system for all available e-Infrastructures, with the ability to compare and reserve services using the EOSC funding tokens, in a manner similar to other online booking systems (Doodle, Appointlet, etc.). The price, time, availability and exact nature of the service should be transparent at the point of booking, and the token held in escrow within the system until the service is provided. It is recommended that tokens are digitally stored and encrypted within a software platform in a secure online account. Once the service has been delivered, the token can be released to the e-Infrastructure provider. Funding tokens can be allocated in full or part payment for services, and the opportunity exists to develop future mechanisms by which further tokens can be accumulated, earned or purchased by users. e-Infrastructures can redeem the tokens that they earn within the platform in exchange for European funding proportionate to the number of EOSC funding tokens they have been allocated.

Allocation of EOSC funding tokens to SMEs and other public and private sector third party stakeholders can be by application, open call, recruitment or curation by an external or otherwise non-aligned party so as to avoid the appearance of cronyism. Development and testing of a robust and secure rewards system platform layer for EOSC for the deployment of this funding delivery and incentivisation mechanism can be implemented in conjunction with the INFRAEOSC initiatives. In line with the recommendations of the EOSC Core Study, an effective virtual token system can open up the possibility to measure the impact of funding on the research results as well as enable real-time policymaking/steering the research at EU level.

Alignment with EU marketplace initiatives

Synergies with initiatives which are being developed in parallel, such as GAIA-X, EuroHPC[10], bloXberg, Industry Commons and the upcoming EIC marketplace have been highlighted by stakeholders and ought to be exploited, to save on duplication and speed up deployment of EOSC. These platforms require the same elements of marketplace infrastructure as EOSC, and are all equally focused on data-driven use cases. If each of these marketplaces were to build its own decentralised system, not only would each be operating on different “railway tracks” but this would hinder ready adoption of common standards, useful data exchanges, interoperability, communications, knowledge and value exchange. The EU Common Market is transferring through digitalisation entirely to a data-driven model, and the current version of the “EU Common Data Market”, if left fragmented, risks ending up looking like a Bazaar. Analysis of each marketplace, however, reveals strengths of individual platforms, which also reflect the strengths of the core communities that drive them:

- bloXberg is a global initiative by the Max Planck Institute - a major EU research organisation which is already involved in the EOSCpilot and the EOSC-hub projects. The principal focus of bloXberg is to empower researchers with robust, autonomous services that provide a transparent footprint and blockchain-authenticated certification of the provenance of their

[10] Covered in greater detail in the Iron Lady document *Solutions for a Sustainable EOSC*, 18, October 2020

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work and Intellectual Property, without revealing its content (see UC23). bloXberg has already grown to 30 global nodes of the blockchain, each maintained by a reputable national research institution secured by long-term funding. bloXberg is grounded in European research community ethos and provides the "railway tracks" upon which other European value applications can be built.

- GAIA-X aims to provide the next generation of a data infrastructure for Europe: a secure, federated system based on extensive stakeholder experience in ICT and telecoms, that meets the highest standards of digital sovereignty while promoting innovation. This project is building an open, transparent digital ecosystem, where data and services can be made available, collated and shared in an environment of trust. At face value GAIA-X can seem identical to EOSC, however an analysis of stakeholders and use cases reveals a particular focus on industrial domains, which can bring new knowledge to EOSC when establishing FAIRification principles.
- EuroHPC is developing a pan-European supercomputing infrastructure. It will permit the EU and participating countries to coordinate their efforts and share resources with the objective of deploying a world-class supercomputing infrastructure in Europe and a competitive innovation ecosystem in supercomputing technologies, applications and skills.
- EIC Market Place aims to make the IP results of the EIC Pathfinder (and its predecessor, FET) explicit and transactionable, allowing Europe to address key problems through responsible innovation that builds on emerging technologies. The EIC Market Place aims to provide intelligent registration of all results of EIC support, traceably linked to the unique knowledge, skills and community members that generated them. During the R&I Days 2020 representatives of national research institutions suggested that the system ought to be rolled out across the Horizon Programme[11].
- Industry Commons responds to the rapid transformation of enabling technologies by creating a platform for hybrid applications across industries. Through the EU OntoCommons project, it lays the foundation for interoperable and standardised data documentation across all materials and manufacturing domains, thereby facilitating data sharing and pushing data-driven innovation to bring out a truly Digital Single Market and new business models for European industry to meet the opportunities of digitalisation and sustainability challenges.

The above is a non-exhaustive list of marketplace platforms currently in development or attempting to scale in the EU. Those listed have been identified during our study to have notable synergies with EOSC. The following stack layers potential strengths of individual platforms, highlighting the EOSC USP among them:

- EOSC: FAIRification and research ethos (core values and validation)
- Industry Commons: data interoperability and standards for interoperability (data exchanges)
- GAIA-X: front end communications and collaborative space supported by strong ICT infrastructure (cloud services, IT)
- EIC: IP registration and tracking, smart contracts, SME and VC end (IPR management)
- bloXberg: distributed ledger for the registration of research IP maintained by research institutions globally (the "railway tracks")
- EuroHPC: pan-European supercomputing infrastructure (processing power)

We are very likely missing other strengths of EU marketplaces which would make this picture complete, and which could be identified with a more dedicated in-depth study, but those that have

[11] "Towards an EIC Market Place", EU Research and Innovation Days, transmitted at 14:30 in HUB 8: European Innovation Council, on the 24th of September 2020 (see https://research-innovation-days.ec.europa.eu/programme)

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been highlighted during the course of this study already present excellent opportunities for collaboration and exploitation of individual stakeholder strengths. Should each of the above marketplaces focus on the development of its respective strengths, they would be wise to adopt robust mechanisms developed by sister platforms to add highly functional layers. The following include some of the clear recommendations for a cooperation strategy with EU marketplace initiatives which have emanated from this study:

- Investigate the use of bloXberg (UC23) as the railway tracks with an existing long-term sustainability model in place, in the context of the development of value adding applications for the EOSC community. An initial testbed for identifying opportunities between bloXberg and EOSC can be investigated as one of the INFRAEOSC initiatives.
- Identify synergies between the 23 use cases from this study with the GAIA-X use cases and work towards common solutions. The approach to the two sets of use cases has been different: GAIA-X use cases focus particularly on the challenges of individual industry sectors, while the EOSC Expansion use cases have been driven by stakeholder research projects which often combine several knowledge domains. Notable synergies can already be identified between UC21 and the GAIA-X cluster of health use cases which involve clinical data; UC19 and the GAIA-X Mobility use cases; UC01; UC10; and UC18 and the GAIA-X Energy use case cluster.
- Develop a prototype for a multimodal communication platform enhanced by rich data-driven applications and routes to e-Infrastructure services as a front end for EOSC, in collaboration with substantial expertise in ICT/communications by GAIA-X and EBU (UC03) expertise in media content platforms, potentially also building on results from Horizon projects in media and social platforms.
- Establish a strong collaboration with the Industry Commons initiative OntoCommons which aims to make a notable contribution to semantic interoperability standards. The upcoming launch of an Industry Commons marketplace project aims to implement and test FAIR standards within the industrial research community. As demonstrated with UC09, Industry Commons demonstrators from OntoCommons can serve as valuable use cases for EOSC. Both Industry Commons initiatives therefore provide a useful testbed for EOSC FAIRification.
- Align the work of EOSC WGs with the development of standards for the registration of IP by the EIC Market Place initiative. The metadata which will be established, with references to documentation, as well as any smart contract conventions, will be relevant for all EU-funded research projects, and will also need to be compliant with FAIR principles.
- Connect EOSC with EURO-HPC as already outlined in the Solutions for a Sustainable EOSC – Iron Lady document.

INFRAEOSC-03 and INFRAEOSC-07 as testbeds for expansion

As already suggested above, it has become evident throughout this study that the INFRAEOSC-03 and INFRAEOSC-07 initiatives should be used to initiate, implement, or prototype as appropriate, a series of actions recommended in this study. The following are examples of the recommendations which can be implemented and tested through the INFRAEOSC initiatives:

- PaNOSC value-added SME application for industry use (UC08)
- EOSC as Community Engagement Platform for the European Citizen Science Association (CSA style action)
- Dynamic multimodal tools for online collaboration (with optional added value applications and e-infrastructure provision)
- A marketplace for pan-EU media applications in partnership with EBU (UC03)

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- Building of a virtual platform for tokenisation, booking of e-Infrastructure services and service value allocation for each token selection field
- Creation of SME-led automatisation and customisation layers on top of EOSC e-infrastructure (eg: AirBnB for compute services)
- Integration of Intellectual Property tracking (in collaboration with UC23) and testing of open licensing models
- A CSA-style implementation of JUST principles for annotation and metadata, with community building
- A roadmap for widening of knowledge circles
- Development and testing of MARLs parameters

In addition to the opportunities for expansion to public and private sector stakeholders presented by these actions, the examples above also include clear routes to economic sustainability models for EOSC that can be tested and developed within that expansion process.

A new RDA WG focusing on solutions for widening public-private cooperation

Following positive feedback from EOSC stakeholders during the EOSC symposium on the 21st of October 2020, a suggestion has been made to initiate a dedicated RDA WG which would identify technical solutions to help the widening of the public-private cooperation, starting with OPEN Principles.[12] This suggestion has been well received and an RDA WG group is currently in progress of being established.

[12] The suggestion by Edit Herczog received positive response, as documented in the EOSC Governance Symposium Zoom Chat Log 19-22 October 2020 and the related recording of the session.

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Summary

This study has revealed several surprising findings. Of the 46 stakeholders interviewed, 54.3% had either never heard of the European Open Science Cloud, or had no knowledge of what the title actually implies. However, when the role of EOSC was explained to them, including the current status and objectives, every single interviewee reacted by listing clear benefits for their work, their projects and their sector. Aside from benefits, we were surprised to discover the sheer volume and diversity of use cases that were presented to us unprompted. Our aim to collect 10 diverse use cases grew to 23 during the course of this study, and it would have grown further should we have carried on interviewing more stakeholders from outer knowledge circles. The pertinence and potential of EOSC, as analysed in this study, is unquestionable.

Perhaps the most surprising finding has been the reaction from 6 industry stakeholders, all of whom suggested that the verification of FAIR data, or "FAIRification", is of key importance for industry, even in B2B commercial data exchanges. Particularly in use cases where one commercial organisation purchases data from another, industry stakeholders would require the data set to be run through EOSC FAIRification in order to establish greater trust in the purchase. This role makes EOSC a key player in commercial data exchanges, while providing a strong motivation for industry and commercial stakeholders to interact with EOSC regardless of the level of openness of the data in question. Building a robust FAIR data system will entail processing large volumes of data sets, all with different parameters, and protected industrial data is one category which must be included if FAIR is to be universally accepted.

An important impact emanating from the above findings is that the adoption of FAIR principles by wider EOSC communities results in the transfer of RRI and value systems as established by the EOSC core research community (including work of relevant WGs from both RDA on the parameters, and EOSC on verification mechanisms). One of the aims of this study was to investigate how to establish a sustainable mechanism for a technology transfer that is grounded in the research communities' ethos and principles, and the above recommendation from wider stakeholder groups provides a clear route to achieving this. Widespread adoption of both FAIR and JUST principles by interviewed stakeholders (as described in Ensuring accountability for RRI) implies that the ethos and principles are expected to radiate outwards from the EOSC core through the expanding knowledge circles, as seen in Figure 3: Expanding EOSC Knowledge Circles strategy building on the EOSC Competence Skillset.

The route to expansion can be reinforced by including key representatives of broader stakeholder communities in EOSC governance and allowing them to act as ambassadors for EOSC within those communities prior to progressing through the knowledge circles. This study has highlighted that EOSC expansion can be leveraged through the expertise, networks and connections already close at hand within EOSC governance, and thus allow for expansion to take place more organically in close collaboration with broader stakeholder communities. Key stakeholders currently present within EOSC core include data expert SMEs and industrial researchers. Key stakeholders currently missing are representatives of citizen science associations, representatives of innovator/independent developer communities, and notably, a category of EOSC stakeholder thus far rather neglected – the clinician or professional practitioner generating data as part of their occupation.

Aside from the common risk from inertia in walled gardens, the biggest omission for EOSC research stakeholders would be to miss out on the knowledge that is present in these broader communities who, as demonstrated in this study's use cases, can considerably multiply research results, speed up knowledge acquisition, help train AI systems, and reveal emerging research directions. Access to these communities opens up the opportunity to interrogate alternative approaches, practices, ways of

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sharing knowledge and reusing knowledge, aside from providing routes to EOSC expansion, social impact and long-term financial sustainability.

For these communities to be truly enabled, the platform needs to be fit for purpose to the extent recommended in Quality vs fit for purpose. A major opportunity which is already available for EOSC expansion is that a large number of useful recommendations from this study can be developed and tested within the INFRAEOSC initiatives as listed in INFRAEOSC-03 and INFRAEOSC-07 as testbeds for expansion. Once the basic parameters of the value system or prototype are established, it ought to be further developed together with early adopters from the broader EOSC community to ensure it is truly fit for purpose. Enabling and empowering young researchers and innovators to adopt the platform and contribute to its expansion will ensure their ongoing vested interest in EOSC.

Collaboration is also highly recommended with EU marketplaces described in Alignment with EU marketplace initiatives, which will all rely on EOSC FAIRification for their successful operation, while also providing useful standards for interoperability, industrial domain and cross-domain use cases, ICT and communications know-how, and sustainable research infrastructures back to EOSC. An EU Common Data Market covering all aspects of data creation and use, both public and private, research and commercial, must be built on common standards and principles, and run on the same “railway tracks”. Openness, intended here as an enabler of autonomy, is based on a set of rules of behaviour which require individual and institutional accountability, appropriate attribution, FAIR data, and JUST stakeholders. EOSC FAIRification opens up otherwise restricted possibilities for data transactions between researchers, industry, SMEs, professional practitioners and citizen scientists on all data marketplace platforms. This reinforces the core function of EOSC as the European FAIRification authority, and as this practice becomes a standard, EOSC is set to become the Web of FAIR Data at a global scale.

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Appendix 1: Use Case documents

UC01. Sentinel Hub

Title: BlueDot Observatory - global monitoring of water bodies on a shoestring

Societal Challenges

Managing water crises is one of the Sustainable Development Goals, and the significant decline in the available quality and quantity of fresh water has been ranked by the World Economic Forum's 2018 Global Risks report as one of the top ten most serious societal risks facing the world.

Most of us – having the privilege to live in the developed world – treat water as an unlimited resource. We usually don't think about where water is coming from and how much of it is available. But even if we did, we may encounter several challenges accessing detailed water-level information. For some of us, the "water ratios" are not that serious. For example, they may impact our ability to wash our cars, water our lawns, or fill our pools. For many, however, water scarcity can be life threatening or can significantly impact their way of life. In late 2017, "Day Zero" was threatening Cape Town, South Africa to be the first city in modern era to run out of water.

In order to raise awareness of the situation and provide factual information, we have set up a global monitoring system, BlueDot Observator, for all surface water bodies that are at risk. It provides a detailed insight into the periodic cycles of lakes' sizes, often revealing a sad truth – the risk of total loss of those water bodies in the not too far future.

Technical Challenges

Open satellite imagery, Copernicus Sentinel-1 and Sentinel-2, are perfect datasets to retrieve data about persistence of water. However, even though the water bodies are relatively small, compared to the overall surface of our planet, they are spread out sporadically so one has to process large amount of data, hundreds of terrabytes, to get the relevant pixels.

How EOSC can help and add value

Sentinel Hub provides an API for immediate access to the relevant satellite data

Sentinel Hub, a satellite imagery processing API running in the cloud within EOSC, makes it possible for the user to ask for the data in the specific time period, retrieving results in less than a second. It is therefore possible to simplify design of the application significantly.

Using lean design and relying on the available services, BlueDot Observatory runs fully automatically, monitoring 15.000 water bodies, for under 100 EUR per month.

A relevant picture representing the use case

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Theewaterskloof Dam near Cape Town, South Africa, filling up after the disastrous drought in 2017 and 2018

Organisations involved

Sinergise

Main contact points

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Anze Zupanc, anze.zupanc@sinergise.com

Relevant links

https://water.blue-dot-observatory.com/38538/2018-06-20

https://water.blue-dot-observatory.com/

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UC02. 3D and Additive Technologies in the Biotech Field

Title 3D and Additive Technologies in the Biotech Field

Societal Challenges

The evolution of medical 3D printing over the last decade has merged paths of both imagination and problem-solving. 3D printing (3DP), otherwise known as additive manufacturing, is the foundation of today's digital medicine. 3D printing for medical prothetics has already brought revolutionary changes. Researchers at the University of Pula in Croatia have demonstrated the state of the art in 3D modelling for medical prosthetics by fast online delivery from design to print to the operating room. Drawings are made upon request for emergency cases, on one occasion when the academic researcher was working in Sweden; sent to Germany for printing in titanium by KLS Martin, and delivered to the operating table in Croatia the following day.

3DP in medical fields can be organized into several broad categories, including: the creation of customized prosthetics, implants, epithesis and anatomical models, tissue and organ fabrication; manufacturing of speciality surgical instruments, pharmaceutical research regarding drug fabrication, dosage forms, delivery, and discovery as well as manufacturing medical devices. Benefits provided by application of 3D printing in medicine include the customization and personalization of medical products, drugs, and equipment and it also provides cost-effectiveness, increased productivity, the democratization of design and manufacturing.

Technical Challenges

Although 3DP is very popular, in Europe and in Croatia this area has just started to gain in its greater popularity. The main problem is to popularize 3DP and instruct doctors how much better, faster and easier it is to work with patients using 3DP technologies. An additional problem is the Croatian market, where materials and printers from the field of 3D printing have only recently appeared. So their price is increased compared to other conventional technologies and materials.

How EOSC can help and add value

Thru EOSC platform presented activities might contribute for better implementation and popularization of 3D and Additive Technologies in the Biotech Field. One way in which this could take place is through the distribution of processing power to EOSC-affiliated departments and stakeholders in a manner similar to the Berkeley SETI Research Centre's SETI at Home programme which ran for 20 years. The SETI at Home software processed data during participating computers' down time, providing a form of parallel, crowd sourced supercomputing which provides the much needed processing power required to move the data capabilities of Biotech Additive Technologies forward. EOSC could also provide access to, for instance, datasets containing measurements of biological characteristics that can be modelled and customised for specific patient needs.

Our main focus is to ensure that EOSC's added value will strongly support open innovation, open science, open to the world and to have the best results not just for the humans but for the animals too. In modern society, every human being and every animal deserve to have the possibility and right to live quality life through the use of new technologies.

A relevant picture representing the use case

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3DP and VR applications in period 2007. - 2020.

Organisations involved

University of Pula (Science-Technology Institute VISIO), Faculty of Medicine University of Rijeka

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Barbara Ptačnik, barbaraptnk@gmail.com

Relevant links

http://www.3d4vr.eu/

http://svenmaricic.eu/Portfolio_Maricic_rez.pdf

Timeline

The use case is implemented and fully operational

- 2021 First phase of computing infrastructure scalability, HPC usage for medical image recognition

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UC03: Open European Media Ecosystem

Title: Open European Media Ecosystem

Technical Challenges

Digital sovereignty is one of the key goals for Europe and the European Commission, with Public Service Media (PSM) holding a critical role for the preservation and promotion of European values and multi-cultural identities.

The unprecedented COVID-19 crisis brings to its extreme the importance of the ability to create a trusted open European media space and has highlighted the added-value mission of European Public Media Broadcasters in informing, educating and entertaining European citizens in difficult times as well as in delivering science and evidence-based information.

However, nearly all digital platforms used by citizens, authorities, institutions and businesses in Europe are provided by private companies from outside Europe - from search engines and social networks to digital shopping platforms and cloud services.

The key technical challenges identified are:

- Demonstrate that alternative media platforms with core components following European values are in fact possible as alternative to dominating foreign content platform.
- Creation of user facing products that are personalised, easy to use and provide a compelling user experience in distributing quality, trustful content.
- Creation of core open source technical modules, creating open standards and interfaces, enabling innovation.
- Progressively create the European ecosystem which will be strong enough to support European digital and cultural sovereignty.

How EOSC can help and add value

Three possible areas of collaboration activities with EOSC

Preserving, promoting and exploiting the cultural and historic value of European public media archives by implementing a set of technical solutions, on top of a federated cloud infrastructure, allowing to:

- Use automatic transcription of audiovisual content to enable indexing and automatic tagging
- Use assistive translation tools to make the content accessible to a broader audience across Europe
- Create central repositories of content / content index to enable search and exploitation of deep archives
- Apply dedicated content tagging / watermarking / identification technique to ensure rights are preserved
- Use recommendation algorithms to provide the best content to every user and to ease the discovery of relevant content.
- Develop all the above by open source software to enable innovation and sharing working solutions in diverse fields (research, news, education and more).

Facilitating **collaboration between media and research sector for a multi-platform program to stimulate interest of young student on science and research** thus endowing a new generation of European citizens with a solid scientific background. This will be achieved through re-use and delivery,

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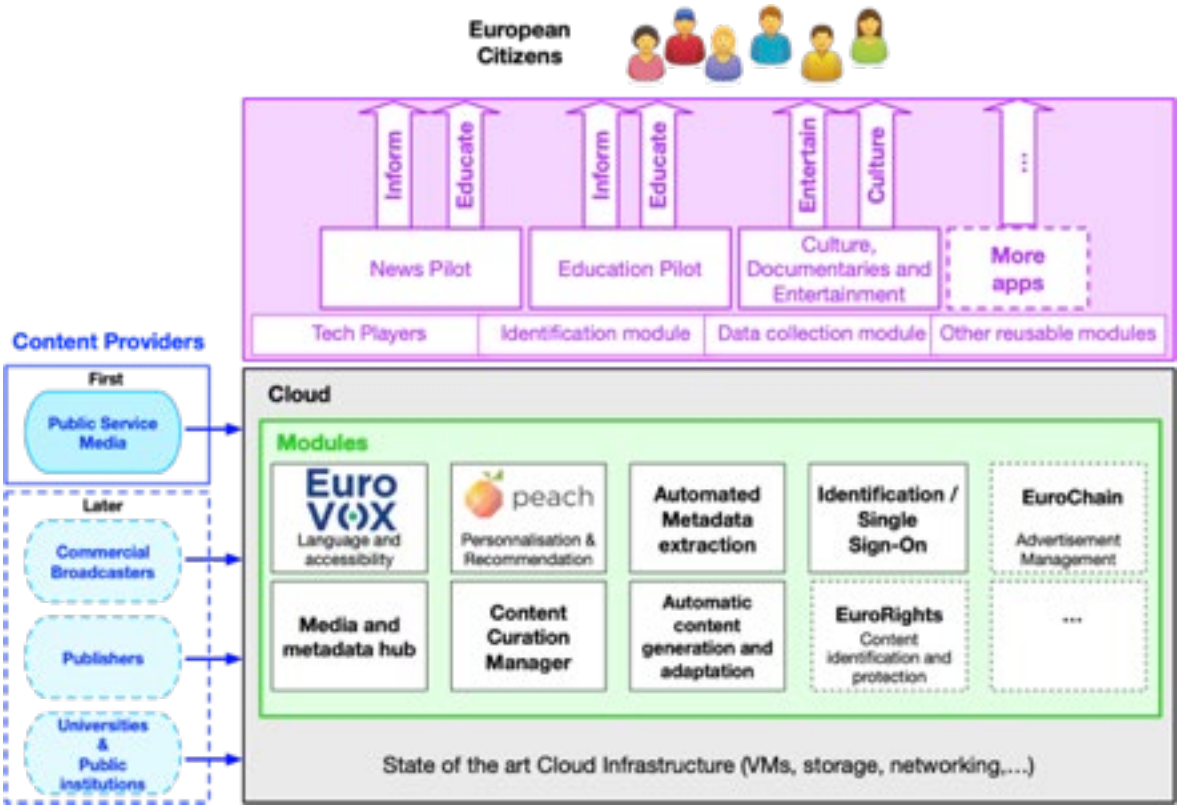
via multi-cast solutions, of educational content from audiovisual archives integrated with the national programs of the national educational services.

Joint procurement of innovative cloud services underpinning a **European Media Data Space**

A relevant picture representing the use case



Organisations involved

- The EBU and a set of its members, most Public Service Media in Europe (BBC, ARD, FranceTV, RAI, RTP, ARTE,… full list: https://www.ebu.ch/about/members)
- Universities and Research institutions CRIT(I), Munich University(D), Pisa University(I).

Main contact points

Antonio Arcidiacono - arcidiacono@ebu.ch

Carmela Asero – asero@ebu.ch

Relevant links

PEACH : https://peach.ebu.io
EuroVOX : https://tech.ebu.ch/eurovox - Ask us for a demo!
Sample of video translated automatically from Spanish to English :
https://u.pcloud.link/publink/show?code=XZ7ayckZVgDzbHfMS2kpDBjYcvPT5mmXCJKk

Timeline

PEACH services are fully mature and used in production since several years. EuroVOX services and tools are in beta form, and are actively developed. Timeline for a mature Open European Media Ecosystem is 5 years, through progressive development of different pilots of 2-3 years (e.g. on the exploitation of news and archives and later on the education/scientific info platform) then advancing towards setting the operational environment for the resulting products.

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UC04: Augmenting the COVID-19 Data Platform with behavioural data

Title Augmenting the COVID-19 Data Platform with behavioural data

Societal Challenges

On 20 April 2020, the European Commission together with several partners launched a European COVID-19 Data Platform to enable the rapid collection and sharing of available research data. Populating this platform with data from the Social Sciences and Humanities aims to pool and augment behavioural and attitudinal data to enable researchers to investigate the opinions and attitudes of European populations during the crisis, and monitor the occurrence and spread of the virus.

Technical Challenges

Data variety presents a challenge to the alignment of catalogues, metadata, and protocols with the life sciences and other parts of the platform. Collecting and combining quantitative and qualitative data in many formats (text, audio, video, social media) and in multiple languages requires multilingual thesauri and ontologies to make data findable and comparable;

Ensuring the security and protection of sensitive data collection and analysis.

How EOSC can help and add value

Adding Social Sciences & Humanities data to the COVID-19 Data Platform, providing contextual data and a knowledge development environment

The fast-track element of the task involves the creation of a catalogue of key datasets for social, economic, psychological analyses, organised by data producer and national service provider in data hubs to replicate the EMBL structure, and supplemented with contextual economic, social, cultural, health, and migration data. The catalogue is supported with background infrastructures such as multilingual thesauri, controlled vocabularies, metadata profiles based on global standards, and data sensitivity tags.

Specific challenges for the social data are their multi-linguality and large variety of data types. Qualitative data have high information value, but require specific techniques for annotations, analysis and extraction of information. Tools and expertise within the SSHOC project will be used to deal with qualitative and multimedia data and to address multilinguality.

A knowledge development track will make use of online surveys and AI techniques, focusing on the knowledge cycle and data interoperability, including non-hierarchical data, via semantic techniques such as Knowledge Graphs. To optimise reusability, concerted and collaborative actions to group and enrich data are envisioned in cooperation with research communities. Bringing relevant data together will increase efficiency, improve comparability and provide all researchers with the same opportunities for using the data. To facilitate cooperation and to provide seamless access even to sensitive data, secured environments will be set up for bringing data and researchers together.

A relevant picture representing the use case

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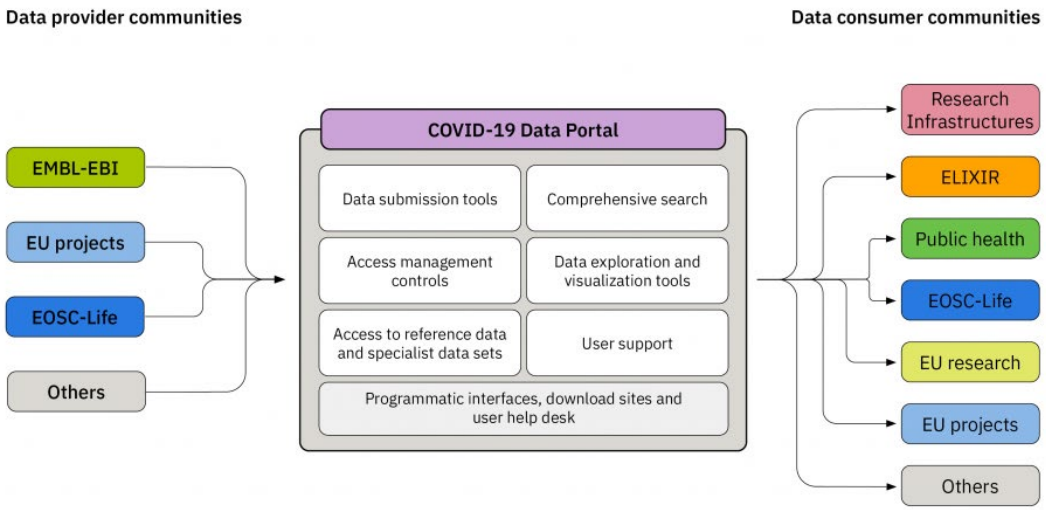

Organisations involved

The European COVID-19 Data Platform is coordinated by the European Commission (EC) and European Molecular Biology Laboratory (EMBL).

Main contact points

info@embl.de

Relevant links

https://www.embl.org/news/science/embl-ebi-launches-covid-19-data-portal

Timeline

Already in progress

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UC05: Apollo in Real Time

Title Apollo in Real Time - Documenting of Planetary Geologic Field Activities in Real Time in Four Dimensions

Societal Challenges

The Apollo explorations of the Moon was the most consequential set of missions for planetary science ever conducted (Jolliff and Robinson, 2019). The missions not only collected 382 kg of samples for study on Earth, but also constituted our first human field exploration of another planetary surface. This "field work" was documented using audio recordings, communications transcripts, video transmissions, post-flight debriefings, and film which constitutes a profound resource for scientific study (Heiken and Jones, 2007).

Unfortunately, much historical data from the Apollo program remains in a wide variety of proprietary analog formats archived within different institutions and substantial scientific information has been produced during post-mission analysis that remains unlinked to mission activities. With the data in this state, it is nearly impossible to establish the exploration context of the lunar samples and the other science activities conducted, and how these activities were conducted within the overall mission context.

Over the past 10 years, a group of volunteer citizen science advocates digitized the analog data of three Apollo missions, Apollo 11, 13, and 17 and pulled their collective mission data into an open dataset. Using this data, the team built the Apollo in Real Time (AiRT) (https://apolloinrealtime.org) platform, a time-indexed playback system that allows researchers and interested members of the general public to replay each mission as it occurred.

This platform clearly demonstrates that digitizing and assembling such historical mission material into a time-based playback system brings together the variety of data sources into an intuitive interface and restores the exploration context of the lunar samples and other scientific activities conducted during and after each mission. Made accessible via an easy to use online software interface, AiRT enables new scientific studies of the data from these missions in ways never before possible.

Technical Challenges

If one did want to have the full context of a particular Apollo lunar sample, they would have to refer to no fewer than three sources; the Apollo Sample Compendium, the Apollo 17 USGS Mission Report, and the Apollo Flight Journal (Meyer, C., 2009; Wolfe, E. W. et al.,1981; Jones, E., 2020). Yet with these resources one would still not have the TV feed from the lunar surface, the full set of surface photos documenting each sample, and immediate access to the archive of publications and online data for the sample. The AiRT platform does this, making it a single platform for the context of samples in a simple, straightforward source.

Retrieving the mission data from different institutions, digitizing it, and cleaning and correcting it is a laborious, manual process. However, the work is worth it. The resulting data remains decoupled from the software platform making it possible to use the data in ways ever previously imagined (example: https://www.c82.net/work/?id=368).

Specifically difficult was the digitization of the historical analog mission recordings were a tremendous, multiyear undertaking (https://www.nasa.gov/feature/nasa-university-of-texas-at-dallas-reveal-apollo-11-behind-the-scenes-audio). The resulting dataset has prooved very fruitful for research ranging from mission planning for the return to the Moon with Artemis, to lingustic studies

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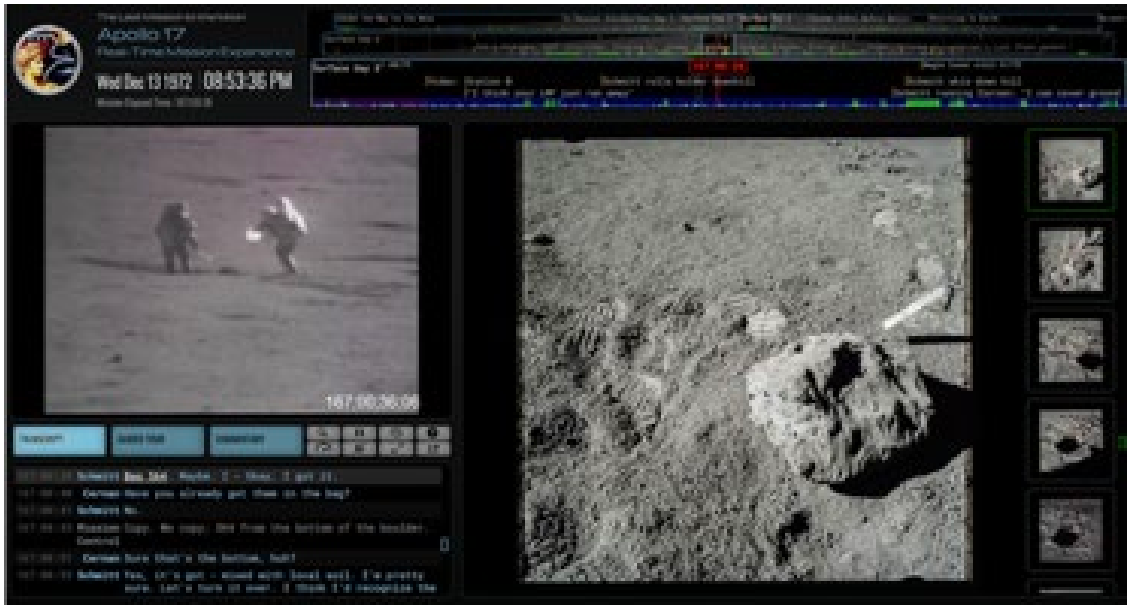
of communication patterns while problemsolving (https://asa.scitation.org/doi/abs/10.1121/1.5137269).

Aside from scientific benefit, AiRT has attracted over 2 million visitors from 224 different countries eager to experience the missions in minute detail. By providing users with the complete dataset played back in real time, we have inadvertently created a compelling experience that is universally appreciated.

How EOSC can help and add value

Historical datasets are equally important to contemporary datasets. Converting them to open data formats invites the scientific community to find itself at an intersection point between their contemporary data and the historical data that some of their founding principles may have been derived from, inviting new discoveries of nuances (or flaws) in the underpinnings of a wide variety of disciplines. EOSC's enablement of all science data across traditionally siloed disciplines applies the power of the information age to the tradition and rigor of the scientific process.

A relevant picture representing the use case



Apollo 17 in Real Time view, the moment sample 78238 was collected (http://apollo17.org?t=167:00:28), which includes context images taken of the source boulder, crew transcript, and a link to sample data when "Bag 564" is clicked. In the minutes leading up to the collection of the sample, Astronaut Schmitt describes the boulder as the only large fragment sitting on the regolith, rather than being partially buried. This additional geologic context is lost when viewing sample data in isolation.

Organisations involved

Volunteer group lead by Ben Feist. Feist subsequently hired by NASA to work on data systems for future missions.

Main contact points

Ben Feist, benjamin.f.feist@nasa.gov

Relevant links

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https://apolloinrealtime.org https://www.nasa.gov/feature/apollo-11-in-real-time-50-years-later
Timeline • 2015 – Apollo 17 v1.0 • 2016 – Apollo 17 v2.0 • 2019 – Apollo 11 • 2020 – Apollo 13 • ~2022 – Apollo 16

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UC06: Galaxy Cruise: Citizen science / volunteering

Title Galaxy Cruise

Societal Challenges GALAXY CRUISE is a Citizen Astronomy project (citizen science project in astronomy) run by the National Astronomical Observatory of Japan (NAOJ). The project uses the data from a large-scale survey program using Hyper Suprime-Cam (HSC), the world's best wide-field imaging camera mounted on the Subaru Telescope. We hope that, while exploring the Universe captured by the Subaru Telescope and classifying the shapes of interacting galaxies, the public and astronomers can come together to solve the mysteries of galaxies and generate new research results.

The project goals are as follows: 1. to establish a citizen participation method for collecting data in the field of astronomy 2. to investigate the effects of galaxy interactions and mergers on the evolution of galaxies by collecting classification data for a wide variety of galaxies 3. to establish a new astronomy communication method through a two-way dialog between research institutes and citizens 4. to heighten awareness of astronomy among educators, non-profit organizations, and industry 5. to gain societal understanding and support for research activities 6. to give back to society through the internet distribution of research results

Technical Challenges

According to the Oxford English Dictionary, “citizen science” is “scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions.” Citizen science is now a popular activity, particularly in Europe and North America. It enables the general public to engage in scientific research by examining publicly available data through the internet. This collaboration benefits both the public and the scientists; the public can appreciate the wonders of astronomy by working with the latest large-scale data from NAOJ; scientists on the other hand can not only collect much more data with the help of the participants but can also disseminate their scientific research.

Galaxies are thought to have evolved through a series of interactions and mergers. However, the effects such processes have on the evolution are not yet fully understood. One of the big problems is that finding interacting galaxies through observations is difficult. NAOJ's Subaru Telescope is conducting an observation project of unprecedented scale, allowing us to discover such interacting galaxies with much higher accuracy than ever before. Yet there is another problem. Since there are innumerable galaxies out there, it is difficult for professional astronomers alone to search the data. The technical challenge lies in connecting citizen scientists with large quantities of data that can be combined, analysed, visualised and evaluated, with those results shared in the broader scientific community.

How EOSC can help and add value

Additional data sets and broader access for citizen scientists to the wealth of publicly funded European scientific research will create a multiplier effect for the Galaxy Cruise project.

At present, the Subaru telescope offers an incredible wealth of data, and the public engagement with that data yields far-reaching understanding of the universe, its history and our place within it. However, by adding further rich data sets that are interoperable and reusable, both the impact and the global reach of the citizen scientists can be greatly enhanced.

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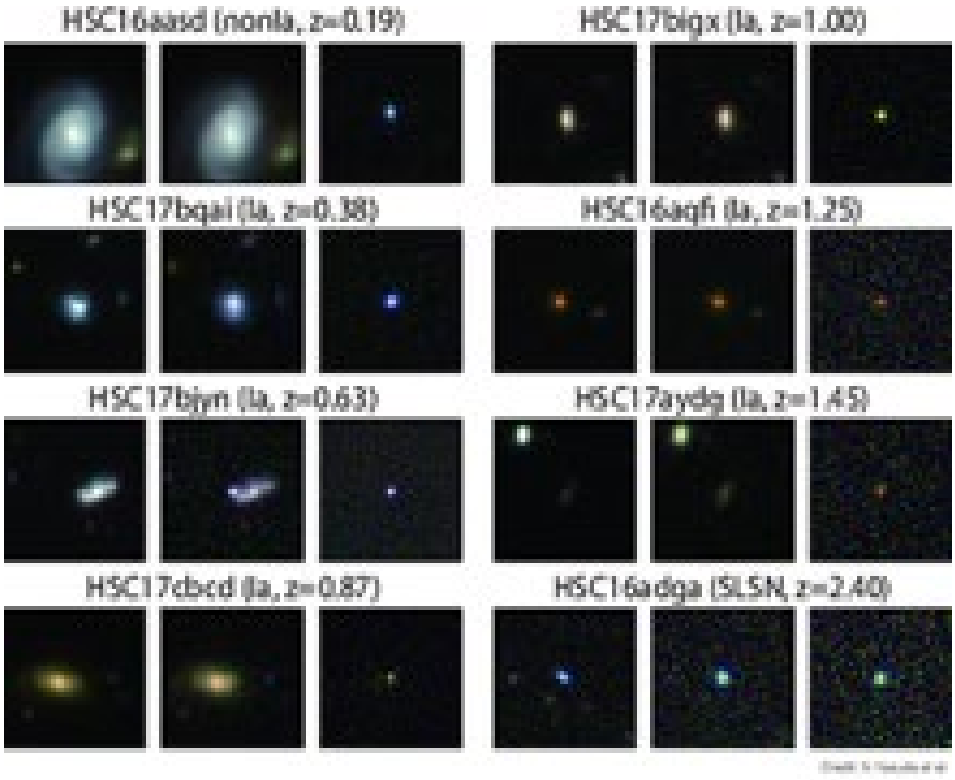
In addition, access to a community of citizen scientists and enthusiasts from within academia will assist with the impact and reach of our project.

A relevant picture representing the use case



Galaxy classification imagery. Citizen scientists review and evaluate galaxy imagery in order to identify their characteristics.

Organisations involved

National Museum of Emerging Science and Innovation

Subaru Telescope

Main contact points

Captain of GALAXY CRUISE / Associate Professor at Subaru Telescope

Masayuki Tanaka: masayuki.tanaka@nao.ac.jp

Relevant links

https://galaxycruise.mtk.nao.ac.jp/en/about.html

Timeline

Galaxy Cruise was launched in late 2019 and since that time 14 individual citizen scientists have been commended for identifying and classifying 8000 galaxies.

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UC07: Education programmes run by citizen science collectives at the Višnjan Observatory

Title: Education programmes run by citizen science collectives at the globally recognised Višnjan Observatory

Societal Challenges

In the coming time where experiential economics takes precedence over technological economics, there will be less and less interest from students in choosing a more complicated school path in which exact sciences and technology dominate. The current and future "Dream Society" will be far more attractive. We consider the existing school system and various activities to reach children who later have to carry the technological framework and scientific technological development of the community to be outdated or inappropriate for that purpose, because they do not contain a key element by which an individual decides to choose challenging, demanding, socially less honored careers. This key element is “peak experience”. When we get a group of gifted children, their education has left it too late to expose them to the experiences that lead to choosing challenging careers.

Over the past 30 years, various support systems and various approaches to this problem have been developed, to show that only a few of them are able to produce "world excellence" in the field of education of future leaders of scientific and technological projects. In the absence of local support and the complexity of accessing funds from the wider community, we relied on experiences and support from the United States and Israel. This period also showed the general inability of the local and wider community to absorb the greatest talents, who mostly choose to go to the United States or northern Europe and Switzerland.

Our approach of early introduction to the scientific method through resident programs and "hands on" participation in projects for children starting from 9 years of age, and introductory programs for outdoor education starting from 3 years of age, and special technological projects involving those over 14 years of age, has proven successful and brought up as best practice by a multitude of scientists, technologists and managers who today lead some of the most significant projects of this type.

Technical Challenges

Technological challenges exist, aside from pratical challenges of insufficient space and equipment. The real technological, scientific and educational research challenges are on the other hand our goal, our happiness, and our journey.

Under the technological challenges, we highlight lack of funds. The existing system, which is not set to evaluate scientific results but focuses on administrative perfection, blocks a good part of human time, which can no longer be used to deal with children, new methods, technology, scientific projects, but instead must constantly be used to justify the researcher’s activities. We could say that protection from administrative burden is the biggest technological challenge of "small" projects that do not have the infrastructure to deal with them.

Here in third place, but in fact the most important component of the technological challenge is the researcher. In the world of constant creation, breaking down scientific and technological paradigms, the researcher is still the most important person: expert, creative, manager, leader. Educating such a future researcher is our most difficult challenge.

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Our challenge is to match the best practice of the education system for working with gifted children by the state of Israel, and the way of financing educational programs in the USA and UK.

How EOSC can help and add value

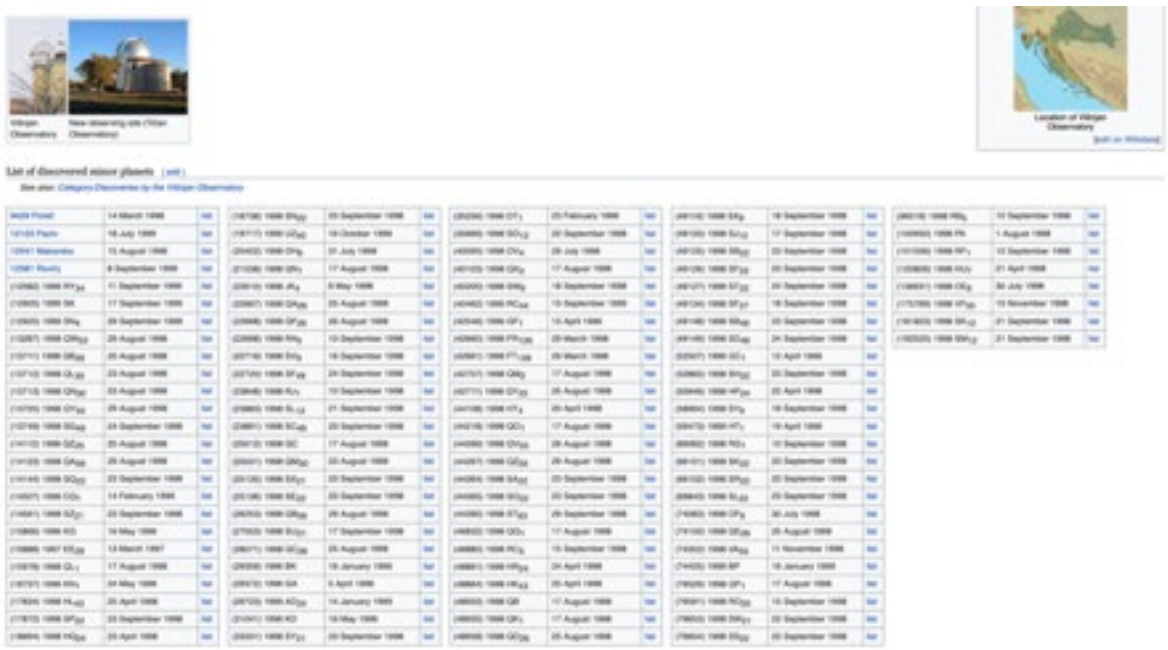
EOSC can help by being more inclusive according to the current policy of equality of all subjects within all EU countries. In Croatia only public (state) institutions have the right to apply for tenders, and only state institutions are exempt from VAT (VAT).

Encouraging the evaluation of project results according to what has been done, and not towards meeting what is in the administrative form, would be a great expression of the will to change in the direction of greater efficiency within the EU.

As for networking, cooperation, it exists with all colleagues in the world, who deal with the same issues. Study exchanges and travel are currently impossible categories for non-governmental institutions. There are no funds (neither time to get funds somewhere) nor interest in travel with questionable utility.

If EOSC can lead on the equality of all institutions throughout the EU this will suffice. We will then manage everything else.

A relevant picture representing the use case



List of discovered minor planets by the Visnjan Observatory

Organisations involved

Visnjan Observatory: several NGOs

As a member of the International Asteroid Warning Network (IAWN), Visnjan is amongst the top five observatories in the world in collecting more near-Earth object (NEO) measurements to determine if they are a threat to Earth.

Without these so called follow-up and confirmation measurements the majority of newly discovered asteroids that are daily discovered mainly from Hawaii, would get lost in a day or even in a matter of

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hours. With our measurements we can ascertain if the discovered object is really there, calculate its trajectory and verify whether it is a potential threat.

We are also members of Spaceguard Foundation, an association set up to support the creation of a system to discover celestial bodies which could potentially be a threat to life on Earth.

Astronomical Society Višnjan is the beneficiary of the institutional support of the National Foundation for the Development of Civil Society for the Stabilization and/or Development of the Association.

Main contact points

Dr. Korado Korlevic

korado@astro.hr

Relevant links

https://en.astro.hr

https://en.wikipedia.org/wiki/Višnjan_Observatory

Timeline

This cluster project of NGOs and individuals has been around for 30 years and is constantly evolving, trying to anticipate the development of technology and society, providing children and parents with all possible support in education. On several occasions, support was offered to the community, sometimes accepted, and more often not because it was seen as outside the system.
In the coming years, we face the challenge of finding and educating a new generation of mentors and assistants, expanding scientific and technological areas, increasing the number of children educated, searching for sponsors and patrons to support gifted children from poor families. The construction of a visitor center and several other laboratories, as well as the design of an educational campus are in the near future.
However future planning, details of the phases and timetable are currently just a wish. Depending on the sponsors, the state takes 25% of our profit needs and 20% of what what the law calls profit tax, even though as an institution in our statutes there is no profit but everything is invested in development.
Progress will therefore be made when it is possible, at the available speed, bit by bit depending on the available means.

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UC08: INFRAEOSC: PaNOSC

Title INFRAEOSC: PaNOSC

Societal Challenges

The PaNOSC project, Photon and Neutron Open Science Cloud, brings together six strategic European research infrastructures (ESRF, CERIC-ERIC, ELI Delivery Consortium, the European Spallation Source, European XFEL and the Institut Laue-Langevin – ILL, and the e-infrastructures EGI and GEANT, with the goal of contributing to the construction and development of the EOSC, an ecosystem allowing universal and cross-disciplinary open access to data through a single access point, for researchers in all scientific fields.

The mission is to contribute to the realization of a data commons for Neutron and Photon science, providing services and tools for data storage, analysis and simulation, for the many scientists from existing and future disciplines using data from photon and neutron sources. To achieve this aim, the exchange of know-how and experiences is crucial to driving a change in culture by embracing Open Science among the targeted scientific communities. This is why the project works closely with the national photon and neutron sources in Europe to develop common policies, strategies and solutions in the area of FAIR data policy, data management and data services.

The challenge is for industry to unlock the value of the scientific data created by PaNOSC in applications such as the development and exploitation of new materials. However, it is not within the remit of the project to provide an interface that will allow industry to query, analyse, interpret and create products and services from the data created through the PaNOSC project. Instead, we envision a use case whereby an agile and creative European SME could bridge that gap and provide the application as a service to industry, in order to interface with the PaNOSC data on the EOSC platform.

Technical Challenges

There is a large volume of data generated by the photon and neutron laboratories gathered together under the PaNOSC umbrella. The technical challenge is to create software as a service (SaaS) that will allow industry to apply the new knowledge created in the research environment. An SME with the commercial incentive to provide this bridge would be able to provide such an innovative service solution.

How EOSC can help and add value

Expanding EOSC to work side by side with creative European SMEs who can bridge the value gap between research and industry would increase the overall value of EOSC to broader industry stakeholders.

A relevant picture representing the use case

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PaNOSC creates FAIR data with the intention that it be made available and used so that its value may be unlocked for European industry and society. SME intermediaries can shape new services for users' needs in novel and unanticipated applications.

Organisations involved (list of organisations)

- ESRF – European Synchrotron Radiation Facility
- Central European Research Infrastructure Consortium (CERIC-ERIC)
- ELI Delivery Consortium
- ESS – European Spallation Source
- European Grid Infrastructure Foundation (EGI)
- European XFEL
- Institut Laue-Langevin (ILL)

Main contact points

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Leader WP3 – Data Catalog Services:
Tobias Richter

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Leader WP6 – EOSC integration:
Jean-François Perrin
Email: perrin@ill.eu

Relevant links

https://www.panosc.eu/

Timeline

- The PaNOSC project is already underway and is a four year project that will contribute significant data sets to EOSC

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UC09: Industry OntoCommons: EvoPlant Skill Matching by Siemens AG

Title: Industry OntoCommons: EvoPlant Skill Matching by Siemens AG

Societal Challenges

EvoPlant Skill Matching aims to show how the use of ontologies and reasoning can significantly improve flexibility in manufacturing, as well as increase transparency and trust of AI systems by using methods for explaining AI-based decision-making. Trust in systems is an important factor for workplace efficiency and collaboration, and only if the automated decision-making process in a factory environment is transparent to humans will it be trusted and accepted by the personnel that runs a factory.

Flexible manufacturing in the context of Industry 4.0 plays an important role in developing the factory of the future and requires enhanced planning, scheduling and control. In particular, the manufacturing planning process needs to be at least partly automated to flexibly react upon low volume production orders. Here, the decision of whether an available machine is capable of performing a required production step can be automated by reasoning over explicit machine capability descriptions expressed in terms of ontologic vocabularies in reference to the background knowledge captured in domain ontologies. This technique is also referred to as skill matching, with an analogy of machine capabilities to human skills. To successfully introduce this and other AI-based methods into production for making machines more autonomous, techniques of explanation are required to establish transparency on AI-based decision making.

Technical Challenges

For the skill matching step this means that at any time an AI system decides that a production step matches with the skills of a particular machine the operator might in principle inquire to know why that is the case, i.e. which of the machine's capabilities lead to such a decision. Likewise, in case of a negative match a production planner or operator needs to know the reasons for incompatibility, e.g. to come up with a solution for situations in which there is currently no suitable machine available. The generation of explanations draws from a set of rich domain ontologies used in the reasoning process. They cover production-relevant domains focused on discrete manufacturing and are layered into a more general stack of ontologies about physical assets, production skills as well as machinery, material and process knowledge. The reasoning and explanation techniques for the skill matching task are embedded in an overall manufacturing planning scenario in which skill matching results are used to automatically allocate production operations to machines in an overall solution for a manufacturing plan.

The technical challenge includes interoperability across data domains but also in the domain of the human/machine relationship. The use case involves a real-world example on a test plant in a Siemens lab, which was built up for investigating innovative manufacturing scenarios with low capacity production. On the test plant, the assembly of cans and caps by various transportation systems and redundant robot stations with different capabilities is varied by additional product inlays as well as different shapes and colors, leading to a high variety in product customization. The planning and reasoning tasks are realized for the assembly and transportation steps, and explanation techniques are utilized to make routing decisions transparent. Determining which machines match up with which products (i.e. which combination of machines with distinct processes can perform operations on different products) will help automate the input the planner gets in order to construct a correct sequence of actions the machines need to perform.

How EOSC can help and add value

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Implementing and incentivising ontological standards in data collection and use, as well as benchmarks for documentation of data collection and application, will contribute greatly to cross domain data interoperability, the ability for EvoPlant Skill Matching to integrate further relevant data to contribute to explainable AI decision-making in the workplace, and will help develop FAIR standards across Knowledge Data, Timeseries Data and Plant Ontologies (Industrial Upper Ontology, ontology for cyber-physical systems and ontology for discrete manufacturing).
A relevant picture representing the use case N/A
Organisations involved Siemens AG University of Oslo
Main contact points Prof. Dimitris Kiritsis - dimitris.kiritsis@epfl.ch
Relevant links **Gocev I., Grimm S., Runkler T.A.** (2018) Explanation of Action Plans Through Ontologies. In: Panetto H., Debruyne C., Proper H., Ardagna C., Roman D., Meersman R. (eds) On the Move to Meaningful Internet Systems. OTM 2018 Conferences. OTM 2018. Lecture Notes in Computer Science, vol 11230. Springer, Cham.
Timeline The use case is to be implemented as part of the EU-funded OntoCommons project which begins in October 2020.

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UC10: ICE Datacenter – Green computing from the ground to the cloud or from the chip to the chiller

Title ICE Datacenter (BDVA i-Space) – Green computing from the ground to the cloud or from the chip to the chiller.

Societal Challenges

A number of Sustainable Development Goals are addressed by the European union Green deal with the respect to computing. Affordable and Clean Energy – since energy is central to nearly every major challenge and opportunity in computing infrastructure. Industry, Innovation, and Infrastructure – due to investments in green infrastructure are crucial to achieving sustainable development. Sustainable Cities and Communities – since there needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more and it will be based on computing including both large data center infrastructures and network edge and device computing. Responsible Consumption and Production – because energy use in producing data services must be done with care**.** Climate Action **-** Climate change is a global challenge that affects everyone, everywhere and computing can both help change and transformation in the struggle to a climate neutral Europe.

Technical Challenges

It is challenging times in the computing and datacenter industry. Growth due to media services, 5G, IoT in industries etc. It is an ongoing clash of technologies like edge and centralized cloud technologies, air and liquid cooling, the use of AI and sustainability. The industry sector is in a state of innovation.

When the smaller edge nodes 10-50 kW are deployed at scale by 2030, a new holistic zero-touch operation paradigm will be born for IT infrastructures. Also mega-sized datacenters have many knobs to turn to make it work as efficiently as possible. Self-optimizing would put great into the datacenters. It requires that all parts of the computing are software defined and software controlled. The power needs to go solid-state and programmable for example.

When edge is deployed everywhere with 6G in place in ten years, the implication is that all non-latency dependent compute can move to sensible locations that make sense in sustainability terms that include industrial symbiosis sites and out of cities. The non-latency dependent cloud workloads can be moved to sites with fossil-free energy.

On the road towards this vision focus will be on taking sensible steps. The first is to meet the challenge of the silos in a datacenter. The running, orchestration, balancing of applications is one silo, the optimization of cooling and operations of servers is another, the room cooling yet another, the power distribution optimization is independent etc. and they never meet. One step is to collect data from all parts in one database available for all separate optimizations.

The next step is to focus on creating energy efficient datacenters. Using server modeling, wind tunnels, control machine learning models and experimental pilot datacenters it is time to reach super low PUE, Power Usage Effectiveness, below 1,01.

Then it is time to work on autonomous edge datacenters trying to develop technologies for zero-touch, on fuel-cell powered edge datacenters to enable efficient heat re-use and operations in power-limited cities, on designing edge nodes to enable green computing for 5G edge application developers, on smart integration of PV-cells with edge modules to optimize tariffs and operations and on automation in edge networks.

How EOSC can help and add value

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

Testing in a flexible full-scale datacenter - without having to invest. With access to massive amounts of research data and compute power. Test and experiment with data center systems or within data science. Add a stand-by team of world-leading scientists at your disposal, contributing to your innovation. ***That is ICE Datacenter***.

The test facility offers access to a unique environment for testing, demonstrations and experiments.

- Big data analysis and machine learning - computer capacity, platforms and tools to handle big data and machine learning used for green AI computing.
- IT and cloud testing and experimental environments for software development, scaling and optimization of infrastructure
- Facility and IT HW - opportunities to test new innovations for the data center's system and hardware for lower energy use, heat re-use or industrial symbiosis
- Tools - Measurements and research that ensure a sustainable society with efficient data centers as part of the energy system

A relevant picture representing the use case

The 5G Edge datacenter testbed including PV cells, microgrid and cooling grid

Organisations involved

RISE Research Institute of Sweden

Main contact points

Tor Björn Minde, tor.bjorn.minde@ri.se

Relevant links

https://www.ri.se/ice

https://ice.ri.se

Timeline

- February 2016: First test module for open hadoop cluster testing
- May 2017: Second test module for facility testing
- March 2018: Third module for Open compute testing and server wind tunnel
- January 2019: Pilot datacenter for energy efficient operations
- May 2019: Edge testbed including microgrids

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- June 2020: Heat box testbed for industrial symbiosis and climate box for module three testing of any climate.
- September 2020: Second test module rebuilt for GPU Kubernetes cluster testing
- December 2020: Fourth module as a new larger testbed for facility testing
- Spring 2021: Pilot for industrial symbiosis green house and datacenter
- Summer 2021: Testbed for a network of edge nodes for 5G use cases
- Fall of 2021: Pilot datacenter for liquid cooling, fuel cells and heat re-use

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

UC11: Cambridge Whisper system in use with evidence for human rights violations in migrant camps

Title: Cambridge Whisper system in use with evidence for human rights violations in migrant camps

Societal Challenges

Migrants and refugees are subjected to police brutality and denied basic rights such as shelter and sanitation. Crimes against migrants and refugees are rarely investigated and children are placed at risk of trafficking and sexual exploitation. The authorities fail to provide medical care or information regarding the asylum process - despite their legal obligation to do so.

These human rights violations frequently are unreported. Survivors and witnesses express frustration at their inability to effectively document violations and the subsequent lack of accountability for those perpetrating this abuse.

With smartphones and social media, it is easier than ever before to document human rights violations. But how can that information become evidence, advocacy and support?

Technical Challenges

Creating high quality evidence capture in a secure way with relevant technology available in refugee camps. Ensuring data can be validated and used to pursue human rights abuse.

How EOSC can help and add value

Access to secure, low latency, low cost and trustworthy infrastructure for amplifying the voices of witnesses reporting human rights abuses.

A relevant picture representing the use case

[Caption: Photo of a Refugee camp, showing living conditions and inhabitants]

Organisations involved

* University of Cambridge

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

* Humans for Rights Network
Main contact points Maddie Harris: info@humansforrightsnetwork.com Whistle Project: info@thewhistle.org
Relevant links https://thewhistle.soc.srcf.net/
Timeline The use case in not completely implemented. Currently in trial with 4 partners: Global Rights Nigeria, End Everyday Racism, Humans for Rights Network, and Supply Chain Organizing Coalition Whistle still has technical developments to be completed to ensure that data capture best suits the relevant devices people have in the camps. For example integrating platforms such as WhatsApp to better enable reporting of human rights abuse via Whistle.

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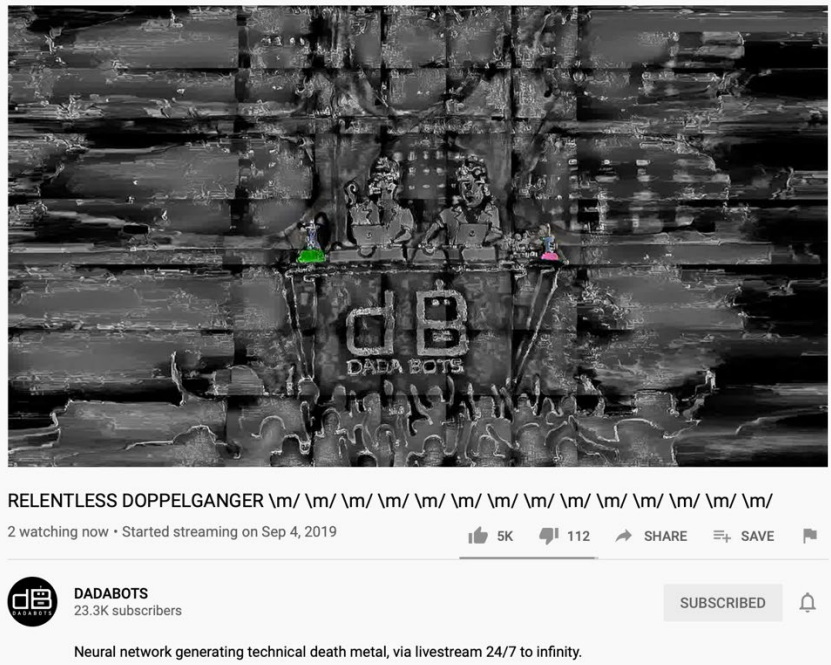
UC12: Neural Networks: Dadabots

Title Neural Networks: Dadabots
Societal Challenges Creating new musical compositions using a trained neural network artificial intelligence extracting data from musical recordings. The network is analysing and processing based on original sample size audio information from existing recordings, however the resulting output does not contain any of the original material on which the algorithm was trained. There is no legal precedent for new works that are both derivative of original works and do not contain or reference the original works in any technical way. Dadabots has worked extensively with copyright lawyers in the United States to address challenges from rights holders on the basis that the new works constitute Fair Use. The Fair Use provision does not apply in Europe and so the training of neural networks on creative works for the purpose of creating new generative works is unsolved.
Technical Challenges Neural network learning requires significant processing capacity and super-computing services as well as large and robust data storage is essential. We envisage that it would be possible to track and trace ID registration through the many thousands of iterations of neural net outputs but to date this technical challenge has not been addressed or solved.
How EOSC can help and add value Processing architecture for neutral network instances and IP tracking for AI generative works. Using the EOSC research e-infrastructure would provide Dadabots with both the capacity for further experimentation with new creative AI works, and the opportunity to integrate with FAIR datasets both for further training and for experimentation with new models of distributed ledger IP tracking capabilities for high-volume iterative creative works. It also provides the precedent for establishing new IP law in the European context.
A relevant picture representing the use case 

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

Organisations involved Dadabots
Main contact points CJ Carr – emperorcj@gmail.com
Relevant links dadabots.com
Timeline January 2021 – New album release. Dadabots in collaboration with Dutch artist Drumcorps.

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

UC13: Accessibility and the Arts: Drake Music Accessible Musical Instrument Collection (AMIC)

Title

Accessibility and the Arts: Drake Music Accessible Musical Instrument Collection (AMIC)

Societal Challenges

Without an appropriate musical instrument, it is often impossible for Disabled people to participate in music-making. Drake Music has worked with a wide range of disabled people at the intersection of disability, music and technology since 1993, we know first-hand how powerful and transformative access to the right music technology and instruments can be.

At the moment there is nowhere for a Disabled musician to go to have access to a full range of accessible musical instruments to see which, if any, are suitable for them. We are currently developing the world's first Accessible Musical Instrument Collection (AMIC) to address this need and to provide a focal point for the large community of Disabled musicians, instrument developers and researchers.

In addition there are not enough accessible instruments available to address the access needs of all Disabled people, and in particular those that a co-designed with Disabled musicians to ensure that their access needs are fully met. Much work needs to be done to develop those instruments in a way that makes them available and affordable for all Disabled people.

Technical Challenges

There are a number of technical challenges we face in terms of building the collection and in terms of making accessible instruments more widely available:

- Access to research into new accessible instruments (that is often never presented to the Disabled community and effectively becomes lost)
- Research into new interfaces and technologies for developing new accessible instruments (e.g. AI, Robotics)
- Research into manufacturing techniques that would allow manufacturing of small-run and bespoke instruments in affordable ways without requiring large commercial production numbers (e.g. 3D printing technologies in a variety of materials to allow local production of instrument designs).
- Research into storage and maintenance of a working collection of digital and electro-acoustic interfaces/instruments/software over time.
- Research into the dissemination and sharing of designs/code/tacit knowledge of opensource and bespoke instruments in a way that will enable Disabled musicians to build or commission versions for themselves.

How EOSC can help and add value

EOSC services can provide access to a broad range of research datasets which meet the above technical challenges and contribute to accessibility solutions for this research project by the TakeItAway consortium funded by the Arts Council England: https://takeitaway.org.uk/creative-united-join-forces-with-leading-access-to-music-organisations/

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

A relevant picture representing the use case

The Kellycaster: An extremely successful accessible instrument developed with John Kelly.

Organisations involved

Drake Music

OHMI

OpenUp Music

Arts Council England

Main contact points

Tim Yates: timyates@drakemusic.org

Relevant links

drakemusic.org

TakeItAway consortium: https://takeitaway.org.uk/creative-united-join-forces-with-leading-access-to-music-organisations/

Timeline

June 2021: Open the collection

- Timelines are fluid due to Covid, but over the following two to three years we will develop a dedicated facility to house the collection, including an accessible maker space and studio as well as dramatically ramp up our instrument development program.

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UC14: Learning sonification by working with EODESM data

Title Learning sonification by working with EODESM data
Societal Challenges Understanding and communicating large amounts of complex data about the environment is a big challenge when facing climate change and destruction of eco-systems. It can be challenging for scientists to present and visualize their data so as to affect decision makers and the public opinion. Sonification, the systematic mapping of data into sound to convey information, is an alternative and/or complementary method to data visualization that can engage audiences with data in a way that can be more sensuous and stimulating. In the Music, Communication and Technology (MCT) program, the students engage with real-world problems where the aim is to create "knowledge for a better world". By learning sonification the students at the program may contribute to communicating insights about all sorts of data. Here, the EODESM maps and datasets can contribute with data that the students can provide data that are directly related to the big societal challenges of our time, and that therefore can be engaging the students.
Technical Challenges The data underlying the maps has to be openly available in a form that invites easy access, exploration and conditioning for students at a graduate level. They also need to have well-structured meta-data that can be understood by the students.
How EOSC can help and add value Listening to data with meaning. EOSC can help by making the datasets easily available in common formats such as xml, txt or csv. EOSC can engage with the MCT student as external partner for Applied Project course, and thereby give direct feedback about the sonifications to the students. Making interactive maps combining visualization and sonification is also a possible area of collaboration.
A relevant picture representing the use case 
Organisations involved Norwegian University of Science and Technology, University of Oslo.
Main contact points Andreas Bergsland, andreas.bergsland@ntnu.no
Relevant links https://mct-master.github.io/sonification/2020/03/09/weather-music.html https://mct-master.github.io/sonification/2020/03/09/Sonifying-Corona.html
Timeline Data sonification is already part of the student curricula and can be amplified with EOSC data

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UC15: Recommendation engine for sustainable and responsible consumption

Title: Recommendation engine for sustainable and responsible consumption

Societal Challenges

Modern lifestyles and consumption patterns have radically changed over the past decades, resulting in unprecedented pressure on the environment. In addition, Material footprint per capita in high-income countries is 60% higher than in upper-middle-income countries and more than 13 times the level of low-income countries.
A shift to more sustainable consumption and production patterns was therefore adopted as the cornerstone of sustainable development during the UN World Summit for Sustainable Development in Johannesburg in 2002. EU Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan launched by the European Commission in July 2008 (EC, 2008)

However, in the industry, e.g. food, retail, fashion, there is no authority to regular the definition of 'sustainable product'. no clear and agreed measurement is suggested for evaluate the environment impacts of consuming certain product: e.g. product CO2 emission, the energy consumption for the producing and transporting product or…

The law of the supply and demand shows, to achieve sustainable consumption and production, a more effective way is to advocate and foster a sustainable consumption lifestyle from consumer side. More and more people having sustainable awareness and willing to make effort to change their lifestyle, however, limited resources are able to guide them through this good transformation.

In order to solve this challenge, we can having relevant data build recommendation engine or incorporate those data in currently recommendation engine to steering people consume more sustainable products and shopping a more responsible way

Technical Challenges

lack of consistence and credible information data source/database to calculate and rank which products are more sustainable, which ways of consumption are more environment friendly

lack of data points provide base line how to calculate, for certain product/product type how much CO2 will be generated by producing or how much energy will be consumed for transporting from place A to B

lack of credible resource guiding the retailor or end-consumer where could access those environment friendly products

3. lack of access to those products having less environment impact

How EOSC can help and add value

EOSC may have credible research data about 1. the credible definition about how to define sustainable consumption 2. having quantitative data of environment impacts for certain product/product type, which can be used for calculated level of 'sustainability', e.g the CO2 emission level of each product or processing/manufacturing methords 3. having recommended product type and product showing lower environment impacts and good for sustainable consumption

A relevant picture representing the use case

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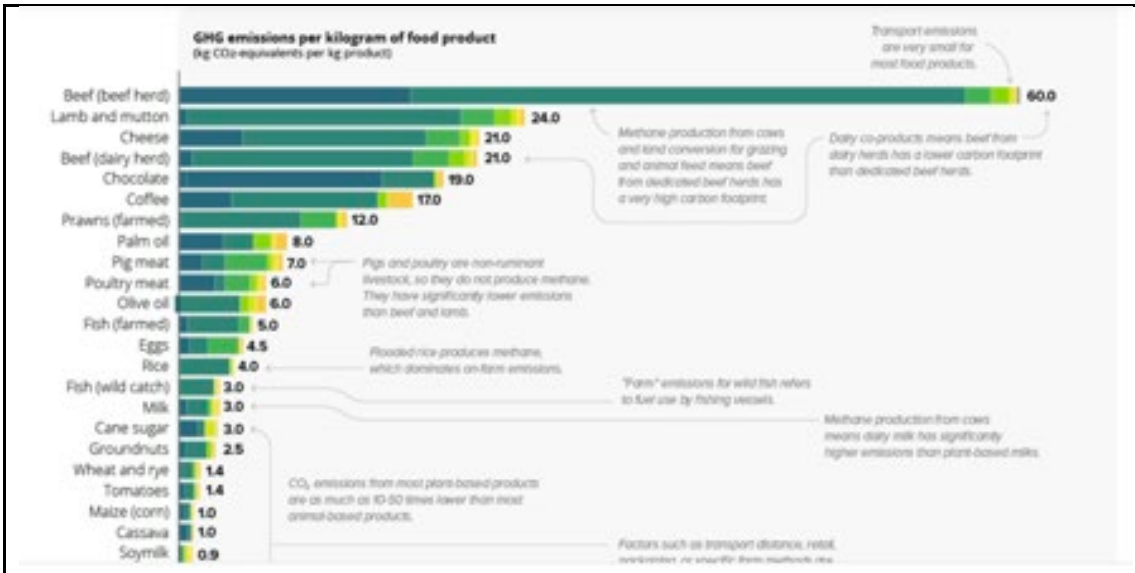

Organisations involved (list of organisations)

Main contact points

Celine.xu@axeljohnson.se

Relevant links

https://sustainabledevelopment.un.org/content/documents/2843WESS2013.pdf

https://www.un.org/sustainabledevelopment/sustainable-consumption-production/

https://www.edba.dauphine.fr/fileadmin/mediatheque/site/edba/pdf/WATSON-Alison-EDBA-Paris-Dauphine-Promotion-7-Executive-Doctorate-in-Business-Administration-challenge-overconsumption-makingsense-legitimacy-meat-industry.pdf

https://www.oneplanetnetwork.org/sites/default/files/20170209_un_communicating_sust_lifestyles_fullreport_lores_2016.pdf

https://www.visualcapitalist.com/visualising-the-greenhouse-gas-impact-of-each-food/

Timeline

We have started to work on a small-scale project since last year. and have a prototype approaching 0.5 million people with positive feedback in Nordic. In order to scale it up and having more impact of society we have a 5 years plan. It is a long-term vision.

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UC16: Training data for inclusive/diverse hacker and maker communities

Title Climate Data Oscillator

Societal Challenges

Climate change is a very real and dramatic occurrence, historical measurements have very clear trends month by month or year by year. This project looked to communicate those trends in an artistic way in order to give audiences a new and more compelling method of understanding and appreciating these trends and the potential societal and personal effect of these changes. In order to do so, the Climate Data Oscillator sonifies those readings in order to explore the relationships between two data sets.

This iteration used global temperature readings and carbon emission data and the resulting tones could be heard as sine waves or midi notes with the pitch representing the data points in time.

Technical Challenges

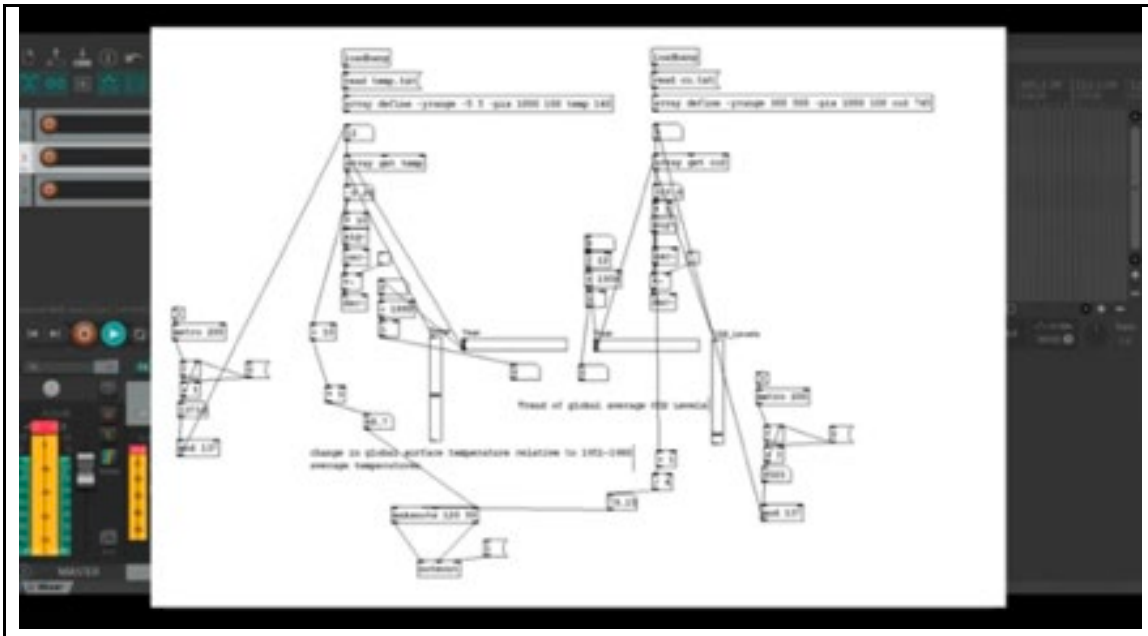
Data was pulled from online databases, converted into simple .txt files via excel in order for puredata to be able to read those values and assign them to an array. It is then possible to control variables such as the year from which to import data and that value is converted into either an oscillating frequency or a MIDI value. The technical implementation of the data sonification is a challenge that can be easily overcome with simple technologies. However, the real technical challenge is in the access to open science data from which these sorts of sonifications and visualisations can be addressed and their meaning made more accessible to a wider public.

How EOSC can help and add value

A wider range of datasets in a simplified and easy to read format would enable the Climate Data Oscillator to develop further into a full instrument with a wide variety of different artistic iterations and applications. With a wider array of variables and datasets, the project has the potential to create complex and unexpected musical compositions that contribute to the public understanding of science, data and the impact of human activity on the natural environment, and potentially encourage positive individual action to help address this grand challenge.

A relevant picture representing the use case

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644



PureData Patch

Organisations involved Vulpestruments (artist Tom Fox)
Main contact points Tom Fox - vulpestruments@gmail.com
Relevant links https://www.youtube.com/watch?v=53-9m5698i4
Timeline Work In Progress

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

UC17: UN and WHO data on distribution and outcome of micronutrients to human populations.

Title

UN and WHO data on distribution and outcome of micronutrients to human populations.

Societal Challenges

Micronutrients are specific vitamins and minerals essential to the human population for health and wellness. Vitamin and mineral deficiency affect people globally. It has an adverse impact on health, wellness and productivity. The lack of micronutrients in people burdens the healthcare system and hinders economic productivity for communities, societies, and nations.
Common micronutrients are in the form of iron, iodine, vitamin A, zinc, and folate. Deficiency in these alone causes micronutrient malnutrition in nearly half of children worldwide younger than five years of age and approximately one-third of the world's population. The human body needs iron to make haemoglobin, the protein which carries oxygen in our blood. A lack of it slows brain function and physical movement and can weaken the immune system. Severe cases cause organ damage and even death.
To address such challenges, micronutrients are delivered to populations through food fortification. This is a process where micronutrients are added to commonly consumed foods, referred to as food vehicles because they deliver nutrition. Very small nutritional supply through food can have a large outcome in productivity, which is why micronutrients are referred to as "micro". In the case of iron deficiency, treatment can restore health and raise community productivity levels by as much as 20%.
Food fortification is done on a massive scale in the worlds' food supply chains to prevent nutritional deficiencies in populations. Micronutrients and food fortification have proved to be one of the most scalable, sustainable, and cost-effective interventions to combat micronutrient malnutrition. However, at least three major problems persist. One, even in countries where policy mandates have been issued, gaps continue to exist due to multiple reasons. Secondly, the data quality around this intervention is a problem hindering proper reports and analysis. Third, and as a result, adjustments in nutrients, policy, and investments cannot be applied properly.

Technical Challenges

Operational and technical challenges abound in this sector. Most of them are around data: compliance data, data sharing, data transparency, quality of data, silos of data, and so on. Underlying the data problems are manual steps, paper trails, archaic systems, unwieldy spreadsheets, interoperability, no incentives or alignments to provide the data. Some examples and elaboration of these technical challenges are highlighted below.
Regulations for food fortification are variously at global, regional, national, then state, and often at smaller local levels making policy fragmented and compliance complex.
Without proper environmental and time conditions, micronutrients erode from the food during logistics, storage and distribution in the value chain from the point of production to the point of consumption. The data on required composition, and therefore efficacy, of micronutrients is fragmented and hard to get.
With multiple dimensions of data being bad, it becomes difficult to do any analysis like comparing across countries to see what is working in one country, not in another, and make adjustments.

Then there are "last mile" data challenges at the consumer level which sometimes are long-spanning measurements of health and wellness results where it matters, at the individual level.

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The technical and societal challenges are compounded in population segments of children and women of childbearing age.

How EOSC can help and add value

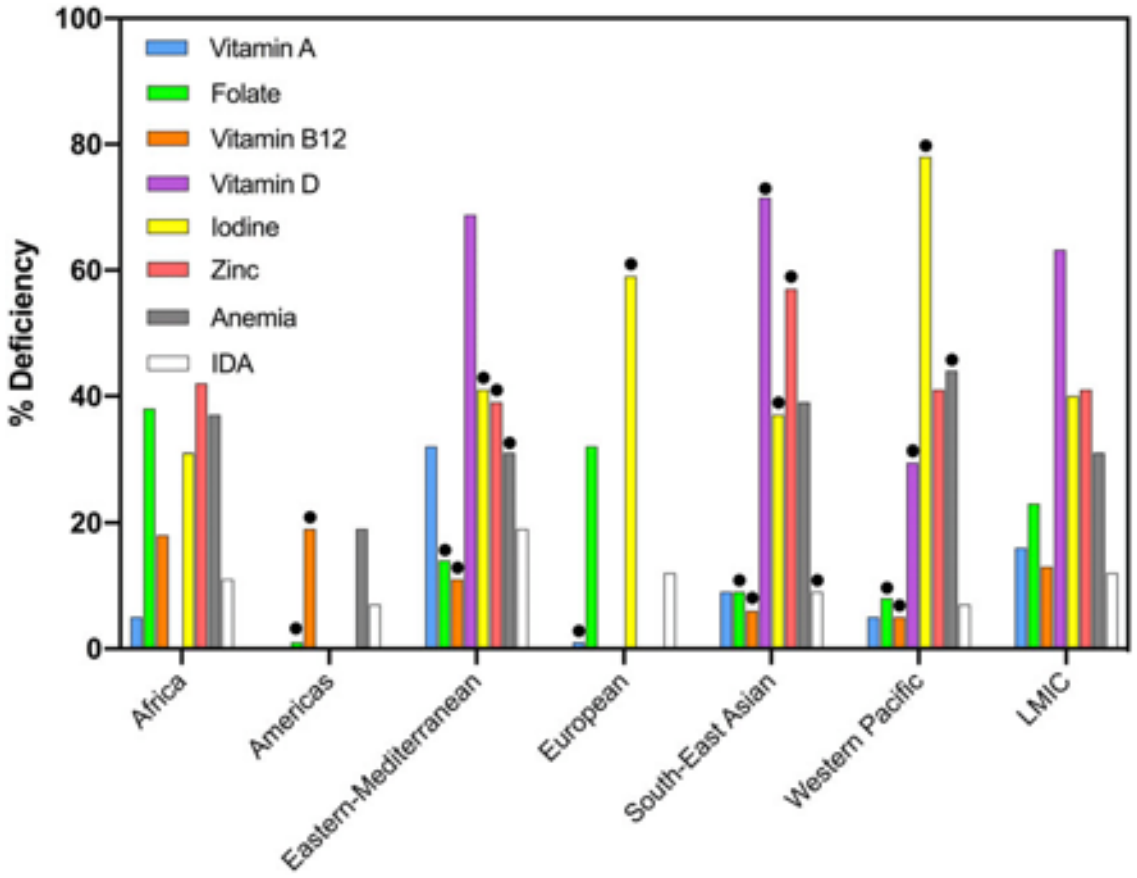
FORTIFY DATA AROUND FORTIFIED FOOD

The EU and the world's food ecosystem is an essential infrastructure and micronutrients are essential consumption to populations. Yet, their methods, processes and systems are manual, archaic, and siloed. Participants in these ecosystems are numerous and fragmented - even at individual country level. EOSC can help and add value by driving a modern innovation agenda with an expanded role in coalescing public, private, and academic sectors focused on data-driven health and nutrition outcomes. This suggested agenda has three pieces.

First, the policy piece can focus on simplification and incentive for compliance instead of (only) penalties for lack thereof. This dovetails with: The **Second** piece of the agenda which is Data and being data-driven. The design of incentives encourage data collection and sharing across ecosystem party siloes resulting in a bedrock of good data on top of which analysis, adjustments and new models can be generated. **Third** piece of the agenda is bringing to bear modern technology and modern approaches that enable the above two.

These are elements EOSC can consider in the process of defining its services roadmap with an expanded value add role.

A relevant picture representing the use case



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Source: Annals of NY Academy of Science / Researchgate - https://www.researchgate.net/publication/333423112_Review_of_the_evidence_regarding_the_use_of_antenatal_multiple_micronutrient_supplementation_in_low-_and_middle-income_countries
Organisations involved United Nations. World Health Organization. Global Fortification Data Exchange. Iodine Global Network. World Food Program. Nutrition International. UNICEF. Nestle. Tata Trust. Others.
Main contact points Gurvinder Ahluwalia, Founder & CEO Digital Twin Labs, LLC serve@digitaltwinlabs.com
Relevant links Reference and acknowledgement - https://fortificationdata.org https://globalnutritionreport.org/events/nutrition-2019/ https://www.who.int/nutrition/topics/micronutrients/en/ https://www.nestle.com/csv/impact/tastier-healthier/micronutrient-fortification Other links - https://www.ign.org, https://www.nutritionintl.org/2017/04/micronutrient-initiative-now-nutrition-international/ https://www.unicef.org/nutrition/index_iodine.html
Timeline To be determined. Not currently implemented.

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UC18: Climate View: Transitional Targets for Local Carbon Abatement

Title ClimateView: Transitional Targets for Local Carbon Abatement

Societal Challenges

Every day, cities across the world are finding that the planet—in a very real sense—is on fire. And following question is frustratingly common: should we begin dousing the problem now with solutions within our grasp, or shall we continue to talk about and measure how quickly we think it will burn?

Technical Challenges

We needed software—alongside new methodologies—to cut through the complexities of:

- *sector interdependencies (the effect one shift has on another landscape segment);*
- *mapping proposed actions to those shifts; and*
- *communicating and scaling to approach this global crisis most effectively (bottom-up).*

The ClimateView Model

ClimateView is the world's first Model-as-a-Service (Maas) designed to help cities plan, understand, and visualize the shifts necessary to address the urgent climate crisis. It was born in 2018 as the Panorama Project for Sweden, adopted in 2020 as a budget priority for the entire nation in 2020—and has since expanded into the United Kingdom and Germany. Our MaaS is powered by Transition Targets®, software encapsulations of 95 "shifts" that are essential and universal to addressing climate change, and which contain the leading *(i) indicators, (ii) calculations, (iii) validations*, and *(iv) best practices* necessary to achieve significant carbon abatement results. This effort is part of the Transition Project, a full- blown Open Data Initiative (ODI) which is curated by the world's brightest researchers on climate change.* The ClimateView Model breaks down the carbon challenge into 7 key stages:

The Global Mission: The Paris Climate Agreement to prevent the world from warming above 2°C over pre-industrial levels.

The Local Goal: A commitment at city level to curb local GHG to support the global mission.

Perspectives: Bundles of Transition Targets that allow you see how entire cross-sectors of a city's total carbon output are affected by shifting the Transition Targets.

Transition Targets: 95 leading indicators, calculations, validations, and best practices which must be shifted to reach the optimal path toward reaching your local abatement goal.

Endeavors: Bundles of Actions that provide reasonable confidence that the Actions proposed will lead to a meaningful shift in the corresponding Transition Target.

Actions: the specific policies, ads, legislation (etc) necessary to drive Endeavors.

Steps: the order in which Actions should be taken to maximize their impacts.

How EOSC can help and add value

ClimateView brings together software and patent-pending methodologies that gets better and stronger with each new data point, across all participating cities, every day. It also encourages transparency among stakeholders by bringing governments and citizens into the same dynamic workspace so they can approach the landscape ahead with clarity and confidence. This presents a unique opportunity for cloud computing partnerships—particularly in Europe—as we collect and curate big data sets that are comparable, AI-address-able*, shareable, and help nations outside of Sweden and the EU ensure the Paris Climate Accord objectives are reached quickly, with minimal

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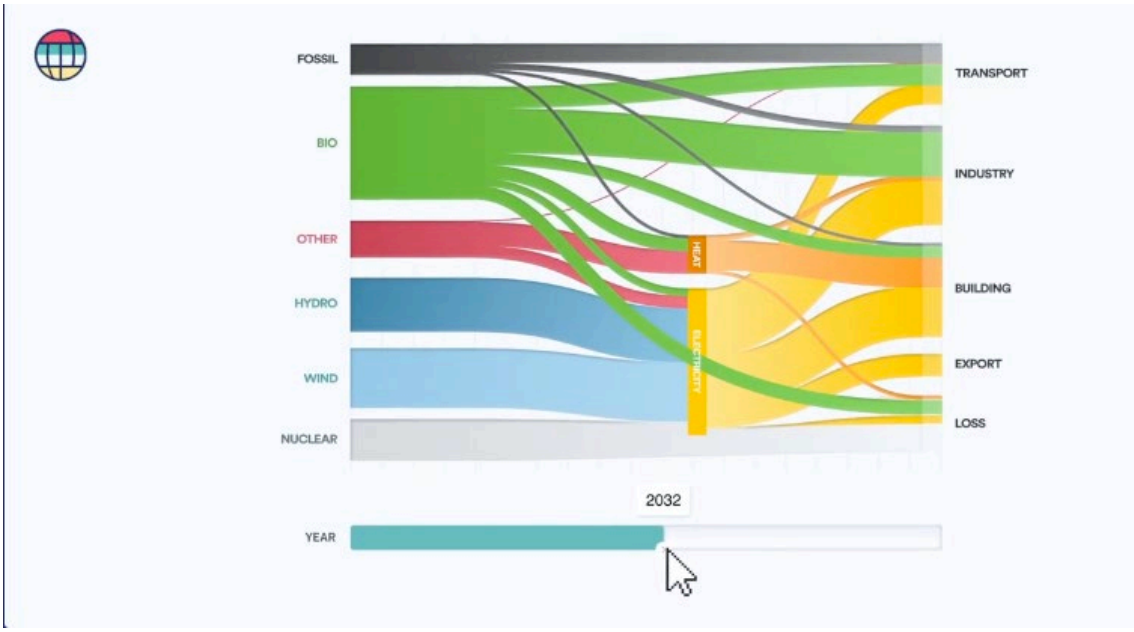
disruption to economic growth, and with maximum participation by the residents who benefit from our collective mitigation efforts. We welcome EOSC's assistance with technical and professional contacts.

A relevant picture representing the use case



Organisations involved

- European Commission
- Swedish Energy Agency
- Global Climate Action Summit
- Exponential Roadmap
- Naturvårdsverket
- Klimatpolitiska Rådet
- Vattenfall
- Stockholm Resilience Centre at Stockholm University
- FutureEarth
- Fossilfritt Sverige
- La Palma Renovable
- Länstyrelsen Västerbotten
- Länstyrelsen I Kronobergs Län
- Uppsala Kommun

Main contact points

Tomer Shalit, CEO, tomer@climateview.global

Relevant links

https://www.climateview.global/

Timeline

Already deployed and in development

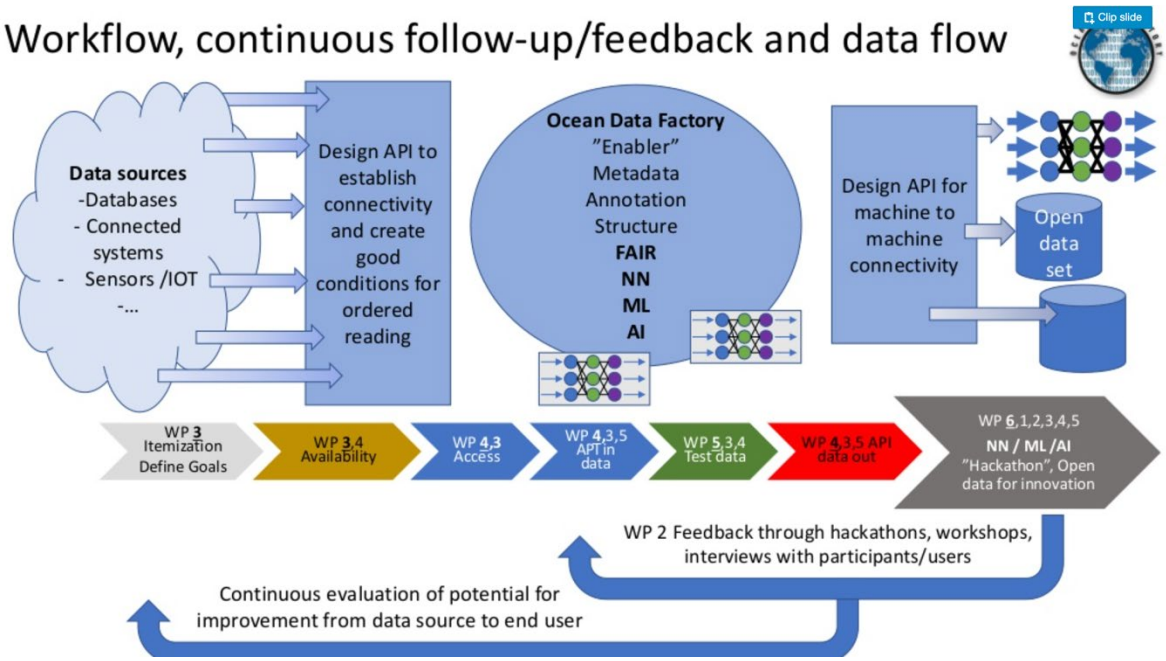
This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

UC19: Volvo – Autonomous Vehicles

Title Volvo Group – Sound Design for Electric & Autonomous mobility
Societal Challenges As electric and autonomous mobility is entering our cities, new challenges arise. One being how quiet they operate. Electric vehicles are 37% and 57% more likely to cause low-speed accidents involving pedestrians and cyclists. UN Regulation No. 138 is an attempt to respond to these risks, stating that at certain speeds vehicles need to emit a sound at a certain volume in order to maintain a safe city for all, not to mention visually impaired people. The solution a so called AVAS (acoustic vehicle alerting system). However, 1.6 million 'healthy life' years are lost in European cities due to environmental noise, primarily traffic. The introduction of AVAS with a loosely defined regulation opens up a whole new possibility for vehicle manufacturers to in detail decide how these vehicles should sound. Will cars, trucks and buses be turned into thousands of sonic billboards? How will these branded sounds affect us over time, even generations?
Technical Challenges How can a sound be emitted in a way that addresses individuals with different sonic prerequisites e.g. hearing impaired or people with noise cancellation head phones. Data that considers weather and terrain as those are factors that absorb and diffuse the emitted sound differently. Data of schools, hospitals, and other key institutions so that passing vehicles may adapt frequencies and volume.
How EOSC can help and add value The impact of artificial engine sound design Provide the vehicle industry with and help navigate through a databank of sound related research in fields such as acoustics, psychoacoustics, auditory science and sound design in their process of developing products that will impact millions of people.
A relevant picture representing the use case (better if it shows the results of the use case + 1 line caption)
Organisations involved Volvo Group Folkestad Sino-Skandinavien AB/Moneo
Main contact points (Name/Surname + email) Fredrik Folkestad, fredrik@folkestad.se
Relevant links https://globalautoregs.com/rules/205-quiet-road-transport-vehicles
Timeline Unfortunately, this is confidential.

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

UC20: Cross-domain collaboration for hyper-local oceanographic research

Title Cross-domain collaboration for hyper-local oceanographic research
Societal Challenges Eutrification is when a body of water becomes overly enriched with minerals and nutrients which induce excessive growth of algae. This process may result in oxygen depletion of the water body after the bacterial degradation of the algae. Local communities are working in partnership with government funding agencies and commercial interests to address the problem of excessive algae due to phosphorous from agriculture and ecotourism. The ODF project is engaging citizen communities through hackathon events in partnership with commercial stakeholders in order to prototype solutions using data and APIs.
Technical Challenges The ability to collaborate between large-scale industries (agriculture, fisheries) and hyper-local communities is problematic in large part due to the commercially sensitive nature of emissions data within different domains. There is the opportunity to work with research as an intermediary for sensitive handling of datasets that can be validated as reusable without breaching commercial sensitivity or intellectual property. Vinnova is supporting the Ocean Data Factory project to enable Sweden to be a global leader for sustainability and innovation in the digital blue economy. The expected result of ODF is that actors in the marine/maritime sector will gain increased competence on APIs and increase their skills and use of AI.
How EOSC can help and add value Access to additional datasets from oceanographic research as well as handling and verification of data between industry, researchers, and other external stakeholders would allow for much greater impact and higher levels of trust between stakeholders.
A relevant picture representing the use case 
Organisations involved Vinnova, The University of Gothenburg, Chalmers University of Technology, RISE (Research Institutes of Sweden), The Swedish National Data Service, The Swedish Metrological and Hydrological Institute, Lysekil Municipality, Alkit Communications AB, Combine Control Systems, Inocean AB, Maranics AB, Medins Sea and Water Consultants AB, MMT Sweden, SeAnalytics AB, eDNAsolutions, Swedish Agency for Marine and Water Management

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

Main contact points Dan Hill – dan.hill@vinnova.se
Relevant links https://www.vinnova.se/en/p/ocean-data-factory/
Timeline June 2019 - June 2021 Ongoing

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

UC21: Neurobica – remote neurofeedback patient data

Title: Neurobica – remote neurofeedback patient data

Societal Challenges

Neuropsychiatric symptoms like Anxiety, Depression, Sleeping Problems and lack of Impulse Control is rising a lot, mainly in this times of forced confinement. Real-Time Neurofeedback as a neuromodulation technique is growing as a tool of self-awareness and self-regulation to fight this symptom. Another big advantage of this technology and methodology is to allow people with assessability problems to be able to interact with the world without the need of using their bodies.

The fact that this technology is fully wearable, wireless, cloud-based and with local-computation, allows any person, in the safety of their houses to wear it and use it for brain training, neuropsychiatric clinical diagnosis and actuation with other IoT devices. We also propose a remote multi-sensory immersive neurofeedback platform (In-Volution) to capture, process, analyze and retrieve the brain data in real-time and store the brain datasets for further research and cross-validation by other research institutions. By using machine-learning batteries we can reduce the latency of the processing pipeline and increase the accuracy of the metrics retrieved to the user, for the brain training and for the actuation itself. Audio-Visual real-time feedback can be retrieved to the user throw many mediums like: VR, Sound, Movement or Light in the way that this mediums act as extensions of the users brain.

Technical Challenges

Our main technical challenges are storing the datasets in a private and secure way. To do so we need powerful and well managed servers that sometimes are very expensive for young start-ups to afford.

How EOSC can help and add value

MuArts BCI routine and software would benefit from EOSC greatly in the way that our datasets can be validated by other institutions and at the same time our algorithms batteries can be cross-validated with other research centers with the simple fact that if they reach the same results and final metric (after full signal processing) it means that both processing algorithms pipelines are processing correctly the datasets. Another advantage would be reducing the costs of storing and managing big amounts of data and share the accountability of the data security and privacy.

A relevant picture representing the use case

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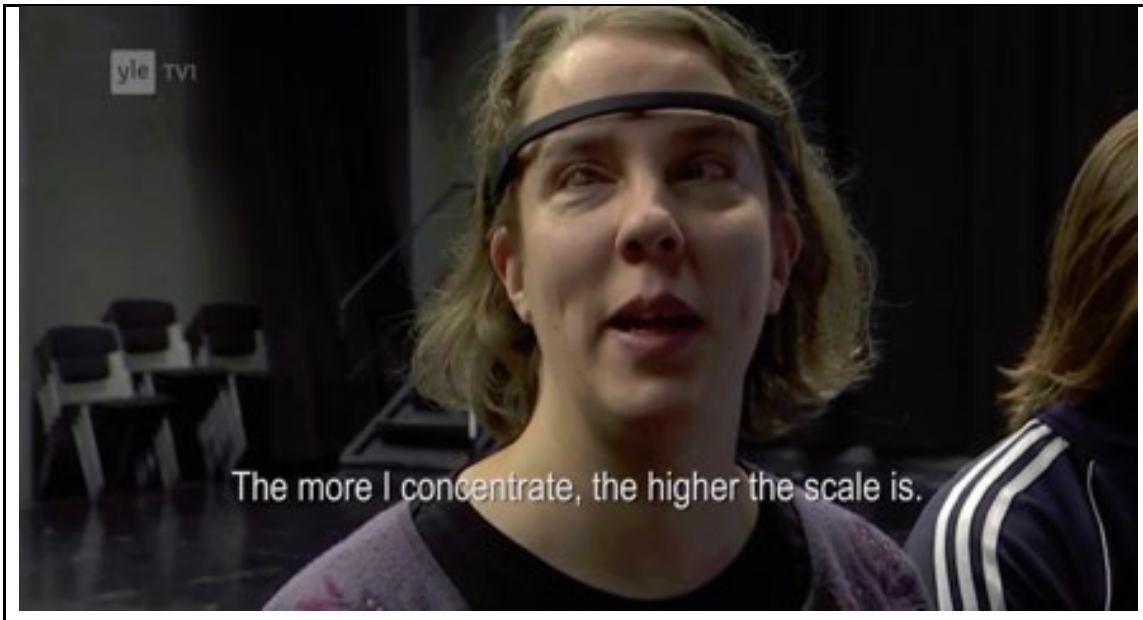

Rikka (blind singer) using the Interaxon Muse headset and our software to control a piano scale up and down with her concentration index so she can create melodies while performing live with other musicians.

Organisations involved

MuArts - https://www.muarts.tech Neurobios - http://www.neurobios.org/ Human2Human - https://www.humantohuman.tech/ TRANS-LATE - https://www.trans-late.tech

Main contact points

Francisco Marques-Teixeira, Francisco.ma.teixeira@gmail.com

Relevant links (links to demos, tools, etc. or any useful reference that can support the use case)

https://www.muarts.tech https://www.trans-late.tech

Timeline

Use case is implemented and fully operational.

We have a stream of datasets coming everyday with QEEG (Quantitative electroencephalography) exams performed to our patients in our 4 clinics. Currently we are using a common clinical EEG cap and our prototype software with the signal processing algorithms batteries, the automated decision making three and the symptoms correlation index.

Furthermore we have a modular, fully wireless and local computation EEG-BCI (electroencephalogram(brain-computer-interface) device prototype that is waiting for further funding so we can go to MVP development and further industrialization. Other milestone is validating our machine-learning model for the BCI-actuation (for IoT-Domotics and Accessibility) mode of our headset. To achieve so we need more datasets and pull of subjects so we can test and validate our algorithm batteries.

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UC22: A prototype for a real time Gravitational Wave (GW) transient signal classifier

Title A prototype for a real time Gravitational Wave (GW) transient signal classifier

Societal Challenges

This architecture defined in WAVEFIER could be potentially useful for any Big Data project. The use of Kafka to help in message queuing is fundamental to avoid any kind of problem of overload, scalability, etc. Deploying on Kubernetes architecture is fundamental to keep isolate the component, which could have different dependencies in terms of OS, third-part library, etc. Wavefier project could potentially be interoperable for various vertical industries, such as in the detection of traffic in cities or for the weather.

To list some of them it may be possible to:
- Provide the researcher with an admin dashboard in order to change the algorithms without the developer intervening.
-Tune the system finding possible bottlenecks
-Use different ML algorithms to define possible improvements to Wavefier-wdf to detect the noise better.

Technical Challenges

The **detection of gravitational waves** has inaugurated the era of gravitational astronomy and opened new challenges for the multi-messenger study of cosmic sources. Thanks to their sensitivity, the Advanced LIGO and Advanced Virgo interferometers will probe a much larger volume of space and expand the capability of discovering new gravitational wave emitters. However, noise identification and its removal remain one of the most challenging problem in GW data analysis. A single GW detector typically produces data with a rate of 7-8 Tb per day with a flux of 40Mb/s. This data have to be analysed in the faster and most efficient way to increase the detection confidence and to obtain information in real time, about likely noise sources and to help the fast alert system for Electromagnetic Follow Up systems.
Glitches are transient noise events that can impact the data quality of the interferometers and their classification is an important task.
The solution implemented is based on a pipeline that allows data to be processed in a scalable, performant and interoperable way using Apache Kafka and technological solutions that ensure interaction and information exchange without constraints on implementations, avoiding ad hoc integrations and open to any kind of integration with other application and services.
Another important objective of the project was to try to **build an architectural solution that could be easily extended in other contexts** to be able to do big data analysis in real time using deep learning algorithms without rewriting from scratch all the architecture. The goal was achieved thanks to the use of Apache Kafka (a high-performance, low-latency, scalable that is used by thousands of services worldwide) and its architectural model and Avro types that allow allows the developer to write only part of the code related to the type of data to be analyzed.
Thanks to **GARR infrastructure** and access to the GARR Container Platform, based on kubernetes, we were able to work without having to take charge of the configuration and physical resources but we were able to concentrate on development and have been able to scale the application according to our needs without having to manage physical machines

How EOSC can help and add value

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The following illustrations is a theoretical simulation of introducing WAVEFIER within the EOSC marketplace and demonstrates, "in practice" how an industrial collaboration project combining renowned researchers, networked organisations, research institutions in their field can effectively carry out scientific experiments with the private sector, in this case an SME allowing already for a widening of EOSC to the private sector and incentivise other industrial players big & small to consider getting involved in the next implementation phase of EOSC.

A relevant picture representing the use case

Organisations involved

WaveFier is the result of an industrial collaboration project developed in 2019 with **Trust-IT Services, an SME based out of UK & now Italy** and "**CNRS - Center National de la Recherche Scientifique in Paris**"in France acting in behalf of the "Laboratori d'Annecy de physique des particules - LAPP UMR n. 51814" carried out in the context of the H2020 **Asterics / Obelics** project of the European union's Commission Programme.
GARR (IT) Provided infrastructure, resources for the support provided;
EGO-VIRGO: Provisioning of sample data & support.

Main contact points

EGO -VIRGO (IT)
Elena Cuoco - Ph.D. researcher Head of Data Science Office @EGO-Virgo "European Gravitational Observatory" - Scientific Supervisor of the project email address: elena.cuoco@ego-gw.it
CNRS-LAPP

Relevant links

This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

" A prototype for a real time pipeline for the detection of transient signals and their automatic classification" Zenodo https://zenodo.org/record/3356656#.X3X0qFlLfAw https://repository.asterics2020.eu/content/wavefier On those registered on GITLAb of LAPP it is possible to download the source code. Anonymously you may access the build. Demo video at this address - password protected contact Trust-IT to peruse: https://home.trust-itservices.com/share.cgi?ssid=0utN6UM
Timeline Project delivered 2019

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UC23: Getting Science on the Blockchain – the Global bloXberg Infrastructure

Title: Getting Science on the Blockchain – the Global bloXberg Infrastructure

Societal Challenges

The bloXberg infrastructure is a secure global blockchain established in early 2019 by a consortium of eleven world-leading research institutions from ten different countries and under the leadership of the Max Planck Society.

The aim of the bloXberg infrastructure is to provide scientists with decentralized services and to foster collaboration among the global scientific community. For example, with consented transactions on the bloXberg infrastructure, research claims need not be limited to one institution alone, but can be confirmed by the whole trusted network. There are more than enough concrete applications and demands for a transparent and safe online system based on blockchains in science: to verify the authenticity of data, guaranteed protection of intellectual property rights, the exchange of valuable research results, peer reviewing, the publication of papers and much more.

bloXberg strives to have sufficient representation from various scientific entities in Europe and worldwide, participating in the consortium, so that the network itself may replace traditional scientific infrastructure such as closed-access publishing of research results, among others.

Technical Challenges

Conventional blockchains such as the Bitcoin Blockchain are inadequate for scientific applications because of their lack of reputation, lack of performance and high energy consumption. A blockchain run by scientists, for science is necessary in order to avoid influence from commercial entities in a direction that is in conflict with the goals of science. To this end, a scientific blockchain established, governed, and developed by the research community is vital to ensure the best interests of science are always kept at the forefront. To live up to the expectations of science such as ratability, continuity, performance, independence from financial markets, and reputation, bloXberg was initiated as a scientific blockchain.

The bloXberg infrastructure is based on the open source blockchain Ethereum, but instead of the more common Proof-of-Work consensus mechanism Proof-of-Authority is used, so that every validation node is operated by a research facility with a known identity - namely the members of the bloXberg consortium. In addition, so-called bergs are used to interact with blockchain applications, which can be compared to bitcoins, but are not traded. That means all of the transactions in the bloXberg network are free.

One further aspect of the bloXberg project is the transparent accessibility and the associated documentation of the interface to bloXberg blockchain. Applications can be built up via the open bloXberg programming interface. This means that everyone – for example scientists or start-ups – can establish and offer complete services and applications on the bloXberg blockchain.

How EOSC can help and add value

A collaboration between bloXberg and EOSC can revolutionize the certification of research data and the Peer Review System in Europe and around the world

1) Certification of Research Data

bloXberg's certification dApp is already being used by scientists to protect their intellectual property by creating a transparent footprint of their work without revealing its content. Everyone who wants get a ‘Proof of Existence’ for all of their data can generate a bloXberg certificate in less than 5 seconds that proves the upload of this data at a certain time. This certificate contains the transaction number

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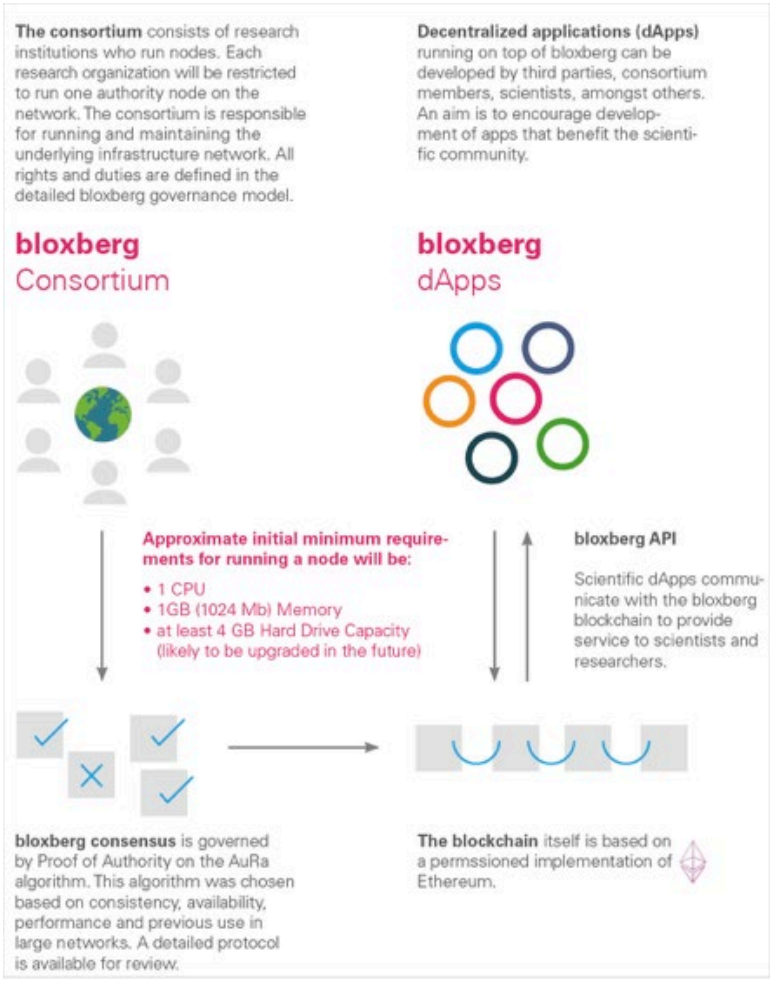
that can be used at any time to validate the certification. However, when using the bloXberg dApp via the web interface, scientists have to ensure the permanent storage of their own data, because bloXberg only stores the transactions, neither the data itself nor the certificate. This has the advantage that the bloXberg infrastructure is fast and requires little hardware, and that the actual data storage is still in the hands of the individual scientist and/or his/her research institution.

While many research institutions have already created their own very good storage facilities for research data, there are still many organizations that do not have access to high quality storage and archiving systems that comply with good scientific practice. By providing a storage option for "blockchainified" research data, a collaboration between the bloXberg blockchain and EOSC would close one of the most important gaps in the research data landscape.

2) Peer Review System

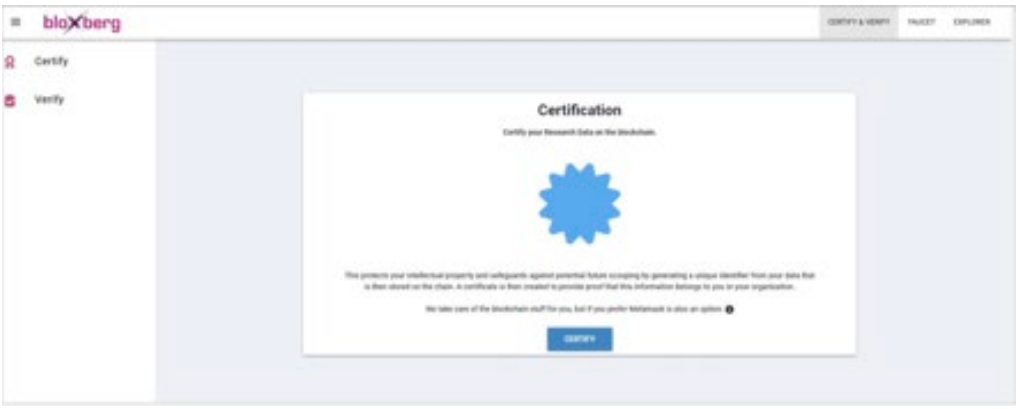
bloXberg is currently working on further applications like the aggregated Peer Review dApp, which connects all involved stakeholders like scientists, funders, publishers, editors etc. to each other to make the processes of peer review more efficient, transparent, traceable and secure. Scientists can easily aggregate, organize and showcase all of their peer reviews and are able to import existing reviews from external sources like Publons, F1000R, open review etc. They can also vouch and verify others' reviews. A completely new approach for future-oriented reputation tokens is currently being evaluated. Here, too, a future collaboration between the EOSC infrastructure and the bloXberg network would create immense synergies and revolutionize the Peer Review System!

A relevant picture representing the use case

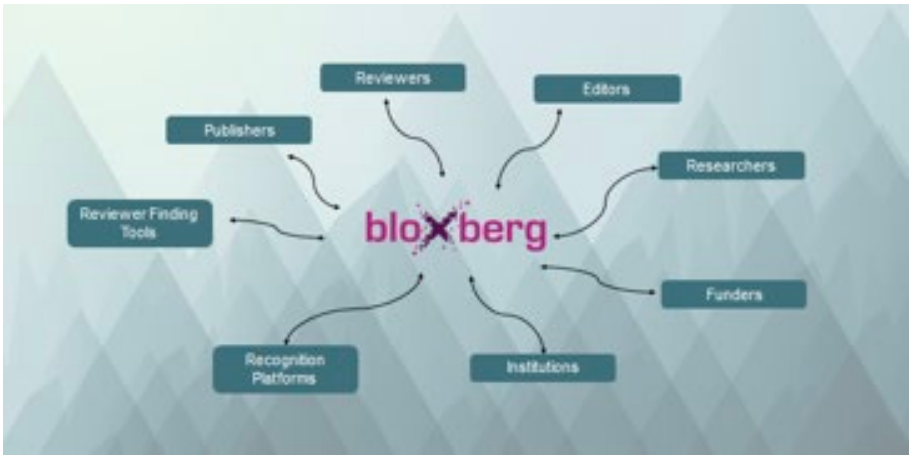


This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

Workflow on the bloXberg blockchain – validation, transactions, creation of blocks and dApps

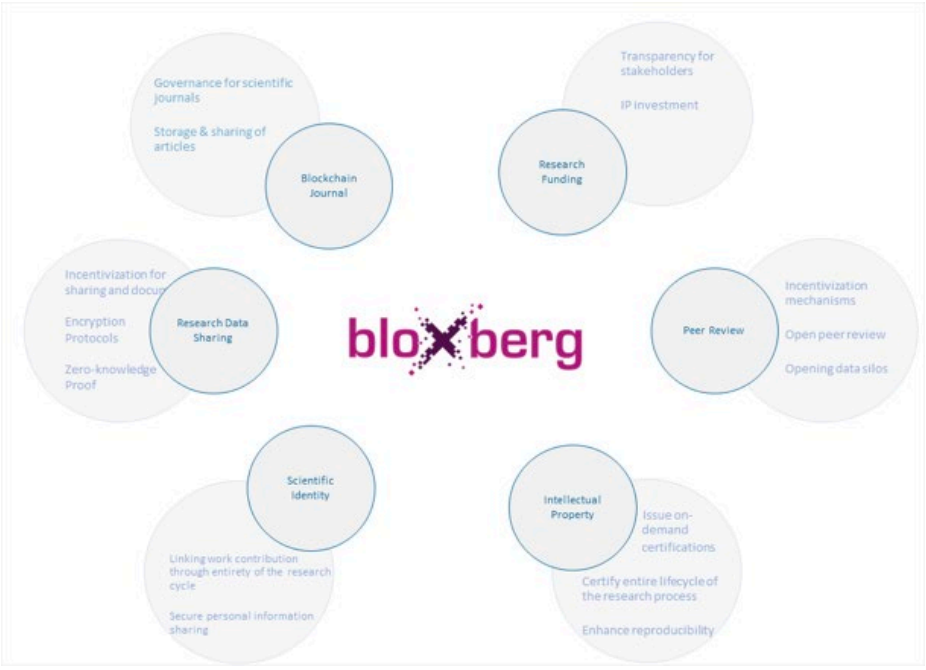


Screenshot of the bloXberg Certification dApp, which is already implemented (https://certify.bloXberg.org/)



This Study has been funded by the EOSCsecretariat.eu which has received funding from the European Union's Horizon Programme call H2020-INFRAEOSC-2018-4, Grant Agreement number 831644

Concept and screenshots of the Peer Review Aggregation dApp (Pilot version December 2020)



Further use-cases for researcher with the decentralized science blockchain bloXberg are planned.

Organisations involved

The bloXberg consortium is rapidly growing and has already 41 members from 21 nations (see list of all research organizations below. A current status of all bloXberg members that are already running an active node as validators can be seen here: https://validators.bloXberg.org/bloXberg-dapps-validators

Aristotle University of Thessaloniki

BAM/Bundesanstalt für Materialforschung und - prüfung

Bogazici University

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Carnegie Mellon University
Carol I National Defence University
Dublin City University
ETH Library
Fachhochschule Technikum Wien
Ferdinand-Steinbeis Institut
Frankfurt School of Finance & Management
Fraunhofer Gesellschaft
Georgia Institute of Technology
HAW Hamburg
Helmholtz-Gemeinschaft Deutscher Forschungszentren
Hochschule Furtwangen (HFU)
Hochschule Heilbronn
Instituto Gulbenkian de Ciência (IGC)
IT University of Copenhagen
Max-Planck-Gesellschaft
Mendel University
Politecnico di Milano
RMIT University
RWTH Aachen University
Technische Universität München
TH Köln
The Open University
Universidad Nacional de Colombia
Universität Kassel
Universität Zürich
University College London (UCL)
University of Belgrade
University of Geneva
University of Johannesburg
University of Malta
University of Nicosia
University of North Florida
University of Pavia
University of Sarajevo

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West University of Timisoara

Westfälische Hochschule

Main contact points (Name/Surname + email)

Vengadasalam / Sandra: vengadasalam@mpdl.mpg.de

Kleinfercher / Friederike: kleinfercher@mpdl.mpg.de

Relevant links

- bloXberg website: https://bloXberg.org/
- bloXberg whitepaper: https://bloXberg.org/wp-content/uploads/2020/02/bloXberg_whitepaper_1.1.pdf
- Max-Planck-Society news: https://www.mpg.de/13417668/first-international-blockchain-for-science-bloXberg
- German government's blockchain strategy paper: https://www.bmwi.de/Redaktion/EN/Publikationen/Digitale-Welt/blockchain-strategy.html
- Fraunhofer Open Access Hub SAIRA for research findings on COVID-19 connected to bloXberg Blockchain: https://www.fraunhofer.de/en/press/research-news/2020/august/share-and-browse-technologies-research-and-best-practices-on-covid-19.html

Timeline

The bloXberg infrastructure is already active as a pilot project since February 2019. Several applications from different commercial and non-commercial stakeholders are already running productively. Selected Milestones:

- February 2019: Genesis of the bloXberg Blockchain with 11 founders
- February 2019: Research Data Certification dApp is implemented
- Since March 2019: 41 bloXberg members
- October 2019: ARTiFACTS Smart Contracts processing on bloXberg (https://artifacts.ai/press/)
- August 2020: Fraunhofer Open Access SAIRA platform for research findings on COVID-19 connected to bloXberg Blockchain (see link above)
- September 2020: Wolfram Blockchain Labs start a collaboration with bloXberg (press release coming soon)
- December 2020: Pilot version of the own Peer Review Aggregation dApp
- 2019-2020: The bloXberg infrastructure is part of several research grant applications, as the applicable blockchain backbone
- 2021 - 2023: Further Application will be implemented (see Fig.4)

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Appendix 2: List of broader EOSC community stakeholders interviewed

Name		#	Affiliation	Short biography	Stakeholder type
Andreas	Bergsland	5	NTNU	Andreas Bergsland is currently Study Programme Leader and holds an Associate Professor position at the Music Technology Program at Norwegian University of Science and Technology (NTNU), where he teaches courses in analytical and aesthetical perspectives on music and technology, music technology history, csound, spatial audio and other subjects. His research interests have included voice in electroacoustic music (PhD entitled "Experiencing voices in Electroacoustic Music" from 2010), live-electronics from a performative perspective, interactive dance and movement-sound interaction for users with and without disabilities.	Academia
Sten-Erik	Björling	22	Luleå University	Sten-Erik Björling is PhD Candidate at Luleå University of Technology, and Council Member at Internet of Things. He is conceptualiser, designer and partner in a number for EU FP 6, FP 7 and H2020 proposals and projects covering Circular Economy (CIRC4Life - approved, myEcoCost - approved), project proposals for communities of practice, advanced maintenance processes in Industry 4.0 etc. Currently conceptualised and designed large parts of a proposal covering global information logistics for circular economy, currently in first phase evaluation.	Academia
Charles	Ess	23	University of Oslo	Charles Ess (PhD, Pennsylvania State University, USA) is Associate Professor in Media Studies, Department of Media and Communication, University of Oslo, and Director, Center for Research in Media Innovation (CeRMI), University of Oslo. He has received awards for teaching and scholarship. His research and publications emphasize cross-cultural and ethical perspectives in Internet Studies, and Information and Computing Ethics.	Academia

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Dimitris	Kiritsis	17	EPFL	Prof. Dr. Dimitris Kiritsis is Faculty Member at the Institute of Mechanical Engineering of the School of Engineering of EPFL, Switzerland, where he is leading a research group on ICT for Sustainable Manufacturing. His research interests are Closed Loop Lifecycle Management, IoT, Semantic Technologies and Data Analytics for Engineering Applications. He served also as Guest Professor at the IMS Center of the University of Cincinnati, and Invited Professor at the University of Technology of Compiègne, the University of Technology of Belfort-Montbéliard and at ParisTech ENSAM Paris. Prof. Kiritsis is actively involved in EU research programs in the area of Factories of the Future and Enabling ICT for Sustainable Manufacturing. He has more than 200 publications. He is Chair of IFIP WG5.7 – Advanced Production Management Systems and member of the Advisory Group of the European Council on Leadership on Enabling Industrial Technologies – AG LEIT-NMBP – and founding member of the International Society for Engineering Asset Management (ISEAM) and of various international scientific communities including EFFRA.	Academia
Amy	Loutfi	28	Örebro University	Amy Loutfi is Pro Vice Chancellor for AI at Örebro University and Professor at the AASS Research Center, Department of Science and Technology. She received her PhD in Computer Science in Örebro in 2006 in the field of robotic olfaction, and a BSc. in Electrical Engineering from the University of New Brunswick, Canada. From 2008-2010 she was the program coordinator for the International Masters in Robotics and Intelligent Systems at Örebro University. In 2011 she was the director of studies for all Computer Engineering programs Örebro University. In 2014 she became the deputy head of the department of Science and Technology. Her general interests include robotics and intelligent systems. More specifically she is interested in Machine Olfaction including Mobile Robot Olfaction, Knowledge Representation and Reasoning for Sensor Systems, Human-Robot Interaction and Social Robotic Telepresence.	Academia

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Sven	Maričić	10	University of Rijeka and Juraj Dobrila University of Pula	Sven Maričić is Assistant Professor, Faculty of Medicine, University of Rijeka, and advisor to the Rector for new technologies at the Juraj Dobrila University of Pula. He obtained a PhD in 2011 on the topic of the development biocompatible parts in biotechnology. He specialises in areas such as production engineering, biotechnology, reconstruction of the maxillofacial region, CAD/CAM 3D modelling and the development of endoscopic surgical instruments, and application of new technology in dental medicine. Head of the Laboratory for Plastic Deformation and Manufacturing Machines (2013 - 2016). Sven fulfilled all the conditions for full professorship already at the age of 34 (among the youngest 10% of scientific advisors in the Republic of Croatia).	Academia
Alexandra	Murray-Leslie	12	NTNU	Alexandra Murray-Leslie is a poly-artist, artistic researcher and co-founder of Chicks on Speed, an internationally renowned cross-disciplinary art group. She is currently Professor at Trondheim Academy of Fine Arts, NTNU, Norwegian University of Science and Technology. She completed her PhD in artistic research at The University of Technology Sydney followed by taking up ARTEC artist in residence at NTNU in 2018.	Academia
Rene	Belsø	27	Danish e-Infrastructure Cooperation (DeIC)	Rene Belsø has been working 20+ years with research policy and research infrastructure provisioning, primarily within the area of information and computing technologies. Belsø has been employed in national- and international government political institutions; been Head of the Danish Center for Scientific Computing, and is now working for the national e-Infrastructure provider organisation – with international matters, mostly with High Performance Computing (HPC) and Data Management infrastructures. He is Danish member of a number of international cooperation bodies, one being "EOSC Rules of Participation Working Group".	EOSC stakeholder

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Jean-Yves	Berthou	42	Inria Saclay Research Center	Dr. Jean Yves BERTHOU has joined Inria in February 2019 as Director of the Inria Saclay Research Center. Created in 2008, the Inria Saclay-Île-de-France research centre has 500 scientists, forming 28 research teams, and 100 staff working in research support departments. The centre is a key player in research in the digital sciences on the Saclay campus. It promotes the values and projects that give Inria its originality in the research landscape: scientific excellence, innovation and multi-disciplinary partnerships to maximise Inria's scientific, economic and societal impact.	EOSC stakeholder
Ignacio	Blanquer	26	Universitat Politècnica de València	Ignacio Blanquer is full professor of parallel, grid and cloud computing in the area of Computer Science and Artificial Intelligence at the Polytechnic University of Valencia, with more than 20 years of teaching experience in undergraduate, postgraduate and PhD courses. Since 1993 he has been linked to the research group in Grid and High-Performance Computing (GRyCAP), being responsible for this group since 2016. His research activity has focused on the application of parallel computing, Grid and cloud technologies to different scientific disciplines, with a special dedication to biomedicine. He has participated in 57 national and European projects, having been the coordinator of three European projects. He is co-author of more than 40 articles in indexed journals and book chapters, in addition to more than 100 communications in international conferences. He acted as the head of the area of applications of the Spanish Network of e-science. He is currently the Spanish delegate of the e-IRG and the coordinator of the Spanish Network on Open Science.	EOSC stakeholder

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Lidia	Borrell-Damián	40	Science Europe	Lidia Borrell-Damián is the newly appointed Secretary General of Science Europe, the association representing major public organisations that fund or perform excellent, ground-breaking research in Europe. In this new role she holds overall responsibility for the strategy and functioning of the organisation. Prior to this she worked for the European University Association (EUA) since 2006 and served as its Director for Research and Innovation (R&I) between January 2014 and mid-September 2019. As the Director for R&I, she was responsible for the overall strategy and activities of EUA in the area, supporting the work and enhancing the role of universities as major research and innovation organisations at the European level in coordination with EUA individual members and the National Rectors' Conferences.	EOSC stakeholder
Shaun	de Witt	38	UK Atomic Energy Authority	Shaun de Witt is Head of High Performance Data Analytics at UK Atomic Energy Authority / Culham Centre for Fusion Energy. He has been working in the field of data management since the 1980's. During this time he had the pleasure of working in a number of fields including astronomy, remote sensing, meteorology, climatology and particle physics. He has also been involved in European projects related to RDM including EUDAT and he is currently engaged with the European Open Science Cloud Initiative. His main interests lie around metadata standards and ontologies, long term data and information preservation, and provenance as key for the exploitation of todays results by researchers in the future, and essential to building trust in data.	EOSC stakeholder

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Francoise	Genova	36	Centre de Donnees astronomiques de Strasbourg (CDS)	Francoise Genova has been the director of the Strasbourg astronomical data centre CDS, and is one of the founding parents of the astronomical Virtual Observatory initiative. She is currently involved in the ESCAPE European Cluster project, in a work package which aims at connecting the Virtual Observatory with the European Open Science Cloud and to continue to improve the FAIRisation of data from for astronomy, astroparticle and heliophysics large facilities. She was a member of the European Commission Expert Group on Turning FAIR data to reality (2017-2018), and one of the authors of the Expert Group Report "Turning FAIR into Reality" (2018). She is a member of the EOSC FAIR WG. She has been an active member of the RDA since its inception. She was a member of the Data Seal of Approval Board (2016-2017), of the WDS Scientific Committee (2009-2015) and of CODATA Executive Committee (2010-2012). She has also been part-time advisor at the French Ministry of Higher Education, Research and Innovation (MESRI) since 2014.	EOSC stakeholder
Sy	Holsinger	30	EGI	Sy Holsinger is the Strategy and Innovation Team Lead and Business Development Manager at the EGI Foundation working on sustainability planning, business model development, market analysis, project management and IT service management implementation. He has over 10 years experience in EU-funded projects, leading commercial exploitation such as in the series of EGEE projects, EGI flagship projects, and currently in the EOSC-hub project. Sy is also a certified expert, trainer and auditor (ISO 19011) in both FitSM (Service Management) and ISO/IEC 27001 (Information Security) standards, and volunteers as Co-chair of ITEMO (IT Education Management Organization) to evolve the FitSM standard. Sy studied Business Communications and Management in the U.S. focusing on project and financial management, business development, marketing and communication messaging.	EOSC stakeholder

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Bob	Jones	45	CERN	Bob Jones is a senior member of the scientific staff at CERN and a leader of the Helix Nebula initiative, a public private partnership to explore the use of commercial cloud services for big data science applications. He is the coordinator for the HNSciCloud Horizon 2020 Pre-Commercial Procurement project which is procuring innovative cloud services to establish a cloud platform for the European research community and contributing the European Open Science Cloud. His experience in the distributed computing arena includes mandates as the technical director and then project director of the EGEE projects (2004-2010) which led to the creation of EGI.	EOSC stakeholder
Patricia	Mergen	37	Royal Museum for Central Africa	Dr. Patricia Mergen is currently Liaison Officer and LEAR for the European Commission at the Royal Museum for Central Africa, Tervuren Belgium. She is since 2016 sub-contractor of the Meise Botanic Garden to act as liaison Office (currently 80%). She is the promoter for Flanders of the implementation of the ESFRI infrastructure DiSSCo (Distributed System of Scientific Collections) She is also mentor for the Global Biodiversity Information Facility (GBIF) Biodiversity Information for Development program (BID). Until end 2013 she was head of the Biodiversity Information and Cyber-taxonomy services of the Africamuseum, where she started in 2005 as responsible for external relations and project management.	EOSC stakeholder
Silvana	Muscella	43	Trust-IT	Silvana Muscella is CEO & founder of the SME Trust-IT Services, an SME providing international marketing & research specialised in fostering ICT solutions globally and across Europe and co-founder of COMMPLA, a boutique software house that delivers multichannel software solutions to commercial clients. Played an instrumental role in connecting stakeholders around standardisation efforts in distributed computing (namely, IEEE, ETSI, OGF, SNIA, DMTF, OASIS, ITU-T). Contributed to the EC's Cloud Expert Group Roadmap on future research priorities & the ETSI Cloud Standards Coordination & and the C-SIG on SLAs. Chair of the EOSC HLEG [2017-2018], member of the Green Grid, IEEE	EOSC stakeholder

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				InterCloud Computing Initiative & an ACM Professional Member. Author of the Cloudscape Series now taken forward in Brazil. Served as at-large director for OGF. External Expert Evaluator for the European Commission since 2009.	
Gergely	Sipos	35	EGI	Gergely is the Head of the Services, Solutions and Support department at the EGI Foundation. He is responsible for the provisioning and innovation of services owned by the EGI Foundation, and for overseeing the operational status of the EGI infrastructure. The three teams of his department, with the help of EGI's national e-infrastructures, perform user community engagement, requirement collection & analysis, service piloting and service customisation for communities, as well as deliver operational services, training and support. Gergely holds an MSc and PhD in computer science with specialisation in management, from the University of Miskolc (Hungary).	EOSC stakeholder
Cathrin	Stover	32	GÉANT	Cathrin Stover is Chief Communications Officer for GÉANT. With more than 20 years of experience working in global telecommunications and the roll-out of network infrastructures across various continents, Cathrin is a highly effective global team leader, successfully working across borders and cultures in complex multi-dimensional projects. Cathrin has belonged to the GÉANT team since 1997, holding various positions as the organisation has grown and developed, always with a specific focus on growing the geographic reach of the GÉANT network and the deepening of the global R&E collaboration for the benefit of the global research and education community. Following the minor reorganisation at the beginning of 2020, Cathrin now carries the overall responsibility for the Marketing Communications and Design teams and additionally the EU Liaison Team. In November 2018, Cathrin was appointed as Vice-Chair of the EOSC Executive Board. Cathrin holds a European Business degree from the FH Osnabrück in Germany.	EOSC stakeholder

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Olaf	Verschoor	39	GÉANT	Olaf Verschoor is GÉANT's Head of Procurement. Olaf joined GÉANT in 2019 as a Procurement Specialist and has been heavily involved in GÉANT's Cloud activities, including the OCRE Project. Prior to joining GÉANT, Olaf has held senior Procurement positions with the Dutch public broadcaster, the Utrecht public authority and Hewlett-Packard.	EOSC stakeholder
Petra	Dalunde	6	Sweden AI	As Node Manager for AI Sweden and a Board member of Stockholm AI Petra is deeply connected to the AI eco system of Sweden. Prior to this role Petra founded Urban ICT Arena in Kista and has been Head of Communications in Stockholm City as well as a Political Advisor in the Mayors' office in the City Hall.	Expert Open Innovation / Government organisation /
Pia	Erkinheimo	41	VAKE - the Finnish State Development Company	Pia Erkinheimo is Programme Director of the Data as an Enabler Programme at Vake – the 2.3 bn € funded Finnish State Development Company focusing on the deployment of AI and related technologies in Finnish business and society. She is Chair of the board at Solved, an online marketplace for clean tech and sustainability knowledge, and Chief Orchestrating Officer at iloom.io, a Natural Language Processing engine for brand & employee experience. She is adviser to the European Commission on Innovation, and is a board member of the largest angel investor network in Europe. She is particularly skilled in Artificial Intelligence, Platform Economy & Strategy, Sustainability & Consumer Cleantech, Circular Economy, Crowdsourcing, Open Innovation & Innovation Management, IT Strategy, and Mobile Applications. She frequently works directly with startups, advising them on strategy and finance, and is completing a PhD in Industrial Management and Strategy at Aalto University.	Expert Open Innovation / Government organisation

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Susanne	Fuglsang	33	Innovation Pioneers	Susanne Fuglsang is an Innovation Catalyst & CEO at Innovation Pioneers. She is also board member at Meetingrid, a member of the advisory board of Hack for Sweden, advisor at the startup generator and VC firm Antler, and a member of the advisory board for Changemaker Education. She has extensive experience in strategy and production of interdisciplinary co-creation processes like Hackathons, Design Sprints and Innovation Events. Her work creates and inspires sustainable change through open innovation projects by co-creation between tech, science, academia, companies and non-profit organisations. Her clients include Volvo, IKEA, Tetra-Pak, Pernod Richard, Astra Zeneca, White Arkitekter, Ericsson, RISE, NASA, Stockholm Science City Foundation, Bonniers, Venture Cup, Swedish IT & Telecom Industries, The Swedish Post and Telecom Authority (PTS) and The City of Stockholm. Susanne is the founder of Geek Girl Plus which educates and inspires senior women to learn new digital, technical and creative skills from other role models in the industry and through networking.	Expert Open Innovation / Government organisation
Konstantinos	Glinos	34	European Commission	Dr Kostas Glinos is Head of Unit for Open Science, European Commission. Kostas works at the European Commission, leading the unit in charge of Open Science in the directorate general for Research & Innovation. Prior to this he held various management positions related to STI policy and R&D funding programmes, including international relations, research infrastructures, cyber-physical systems, future and emerging technologies and big research data. In the academic year 2017-2018 he was a Fellow at the Lee Kuan Yew School of Public Policy at the National University of Singapore. Before joining the Commission in 1992 Kostas worked in the chemical industry in the USA and Belgium, lectured at the University and carried out research. He holds a PhD in engineering from the University of Massachusetts and an Advanced Professional Certificate in investment management from Drexel University.	Expert Open Innovation / Government organisation

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Dan	Hill	20	Vinnova	Dan Hill is Director of Strategic Design at Vinnova, the Swedish government's innovation agency. A designer and urbanist, Dan's previous leadership positions have produced innovative, influential projects and organisations, ranging across built environment (Arup in Australia and UK, Future Cities Catapult in UK), education and research (Fabrica in Italy), government and social innovation (SITRA in Finland), and media (BBC and Monocle in UK), each one transformed positively via digital technology and a holistic approach to design. He has lived and worked in the UK, Australia, Finland, Italy and Sweden. As well as being Visiting Professor of Practice at the UCL Institute for Innovation and Public Purpose (IIPP), Dan is also a visiting professor at Design Academy Eindhoven, an adjunct professor at RMIT University in Melbourne, and one of the Mayor of London's Design Advocates. He is the author of the influential playbook, "Dark Matter & Trojan Horses: A Strategic Design Vocabulary" (Strelka Press, 2012). He writes at https://medium.com/@cityofsound.	Expert Open Innovation / Government organisation
Mantalena	Kaili	9	ELON Tech	Mantalena Kaili is Executive Director of ELONTech, an initiative of Law and Technology professionals and researchers who aim to explore the interface of the two fields, the challenges and the barriers between regulation and innovation, as well as the transformation of law enacting and enforcement, the introduction of the decentralized organizations and the disruption that technology brings across all sectors of the economy. She is head policy advisor and close collaborator in the office of her sister, Greek MEP Eva Kaili, who is Chair of the European Parliament's Science and Technology Options Assessment body (STOA) and has been working intensively on promoting innovation as a driving force of the establishment of the European Digital Single Market. Mantalena also acts as policy advisor to the Maritime Economic Forum – a Forum for the Shipping and Blue Economy Opportunities for the City of Thessaloniki.	Expert Open Innovation / Government organisation

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Anette	Novak	4	Swedish Media Council	Anette Novak is Director of the Swedish Media Council, the government agency charged with the protection of children and young people from harmful effects of the media and to help them to become more aware media users. Prior to this role, she was CEO of the Interactive Institute Swedish ICT (now RISE Interactive), an experimental IT and design research institute that creates results by combining art, design and technology, and ran her own consulting business focusing on change processes mainly in the media field. She is also a regular keynote speaker on issues of media and innovation.	Expert Open Innovation / Government organisation
Bror	Salmelin	8	Living Labs, previously European Commission	Bror Salmelin was, until his recent retirement, the adviser for Innovation Systems at the European Commission, Directorate General for Communications, Network, Content, and Technology (DG CONNECT) where he was responsible for Open innovation and Modern innovation systems. He managed the activities of the Open Innovation Strategy and Policy Group (OISPG), an industry-led group advising on strategic priorities for open and service innovation. As a head of unit, he developed the concept of European Network of Living Labs, which has grown through EU presidencies to a 150+ sites innovation network for ICT-intense services. Previously, He held the position of Deputy of the ICT Section in Technology Development Centre and served as the Finnish representative at ESPRIT/IST programme of the EU.	Expert Open Innovation / Government organisation /

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Gurvinder	Ahluwhalia	13	Digital Twin Labs, formerly IBM US	Gurvinder Singh Ahluwalia is the Founder & CEO of Digital Twin Lab, a product and platform development company bringing together Blockchain, AI/ML, IoT, and Cloud. He is the Cofounder & Chief Product Officer of StreamSum, an AI platform company for streaming video analytics of live sport an other events. Gurvinder is the former Chief Technology Officer of IBM's Blockchain-IoT-Cloud unit for North America. He deployed the world's second largest network at the dawn of TCP/IP; served to pioneer the use of RFID in supply chain which culminated into the MIT Auto-ID initiative coining there of the term "Internet of Things". He is a frequent speaker at forums including Davos, Horasis, STARTS European Commission, Stanford, US Federal Reserve, US Department of State, MIT, World Automotive Conference, World Food Congress, Google, UC Berkeley, Diamler Benz, and Samsung Developer Conference. Gurvinder is Adjunct Faculty at University of Texas Dallas. He is an alumnus of the IBM Academy of Technology and an Industry Associate at the University College of London.	Industry
Antonio	Arcidiacono	2	EBU	Antonio Arcidiacono is the EBU Director of Technology & Innovation. Antonio has extensive experience in conceiving, developing and taking new products and services to market. Antonio was Director of Innovation, and a Member of the Management Committee, at Eutelsat from 2008 -2018 where he was responsible for launching innovative IP based satellite services. He joined Eutelsat in 1990 and took part in key phases of its development from an international organization to privatization in 2001 and to the IPO in 2005. Before working at Eutelsat, Antonio worked for the European Space Agency and started his career working for Telespazio and Selenia Spazio. Antonio has a Doctorate in Electronics & Telecommunications Engineering from the University of Pisa. He is fluent in Italian, English and French.	Industry

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Carmela	Asero	2	EBU, previously European Commission	Carmela Asero is European Project Coordinator at EBU. Previously she was policy analyst at the European Commission - DG Research and Innovation (DG RTD). In recent years she worked in the area of policy and strategy in different EU projects on cloud computing alongside organizations such as CERN, Cloud Security Alliance and European Grid Infrastructures. Between 2008 and 2011 Carmela was scientific project officer at the European Commission, DG Connect. She supported the European Commission as moderator for networking and cloud thematic workshops at Digital Agenda Assembly of 2012 and 2013 and, in many occasion, as expert evaluator for the 7th Framework Programme and Horizon 2020. Carmela holds an MA in Economics, an MA in Diplomatic Studies and a MSc in e-Business.	Industry
Jurry	de la Mar	44	Deutsche Telekom / GAIA-X	Jurry de la Mar currently has the responsibility for the Galileo Satellite Navigation, Copernicus Earth Observation and Helix Nebula Science Cloud programmes within T-Systems. In 2012 he was one of the initiators to create together with CERN, EMBL and ESA the Helix Nebula Initiative that fosters the development and uptake of cloud computing in science in Europe. From 2000 till 2003 he was located to Singapore as Head of Deutsche Telekom's sales and operations in the region South East Asia and India. He joined Deutsche Telekom in 1994. He began his career with Siemens in the medical division and worked in Germany, Netherlands and Sweden. He holds a Ph.D. in Nuclear Physics and a Master in Informatics, both from Free University in Amsterdam. Born in the Netherlands, he grew up in Africa and Asia, lived and worked in various countries and therefore has a strong multi-cultural background.	Industry
Fredrik	Folkestad	19	Volvo	Fredrik Folkestad is Senior Design Consultant at Volvo Cars, specialising in autonomous vehicles. His research focuses on sound design and audiovisual translation, designing AVAS sounds for both electric and autonomous vehicles.	Industry

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Christian	Guttman	11	Tieto-Evry	Global Vice-President for Artificial Intelligence, Tieto Evry, named one of the top 100 global AI leaders in Artificial Intelligence, Machine Learning, and Data Science, has many years of practical experience in the field. Advised both kings and queens on the social role of AI and been awarded by the crown prince of the United Arab Emirates. In his career, he has built 100's of wide-ranging AI systems. He is also involved in major European initiatives, advising the top commissioners in Brussels on upcoming AI regulations.	Industry
Celine	Xu	3	Axel Jonsson, previously Data Scientist and Senior Consultant for Accenture	Celine works as a senior data Scientist at Axel Johnson group, responsible for inspiring and supporting the companies within the group to develop and execute the advanced analytics, and applied AI capability. She was previously Data Scientist and Senior Consultant for Accenture focusing on Telecom, banking and consumer goods industry. Specialties: Analytical Techniques: Business modeling, Customer value analytics, Customer journey solutions, Pricing, Google analytics, Social media anlaysis, Strategy configuration and Operational efficiency optimization. Data Analysis Skills: Advance prediction, Classification modeling, Clustering, Association & sequence modeling, Dimension reduction modeling, CNN,RNN,LSTM, Time Series analysis &Regression, Optimization Algorithms and Data visualization.	Industry
CJ	Carr	21	Dadabots	Founder Dadabots, Turing-test competition winner who relishes in tricking people into believing computer-created music is human. Read his NIPS 2017 paper on "Generating Black Metal and Math Rock: Beyond Bach, Beethoven, and Beatles". CJ has participated in 50 hackathons, which is way too many all-nighters drinking tea and coding. He specialises in machine learning, neural networks, digital signal processing, natural language processing, music information retrieval, generative music, computational creativity, web audio, python, javascript, full stack web development, AWS, GCP, computer game design, music education, music production, guitar, percussion, didgeridoo, throat singing, overtone singing, beatboxing, footwork dancing, hackathon organization, startups, parkour.	Innovation Community / Innovative SME

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Tom	Fox	1	Beechwoood Park School	Tom Fox is Head of Design Technology at Beechwood Park School, MTF Sparks workshop coordinator for MTF Labs, and Creative Director for London-based arts collective Hackoustic. He has performed or talked at The Tate Modern, The Royal College of Music, The Royal College of Art, and many European music tech festivals. He is winner of multiple grand challenge hackathons and grand prizes.	Innovation Community / Innovative SME
Grega	Milčinski	18	Sinergise	Grega Milčinski is CEO of Sinergise, an innovative SME. He studied Physics and co-founded Cosylab inc. at age 21, a company developing control systems for particle accelerators and large experiments in physics. In 2008 Grega moved to become CEO and co-founder of Sinergise, specialising in software for advanced geospatial applications, helping Europe to efficiently manage and control agriculture policy and introducing land administration systems to developing countries in Africa. With his colleagues they have recognised the potential of open Copernicus earth observation data early but soon hit a wall trying to use existing technologies to work with these large datasets. Deciding to do something about it, Sentinel Hub was born. A Copernicus Masters award winning service for processing and distribution of satellite data is exploiting AWS Open Public Datasets. After working with governmental clients in Balkan, Western Europe, Asia and Africa, Grega is now building a global Internet business.	Innovation Community / Innovative SME
Tomer	Shalit	14	ClimateView	Tomer Shalit is CEO of ClimateView, an Innovative SME. ClimateView provides a software platform featuring environmental data, policies and proposals driven by Transitional Targets, to power nations, cities and companies in their decision and policy-making processes on climate. The tool provides both an overview of the work towards tackling climate change as well as the ability to drill down into the more granular detail, including the current CO2 emissions per sector, proposed and approved policies, and indicators of the progress made.	Innovation Community / Innovative SME

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Francisco	Teixeira	24	Neurobios - Neuroscience Institute	Francisco Teixeira is director of the division of Neurofeedback at Neurobios - Neuroscience Institute and partner at MuArts, a brain-computer-interfaces software and hardware development project. He is winner of The Global Hack - Hack the Crisis - Covid-19 - Mental Health track worldwide, the World Wearables Cup 2018, and finalist of the Ars Electronica STARTS Prize 2016. He has a BSc in Psychology and a MSc in Neuroscience from King´s College London.	Innovation Community / Innovative SME
Joseph	Wilk	15	SWCTN	Joseph Wilk is SWCTN Automation Fellow. He is an artist working with programming code, realtime media & audio. He has a Masters Degree in AI, over 20 years of programming experience, and of performing live coding with music and visuals. He is part of the core developer team of Sonic Pi (teaching music and programming in schools), works with professional composers building instruments in code, and creates visual performances using 3D game engines (like Unity) and OpenGL shaders.	Innovation Community / Innovative SME
Tim	Yates	16	Drake Music - national arts charity	Tim Yates is Research & Development Programme Leader & Associate Musician at Drake Music. He makes, builds and finds instruments of all kinds for performance and installation. He has shown work at the Tate Modern, the V&A and Soundfjord amongst many other places. Tim is the founder and Director of Hackoustic, a group dedicated to hacking and experimenting with sound. As part of the Hackoustic team he has run numerous events of many types including running a four day festival as part of WeAreRobots in London, presenting over 35 sound-artists, musicians and scientists, and curating and producing 12 projects and 9 artists on the first night of the Tate Late event. He is a classically trained guitarist and holds a Masters degree in composition from the Royal College of Music. He is an experienced classical guitar teacher with 14 years teaching experience.	Innovation Community / Innovative SME

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Ben	Feist	7	NASA	Ben Feist is Software Engineer, Data Visualization & Informatics at NASA - National Aeronautics and Space Administration. Consultant and researcher at the Astromaterials Research & Exploration Science (ARES) Division at Johnson Space Center, and the Planetary Geophysics and Geochemistry Lab at Goddard Space Flight Center via an independent contract under the Jacobs/JETS contract. Apollo Historian. Creator of apollo17.org and apolloinrealtime.org (Apollo 11 in Real Time interactive experience). Continuing visualization of historical NASA missions and applying these techniques to NASA's current and future operations. Part of the team that restored the Apollo Mission Control National Historical Landmark at JSC.	National and international research organisation supporting research and citizen science
Margaret	Gold	45	European Citizen Science Association (ECSA)	Margaret is a mobile industry veteran now applying mobile and web technologies to participatory science in the field of Citizen Science. She is currently a Project Officer on the WeObserve project, LandSense project and EU-Citizen.Science project for the European Citizen Science Association. Before that she was Science Community Coordinator at the Natural History Museum in London, working with the Digital Collections Programme and running Citizen Science projects online. For more than 15 years she has worked with entrepreneurs and inventors to launch new businesses to market, has helped corporates to expand their offerings with innovative new products and services, and has run creative collaboration events (such as Hack Days and ThinkCamps) that apply technologies in new fields.	National and international research organisation supporting research and citizen science
Friederike	Kleinfercher	29	Max Planck Institute - bloXberg	Friederike Kleinfercher is the deputy head of the Digital Labs department of the Max Planck Digital Library (MPDL) in Munich, developing sustainable services on new technologies for more than 14,000 scientists from Max Planck Institutes worldwide. Manifesting the mission of the Digital Labs department, to bring innovative services to academia, Friederike is one of the initiators and founders of the first truly global scientific blockchain, bloXberg. Friederike holds a	National and international research organisation supporting research and citizen science

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				diploma in Media Computing Science of the Ludwigs-Maximilians-University in Munich.	
Tor Björn	Minde	31	RISE - Research Institutes of Sweden - ICE Data Centre, previously Head of Research Strategies at Ericsson Research.	Tor Björn Minde is Head of Lab at RISE ICE Datacenter in Luleå, Sweden. He was recently head of research strategies at Ericsson Research with 35 years experience at Ericsson in mobile communication, cloud, machine learning, multimedia & applications. He also holds an adjunct professorship at Luleå University of Technology in signal processing. His main research interests are sensor, context aware, datacenter and machine learning technologies. He has led the team behind Ericsson Labs with the objective to improve ability in open innovation offering experimental API's for mobile applications. Lately his main focus has been on large-scale cloud and big data infrastructures for energy efficient, autonomous and smart grid integrated operations.	National and international research organisation supporting research and citizen science
Masayuki	Tanaka	25	National Astronomical Observatory of Japan - Fujitsu Global	Masayuki Tanaka is Associate Professor, Department of Astronomical Science at the National Astronomical Observatory of Japan - Fujitsu Global. He specialises in Galaxy Formation and Evolution, Observational Cosmology, and Photometric Redshifts.The Hyper Suprime-Cam Strategic Program, which is the biggest observing program at Subaru, is currently underway. This is a 300-night program and many interesting discoveries in cosmology, galaxy evolution, and Miky Way science are expected. Masayuki-san is working on a wide range of science using data from the survey, e.g., (a) massive galaxy formation in the early universe, (b) galaxy formation and evolution and their dependence on environment, (c) near-field cosmology with nearby dwarf galaxies, and (d) high-accuracy photometric redshifts.	National and international research organisation supporting research and citizen science

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Kumiko	Usuda-Sato	25	National Astronomical Observatory of Japan - Fujitsu Global	Kumiko Usuda-Sato heads the Public Relations Center at the National Astronomical Observatory of Japan - Fujitsu Global. She is in charge of engaging citizen scientists in the Galaxy Cruise project and Communicating Astronomy with the Public.	National and international research organisation supporting research and citizen science
Sandra	Vengadasalam	29	Max Planck Institute - bloXberg	Sandra Vengadasalam leads the department Digital Labs of the Max Planck Digital Library (MPDL) in Munich, which serves a community of 14,000 scientists across 84 Max Planck Institutes worldwide. Blockchain technology and specifically innovative services for academia based on blockchain technology, is a passion for Sandra and her team. Furthermore, Sandra is one of the founders of the Max Planck Open Access Ambassadors initiative – a network of young PhD students disseminating the principles of Open Access and Open Science between young scientists. Before MPDL, Sandra obtained her PhD in biology focusing on molecular biology and biochemistry. After her doctorate she worked as PostDoc in the field of Epigenetics and Chromatin Remodeling at the Adolf-Butenandt-Institute in Munich. In her spare time, she was the chairperson of the Youth Symphony Orchestra in Munich and still plays violin and harp.	National and international research organisation supporting research and citizen science

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Appendix 3: Additional proposed methodology

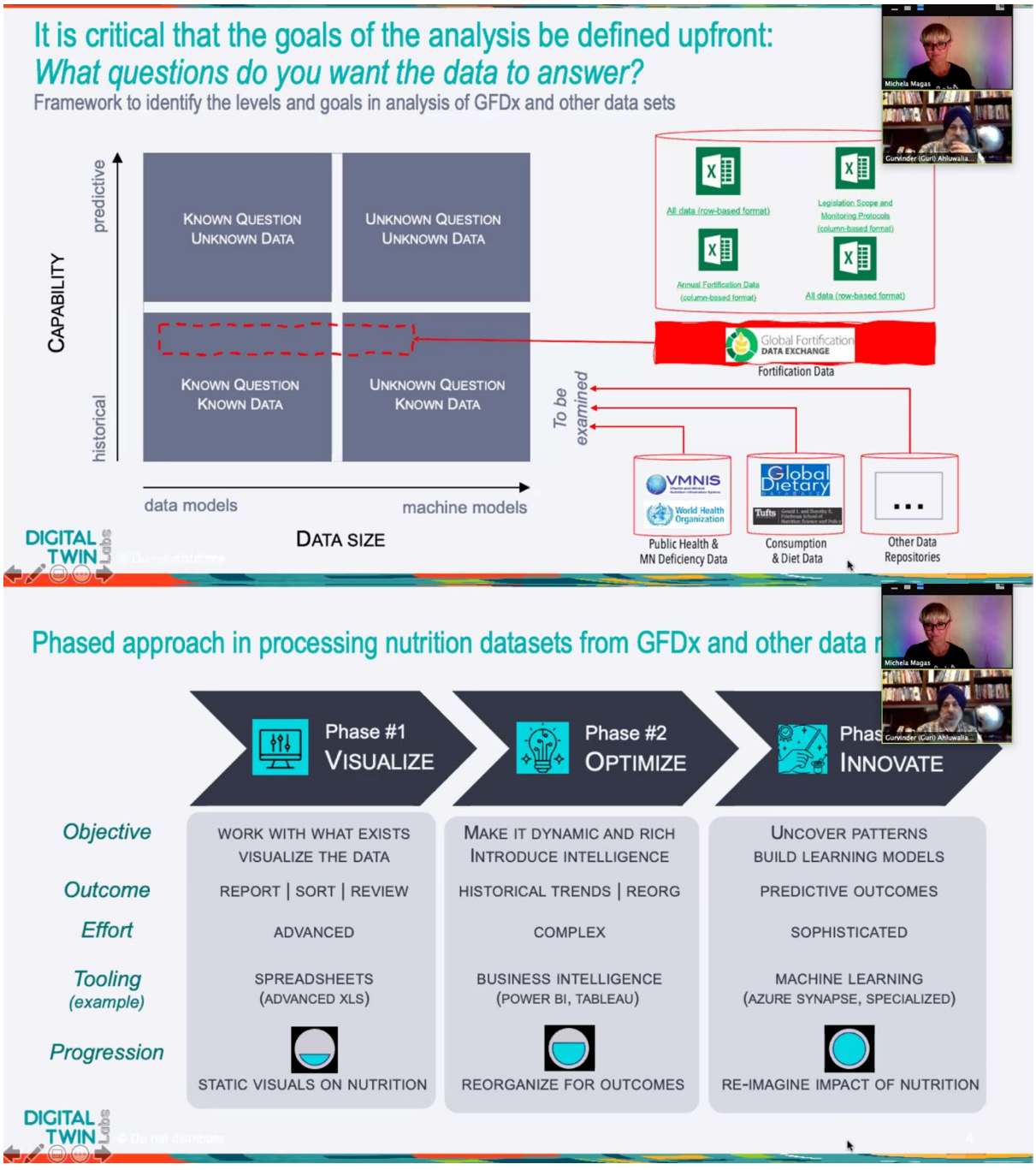

Figure 5: Evolving methodology with Digital Twin Labs

The above Phases of data processing were updated by addition of imaginary scenarios in Phase 2, to enable to uncover not only predictive outcomes according to historical trends, but also innovation potential based on emerging market models. See

Source: Gurvinder Ahluwhalia, Digital Twin Labs, 7 September 2020.

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